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# NEW KANGAROO MICE, GENUS *MICRODIPODOPS* (RODENTIA: HETEROMYIDAE), FROM IDAHO AND NEVADA

John C. Hafner

*Abstract.*—Two new subspecies of kangaroo mice (*Microdipodops*) are described from the Great Basin region of North America: *M. megacephalus atrirelictus* from southwestern Idaho and *M. pallidus restrictus* from southwestern Nevada. The single known population of *atrirelictus* is isolated from other populations of kangaroo mice by over 100 km of unsuitable habitat and constitutes the first record of the genus in the state. This taxon is large in most cranial and external measurements, extremely dark in dorsal pelage color, and is characterized by the 40-$\beta$ (40 chromosomes, totally biarmed autosomes) karyotype. The subspecies *restrictus,* known only from the type-locality, is small in most cranial characters and has the 42-$\alpha$ (5 pairs of acrocentric autosomes) karyotype. This new subspecies of *M. pallidus* exhibits a karyotype similar to *M. p. pallidus,* and a morphology like that of *M. p. ruficollaris.* Moreover, both subspecies described herein show a level of biochemical differentiation that is in accord with their high degree of morphological and chromosomal distinctiveness.

Kangaroo mice (genus *Microdipodops*) belong to one of the most morphologically heterogeneous groups of mammals: the rodent superfamily Geomyoidea. This superfamily is autochthonous in North America and comprises a diverse assemblage of forms including those which are fossorial herbivores (pocket gophers; family Geomyidae) and those which are either quadrupedal (scansorial) or bipedal (richochetal) granivores (kangaroo mice, kangaroo rats, pocket mice and spiny pocket mice; family Heteromyidae). The genus *Microdipodops* was described by Merriam in 1891 and was immediately recognized as a bizarre form even in the context of such a heterogeneous assemblage. Kangaroo mice are tiny, bipedal rodents with enormous heads and large, furry hind feet. Indeed, *Microdipodops* shows the greatest relative head size (head size : body size) known among mammals extant or extinct.

In comparison with other geomyoid genera, the genus *Microdipodops* contains few species and occupies a very small geographic range. Only two species of kangaroo mice are recognized, *M. megacephalus* and *M. pallidus,* and both are desert-adapted forms which are restricted in distribution to the Great Basin Desert region (Hall 1941; Hafner *et al.* 1979; Hafner 1981). Kangaroo mice are not distributed ubiquitously across the Great Basin, but occur in a highly dissected manner reflecting largely their predilection for aeolian soils. In the course of field work for an evolutionary study of kangaroo mice (Hafner 1981), two new forms were identified, each from disjunct and geographically isolated areas. The new *Microdipodops* taxa include a subspecies of *M. megacephalus* from extreme southwestern Idaho and one of *M. pallidus* from southwestern Nevada. Kangaroo mice heretofore were unreported from Idaho (Davis 1939). Hence, the known geographic distribution of *M. megacephalus* now spans the broad bounds of the Great Basin region and includes principally Nevada and its neighboring states of California, Oregon, Idaho, and Utah. The distribution of *M. pallidus,* in contrast, is confined to Nevada and the eastern margins of California.

## Methods and Materials

*Morphological considerations.*—The specimens described herein were compared with geographically adjacent forms (subspecies taxonomy follows Hafner 1981). In total, five populations were sampled for comparison with the new Idahoan kangaroo mice, and two samples were selected for comparison with the new *M. pallidus* form from southwestern Nevada. Morphological differentiation among the nine samples was assayed by examination of a battery of cranial morphometric characters and pelage colorimetric variables in adult specimens of kangaroo mice. The criterion for selecting adult specimens for the cranial morphometric portion of the analysis included presence of extensive wear on the permanent fourth upper premolar. All specimens used in the colorimetric analyses showed adult dorsal pelage coloration. In the computation of statistics sexes were pooled inasmuch as kangaroo mice are known to lack secondary sexual differences in the characters under study (Hall 1941, 1946; Schitoskey 1968; Hafner 1976). Sixteen cranial measurements (in mm) were taken with dial calipers: greatest length of skull, greatest breadth (across mastoids), basal length, bullar length, maxillary breadth, nasal length, least interorbital breadth, greatest expanse of lateral face of zygoma (width of zygomatic process of maxilla), least expanse of lateral face of zygoma (taken at the maxillary base of zygoma), greatest length incisive foramina, length incisive foramina at point of greatest breadth (a measure of the posterior foraminal divergence taken from the anterior margin of incisive foramina), greatest breadth incisive foramina, greatest pterygoidal breadth (across distal end of one pterygoid), arching of cranial dome (from the dorsal margin of the foramin magnum to a line tangential to the nasal-frontal plane), mandibular length, and angular bifurcation (a measure of the expansion of the wings of the angular process of the dentary; see Hafner *et al.* 1979). Variation in mid-dorsal pelage coloration was measured using a Bausch and Lomb Spectronic 505 Spectrophotometer. Three colorimetric variables were computed from reflectance curves: relative brightness (=value), dominant wavelength (=hue), and excitation purity (=chroma or saturation). A full description of the characters and methods of taking and recording data is presented elsewhere (Hafner 1981). Holotypic specimens described herein were prepared following the skin-plus-skeleton technique (Hafner *et al.* 1984).

*Protein electrophoresis.*—Biochemical variation was examined in samples representing all subspecies under study except *M. m. nexus.* Polyacrylamide gel electrophoresis was used to examine patterns of variation in plasma proteins and nonspecific esterases. This technique, which focuses on "rapidly evolving" proteins, allows for higher resolution at the lower taxonomic levels than does the conventional starch gel (specific-staining) approach. Following electrophoretic separation, the gels were treated according to electrophoretic procedures for general staining. Thirty-two protein bands (presumptive loci) were analyzed and individuals were compared and scored for similarity (*S*) to assess degree of biochemical differentiation. A full description of this technique and its application to *Microdipodops* systematics is given elsewhere (Hafner 1981).

*Chromosomal analysis.*—The karyotypes of two specimens of *M. p. restrictus* (including the holotype) and one specimen of *M. m. atrirelictus* (the holotype) were compared with those of all other named forms of *Microdipodops* (Hafner 1981). Non-preferentially stained karyotypes were prepared using a modification of Patton's (1967) in vivo bone marrow technique. Terminology and chromosomal descriptions follow Hafner (1981). All karyotypic preparations are deposited as voucher material in the Museum of Vertebrate Zoology, University of California, Berkeley.

*Comparative material examined.*—All study specimens used for comparison with the new subspecies are deposited in the Museum of Vertebrate Zoology (MVZ). The five *M. megacephalus* samples chosen are as follows: *M. m. oregonus,* 2 mi. S Borax Spring, S end Lake Alvord, 4300 ft., Harney Co., Oregon; *M. m. ambiguus,* 1¼ mi. N Sulphur, 4050 ft., Pershing Co., Nevada; *M. m. californicus,* 7 mi. N Winnemucca, 4600 ft., Humboldt Co., Nevada; *M. m. nexus,* 3 mi. S Inzenhood, Lander Co., Nevada; and *M. m. megacephalus,* 22.8 mi. N, 3.6 mi. W Eureka, 5850 ft., Eureka Co., Nevada, and 4 mi. SE Romano, Diamond Valley, Eureka Co., Nevada. The two *M. pallidus* samples selected include: *M. p. pallidus,* Mountain Well, 5600 ft., Churchill Co., Nevada; and *M. p. ruficollaris,* 2½ mi. S Lock's Ranch, 3¼ mi. S Lock's Ranch, 9 mi. S Lock's Ranch, and Able Spring, 12½ mi. S Lock's Ranch, Railroad Valley, 5000 ft., Nye Co., Nevada. Sample sizes are given below and in Tables 1 and 2. These samples, except those of *californicus* and *megacephalus,* represent type or near-type localities for each of the subspecies.

## *Microdipodops megacephalus atrirelictus,* new subspecies

*Holotype.*—Adult female; skin, skull, skeleton (appendicular elements complete on left side only), frozen tissue, karyotype: MVZ 160039; coll. 8 Oct 1978, John C. Hafner; original number 1428; condition good.

*Type-locality.*—11 mi. S, 44.2 mi. W Riddle, 5000 ft., Owyhee Co., Idaho.

*Distribution.*—Known only from the immediate vicinity of the type-locality in extreme southwestern Idaho (southwestern Owyhee County) near the boundaries of Oregon and Nevada.

*Measurements of the holotype.*—Morphometric data for the holotype including external measurements (transcribed from the specimen tag) and cranial characters are as follows: total length, 169; tail length, 93; hind foot, 26; ear, 12; greatest length of skull, 29.27; greatest breadth, 19.16; basal length, 19.06; bullar length, 14.60; maxillary breadth, 11.62; nasal length, 10.35; least interorbital breadth, 6.69; greatest expanse of lateral face of zygoma, 1.32; least expanse of lateral face of zygoma, 0.94; greatest length of incisive foramina, 2.19; length incisive foramina at point of greatest breadth, 1.52; greatest breadth of incisive foramina, 0.73; greatest breadth of pterygoids, 0.61; arching of cranial dome, 6.49; mandibular length, 10.85; and angular bifurcation, 0.36.

*Diagnosis and description.*—These kangaroo mice are the largest in general body size and darkest in dorsal pelage color of all known populations of *M. megacephalus.* With respect to cranial measurements (Table 1), *atrirelictus* is particularly large in greatest breadth of skull, basal length, bullar length and mandibular length. The dorsal aspect of the skull is relatively flat and the nasals are short. The incisive foramina are short, narrow, and nearly parallel sided (not diverging

Table 1.—Mean values of cranial variables for selected samples of *Microdipodops* (2 SE and N shown in parentheses). Measurements are in millimeters.

| Subspecies | Greatest length | Greatest breadth | Basal length | Bullar length |
|---|---|---|---|---|
| | | *Microdipodops megacephalus* | | |
| *atrirelictus* | 28.705 (.635, 4) | 19.325 (.121, 4) | 18,598 (.466, 4) | 14.715 (.251, 4) |
| *oregonus* | 28.257 (.268, 11) | 18.587 (.328, 11) | 18.275 (.230, 10) | 14.103 (.298, 11) |
| *ambiguus* | 28.864 (.292, 11) | 19.237 (.280, 11) | 18.382 (.198, 11) | 14.845 (.240, 11) |
| *californicus* | 28.729 (.290, 12) | 18.933 (.258, 12) | 18.441 (.210, 12) | 14.304 (.182, 12) |
| *nexus* | 28.750 (.234, 12) | 19.392 (.172, 12) | 18.291 (.188, 9) | 14.827 (.180, 12) |
| *megacephalus* | 28.435 (.342, 12) | 18.862 (.222, 12) | 18.444 (.280, 12) | 14.567 (.188, 12) |
| | | *Microdipodops pallidus* | | |
| *restrictus* | 28.380 (.332, 7) | 19.417 (.222, 7) | 18.289 (.158, 7) | 14.464 (.208, 7) |
| *pallidus* | 28.774 (.354, 14) | 19.548 (.326, 14) | 18.428 (.234, 12) | 14.624 (.250, 14) |
| *ruficollaris* | 28.400 (.444, 8) | 19.452 (.436, 8) | 18.173 (.306, 7) | 14.640 (.286, 8) |

| Subspecies | Maxillary breadth | Nasal length | Least interoribital breadth | Greatest expanse of lateral face of zygoma |
|---|---|---|---|---|
| | | *Microdipodops megacephalus* | | |
| *atrirelictus* | 11.790 (.211, 4) | 9.875 (.388, 4) | 6.595 (.073, 4) | 1.420 (.067, 4) |
| *oregonus* | 11.819 (.154, 11) | 10.202 (.192, 11) | 6.866 (.092, 11) | 1.575 (.054, 11) |
| *ambiguus* | 11.616 (.196, 11) | 10.027 (.146, 11) | 6.571 (.098, 11) | 1.517 (.068, 11) |
| *californicus* | 11.709 (.208, 12) | 10.266 (.192, 12) | 6.513 (.100, 12) | 1.472 (.072, 12) |
| *nexus* | 11.524 (.192, 12) | 9.997 (.134, 12) | 6.498 (.092, 12) | 1.464 (.096, 11) |
| *megacephalus* | 11.649 (.118, 12) | 9.788 (.152, 12) | 6.640 (.072, 12) | 1.387 (.092, 12) |
| | | *Microdipodops pallidus* | | |
| *restrictus* | 11.917 (.310, 7) | 9.991 (.282, 7) | 6.623 (.134, 7) | 1.479 (.084, 7) |
| *pallidus* | 12.132 (.208, 13) | 10.117 (.168, 14) | 6.741 (.106, 14) | 1.542 (.068, 14) |
| *ruficollaris* | 12.155 (.274, 8) | 9.692 (.118, 8) | 6.838 (.084, 8) | 1.538 (.050, 8) |

| Subspecies | Least expanse of lateral face of zygoma | Greatest length incisive foramina | Length incisive foramina at point of greatest breadth | Greatest breadth incisive foramina |
|---|---|---|---|---|
| | | *Microdipodops megacephalus* | | |
| *atrirelictus* | 1.013 (.086, 4) | 2.325 (.117, 4) | 1.713 (.133, 4) | 0.858 (.105, 4) |
| *oregonus* | 1.135 (.064, 11) | 2.531 (.058, 11) | 2.035 (.086, 11) | 1.098 (.066, 11) |
| *ambiguus* | 1.135 (.066, 11) | 2.515 (.094, 11) | 2.040 (.072, 11) | 0.980 (.078, 11) |
| *californicus* | 1.185 (.078, 12) | 2.359 (.052, 12) | 1.822 (.080, 12) | 0.990 (.036, 12) |
| *nexus* | 1.023 (.074, 12) | 2.434 (.072, 12) | 1.950 (.064, 12) | 0.960 (.042, 12) |
| *megacephalus* | 0.981 (.086, 12) | 2.412 (.078, 12) | 1.915 (.096, 12) | 1.050 (.068, 12) |
| | | *Microdipodops pallidus* | | |
| *restrictus* | 1.126 (.058, 7) | 2.239 (.098, 7) | 1.584 (.220, 7) | 0.954 (.044, 7) |
| *pallidus* | 1.044 (.048, 14) | 2.353 (.072, 14) | 1.156 (.214, 14) | 0.918 (.036, 14) |
| *ruficollaris* | 1.234 (.034, 8) | 2.354 (.072, 8) | 1.371 (.122, 8) | 1.023 (.060, 8) |

| Subspecies | Greatest pterygoidal breadth | Arching of cranial dome | Mandibular length | Angular bifurcation |
|---|---|---|---|---|
| | | *Microdipodops megacephalus* | | |
| *atrirelictus* | 0.718 (.076, 4) | 6.320 (.145, 4) | 10.638 (.274, 4) | 0.403 (.039, 4) |
| *oregonus* | 0.757 (.040, 10) | 6.433 (.222, 11) | 10.440 (.066, 11) | 0.329 (.022, 11) |
| *ambiguus* | 0.737 (.070, 10) | 6.688 (.212, 11) | 10.292 (.106, 11) | 0.267 (.040, 11) |
| *californicus* | 0.772 (.062, 12) | 6.474 (.144, 12) | 10.512 (.124, 12) | 0.321 (.050, 12) |
| *nexus* | 0.745 (.080, 8) | 6.419 (.166, 12) | 10.317 (.126, 12) | 0.436 (.032, 12) |
| *megacephalus* | 0.705 (.044, 11) | 6.482 (.208, 12) | 10.409 (.102, 12) | 0.286 (.026, 12) |
| | | *Microdipodops pallidus* | | |
| *restrictus* | 0.856 (.040, 7) | 6.960 (.272, 7) | 10.509 (.146, 7) | 0.469 (.070, 7) |
| *pallidus* | 0.974 (.044, 12) | 6.971 (.200, 14) | 10.761 (.126, 14) | 0.494 (.032, 14) |
| *ruficollaris* | 0.979 (.056, 8) | 6.905 (.188, 8) | 10.586 (.242, 8) | 0.534 (.054, 8) |

Table 2.—Mean values of colorimetric variables for selected populations of *Microdipodops* (2 SE shown in parentheses). Relative brightness and excitation purity are given in per cent and dominant wavelength is in millimicrons.

| Subspecies | N | Relative brightness | Dominant wavelength | Excitation purity |
|---|---|---|---|---|
| | | *Microdipodops megacephalus* | | |
| *atrirelictus* | 5 | 58.984 (0.806) | 576.600 (1.624) | .037 (.006) |
| *oregonus* | 19 | 58.387 (0.802) | 577.737 (0.730) | .049 (.004) |
| *ambiguus* | 19 | 72.122 (1.668) | 580.579 (0.232) | .104 (.004) |
| *californicus* | 20 | 71.165 (1.308) | 580.500 (0.308) | .104 (.004) |
| *nexus* | 19 | 64.054 (0.892) | 579.842 (0.382) | .082 (.004) |
| *megacephalus* | 19 | 60.327 (2.894) | 577.316 (1.082) | .050 (.006) |
| | | *Microdipodops pallidus* | | |
| *restrictus* | 7 | 76.877 (1.808) | 581.000 (0.618) | .099 (.008) |
| *pallidus* | 20 | 75.709 (1.456) | 581.350 (0.218) | .119 (.004) |
| *ruficollaris* | 17 | 74.901 (1.282) | 580.118 (0.890) | .101 (.004) |

posteriorly). Chromosomally, *atrirelictus* has a diploid number of 40 and a fundamental number (autosomal arm number) of 76; this is the 40-$\beta$ karyotype (Hafner 1981), which has all biarmed autosomes. The dorsal pelage of *atrirelictus* is dark and registers relatively low values for excitation purity (Table 2). The pelage of the tail dorsum is black from base to tip. The ventral pelage is characterized by having distinct plumbeous bases on the belly hair.

*Comparisons.*—From *oregonus, ambiguus,* and *megacephalus,* this subspecies differs in having the 40-$\beta$ karyotype (and not the 40-$\alpha$ karyotype with the characteristic small pair of acrocentric autosomes; see Hafner 1981), larger overall body size, greater cranial measurements (e.g., greatest breadth, basal length, and mandibular length), and darker dorsal pelage color (Tables 1 and 2). Kangaroo mice from Idaho, although sharing the 40-$\beta$ karyotype with *californicus* (Hafner 1981), differ from that subspecies in having darker dorsal pelage, larger body size and cranial measurements, and plumbeous bases on the hairs of the venter (instead of pure white belly hairs). From *nexus,* whose karyotype is unknown, *atrirelictus* is also readily distinguished by its larger size (particularly basal length and mandibular length) and darker pelage (Tables 1 and 2).

*Comments.*—This new subspecies from Idaho is among the most highly differentiated infraspecific taxa in *Microdipodops.* Attendant with the high degree of morphological distinctness of *atrirelictus,* is its great extent of protein electromorphic divergence (Hafner 1981). Analysis of protein electrophoregrams reveals that *atrirelictus* represents a singular genetic subcluster within *M. megacephalus* (overall genetic similarity between *atrirelictus* and other *M. megacephalus* populations is low [$\bar{S} = 0.60$]; see Hafner 1981). Moreover, among all known *M. megacephalus* populations, *atrirelictus* possesses a unique combination of three characters: nearly black dorsal pelage, plumbeous bases to the hairs of the venter, and the 40-$\beta$ karyotype.

These kangaroo mice are isolated near the East Little Owyhee River region and are well separated from other known populations of kangaroo mice by over 100 km of apparently unsuitable habitat. In consideration of the morphological and genetic distinctness of *atrirelictus* and its marginal geographic position (actually lying just outside the northern bounds of the hydrographically defined Great Basin), it appears that these kangaroo mice represent a relictual distributional islet of *M. megacephalus.* Further, the genetic and morphological information argue against the notion that the Idahoan mice represent a very recent immigrant into the Owyhee region.

The environs about the general vicinity of the type-locality are atypical for kangaroo mice; the area is extremely rocky, much of the region is steeply dissected by canyons and the soil is generally alkali-caked or gravelly. Notwithstanding this, the holotype was collected on a sandy strandline along the course of a dry arroyo which funnels into the East Little Owyhee River. Here the floral association included *Artemisia, Tetradymia,* and scattered clumps of perennial grasses, including *Oryzopsis,* and was similar to typical *M. megacephalus* habitat (Fig. 1). The other specimens of *atrirelictus* were collected above the type locality on the sagebrush flats immediately to the west (John A. White, pers. comm.). The form *atrirelictus* is not common locally and is known from only five specimens. Indeed, the holotype was the only kangaroo mouse taken at the type-locality out of a total of 410 trapnights.

*Specimens examined.*—In addition to the holotype, one juvenile (skin in molt) and three adults were examined (all from the near vicinity of the type-locality). The last four specimens (all from the same general locality; John A. White, pers. comm.) are deposited in the Idaho Museum of Natural History, Idaho State University (specimen tags bearing IMNH or ISU numbers) as follows: ½ mi. N Nevada, 2½ mi. E Oregon, Owyhee Co., Idaho (693, 694 IMNH); Starr Valley, NW ¼ Section 19, T16S, R5W, B.M., Owyhee Co., Idaho (259 IMNH); Near Starr Valley, NW ¼, NW ¼ Section 19, T16S, R5W, B.M., Owyhee Co., Idaho (R-526 ISU).

*Etymology.*—The subspecific epithet is derived from the Latin root *atr,* meaning black, and *relict,* meaning left behind. This name was selected to express both the distinctive morphological and historical biogeographical attributes of the new subspecies.

### *Microdipodops pallidus restrictus,* new subspecies

*Holotype.*—Adult male; skin, skull, skeleton (appendicular elements present on left side only), frozen tissue, and karyotype: MVZ 159970; coll. 2 Aug 1979, John C. Hafner; original number 1463; condition good.

*Type-locality.*—8.9 mi. S, 1.2 mi. E Mina, 4400 ft., Mineral Co., Nevada.

*Distribution.*—Known only from type-locality. This population seems to be restricted to a small distribution in Soda Spring Valley at the southern end of Rhodes Salt Marsh, and isolated from surrounding populations of *M. pallidus* in Mineral County.

*Measurements of the holotype.*—External measurements (taken from the specimen label) and cranial morphometric characters for the holotype are as follows: total length, 158; tail length, 89; hind foot, 25.5; ear, 12; greatest length of skull, 28.01; greatest breadth, 19.53; basal length, 18.32; bullar length, 14.53; maxillary breadth, 12.49; nasal length, 10.14; least interorbital breadth, 6.59; greatest expanse of lateral face of zygoma, 1.68; least expanse of lateral face of zygoma, 1.22; greatest length incisive foramina, 2.23; length incisive foramina at point of greatest breadth, 1.76; greatest breadth incisive foramina, 1.03; greatest breadth ptery-

Fig. 1. Type-locality of *Microdipodops megacephalus atrirelictus*: 11 mi. S, 44.2 mi. W Riddle, 5000 ft., Owyhee Co., Idaho. This view, facing north, illustrates the general topography of the area. The holotype was collected near a sandy wash (center of photograph), whereas other specimens were collected in seemingly less-favorable habitat on the mesas to the west.

goids, 0.76; arching of cranial dome, 6.28; mandibular length, 10.38; and angular bifurcation, 0.58.

*Diagnosis and description.*—Kangaroo mice of this subspecies are small in overall cranial measurements, including: greatest length of skull, bullar length, maxillary breadth, and greatest length of incisive foramina (Table 1). Further, in *restrictus* the ratio between the least and greatest expanse of the lateral face of the zygoma is large (see Table 1), which reflects a lesser relative development of a "zygomatic plate" along the zygoma. Also, the pterygoids are narrow and the nasals are short. With respect to colorimetric characters, this subspecies is characterized by having a small value for excitation purity of the dorsal pelage (Table 2). Chromosomally, *restrictus* has the 42-$\alpha$ karyotype (Hafner 1981), which has 42 chromosomes and a fundamental number of 70 (five pairs of acrocentric autosomes).

*Comparisons.*—Cranial and colorimetric variables of *restrictus* and the only other two subspecies, *pallidus* and *ruficollaris* (Hafner 1981), are presented in Tables 1 and 2. From *pallidus,* (the main western subspecies that largely surrounds *restrictus* in distribution), *restrictus* differs in having shorter nasals, larger measurements for the least expanse of lateral face of zygoma and smaller values for excitation purity of the dorsal pelage. Kangaroo mice of the subspecies *restrictus* differ from *ruficollaris* (the eastern *M. pallidus* subspecies) in having the 42-$\alpha$

Fig. 2. Type-locality of *Microdipodops pallidus restrictus*: 8.9 mi. S, 1.2 mi. E Mina, 4400 ft., Mineral Co., Nevada. Kangaroo mice of this subspecies are found on and immediately about these semi-stabilized sand dunes (view is facing north).

karyotype instead of the 42-$\beta$ (totally biarmed autosomes; see Hafner 1981) karyotype.

*Comments.*—The form *restrictus,* although distributed in the western portion of the species' range, is morphologically unlike the other western subspecies, *pallidus,* and remarkably similar to *ruficollaris* of the east. Interestingly though, *restrictus* differs markedly in karyotype from the eastern subspecies and possesses the same karyotype found throughout the majority of the range of *pallidus.* Hence, *restrictus* combines characters found in both of these other forms. In addition to the morphological and chromosomal differentiation of *restrictus,* this new subspecies is biochemically quite distinct. Indeed, the degree of biochemical differentiation between *restrictus* and samples of *pallidus* ($\bar{S} = 0.60$) and *ruficollaris* ($\bar{S}$) = 0.62) is commensurate with that observed between *pallidus* and *ruficollaris* ($\bar{S} = 0.64$; see Hafner 1981).

The geographic distribution of *restrictus* is very limited in comparison to *pallidus* and *ruficollaris.* This subspecies is known from one isolated locality in southeastern Mineral County and more collecting is needed to document the extent of its geographic range. The habitat at the type-locality is characterized by semi-stabilized sand dunes several meters in height (Fig. 2). The vegetation is sparse and the flora is dominated by *Sarcobatus* and *Atriplex.* This restricted sand dune system is separated from other known localities of *M. pallidus* by approximately

30 km of alkali-caked and/or hardpan, gravelly soils, which are not suitable for *M. pallidus* habitation.

*Specimens examined.*—A total of 14 specimens was examined (MVZ 159969–159982) all from the type-locality.

*Etymology.*—The subspecific epithet, *restrictus,* is derived from the Latin root *restrict,* and was chosen to reflect both the small geographic range of the new subspecies and its isolation from other populations of the species.

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# MISSISSIPPIELLIDAE, A NEW EULOBOSINID ("THECAMOEBINID") FAMILY (PROTOZOA)

Richard W. Huddleston and Drew Haman

*Abstract.*—The genus *Mississippiella* Haman, 1982, based on the uniqueness of test composition and construction, along with distinctive apertural morphology, is transferred from the family Paraquadrulidae Deflandre, to the new family Mississippiellidae.

The Paraquadrulidae was, prior to the discovery of the genus *Mississippiella* by Haman (1982a, b) the only thecamoebian family known to possess an external secreted calcite test (Loeblich and Tappan 1964). This led Haman (1982a, b) to assign *Mississippiella* to this family despite the fact that *Paraquadrula* Deflandre was known only from western European mosses.

Loeblich and Tappan (1964) along with Ogden and Hedley (1980), accept the Paraquadrulidae as a distinct family based on test composition. Page (1982), however, places the genus *Paraquadrula* in the family Nebelidae (which he equates with the Hyalosphenidae), but does acknowledge that "The one calcareous genus (*Paraquadrula*) is sometimes separated into a family." The uncertainty of systematic placement of this calcareous entity is typical of the overall arcellacean classification, a state of affairs lamented upon by Medioli and Scott (1983).

We subscribe to the viewpoint that until stability is attained in arcellacean classification, newly discovered forms should be retained as distinct entities if they differ from previously described taxa. This viewpoint is followed even when the new forms occur with less than optimal abundance. If additional information on the new organism becomes available, which clearly demonstrates a biological affinity to another taxon, it is at that time that any systematic grouping should be undertaken. Presumptive grouping may lead to erroneous observations and conclusions. The retention of the new entity may occur at any level within the hierarchal system and simply depends upon the existing classification scheme. Consequently, based on the significant morphological differences between *Paraquadrula* and *Mississippiella,* plus the fact that the former genus is placed in an accepted family, we remove *Mississippiella* from the Paraquadrulidae and establish the family Mississippiellidae to accommodate the form. A revision of the family Paraquadrulidae to accommodate *Mississippiella* is not believed prudent at this time and would only add to the confusion, detailed above, concerning this family. We are fully cognizant that other workers on the Arcellacea may differ with our philosophy but we believe it to be expedient at present as the "microclassification of the group remains . . . in a chaotic state" (Medioli and Scott 1983: 6).

Page (1982) claimed that the test of *Paraquadrula* is formed by a calcium replacement of the original silica; however, other workers believe that the quadrangular plates characteristic of this genus are formed of secreted calcite (Loeblich and Tappan 1964; Ogden and Hedley 1980). We favor the second opinion. X-ray energy dispersant analysis of *Mississippiella* utilizing a Kevex 10-channel recorder showed the test composition to be almost pure calcite with no trace of silica (Haman 1982a, Fig. 27). *Paraquadrula* has been described as having a test composed of "quadrangular calcareous plates which may have thickened rims" (Loeblich and Tappan 1964:C34). The presence of plates or "scales" is a consistent feature found in nearly all nonproteinaceous thecamoebinids possessing a secreted test of either calcareous or siliceous composition. *Mississippiella* clearly diverges from this pattern by displaying autogenous intergrowths of euhedral calcite rhombs comprising the test.

Ogden and Hedley (1980:3) diagnosed the shells of testate amoebae as being "proteinaceous, agglutinate, siliceous, or calcareous in composition" and that their morphology would normally "consist of one single aperture." This last criterion cannot be regarded as a critical thecamoebinid feature as demonstrated by the estuarine-marine genus *Trichosphaerium* Doflein which possess multiple circular apertures. *Mississippiella* has an "aperture composed of a series of predominantly ovate openings, variable in number, 10–18 arranged in a crescentic series" (Haman 1982a:366). While the majority of thecamoebinids have a single aperture (Ogden and Hedley 1980), forms with multiple apertures exist (Page 1982). In addition, Ogden and Hedley (1980) illustrate numerous species which display apertural modifications in the form of circum-apertural pores. Grospietsch (1965) reported that one form of *Hyalosphenia papilio* Leidy has a simple concave aperture, while another has several apertural pores. The openings present on tests of *Mississippiella* are believed to represent the true aperture and not pores as illustrated by Ogden and Hedley (1980). *Paraquadrula* possesses a terminal aperture that is described as oval (Ogden and Hedley 1980) or as oval to slitlike (Loeblich and Tappan 1964) and differs markedly from *Mississippiella. Mississippiella* differs from all thecamoebinid taxa described to date based on apertural characters.

The possession by *Mississippiella* of a secreted, calcitic, non-porcellaneous, imperforate, unichambered test is sufficient to warrant placement within the Arcellinida as defined by Sheehan and Banner (1973), despite the fact that information on the pseudopodia is not currently available and the fact that *Mississippiella* displays features not previously known to exist in thecamoebinids.

Page (1982) divides the Arcellinida into two suborders, the Eulobosina and the Trichosida. The second suborder is characterized by the single family Trichosphaeriidae and the single genus *Trichosphaerium.* Sheehan and Banner (1973) published a detailed study on this genus and determined that *Trichosphaerium* possesses an external, flexible spicular test with quasi-permanent apertures. Such characteristics clearly exclude *Mississippiella* from this suborder; therefore, this genus is placed in the Eulobosina. The affinities and differences of *Mississippiella* to and from other eulobosinid taxa have been detailed above. From this discussion it is evident that *Mississippiella* does not demonstrate equitability with any established thecamoebinid genus or family, and warrants the establishment of a new family, the Mississippiellidae. As the family is monotypic, the characters of the family are those of the genus.

## Mississippiellidae, new family

*Diagnosis.*—Test free, unilocular, circular to subcircular in outline, discoidal to hemispherical in side view, ventral surface flat to concave; dorsal surface convex; aperture composed of series of predominantly ovate openings, variable in number, 10–18, arrranged in crescentic pattern towards one side of ventral surface; wall composed of autogenous intergrowths of euhedral calcite rhombs.

*Type-genus.—Mississippiella* Haman, 1982.

*Type-species.—Mississippiella multiapertura* Haman, 1982.

*Type-illustrations.*—Haman (1982:holotype, pl. 2, figs. 11–15; paratypes, pl. 2, figs. 16–22).

*Etymology.*—The family name is derived from the type-locality, the Mississippi Delta.

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# FIRST RECORD OF THE GENUS *ZEBRIAS* (PISCES: PLEURONECTIFORMES: SOLEIDAE) FROM THE PHILIPPINE ISLANDS, WITH THE DESCRIPTION OF A NEW SPECIES

Jeffrey A. Seigel and Thomas A. Adamson

*Abstract.*—*Zebrias lucapensis* is described from two specimens trawled in Lingayen Gulf, Luzon, Philippines, and represents the first record of the soleid genus *Zebrias* from the Philippine Islands. Of the 16 previously described nominal species of *Zebrias,* the new species most closely resembles *Z. crossolepis* from coastal China. *Zebrias crossolepis* differs from the new species in number of bands on the body, size of the ocular-side pectoral fin, and relative length of the spinulated portion of the ocular-side body scales.

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The genus *Zebrias* Jordan and Snyder includes 17 nominal species of small, banded soles found throughout the Indo-West Pacific from east Africa, the Red Sea, Persian Gulf, India, Australia and Tasmania, to coastal China, Taiwan, and Japan. Chabanaud (1934) listed eight species of *Zebrias* from the coasts of Australia, India, the "Malay Archipelago," "Indo-China" and Japan. Subsequent authors (Herre and Myers 1937; Ochiai 1963, 1966; Punpoka 1964; Cheng and Chang 1965; Smith 1965; Rama Rao 1967; Talwar and Chakrapani 1967; Dor 1970; Kailola 1974; Scott 1975; Joglekar 1976; Hussain and Khan 1981; Shen and Lee 1981) have recognized from one to 11 species throughout the Indo-West Pacific, excluding the Philippine Islands. Herre (1953) and more recent authors (Murdy 1979; Rau and Rau 1980; Schroeder 1980; Fourmanoir 1981; Murdy *et al.* 1981) have not recorded *Zebrias* from the Philippine Islands.

Among collections made to assess the fish fauna of the Hundred Islands region of western Lingayen Gulf, Luzon, Philippines, were two specimens of an undescribed species of *Zebrias,* which constitute the first record of the genus from the Philippine Islands and form the basis for the following description.

## Methods and Materials

Counts and measurements follow Hubbs and Lagler (1947) and Ochiai (1963). Standard length (SL) is used throughout and rounded to the nearest 0.5 mm. Scale terminology follows Chabanaud (1934), Ochiai (1963) and Joglekar (1976). Material is deposited in the Natural History Museum of Los Angeles County (LACM). One specimen of *Brachirus selheimi* was borrowed from the Australian Museum, Sydney (AMS).

## *Zebrias lucapensis,* new species
Fig. 1

*Holotype.*—LACM 37436-6, 83.5 mm; Philippines, Lingayen Gulf, vicinity of Hundred Islands, local fisherman, trawl, 9 Mar 1978.

*Paratype.*—LACM 37436-8, 83.0 mm; collected with holotype.

*Diagnosis.*—A species of *Zebrias* that differs from *Z. zebra, Z. altipinnis, Z. fasciatus, Z. japonicus, Z. synapturoides* and *Z. maculosus* by having eyes contiguous (without interorbital space); from *Z. quagga* by lack of orbital tentacles; from *Z. craticula* and *Z. cancellata* by dorsal and anal fins not fully contiguous with caudal fin; from *Z. callizona* by number of dorsal-fin rays (82–87 in *Z. callizona*; 71–72 in *Z. lucapensis*); from *Z. annandalei, Z. cochinensis* and *Z. regani* by number of pored lateral line scales (102–105 in *Z. annandalei*; 90 in *Z. cochinensis*; 82–90 in *Z. regani*; 63–68 in *Z. lucapensis*); and from *Z. keralensis* and *Z. crossolepis* by total number and status (single or paired) of bands on head and body (13 single bands in *Z. keralensis*; nine paired (18) bands in *Z. crossolepis*; 16–18 mostly unpaired bands in *Z. lucapensis*).

*Description.*—(Meristics and morphometrics for the paratype are indicated in parentheses when differing from holotype.) Dorsal-fin rays 72 (71); anal-fin rays 56; pectoral-fin rays 11, 11; pelvic-fin rays 5, 4 (5, 5); caudal-fin rays 18; lateral line scales 63 (68); vertebrae 9 + 34 = 43. Body depth 2.70 (2.72) in SL; head length (HL) 4.64 (4.88) in SL; caudal length 3.63 (3.60) in SL; upper eye diameter 4.25 (4.59) in HL; pectoral length 6.9, 6.0 (6.25, 5.14) in HL.

Eyes contiguous, upper eye slightly in advance of the lower; no interorbital scales; orbital tentacles absent. Anterior nostril on ocular side with long tube reaching to anterior margin of lower eye when depressed; posterior nostril on ocular side with a short tube, not reaching lower eye; nostrils on blind side inconspicuous. Mouth subterminal, gape extending to vertical through center of lower eye; teeth small, in bands, present only at rear of upper and lower jaws on blind side. Blind side of head with small papillae anteriorly. Opercular margins fringed with minute tentacles.

Scales strongly ctenoid on both sides, those of ocular side with 8 to 15 marginal spinules and 5 to 11 basal grooves, those of blind side with 12 to 16 marginal spinules and 9 to 13 basal grooves; spinulated portion of scale 33–40% of its total length. Tubed lateral-line scales cycloid; lateral-line system well developed on both sides of body.

Dorsal fin originating slightly in front of anterior margin of upper eye and extending to base of caudal fin, with which it is only partially contiguous. Anal fin originating just posterior to pelvic fins, similar to dorsal fin in attachment to caudal fin. Caudal fin relatively long, extending beyond ends of posteriormost dorsal- and anal-fin rays. Dorsal- and anal-fin rays bifid distally. Pectoral fins broad-based, subequal, connected to branchiostegal membranes dorsally. Pelvic fins of equal size, free from anal fin; separate (not united) but connected proximally by skin.

*Color.*—After fixation in formalin and storage in ethanol, ocular side light greyish-brown, with 16–18 narrow, dark brown bands on body extending onto dorsal and anal fins; bands about as wide as interspaces between them, a few occurring in pairs (paratype); edges of bands darker than midsections. Pectoral fin of blind side dark brown, that of ocular side dusky. Proximal and distal areas of caudal fin dark brown. Pelvic fin of blind side darker than that of ocular side. Blind side of body generally white with scattered dots of pigmentation becoming dusky toward body margins. Dorsal and anal fins on blind side dark brown.

*Distribution.*—Known only from Lingayen Gulf, Luzon, Philippines.

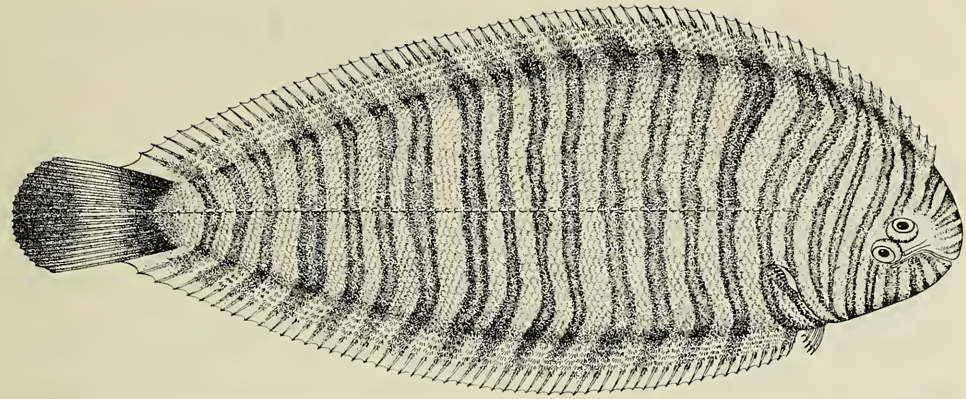

Fig. 1. *Zebrias lucapensis,* holotype, LACM 37436-6, 83.5 mm SL, vicinity of Hundred Islands, Lingayen Gulf, Luzon, Philippines.

*Etymology.*—The name *lucapensis* is an adjective designated in honor of the people of the coastal village of Lucap, Pangasinan Province, Philippines.

*Remarks.*—Of the 16 previously described, nominal species of *Zebrias, Z. lucapensis* most closely resembles *Z. crossolepis* Cheng and Chang from coastal China. *Zebrias lucapensis* may be distinguished from *Z. crossolepis* by number of bands on the body (16–18 mostly unpaired bands in *lucapensis*; 9 paired bands in *crossolepis*), size of the ocular-side pectoral fin (14–18% HL in *lucapensis*; 15.7–20.8 [X = 18.5%] HL in *crossolepis*), and by relative length of the spinulated portion of ocular-side body scales (33–40% of scale spinulated in *lucapensis*; 45–57% in *crossolepis*).

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# THE CORRECT NAME FOR THE PALEARCTIC BROWN, OR FLAT-SKULLED, SHREW IS *SOREX ROBORATUS*

Robert S. Hoffmann

*Abstract.*—Examination of the holotypes of *Sorex roboratus* Hollister, 1913, and *Sorex vir* Allen, 1914, and comparisons with series of other Palearctic species of *Sorex* reveals that *S. roboratus* is the oldest valid name for this taxon, and that *S. vir* must be regarded as a junior synonym for the species. Geographic variation in *Sorex roboratus* is reviewed, and a new taxonomic arrangement proposed.

During the period of indiscriminate taxonomic "lumping," the number of species of *Sorex* recognized in the fauna of the Soviet Union was reduced to six (Bobrinskii *et al.* 1944) or seven (Ellermann and Morrison-Scott 1951). Several taxa considered subspecies of *Sorex araneus* by these workers were revealed by subsequent investigations to be independent species—*S. asper, S. caucasicus, S. daphaenodon, S. isodon, S. raddei, S. arcticus* (=*S. tundrensis,* Junge *et al.* 1983), *S. unguiculatus,* and a species usually called *S. vir* (Stroganov 1957, Dolgov 1967, Corbet 1978). However, Yudin (1971, and references cited therein) maintained that the correct name for this latter species was *S. roboratus.* Neither he nor Dolgov were able to examine the holotypes of these two taxa, which are housed in the Museum of Comparative Zoology of Harvard University and the National Museum of Natural History, Washington, D.C., respectively, and which are crucial to the question.

I have examined both holotypes, compared them with relevant material of other Palearctic *Sorex* (20 nominal taxa, 274 individuals including 14 other holotypes; see "Specimens Examined") and conclude that Yudin's view, that *S. roboratus* is the oldest valid name for this species, is correct, for the reasons given below. Three external measurements were taken from collector's labels. Seven cranial measurements were made to the nearest 0.1 mm with dial calipers. These include: 1) condyloincisive length (CIL): occipital condyles to anterior tips of first incisors; 2) cranial breadth (CB): greatest breadth of braincase, approximately across the mastoids; 3) maxillary breadth (MB): greatest distance between tips of maxillary processes; 4) M2 to M2 breadth (M2–M2): greatest distance between anterior labial margins of second upper molars; 5) interorbital breadth (IOB): least lateral diameter of skull at anterior end of orbits, just posterior to maxillary process; 6) palatoincisive length (PIL); posterior margin of palate in midline to anterior tips of first incisors; 7) upper tooth row length (UTRL): greatest length of tooth row from posterior margin of alveolus of M3 to anterior tip of I1. These measurements were selected for the speed and accuracy with which they could be made, and some differ from those of earlier investigators. For example, condylobasal length is a traditional measure of skull length, but it is usually difficult and time-consuming to measure the anterior margin of the premaxillary bone.

Employing the anterior tips of the first incisors for the anterior terminator results in a more accurate and repeatable measurement among specimens of comparable incisor wear and rotation. Individual specimens classed as overwintered adults were excluded from comparisons, because of the amount of incisor wear and rotation.

### *Sorex roboratus* Hollister, 1913

Hollister (1913a) based this name on a specimen from 5 mi S Dapucha (=Tapucha), Altai Mountains, Gorno-Altaisk Autonomous Oblast, R.S.F.S.R., U.S.S.R. This locality was not located on maps, but Hollister (1913b) described it as about 125 miles southeast of Biisk, along the "post road" (Chuiskii Trakt) that follows the valley of the Katun and Chuya rivers. This would place Tapucha (Fig. 1) somewhere between the present towns of Shebalino and Tuekta, probably near Seminskii Pass. The holotype is a skin and badly broken skull, a male with unworn teeth, trapped by Hollister (orig. no. 4451), 7 August 1912, in a dense *Pinus cembra* forest, and represents one of ten *Sorex* captured by Hollister from two locations in the Altai Mountains. Hollister (1913a) believed that the nine specimens other than the holotype of *S. roboratus* were assignable to *S. araneus borealis.* Stroganov (1957) has shown, however, that the name *S. borealis* should be restricted to those populations of *S. "arcticus"* (i.e., *S. tundrensis*) inhabiting the tundra and northern taiga zone from the Yenesei River to Chukotka (see map, Fig. 2, in Junge *et al.* 1983), thus throwing into question the identity of Hollister's shrews; moreover, Stroganov (1957) placed *S. roboratus* as a subspecies of *S. araneus.*

Dolgov followed Stroganov in regarding *S. roboratus* as a synonym of *S. araneus.* However, Dolgov (1964, 1966, 1967) and Yudin and others (1967, 1979) recognized that four medium to large species of *Sorex* were geographically sympatric in the Altai Mountains—*S. araneus, S. arcticus* (=*tundrensis*), *S. isodon,* and the largest species, which they named *S. roboratus* or *S. vir,* respectively. I have re-examined nine of the ten *Sorex* referred to by Hollister, and find that they represent three species rather than two as he thought. Six from Tchegan-Burgazi (=Chagan-Burgazy) Pass are all *Sorex tundrensis,* probably *S. t. schnitnikovi* (Junge *et al.* 1983). From Tapucha, in addition to the holotype of *S. roboratus,* there are two specimens of *S. araneus.*

### *Sorex vir* G. Allen, 1914

This name is based on a specimen captured by J. Koren at Nizhni Kolymsk, Yakutsk A.S.S.R., R.S.F.S.R., U.S.S.R. (Fig. 1). It was part of a large series of skins and skulls of this species taken during the fall–winter of 1911, and now for the most part preserved at the Museum of Comparative Zoology. Koren also obtained several other species of *Sorex* at that time, including *S. tundrensis borealis* (incl. *S. t. ultimus*), *S. daphaenodon sanguinidens,* and *S. caecutiens koreni.* In contrast to *S. roboratus, S. vir* has been regarded as polytypic. Its distribution is eastern Palearctic—*S. v. vir* occurring from the lower Ob River to Chukotka; *S. v. thomasi* in Transbaikalia, and *S. v. platycranius* in a restricted range in the Ussuri and Amur river regions of the Soviet Far East (Fig. 1). Like *S. roboratus* in the Altai, *S. vir* is the largest of the sympatric *Sorex* that co-occur

Fig. 1. Map of Siberia and adjacent Mongolia, showing type localities of *Sorex roboratus,* and collecting localities for some samples used in this study. Open symbols: type localities; solid symbols, other specimens examined. Triangles, *S. roboratus*; circles, *S. araneus*; squares, *S. tundrensis.* Dotted line, eastern and southern range boundary of *S. araneus*; dashed line, western and southern range boundary of *S. tundrensis*; dash-and-dotted line, western and southern range boundary of *S. roboratus.*

in eastern Siberia (except in the Ussuri region, where the even larger *S. mirabilis* is found).

## Comparisons

The basic question to be answered is: to which species of shrew should the holotype of *S. roboratus* be assigned? Cranial and external measurements are presented for selected specimens in Table 1. In most cranial dimensions, both *S. roboratus* and *S. vir* are larger than shrews of the *S. araneus* and *S. tundrensis* populations with which they occur. Where *S. araneus* and *S. tundrensis* occur together in the Altai, the former species is larger in most dimensions. However, *S. araneus* exhibits some size variation, being nearly as large as *S. roboratus* at Kebezen' but only a little larger than *S. tundrensis* at Tapucha (Fig. 1). Specimens from Barnaul and Toguchin are intermediate in size.

Fortunately, other characters help to separate the four nominal species. Pelage colors differ, both in summer and winter, in that in *S. roboratus* and *S. vir* the back and sides are the same color, whereas in *S. araneus* and *S. tundrensis* the sides are lighter than the back. This contrasting "side stripe" is most prominent in adult *S. tundrensis* in winter pelage. The side stripe in adult *S. araneus* in winter pelage is more buff and contrasts less, while in neither species does it contrast as strongly with dorsal color in summer pelage. In juveniles of both *S. araneus* and *S. tundrensis* the side stripe is usually faint.

Table 1.—External and cranial dimensions of Siberian *Sorex*.

| | Head-body | Tail | Hind foot | CIL | CB | MB | $M^2$–$M^2$ | IOB | PIL | UTRL |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *Sorex roboratus roboratus*, Gorno-Altaisk. Aut. Obl., Tapucha | | | | | | |
| Holotype | 71 | 41 | 15 | 22.0 | 9.8 | — | 5.5 | — | — | 9.3 |
| | | | | *Sorex roboratus roboratus*, Gorno-Altaisk. Aut. Obl., Kebezen' | | | | | | |
| $\bar{x}$ | 79.0 | 41.2 | 13.3 | 21.8 | 9.7 | 5.8 | 5.2 | 3.6 | 9.8 | 9.3 |
| ±SE m | 2.1 | .43 | .38 | .057 | .101 | .025 | .020 | .019 | .039 | .035 |
| Range | 76–83 | 40.5–42 | 12.7–14 | 21.4–22.5 | 9.4–10.3 | 5.6–6.0 | 5.1–5.5 | 3.4–3.8 | 9.3–10.1 | 8.9–9.6 |
| n | 3 | 3 | 3 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| | | | | *Sorex roboratus roboratus*, Novosibirsk Obl. | | | | | | |
| | 71 | 43 | 13 | 21.9 | 9.9 | 5.7 | 5.1 | 3.7 | 9.8 | 9.35 |
| | | | | *Sorex roboratus vir*, Chukotka, Nizhni Kolymsk | | | | | | |
| Holotype | 71.5 | 37 | 14.6 | 20.9 | 9.4 | 5.8 | 5.2 | 3.9 | 9.0 | 8.6 |
| $\bar{x}$ | 71.0 | 36.4 | 14.7 | 20.9 | 9.5 | 5.7 | 5.1 | 3.8 | 9.0 | 8.6 |
| ±SE m | 1.85 | .35 | .13 | .075 | .044 | .032 | .027 | .031 | .043 | .046 |
| Range | 58–87 | 31–43 | 12–15.5 | 20.6–21.8 | 9.3–9.9 | 5.5–5.9 | 4.9–5.3 | 3.6–4.0 | 8.7–9.3 | 8.2–9.0 |
| n | 48 | 47 | 48 | 20 | 20 | 18 | 18 | 18 | 20 | 18 |
| | | | | *Sorex roboratus thomasi*, Irkutsk. Obl.; Mongolia | | | | | | |
| $\bar{x}$ | 65.1 | 35.6 | 12.9 | 20.6 | 9.2 | 5.4 | 4.9 | 3.6 | 8.9 | 8.7 |
| ±SE m | 1.13 | .81 | .196 | .144 | .108 | — | — | — | .052 | .063 |
| Range | 58–73 | 30–41 | 11–14 | 20.0–21.1 | 8.9–9.7 | 5.3–5.4 | 4.8–5.0 | 3.5–3.6 | 8.8–9.0 | 8.5–8.9 |
| n | 19 | 19 | 19 | 7 | 7 | 2 | 2 | 2 | 4 | 7 |
| | | | | *Sorex roboratus platycranius*, Khabarovsk. Krai | | | | | | |
| | 75 | 35 | 15 | 21.1 | 9.2 | 5.8 | — | — | 9.4 | 9.1 |
| | 80 | 40 | 15 | 21.5 | 9.1 | 5.5 | — | — | 9.4 | 9.1 |
| | | | | *Sorex araneus araneus*, Gorno-Altaisk. Aut. Obl., Kebezen' | | | | | | |
| $\bar{x}$ | 77.9 | 44.2 | 12.9 | 20.9 | 9.9 | 5.5 | 5.1 | 3.8 | 9.5 | 9.1 |
| ±SE m | 3.83 | 1.62 | .155 | .064 | .038 | .033 | .023 | .023 | .043 | .039 |
| Range | 67–83.5 | 42–49 | 12.5–13.2 | 20.0–21.6 | 9.6–10.4 | 5.0–5.9 | 4.9–5.3 | 3.6–4.0 | 8.9–9.9 | 8.6–9.5 |
| n | 4 | 4 | 4 | 27 | 27 | 28 | 28 | 28 | 28 | 28 |

Table 1.—Continued.

| | Head-body | Tail | Hind foot | CIL | CB | MB | M²–M² | IOB | PIL | UTRL |
|---|---|---|---|---|---|---|---|---|---|---|
| *Sorex araneus araneus,* Gorno-Altaisk. Aut. Obl., Tapucha | | | | | | | | | | |
| | 64 | 37 | 12 | 18.7 | 9.3 | 5.0 | 4.5 | 3.3 | 8.2 | 8.1 |
| | 62 | 39 | 12 | 18.9 | 9.4 | 5.0 | 4.6 | 3.4 | 8.3 | 7.9 |
| *Sorex araneus araneus,* Altaisk. Krai, vic. Barnaul; Novosibirsk Obl. | | | | | | | | | | |
| $\bar{x}$ | 79.9 | 45.7 | 12.7 | 20.2 | 9.8 | 5.6 | 5.1 | 3.9 | 9.2 | 8.8 |
| ±SE m | 1.90 | 1.09 | .11 | .199 | .089 | .029 | .044 | .044 | .017 | .087 |
| Range | 74–85.5 | 42–48.5 | 12.5–13 | 19.5–20.7 | 9.6–10.1 | 5.5–5.6 | 5.0–5.2 | 3.8–4.0 | 9.1–9.2 | 8.6–9.1 |
| n | 5 | 5 | 5 | 5 | 5 | 3 | 3 | 3 | 3 | 3 |
| *Sorex tundrensis schnitnikovi,* Gorno-Altaisk. Aut. Obl., Chagan-Burgazi Pass | | | | | | | | | | |
| $\bar{x}$ | 64.3 | 35.5 | 12.2 | 18.1 | 9.0 | 4.8 | 4.5 | 3.4 | 7.7 | 7.5 |
| ±SE m | 1.15 | 1.38 | .17 | .232 | .092 | .085 | .031 | .047 | .117 | .137 |
| Range | 61–67 | 31–40 | 11–12.5 | 17.6–18.5 | 8.9–9.3 | 4.6–5.0 | 4.4–4.6 | 3.3–3.5 | 7.5–7.9 | 7.2–7.8 |
| n | 6 | 6 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| *Sorex tundrensis* ssp. Novosibirsk., Irkutsk. Obl.; Mongolia | | | | | | | | | | |
| $\bar{m}$ | 59.8 | 34.0 | 11.7 | 17.6 | 8.6 | 5.0 | 4.5 | 3.3 | 7.8 | 7.3 |
| ±SE m | 1.78 | .097 | .28 | .458 | — | .176 | .142 | .120 | .138 | .232 |
| Range | 55–65 | 30–37 | 11–12.5 | 17.0–18.5 | 8.2–9.0 | 4.8–5.4 | 4.4–4.8 | 3.1–3.5 | 7.1–8.3 | 7.0–7.8 |
| n | 6 | 6 | 6 | 3 | 2 | 3 | 3 | 3 | 9 | 3 |

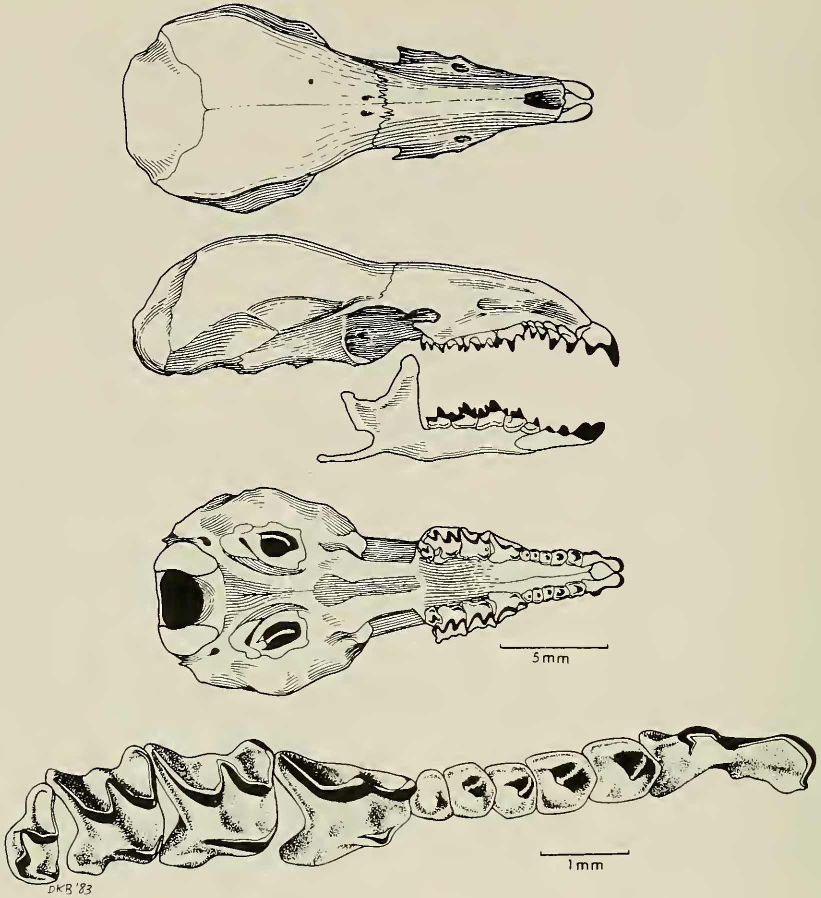

Fig. 2. Skull of *Sorex roboratus roboratus,* juvenile, from Mirnyi, Toguchinsk. rai., Novosibirsk. Obl., U.S.S.R. (UMZ 13005). Dorsal, lateral, and ventral views; enlarged occlusal view of upper tooth row.

Qualitative dental characters also distinguish the taxa. In both *S. roboratus* and *S. vir* in lateral view the anterior pair of maxillary unicuspid teeth (1, 2) are large and subequal, and the next two (3, 4) are markedly smaller and again subequal although the posterior unicuspid of each pair (2, 4) is usually smaller than the anterior (1, 3) (Fig. 2). In *S. araneus* and *S. tundrensis* the first two unicuspids are also large and subequal, but the unicuspid series tends to decrease in size more gradually from unicuspids 2 through 4 (Figs. 3, 4). However, the toothrow in *S. tundrensis* appears more crowded than that of *S. araneus,* and the unicuspids are quadrate in shape, to wider than long (Fig. 4), whereas in *S. araneus* the toothrow is less crowded, and the unicuspids are usually longer than wide (Fig. 3) (Junge and Hoffmann 1982; Junge *et al.* 1983).

The holotypes of *S. roboratus* and *S. vir* are also characterized by the posterior margins of the maxillary molariform teeth, particularly P4 and M2, being deeply excavated (Fig. 2) (Corbet 1978). In contrast, the posterior margins of the upper

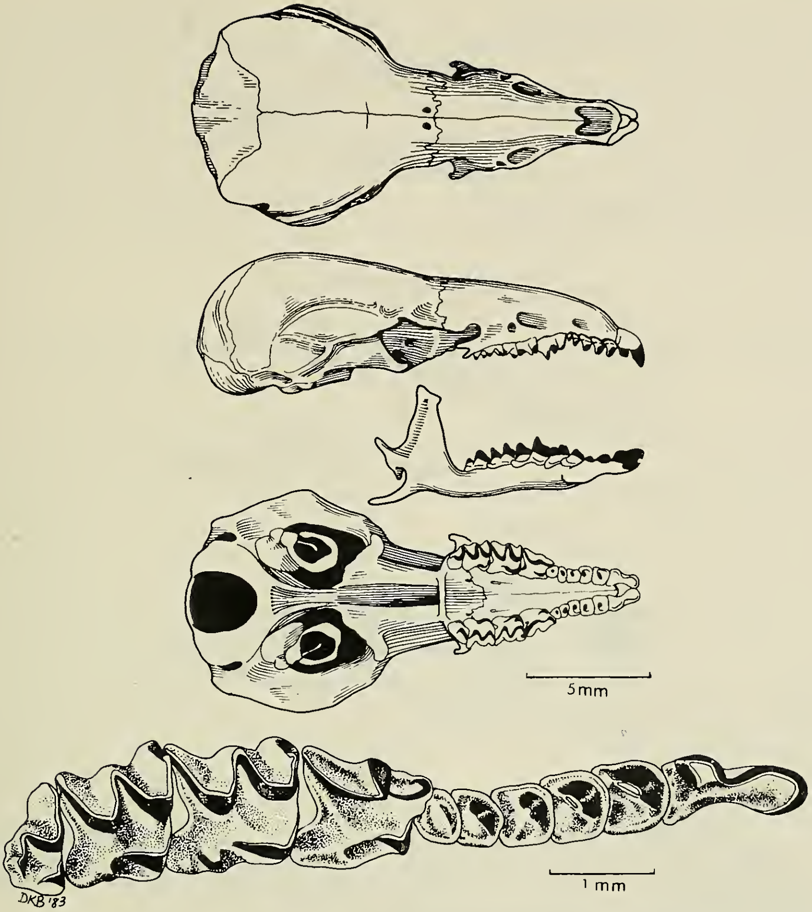

Fig. 3. Skull of *Sorex araneus araneus,* juvenile, from Tapucha, Gorno-Altaisk. Aut. Obl., U.S.S.R. (USNM 175438). Dorsal, lateral, and ventral views; enlarged occlusal view of upper tooth row.

molariform teeth of *S. araneus* and *S. tundrensis* are only moderately excavated (Figs. 3, 4). In *S. roboratus* and *S. vir* P4 is also relatively longer and narrower than in the other two species. Thus, the holotype of *S. roboratus* shares cranial and external characters with *S. vir,* including the holotype, that distinguish it from both *S. araneus* and *S. tundrensis* with which it is sympatric in the Altai Mountains. *Sorex roboratus* is not assignable to any other species of *Sorex* in the Altai (*S. isodon* is smaller, with gradually decreasing unicuspid size and narrow rostrum; *S. caecutiens, S. minutus* and *S. minutissimus* are much smaller). Thus, *S. roboratus* and *S. vir* should be regarded as conspecific, and the former name has priority.

*Sorex roboratus* varies geographically in size and relative proportions. *Sorex r. roboratus* from the Altai Mountains and the surrounding region is the largest, with a broader, more massive skull. The holotype of *S. araneus tomensis* Ognev, 1921, formerly assigned to *S. araneus,* belongs to this large subspecies, and must be considered a junior synonym of *S. r. roboratus. Sorex roboratus vir* is smaller,

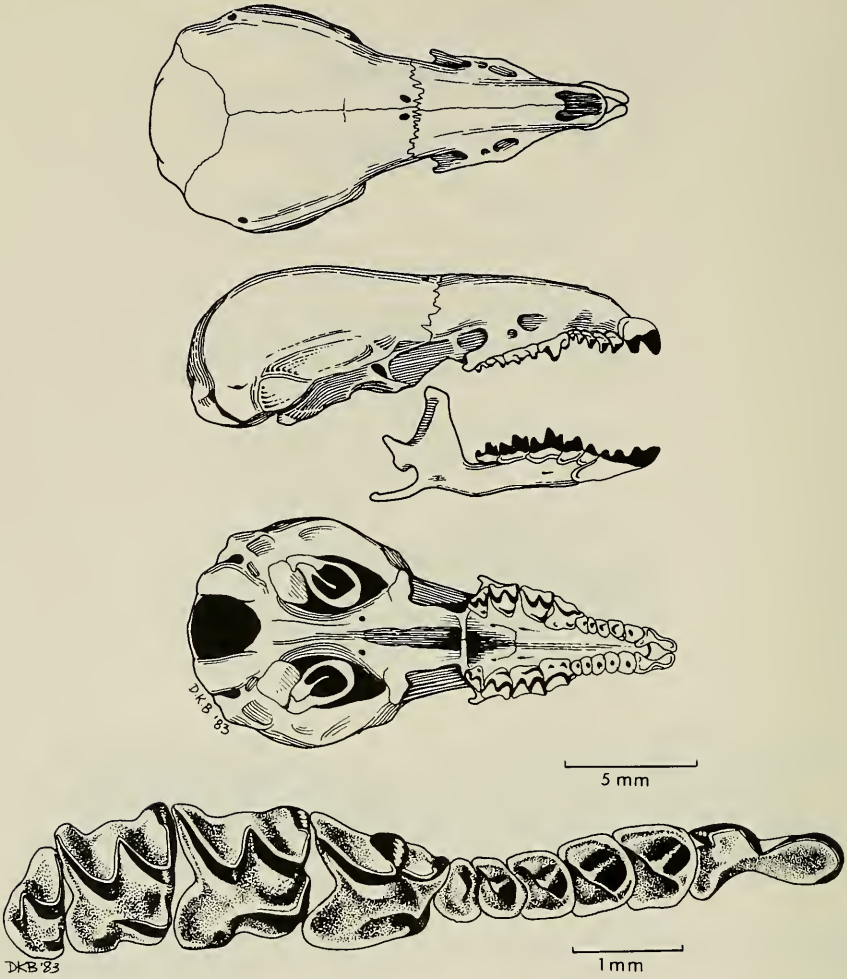

Fig. 4. Skull of *Sorex tundrensis schnitnikovi,* juvenile, from Chagan-Burgazy Pass, Gorno-Altaisk. Aut. Obl., U.S.S.R. (USNM 175430). Dorsal, lateral, and ventral views; enlarged occlusal view of upper tooth row.

with a generally narrower, less massive skull but with wider interorbital region; the tail is also much shorter. *Sorex vir jacutensis* Dukelski, 1928, (originally described as a subspecies of *S. araneus*), which was recognized as a subspecies by Stroganov (1957), is similar in size and proportions to *S. r. vir,* and I regard it, as well as *S. vir turuchanensis* Naumov, 1931, and *S. dukelskiae* Ognev, 1933, to be junior synonyms of *S. r. vir.* This subspecies inhabits central and eastern Siberia from the Sayan Mountains to Lake Baikal on the south, and from the Ob River to Chukotka on the north. The last two subspecies I recognize have more limited ranges. *Sorex roboratus thomasi* inhabits Transbaikaliya, and is the smallest geographic race, being only slightly larger than sympatric populations of *S. tundrensis,* though easily distinguished by cranial morphology (see above). *Sorex macropygmaeus araneoides* Ognev, 1921, has been considered a junior synonym of *S. araneus* (Bobrinskii *et al.* 1944) or *S. c. caecutiens* (Stroganov 1957; Corbet 1978), but examination of the holotype reveals that it is virtually identical with the holotype of *S. r. thomasi.* Both were taken near Barguzin, share the diagnostic cranial features of *S. roboratus,* and are larger than sympatric *S. tundrensis* and *S. caecutiens.* The range of *S. r. platycranius* adjoins that of *S. r. thomasi* along the Amur River and extends to the Primorskii Krai. This subspecies is larger than *S. r. thomasi,* being about the size of *S. r. vir,* but it has a relatively longer tail and rostrum; it is known from only a few specimens.

## Taxonomic Conclusions

The correct names and synonyms for the subspecies and other nominal taxa of *Sorex roboratus* are summarized below:

*Sorex roboratus roboratus* Hollister, 1913. Type locality, Tapucha, Gorno-Altaisk Autonomous Oblast, R.S.F.S.R., U.S.S.R.
  *S. araneus tomensis* Ognev, 1921. Type locality, vic. Barnaul, Altaisk. Krai, R.S.F.S.R., U.S.S.R.
*Sorex roboratus vir* Allen, 1914. Type locality, Nizhni Kolymsk, Yakutsk. A.S.S.R., R.S.F.S.R., U.S.S.R.
  *S. araneus jacutensis* Dukelski (=Dukel'skaya) 1928. Type locality, Suntar, Yakutsk. A.S.S.R., R.S.F.S.R., U.S.S.R.
  *S. vir turuchanensis* Naumov, 1931. Type locality, Artyugin River, tributary of Yenesei River, Turukhansk. rai., Krasnoyarsk. Krai, R.S.F.S.R., U.S.S.R.
  *S. dukelskiae* Ognev, 1933. Type locality, Yanov Stan, on Turukhana River, Krasnoyarsk. Krai, R.S.F.S.R., U.S.S.R.
*Sorex roboratus thomasi* Ognev, 1921. Type locality, Budarman River, tributary of Sosnovka River, vic. Barguzin, Buryat-Mongolsk. A.S.S.R., R.S.F.S.R., U.S.S.R.
  *S. aranoides* Ognev, 1921. Type locality, Sosnovka River valley, near Barguzin, Buryat-Mongolsk. A.S.S.R., R.S.F.S.F., U.S.S.R.
*Sorex roboratus platycranius* Ognev,. 1921. Type locality, vic. Voroshilov, Primorsk. Krai, R.S.F.S.R., U.S.S.R.

## Specimens examined

Abbreviations: AMNH, American Museum of Natural History, New York; BMNH, British Museum (Natural History), London; FMNH, Field Museum of Natural History, Chicago; KU, Museum of Natural History, University of Kansas, Lawrence; MCZ, Museum of Comparative Zoology, Harvard University, Cambridge; MGU, Moscow State University, Moscow; MVZ, Museum of Vertebrate Zoology, University of California, Berkeley; UMZ, University of Montana Zoological Museum, Missoula; USNM, National Museum of Natural History, Washington; ZIN, Zoological Institute, Academy of Sciences, Leningrad.

*Sorex roboratus roboratus.* (51) U.S.S.R: R.S.F.S.R., *Gorno-Altaisk Aut. Obl.,* Tapucha (USNM 175436, holotype); Kebezen'sk. rai. (MGU 73624, -27, -29, 74325, -28, -30, -40, -46, -48, -49, -52, -54 through -56, -62, -64, -65 -66, -70, -71, -73, -74, -76, -77, -79, -82, -85, -87, 77742, 82182) *Altaisk. Krai,* vic. Barnaul (ZIN 9173, holotype *S. araneus tomensis*). *Novosibrisk. Obl.,* Toguchinsk. rai., vic. Mirnyi (UMZ 13005); *Buryat-Mongolsk. Aut. Obl.,* 100 mi W Lake Baikal (BMNH 12.4.1.1, -2); *Irkutsk. Ob.,* Alzamai (BMNH 14.11.1.8); Listvyank (BMNH 15.3.9.1 through 9; 14.11.1. 2 through 7).

*Sorex roboratus vir.* (52) U.S.S.R.: R.S.F.S.R., *Yakutsk. A.S.S.R.,* Nizhni Kolymsk (MCZ 15068, holotype; 15018, -23 through -31, -33 through -38, -40, -42 through -44, -46 through -51, -53 through -59, -64 through -66, -70 through -74, -82; AMNH 38880, -81; FMNH 34107 through -09; MVZ 81167); Suntar (MGU 4819, holotype *S. araneus jacutensis*); *Krasnoyarsk. Krai,* Turukhansk. rai., Artyugin R., trib. Yenesei (MGU 13455, holotype, *S. dukelskiae*); Yanov Stan, Turukhana R. (ZIN 10561, holotype, *S. vir turuchanensis*).

*Sorex roboratus thomasi.* (10) U.S.S.R.: R.S.F.S.R., *Buryat-Mongolsk. A.S.S.R.,* Budarman R., trib. Sosnovka R., vic. Barguzin (ZIN 11904, holotype); Sosnovka R. valley, vic. Barguzin (ZIN 11905, holotype, *S. aranoides*). MONGOLIAN PEOPLES REPUBLIC: *Tov Aymak,* 45 mi N Urga (=Ulan Bator) (AMNH 45573, -80, -81, -90; FMNH 39317, -18; MCZ 45588, -89).

*Sorex roboratus platycranius.* (3) U.S.S.R.: R.S.F.S.R., *Primorsk. Krai,* vic. Voroshilov (ZIN 2392, holotype); *Khabarovsk. Krai,* 60 mi N Khabarovsk, Nelta River (AMNH 85468, -69).

*Sorex araneus araneus.* (40) U.S.S.R.: R.S.F.S.R., *Zapadnaya (=Kalininsk.) Obl.,* Ostashkovsk. rai., Petropavlovsk (MCZ 32778 through -80); *Leningradsk. Obl.,* Valdansk. rai., Yakonova (MCZ 32781); *Novosibirsk Obl.,* Toguchinsk. rai., vic. Mirnyi (UMZ 13003, -04); *Altaisk. Krai,* near Barnaul (BMNH 28.10.24.1, -.2; MCZ 23952, -53); *Gorno-Altaisk Aut. Obl.,* Tapucha (USNM 175437, -38); Kebezen'sk. rai. (MGU 73632, -35, -36, -39, 734185, -87, -88, -91 through -95, -97, 74204 through -13, -15, -18, -20, -24); Turochaksk. rai. (MGU 73671).

*Sorex tundrensis borealis.* (51) U.S.S.R.: R.S.F.S.R., *Koryaksk. Nats. Okr.,* Gichiga (AMNH) 18626, -27, -33, -37, -42, -49); *Yakutsk. A.S.S.R.,* Nizhni Kolymsk (AMNH 38884, -85; MCZ 14992, -95, -97 through -99, 15001, -02, -69, -76, -78 through -80, -84); *Chukotsk. Nats. Okr.,* Palyavaam River (MGU 88237, -44, -48, -50, -53, -58, -59, -63 through -65, -68, -69, -71 through -73, -77 through -79, -82, -85, -88, -89, -92, -96, -300, -01, -04, -05, -10, -11).

*Sorex tundrensis baikalensis.* (6) U.S.S.R.: R.S.F.S.R., *Chitinsk. Ob.,* Gornyi Zerentui (MGU 2710, holotype); *Primorsk. Krai,* Nadezhdinsk. Obl., Razdol'noe (KU 121366). MONGOLIAN PEOPLES REPUBLIC: *Tov Aymak,* 15 mi N Urga (=Ulan Bator) (AMNH 45595; MCZ 20744); 45 mi N Urga (FMNH 39312, -14).

*Sorex tundrensis petschorae.* (3) U.S.S.R.: R.S.F.S.R., *Arkhangel'sk. Obl.,* Pvimva (ZIN 8459, holotype); *Tyumensk. Obl.,* Purovsk. rai., Samburg (KU 121364–65).

*Sorex tundrensis schnitnikovi.* (7) U.S.S.R.: R.S.F.S.R., *Gorno-Altaisk. Aut. Obl.,* Tchegan-Burgazi (=Chagan-Burgazy) Pass (USNM 175429 through -31; MCZ 14373 through -75); Kazakh S.S.R., *Vostochno-Kazakhstansk. Obl.,* Kopal (ZIN 8641, holotype).

*Sorex tundrensis sibiriensis.* (12) U.S.S.R.: R.S.F.S.R., *Kemerovsk. Obl.,* Kol'chugino Sta., 4 km SE Leninsk- Kuznetskii (ZIN 6527, holotype); *Novosibirsk. Obl.,* vic. Novosibirsk (USNM 253025); *Krasnoyarsk. Krai,* Sev. Vostochnoe, 40 km SE Minussinsk (MGU 13452, holotype *S. jenissejensis*); "Yenesei region" (probably *Irkutsk. Obl.,* Alzamai) (BMNH 14.11.1.9 through -11);

"Irkutsk region" (probably *Irkutsk. Obl.,* Listvyanka) (BMNH 14.11.1.12, -13); *Buryat-Mongolsk. A.S.S.R.,* Sayan Mts., 100 mi W of Lake Baikal (BMNH 12.4.1.3. through -.5, -.6, holotype *S. centralis*).

*Sorex isodon isodon.* (28) U.S.S.R.,: R.S.F.S.R., *Gorno-Altaisk. Aut. Obl.,* Turochaksk. rai. (MGU 73642, -47); Kebezen'sk. rai (MGU 73643 through -46, -51, -52, -56, -58, -61 through -65, -67, -72 through -79, -81, -82, -88); *Buryat-Mongolsk. A.S.S.R.,* Sosnovka River, [N of] Barguzin (MGU 13486, holotype).

*Sorex caecutiens caecutiens.* (12) U.S.S.R.: R.S.F.S.R., *Gorno-Altaisk. Aut. Obl.,* Biisk. rai. Ongudai (ZIN 6409, holotype, *S. c. altaicus*) Turochaksk. rai. (MGU 110062); Kebezen'sk. rai. (MGU 73999, 74000, -02, -05, -06, -08, -15, -55, -58); *Tomsk. Obl.,* Listshchi River (UMZ 13009).

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# TAXONOMIC STATUS AND RELATIONSHIPS OF THE SWAN ISLAND HUTIA, *GEOCAPROMYS THORACATUS* (MAMMALIA: RODENTIA: CAPROMYIDAE), AND THE ZOOGEOGRAPHY OF THE SWAN ISLANDS VERTEBRATE FAUNA

Gary S. Morgan

*Abstract.*—Comparisons of external and cranial characters in the three Recent species of *Geocapromys* demonstrate that the Swan Island Hutia, *G. thoracatus,* is a distinct species, rather than a subspecies of the Jamaican Hutia, *G. brownii,* as it has been regarded by most recent authors. Based on derived characters of the zygomatic arch region, *G. thoracatus* and *G. brownii* are closely related and constitute a species-group within *Geocapromys.* The third extant species of the genus, *G. ingrahami* from the Bahamas, and at least four extinct species referable to *Geocapromys* form a second species-group. All available information pertaining to the recent extinction of the Swan Island Hutia is reviewed. Zoogeographic analysis of the Swan Islands vertebrate fauna reveals that the majority of species have been derived from the West Indies, substantiating placement of the Swan Islands in the West Indian Subregion of the Neotropical Region. Overwater dispersal is advocated to explain the origin of the fauna, as the geological history of the Swan Islands precludes vicariance as a tenable biogeographic hypothesis.

> "There are some islands which are so small and isolated that the mere presence, or the mere absence, of certain birds and mammals on them, lends them just that touch of interest which they would not otherwise possess." Percy Lowe (1911: 38).

*Geocapromys thoracatus,* a member of the endemic West Indian hystricognath rodent family Capromyidae, is known only from Little Swan Island, a tiny (2 km$^2$), remote, limestone island located in the northwestern Caribbean Sea. The taxonomic status of *G. thoracatus* has been unclear from the beginning. When True (1888) described *G. thoracatus* as a subspecies of the Jamaican Hutia, *Capromys brachyurus* Hill, 1851 (=*C. brownii* Fischer, 1830), he compared only external characteristics of the two forms. Jamaican specimens were not available to True, so his comparisons were based on Hill's original description of *C. brachyurus* in Gosse (1851). True (1888:470) distinguished *thoracatus* from *brachyurus* on the basis of ". . . the white band of fur across the breast, the gray throat, and brown and ochreous (not blackish) hind feet . . . ." He noted that the Little Swan specimens, of which he had two, closely resembled *C. brachyurus* in size and proportions. This last observation is puzzling, because all later workers have mentioned the considerably larger size of the Jamaican animal.

In his original description of *Capromys ingrahami* from East Plana Cay, a small island in the Crooked-Acklins group in the south-central Bahamas, J. A. Allen (1891) compared the species with *C. thoracatus.* He noted that these two species were similar in overall coloration, but that *C. ingrahami* was a smaller animal with a relatively longer tail, and also differed in cranial features. Except for the narrower jugal and less pronounced lateral jugal fossa of *C. ingrahami,* most of Allen's characters are of doubtful value as judged from larger samples.

Chapman (1901), in his revision of *Capromys,* erected the subgenus *Geocapromys* to include the short-tailed members of the genus: *G. brownii, G. thoracatus,* and *G. ingrahami.* Compared with the other two species, Chapman found that the skull of *G. brownii* is larger, lacks supraorbital processes and is relatively broader at the interorbital constriction. In a direct comparison of *G. brownii* and *G. thoracatus,* Chapman (1901:321) made the following observations: "The acquisition of the above-mentioned specimen of *C. brownii* (=*brachyurus* auct.) permits, for the first time, actual comparison of *thoracatus* with the form to which it has generally been supposed to be subspecifically related. The result shows the two animals to differ widely from each other in color, dimensions, particularly of the ears, and in cranial characters. In fact, *thoracatus* proves to be much more closely related to *ingrahami,* from which indeed it is to be distinguished externally only by size, the two known specimens of *thoracatus* agreeing exactly in color with the prevailing type of *C. ingrahami* as it is shown by a series of twelve specimens in the America Museum." Based on the differences between *G. brownii* and *G. thoracatus,* Chapman regarded the latter as a full species.

G. M. Allen elevated *Geocapromys* to generic rank and in so doing, he noted (1917:8–9), "Three living species are included in this genus. Of these, *Geocapromys brownii,* of Jamaica, is the largest. The two others, *G. thoracatus* of Little Swan Island, and *G. ingrahami* of Plana Keys, Bahamas, are smaller, and much more resemble each other in their gray type of coloring than they do the large dark brown animal of Jamaica. As Chapman pointed out, these may indicate two species groups." Allen also mentioned that the incisors are very pale yellow in *G. brownii* and *G. ingrahami* and ivory white in *G. thoracatus*; however, every specimen of *G. brownii* I have examined has dark, yellowish-orange incisors.

In a report on the generic characters of *Geocapromys,* Miller (1929) noted that the ascending process of the maxilla is essentially vertical in *G. ingrahami* and posteriorly sloping in *G. brownii* and *G. thoracatus.* Lawrence (1934) presented a key summarizing the cranial characters of all the then known species of *Geocapromys,* both living and extinct. She distinguished *G. brownii* based on its larger size, anterior inflation of the frontals, constriction of the frontals posterior to the supraorbital processes, and short, bluntly triangular supraorbital processes. *Geocapromys thoracatus* was differentiated from *G. brownii* by its smaller size and from *G. ingrahami* by the pronounced jugal spine and more vertical posterior margin of the jugals.

*Geocapromys thoracatus* was recognized as a distinct species from the time Chapman (1901) first accorded it full specific rank until Mohr (1939) relegated it to its current status as a subspecies of *G. brownii.* Almost all authors have followed Mohr in calling the Swan Island Hutia, *G. brownii thoracatus* (Clough 1972, 1976; Hall 1981; Oliver 1976, 1977; Varona 1974). Furthermore, Mohr (1939) reduced *Geocapromys* to its former status as a subgenus of *Capromys,* a usage that has gained favor with some recent authors (Hall 1981; Varona 1974). However, based on nine external and cranial characters, I recognize *Geocapromys* as a distinct genus. External features which differentiate *Geocapromys* from *Capromys* are the short tail, reduced first digit on the front foot, and the shorter, finer fur. Cranial characters separating the two genera are discussed in detail by Morgan (1977) and Woods and Howland (1979). The most significant diagnostic features of *Geocapromys* noted by these authors are: the less arched or more procumbent incisors, the origin of the upper incisor root capsule high on the maxilla above the $P^4$, the broad vertically or posteriorly oriented superior zygomatic root of the maxilla, the tendency toward anterior convergence of the upper tooth rows, the labial inclination of the occlusal surface of the cheek teeth, and the presence of an additional anterolingual re-entrant (anteroflexid) on the $P_4$.

In a study of the living and extinct species of *Geocapromys* undertaken to determine the affinities of an undescribed extinct species of the genus from the Cayman Islands (Morgan 1977), it became clear to me that the external and cranial differences between *G. thoracatus* and *G. brownii* represented distinctions between species, not subspecies. Many of these differences have been pointed out by previous authors, but they have not been adequately summarized. For the sake of completeness, I have included *G. ingrahami* in my descriptions and analyses.

*Methods and specimens.*—External measurements are those of the original collectors and were taken from skin labels. Cranial measurements were taken with dial calipers and rounded to the nearest 0.1 mm. In addition to the standard mammalian cranial measurements, as defined in DeBlase and Martin (1974), other measurements were taken. Those that require further explanation include: the internal width of palate taken between the anterolingual edges of alveoli of $P^4$ and $M^1$ and at the posterior palatal margin; the occlusal lengths of the upper and lower tooth rows are measurements of the teeth—not alveoli; length of dentary taken from posterior tip of angular process to anterior extension of incisor alveolus; and length of mandibular symphysis taken from posterior edge of alveolar sheath to anterior extension of incisor alveolus. Only adults were measured, as determined by the eruption and wear on $M^3_3$ and by fusion of the basioccipital and basisphenoid. For two reasons the sexes were combined in the statistical analyses. First, the sex was not recorded on 25 of the 65 specimens examined. Second, the presence of an enlarged clitoris in female *Geocapromys* increases the likelihood that individuals were incorrectly sexed in the field. For example, of the 25 sexed specimens of *G. thoracatus* and *G. ingrahami* examined, only three were recorded as females. Descriptive morphological terms are standard except certain terms used to describe hystricognathous rodents (Woods and Howland 1979). Dental terminology follows Wood and Patterson (1959:287).

I examined and measured the majority of existing specimens of Recent *Geocapromys*, including all specimens from the following museums: American Museum of Natural History (AMNH), British Museum (Natural History) (BMNH), Florida State Museum (UF), Museum of Comparative Zoology (MCZ), and National Museum of Natural History, Smithsonian Institution (USNM). The following specimens were examined:

*Geocapromys brownii* (23; 9 ♂♂, 6 ♀♀, 8?) JAMAICA: Portland Parish, John Crow Mountains, AMNH (7), MCZ (2), UF (1); Stony Hill, UF (1); St. Thomas Parish, Cuna Cuna, AMNH (1), MCZ (1), USNM (2); St. Catherine Parish, Worthy Park, UF (2); no specific locality, AMNH (2), BMNH (2), MCZ (3).

*Geocapromys ingrahami* (21; 9 ♂♂, 1 ♀, 11?) BAHAMAS, East Plana Cay, AMNH (8, including type), BMNH (2), MCZ (8), USNM (3).

*Geocapromys thoracatus* (21; 13 ♂♂, 2 ♀♀, 6?) SWAN ISLANDS, Little Swan Island, AMNH (2), BMNH (7), MCZ (10), USNM (2, including type).

## Morphological Comparisons

*External characters.*—The most obvious difference among the three species of *Geocapromys* is size (Table 1): *G. brownii* is largest in body size, *G. thoracatus* is intermediate, and *G. ingrahami* is smallest. As noted by many previous workers, *G. thoracatus* and *G. ingrahami* are similar in overall coloration. Both species have grayish-brown upperparts and a light brown to tan venter. In these two species, the majority of hairs on the back are light brown at the base with tan tips, but interspersed with these, especially in the middle of the back, are longer unbanded dark brown hairs. These darker hairs, together with the paler banded hairs, produce the grayish-brown color of the dorsum. *Geocapromys thoracatus* has a cream-colored collar 1–3 cm in width that extends transversely across the chest between the front limbs, hence the specific epithet. *Geocapromys ingrahami* lacks this bar, but some individuals do have a cream-colored spot between the front limbs that may extend posteriorly to the genital region. Compared to the two smaller species, *G. brownii* is a much darker animal, being dark reddish-brown to blackish-brown on the dorsum and medium brown on the belly. The dorsal guard hairs are alternately banded reddish-brown and dark brown or black, with longer black hairs interspersed. Unlike the other two species, *G. brownii* has no lighter colored spots or bars on the underside.

The tail is short in all *Geocapromys,* but it varies among the three species (Table 1). The tail is shorter than the hind foot and sparsely furred in *G. brownii,* approximately equal in length to the hind foot and sparsely furred in *G. thoracatus,* and longer than the hind foot and densely furred with short, reddish-brown hairs in *G. ingrahami.* The difference in tail length between the three species appears to be correlated with the number of caudal vertebrae. The longest-tailed species, *G. ingrahami,* has an average of 19 caudal vertebrae, *G. thoracatus* has 17, and *G. brownii* 14.

The ears also differ in size (Table I) and morphology among the living members of the genus. *Geocapromys thoracatus* has comparatively large ears that appear to be almost naked, although both the internal and external surfaces have a sparse covering of short, fine hairs. *Geocapromys brownii* has small ears that are covered by a dense mat of short, fine hairs and in addition has two tufts of longer hair on the inner surface of the pinna, one above and behind the meatus and the other directly posterior to the meatus on the ventrolateral margin of the ear. *Geocapromys ingrahami* has intermediate-sized ears that are clothed with long, posteriorly directed hairs. As in *G. brownii,* there are two tufts of hair along the inner dorsal margin of the ear, although the tufts are much more prominent in *G. ingrahami.* The presence of long ear tufts in *G. ingrahami* appears to be unique within the Capromyidae. Most species of *Capromys* have nearly naked ears, resembling those of *G. thoracatus.*

*Cranium.*—The most obvious difference between the cranium of *Geocapromys brownii* on the one hand and *G. thoracatus* and *G. ingrahami* on the other, is the larger size of the former (Table 1, Figs. 1, 2). *Geocapromys brownii* averages 15–

Table 1.—External, skull, and dental measurements (in mm) of *Geocapromys brownii, G. thoracatus,* and *G. ingrahami.* The mean, standard deviation, sample size (in parentheses), and observed range, respectively, are given for each measurement.

| Measurement | *Geocapromys brownii* | *Geocapromys thoracatus* | *Geocapromys ingrahami* |
|---|---|---|---|
| Length of head and body | 410 ± 24 (12)<br>372–448 | 338 ± 4 (5)<br>334–343 | 308 ± 21 (4)<br>280–326 |
| Length of tail | 48 ± 8 (13)<br>40–64 | 65 ± 5 (5)<br>57–70 | 77 ± 5 (7)<br>70–85 |
| Length of hindfoot | 70 ± 6 (14)<br>60–78 | 66 ± 2 (5)<br>64–70 | 58 ± 5 (7)<br>53–65 |
| Length of ear (from notch) | 20 ± 1 (5)<br>19–21 | 26 ± 1 (8)<br>24–28 | 19 ± 4 (7)<br>15–24 |
| Number of caudal vertebrae | 14 ± 1 (7)<br>12–15 | 17 ± 1 (8)<br>15–18 | 19 ± 1 (5)<br>18–19 |
| Greatest length of skull | 81.1 ± 3.7 (19)<br>75.1–87.0 | 68.6 ± 1.8 (19)<br>65.9–73.0 | 63.2 ± 1.2 (16)<br>61.5–65.6 |
| Condylobasal length | 75.3 ± 4.0 (14)<br>68.9–81.6 | 63.6 ± 2.0 (18)<br>60.4–67.9 | 59.3 ± 1.4 (12)<br>57.5–61.6 |
| Zygomatic breadth | 43.7 ± 2.5 (18)<br>39.1–48.4 | 34.8 ± 1.3 (18)<br>32.7–36.9 | 32.8 ± 1.3 (18)<br>30.3–34.9 |
| Breadth at auditory meatus | 29.5 ± 1.1 (17)<br>27.2–30.9 | 25.0 ± 0.9 (17)<br>23.4–27.1 | 24.4 ± 1.0 (15)<br>23.2–26.5 |
| Breadth of frontals anterior to supraorbital processes | 23.9 ± 1.2 (18)<br>20.5–26.1 | 17.8 ± 0.8 (21)<br>16.3–19.3 | 17.1 ± 0.8 (19)<br>15.3–18.5 |
| Breadth of frontals posterior to supraorbital processes | 19.7 ± 1.2 (19)<br>18.0–22.6 | 19.9 ± 0.8 (21)<br>18.8–21.3 | 17.9 ± 0.7 (19)<br>17.1–19.3 |
| Breadth of superior zygomatic root of maxilla | 5.5 ± 0.9 (19)<br>4.0–7.6 | 4.5 ± 0.3 (20)<br>4.0–5.2 | 3.2 ± 0.6 (18)<br>1.9–4.3 |
| Breadth of palate anterior to P$^4$ | 3.4 ± 0.5 (18)<br>2.6–4.2 | 2.6 ± 0.3 (21)<br>2.3–3.1 | 2.4 ± 0.3 (19)<br>1.9–2.8 |
| Breadth of palate between P$^4$ and M$^1$ | 3.4 ± 0.6 (16)<br>2.4–4.6 | 2.9 ± 0.3 (19)<br>2.3–3.7 | 2.2 ± 0.3 (19)<br>1.6–2.8 |
| Breadth of palate at posterior palatal margin | 6.4 ± 0.4 (18)<br>5.5–7.0 | 5.6 ± 0.3 (19)<br>5.3–6.5 | 4.8 ± 0.4 (19)<br>3.8–5.6 |
| Length of upper diastema | 19.6 ± 1.1 (19)<br>17.9–21.6 | 17.0 ± 0.6 (20)<br>16.0–18.5 | 15.4 ± 0.5 (18)<br>14.7–16.6 |
| Alveolar length of upper tooth row | 19.3 ± 0.7 (19)<br>18.0–20.3 | 15.2 ± 0.5 (21)<br>14.4–15.9 | 15.6 ± 0.5 (19)<br>14.8–16.4 |
| Occlusal length of upper cheek teeth | 18.1 ± 0.7 (11)<br>17.0–19.4 | 14.1 ± 0.6 (21)<br>12.8–15.4 | 14.6 ± 0.6 (18)<br>13.3–15.6 |
| Greatest length of mandible | 55.8 ± 2.7 (17)<br>50.7–59.8 | 45.2 ± 1.6 (18)<br>41.4–48.3 | 41.3 ± 1.7 (15)<br>38.0–43.2 |
| Length of lower diastema | 13.7 ± 1.0 (19)<br>12.6–16.0 | 12.8 ± 0.7 (20)<br>11.5–14.3 | 10.1 ± 0.6 (18)<br>9.2–11.3 |
| Alveolar length of lower tooth row | 19.1 ± 1.0 (19)<br>17.5–21.0 | 14.6 ± 0.5 (20)<br>13.3–15.4 | 15.2 ± 0.6 (17)<br>13.9–16.2 |
| Occlusal length of lower cheek teeth | 18.7 ± 1.0 (12)<br>17.3–20.8 | 14.4 ± 0.6 (20)<br>13.5–15.5 | 14.6 ± 0.6 (17)<br>13.7–15.6 |

20% larger than *G. thoracatus,* depending on the measurement, with almost no overlap between the smallest *G. brownii* and the largest *G. thoracatus. G. ingrahami* is slightly smaller (6–8%) than *G. thoracatus,* but there is broad overlap between them in some measurements.

One of the most characteristic features of *Geocapromys brownii* is the prominent inflation of the frontals medial to the anterior edge of the orbits. The degree of frontal inflation varies individually, but all show some evidence of it. When viewed laterally, the frontals are seen to form a noticeable bulge in the dorsal profile of the skull (Fig. 1D). The inflation of the frontal sinuses begins immediately posterior to the nasofrontal suture, extends posteriorly to the level of the supraorbital processes, and is also present on the orbital wall dorsal to the lacrimals. The frontals are not inflated in *G. thoracatus* or *G. ingrahami.* Although the functional significance of frontal inflation is not known, it is present in several other groups of hystricognath rodents, particularly in the porcupines *Coendou* and *Hystrix.* Anterior to the frontoparietal suture, the interorbital region is strongly constricted in *G. brownii,* but not in the other two species. The anteriorly inflated and posteriorly constricted frontals of *G. brownii* are thus considerably broader anterior to the supraorbital processes than posterior to them. This contrasts with *G. thoracatus,* in which the frontals are always broader posterior to the supraorbital processes, and with *G. ingrahami,* in which the two measurements are nearly equal.

Most specimens of *Geocapromys brownii* have a moderate to strongly developed sagittal crest formed by the convergence of weak temporal crests. The temporal crests are stronger in *G. thoracatus* and *G. ingrahami,* but never meet to form a sagittal crest in the latter, and only rarely meet to form a weak crest in the former. Compared to the other two species, *G. ingrahami* has an inflated and foreshortened braincase and a constricted pterygoid region. The auditory bullae of *G. ingrahami* are also inflated, whereas those of *G. brownii* and *G. thoracatus* are not. In posterior view, the bullae of *G.ingrahami* project ventral to the occipital condyles, whereas in the other two species the ventral surface of the bullae is always dorsal to the condyles. Additionally, the bullae of *G. ingrahami* are comparatively shorter, broader anteriorly, and have a larger external auditory meatus. The combination of the inflated bullae and a narrower basioccipital results in the anterior portions of the bullae being in closer approximation in *G. ingrahami* than in its congeners.

In all *Geocapromys,* the lateral jugal fossa is present, being particularly large in *G. brownii,* slightly smaller in *G. thoracatus,* and reduced in *G. ingrahami.* The enlarged jugal fossa of *G. brownii* is partially the result of a prominent jugal spine on the posteroventral edge of the jugal. The jugal spine is present, but smaller in *G. thoracatus* and absent in *G. ingrahami.* In lateral view, the posterior portion of the zygomatic arch appears to be rotated ventrally in *G. brownii* and *G. thoracatus* in comparison to that of *G. ingrahami* or *Capromys.* The downturning or flexion of the zygomatic arch region is best observed in the relationship between the ventral border of the jugal and the alveolar margin of the upper cheek teeth. The ventral border of the zygomatic arch is inclined relative to the alveolar margin

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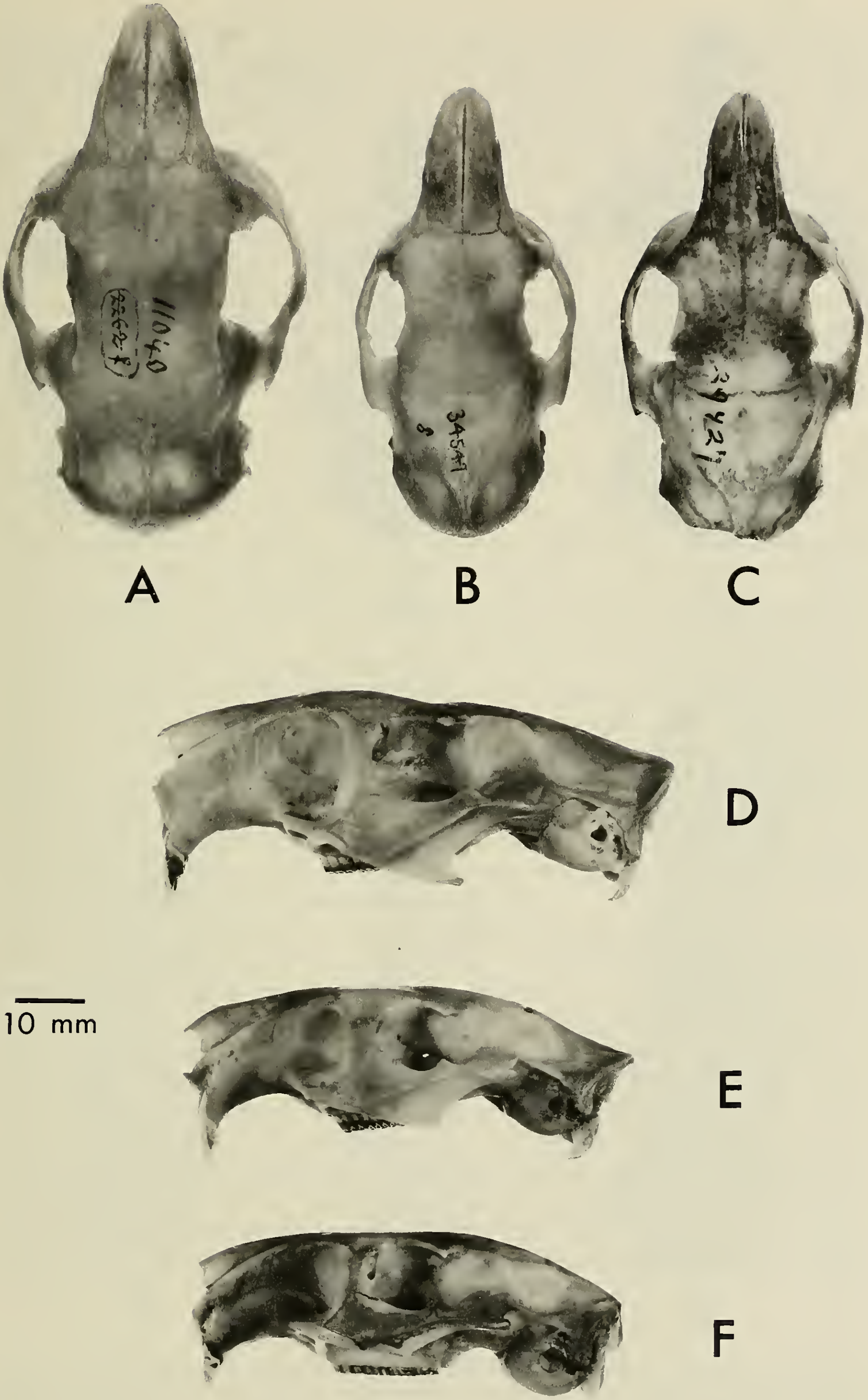
Fig. 1. Dorsal (A–C) and left lateral (D–F) views of cranium of *Geocapromys* species. A, D, *G. brownii,* MCZ 11040, Jamaica; B, E, *G. thoracatus,* AMNH 34547, Little Swan Island; C, F, *G. ingrahami,* MCZ 29427, East Plana Cay, Bahamas. All photographs are natural size.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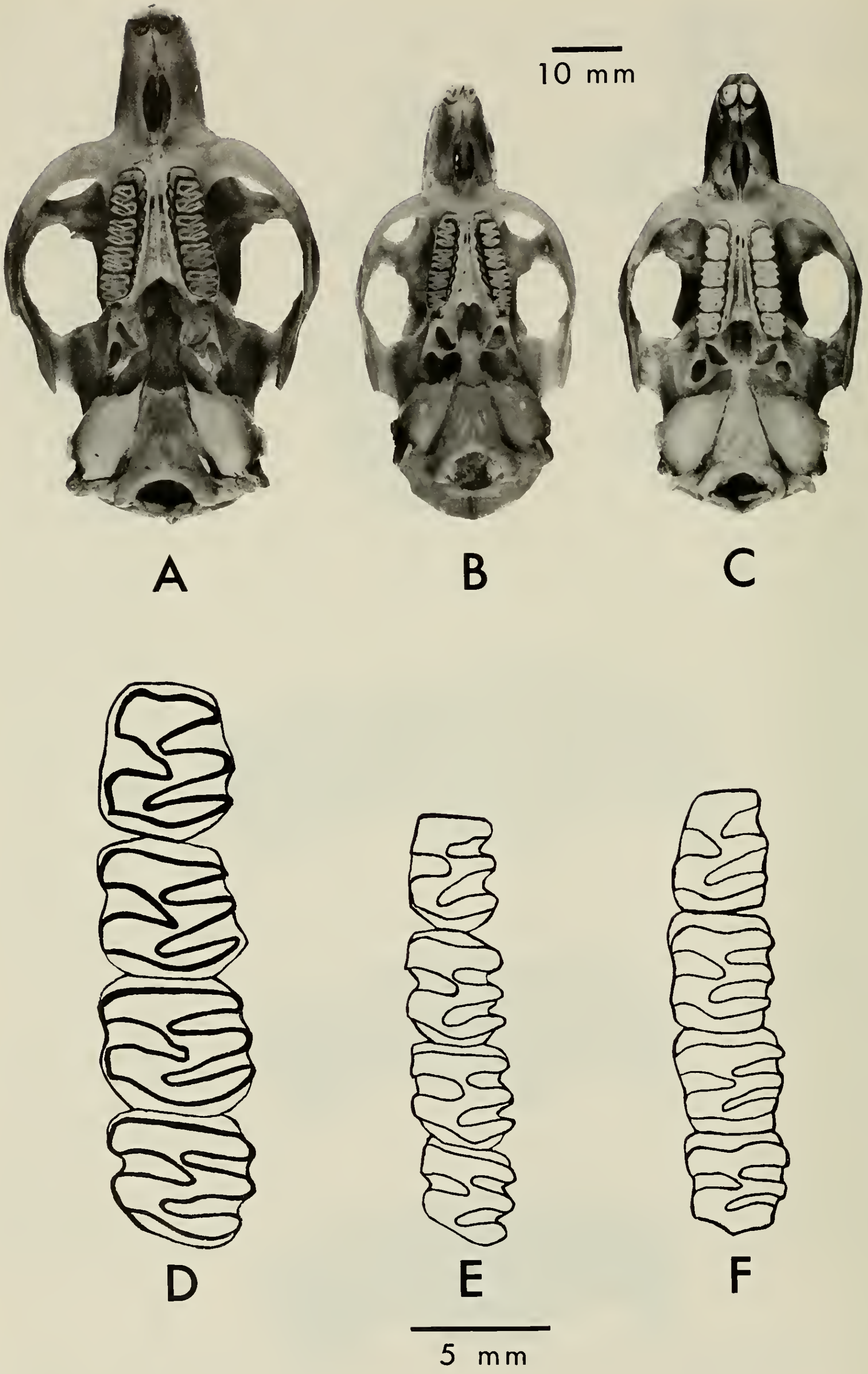
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5 mm

and projects ventral to it in *G. brownii* and *G. thoracatus.* In most specimens of these two species the jugal spine, the ventralmost portion of the zygomatic arch, is ventral to the occlusal surface of the cheek teeth. In *G. ingrahami,* the ventral border of the zygomatic arch is essentially parallel to the alveolar margin and does not project ventral to it. Apparently, as a result of the ventral rotation of the zygomatic arch, the superior zygomatic root of the maxilla in *G. brownii* and *G. thoracatus* is inclined posteriorly relative to a perpendicular line drawn through the alveolar margin. In addition, the superior zygomatic root in these two species is relatively broader than in *G. ingrahami* or *Capromys.* The superior zygomatic root of *G. ingrahami* is perpendicular or inclined slightly anteriorly. The zygomatic arches in *G. brownii* are broadest anteriorly, whereas in *G. thoracatus* and *G. ingrahami* the lateral margins of the zygomatics are parallel.

The upper tooth rows converge anteriorly in all *Geocapromys* more so than in *Capromys. Geocapromys ingrahami* shows the greatest tendency toward this convergence, *G. brownii* the least. The upper tooth rows of *G. ingrahami* do not diverge as strongly as in *G. brownii* and *G. thoracatus* and as a result, the internal nares are constricted laterally. The anterior convergence of the upper tooth rows and constriction of the internal nares are carried to an extreme in several extinct species of *Geocapromys* in which the tooth rows nearly meet anteriorly. In contrast to the condition in *G. ingrahami,* the opening of the internal nares is constricted vertically in *G. thoracatus* due to the dorsal inclination of the palate from anterior to posterior. The median ridge of the palate has been used to distinguish species of *Geocapromys,* but I found this character to be highly variable in all species except *G. thoracatus. Geocapromys thoracatus* has a small spinous process that projects 1–2 mm beyond the posterior palatal margin along the midline; this process was not observed in any other species of the genus. Both the alveolar and occlusal lengths of the upper tooth rows are shorter in *G. thoracatus* than in *G. ingrahami,* even though the former is larger in most other cranial measurements. This derives from the comparatively small cheek teeth of *G. thoracatus,* a feature discussed in greater detail in the Dentition section.

*Mandible.*—The coronoid process is triangular and vertical in *Geocapromys thoracatus* and *G. ingrahami,* whereas in *G. brownii* the tip of the coronoid is curved posteriorly. The masseteric crest is broad and rounded laterally in *G. thoracatus,* but is narrower in *G. brownii* and *G. ingrahami.* The pterygoid shelf of the angular process is also broader in *G. thoracatus.* The articular surface of the condyloid process is anteroposteriorly elongate in *G. brownii* and *G. ingrahami,* but is nearly circular in *G. thoracatus.* A postcondyloid process is well developed in *G. brownii,* somewhat smaller in *G. ingrahami,* and reduced in *G. thoracatus.* As in the upper cheek teeth, the lower teeth in *G. thoracatus* are shorter and narrower than in the other species and consequently, the alveolar and occlusal lengths of the tooth rows are shorter. The mandibular tooth rows are closer in *G. ingrahami* than in the other two species, but are not as convergent

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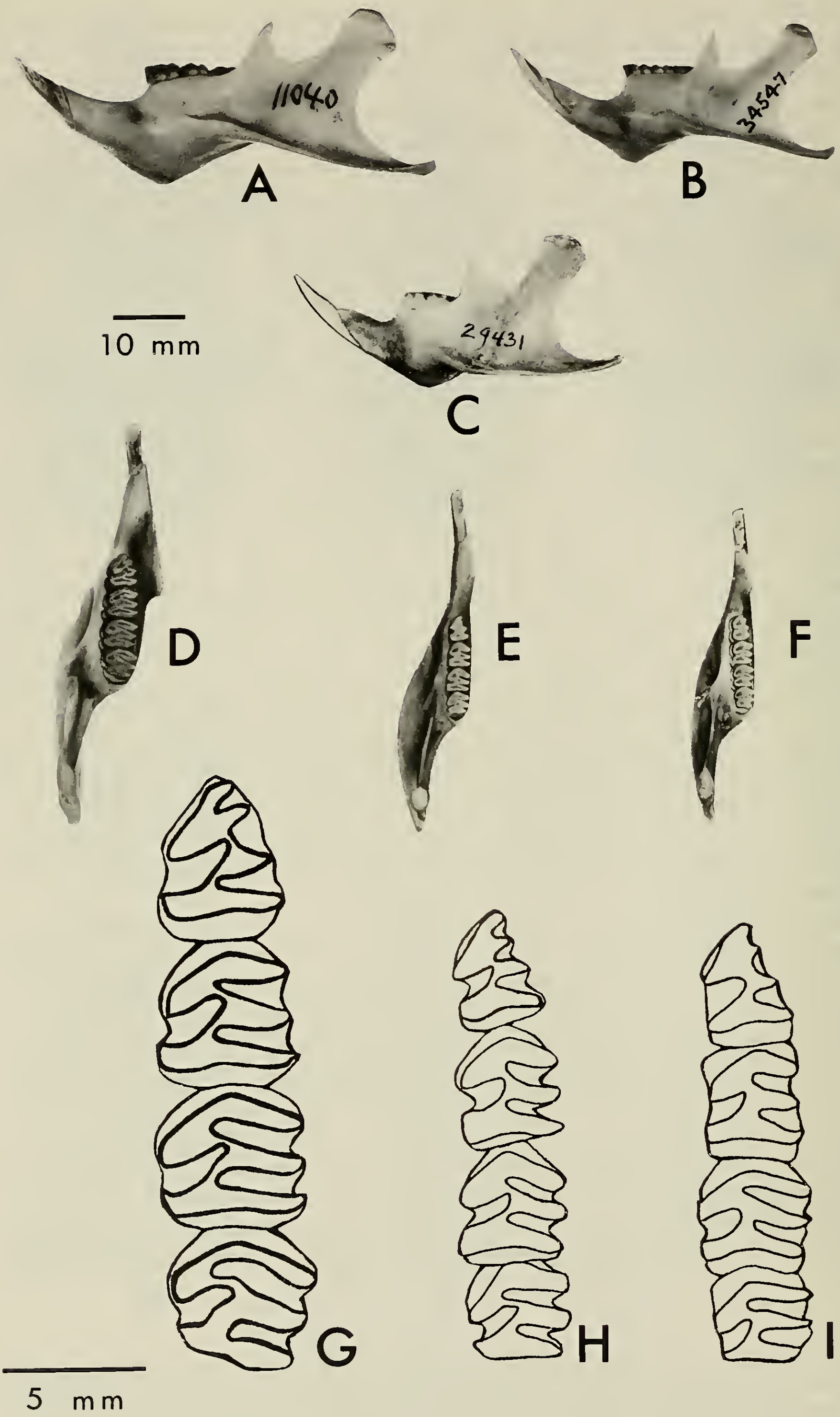
Fig. 2. Ventral views of cranium (A–C) and occlusal outlines of maxillary cheek teeth (D–F) of *Geocapromys* species. A, D, *G. brownii,* MCZ 11040, Jamaica; B, E, *G. thoracatus,* AMNH 34547, Little Swan Island; C, F, *G. ingrahami,* MCZ 29427, East Plana Cay, Bahamas. Photographs of crania (A–C) are natural size, occlusal outlines of cheek teeth (D–F) are 4× natural size.


11040
A
34547
B
10 mm
29431
C
D
E
F
G
H
I
5 mm

as are their upper counterparts. *Geocapromys ingrahami* has a relatively shorter diastema than do the other two species.

*Dentition.*—In the cheek teeth of *Geocapromys,* cement is present on that portion of the crown not enclosed by the continuous enamel band, except on the anterior margin of $P^4$ and the posterior margin of $M_3$. However, the cement is reduced on all cheek teeth of *G. thoracatus* in comparison to its congeners. In particular, the cement in *G. thoracatus* is thin on the anterior edge of $P_4$ and absent from the anterolingual edges of $M_1$-$M_3$ and the posterolabial edges of $P^4$-$M^2$. The edges of the labial lophs and lingual lophids on the upper and lower molars respectively, are more prominent in *G. thoracatus* because the flexi and flexids are not filled entirely to their margins with cement as they are in *G. brownii* and *G. ingrahami.* The thinner layer of cement on the anterior and posterior margins of the cheek teeth in *G. thoracatus* almost certainly accounts for the shorter tooth row lengths observed in this species.

The presence of a small anterolingual re-entrant (anteroflexid) on $P_4$ is characteristic of all *Geocapromys.* This may be a primitive character, as an anteroflexid or anterofossetid on $P_4$ is found in echimyids, the presumed sister group of the capromyids. However, the presence of an incipient anteroflexid in some specimens of *Capromys pilorides* indicates that the anteroflexid of *Geocapromys* may be secondarily derived from the condition found in *Capromys* and hence, not strictly homologous with the flexid located in the same position in echimyids. Whether the anteroflexid on $P_4$ is a primitive character or a neomorph, its morphology differs among the species of *Geocapromys* and is useful in distinguishing them. In *G. brownii,* the anteroflexid is well developed, extending to the midline of $P_4$ in most specimens and separating the anterolophid into two parts. The medial lingual re-entrant (mesoflexid) nearly contacts the hypoflexid. The posterolingual re-entrant (metaflexid) contacts or nearly contacts the posterior enamel band of the hypoflexid. The anteroflexid is well developed in *G. thoracatus,* but it does not extend to the midline of $P_4$, nor does it appear to separate the anterolophid into two distinct lophids. The mesoflexid and metaflexid are as in *G. brownii,* except that the metaflexid never distorts the posterior margin of the hypoflexid as it does in some specimens of *G. brownii.* The anteroflexid is invariably present in *G. ingrahami* but it is very small compared to that in the other two species. The mesoflexid of *G. ingrahami* is broad and shallow. The metaflexid extends farther lingually than the mesoflexid, but does not contact the hypoflexid.

The differences in the upper dentition between the species of *Geocapromys* are not as pronounced as in the lowers. The paraflexus and hypoflexus of all upper cheek teeth in *G. brownii* and *G. thoracatus* are in contact along the longitudinal midline, effectively isolating the protoloph. This is also true of the upper molars in *G. ingrahami,* but the paraflexus and hypoflexus are not in contact on $P^4$.

Color of the incisors has been used in the past to distinguish species of *Geocapromys.* This character must be used with care because a change in incisor

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Fig. 3. Lateral (A–C) and occlusal (D–F) views of left mandible and occlusal outlines of mandibular cheek teeth (G–I) of *Geocapromys* species. A, D, G, *G. brownii,* MCZ 11040, Jamaica; B, E, H, *G. thoracatus,* AMNH 34547, Little Swan Island; C, F, I, *G. ingrahami,* MCZ 29431, East Plana Cay, Bahamas. Photographs of mandibles (A–F) are natural size, occlusal outlines of cheek teeth (G–I) are 4× natural size.

coloration can result from certain preparation techniques or from long submersion in preservative fluids. Still, there is a consistent difference in incisor color between *G. brownii,* in which the incisors are almost always bright yellowish-orange and *G. thoracatus* and *G. ingrahami* in which the incisors are pale yellow or cream-colored.

*Relationships of the Recent species of Geocapromys.*—The three Recent species of *Geocapromys* can be readily distinguished from one another on the basis of external, cranial, and dental features. In addition, there are four or five extinct species in the genus, several of which are as distinctive as the Recent species. Three extinct species of *Geocapromys* have been described from Cuba, an undescribed species is known from cave deposits in the Cayman Islands, and fossils of an undetermined number of forms have been recovered from nine of the Bahama Islands. Because of the large number of *Geocapromys* fossils known, I am postponing a detailed discussion of the intrageneric relationships to a future paper reviewing the extinct species. Although the evolutionary history of *Geocapromys* is incomplete without inclusion of the fossils, it seems appropriate to discuss several characters that separate the Recent species into distinct lineages or species-groups, as these will prove useful when the fossil taxa are considered.

Before discussing the relationships within *Geocapromys,* it is necessary to review briefly the broader affinities of the genus in order to establish my criteria for the determination of primitive and derived character states. The Echimyidae and Capromyidae are closely related based on several shared derived characters: the presence of a lateral process of the supraoccipital, the presence of a lateral jugal fossa, and the retention of $dP^4_4$. These and other cranial and dental features suggest strongly that echimyids are the mainland group from which capromyids were derived. Compared to echimyids, capromyids are derived in the possession of high-crowned, rootless, and evergrowing cheek teeth; the presence of cement on the tooth crowns; the absence of a metaloph/metalophid on all cheek teeth; and prominent paraoccipital processes that stand apart from the bullae. *Capromys* resembles echimyids and differs from *Geocapromys* in the possession of a long, well-furred tail; thin, anteriorly oriented superior zygomatic root of the maxilla; narrow jugal; relatively large orbit; and more highly arched, nonprocumbent incisors. Based on the widespread occurrence of these characters in the Echimyidae and other capromyids, they are considered primitive in *Capromys.* In the following analysis, the presence of a particular character in echimyids and *Capromys* would be the basis for regarding that structure as primitive in *Geocapromys.* Similarly, a character present in one or more species of *Geocapromys,* but not in *Capromys* or echimyids, would be considered derived.

*Geocapromys brownii* is derived relative to its congeners, *Capromys,* and echimyids in several cranial features, including the inflated frontal sinuses, the posterior constriction of the frontals, the well developed sagittal crest, and the anteriorly broadened zygomatic arches. Derived features of *G. thoracatus* are the dorsally sloping palate, the vertical constriction of the internal nares, the posterior palatal spine, and the relatively small teeth. *Geocapromys brownii* and *G. thoracatus* share a unique complex of derived characters in the zygomatic arch region. These include the broad, posteriorly oriented superior zygomatic root, deeper jugal, smaller orbit, and ventral rotation of the entire zygomatic arch. Based on these derived features, *G. brownii* and *G. thoracatus* appear to represent a lineage distinct from other *Geocapromys* species and are here designated the *brownii* species-group. The close relationship of these two forms is not surprising considering that most recent workers have regarded them as conspecific.

*Geocapromys ingrahami* is distinguished from *G. brownii* and *G. thoracatus* by its shortened, inflated braincase, constricted pterygoid region, incipiently convergent upper tooth rows, lateral constriction of the internal nares, and inflated auditory bullae. Within the Capromyidae these characters are all derived. *Capromys nanus* also has a shortened, swollen braincase and inflated bullae, but is clearly not closely related to *G. ingrahami* and appears to have developed these features independently. The extinct taxa of *Geocapromys* from Cuba, the Bahamas, and the Cayman Islands possess most of the derived characters present in *G. ingrahami,* although the expression of these characters varies significantly between species. My preliminary analysis of these extinct forms indicates that they are most closely related to *G. ingrahami* and are here grouped with the latter in the *ingrahami* species-group of *Geocapromys* species.

*Extinction of the Swan Island Hutia.*—From the time of its discovery in 1887 by Charles Townsend, the naturalist aboard the U.S. Fish Commission Steamer *Albatross,* until its extinction less than a century later, *Geocapromys thoracatus* was known to occur only on Little Swan Island. Even though Great Swan Island is less than 0.5 km west of Little Swan, is larger, and supports a more luxuriant vegetation, there is no evidence that the hutia ever occurred there. This is analogous to the situation in the Bahamas where *G. ingrahami* lives in large numbers on East Plana Cay, but has never been found on West Plana Cay, an island of similar size only 3 km to the west (J. A. Allen 1891; Clough 1972). Clough and Fulk (1971) do note that there is very little exposed limestone on West Plana Cay compared to East Plana Cay. The coral rock on West Plana Cay is covered by soil and supports a thicker, higher vegetation than does the eastern island. Most of the limestone in the central portion of Great Swan Island is also soil-covered, whereas Little Swan is almost totally devoid of soil. No species of *Geocapromys* is known to dig its own burrows; instead they live in natural cavities, especially small caves and solution holes in limestone karst areas. It seems probable that Great Swan Island and West Plana Cay are unsuitable for hutias because these islands lack large areas of exposed limestone and the myriad of caves and solution holes which are the inevitable result of the chemical weathering of a limestone terrain in the West Indies. This hypothesis has some corroboration in the distribution of *G. brownii* in Jamaica, where it occurs primarily in areas where there are extensive limestone outcrops.

Naturalists in the early part of this century found hutias to be extremely abundant on Little Swan Island. Lowe (1911:114) ". . . saw at least a dozen others [in addition to the two he had already captured] running about and bolting into the big crevasses with which the island is seamed." George Nelson collected 15 Swan Island Hutias for the Museum of Comparative Zoology in March and April of 1912. Even Lord Moyne, who was the last person to collect *Geocapromys thoracatus,* found hutias so abundant on Little Swan in 1937 that (Moyne 1938:82) ". . . four men from the western island with neither nets nor traps caught twelve alive for us in about two hours." Based on this evidence *G. thoracatus* must have become extinct extremely rapidly, as it was last seen alive sometime in the early 1950's. The Swan Islands suffered a devastating hurricane in 1955, and in the late 1950's or early 1960's a box of unwanted cats was released on Little Swan (Clough 1976). The combination of these two events undoubtedly resulted in the

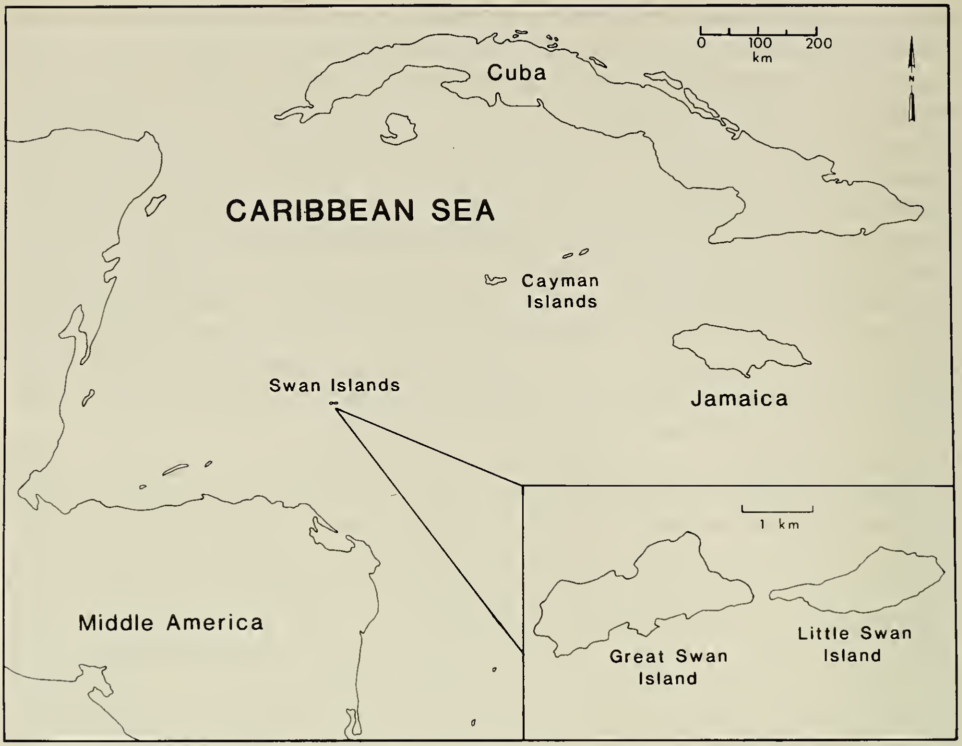

Fig. 4. Outline map of western Caribbean Sea showing all islands and mainland areas mentioned in text. Inset in lower right hand corner is enlarged map of Swan Islands.

demise of the Swan Island Hutia. Stewart (1962) and his crew did not find hutias on Little Swan in 1960, nor did they see any of their previously omnipresent fecal pellets. Ronald Crombie and Stephen Busack spent two days on Little Swan in February 1974 collecting reptiles for the Smithsonian Institution, but saw no hutias or fecal pellets (R. I. Crombie, pers. comm.). Garrett Clough and Robert Howe (Clough 1976) spent five days on Little Swan in July and August of 1974 specifically looking for *G. thoracatus* or evidence of its existence there. No hutias or fecal pellets were found and a weathered skull served as the only testimony that the species had ever occurred on the island. Taking into account the great abundance of hutias seen on Little Swan Island by earlier visitors and the total lack of evidence of their existence there after 1960, it appears almost certain that *G. thoracatus* is extinct.

*Zoogeography of the Swan Islands.*—The Swan Islands are among the most isolated islands in the West Indies. They are located at 17°24′N latitude and 83°56′W longitude, approximately 180 km north of the nearest point on the Middle American mainland and 350 km southwest of Grand Cayman, the closest island in the West Indies (Fig. 4). The Swan Islands lie atop an isolated rise on the southern wall of the Cayman Trench, a deep submarine trench that separates the Swan Islands, Nicaraguan Plateau, and Jamaica on the south from the Cayman Ridge (including the Cayman Islands) and Cuba on the north. After the middle Miocene, localized vertical uplift raised the Swan Islands near or above sea level, while the surrounding crust subsided (Perfit and Heezen 1978). Since the late

Table 2.—Zoogeographic affinities of the Swan Islands vertebrate fauna.

| Species | General affinities | Specific affinities |
|---|---|---|
| Reptilia[1] | | |
| *Ameiva ameiva fuliginosa* | Middle America | Isla de Providencia |
| **Anolis sagrei nelsoni* | indeterminate | indeterminate |
| **Aristelliger praesignis nelsoni* | West Indies | Jamaica and Cayman Islands |
| *Cnemidophorus l. lemniscatus* | Middle America | indeterminate |
| *Iguana iguana* | Middle America | indeterminate |
| *Leiocephalus carinatus varius* | West Indies | Cayman Islands |
| **Sphaerodactylus notatus exsul* | West Indies | Cuba |
| **Alsophis cantherigerus brooksi* | West Indies | Cuba and Cayman Islands |
| *Leptotyphlops goudoti magnamaculata* | Middle America | Isla de Providencia and Isla San Andres |
| Aves[2] | | |
| *Sula l. leucogaster* | indeterminate | indeterminate |
| *Sula s. sula* | indeterminate | indeterminate |
| *Fregata magnificens* | indeterminate | indeterminate |
| *Columba leucocephala* | West Indies | indeterminate |
| *Coccyzus minor nesiotes* | West Indies | Jamaica and Cayman Islands |
| *Crotophaga ani* | West Indies | indeterminate |
| *Mimocichla plumbea rubripes* | West Indies | Cuba |
| **Dendroica vitellina nelsoni* | West Indies | Cayman Islands |
| Mammalia | | |
| †*Geocapromys thoracatus* | West Indies | Jamaica |

* Endemic subspecies.
† Endemic species.
[1] Data from MacLean *et al.* (1977) and Schwartz and Thomas (1975).
[2] Data from Paynter (1956).

Miocene they have existed as either low islands or shallow carbonate banks. Depths in excess of 2000 m are encountered within 30 km of the Swan Islands in any direction. Based on these profound depths and the rates of subsidence for the surrounding ocean floor over the past 20 million years (Perfit and Heezen 1978), it appears that the Swan Islands have never been connected to other land. However, during periods of lower sea level, especially during Pleistocene glacial intervals, portions of the Nicaraguan Plateau may have been emergent and in closer proximity to the Swan Islands than the mainland is at present, perhaps as close as 100 km.

The lack of evidence for land connection between the Swan Islands and either the Middle American mainland or any of the West Indian islands eliminates the geographic fragmentation and subsequent vicariance of an ancestral biota as a viable hypothesis for the origin of the Swan Islands fauna. Dispersal remains as the only explanation for the existence of a vertebrate fauna on the Swan Islands. Darlington (1937) noted that in the Greater Antilles most storm tracks, particularly hurricanes, and the prevailing trade winds come from the northeast, favoring dispersal of organisms from the Greater Antilles to the Swan Islands. Present-day currents, on the other hand, come out of the southeast; however, current patterns in the Caribbean may have been radically different prior to the connection of North and South America in the late Pliocene or early Pleistocene.

The vertebrate fauna of the Swan Islands consists of 18 species: nine reptiles, eight birds, and one mammal. Table 2 lists the vertebrates known to breed in the Swan Islands and summarizes the general (mainland or West Indian) and specific zoogeographic affinities of each species. Additional indigenous species of vertebrates may be added with future collecting, although the likelihood of adding more than a few species is slight, considering the many naturalists who have collected in the Swan Islands (at least ten, based on the literature). The Swan Islands will be considered as a zoogeographic unit in my analysis despite several examples of anomalies in distribution between the islands, the most notable being the presence of *Geocapromys thoracatus* on Little Swan, but not on Great Swan.

The herpetofauna of the Swan Islands is entirely reptilian, consisting of seven lizards and two snakes (MacLean *et al.* 1977; Schwartz and Thomas 1975). Of these nine species, four have mainland affinities, four are derived from the West Indies, and one occurs in both regions. None of the species of mainland origin are represented by endemic subspecies, although subspecies of *Ameiva ameiva* and *Leptotyphlops goudoti* are restricted to the Swan Islands and one or more islands off the coast of Honduras and Nicaragua. In contrast, three of the four reptiles of West Indian origin have endemic subspecies in the Swan Islands and the fourth, *Leiocephalus carinatus varius,* occurs only in the Swan and Cayman Islands. Excluding sea birds, which are too widely distributed for zoogeographic analysis, only five species of land birds breed in the Swan Islands (Paynter 1956) and all are clearly derived from the West Indies. An endemic subspecies of *Dendroica vitellina* occurs in the Swan Islands, a species found elsewhere only in the Cayman Islands. *Geocapromys thoracatus* is the only mammal recorded from the Swan Islands, and it is also the only endemic species of vertebrate known from the two islands. The Swan Island Hutia has its closest affinities with the Jamaican species, *G. brownii.*

The land snail fauna of the Swan Islands provides an interesting comparison with the vertebrates. The land snails are more diverse than the vertebrates, represented by at least 22 species (Pilsbry 1930). Eight of these species are so widely distributed in the West Indies and Middle America that the origin of the Swan Island forms cannot be determined. Eleven species are conspecific with or related to West Indian forms, whereas only three species have been derived from the Middle American mainland. Furthermore, of the nine endemic species of land snails found in the Swan Islands, all but one are of West Indian origin. Pilsbry (1930) noted that the endemic land snails showed a special resemblance to forms from Jamaica and Grand Cayman, especially the latter.

The endemic nature of the West Indian complement of the vertebrate fauna, including one endemic species and four subspecies, together with the high endemism of the Swan Island land snails with West Indian affinities, suggests that this portion of the fauna has been isolated in the Swan Islands for a longer period of time than the species derived from the Middle American mainland. This assumes that evolutionary rates among Swan Island species have been constant and that the greater degree of morphological differentiation shown by the West Indian component of the fauna indicates a longer period of isolation. Since the Swan Islands lack a fossil record of terrestrial species, this hypothesis is not testable, nor does there appear to be a clear explanation for the supposedly greater antiquity of the West Indian forms. Even if the individual species have remained static in an evolutionary sense since becoming isolated on the Swan Islands, the endemic forms, at least among the vertebrates, probably originated no earlier than the Pleistocene.

The zoogeographic data indicate that the Swan Islands vertebrate fauna, although small, is complex and has been derived from a diversity of sources, including Cuba, Jamaica, the Cayman Islands, the Caribbean coast of Middle America from the Yucatan Peninsula to Nicaragua, and several islands off the coast of Honduras and Nicaragua. More of the species (nine) share affinities with forms from the Cayman Islands than from any other single source area. Two generalized distributional patterns or tracks (sensu Rosen 1976) are evident from the zoogeographic data. The most important generalized track connects the Swan Islands with Cuba, Jamaica, and the Cayman Islands, accounting for 10 species (70%) of the vertebrates of known zoogeographic affinities. A smaller track, accounting for four species (30%), links the Swan Islands with the Middle American mainland. As discussed above, these distributional tracks are best explained by overwater dispersal rather than vicariance, the latter being falsifiable on geological grounds. Both Hershkovitz (1958) and Koopman (1959) placed the Swan Islands in the West Indian Subregion of the Neotropical Region based solely on the presence of *Geocapromys thoracatus*. Zoogeographic analysis of the remainder of the vertebrate fauna substantiates the placement of the Swan Islands in the West Indian Subregion.

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# *LOLLIGUNCULA ARGUS,* A NEW SPECIES OF LOLIGINID SQUID (CEPHALOPODA: MYOPSIDA) FROM THE TROPICAL EASTERN PACIFIC

Thomas F. Brakoniecki and Clyde F. E. Roper

*Abstract.*—A new species of myopsid squid, *Lolliguncula argus,* is described from the tropical eastern Pacific. It is characterized by its small size at maturity (males 20.8–*26.8*–29.6 mm ML, females 20.6–*32.3*–38.8 mm ML), the lack of buccal suckers, and it is the only known myopsid to have its primary hectocotylization on the right ventral arm instead of the left.

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Among the cephalopods collected during a cruise of the M/V *Argosy* off the coast of Ecuador, were several unidentifiable lots of small but mature loliginids. Detailed examination showed that these were best referred to the genus *Lolligunucula* Steenstrup, 1881, but they were neither *L. panamensis* Berry, 1911, nor *L. tydeus* Brakoniecki, 1980. These small distinctive squids represent, therefore, an undescribed species.

All measurements (in mm) and indices are as defined by Roper and Voss (1983), with the following addition:

VLI—vane length index—length of the vanes from the anterior vane insertions to the posterior end of the gladius as a percentage of gladius length.

CBLI—cement body length index—length of cement body as a percentage of spermatophore length.

## *Lolliguncula argus,* new species
Figs. 1, 2

*Material examined.*—Holotype: male ML 28.6 mm, M/V *Argosy* sta 85, La Plata Is., Ecuador, 01°16′S 81°05′W, 10 Oct 1961, USNM 815750. Paratypes: 2 males ML 20.8–29.6 mm, 1 female ML 38.8 mm, taken with holotype, UMML 31.1822.—3 females ML 34.0–35.4 mm, M/V *Argosy* sta 49, La Plata Is., Ecuador, 29 Sep 1961, USNM 815751.—7 males ML 26.0–28.2 mm, 3 females ML 20.6–32.3 mm, M/V *Argosy* sta 63, La Plata Is., Ecuador, 3 Oct 1961, USNM 815752.—3 females ML 31.4–33.8 mm, M/V *Argosy* sta 79, La Plata Is., Ecuador, 9 Oct 1961, USNM 815753. Other material: 13 males M/V *Argosy* sta 45, La Plata Is., Ecuador, 28 Sep 1961, UMML 31.1823.—1 male, 5 females, M/V *Argosy* sta 49, La Plata Is., Ecuador, 29 Sep 1961, UMML 31.1824.—5 males, 2 females, M/V *Argosy* sta 52, La Plata Is., Ecuador, 30 Sep 1961, UMML 31.1825.—9 males, 1 female, M/V *Argosy* sta 67, La Plata Is., Ecuador, 5–6 Oct 1961, UMML 31.1826.—1 male, 1 female, M/V *Argosy* sta 69, La Plata Is., Ecuador, 6 Oct 1961, UMML 31.1827.—87 males, 14 females, M/V *Argosy* sta 79, La Plata Is., Ecuador, 9 Oct 1961, UMML 31.1828.—2 males, taken with holotype, UMML 31.1829.—1 female, Los Frailes, B. C., Mexico, 23°21′N, 109°25′W, 24 Mar 1957, UMML 31.1830.—5 males, 5 females, Scripps Institution Acc. No. BI-65-I. RR 65-50 +

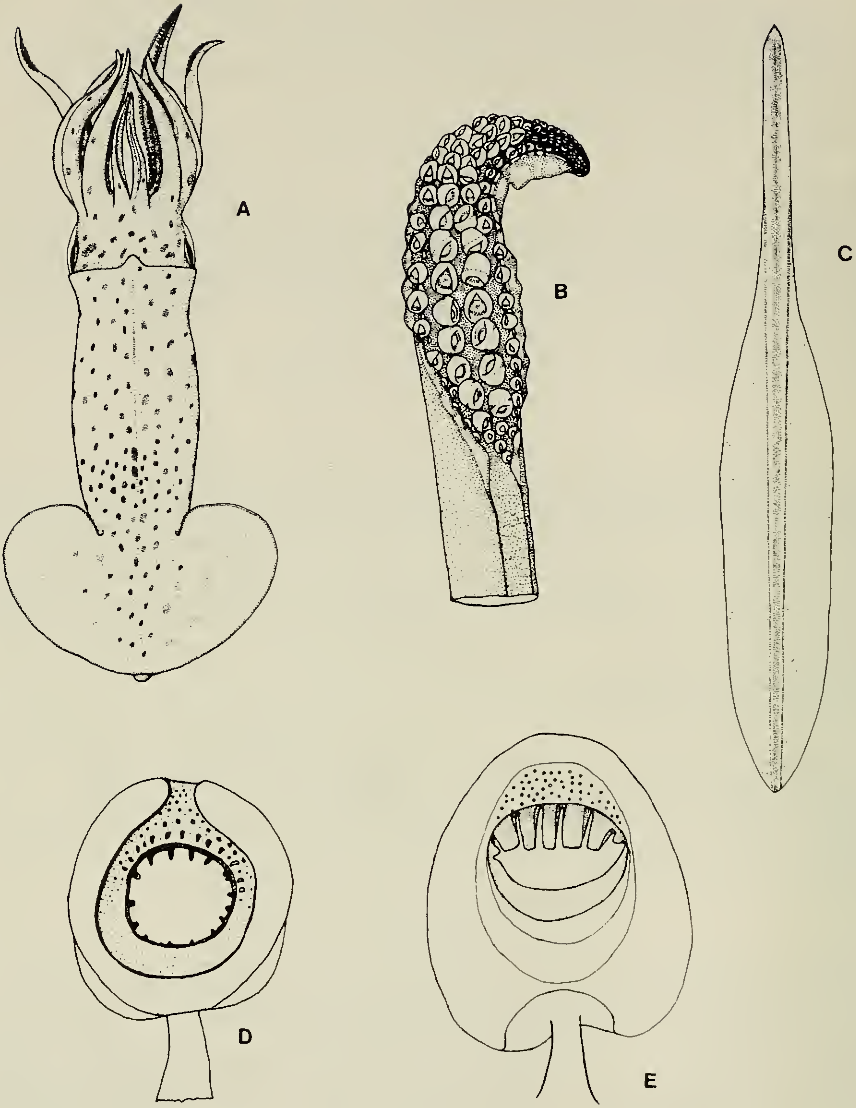

Fig. 1. *Lolliguncula argus:* A, Dorsal view of holotype 28.6 mm ML, USNM 815750; B, Tentacular club from female 33.8 mm ML, USNM 815753; C, Gladius from male 27.6 mm ML, USNM 815752; D, Large tentacular sucker from median row of female 33.8 mm ML, USNM 815753; E, Sucker from right arm III row 7 of male 29.6 mm ML, UMML 31.1822.

51, Bahia Santo Inez, Mexico, 26°56.0′N, 11°50.9′W to 26°59.9′N, 111°58.8′W, 14 Jul 1965.

*Description.*—The mantle is short, cylindrical and bluntly pointed posteriorly. Females generally are larger than males at maturity (ML males 20.8–*26.8*–29.6 mm, females 20.6–32.3–38.8). The mantle width is about ⅓ of the length (MWI males 31.1–*33.5*–35.6, females 25.7–*30.4*–34.4). The anterior margin is wide, slightly flared, with a distinct dorsal lappet marking the anterior end of the gladius.

Table 1.—Measurements (in mm) and indices of ten *Lolliguncula argus*, new species (holotype ML = 28.6 mm).

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ML | 20.8 | 26.0 | 26.2 | 26.8 | 27.0 | 27.2 | 27.6 | 28.2 | 28.6 | 29.6 |
| MWI | 35.6 | 33.8 | 33.6 | 33.6 | 33.3 | 35.3 | 34.1 | 31.2 | 33.6 | 31.1 |
| HWI | 33.7 | 33.1 | 32.1 | 33.6 | 34.1 | 35.3 | 34.8 | 33.3 | 32.9 | 31.8 |
| FLI | 26.0 | 26.2 | 31.3 | 29.9 | 26.7 | 25.7 | 26.8 | 24.8 | 28.0 | 25.0 |
| FWI | 48.1 | 49.2 | 45.8 | 50.0 | 44.4 | 44.8 | 54.3 | 46.8 | 53.1 | 47.3 |
| ALI I | 27.2 | 22.3 | 24.4 | 22.4 | 21.5 | 21.3 | 21.7 | 21.3 | 24.5 | 20.9 |
| ALI II | 37.5 | 30.0 | 33.6 | 29.9 | 31.1 | 31.6 | 33.3 | 29.1 | 34.3 | 31.1 |
| ALI III | 47.1 | 37.7 | 34.4 | 35.1 | 33.3 | 32.4 | 36.2 | 31.2 | 39.9 | 35.1 |
| ALI IVr | 52.9 | 50.0 | 46.6 | 47.8 | 45.9 | 45.6 | 49.3 | 44.7 | 45.5 | 45.3 |
| ALI IVl | 34.6 | 33.1 | 35.9 | 33.6 | — | 31.6 | 33.3 | 30.5 | 32.9 | 33.1 |
| HcLI | 60.0 | 64.6 | 65.6 | 60.9 | 64.5 | 64.5 | 67.2 | 63.5 | 56.9 | 58.2 |
| TtLI | 76.9 | 36.9 | — | 42.5 | 36.3 | 39.7 | 43.5 | 41.8 | 44.1 | 39.9 |
| ClLI | 27.9 | 16.2 | — | 17.9 | 14.8 | 14.7 | 15.9 | 15.6 | 20.3 | 17.6 |
| GWI | — | — | 19.1 | 15.6 | 17.8 | 17.4 | 18.6 | — | — | — |
| VLI | — | — | 64.1 | 66.7 | 65.2 | 70.3 | 72.9 | — | — | — |
| RWI | — | — | 5.3 | 4.4 | 5.9 | 5.1 | 4.3 | — | — | — |

The ventral margin is deeply indented ventral to the funnel, with pointed lappets at the location of the mantle–funnel locking apparatus.

The fins are small, nearly elliptical in outline, their length about ¼ and their width about ½ of the mantle length (FLI males 24.8–*27.0*–31.3, females 24.3–*27.3*–29.9; FWI males 44.4–*48.4*–53.1, females 45.2–*49.0*–52.2).

Head width is about ¼ to ⅓ of the mantle length and is slightly narrower in mature females than in mature males (HWI males 31.8–*33.5*–35.3, females 25.7–*28.3*–31.0).

The funnel is short and stout. The mantle-funnel locking apparatus is of the simple, straight, ridge-and-groove type. The dorsal member of the funnel organ is Λ-shaped and the ventral pads are small, oval.

The buccal membrane is 7-lobed with supports attached dorsally on arms I and II and ventrally on arms III and IV. The lobes are reduced in size and buccal

Table 2.—Measurements (in mm) and indices of ten females of *Lolliguncula argus*, new species.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ML | 20.6 | 28.6 | 31.4 | 32.2 | 33.4 | 33.8 | 34.0 | 35.0 | 35.4 | 38.8 |
| MWI | 34.0 | 33.6 | 33.1 | 29.2 | 29.9 | 30.8 | 29.4 | 25.7 | 29.9 | 28.3 |
| HWI | 30.1 | 28.7 | 27.4 | 28.0 | 29.9 | 29.0 | 27.1 | 25.7 | 31.0 | 26.3 |
| FLI | 24.3 | 25.9 | 28.0 | 29.2 | 29.9 | 26.7 | 26.5 | 26.3 | 26.6 | 29.4 |
| FWI | 44.7 | 49.0 | 52.2 | 47.8 | 48.5 | 52.1 | 50.6 | 48.0 | 45.2 | 51.5 |
| ALI I | 19.4 | 20.3 | 19.1 | 20.5 | 19.8 | 17.8 | 19.4 | 17.1 | 19.2 | 17.5 |
| ALI II | 28.2 | 31.5 | 28.7 | 28.6 | 28.1 | 27.2 | 30.0 | 24.0 | — | 25.8 |
| ALI III | 31.1 | 34.3 | 29.9 | 32.9 | 31.1 | 29.7 | 33.5 | 29.7 | 29.9 | 27.8 |
| ALI IVr | 27.2 | 26.6 | 28.7 | 28.0 | 26.9 | 28.4 | 27.1 | 26.9 | 28.2 | 26.8 |
| ALI IVl | 28.2 | 27.3 | 28.7 | 28.0 | 27.5 | 26.7 | 26.5 | 27.4 | 27.7 | 27.3 |
| TtLI | 37.9 | 29.4 | 37.6 | 39.1 | 32.3 | 27.8 | 38.2 | 37.7 | 41.2 | 29.9 |
| ClLI | 19.4 | 14.7 | 16.6 | 15.5 | 14.4 | 14.8 | 11.8 | 13.1 | 14.1 | 15.5 |
| GWI | — | 16.6 | — | — | — | — | — | — | — | 17.4 |
| VLI | — | 72.4 | — | — | — | — | — | — | — | 70.8 |
| RWI | — | 4.1 | — | — | — | — | — | — | — | 3.1 |

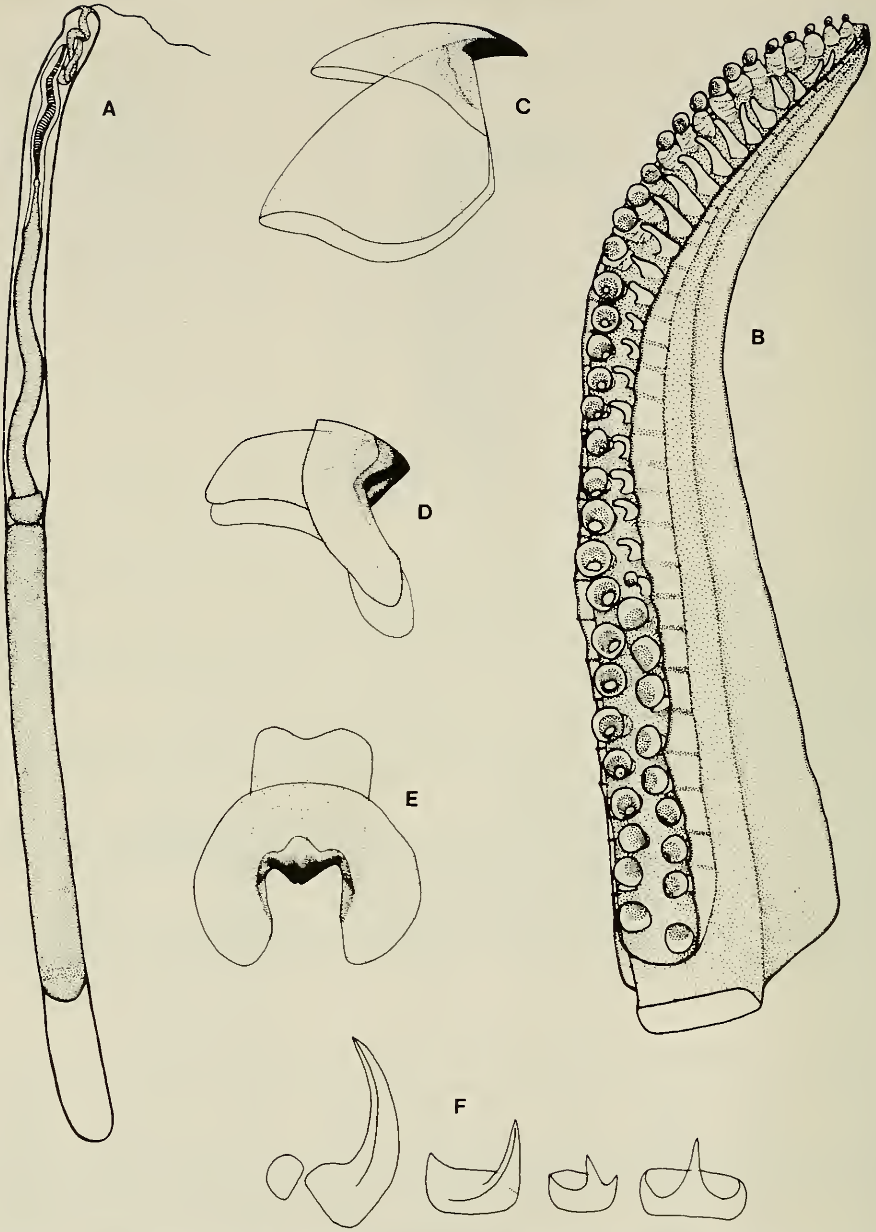

Fig. 2. *Lolliguncula argus:* A, Spermatophore from holotype 28.6 mm ML, USNM 815750; B, Hectocotylus from same; C, upper beak from male 26.8 mm ML, USNM 815752; D, E, Lower beak from same; F, Radula from same.

suckers are lacking. Spermatophores are implanted in females on a spermatophore receptacle on the ventral part of the buccal membrane and on the gills. Spermatophores on the gills generally are concentrated on the anterior lobe of the right gill.

Table 3.—Summary of indices of *Lolliguncula argus*, new species (n = 10 males, 10 females).

| Index | Range and mean males | Range and mean females |
|---|---|---|
| Mantle length | 20.8–*26.8*–29.6 | 20.6–*32.3*–38.8 |
| MWI | 31.1–*33.5*–35.6 | 25.7–*30.4*–34.0 |
| HWI | 31.8–*33.5*–35.3 | 25.7–*28.3*–31.0 |
| FLI | 24.8–*27.0*–31.3 | 24.3–*27.3*–29.9 |
| FWI | 44.4–*48.4*–53.1 | 45.2–*49.0*–52.2 |
| ALI I | 20.9–*22.8*–27.9 | 17.1–*19.0*–20.5 |
| ALI II | 29.1–*32.2*–37.5 | 24.0–*28.0*–31.5 |
| ALI III | 31.2–*36.2*–47.1 | 27.8–*31.0*–34.3 |
| ALI IVr | 44.7–*47.4*–52.9 | 26.6–*27.5*–28.7 |
| ALI IVl | 30.5–*33.2*–35.9 | 26.5–*27.5*–28.7 |
| HcLI | 56.9–*62.6*–67.2 | — |
| TtLI | 36.3–*44.6*–76.9 | 27.8–*35.1*–41.2 |
| ClLI | 14.7–*17.9*–27.9 | 11.8–*15.0*–19.4 |
| GWI | 15.6–*17.7*–19.1 | — |
| VLI | 64.1–*67.8*–72.9 | — |
| RWI | 4.3– *5.0*– 5.9 | — |

The arms are of moderate length and in the order III.II ≥ IV.I in females and IVr.III.IVl.II.I in males. The arms of mature males generally are longer than those of mature females (Table 3). Dorsal and ventral protective membranes border the sucker rows on all of the arms. The suckers are small and biserially arranged. The sucker rings have about 5 long, blunt teeth on the distal margins; the proximal margins are smooth (Fig. 1E). The proximal suckers on arms I, II, and III are enlarged in males.

The right ventral arm is hectocotylized (Fig. 2B) in males for about ⅔ of its length distally (HcLI 56.9–*62.6*–67.2). About 7 to 9 pairs of normal suckers lie proximally, then the dorsal suckers become greatly reduced in size and are located on small, narrowly triangular pedicels. Only the first 2 or 3 of the modified suckers retain their chitinous rings. The dorsal suckers disappear completely around row 18 or 19, followed distally by pedicels that become markedly longer and thicker until row 21 or 22, then diminishing in size to the arm tip. The only modification to the ventral suckers consists of a slight increase in the length and thickness of their pedicels in the distalmost 10–15 rows. The hectocotylized arm is significantly longer than its unmodified fellow arm (OAI 29.8%–*43.0%*–52.8%).

Tentacular stalks are short and compressed, each with a dorsal keel that expands into a swimming membrane at the base of the club. A median groove extends along the oral surface to the base of the club where the margins diverge to form

Table 4.—Ranges and means of indices of ten spermatophores taken from each of four males (holotype ML = 28.6 mm).

| ML | SpLI | CBLI | SMLI |
|---|---|---|---|
| 20.8 mm | 7.7–*7.9*–8.0 | 27.4–*27.9*–28.4 | 37.0–*38.5*–40.7 |
| 24.0 mm | 6.8–*7.0*–7.3 | 28.9–*30.0*–30.6 | 35.7–*37.9*–40.0 |
| 26.2 mm | 6.9–*7.0*–7.2 | 27.2–*28.1*–28.3 | 37.4–*38.7*–39.6 |
| 28.6 mm | 6.5–*6.6*–6.7 | 28.4–*29.3*–30.1 | 40.4–*41.9*–44.1 |

the 2 protective membranes. A distinct manus and dactylus are present but there is no distinguishable caprus (Fig. 1B). About 22 to 27 transverse rows of suckers are arranged in 4 longitudinal rows. The suckers of the manus are enlarged, with those of the marginal rows about ½ the size of the median ones. The chitinous sucker rings have regularly spaced, pointed teeth that are longest on the distal margins of the median suckers (Fig. 1D) and on the outer lateral margins of the marginal suckers.

Spermatophores (Fig. 2A) were removed from 4 males of mantle lengths 20.8, 24.0, 26.2, and 28.6 mm. The spermatophores are small and thin; their lengths vary from 1.6 to 1.9 mm (SpLI 6.5–8.0). The cement body is long and slender and occupies slightly less than ⅓ of the spermatophore length (CBLI 27.2–30.6). The sperm mass occupies slightly over ⅓ of the spermatophore length (SMLI 35.7–44.1). Ranges and means of spermatophore indices are given in Table 4.

The free rachis of the gladius (Fig. 1C) is long with straight, convergent borders; it ends anteriorly in an acute point (RWI 4.3–*5.0*–5.9; VLI 64.1–*67.8*–72.9). The anterior vane extensions are short, narrow and poorly demarcated from the rachis. The anterior vane shoulders are convex. The lateral vane borders are long and straight to slightly concave (GWI 15.6–*17.7*–19.1). A slightly thickened band arises along the margin of the anterior vane shoulder and extends to the posterior tip of the gladius, obliquely bisecting each vane.

The radula has 7 transverse rows of teeth; marginal plates present. The central and lateral teeth and plate of only one side of one row were drawn (Fig. 2F). The beaks are generally light in color, but some variation exists (Fig. 2C, D, E). No angle point or tooth occurs in the jaw angle of the lower beak.

*Distribution.*—*Lolliguncula argus* is known from the coastal waters of the eastern Pacific Ocean from La Plata Island, Ecuador to the Gulf of California, Mexico. *Lolliguncula argus* appears to be a tropical species and, therefore, it seems unlikely that the range limits will extend very far to the north or south of the current records. All known specimens were taken at or near the surface.

*Holotype.*—Male ML 28.6 mm, National Museum of Natural History, USNM 815750.

*Type-locality.*—La Plata Island, Ecuador, 01°16′S, 81°05′W, 10 Oct 1961, night light dip net.

*Etymology.*—The specific name honors the ship M/V *Argosy.*

*Discussion.*—Several characters can be used to separate *Lolliguncula argus* from the other species of *Lolliguncula* known to occur in the coastal waters of the Americas: *L. brevis* (Blainville, 1823), *L. panamensis* Berry, 1911, and *L. tydeus* Brakoniecki, 1980. Unlike the other species, *Lolliguncula argus* has no suckers on the lobes of the buccal membrane. Male specimens of *Lolliguncula argus* have enlarged proximal suckers on arm pairs I, II, and III, while the males of the other species have no enlarged suckers. The eastern Atlantic species, *Lolliguncula mercatoris* Adam, 1941, also lacks buccal suckers and males have enlarged proximal suckers on arms II and III. *Lolliguncula mercatoris,* however, has two rows of long, fleshy papillae on its hectocotylus. On the hectocotylus of *Lolliguncula argus,* like the other American lolligunculas, only the dorsal sucker row is modified into long, fleshy papillae while the ventral row is unmodified. *Lolliguncula argus* is the only known myopsid to have its primary hectocotylization on the right ventral arm instead of the left.

## Acknowledgments

We wish to acknowledge Alfred C. Glassell, Jr. who sponsored the expedition and made the *Argosy* available as a research vessal. We would like to thank N. A. Voss, G. L. Voss, and S. M. Candela for their comments and suggestions. We are also grateful to M. J. Sweeney for his invaluable technical assistance. This is a scientific contribution from the Rosenstiel School of Marine and Atmospheric Science, University of Miami.

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# DESCRIPTION OF A WOOD DWELLING SIPUNCULAN, *PHASCOLOSOMA TURNERAE*, NEW SPECIES

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*Abstract.*—*Phascolosoma turnerae,* a new species of the phylum Sipuncula, is described from 104 specimens collected at depths of 1,135–1,184 meters in the Straits of Florida, south of Key West and from 366–412 meters in the northern Gulf of Mexico, south of Mobile, Alabama. The specimens were found in association with submerged wood, occupying burrows in the wood. In the sample from the Straits of Florida, pogonophoran tubes had penetrated the wood and were frequently entwined around the bodies of the sipunculans.

## *Phascolosoma turnerae,* new species
Fig. 1–4

*Material examined.*—85 specimens, 2 with extended tentacles (20 dissected, 1 prepared for scanning electron microscopy). *Gerda* Station 448, Rosenstiel School of Marine and Atmospheric Science, University of Miami; 1 Dec 1964; 620–647 fathoms; 23°54′N, 82°21′W.

19 specimens (5 dissected) M/V *Oregon* Station 3753, Bureau of Commercial Fisheries, United States Fish and Wildlife Service, Pascagoula, Mississippi; 28 Aug 1962; 200–225 fathoms; 29°13.5′N, 87°58.5′W.

Holotype: USNM 96687 (dissected), from *Gerda* Station 448. Fig. 1a, b, c, d.

Paratypes: USNM 96688 (Fig. 1f, dissected), 96689 (Fig. 1g), 96690 (Fig. 1e) from *Gerda* station 448.

*Diagnosis.*—Introvert nearly equal in length to trunk; approximately 50 rows of closely apposed hooks on anteriormost introvert followed posteriorly by rows of more widely spaced hooks; most posterior rows incomplete dorsally. Tentacular crown dorsal to mouth, larger in proportion to body size than usual for *Phascolosoma*; 14–22 digitiform tentacles. Exceptionally large mammillate papillae with prominent apical protuberances; papillae largest and most numerous at base of introvert and posterior trunk. Surface of papillae covered with small, granular platelets, also scattered on non-papillary body surface. Longitudinal body wall musculature separated into anastomosing bundles. Four retractor muscles, dorsals arising in middle third of trunk, ventrals in posterior third; retractor muscles separate for most of length. Spindle muscle attached posteriorly at extremity of trunk and anteriorly immediately above anus. One fixing muscle, attaching lower esophagus to body wall in mid-trunk to left of ventral nerve cord. Intestinal coil with approximately 15 single coils. Contractile vessel simple. Nephridia attached nearly entire length to body wall; nephridiopores at approximate level of anus. Hooks sharply bent distally with clear streak close to convex surface; relatively narrow at base with basal rootlets on concave side.

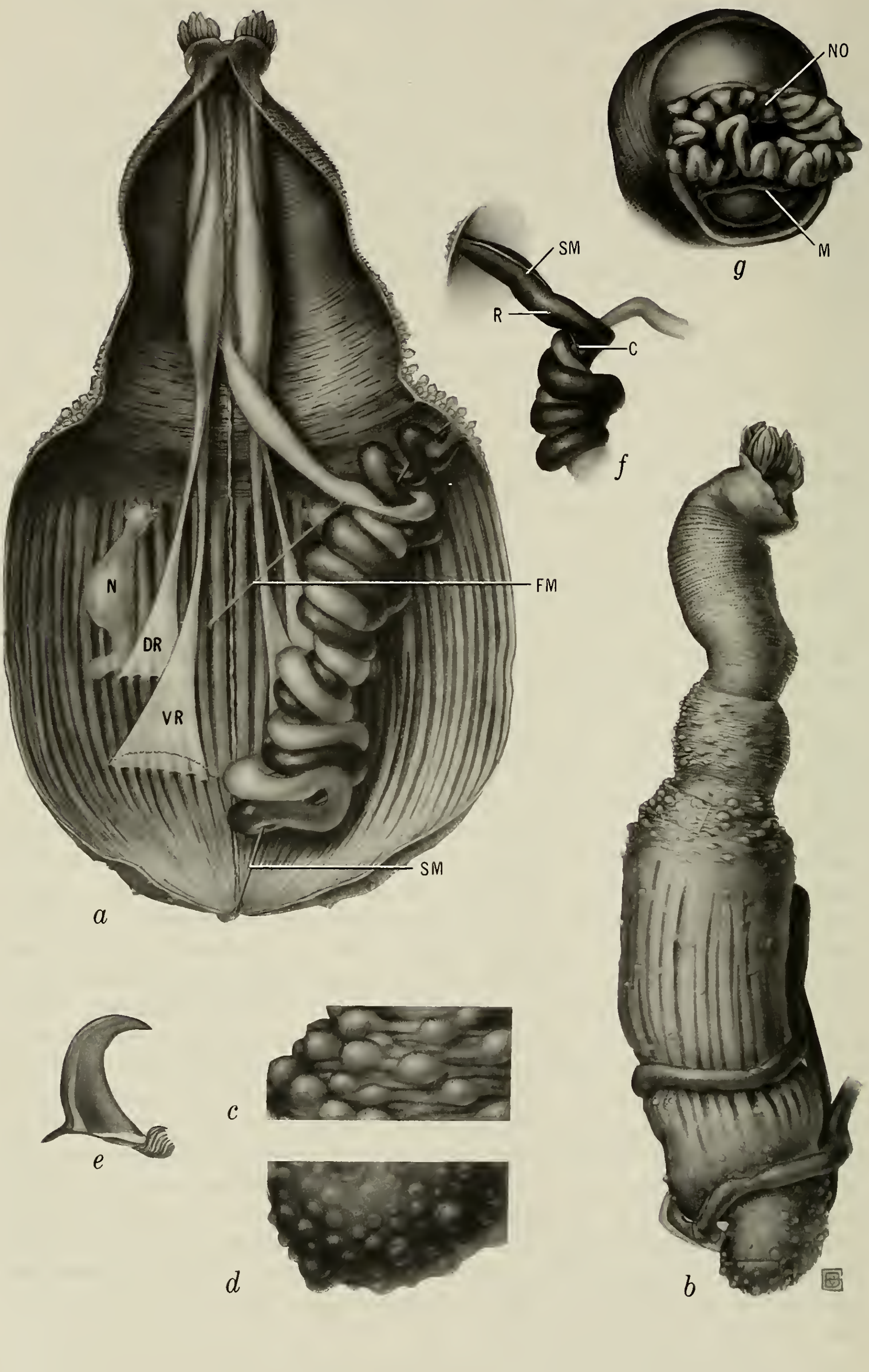
*Description.*—Trunk measurements average 6.7 mm (n = 80) in length for specimens from the *Gerda* collections and 12.8 mm (n = 14) for those from the M/V *Oregon.* The ranges for the two groups are, respectively, 3.5–11.4 mm and 7.4–17.3 mm. In two specimens, both from the *Gerda* collections, the introvert and tentacles are fully extended; in others the introvert is in varying states of contraction. One of the extended specimens has a total length of 12 mm (Holotype USNM 96687) and the other (Paratype USNM 96689) a total length of 17 mm. In the former the ratio of introvert to trunk is 1:1.4 and in the latter 1:1.1. In both specimens the relatively stout introvert is about one-half the maximum width of the trunk. The introvert is approximately one-third as wide as long; proportions are the same for the trunk. The short, thick, digitiform tentacles number 14 in the holotype and 22 in the paratype. They are arranged dorsal to the mouth in a circle that is interrupted at the mid-dorsal line by a heart-shaped nuchal organ. The color of the body of these preserved specimens is generally a pale grayish yellow, the posterior and anterior trunk being somewhat darker than the middle. The anterior introvert has a brownish appearance because of its dark-colored hooks.

On the extended introvert of the holotype there are 70 rows of hooks. The first 25 rows are completely formed whereas those following may be incomplete dorsally (especially noticeable in rows 25 to 45). Following the first 52 rows in which the hooks are closely apposed, the individual hooks are more widely set apart. Scattered hooks are present after row 70, but no longer is there an obvious arrangement in rows. Hooks in the first 5 to 6 rows are light tannish yellow, whereas the remainder are dark brown. The most anterior 5 rows are smaller than those that follow, except for the farthest posterior ones which become increasingly smaller toward the posterior introvert.

The form of the hook is simple (Figs. 1e, 2). The end is sharply curved, and, within the hook near the convex curvature a clear streak runs from base to apex gradually decreasing in width toward the apex. The hooks are best developed in rows 6 to 50. Measurements of hooks from rows 5 to 19 in paratype USNM 96690 show an average basal width of 0.044 mm and an average height of 0.051 mm. The basal processes number about 10 on each hook. Introvert papillae appear at regular intervals between the rows of hooks (Fig. 2).

The body wall is rather thin, particularly in the mid-trunk region where the longitudinal muscle bands are visible through the integument. The most distinctive features of this species are the size and shape of the papillae at the anterior and posterior trunk (Figs. 1b, c, d; 3). In these regions the papillae are numerous, concentrated, and mammillate in shape, each with a central protuberance bearing a pore. Most commonly the width and height are approximately equal although either one may exceed the other slightly. The largest papillae measure 0.16 × 0.16 mm in width and height in specimens from the *Gerda* collections which range in trunk length from 7 to 10 mm. Papillae of the somewhat larger specimens from the M/V *Oregon* collections, which range in trunk length from 17 to 18 mm, show a maximum width and height of 0.24 × 0.30 mm. In contracted specimens the base of the papillae may be constricted to form a narrow stalk. Papillae in the midtrunk region are few, scattered and much flattened. The largest among them are the same diameter as the largest of the anterior and posterior papillae, but they have little or no elevation. Embedded in the integument of the papillae are small, well-separated platelets, ranging from colorless to light brown. Similar platelets are found scattered throughout the skin, although they are more concentrated on the papillae. The central protuberance of the papilla frequently appears brown.

The bundles of the longitudinal musculature undergo considerable splitting and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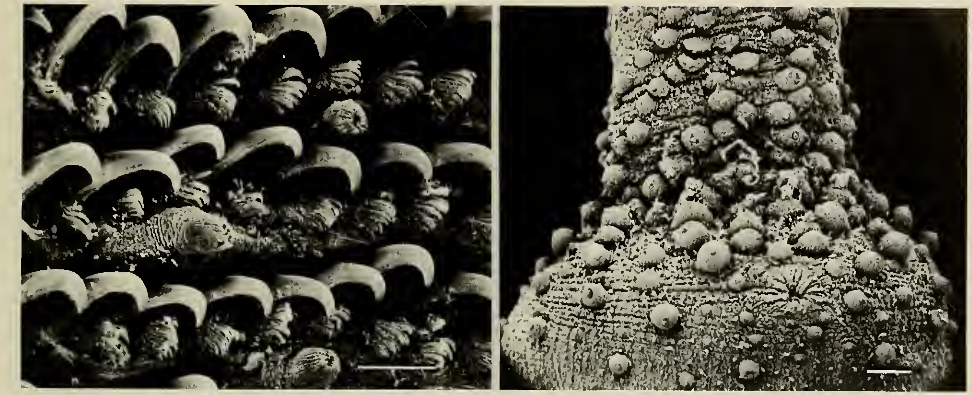

Figs. 2–3, *Phascolosoma turnerae:* 2, (left) Rows of hooks from the anterior introvert (scanning electron micrograph, scale = 20 μm); 3, (right) Papillae of anterior trunk and posterior introvert (scanning electron micrograph, scale = 200 μm).

anastomosis; therefore any counts of the bundles show great variability (Fig. 1a). Two counts were made on 10 dissected specimens: one anteriorly near the level of the nephridiopores and a second more posteriorly near the level of the attachment of the ventral retractors. Anteriorly the average was 25, ranging from 20 to 32, whereas posteriorly it was 33, with a range from 28 to 38. In the holotype the anterior and posterior counts are 25 and 35 respectively and in the paratype USNM 96688, 20 and 38.

The nephridia are single-lobed and vary considerably in their state of distension. In specimens from the *Gerda* collections, lengths of nephridia are 24 to 37% of the length of the trunk; whereas in specimens from the *Oregon* collections, nephridial lengths are about 50% the length of the trunk. Nephridia are attached by mesenteries to the body wall for at least 75% of their length in most specimens, the percentage depending on the degree of nephridial distension. Nephridiopores open to the exterior at the same level as or slightly anterior to the anus.

There are 4 separate retractor muscles that unite far anteriorly near the brain. The 2 dorsals attach to the body wall in the mid-trunk region and the ventrals attach in the most posterior one-third of the trunk, usually at a distance of about one-third the trunk length from the posterior end. A gonad extends as a thin band of tissue along the base of the ventral retractor muscles and continues between them, running under the ventral nerve cord.

⟵

Fig. 1. *Phascolosoma turnerae:* a, Dissected specimen showing dorsal retractor muscles (DR), ventral retractor muscles (VR), gonad at base of ventral retractors, anastomosing longitudinal muscle bundles, intestinal coil, spindle muscle (SM), fixing muscle (FM), nephridia (N), and ventral nerve cord (Holotype USNM 96687); b, External view of entire specimen showing entwining pogonophoran (Holotype USNM 96687); c, Enlargement of papillae from anterior trunk near region of anus; d, Enlargement of papillae from the posterior end of the body; e, Hook from anterior introvert (Paratype USNM 96690); f, Anterior intestinal coil from different specimen to show anterior attachment of spindle muscle (SM), caecum (C), and rectum (R) (Paratype USNM 96688); g, Apical view of tentacular crown, nuchal organ (NO), and mouth (M) (Paratype USNM 96689).

In specimens from the *Gerda* collection the number of single coils in the intestine ranges from 13 to 19. In specimens from the M/V *Oregon* the number is 10. The holotype and dissected paratype USNM 96688 each has 15. One fixing muscle attaches the posterior esophagus near its entry to the intestinal coil to the body wall left of the ventral nerve cord in the mid-trunk region. In some specimens the fixing muscle splits, the second branch attaching to the last ascending coil of the intestine. A small caecum is located where the last ascending intestinal coil joins the rectun. A spindle muscle, running through the center of the intestinal coil, attaches to the body wall posteriorly at the tip of the animal and anteriorly just above the anus.

*Remarks.—Phascolosoma turnerae* clearly belongs to the group within the genus *Phascolosoma* recognized by Stephen and Edmonds (1972) as the subgenus *Phascolosoma.* This taxon is diagnosed to include species having two pairs of retractor muscles, simple contractile vessel, and spindle muscle fastened posteriorly. Of the 39 species listed by Stephen and Edmonds only three lack hooks and the remaining 36, along with *Phascolosoma turnerae,* possess hooks on the introvert which serve as diagnostic taxonomic characters. These species with hooks are very similar in general body form and structure and are most easily distinguished by form and structure of hooks and papillae.

The hook of *Phascolosoma turnerae* is simple and readily distinguished from that of other species of *Phascolosoma.* The clear streak follows the curvature of the hook along the convex side. It remains near the convex side of the base of the hook, and does not bisect the base as in some other species. Complexities such as expansions of the clear streak, clear basal triangular areas and accessory teeth, characteristic of hooks of many species of sipunculans, are lacking in *P. turnerae.*

Other characteristic features of *Phascolosoma turnerae,* in combination with the form of the hook, serve to distinguish this species from other hooked species in the subgenus *Phascolosoma.* These features are the conspicuous mammillate papillae concentrated at the anterior and posterior trunk and the proportionately large tentacular crown.

Species of *Phascolosoma* are commonly found in shallow waters, but collections of *P. turnerae* were from 366 to 1184 meters in depth. Another *Phascolosoma* known from deep waters is *P. abyssorum,* found off the coast of southwest Ireland at 1096 meters (Southern 1913). This species is readily distinguished from *P. turnerae* by the manner in which its retractor muscles unite. In the former species, four retractor muscles, which are distinguishable in the esophageal region, are reduced to two near the level of the beginning of the intestine by the union of the dorsal and ventral muscles on each side. The single pair of muscles thus formed continues posteriorly to an attachment to the body wall in the mid-trunk. The four retractor muscles of *P. turnerae,* on the other hand, are completely separate for their entire lengths; the two dorsals attach to the body wall in the mid-trunk and the two ventrals in the posterior one-third of the trunk.

*Phascolosoma turnerae* has been found only in association with submerged wood. In the samples from the Straits of Florida (*Gerda* station) the sipunculans were present in great densities in the wood (Fig. 4). The sipunculans fit tightly within their burrows and each burrow resembles the outline of its occupant in size and shape. The anterior end of the sipunculan is directed toward the opening

Fig. 4. Photograph of wood sample containing sipunculans. From *Gerda* Cruise 448. Photograph courtesy of Ruth Turner.

of the burrow. These burrows are not lined with a calcareous layer as are those of teredinids. Whether the sipunculans make their own burrows, as they are known to do in calcareous substrata (Rice 1969, 1976) or whether they enter empty teredinid burrows and dissolve the calcareous lining is not known. As pointed out by Dr. Ruth Turner, who provided the specimens from the *Gerda* material, the burrows of the sipunculans are generally at right angles to the grain of the wood whereas those of the teredinids are not thus restricted. Sipunculans possess no known mechanisms for burrowing into wood. However, if the wood were softened by the activity of bacteria or fungi, it seems feasible that a sipunculan, entering a small hole or crevice as a juvenile, might enlarge the cavity as it grows by movements of the body against the surrounding wood to form a burrow.

Wolff (1979) reports finding three specimens of the wide-spread deep-sea species *Golfingia (Phascoloides) schuttei* in mud-filled cavities in wood or in a crevice of wood. He assumed that the specimens were using the wood for shelter, but he was unable to determine whether they were feeding on it. In the case of *P. turnerae,* the sipunculans are undoubtedly utilizing the wood for shelter. Because their introverts are directed toward the outside of the burrow, it is unlikely that they are using the wood as a major source of food. Examination of the gut contents of a few specimens showed that they were packed with a whitish gray fine particulate matter believed to be a fine sediment. A few fragments of calcareous material, foraminiferans, and a few wood fibers were found among the particulate matter and could have originated from within the sediment surrounding the submerged wood or from the surface of the wood itself.

The sipunculans from the M/V *Oregon* collection were in a bottle along with a piece of wood which was riddled with empty burrows. Because of the presence of the wood with the sample, it is assumed that the sipunculans were in some way associated with it, although no such notations were made in the station records.

An interesting association is found between the sipunculans in the wood and wood-inhabiting pogonophorans. In the sample from the *Gerda* cruise, pogonophoran tubes penetrated throughout the wood and were entwined around the bodies of many of the sipunculans (Fig. 1b). The pogonophorans have been identified by Dr. Eve Southward as belonging to the genus *Sclerolinum.* The material available was insufficient for specific identification.

*Etymology.*—The species is named for Dr. Ruth Turner, Museum of Comparative Zoology, Harvard University, who first recognized these wood-dwelling sipunculans and provided the material from the *Gerda* cruise.

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# A SYNOPSIS OF THE *LACCORNIS DIFFORMIS* SPECIES GROUP WITH A REVISED KEY TO NORTH AMERICAN SPECIES OF *LACCORNIS* DES GOZIS (COLEOPTERA: DYTISCIDAE)

G. W. Wolfe and P. J. Spangler

*Abstract*—Two new species of *Laccornis, L. etnieri* and *L. schusteri,* closely related to *L. difformis* (LeConte) are described. *Laccornis difformis* is redescribed. The most conclusive diagnostic structure is the unique male anterior protarsal claw. A revised key to the Nearctic species of *Laccornis* is included.

A worldwide revision of *Laccornis* Des Gozis (1914) has been initiated by one of us (GWW). In order to provide names to be used in that revision and several other studies nearing completion, two new species of the *difformis* group are described here, and *L. difformis* is redescribed.

Species of the *L. difformis* group are distinguishable from other members of *Laccornis* by the following unique set of characters: 1) male metafemora each with a dense fringe of long setae at posterior edge; 2) male antennal segments 3 to 5 laterally expanded (Figs. 1, 3, 4); (3) aedeagus laterally expanded to form a broad, flat, irregular oval shape (Figs. 8–16).

The best way to distinguish specimens of the three species discussed herein is by comparison of the structure of the male anterior protarsal claw. Females of this group may be separated reliably only by association with males.

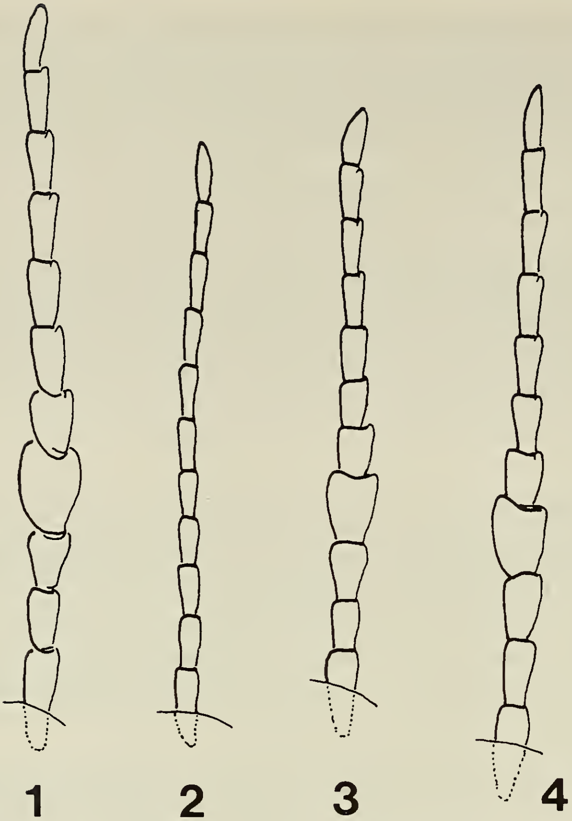
## *Laccornis difformis* (LeConte)
Figs. 1, 2, 5, 8–10, 17

*Hydroporus difformis* LeConte, 1855:298.
*Agaporus difformis.*—Fall, 1923:124.
*Laccornis difformis.*—Leech, 1940:126.

*Diagnosis.*—Characterized by distinctly modified (broadened) fourth antennal segment (Fig. 1); anterior protarsal claw expanded and acute apex centrally positioned when viewed laterally (Fig. 5); acute apex of aedeagus deflected at right angle to plane of aedeagus, in lateral view (Fig. 8).

*Redescription.*—The holotype male is in poor condition; therefore, the following description is supplemented with other comparative material deposited with the type. Holotype: Length, 6.2 mm; width, 3.0 mm. (The form is somewhat obscured in the teneral type because the specimen is pinned through the elytron.) Head, pronotum, and elytra in continuous outline; maximum width approximately ⅓ from base of elytra. Although not obvious in type, dorsal outline rather tapered in posterior ⅔. Lateral margins of pronotum evenly rounded toward anterior angles; with distinct, uniformly narrow lateral bead; bead about ¼ as wide as second antennal segment.

(The coloration is obscure in the pale, teneral type.) Head and antennae light



Figs. 1–4. Antenna: 1 & 2, *Laccornis difformis* (LeConte): 1, Male; 2, Female; 3, *Laccornis etnieri,* n. sp., male; 4. *Laccornis schusteri,* n. sp., male.

reddish brown. Pronotum darker reddish brown laterally, vaguely lighter discally. Elytra lighter reddish brown in basal fifth; posterior ⅘ dark reddish brown, approaching darker areas of pronotum in color. Ventrally, head, procoxae, mesocoxae, femora, and epipleura reddish yellow. Metafemora darker reddish yellow. Metepisterna, metacoxae, and abdominal sterna darker reddish brown. First abdominal sterna somewhat lighter than sterna 4–6.

Prosternal process abruptly declivous anteriorly; declivity granulose and slightly rugose; prosternal area in front of procoxae granulose. Prosternal process with medial longitudinal ridge behind declivity and ending just before tip; narrower between anterior coxae then expanding gradually to twice intercoxal width; lateral edges margined; tip bountly rounded. Metasternum shallowly depressed to receive prosternal process; metasternum very shallowly sulcate behind depression.

Body surfaces not distinctly shining. Dorsal surface of head, pronotum, and elytra with minute but perceptible microreticulation. Punctation of head rather dense, of two sizes; larger punctures moderately fine; smaller punctures extremely minute. Pronotal punctation also of two sizes; sparser and finer distally. Elytral punctation coarser; very slightly denser basally, laterally, and apically; punctures of two sizes; extremely minute punctures (visible at 60×) interspersed among larger punctures. Ventral surface and appendages microreticulate. Metepisternum

Figs. 5–7. Male protarsal claws: 5, *Laccornis difformis* (LeConte); 6, *Laccornis etnieri*, n. sp.; 7, *Laccornis schusteri*, n. sp., 270×.

reticulate medially then progressively rugose laterally. Metacoxa with oblique strigae intermixed with very fine, sparse punctures. Abdomen with oblique strigae on sterna 1 and 2; strigae become more laterally oriented on discal area of sterna 3 to 5.

Posterior femur with dense fringe of long, golden, hairlike setae along posterior edge. Male with antennal segments 3, 4, and 5 wider; segment 4 distinctly so (about 43% wider than 2nd segment). Protarsi somewhat expanded. (On LeConte's type, only one completely intact protarsus is present. Although the tip of the anterior claw is broken off, the distinctive shape is recognizable, and the type could be associated with other available specimens of the species.) Anterior claw expanded; apex acute (Fig. 5).

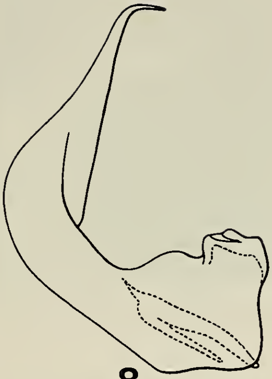
Aedeagus distinctly bent at tip when viewed laterally. In dorsal view, aedeagus rather acute apically (posteriorly) then broadly expanding anteriorly (Fig. 9). (The type was too fragile to allow dissection of the aedeagus. Association by the anterior protarsal claw, however, is conclusive and another specimen was dissected for the illustration of the aedeagus.)

*Females.*—Similar to males except antenna and protarsal claw not modified; medial line of prosternal process not as carinate; and metafemora non-setose.

*Variation.*—(Measured specimens from Peekskill, New York.) Males (n = 10): L = 5.9 mm (range 6.0 mm–5.7 mm); W = 2.9 mm (range 3.0 mm–2.7 mm). Females (n = 10): L = 6.0 mm (range 6.4 mm–5.6 mm); W = 2.8 mm (range 2.9 mm–2.7 mm). Dorsal coloration varies from specimens with rather uniformly reddish brown head, pronotum, and elytra to specimens that are rather distinctly bicolored. In the latter, the head and the basal areas of the elytra are lighter yellowish brown and the remainder of the elytra is dark reddish brown. In the most distinctly marked specimens, the lighter basal area of the elytra appears as a distinct basal band, even when viewed macroscopically. Teneral specimens are light brown and the light yellowish basal area may extend along the suture to the apex of the elytra.

*Type data.*—LeConte specifically mentions that only one specimen, from Georgia, was available for his description. That specimen is, therefore, the holotype; it is deposited in the MCZ.

*Material examined.*— HOLOTYPE: GEORGIA (no additional data) (MCZ).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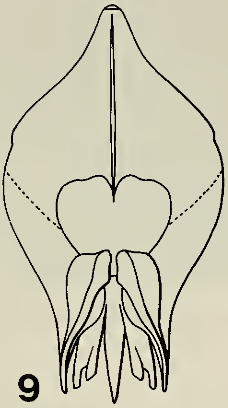
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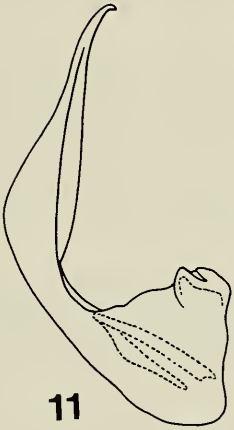
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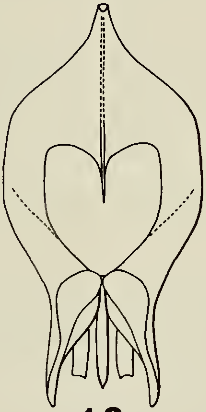
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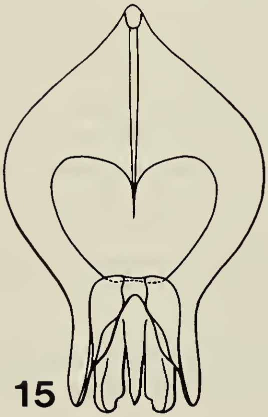
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Other material examined: MARYLAND: Anne Arundel County: Bowie, Patuxent Refuge, 26 Feb 1945, Stickel, 1 male, 1 female (NMNH).—Talbot County: Easton, 13 Oct 1973, P. & P. Spangler, 1 female (NMNH).—Wittman, 26 & 27 May 1973, W. E. Steiner, Jr., 1 male, 3 females (NMNH).—Wittman, 12 Jul 1978, P. J. Spangler, 3 males, 6 females (NMNH). MASSACHUSETTS: Middlesex County: Melrose, 15 Mar, D. H. Clemons, 2 females (NMNH).—Stoneham, L. S. Stevens, 1 male, 2 females (CAS).—Stoneham, May 1914, F. A. Sheriff, 1 male, 1 female (CAS).—Bristol County: Falls River, H. C. Fall, 1 male (CAS).—Falls River, 22 Apr 1922, N. S. Easton, 1 male, 1 female (CAS). NEW JERSEY: Burlington County: Chatsworth, 25 May 1929, J. W. Green, 1 female (CAS).—Essex County: 30 Apr 1900, Roberts Coll., 1 male, 1 female (AMNH).—Millburn, Apr 1924, Sherman Coll., 1 female (NMNH).—Millburn, 30 Apr 1924, J. D. Sherman, 1 male (AMNH).—Ocean County: Lakehurst, 1 Sep, J. D. Sherman, 1 male (NMNH). NEW YORK: Suffolk County: Greenport, Long Island, 19 Jul 1942, Roy Latham, 1 male (CU).—Greenport, Long Island, 19 Jul 1942, Roy Latham, 1 male (NYSM).—Greenport, Long Island, 21 Aug 1940, Roy Latham, 1 male, 1 female (NYSM).—Riverhead, Long Island, 19 Jul 1942, Roy Latham, 1 male (NYSM).—Richmond County: Staten Island, J. D. Sherman Coll., 2 females (NMNH).—Staten Island, 5 May, J. D. Sherman Coll., 1 male (NMNH).—Westchester County: Peekskill, 7 Jul 1888, 1 female; 3 Jun 1890, 3 females; 1 Jun 1891, 5 females; 30 May 1900, 12 males, 15 females; 30 May 1901, 2 males, 2 females; 1926, 20 males, 18 females; all collected by J. D. Sherman and all in (NMNH).—J. D. Sherman, 2 females, Hippong Coll. (CAS).—Roberts Coll., 1 male, 1 female (MCZ); 30 May 1901, 11 males, 10 females, all in Roberts Coll. (AMNH).—Hubbard and Schwarz, 1 male, 2 females (NMNH).—1933, Wickham Coll., 1 female (NMNH).—30 May 1901, Van Dyke Coll., 7 males, 6 females (CAS).—May 1930, H. C. Fall Coll., 2 males (MCZ).—White Plains, 13 Apr 1924, E. H. P. Squire, 1 male (CU). NORTH CAROLINA: Nash County: Rocky Mt., 2 Jun 1971, Coll. Matta. SOUTH CAROLINA: Georgetown County: Murrell's Inlet, 21 Apr 1974, W. E. Steiner, Jr., 1 male, 1 female (NMNH).

This taxon apparently is restricted to the Atlantic Coast in eastern North America (Fig. 17). The northern and southern limits are uncertain. Fall (1923) mentions specimens from Marquette, Michigan, but all specimens available from that locality have proved to be *L. latens,* which was described at a later date by Fall (1937). Malcolm (1971) mentions specimens, now apparently lost, from Maine. Two female specimens from Rhode Island and in the University of Michigan collection are probably *L. difformis.* The southernmost record *L. difformis* is LeConte's holotype, with no specific locality data other than the state, Georgia. That specimen may be from either the Atlantic or Gulf Coast. The farthest inland locality from which members of this species have been taken is in North Carolina (Rocky Mt., Nash County). The known ranges of *L. difformis* and *L. etnieri* closely approach each other in Maryland, in the vicinity of Washington, D.C.

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Figs. 8–16. Male genitalia: 8–10, *Laccornis difformis* (LeConte): 8, Median lobe, lv; 9, Median lobe, vv; 10, Paramere, lv. 11–13, *Laccornis etnieri,* n. sp.: 11, Median lobe, lv; 12, Median lobe, vv; 13, Paramere, lv. 14–16, *Laccornis schusteri,* n. sp.: 14, Median lobe, lv; 15, Median lobe, vv; 16, Paramere, lv. lv = lateral view, vv = ventral view.

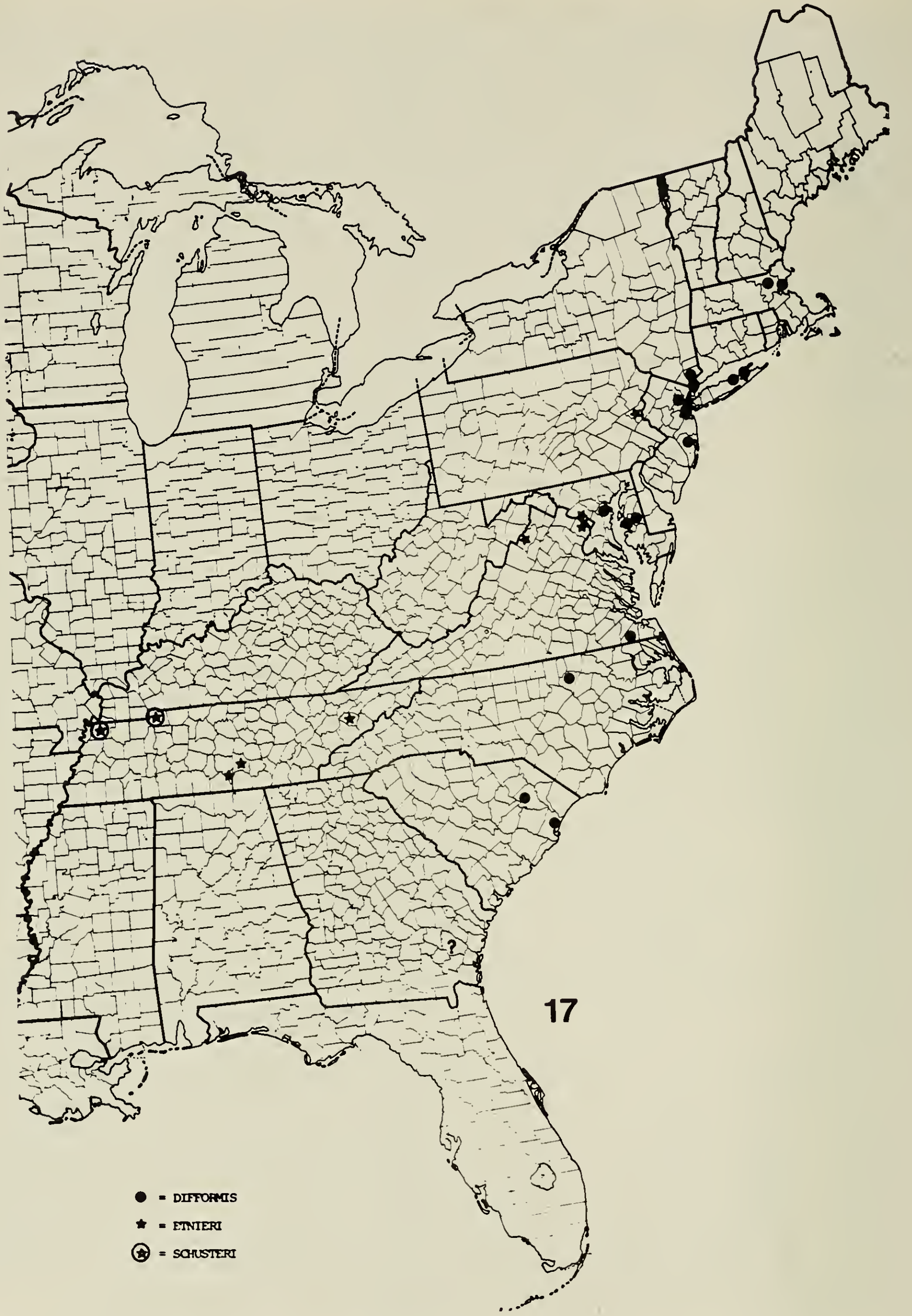

Fig. 17. Known distribution of *Laccornis difformis* (LeConte), *Laccornis etnieri,* n. sp., and *Laccornis schusteri,* n. sp.

*Habitat.*—This species inhabits woodland ponds, especially in flood plains along rivers, and swampy areas in lowland coastal situations.

### *Laccornis etnieri*, new species
Figs. 3, 6, 11–13, 17

*Diagnosis.*—Distinguished from all other members of *Laccornis* by the following combination of male characters: 1) fourth antennal segment distinctly wider than any other antennal segment (Fig. 3); 2) anterior protarsal claw expanded, with apex truncate except for acute, laterally displaced, short projection (Fig. 6); 3) aedeagal apex only slightly deflected in lateral view (Fig. 11).

*Holotype male.*—Length, 5.7 mm; width, 2.8 mm. The shape, prothorax, antennal modifications, and punctation are essentially as in *L. difformis.*

Head reddish brown; antennae somewhat lighter. Pronotum darker reddish brown, vaguely lighter laterally. Elytra basally the same reddish brown as head, then suffusing into darker brown discally; apically, elytra never as dark as pronotum. Ventrally reddish brown; metacoxal plates and abdominal sterna darker. Legs and epipleura reddish brown.

Metafemur with dense fringe of long, golden, natatory, hairlike setae along posterior margin. Protarsus slightly modified, broader than protarsus of female. Anterior protarsal claw (Fig. 6) expanded, truncate; anterolateral projection slender, with acute tip.

Genitalia (Figs. 11–13) similar to genitalia of *L. difformis* but bent tip of median lobe much shorter and less distinctly deflected.

*Allotype.*—Length, 6.0; width, 2.8 mm. The only female taken in association with a male is teneral. However, the following structural features are significant; antenna and anterior protarsal claw unmodified. Prosternal process is somewhat longitudinally carinate but not as distinctly carinate as in male specimens. Metafemur without dense fringe of natatory hairlike setae.

*Variation.*—Males (n = 10): L = 5.6 mm (range 6.0 mm–5.2 mm); W = 2.8 (range 3.0 mm–2.7 mm). Females (n = 5): L = 5.5 mm (range 5.8 mm–5.4 mm); W = 2.8 mm (range 2.8 mm–2.6 mm). Dorsal coloration varies from rather uniformly reddish brown to specimens with a suffused light basal elytral band. In some specimens the pronotum is somewhat darker than the head.

*Etymology.*—This species is named for Dr. David Etnier, who has enthusiastically provided assistance and guidance to many students of Ichthyology and Aquatic Entomology. He has generously made many collections of aquatic Coleoptera for us from Alaska and Minnesota to provide comparative material to supplement studies in Tennessee and the southeast.

*Type data.*—HOLOTYPE: TENNESSEE: Jefferson County: Temporary pond on Co. Rd. approximately 1 mile from Eslinger Rd., Apr 1976, G. W. Wolfe; NMNH Type No. 76129, deposited in the National Museum of Natural History, Smithsonian Institution. ALLOTYPE: TENNESSEE: Coffee County: Goose Pond at Arnold Center, near the headwaters of Brumalow Creek, 12 Jun 1976, G. W. Wolfe (NMNH). PARATYPES: TENNESSEE: Moore County: King Swamp along Turkey Cr. Rd., off Co. Rd. 6372 in northeastern Moore Co. by Franklin Co. line, 7 May 1977, 1 male, G. W. Wolfe, G. A. Schuster, B. S. Wunderlin.—Coffee

County: Goose Pond at Arnold Center, near the headwaters of Brumalow Creek, 12 Jun 1976, G. W. Wolfe, 1 male.—Overton County: Woodland swamp on Co. Rd. 4327, 1.2 mi. S. Jct. with Co. Rd. 4393, 23 Apr 1977, 1 female, G. W. Wolfe. VIRGINIA: Fairfax County: Great Falls, J. D. Sherman Coll., Sep 1928, 1 male, 1 female (NMNH).—Shenandoah County: 20 Jul 1973, 2 males, J. F. Matta (ODU). PENNSYLVANIA: Northampton County: Belfast, 29 Jun 1948, 1 male, J. W. Green (CAS). MARYLAND: Montgomery County: Woodland pond on mainland near Plummers Is., 23 Oct 1965, 2 males, 4 females; 21 Jan 1960, 1 male; 5 Jul 1960, 1 male; 1 Feb 1964, 3 females, all by P. J. Spangler (NMNH).—6 Nov 1921, 2 males, 1 female, Schwarz and Barber Coll. (NMNH).

There are relatively few collections of this species available. However, we predict that specimens of *L. etnieri* are common in non-coastal regions of eastern North America.

### *Laccornis schusteri,* new species
Figs. 4, 7, 14–16, 17

*Diagnosis.*—Males of *L. schusteri* are distinguishable among species of *Laccornis* by the following characters: 1) fourth antennal segment distinctly wider than other antennal segments (Fig. 4); 2) anterior protarsal claw expanded, apex truncate except for robust, laterally displaced, long, tapered projection (Fig. 7); 3) aedeagal apex deflected slightly more than 90 degrees in lateral view, actually appearing a little reflexed (Fig. 14).

*Holotype male.*—Length, 6.1 mm; width, 3.1 mm. Shape, prosternal process, antennal modifications, and punctation are essentially as in the previous two species. Head reddish brown; antennae somewhat lighter. Pronotum darker reddish brown. Basal fifth of elytra yellowish, then becoming reddish brown in posterior ⅘; posterior portions of elytra darker than the head but a little lighter than pronotum. Ventrally, head, procoxae and mesocoxae, legs and epipleura yellowish. Metacoxae and abdomen dark reddish brown; posterior abdominal segments more infuscate.

Posterior edge of metafemur with dense, long setae. Protarsus slightly expanded. Anterior protarsal claw (Fig. 7) narrowly expanded; anterolateral projection robust, long, and tapered.

Aedeagus very similar to that of males of *L. difformis* but somewhat more broadly expanded and tip slightly more reflexed (Figs. 14–16).

*Allotype.*—Length, 5.9 mm.; width, 2.9 mm. Prosternal process rounded, not longitudinally carinate. Antenna and protarsal claw unmodified; posterior femur without fringe of dense setae.

*Variation.*—Males (n = 10): L = 5.9 mm (range 6.1 mm–5.6 mm); W = 2.9 mm (range 3.0 mm–2.7 mm). Females (n = 6): L = 5.7 mm (range 5.9 mm–5.4 mm); W = 2.8 (range 3.0 mm–2.7 mm). Most specimens are rather well marked. The most distinctly marked specimens possess a yellowish basal band on the elytra, yellowish head, and uniformly dark pronotum and posterior ⅘ of elytra. In other specimens, the discal area of the pronotum and posterior portions of the elytra are lighter reddish brown. Some specimens are almost uniformly reddish brown in dorsal view. Ventrally the metasternum and metacoxae are usually reddish in color with the abdominal segments becoming progressively darker; the last two abdominal segments appear infuscate in the metacoxal and metasternal areas.

*Etymology.*—This species is named for Dr. Guenter A. Schuster. He has generously collected material for us in southeastern North America and his studies involving Trichoptera have contributed important knowledge to aquatic entomology.

*Type-data.*— HOLOTYPE AND ALLOTYPE: TENNESSEE: Stewart County: Cotrell Pond, 12 Jun 1977, G. W. Wolfe; NMNH Type No. 76130, deposited in the National Museum of Natural History, Smithsonian Institution. PARATYPES: Stewart County: Same locality data as holotype and allotype, 14 males, 9 females.

*Other material examined.*—TENNESSEE: Obion County: 3 miles east of Obion, 12 Jul 1977, G. W. Wolfe, 4 males, 2 females.

So far this taxon is known only from two localities in western Tennessee; however, the locality in Stewart County is just east of the Tennessee River, on the western edge of the western highland rim. It is possible that this species is most common in the coastal plain region of Tennessee and farther south on the gulf coast.

*Habitat.*—Found in woodland pools. The two known localities were heavily shaded and the substrate was composed of leaves and detritus; very little rooted vegetation was evident.

## Taxonomic and Distributional Summary

*Laccornis difformis, L. etnieri,* and *L. schusteri* are considered a monophyletic group because each species possesses a broadly expanded aedeagus (Figs. 9, 12, 15), in dorsal view. This aedeagal shape is unknown in any other hydroporine including other species of *Laccornis.* Based on anterior protarsal claw structure, the sister taxon to the *difformis* group is probably *L. latens* Fall. Fall (1937) previously noted similarity between *L. difformis* and *L. latens.*

*Laccornis difformis, L. etnieri,* and *L. schusteri* are structurally similar; indeed, specific status was doubted until distributional information was closely examined. *Laccornis difformis* occurs primarily in Atlantic coastal areas. The distribution of *L. etnieri* is centered in non-coastal areas to the west of *L. difformis.* Despite the fact that these two species have been collected at proximate localities in Maryland and eastern Virginia, no specimens were discovered with the male protarsal claws intermediate in shape, thus suggesting to us that the two taxa are reproductively isolated.

*Laccornis schusteri* is known only from two localities, but specimens of that species are as different from those of either *L. difformis* or *L. etnieri* as the latter two are from each other. *Laccornis schusteri* and *L. etnieri* are both known from Tennessee; however, collections in woodland pools throughout the state have never produced hybrid specimens.

Sympatry among members of the *L. difformis* species group is unknown.

Our interpretation herein indicates that the larva and pupa described by Spangler and Gordon (1973) as *L. difformis* represents the immature stages of *L. etnieri.*

## Key to Males of the Nearctic Species of *Laccornis*
## (Modified from Leech 1940)

1\. Male anterior protarsal claw distinctly acutely toothed at middle. Antennal segments 3–7 distinctly broadened. Metacoxal plate distinctly punctate, often subrugose; punctures slightly finer than those on elytron. Male with elytra more attenuate posteriorly; mesofemur and metafemur fringed with long setae on posterior margin ............ 2

– Male anterior protarsal claw broadened and/or contorted. At most, antennal segments 3–5 somewhat broadened. Metacoxal plate finely strigate or very finely and sparsely punctate, or both. Male with elytra more attenuated than in female, or not. Mesofemur never with posterior fringe of setae. Metafemur fringed posteriorly or not ......... 3

2(1). Elytra coarsely and rather evenly punctate; with very few small punctures intermixed. Aedeagal apex reflexed; reflexed portion long and ligulate; apex acute .................................. *pacificus* Leech

– Elytra moderately coarsely punctate; punctures intermixed, large ones sparse and irregular, small ones numerous and well defined. Aedeagal apex reflexed, but reflexed portion long and spatulate; apex rounded .............................................. *conoideus* (LeConte)

3(1). Elytra extremely finely punctate; strongly attenuate posteriorly in both sexes. Color yellowish brown. Size larger (>5.85 mm). Male anterior protarsal claw a little contorted and foliate. Metafemur of male without fringe of long setae on posterior margin ................ *deltoides* (Fall)

– Elytra more coarsely punctate; moderately attenuated posteriorly, more strongly so in male. Size smaller (<5.85 mm). Male protarsal claw distinctly contorted and foliate (Figs. 5–7). Metafemur with or without fringe of setae. Color light to dark reddish brown ................. 4

4(3). Pronotum piceous, darker than head or elytral base. Male metafemur without fringe of long setae along posterior margin. Aedeagal apex reflexed; broadly triangular at tip ........................ *latens* (Fall)

– Pronotum reddish brown at least discally, little or not darker than head or base of elytra. Metafemur of male with fringe of long setae on posterior margin ............................................ 5

5(4). Male anterior protarsal claw expanded; apex acute (Fig. 5) .........
.............................................. *difformis* (LeConte)

– Male anterior protarsal claw truncate; with either slender anterolateral process (Fig. 6) or long robust anterolateral process (Fig. 7) ........ 6

6(5). Male anterior protarsal claw with extremely elongate robust lateral process (Fig. 7). Tip of aedeagus distinctly bent; bent portion long in lateral view (Fig. 14) ........................... *schusteri,* new species

– Anterior protarsal claw broadly truncate; with short lateral process (Fig. 6). Tip of aedeagus feebly bent; bent portion short in lateral view (Fig. 11) .................................. *etnieri,* new species

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California Academy of Sciences (CAS); Cornell University (CU); American Museum of Natural History (AMNH); Old Dominion University (ODU); Museum of Comparative Zoology at Harvard (MCZ); New York State Museum (NYSM); and the University of Minnesota (UM). Our thanks are extended to the curators of those collections. We acknowledge and thank Dr. Guenter A. Schuster, Dr. J. F. Matta, and Ms. Belinda S. Wunderlin for their assistance with collecting some of the specimens included in this study. We also thank Mrs. Susann Braden, Smithsonian Institution scanning electron microscopist, for the micrographs and Michael Druckenbrod, former Smithsonian Institution biological illustrator, for preparing the line drawings of the aedeagi (Figs. 8–16).

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## Addendum

Since submission of this paper for publication, specimens of *Laccornis oblongus* Stephens were discovered from Canada with the following locality information: Tununuk, N.W.T., 10 Aug 1930, O. Bryant/Mackenzie River 1930 Trip, Lot 114 O. Bryant. This is the first discovery of a Palearctic species of *Laccornis* in the Nearctic region; as far as we know, *L. oblongus* is the only species of *Laccornis* with a circumboreal distribution.

Male specimens of *L. oblongus* can be included in the above key by making couplet 1 trichotomus by inserting the following addition at the beginning of couplet 1; the rest of couplet 1 remains unchanged.

1. Male anterior protarsal claw unmodified (i.e. neither toothed nor broadened and contorted); antennal segments 3–7 not broadened ........................................ *oblongus* Stephens

The aedeagus of *L. oblongus* is illustrated in Leech (1940).

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# TWO NEW SPECIES OF PROTURA (INSECTA) FROM NORTH AMERICA

Ernest C. Bernard

*Abstract.*—*Eosentomon adakense,* n. sp. (Eosentomidae) from the Aleutian Islands and *Neocondeellum americanum,* n. sp. (Protentomidae) from Tennessee are described and figured. *Eosentomon adakense* differs from other *Eosentomon* species by the possession of long middle and hind empodia, sensillum b′1, labral setae, and six setae on sternites IX and X. A key to *Eosentomon* species with long hind empodia is given. *Neocondeellum americanum* differs from all other *Neocondeellum* species by the possession of two minute sensilla on the foretarsus in addition to the normal five.

This paper contains the descriptions of two species of Protura, one from Adak Island in the Aleutian chain and the other from eastern Tennessee. The new species of *Neocondeellum* Tuxen and Yin described in this paper represents the first record of the genus from North America.

## Methods

Specimens were collected by a sugar flotation-centrifugation method (Jenkins 1964) and preserved in 95% ethanol, then mounted in polyvinyl alcohol-lactophenol and dried in a 60°C oven to expand and clear the bodies. Terminology used in this paper is largely that of Tuxen (1964). Holotypes and paratypes numbered in the text are deposited in the U.S. National Museum of Natural History.

### *Eosentomon adakense,* new species
Figs. 1, 3–15; Table 1

*Color and dimensions.*—Body fragile, sclerites yellowish only on the last several abdominal segments. Length of holotype female 836 μm, that of allotype male 759 μm. Length of foretarsus without claw 82 μm in female, 80 μm in male. Length of head without labrum 109 μm in female, 116 μm in male. LR = 12, PR = 9.6 (range = 9.1–10.3); TR = 5.7 (4.9–6.4).

*Morphology.*—Pseudoculus broadly oval with a weak longitudinal line and a pair of weak, oval depressions in the center (Fig. 11). Clypeal apodeme small but stout, the sides connected only anteriorly. Labrum (Fig. 5) short and inconspicuous, the anterior edge shallowly V-shaped; labral setae present, not extending past anterior edge of labrum. Rostral setae not inflated. Mandible (Fig. 9) with three teeth, two of them terminal and inner tooth subterminal. Galea of maxilla (Fig. 7) broad, with two exterior spines, more anterior one long, rounded median digit bent outward, and two inner digits bent slightly inward. Outer lobe of lacinia short, slightly curved, inner edge smooth; inner lobe slender, strongly curved (Fig. 8). Six outer setae of labium in three groups: one anterior, three in middle, two posteriorly (Fig. 6); anterior tip of labium with few irregular, minute teeth and three weak thickenings.

Table 1.—Chaetotaxy of *Eosentomon adakense* n. sp.

| | | | Formula | Composition |
|---|---|---|---|---|
| | (Dorsal) | | | |
| Thorax | | I | 4 | |
| | | II | 8 | a 1, 2, 3, 4 |
| | | | 14 | p 1, 1′, 2, 2′, 3, 3′, 4 |
| | | III | 10 | a 1, 2, 3, 4, 4′ |
| | | | 14 | p 1, 1′, 2, 2′, 3, 3′, 4 |
| Abdomen | | I | 4 | a 1, 2 |
| | | | 10 | p 1, 1′, 2, 3, 3′ |
| | | II–IV | 10 | a 1, 2, 3, 4, 5 |
| | | | 16 | p 1, 1′, 2, 2′, 3, 4, 4′, 5 |
| | | V–VI | 8 | a 1, 2, 4, 5 |
| | | | 16 | p 1, 1′, 2, 2′, 3, 4, 4′, 5 |
| | | VII | 6 | a 2, 4, 5 |
| | | | 16 | p 1, 1′, 2, 2′, 3, 4, 4′, 5 |
| | | VIII | 4 | a 1, 3 |
| | | | 9 | p c, 1, 1′, 2, 3 |
| | | IX–XI | 8 | p 1, 2, 3, 4 |
| | | XII | 9 | |
| | (Ventral) | | | |
| Thorax | | I–II | 8 | |
| | | | 6 | |
| | | III | 10 | |
| | | | 8 | |
| Abdomen | | I | 4 | a 2, 3 |
| | | | 4 | p 1, 2 |
| | | II–III | 6 | a 2, 3, 4 |
| | | | 4 | p 1, 2 |
| | | IV–VII | 6 | a 2, 3, 4 |
| | | | 10 | p 1, 2, 2′, 2″, 3 |
| | | VIII | 2 | a 2 |
| | | | 7 | p c, 1, 1′, 2 |
| | | IX–X | 6 | p 1, 1′, 2 |
| | | XI | 8 | p 1, 2, 3, 4 |
| | | XII | 10 | |

Empodium of foretarsus nearly as long as claw, EUI = 0.98 (0.9–1.1). Empodia of middle and hind legs well-developed (Figs. 12–13), EUII = 0.59 (0.54– 0.63), EUIII = 0.58 (0.58–9.59).

Central lobe of praecosta not indented. Squama genitalis of female (Fig. 15) weakly sclerotized, caput processus nearly straight distally but curving proximally into corpus processus. Median sclerotizations not seen. Filum processus longer than stylus; stylus tip broadly rounded. Male squama genitalis identical to that of other *Eosentomon* species.

*Chaetotaxy.*—Paired sensilla behind the pseudoculus minute, pyriform (Fig. 10).

Figs. 1–2. *Eosentomon adakense:* 1, Dorsal view of holotype female. *Neocondeellum americanum:* 2, Dorsal view of holotype female. Scales in μm.

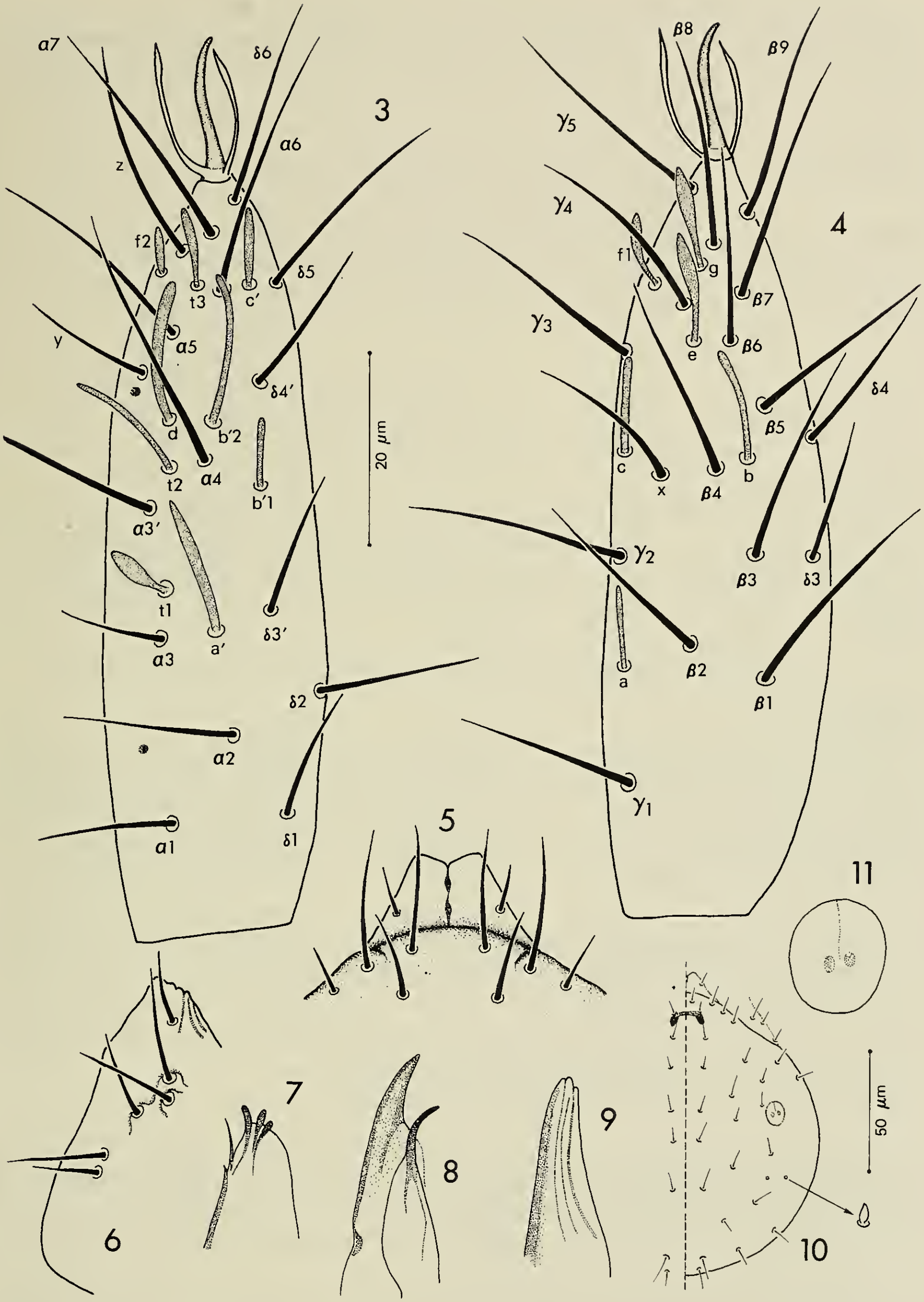
In foretarsus, sensillum *b′1* present; sensillum *a* short and slender, not reaching seta $\gamma 2$; *b* reaching the base of $\beta 6$, *c* reaching $\gamma 3$; *d* broad and long; *f1, e,* and *g* spatulate, *f2* short. Sensillum *a′* broad and long; *b′2* about as long as *d* and twice the length of *b′1*; *c′* present, reaching to the base of seta $\delta 6$. Sensillum *t1* closer to $\alpha 3$ than to $\alpha 3'$; BS = 0.86; *t2* slender, *t3* clavate (Figs. 3–4). Foretarsal pits located level with seta $\alpha 2$ and slightly posterior to seta *y*.

Thoracic and abdominal setal compositions as given in Table 1. Accessory setae p1′ and p2′ of tergites II–VI nearly twice the length of p1 and p2 (Fig. 14).

*Collection data.*—Holotype female (Type #101410) and allotype male extracted from soil collected by M. P. Williams at Kuluk Bay, Adak Island, Aleutian Islands, Alaska, 13 Aug 1978.

*Diagnosis.*—*Eosentomon adakense* can be separated from most other *Eosentomon* species by the presence of long hind empodia. From the fifteen previously described species with long hind empodia, *E. adakense* can be differentiated by the following characteristics: sensillum b′1 present, empodium of middle leg long, labral setae present, sternites IX and X with six setae.

The following key will serve to differentiate those species of *Eosentomon* which have long hind empodia. The key is based primarily on original and revised descriptions from several sources.



Figs. 3–11. *Eosentomon adakense:* 3, Foretarsus, dorsal view; 4, Foretarsus, ventral view; 5, Labrum, dorsal view; 6, Right prelabium, ventral view (palpus not drawn); 7, Left galea of maxilla; 8, Left lacinia of maxilla; 9, Left mandible; 10, Pseudoculus; 11, Right side of head, dorsal view, and enlargement of cephalic sensillum. (50 μm scale applies to Fig. 10, 20 μm scale to all others.)

Table 2.—Chaetotaxy of *Neocondeellum americanum* n. sp.

| | | Formula | Composition |
|---|---|---|---|
| | (Dorsal) | | |
| Thorax | I | 4 | |
| | II–III | 6 | a 1, 2, 3 |
| | | 14 | p 1, 1′, 2, 2′, 3, 4, 4′ |
| Abdomen | I | 4 | a 1, 2 |
| | | 14 | p 1, 1′, 2, 2′, 3, 4, 4′ |
| | II–VI | 4 | a 1, 2 |
| | | 14[1] | p 1, 2, 2′, 3, 4, 4′, 5 |
| | VII | 4 | a 1, 5 |
| | | 18 | p 1, 1′, 2, 2′, 3, 3′, 4, 4′, 5 |
| | VIII | 6 | a 1, 3, 5 |
| | | 12 | p 1, 1′, 2, 3, 4, 5 |
| | IX | 12 | p 1, 1′, 2, 2′, 3, 4 |
| | X | 10 | p 1, 2, 3, 4, 5 |
| | XI | 8 | p 1, 2, 3, 4 |
| | XII | 9 | |
| | (Ventral) | | |
| Thorax | I | 10 | |
| | II | 12 | |
| | III | 14 | |
| Abdomen | I | 4 | a 1, 2 |
| | | 4 | p 1, 1′ |
| | II–III | 4[2] | a 1, 2 |
| | | 5 | p c, 1, 2 |
| | IV–V | 4 | a 1, 2 |
| | | 8 | p 1, 1′, 2, 3 |
| | VI–VII | 4 | a 1, 2 |
| | | 9 | p c, 1, 1′, 2, 3 |
| | VIII | 6 | p 1, 1′, 2 |
| | IX–X | 4 | p 1, 2 |
| | XI | 6 | |
| | XII | 6 | |

[1] Seta p2 missing on terg. 5, right side, of holotype.

[2] Holotype with an a c seta on stern. III.

1. Sensillum b′1 present .................................................. 6
– Sensillum b′1 absent .................................................. 2
2. Sensillum t1 closer to seta $\alpha3$ than to $\alpha3'$ .......................... 3
– Sensillum t1 very close to seta $\alpha3'$ .............................. 5
3. Sternite VIII with two anterior setae .............................. 4
– Sternite VIII without anterior setae .................... *cocqueti* Conde
4. Sternites IX–X with six setae .................... *brevicorpusculum* Yin
– Sternites IX–X with four setae ......................... *sociale* Bernard
5. Abdominal tergites V and VI with ten anterior setae; sensillum c′ well-developed ................................ *notiale* Tuxen & Imadate
– Abdominal tergites V and VI with eight anterior setae; sensillum c′ very short, mammiform ................................ *erwini* Copeland

6. Sternite VIII with 7 p-setae .................................... 7
– Sternite VIII with 9 p-setae ...................... *novemchaetum* Yin
7. Sensillum e present ................................................ 9
– Sensillum e absent ................................................ 8
8. Filum processus more than two-thirds length of stylus ...... *meihwa* Yin
– Filum processus less than half length of stylus ............ *babai* Imadate
9. Empodium on middle leg more than half length of claw ............ 10
– Empodium on middle leg less than half length of claw ............. 11
10. Labral setae present; sternites IX and X with six setae .... *adakense,* n. sp.
– Labral setae absent; sternites IX and X with four setae .. *saharense* Conde
11. Labral setae present ............................................ 12
– Labral setae absent .............................................. 15
12. Sternite VIII with two anterior setae ........................... 13
– Sternite VIII without anterior setae .................. *pallidum* Ewing
13. Tergite VII with six anterior setae; tergite XI with six setae .........
............................................................ *brassicae* Bernard
– Tergite VII with eight anterior setae; tergite XI with eight setae ..... 14
14. Corpus processus strongly sclerotized, slender ............ *pruni* Bernard
– Corpus processus weakly sclerotized, broad .... *pinusbanksianae* Bernard
15. Sensillum f1 twice as long as f2; sternites IX–X with six setae .......
........................................................... *udagawai* Imadate
– Sensilla f1 and f2 of equal length; sternites IX–X with four setae ....
................................................................ *simile* Conde

Imadate (1974) examined several Chinese *Eosentomon* species described by Yin (1965) and determined that some possessed long hind empodia. These are included in the key above, with the exception of *E. orientalis* Yin. Imadate could find no differences between *E. orientalis* and *E. udagawai* Imadate, 1961, and was inclined to consider them synonyms. Thus *E. orientalis* is not included in the key.

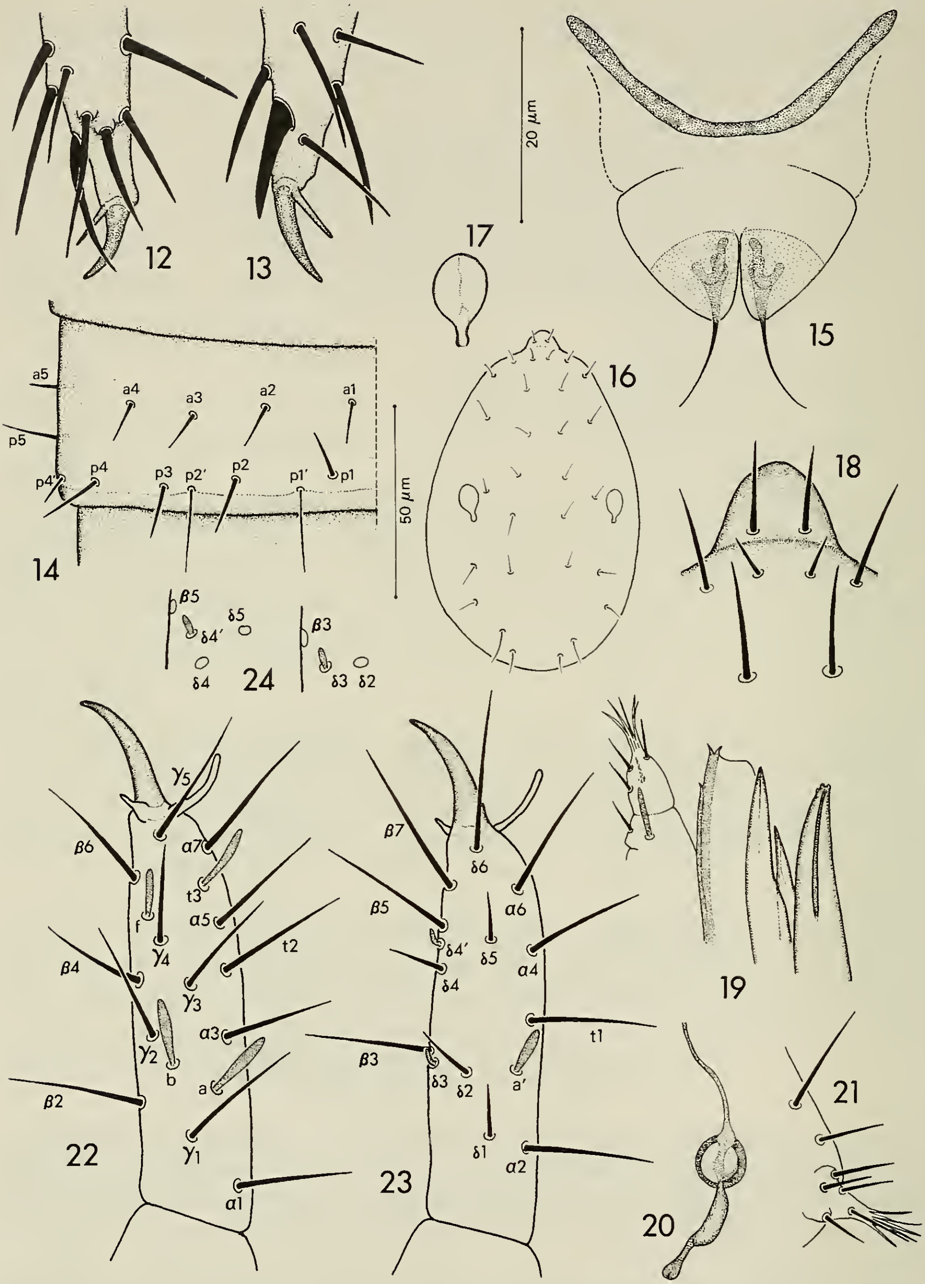
Bernard (1975) described *E. pinusbanksianum* from Michigan. Dr. George C. Steyskal (in litt., 29 Oct 1976) pointed out that the specific name was incorrectly formed and needed alteration. It is therefore emended to *E. pinusbanksianae.*

### *Neocondeellum americanum,* new species

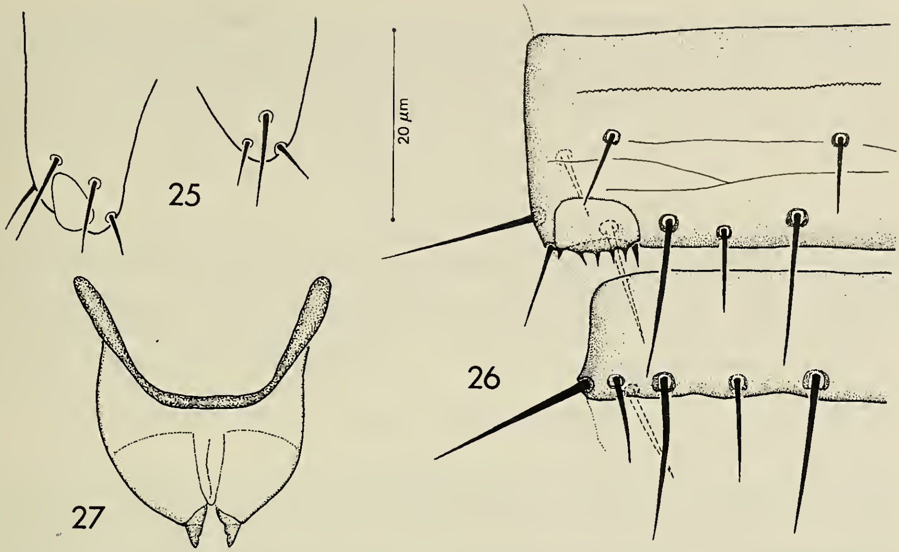
Figs. 2, 16–27; Table 2

*Color and dimensions.*—Body slender, sclerotization prominent only on the last five abdominal segments. Length of holotype female 787 μm, that of two paratype females 784 μm (range = 771–798 μm). Length of foretarsus without claw 42 μm for all females; length of head without labrum 83 μm for females. LR = 19; PR = 10.0, TR = 3.0.

*Morphology.*—Pseudoculus oval with posterior prolongation about one-third its length, median line very weak (Fig. 17). Labrum very short, rounded (Figs. 16–17), with one pair of setae. Mandible with 3 minute, rounded teeth, 2 terminal and 1 subterminal, and prominent median groove (Fig. 19); lobes of lacinia straight and stout anteriorly, bluntly pointed; galea broad, thickened only along outer edge, with two diverging, pointed lobes terminally and third, minute, pointed lobe on exterior edge. Maxillary palpus with only 1 sensillum-like seta. Labial



Figs. 12–24. *Eosentomon adakense:* 12, Middle tarsus; 13, Hind tarsus; 14, Tergite VI, left side, 15, Female squama genitalis. *Neocondeellum americanum:* 16, Head, dorsal view; 17, Pseudoculus; 18, Labrum; 19, Mouthparts of left side (left to right: maxillary palpus, galea, lacinia, mandible); 20, Canal of maxillary gland, proximal portion; 21, Labial palpus; 22, Foretarsus, exterior view; 23, Foretarsus, interior view; 24, Arrangements of minute foretarsal sensilla on a paratype. (50 μm scale applies to Fig. 16, 20 μm scale to all others.)



Figs. 25–27. *Neocondeellum americanum:* 25, Appendages of first and third abdominal segments; 26, Tergites VIII–IX, left side; 27, Female squama genitalis.

palpus with terminal tuft of seta-like lobes and 5 other setae (Fig. 21). Canal of maxillary gland similar to that of other members of genus, posterior portion swollen for more than half its length then narrowed to slightly enlarged terminus; calyx round (Fig. 20).

Empodium of foretarsus short, about one-sixth length of claw; middle and hind legs similar to those of other *Neocondeellum* species. Appendages of first abdominal segment with 4 setae, those of second and third segments with 3 setae each (Fig. 25). Upper edge of gland cover on tergite VIII with 5 teeth; lower edge smooth except for 1 tooth on interior corner (Fig. 26). Female squama genitalis with enlarged arms on basal apodeme; acrostylus conoid, with narrowly rounded tip and 1 or 2 indentations on interior surface (Fig. 27).

Males not seen.

*Chaetotaxy.*—Head with 4 setae between pseudoculi (Fig. 16).

Foretarsus characterized by presence of 2 minute sensilla ventrally, one apparently reduced, modified δ3, the other a doubled δ4 and thus labeled δ4′ (Figs. 23–24); these 2 sensilla appearing bent in profile on holotype (Fig. 23), but appearing peg-like when seen less obliquely on paratype (Fig. 24). Sensilla *a, b,* and *t3* of equal length and longer than *a′* and *f* (Figs. 23–24).

Thoracic and abdominal compositions as given in Table 2. Tergite VIII with 3 anterior and 6 posterior setae on each side; tergite IX with 6 setae on each side (Fig. 26).

*Collection data.*—Holotype female (Type #101411) and one paratype female extracted from soil collected under turf and yellowwood trees (*Cladrastis lutea* (Michx.) K. Koch) on the west side of the Plant Sciences Building, University of Tennessee, Knoxville, 24 Feb 1984; and one paratype female collected from the same locality 15 Feb 1978.

*Diagnosis.—Neocondeellum americanum* differs from the other four species of the genus (Tuxen and Yin 1982) by the sensillar nature of seta δ3 and the presence of an extra sensillum here designated δ4′. Additionally, the maxillary sensilla of *N. americanum* consist of one typical sensillum and a setiform sensillum, a dichotomy shared only with *N. matobai* (Imadate, 1973; see Tuxen and Yin 1982).

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# A NEW MEMBER OF THE GENUS *DISTOCAMBARUS* (DECAPODA: CAMBARIDAE) FROM THE SALUDA BASIN, SOUTH CAROLINA

Horton H. Hobbs, Jr. and Paul H. Carlson

*Abstract.*—The burrowing crayfish *Distocambarus* (*Fitzcambarus*) *youngineri* is described from two localities in the southwestern part of Newberry County, South Carolina. In most respects it resembles the sympatric *D.* (*F.*) *carlsoni,* but the first pleopod of the male differs little from that of its more primitive congeners assigned to the nominate subgenus.

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Within the Saluda River basin of South Carolina, a number of isolated colonies of crayfishes belonging to the genus *Distocambarus* have been found, and inasmuch as the ranges of the three species represented in them are sympatric, we are puzzled that we have not found them to be at least occasionally syntopic. The species described here appears to have established fewer populations than have *Distocambarus* (*D.*) *crockeri* Hobbs and Carlson (1983:421) and *D.* (*Fitzcambarus*) *carlsoni* Hobbs (1983:430), both of which also frequent the Savannah watershed. Despite our being unable to locate additional localities for it other than the two that have been discovered in the southwestern part of Newberry County, we believe that other colonies must exist elsewhere in the Saluda Basin.

Because of the combination of characteristics exhibited by this crayfish, to assign it to either of the subgenera that have been recognized requires an emendation of the existing diagnoses (Hobbs 1983:429, 430). The following are offered in support of our concept of the affinities of this crayfish that are discussed under "Relationships."

## Subgenus *Distocambarus* Hobbs, 1981

*Diagnosis.*—Chela of male with mesial margin of palm distinctly longer than width of palm; carpus of cheliped weakly expanded distally; second pereiopod lacking conspicuous fringe of setae on merus; areola in animals with carapace length greater than 20 mm usually less than 15 times as long as wide; color although variable (brownish, greenish, or lavender) never with reddish or pinkish suffusion; female with annulus ventralis moving through arc of at least 50 degrees, and postannular sclerite conspicuously large, almost as long as annulus ventralis; burrows usually with only one or two openings to surface and consisting basically of single subvertical passageway and secondary short branch leading to surface.

Comprising two species: *Distocambarus* (*D.*) *crockeri* Hobbs and Carlson (1983: 421) and *D.* (*D.*) *devexus* (Hobbs, 1981:302).

## Subgenus *Fitzcambarus* Hobbs, 1983

*Diagnosis.*—Chela of male with mesial margin of palm distinctly shorter than width of palm; carpus of cheliped expanded distally; second pereiopod with conspicuous fringe of setae extending distally from at least midlength of merus distally onto dactyl; areola in animals with carapace length greater than 19 mm seldom less than 15 times longer than wide; color variable (brownish, greenish, blue, or pinkish lavender) but usually pinkish lavender; female with annulus ventralis moving through arc of no more than 50 degrees, and postannular sclerite not conspicuously large, its length not greater than half that of annulus ventralis; except during droughts, burrows almost always with multiple openings to surface and usually with complex system of galleries.

Comprising two species: *Distocambarus* (*F.*) *carlsoni* Hobbs (1983:430) and *D.* (*F.*) *youngineri* (described herein).

### *Distocambarus* (*Fitzcambarus*) *youngineri*, new species
Fig. 1

*Diagnosis.*—Body and eyes pigmented, latter small but well developed. Rostrum without marginal spines, tubercles, and median carina. Carapace with 1 to several small cervical tubercles. Areola 13 to 24 (average, 17.6) times as long as broad, and constituting 37.6 to 41.9 (average, 38.9) percent of entire length of carapace (41.9 to 46.6, average 44.6, percent of postorbital carapace length). Ventral surface of ischium of third maxilliped only partly obscured by plumose setae. First 3 pairs of pereiopods without conspicuous ventral brush of setae extending from basis to merus, although second pereiopod with distoventral half of merus and margins of more distal podomeres with fringe of long setae. First pair of pereiopods with ventral surface of merus densely tuberculate, corresponding surface of proximal part of both fingers lacking tubercles. First pleopods of first form male with small but distinct cephalic shoulder at base of conspicuous, corneous, subquadrangular, platelike caudodistally and somewhat mesially directed central projection; cephalic process vestigial at best, not clearly defined; mesial process broad basally, tapering distally in long pointed element directed caudodistally and slightly laterally. Mesial ramus of uropod with distomedian spine very small but almost or quite reaching margin of ramus. Female with anterior part of annulus ventralis membranous across which hingelike motion accomplished; postannular sclerite not half so long as annulus; first pleopods rudimentary, in form of small tuberculiform prominences.

Holotypic male, form I:—Cephalothorax (Fig. 1a, h) subovate, compressed laterally; maximum width of carapace greater than height at caudodorsal margin of cervical groove (12.1 and 10.4 mm). Abdomen distinctly narrower than thorax (9.0 and 12.1 mm). Areola 17.2 times as long as wide but with only 1 punctation in narrowest part. Cephalic section of carapace about 1.4 times as long as areola, latter comprising 41.9 percent of total length of carapace (45.8 percent of postorbital carapace length). Surface of carapace mostly punctate, few small tubercles in anteroventral branchiostegal region. Rostrum broader than long with margins tapering gently from base and slightly more sharply from base of poorly defined acumen to tip; latter reaching base of ultimate podomere of antennular peduncle; rostral margins not conspicuously thickened; upper surface distinctly concave and bearing, in addition to usual marginal punctations, few large, comparatively deep punctations. Subrostral ridge moderately well developed and evident in dorsal aspect to end of basal third of rostrum. Suborbital angle obtuse but distinct.

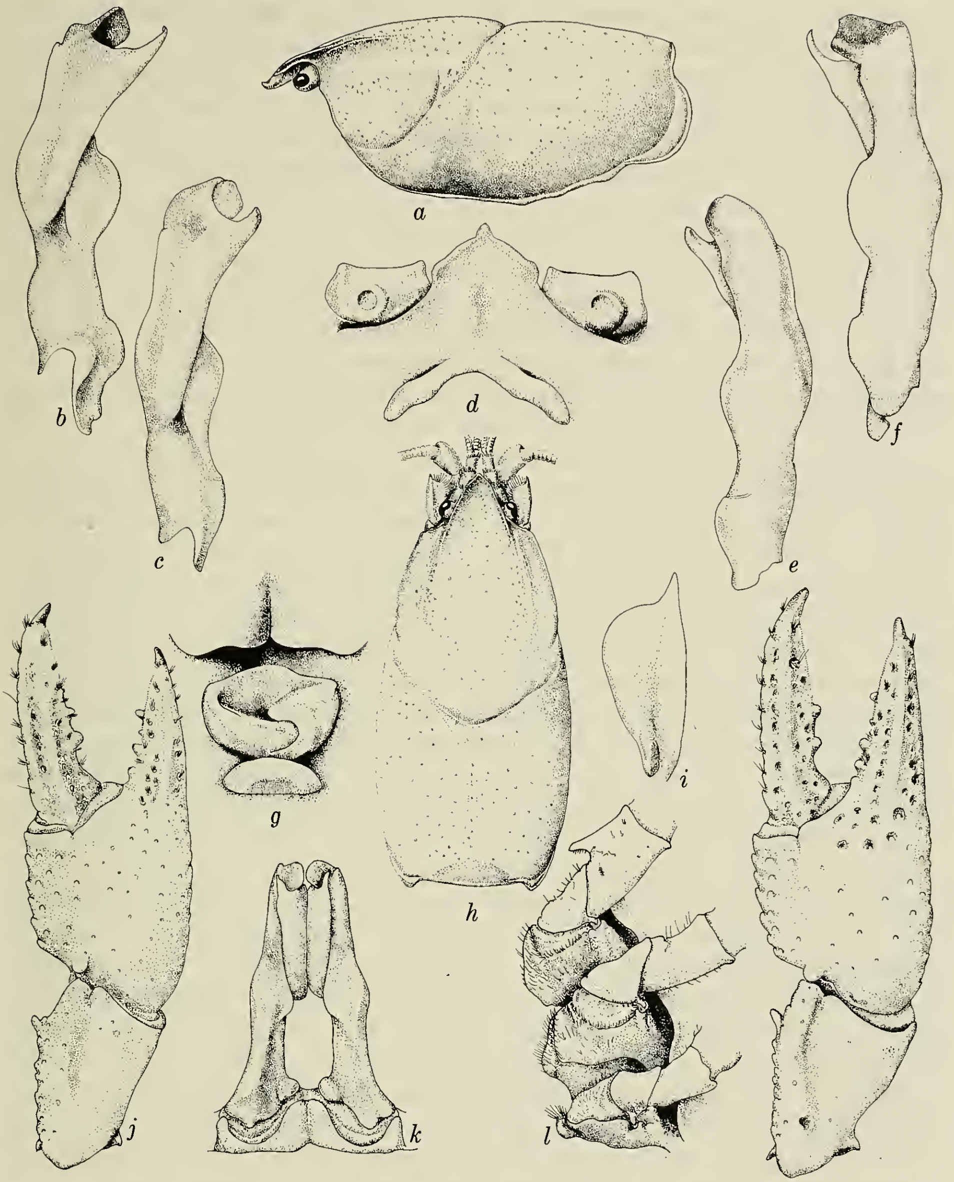

Fig. 1. *Distocambarus* (*F.*) *youngineri* (all from holotype except c, e from morphotype, and g, j from allotype): a, Lateral view of carapace; b, c, Mesial view of first pleopod; d, Epistome; e, f, Lateral view of first pleopod; g, Annulus ventralis and adjacent sternites; h, Dorsal view of carapace; i, Antennal scale; j, m, Dorsal view of distal podomeres of cheliped; k, Caudal view of first pleopods; l, Proximal podomeres of third, fourth, and fifth pereiopods.

Postorbital ridge clearly defined but merging insensibly with carapace anteriorly. Branchiostegal and cervical spines absent, latter represented by very small tubercle.

Abdomen shorter than carapace (21.5 and 24.6 mm). Pleura of second through fifth abdominal segments rounded ventrally, lacking caudoventral angle. Cephalic section of scabrous telson with 1 strong, fixed spine in each caudolateral corner. Cephalic lobe of epistome (Fig. 1d) subtriangular with short anteromedian projection, margins slightly elevated ventrally; main body of epistome with shallow median depression but lacking distinct fovea; epistomal zygoma broadly arched. Ventral surface of proximal podomere of antennular peduncle lacking spine. Antennal peduncle with usual spine on ventral surface of basal podomere reduced to minute tubercle; flagellum reaching about midlength of areola. Antennal scale (Fig. 1i) 2.4 times as long as broad, widest distinctly distal to midlength; greatest width of lamellar area little more than 1.5 times that of thickened lateral part.

Third maxilliped overreaching antennal peduncle by length of ultimate podomere; mesial sector of ventral surface of ischium with clusters of stiff, long setae; lateral sector studded with clusters of shorter, plumose setae which also forming submarginal lateral row; merus with setae similarly disposed.

Right chela (Fig. 1m) subelliptical in section, strongly depressed; palm 1.4 times as broad as length of mesial margin; length of latter almost one-third that of entire length of chela; most of palm studded with squamous to subsquamous tubercles. Mesial margin of palm with row of 6 (5 on left) tubercles flanked dorsolaterally by row of 6 (4 on left). Both fingers with well defined dorsomedian ridges flanked by setiferous punctations. Opposable margin of fixed finger with row of 3 tubercles, second from base largest, along proximal two-fifths of finger and single row of minute denticles extending between and distal to tubercles from base to corneous tip of finger; prominent tubercle also present below row slightly beyond midlength of finger; lateral margin of finger costate with row of 5 deep, setiferous punctations. Opposable margin of dactyl with 2 large tubercles on proximal half beyond which single row of minute denticles extending to corneous tip of finger, and shallow, rounded excavation present along basal part of finger; mesial margin with 1 or 2 tubercles proximally, followed distally by row of setiferous punctations. Ventrolateral surface of chela with conspicuous longitudinal row of long setae which extending from bases of tubercles in proximal part of row and from ventrolateral punctations on finger.

Carpus of cheliped distinctly longer than mesial margin of palm of chela (7.3 and 4.5 mm) and bearing slightly sinuous dorsal furrow; dorsal surface of podomere sparsely punctate, mesial surface with upper longitudinal row of 5 small squamous tubercles and cluster of 8 larger ones below row, distalmost of cluster largest; mesial surface with few additional small tubercles, and ventrodistal margin with single large tubercle articulating with proximal ventrolateral condyle on propodus.

Merus with usual tubercles dorsally, distalmost larger than others; mesial face with few small scattered tubercles present on distal half; lateral surface sparsely punctate; ventral surface tuberculate: 11 tubercles in irregular lateral row and 12 in mesial row, other tubercles and plumose setae present between rows; tubercles in both rows increasing slightly in size distally, but none spiniform. Ischium with row of 4 tubercles ventromesially, otherwise punctate.

Hook on ischium of third pereiopod (Fig. 1l) simple, slightly flattened, but subacute, and barely overreaching basioischial articulation, not opposed by strong tubercle on basis. Ventral membrane of coxa of fifth pereiopod conspicuously setose. Plumose pubescence associated with sternum and coxae of all pereiopods very prominent (not shown in illustration).

First pleopods (Fig. 1b, f, k) typical of genus in being symmetrical, not contiguous at base, reaching coxae of third pereiopods, bearing strong caudoproximal lobe and broadly rounded proximomedian lobe, flexed caudally slightly distal to midlength, and lacking subapical setae. Terminal elements described in "Diagnosis."

Uropods with only mesial lobe of proximal podomere bearing acute spine, that on lateral lobe rudimentary; mesial ramus with distomedian spine small and almost or quite reaching distal margin of ramus.

*Allotypic female.*—Differing from holotype, other than in secondary sexual features, in following respects: acumen of rostrum with base more clearly defined and reaching midlength of ultimate podomere of antennular peduncle; subrostral ridge evident in dorsal aspect to base of acumen; cephalic section of telson with 2 spines in each caudolateral corner, more mesial pair smaller and movable; median fovea present on epistome; flagellum of antennule reaching caudal margin of carapace; ischium of third maxilliped lacking tufts of plumose setae between lateral marginal row and mesial sector, latter bearing clusters of long stiff setae: mesial margin of palm of right chela (Fig. 1j) with row of 5 tubercles (6 on left) flanked dorsolaterally by row of 4; lateral margin of fixed finger with row of 7 setiferous punctations; opposable margin of dactyl with row of 3 tubercles (left with 4), distalmost smallest; mesial surface of carpus with 5 small tubercles interspersed among 5 larger ones; small tubercle present on ventrodistal margin of carpus opposite ventral condyle on proximal margin of propodus. (See "Measurements.")

Segment of sternum between fourth pereiopods with very narrow median fissure (expanding anteriorly) extending entire length.

Annulus ventralis (Fig. 1g) hinged between caudal sclerotized part and semimembranous anterior region (moving through arc of some 30 to 45 degrees), approximately 1.4 times as broad as long; anterior section broadly excavate; tongue descending into centrally located fossa from high sinistral wall; sinus originating in fossa near median line, extending sinistrally and making almost U-turn from which extending caudodextrally to median line where ending on caudal face of annulus.

Postannular sclerite almost three-fourths as wide as annulus ventralis, but distinctly less than half as long; central area elevated (ventrally) with anterior face convex and posterior surface flattened.

*Morphotypic male, form II.*—Except in secondary sexual characters, differing in no conspicuous way from holotype, few differences noted, probably reflecting juvenile condition of specimen: subrostral ridges evident in dorsal aspect from orbit almost to base of acumen; cephalic lobe of epistome lacking anteromedian projection; flagellum of antenna almost reaching caudal margin of carapace; fixed finger of chela with only 2 tubercles in row on proximal opposable margin, and other tubercles on chela not arranged precisely as in holotype, but possessing same numbers on either right or left members; ventral surface of merus of cheliped with lateral row of 8 tubercles and mesial row of 10.

Hook on ischium of third pereiopod tuberculiform, not projecting nearly so far proximally as that in holotype, and plumose setae on sternum and coxae of pereiopods much shorter, not obscuring distal part of first pleopods; latter (Fig. 1c, e) with oblique juvenile suture in proximal half of appendage, shoulder on cephalic surface situated slightly more proximally than in holotype; both terminal elements heavier and less attenuate, non-corneous central projection not nearly so lamelliform, and not even rudiment of cephalic process discernible.

*Color notes.*—Holotypic male with carapace mostly pale bluish lavender fading ventrally to pinkish cream; antennal, mandibular, and most of hepatic and anteroventral branchiostegal areas also pinkish cream. Caudodorsal ridge almost white. First through fifth abdominal terga brownish red suffused with lavender, fading caudally; tergum of sixth segment, telson, and uropods translucent, that of sixth segment with faint pink tint. Pleura translucent with pinkish cream blush. Dorsum of cheliped bluish lavender from midlength of merus distally, color intensified at distal end of merus and carpus and along mesial margin of palm and proximomesial part of dactyl; ventrolateral part of propodus and ventral and ventrolateral parts of all podomeres pinkish cream. Remaining pereiopods pinkish cream with lavender suffusion, latter intensified on distal half of merus and on proximal half of carpus. Eyestalks, antennules and antennae uniformly pale bluish lavender; third maxilliped and ventral part of body pinkish cream.

Paratypic male, form I, with carapace distinctly reddish tan, fading to pink laterally, dorsolateral parts of rostrum and posterior flank of cervical groove darker than elsewhere. Abdomen as in holotype except tergum of sixth segment and marginal areas of pleura, uropods, and telson pale pinkish orange. Antennules and antennae reddish, only little paler than carapace, dorsodistal parts of podomeres of peduncles darker than elsewhere. Chelipeds pinkish orange with brownish triangular mark on dorsodistal part of merus, similarly colored marks flanking groove on dorsal surface of carpus becoming very dark where merging distally. Chela with dorsal dark band across distal part of palm (ridge at base of dactyl almost black) and proximodorsal parts of both fingers dark, becoming lighter toward ends; dactyl darker than propodus; tubercles on mesial part of palm very dark. Ventral surface of chela deep pink. Other pereiopods pinkish orange with dark suffusion on distal part of merus and carpus, distal margin of merus especially dark. Third maxilliped and venter pinkish to purplish cream.

Females almost concolorous: lavender to lavender pink with dark markings on dorsum of chelipeds from merus distally.

Measurements (mm)

| | Holotype | Allotype | Morphotype |
|---|---|---|---|
| Carapace | | | |
| Height | 10.4 | 12.2 | 8.5 |
| Width | 12.1 | 15.0 | 9.7 |
| Entire length | 24.6 | 30.6 | 20.1 |
| Postorbital length | 22.5 | 26.9 | 17.6 |
| Areola | | | |
| Width | 0.6 | 0.9 | 0.5 |
| Length | 10.3 | 12.2 | 8.0 |
| Rostrum | | | |
| Width | 4.7 | 5.2 | 3.4 |
| Length | 4.3 | 5.0 | 3.0 |

| | | | |
|---|---|---|---|
| Chela | | | |
| Length of mesial margin of palm | 4.5 | 5.5 | 2.8 |
| Width of palm | 6.2 | 7.4 | 4.0 |
| Length of lateral margin | 13.2 | 16.5 | 8.7 |
| Length of dactyl | 8.5 | 10.1 | 4.5 |
| Carpus of cheliped | | | |
| Width | 4.3 | 5.4 | 3.1 |
| Length | 7.3 | 9.0 | 5.0 |
| Abdomen | | | |
| Width | 9.0 | 11.1 | 7.2 |
| Length | 21.5 | 25.0 | 15.8 |

*Types.*—The holotypic male, form I, allotypic female, and morphotypic male, form II (numbers 208413, 208414, and 208415, respectively) are deposited in the National Museum of Natural History, Smithsonian Institution, as are the following paratypes: 4 ♂I, 2 ♂II, 17 ♀, 9j ♂, 14j ♀, 3 ♀ with young.

*Type-locality.*—Burrows in area adjacent to small woodland pool, about 50 m southwest of State Route 58 on Route 22 (11 airmiles due west of Newberry, Newberry County, South Carolina) (34°18′N, 81°48′W). There in a wooded area supporting a dense growth of *Pinus, Quercus,* and *Nyssa,* the chimneys constructed by members of *Distocambarus* (*F.*) *youngineri* mark the complex systems of galleries that have been excavated in the sandy clay soil.

*Range.*—Even though intensive searches have been made to discover other colonies of this crayfish, until now it has been found in only one locality other than that cited above: roadside ditch on State Highway 121, 0.15 mile northeast of its junction with State Highway 34, just east of Silverstreet, and only nine airmiles from the type-locality.

*Specimens examined.*—Thirty-one specimens have been collected from the type-locality as follows, 3 ♀, 1j ♂, 2j ♀, 17 Dec 1982, PHC, collector; 2 ♂I, 7 ♀, 2j ♂, 3j ♀, 2 ♀ with yng, 6 Mar 1983, PHC; 3 ♀, 1j ♀, 22 Jun 1983, PHC; 2 ♀, 3j ♂, 29 Oct 1983, PHC, GBH, HHH. From the other locality just east of Silverstreet, the following are available: 1 ♂II, 1J ♀, 11 Nov 1983, PHC; 3 ♂I, 1 ♂II, 3 ♀, 3j ♂, 7j ♀, 1 ♀ with yng, 18 Feb 1984, PHC.

*Variations.*—Most of the variations noted in this crayfish are indeed minor ones. The ratio of the length of the carapace to that of the areola in specimens from the type-locality ranges from 37.1 to 40.5 (average 38.9) whereas that in the other locality is 37.8 to 40.8 (average 39.1), the range of the corresponding ratios of the areola length to postorbital carapace length 42.2 to 46.1 (average 44.4), and 41.9 to 46.4 (average 45.1), and that of the corresponding ratios of the length to the width of the areola 13.0 to 24.0 (average 18.1) and 10.0 to 18.0 (average 16.4 mm), thus even though the areolae of specimens from the type-locality are slightly shorter and narrower than that found in the other locality, specimens from the two places cannot be separated with certainty. The rostrum exhibits perhaps the most conspicuous variations: it ranges from subtriangular to broadly subovate, and the acumen may or may not be rather clearly delimited basally; in all specimens it is somewhat deflected ventrally, and in one very strongly so; the apex of the acumen may not reach the base of the penultimate podomere of the antennular peduncle, or it may overreach it. The mesial surface of the chela bears a row of 5 to 7 tubercles, and the row immediately dorsolateral to it consists of 4 to 6. The opposable margin of the fixed finger bears a row of 2 to 4 tubercles in addition to the more distoventrally situated tubercle, and the dactyl also exhibits a row of 2 to 4 of them.

*Size.*—The largest specimen available is a female, which has a carapace length of 31.7 (postorbital carapace length 27.4) mm. The corresponding length of the smallest and largest first form males available are 12.1 (10.4) mm and 29.2 (25.6) mm. The smallest female carrying young (no ovigerous females have been found) has corresponding lengths of 27.1 (23.4) mm.

*Life history notes.*—Two first form males, each found in a burrow with a female, were collected on 6 March 1983, and three were obtained on 18 February 1984 when some of the females taken were observed to bear sperm plugs in their annuli ventrales. A first form male and a female with carapace lengths of 26.5 and 29.4 mm, respectively, were found together in a burrow on 18 February 1984. Young with carapace lengths of 6.8 to 11.8 mm were obtained from the burrow of a female on 18 February 1984, and others with corresponding lengths of 7.9 to 11.0 with two females on 6 March 1983.

*Ecological notes.*—*Distocambarus* (*F.*) *youngineri* is a primary burrower, and its abode is generally marked by three or four openings, one or more being sealed by a capped turret. Irregular horizontal galleries, 30–60 mm beneath the soil surface connect the openings, and one or two vertical to subvertical shafts penetrate the groundwater, reaching a maximum depth of about 60 to 70 cm below the soil surface.

One of the burrows excavated in December, 1982, and all of those dissected in June and October, 1983, were much less complex than others investigated in December, 1982, and in March, 1983. These simple burrows consisted of only one subvertical shaft which led beneath the surface of the groundwater. During drought conditions the sandy-clay soil became so hard that excavating an entire burrow would have been exceedingly difficult, but there was evidence that some of the upper galleries had been filled with soil that presumably had been removed from the wet fundus of the main vertical shaft. As a result, the burrows seemed to be comparatively simple during these periods.

On March 6, 1983, one pair was found in a horizontal passageway, only 30 to 40 mm beneath the soil surface. Most other specimens were encountered deep under the water in the somewhat enlarged chambers at the bases of the subvertical passages. Juveniles appear to have constructed simple burrows emanating from that occupied by the mother.

The only features that appear to distinguish most burrows occupied by first form males from those of females are their proximity to the more permanent surface water and, except for those complex burrows in which a female is also present (presumably the male is the temporary occupant), they are comparatively simple. The small woodland pool at the type-locality was carefully sampled on two occasions, and on neither was a crayfish found in it. Moreover, no openings to flooded tunnels could be located.

No other crayfishes were found in the immediate areas occupied by *D.* (*F.*) *youngineri.*

*Relationships.*—This crayfish has its closest affinities with *Distocambarus* (*F.*) *carlsoni,* sharing with it, among other features a rostrum that is shorter than wide, a comparatively narrow areola, a reduced abdomen, a cheliped in which the mesial margin of the palm of the chela of the male is shorter than the maximum width of the podomere and shorter than the carpus, stocky first pleopods in which the central projection is more strongly recurved than in the other two members of the nominate subgenus, an annulus ventralis that is movable through an arc of no more than 50 degrees, and a wedgelike postannular sclerite that is not conspicuous and not nearly so long as the annulus. It differs from *D.* (*F.*) *carlsoni* most conspicuously in the secondary sexual features of the male and in the more strongly tuberculate ventral surface of the merus of the cheliped. The shorter, broader, subquadrangular shape of the central projection of the first pleopod of the first form male is strikingly different from the elongate bladelike element in *D.* (*F.*) *carlsoni,* as is the mesial process which projects caudodistally rather than caudally. In the female, the cephalic region of the annulus ventralis is broadly and comparatively deeply excavate whereas in the typical form of *D.* (*F.*) *carlsoni* it is seldom more than narrowly, and usually quite shallowly excavate.

Had this crayfish not been discovered there would be less evidence for our conclusion that *D.* (*F.*) *carlsoni* should be considered a congener of *D.* (*D.*) *crockeri* and *D.* (*D.*) *devexus* (Hobbs 1981:302). Possessing a first pleopod in the male that markedly resembles that of the last two mentioned species, but having a body and chelipeds that are clearly more like those of *D.* (*F.*) *carlsoni, D.* (*F.*) *youngineri* seems to tie the latter even more firmly to these two species. Moreover, the discovery that sperm plugs occur in the annuli ventrales of *D. carlsoni* and *D. youngineri,* a feature that to our knowledge has never been observed in a member of the genus *Cambarus,* lends greater assurance that *D. carlsoni* is not, as the first pleopods of the male suggest, a product of the cambaroid line of evolution. With little imagination one might visualize *D. youngineri* as an arrested state in the evolution of *D. carlsoni* from a more primitive *D. crockeri*-like ancestor.

*Etymology.*—This crayfish is named in honor of our mutual friend, Edward M. Younginer of the Department of Health and Environmental Control, Columbia, South Carolina, who not only has offered us encouragement throughout the course of our study of the crayfishes of South Carolina, but also has assisted us in obtaining many of the collections that are now available.

## Acknowledgments

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# *OMAN YPSILON,* A NEW GENUS AND SPECIES OF BLENNIID FISH FROM THE INDIAN OCEAN

Victor G. Springer

*Abstract.*—*Oman ypsilon* is described, based on a single specimen from Sur, Oman. The taxon differs from all other Omobranchini in having the following combination of characters: dorsal-fin spines X; pectoral-fin rays 13; infraorbital bones 4; nasal bones not touching or joined to each other; interorbital pores 2; median supratemporal sensory canal pore absent; ventral hypural plate fused to complex urostylar centrum. A key is given to the seven genera of Omobranchini.

The classification of the omobranchin genera was last considered by Springer (1972). Subsequently (Springer and Gomon 1975; Springer 1981; Bath 1983), several new species, but no new genera, have been described in the tribe.

The present study was initiated as a result of a query from Dr. Richard Winterbottom, who had obtained a specimen of omobranchin that he was unable to assign to a genus or species. Dr. Winterbottom kindly allowed me to study the specimen and describe it. Although the specimen is assignable to the Omobranchini, and superficially resembles species of *Omobranchus, Omox,* and *Parenchelyurus,* its complex of characters does not clearly place it in any of the presently recognized omobranchin genera.

Before I decided to describe a new genus for the specimen, I attempted a cladistic analysis of the Omobranchini to determine if the new species might be placed reasonably in one of the three genera it resembled. I spent considerable time searching for, and coding, characters for the analysis, which was performed using the well-known WAGNER 78 computer program developed by J. S. Farris. Ultimately, insoluble problems with coding characters, lack of enough characters to resolve relationships, and peculiarities of the computer program convinced me to abandon the results of the analysis. I wish to emphasize that my decision was not based on disagreement with the results of the analysis but on dissatisfaction with the soundness and sufficiency of the data and program on which the analysis was based.

*Methods.*—Measurements were made to the nearest 0.1 mm using needlepoint dial calipers. Standard length (SL) was measured from the mid-tip of the snout to the mid-base of the caudal fin. Vertical-fin elements were measured from the rear axil at the base of the element to the distal tip of the element, without allowance for curvature of the element. Gill-opening depth is the distance between the dorsalmost and ventralmost points of the opening. Other measurements are self-explanatory.

The holotype was cleared using the trypsin method and stained with alizarin red s and alcian blue.

Other methods and terminology follow those of Springer (1972).

## Key to the Genera of Omobranchini

1. Cirri present on rims of anterior and posterior nostrils; circumorbital pores 9 to 12 (usually 10); one or more supratemporal canal pores on occiput just anterior to median supratemporal pore ......... *Laiphognathus* Smith
– No cirri present on rims of nostrils (anterior nostril may open at end of slender tube); circumorbital pores 6 to 10 (rarely more than 9, and modally less than 9, in any species); no supratemporal canal pores on occiput anterior to median supratemporal pore, which may be absent ......... 2
2. Mandibular pores 2 .............................................. 3
– Mandibular pores 3 .............................................. 4
3. Dorsal-fin spines modally 11 or 12; pectoral-fin rays modally 13 ...... ............................................ *Parenchelyurus* Springer
– Dorsal-fin spines modally 7 to 10; pectoral-fin rays modally 14 to 16 .. ............................................ *Enchelyurus* Peters*
4. Dorsal-fin spines 10; ventral hypural plate fused to urostylar complex; median supratemporal pore absent; interorbital pores 2; gill opening extending ventrally to level opposite base of dorsalmost pectoral-fin ray .. ............................................ *Oman* Springer
– Dorsal-fin spines modally 11 to 13; ventral hypural plate autogenous; median supratemporal pore present or absent; interorbital pores modally 2 to 4; gill opening varying from restricted to area dorsal to level of pectoral-fin base to extending ventrally to level opposite ventralmost pectoral-fin ray .............................................. 5
5. Median supratemporal pore usually present; interorbital pores modally 2 or 3; lateral-line tubes present or absent; gill opening restricted to area dorsal to level of 7th from dorsalmost pectoral-fin ray (usually restricted to level dorsal to 3rd from dorsalmost ray); infraorbital bones 4 or 5 (5 in most species); thin, fleshy crest on top of head present or absent .... ............................................ *Omobranchus* Ehrenberg
– Median supratemporal pore usually absent; interorbital pores modally 4; lateral-line tubes absent; gill opening extending ventrally at least to level of 8th from dorsalmost pectoral-fin ray; infraorbital bones 3 or 4 (usually 4); no fleshy crest on top of head .............................. 6
6. Total dorsal-fin elements 30 or 31; segmented anal-fin rays 20 or 21; nasal bones joined dorsally ............................ *Haptogenys* Springer

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* Smith-Vaniz (1976:154) followed Springer (1972) in reporting that the postcleithra of *Enchelyurus* (Omobranchini) consist of a few fragments of bone. Actually, the ventral postcleithrum of *Enchelyurus* is always present and complete, and appears similar to that of *Phenablennius* (Phenablenniini; Springer and Smith-Vaniz 1972), which completely lacks the dorsal postcleithrum. The dorsal postcleithrum of *Enchelyurus* is either absent or reduced to a fragment of bone that appears near the dorsal end of the ventral postcleithrum.

Other than *Enchelyurus* and *Phenablennius*, only *Praealticus* Schultz and Chapman (Salariini) among the Blenniidae has modified the structure of the postcleithra. In *Praealticus*, the dorsal postcleithrum is represented by a dorsally positioned fragment of bone; another fragment of bone occurs ventral to the dorsal fragment, but it is not clear whether this represents a second fragment of the dorsal postcleithrum or a fragment of the ventral postcleithrum (Smith-Vaniz and Springer 1971, fig. 15).

– Total dorsal-fin elements 27 to 29; segmented anal-fin rays 17 to 19; nasal bones separated for their entire length .................. *Omox* Springer†

## *Oman,* new genus

*Diagnosis.*—A member of the blenniid tribe Omobranchini with: ventral hypural plate fused to complex urostylar centrum; basibranchials 2 and 3 reduced, present only as cartilage; frontals not fused to each other; basisphenoid well developed (but lacking belophragm); no kinethmoid (Springer 1968: fig. 13); dorsal and ventral postcleithra normal; nasal bones not touching each other; no cirri on head; median supratemporal sensory canal pore absent; interorbital pores 2.

*Etymology.*—*Oman* is derived from the name of the country of origin of the type species. The gender is feminine; the stem is "oman."

*Type-species.*—*Oman ypsilon* Springer.

*Comparisons.*—The genera of Omobranchini can be distinguished in the above key. A fuller comparison is given in Table 1.

## *Oman ypsilon,* new species
Fig. 1

*Description* (based on holotype and only known specimen; characters in generic diagnosis not repeated here).—Dorsal fin X, 25; slightly notched between spines and rays; attached by membrane to caudal-fin origin. Anal fin II, 24; attached by membrane to caudal peduncle. Vertebrae 11 + 29. Epipleural ribs on vertebrae 1 to 12; pleural ribs on vertebrae 3 to 11. Pectoral fin 13 (both sides). Pelvic fins I, 2 (left pelvic fin with splint of bone, probably representing vestigial third ray, closely applied to base of innermost segmented ray); membrane between segmented rays incised one-half length of innermost ray. Caudal fin with 6 dorsal and 6 ventral procurrent rays, 7 dorsal and 6 ventral segmented rays, and one epural; posteriormost dorsal procurrent ray and posteriormost ventral procurrent ray each attached to its own roundish, plate-like procurrent cartilage; anterior 5 dorsal procurrent rays attached to elongate procurrent cartilage reaching anteriorly to point dorsal to tip of neural spine of third preural vertebra (PU3); anterior 5 ventral procurrent rays attached to elongate procurrent cartilage reaching anteriorly to point ventral to tip of hemal spine of PU3; hypural 5 absent. Branchiostegals 6. Upper jaw and lower jaw each with recurved canine tooth posteriorly on each side and 23 incisor teeth. Infraorbital bones 4, dorsalmost very small. Ventralmost point of gill opening opposite level of dorsalmost pectoral-fin ray.

Sensory canal pores (left–right): Circumorbital (=supraorbital + infraorbital) 9-8; interorbital 2 (total); mandibular 3-3; preopercular 6-5; supratemporal 4-4 (no median predorsal pore); bi-pored lateral-line tubes 0-2, reaching posteriorly to vertical from interspace between dorsal-fin spines 2 and 3 (on right side of specimen).

Measurements in mm (and as percent SL): Standard length 32.5; head length 7.0 (21.5); snout length 2.4 (13.5); orbital diameter 2.1 (6.5); interorbital width

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† Because of superficial external similarity, it is possible that *Phenablennius* (Phenablenniini) will key to *Omox. Phenablennius* differs most obviously from *Omox* in having 3 segmented pelvic-fin rays (versus 2) and 6 circumorbital sensory pores (versus 7 or 8, rarely 7).

Fig. 1. *Oman ypsilon*, Royal Ontario Museum 40208, male 32.5 mm SL, Sur, Oman (drawn by P. K. Hollingsworth).

Table 1.—Comparison of characters among the genera of Omobranchini. Abbreviations: A = absent; Au = autogenous; BB = basibranchials; C = cartilaginous; CO = circumorbital; Dpc = dorsal postcleithrum; F = fused; Fc = fused to complex urostylar centrum; IO = interorbital; MS = median supratemporal; N = normal; P = present; S = separate; V = vestigial; Vhp = ventral hypural plate. Parenthetical numbers after generic names indicate number of included species.

| Character | *Omobranchus* (21) | *Omox* (2) | *Parenchelyurus* (2) | *Laiphognathus* (1) | *Haptogenys* (1) | *Enchelyurus* (5) | *Oman* (1) |
|---|---|---|---|---|---|---|---|
| Dorsal-fin | | | | | | | |
| Spines | 10 to 14 (modally 12 or 13) | 12 | 11 to 13 (rarely 13) | 10 to 12 (rarely 10 or 12) | 12 | 6 to 11 (rarely 6 or 11) | 10 |
| Rays | 16 to 26 | 15 to 17 | 17 to 20 | 18 to 21 | 17 to 19 | 19 to 27 | 25 |
| Anal-fin rays | 18 to 27 | 17 to 19 | 18 to 21 | 19 to 23 | 20 to 21 | 18 to 24 | 24 |
| Vertebrae | | | | | | | |
| Precaudal | 10 to 12 | 10 | 10 to 11 (rarely 11) | 10 | 10 | 9 to 12 (rarely 9 or 12) | 11 |
| Caudal | 26 to 33 | 24 to 26 | 24 to 28 | 25 to 29 | 28 | 23 to 30 | 29 |
| Pectoral fin | 12 to 14 (modally 13) | 12 or 13 | 13 or 14 (rarely 14) | 12 to 14 (rarely 14) | 13 | 13 to 17 (rarely 13 or 17) | 13 |
| Lateral-line tubes | 0 to 10 | 0 | 0 or 5 to 11 | 0 to 5 (rarely 0) | 0 | 3 to 10 (rarely 9 or 10) | 0 or 1 |
| MS pore | P | P or A (usually A) | P | P | A | P | A |
| IO pores | 1 to 4 (rarely 1 or 4) | 3 to 5 (usually 4) | 3 | 3 | 4 | 3 | 2 |
| MP pores | 3 | 3 | 2 | 3 | 2 or 3 (usually 3) | 2 | 3 |
| CO pores | 6 to 10 (modally 7 or 8) | 7 or 8 (rarely 7) | 6 to 8 (usually 7) | 9 to 12 (modally 10) | 8 | 7 | 8 or 9 |
| Nasal bones | S | S | S | S | joined | S | S |
| Infraorbitals | 4 or 5 | 3 or 4 | 4 | 4 | 4 | 3 | 4 |
| Frontals | S | S | S | S | S | F | S |
| Kinethmoid | A | A | P or A | P or A | P | P | A |

Table 1.—Continued.

| Character | *Omobranchus* (21) | *Omox* (2) | *Parenchelyurus* (2) | *Laiphognathus* (1) | *Haptogenys* (1) | *Enchelyurus* (5) | *Oman* (1) |
|---|---|---|---|---|---|---|---|
| BB 1 and 2 | N | N | V or C | C | N | N | C |
| Hypural 5 | P or A | P or A | A | A | A | A | A |
| Vhp | Au | Au | Au | Fc | Au | Fc | Fc |
| Epurals | 1 or 2 | 1 | 1 | 1 | 1 | 2 | 1 |
| Dpc | P | P | P | P | P | A | P |
| Cirri on nostrils | A | A | A | P | A | A | A |
| Fleshy crest on head | P or A | A | A | A | A | A | A |

0.7 (2.2); predorsal length 7.6 (23.4); preanal length 4.5 (13.8); depth at anus 5.3 (16.3); caudal peduncle depth 2.3 (7.3); caudal peduncle length 2.4 (13.5); length of: 1st dorsal-fin spine 1.5 (4.6), 2nd dorsal-fin spine 1.7 (5.2), 5th dorsal-fin spine 2.6 (8.0), 10th dorsal-fin spine 2.7 (8.3), 5th dorsal-fin ray 3.4 (10.5), 10th dorsal-fin ray 3.8 (11.7), 15th dorsal-fin ray 4.2 (12.9), 20th dorsal-fin ray 3.9 (12.0), 25th dorsal-fin ray 2.2 (6.8), 1st anal-fin spine 0.5 (1.5), 2nd anal-fin spine 1.1 (3.4), 1st anal-fin ray 1.8 (5.5), 5th anal-fin ray 2.3 (7.1), 10th anal-fin ray 2.7 (8.3), 15th anal-fin ray 3.1 (9.5), 20th anal-fin ray 2.8 (8.6), 24th anal-fin ray 2.3 (7.1), longest segmented pelvic-fin ray 4.0 (12.3), shortest segmented pelvic-fin ray 2.8 (8.6), longest pectoral-fin ray 5.0 (15.4), longest caudal-fin ray 5.7 (17.5); gill opening depth 1.0 (3.1).

Color pattern (preserved): Ground color of head and body pale. Prominent dark-dusky, U-shaped marking on head, with arm of U originating laterally on nape, extending anteroventrally along nape and over eye, down to and around snout tip, and up opposite side of head; sparsely distributed group of melanophores extending posteriorly from mid-postorbital margin; indications on body of about 9 narrow, irregularly-shaped bands of sparsely distributed melanophores separated by wider unmarked areas. Membranes of spinous dorsal fin covered with fine, evenly-distributed melanophores; segmented-ray portion with melanophores restricted mostly to distal margin of fin. Anal fin with hazy stripe of fine melanophores along distal margin. Caudal fin with darkly dusky band of melanophores distally. Pectoral fins with sparsely distributed melanophores distally. Pelvic fins unmarked.

*Holotype.*—Royal Ontario Museum 40208, male, 32.5 mm SL (now cleared and stained and partially dissected), Sur, Oman (22°35′39″N, 59°32′E), depth 4 m, sandy rock reef over rocky sand, 100 m from shore, 1 Jun 1981, B. N. G. Simm.

*Etymology.*—The species name, here used as a noun in apposition, is based on the Greek name of the letter "U," in reference to the dark U-shaped marking on the anterodorsal surface of the head.

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# *PERIOCULODES CERASINUS*, N. SP., THE FIRST RECORD OF THE GENUS FROM THE CARIBBEAN SEA (AMPHIPODA: OEDICEROTIDAE)

James Darwin Thomas and J. L. Barnard

*Abstract.—Perioculodes cerasinus,* a probable cryptic fossorial amphipod with embedded white orbicular ommatidia in bright ruby eyes is described from Tobago, Belize, Florida Keys, and Biscayne Bay, Florida. The eyes are separated either into two lunes or combined side to side into one large irregular brow. This is the first western Atlantic record of a generic group heretofore confined to the warm eastern Atlantic and Indian Oceans. Close affinity appears to be with the type-species of the genus, *P. longimanus,* from the eastern Atlantic Ocean.

The paucity of exploration for amphipods in the west tropical Atlantic is no better emphasized than by the present species which has come to light in collections from as far spread as Tobago, Belize, and Biscayne Bay, Florida. These collections have been made in just the past two years. The species has been observed alive on several occasions.

The ring-like eye in life is quite noticeable because of the jewel-like appearance: diamonds glinting from a bed of rubies.

This new species has some affinities with the west African *Perioculopsis lophopus* Schellenberg, 1925, from the Gulf of Guinea but is also close to *Perioculodes longimanus* (Bate and Westwood) (see Sars 1895) distributed in the eastern Atlantic from Norway south to the Cape of Good Hope and into the warm Indian Ocean.

Unfortunately, there are numerous taxonomic difficulties in this group as described below.

## Oedicerotidae

## *Perioculodes* Sars

*Perioculodes* Sars 1895:312.—Lincoln 1979:338.

*Diagnosis.*—Eyes when present forming anterodorsal ring from side to side, ring sometimes divided into two pieces. Peduncular articles of antennae 1 stout in male. Incisors projecting and toothed, each mandible with toothed lacinia mobilis, raker row, and weak, non-triturative molar bearing spines; mandibular palp feeble, in female articles 1 and 3 short, of equal length; in male article 3 elongate. Inner lobes of lower lip coalesced but fusion line occasionally marked as raphus. Inner plates of maxillae 1–2 poorly setose, outer plate of maxilla 1 with 7 spines, palp 2-articulate. Maxilla 2 feeble. Maxillipedal plates moderately to poorly armed, inner small, outer large, dactyl elongate and unguiform.

Gnathopods 1–2 alike in both sexes, of similar size, with short article 5 (wrist) bearing long posterior lobe guarding article 6 completely, article 6 (hand) long and subrectangular, palm oblique, well defined. Coxa 6 not bevelled posteroventrally.

Epimera simple. Uropod 2 reaching near apex of uropod 3. Gills present on coxae 2–6, gill on coxa 4 largest and most adze-shaped, on coxa 6 smallest and most sausage-shaped. Normal oostegites present on coxae 3–5, thin, weakly setose, coxa 2 with vestigial oostegite bearing 1 seta.

*Variables*.—Peduncle of antenna 2 short in male, with article 3 short, but occasionaly species with female antenna 1 bearing elongate articles, article 3 especially elongate. Coxae variable, in type-species coxae 1–4 forming one group, and coxae 5–7 forming second group but in other species no distinct grouping; in other species with coxae 1–3 forming a short group, coxae 5–7 forming long group. Gnathopods elongate or not. Dactyls of pereopods 3–4 long, medium or short. Pereopods 3–7 variable in dimensions and armaments. Urosomites 2–3 separate or fused. Telson emarginate or rounded apically.

*Type-species.—Monoculodes longimanus* Bate and Westwood (by monotypy).

*Remarks.*—The variability of known characters in the species of this genus and the lack of knowledge of many characters precludes any division into genera at this time. Whether or not *Perioculopsis* Schellenberg (1925) is distinctive must also be reviewed when it is more adequately illustrated.

### *Perioculodes cerasinus*, new species

Figs. 1–3

*Description of holotype male "h" 1.57 mm.*—Head extremely broad, as long as first 3 pereonites combined, rostrum thick and of medium forward extension; eyes in life ruby red with diamond white ommatidia sparkling from ruby matrix, divided into 2 arcs separated by small space, because of head-width eyes very large for body size. Antennae 1–2 short, extending equally, peduncle of antenna 1 short, article 1 scarcely extending beyond apex of rostrum, articles 2 and 3 slightly shorter and therefore scarcely longer than wide; primary flagellum about as long as peduncle, with 5 articles, one aesthetasc each on articles 3–4; accessory flagellum marked by vestigial hump and setule. Gland cone of antenna 2 (see special figure) small; article 4 of peduncle as long as article 1 of antenna 1, article 5 slightly shorter, flagellum shorter than peduncle, with 4 articles.

Prebuccal complex bulbous anteriorly, ventral margin of upper lip weakly sinuate and with weak ventral midprotrusion. Left mandibular incisor with 3 main teeth formed in phoxocephalid fashion, long margin between main teeth serrate, lacinia mobilis either absent or represented by first raker, raker spines thus 4 in number, simple, molar obsolescent, marked by triad of spines; article 1 of palp elongate, article 2 thick, with 3 setae, article 3 shorter than 1, stubby, setae = 2E. Inner lobes of lower lip fused, dome-shaped, with middle raphus, outer lobes widely spread, inflated, each with weak cone and weak mandibular lobe. Inner plate of maxilla 1 broad, recumbant (tilting towards outer plate), in illustrations shown tilted and straightened with one apical spine, inner plate broad and short, with 7 apical spines, palp weakly 2-articulate, symmetrical on both sides, with 5 apical and subapical spines. Maxilla 2 feeble, composed of two broad plates sparsely armed, inner plate with 2 medial setae towards apex. Inner plate of maxilliped ordinary, with 3 apical setae, innermost attached ventrally; outer plate

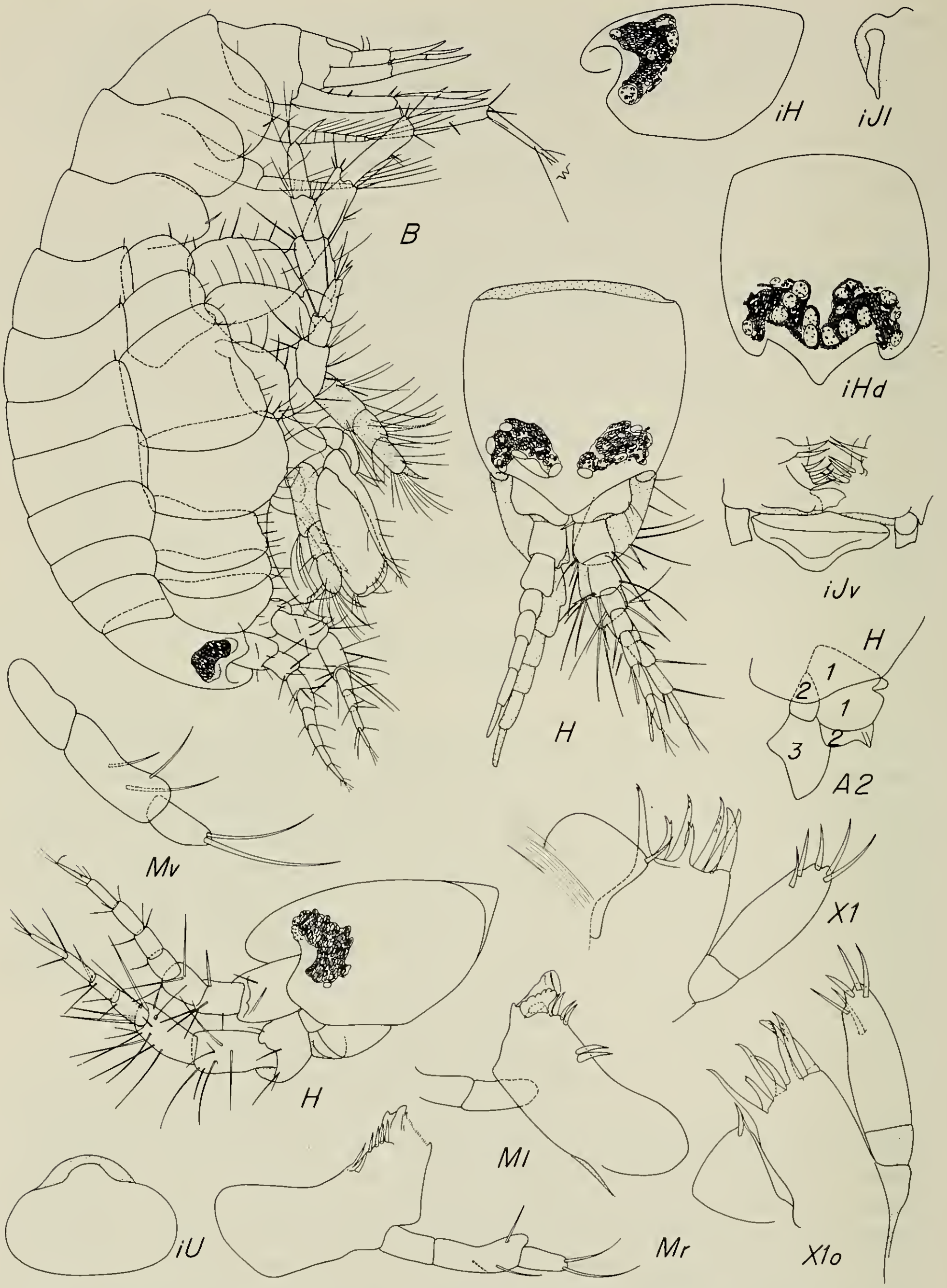

Fig. 1. Capital letters denote main parts in following list; lower case letters to left of capital letters or in body of figure indicate modifications as per following list; lower case letters to right of capital letters indicate specimens described in captions: B, body; C, coxa; E, epimeron; F, accessory flagellum; G, gnathopod; H, head; J, prebuccal; L, labium; M, mandible; P, pereopod; R, uropod; S, maxilliped; T, telson; U, labrum; V, palp; W, pleon; X, maxilla; Y, oostegite; Z, gill; d, dorsal; l, lateral; o, opposite; r, right; v, ventral. *Perioculodes cerasinus*, unattributed figures, holotype, male "h" 1.5 mm; i = female "i" 1.81 mm.

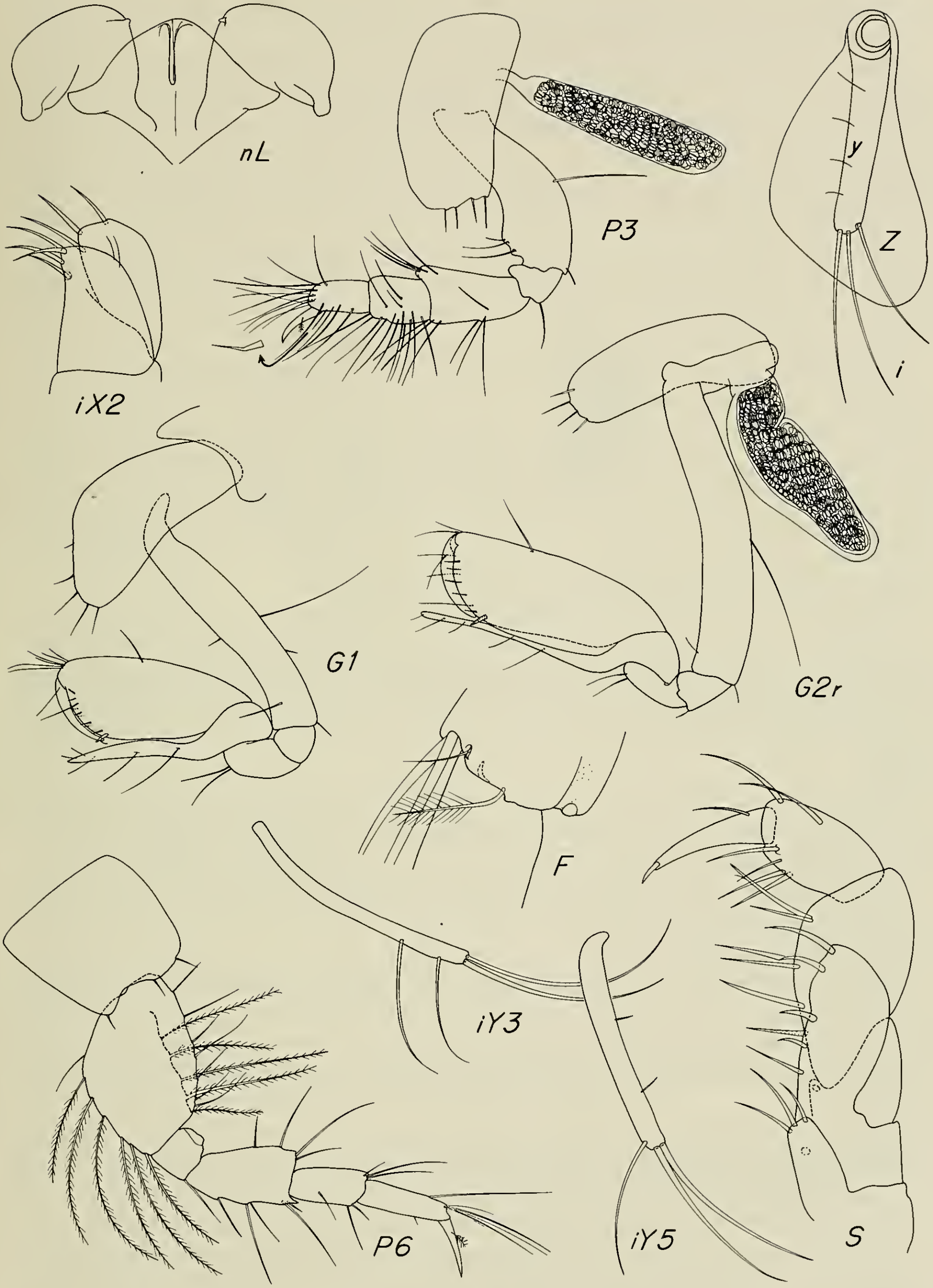

Fig. 2. *Perioculodes cerasinus,* unattributed figures, holotype, male "h" 1.5 mm; i = female "i" 1.81 mm; n = male "n" 1.90 mm.

of ordinary size but sparsely armed, with only 5 medial spines, palp stout, dactyl elongate, unguiform, with short nail.

Coxae 1–3 forming short group together, coxae 4–7 forming longer group together, coxa 7 not distinguished from coxae 4–6, ventral setae sparse, coxa 1 bevelled anteroventrally, coxa 2 much narrower than coxae 1 and 3, coxa 5 scarcely bilobate. Hand of gnathopod 1 shorter than that of gnathopod 2, wrist lobe also slightly shorter, both lobes extending beyond proximal extent of palms. Pereopods 3–4 without major spines, all other armaments of setal form. Pereopod 5 especially small relative to body size, article 2 feeble, medial face of article 2 on pereopods 5–6 with vertical setal row; pereopod 7 not as elongate as in most oedicerotids, article 2 ovate, dactyl with 3 setae. Gills on coxae 2–6, that on 4 largest, mostly adze-shaped but becoming smaller and more sausage-shaped on coxae 5 and 6.

Epimera 1–3 plain, rounded posteroventrally, each segment bearing single ventrofacial spine. Peduncle of uropod 1 with 3 dorsolateral spines, long gap between spines 2 and 3. Urosomites 2–3 fused; peduncle of uropod 2 with one apicolateral spine; each peduncle with one apicomedial spine; each ramus of uropods 1–2 with one dorsal spine; outer ramus of uropod 2 shortened. Uropod 3 feeble, peduncle about half as long as peduncle of uropod 2, rami longer than peduncle, outer shorter than inner, both naked. Telson ovate, margins entire, apex with 2 separated setules and each apicolateral face with pair of setules.

*Female "i" 1.81 mm.*—Like male but with oostegites, no other conspicuous secondary sexual characters but this specimen larger and better developed than holotype: eyes larger and pair abutting medially (see illustration); epimeron 1 with 2 ventral spines; peduncle of uropod 1 with 5 lateral spines, gap still present, of uropod 2 with 2 dorsolateral spines; outer rami of uropods 1–2 with 2 spines each.

Oostegites thin, that of coxa 2 rudimentary, with 1 apical seta, others long and thin, setal formulae of all as follows: anterior setae = 0-2-2-1, distal setae = 1-2-2-2, posterior setae = 0-0-0-0, anterior setules = 0, posterior setules = 0-0-1-2.

*Male "g" 1.70 mm.*—Better developed than holotype: epimeron 1 with 2 ventral spines; outer rami of uropods 1–2 with 2 dorsal spines; each ramus of uropod 3 with one dorsal spine.

*Male "n" 1.90 mm.*—Left epimeron 1 with midfacial spine-seta, 1 ventral seta, right side with 3 facials and 2 ventrals (illustrated); spine on epimeron 3 very posteriad; peduncle of uropod 1 with 5 dorsolateral spines, no gap, uropod 2 with 2; outer rami of uropods 1–2 with 2 spines each; each ramus of uropod 3 with 1 spine.

*Juvenile "j" 1.30 mm.*—Spines on epimera 1, 2, 3 = 1-1-0. Peduncle of uropod 3 with 3 dorsolateral spines, one gap, uropod 2 with 2 spines, rami of uropods 1–2 each with 1 spine, rami of uropod 3 naked.

*Male "p" 2.04 mm and male "q" 1.77 mm.*—Eyes faded totally in preservative, thus apparent only as foam and bubbles inside head. Uropods like male "n."

*Male "p" 2.04 mm and male "q" 1.77 mm.*—Eyes faded totally in preservative, thus apparent only as foam and bubbles inside head. Uropods like male "n."

*Notes.*—Largest specimen from Bacha Shoal, Florida, specimen "i" 2.75 mm, with following spine counts: uropod 1 peduncle = 6, outer ramus 2–3, inner ramus 1; uropod 2 peduncle 2, outer ramus 2, inner ramus 1; uropod 3 outer ramus 1,

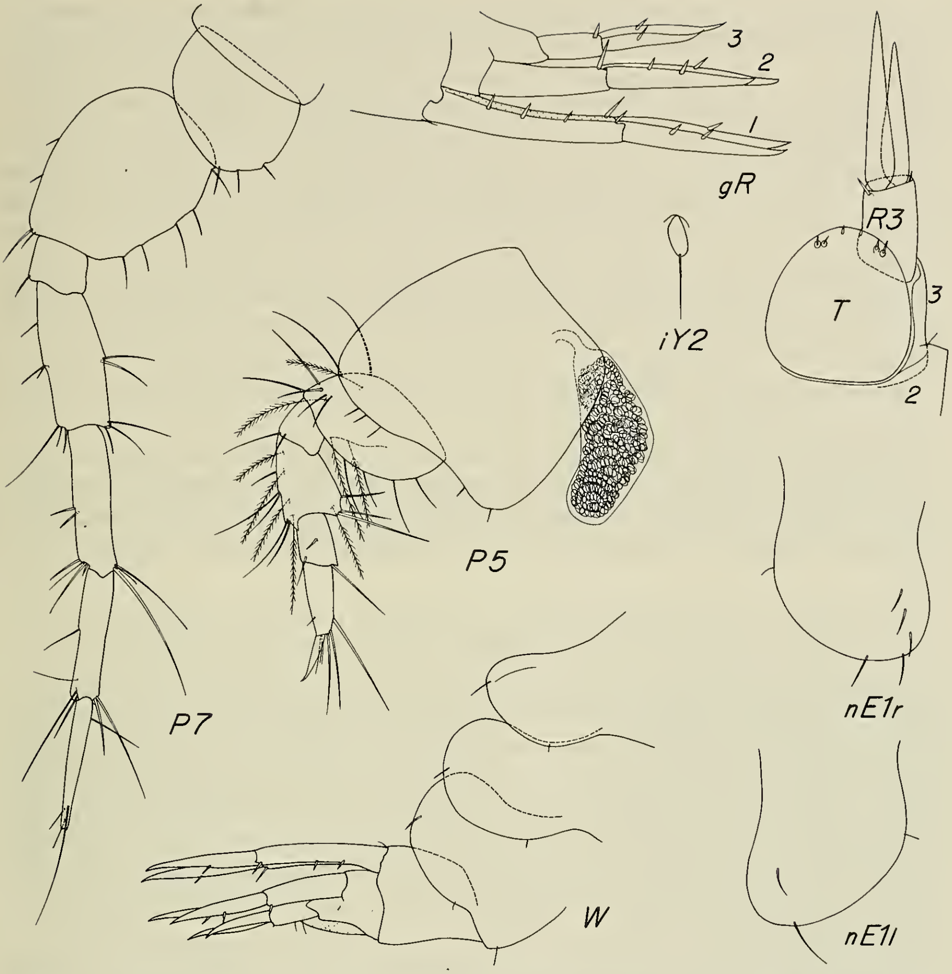

Fig. 3. *Perioculodes cerasinus,* unattributed figures, holotype, male "h" 1.5 mm; g = male "g" 1.7 mm; i = female "i" 1.81 mm; n = male "n" 1.9 mm.

inner ramus 1. The numerous peduncular spines of uropod 1 show no extravagant gaps. Article 2 of pereopod 7 with 8 posterior setae.

Largest specimen from Belize, specimen "z" 2.85 mm, with following spine counts: uropod 1 peduncle 6 (no extravagant gaps), outer ramus 2, inner ramus 1; uropod 2 peduncle 2, outer ramus 2, inner ramus 1.

*Illustrations.*—Main view of upper lip shown obliquely from below.

*Etymology.*—From "cerasinus," cherry colored.

*Holotype.*—USNM No. 195131, male "h" 1.57 mm, illustrated.

*Type-locality.*—Tobago, Kilwyn Bay, 2 Oct 1983, 1 m, in algae on sand reef, coll. J. L. Barnard.

*Material.*—The type-locality, female "i" 1.81 mm (illustrated), juvenile "j" 1.30 mm and 4 other specimens, "k, l, m, n." Florida Keys, Looe Key, Sta LKR

4H, 9 Oct 1983, 1 m, west end of rubble zone in backreef area, coll. J. D. Thomas, male "g" 1.70 mm (illustrated) and one other specimen.—Biscayne Bay, Florida, sta 35-4, 152 m east of Intracoastal Waterway Marker 65, 1.3 m, dense *Thalassia* and *Halodule,* 5 Mar 1983, coll. Biosystems Research Inc., Miami; specimen "p" 2.04 mm, specimen "q" 1.77 mm.—Bacha Shoal, Florida, 13 Oct 1982, nighttime suction dredge, coll. Dr. Iver Brook, 3 specimens, largest "i" = 2.75 mm.—Belize, region of Carrie Bow Cay, in South Water Cay Channel, 15 Jun 1980, 8.2 m, in patch reef and coral rubble with small attached coral heads, coll. J. D. Thomas (2 specimens).

*Ecology.*—Cryptic, usually collected in formalin washes of coral, coral rubble, or other hard substrates. Probably occupying isolated sediment-filled areas or cavities.

*Color.*—In life, pale white to ivory body, eyes deep cherry red. Red eye color persists in formaldehyde, fades in alcohol.

*Relationship.*—The species of *Perioculodes* are very diverse but we cannot find any differences of generic value between the type-species, *P. longimanus,* and our species, as they are either integrated by attributes of other species or because the sexual dimorphism in antennae of some of the species has not yet been worked out.

*Perioculodes cerasinus* differs from *Perioculodes longimanus* (Bate and Westwood) (eastern Atlantic), the type-species of *Perioculodes* Sars (1895), in the (1) short peduncle of female antenna 1 with article 3 being especially short; (2) presence of a raphus on the inner plate of the lower lip; (3) shorter article 6 on gnathopods 1 and 2; (4) division of coxae 1–3 and coxae 4–7 into groups with coxa 7 not disjunctly shorter than others within its series; (5) short peduncle of uropod 3 which is about half as long as the peduncle of uropod 2 (but as long as the peduncle in *P. longimanus*). In *Perioculodes longimanus* there is a sexual diversity in antennae which we have as yet not found in *P. cerasinus.* The first article of the mandibular palp is shorter and article 2 much more setose in *Perioculodes longimanus.*

*Perioculodes cerasinus* differs from the Indian Ocean *Perioculodes megapleon* Giles, 1888 (see also Pillai 1957; Rabindranath 1972; and Ledoyer 1973, 1979) in the short uropod 3, less setose maxilla 2 and antenna 2 in both sexes, the non-excavate telson, the much less armed dactyl of pereopod 7 and the much more sparsely setose pereopods 5–7 in general. *Perioculodes megapleon* appears to have the same coxal arrangement and the short article 3 on antenna 1 of the female as in our species.

*Perioculodes serra* Walker, 1904 (and see Ledoyer 1979) from the Indian Ocean has the short article 3 of antenna 1 and apparent short uropod 3 of our species, but the outer ramus of uropod 1 of *P. serra* is very short and the inner ramus grossly serrate; coxae 4–5 of *P. serra* have bent posteroventral lobes, mandibular palp articles 2–3 are strongly setose, the dactyls of pereopods 3 (and 4) are tiny, article 2 of pereopod 5 has a large posteroventral lobe and the general pereopod proportions are distinctive.

*Perioculodes acuticoxa* Ledoyer, 1973, differs from *P. cerasinus* in the very elongate and thin gnathopods, the presence of an anteroventral cusp on coxa 3, the slightly more spinose uropods 1–2, the truncate telson, and the different proportions and setae patterns of pereopods 6 and 7.

*Perioculodes aequimanus* Kossman, 1880, (see Stebbing 1906) is poorly described but has the same elongate gnathopods of *P. acuticoxa* and may be a synonym of that species.

*Perioculodes pallidus* Griffiths, 1975, from South Africa in 39 meters, has nine possible generic characters of distinction from the type-species, *P. longimanus,* as follows: (1) lack of eyes; (2) long rostrum; (3) poor to undeveloped lacinia mobilis; (4) enlarged pereopod 6; (5) naked uropods; (6, 7, 8) short uropods 2–3 with unequal rami on uropod 3; (9) emarginate telson.

Our species differs from *Perioculopsis lophopus* Schellenberg from Ghana in the (1) absence of a distoventral tooth on article 1 of antenna 1; (2) the smallness of the gland cone on antenna 2; (3) the well-toothed mandibular incisors; (4) the unbevelled posteroventral margin of coxa 6; (5) the equally extending rami of uropods 1–2 (in *Perioculopsis* the outer rami are shortened); and (6) the nonexcavate posterior margin of the telson.

The fusion of pleonites 5–6 in our species appears to be an apomorphic character quite remote from the same apomorphic expression in the Paracalliopiidae, an Indo-Pacific family with affinities to Oedicerotidae.

*Distribution.*—Biscayne Bay, Florida to Florida Keys to Tobago and Belize, 1–8 m.

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# *ZENARCHOPTERUS ORNITHOCEPHALA,* A NEW SPECIES OF FRESHWATER HALFBEAK (PISCES: HEMIRAMPHIDAE) FROM THE VOGELKOP PENINSULA OF NEW GUINEA

Bruce B. Collette

*Abstract.*—*Zenarchopterus ornithocephala* is the fifth freshwater species of the genus known from New Guinea. It resembles *Z. alleni* Collette and *Z. robertsi* Collette in having moderately high numbers of predorsal scales (more than 47), a connection of the supraorbital lateral-line canals across the top of the head, and a moderately large body size, but differs from those two species in having only the sixth anal fin ray enlarged in males instead of the fifth and sixth. It further resembles *Z. alleni* in having many vertebrae (49–50) but differs in having fewer predorsal scales (48–52 vs. 66), and a pectoral fin shorter than the head length.

Dr. Gerald R. Allen recently spent four months collecting in the freshwaters of New Guinea (Allen 1984). According to Dr. Allen (pers. comm.), the highlight of his 1982 trip was a 10-day foray via single engine Cessna in Irian Jaya, the Indonesian western half of the island of New Guinea. Among the new fish species collected on the Vogelkop Peninsula (Fig. 1) were a new *Melanotaenia,* a new teraponid, and a new *Zenarchopterus,* the fifth known from the freshwaters of New Guinea. The purpose of this paper is to describe the new species of *Zenarchopterus.* Methodology follows my previous papers on halfbeaks (Collette 1974, 1982). Material examined is in the collections of the Lembaga Biologi Nasional (National Biological Institute), Bogor, Indonesia (LBN); National Museum of Natural History, Washington, D.C. (USNM); the Western Australia Museum, Perth (WAM); and the Zoölogisch Museum, Universiteit van Amsterdam (ZMA).

## *Zenarchopterus ornithocephala,* new species
Fig. 2

*Diagnosis.*—Sixth anal fin ray of adult male enlarged (Fig. 3A). Many total predorsal scales (48–52), position of predorsal scale that overlaps scales both anteriorly and posteriorly far anterior, 45 scales anterior to origin of dorsal fin. Upper jaw longer than wide (width divided by length 0.74–0.84); lower jaw about equal to head length (head length divided by lower jaw length 0.96–1.01). Pectoral fin much shorter than head length (head length divided by pectoral length 1.55–1.72). No dorsal fin rays modified in males.

*Description.*—Dorsal and anal fin rays 14; pectoral fin rays 10. Vertebrae (31–32) + 18 = 49–50. Gill rakers on first arch (4–5) + (13–14) = 17–19, on second arch (0–2) + (14–15) = 14–16. Left and right supraorbital lateral line canals connected across top of head (Fig. 4A–B).

*Types.*—Holotype: LBN 5419 (♂, 124 mm SL); Irian Jaya; Vogelkop Peninsula; stream at Fruata, 2°59′S, 133°32′E; G. R. Allen and H. Bleher; 16 Nov 1982.—

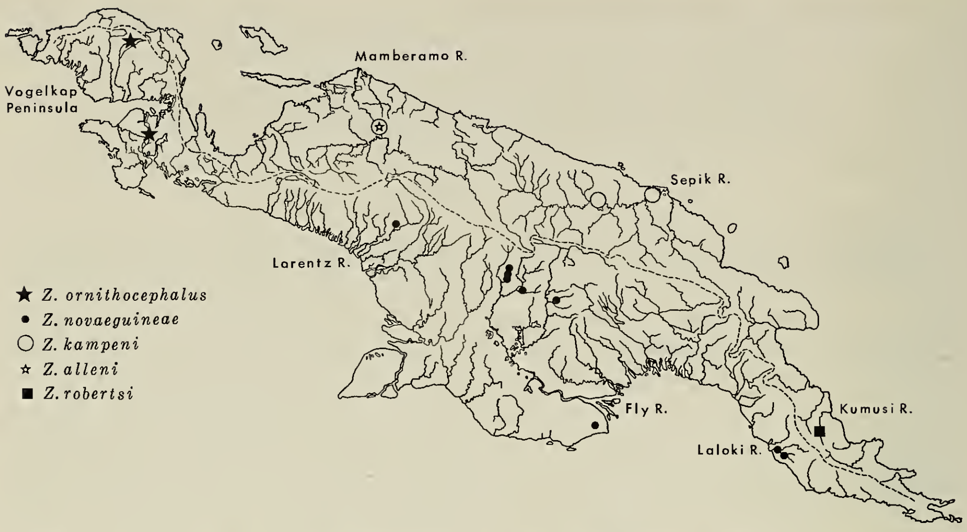

Fig. 1. Location of New Guinea rivers known to contain freshwater species of *Zenarchopterus*: *Z. ornithocephala* on the Vogelkop Peninsula; *Z. alleni* in the Mamberamo; *Z. kampeni* in the Mamberamo, Ramu, and Sepik; *Z. robertsi* in the Kumusi; and *Z. novaeguineae* in the Laloki, Fly, and Lorentz.

Paratypes: WAM P-27868-004 (♂, 93.9 mm SL) and USNM 266413 (♂, 94.5 mm SL); Irian Jaya; Vogelkop Peninsula; stream at Senopi, 0°50′S, 132°56′E; G. R. Allen and W. Tins; 18 Nov 1982.

*Etymology.*—A noun in apposition, from the Greek *ornis, ornithos* (bird) and *kephale* (head), after the Vogelkop (birdhead) Peninsula.

*Habitat.*—Notes on the habitat were kindly provided by Dr. Allen. Both sites were rainforest streams with slight turbidity. The bottom consisted of sand and gravel. The stream at Fruata was in mainly flat country at an elevation of 90 m; the stream at Senopi was in hilly terrain with a moderately fast flow at an elevation of 460 m. The pH was 7.8 and water temperature 28.3°C at Fruata; 7.5 and 27.5°C at Senopi.

*Comparisons.*—The five freshwater New Guinea species of *Zenarchopterus* share two specializations. They have more predorsal scales (33–66) than the other 13 species in the genus (26–34). They reach a larger maximum standard length (124–173 mm SL) than the marine species (126 mm, Collette 1982). The next largest species are *Z. buffonis* (Valenciennes)—126 mm; *Z. caudovittatus* (Weber)—123 mm; *Z. ectuntio* (Hamilton-Buchanan)—122 mm; and *Z. dispar* (Valenciennes)—121 mm.

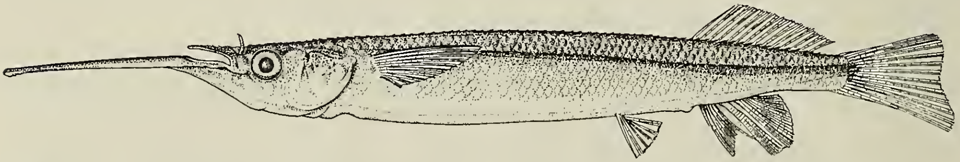

Fig. 2. *Zenarchopterus ornithocephala* LBN 5419, holotype, 124 mm, male; Irian Jaya; Vogelkop Peninsula; Fruata.

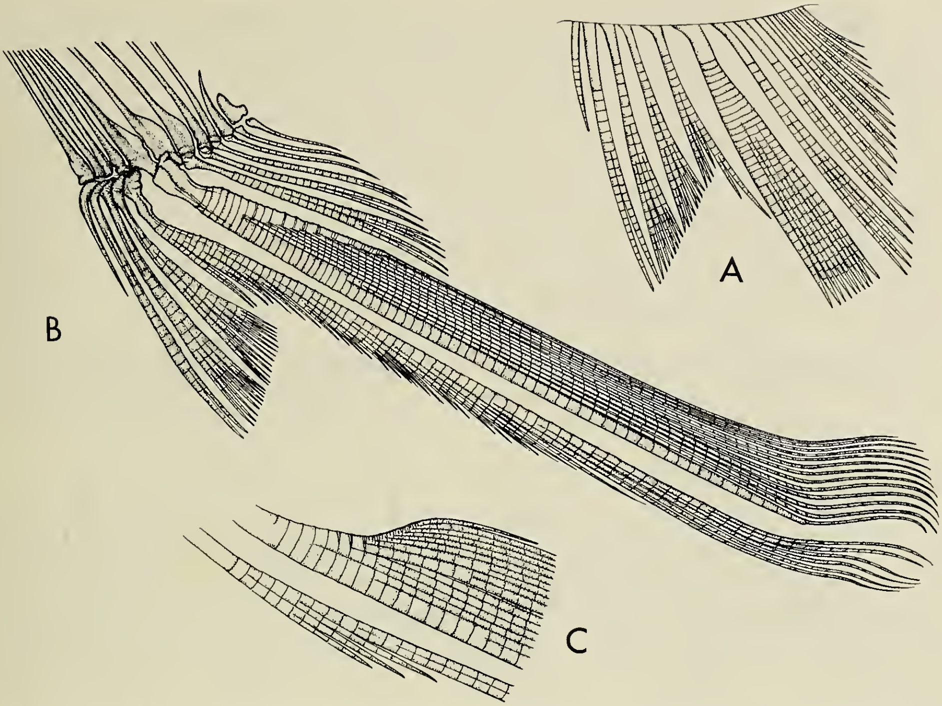

Fig. 3. Anal fin in males of three freshwater species of *Zenarchopterus* from New Guinea. A, *Z. ornithocephala,* holotype, LBN 5419; B, *Z. robertsi,* USNM 219229, 126 mm SL; C, *Z. alleni,* holotype, ZMA 116.479, basal portion of rays 5 and 6 only. (B and C from Collette 1982:fig. 3A–B).

Based on number of predorsal scales, maximum length, and male anal fin structure, the New Guinea freshwater species can be divided into two species groups: *Zenarchopterus kampeni* (Weber) and *novaeguineae* (Weber) have 33–47 predorsal scales; and the other three species have still higher counts, *robertsi* Collette and *ornithocephala* with 47–53 and *alleni* Collette with 66. *Zenarchopterus kampeni* and *novaeguineae* reach the largest size, 161 and 173 mm SL respectively. The other three freshwater New Guinea species are smaller, maximum sizes of 131 mm (*robertsi*), 130 mm (the unique holotype of *alleni*), and 124 mm (*ornithocephala*). *Zenarchopterus kampeni* and *novaeguineae* have the sixth anal fin ray enlarged and paddle-shaped (Collette 1982:fig. 3C–D); *robertsi* and *alleni* have the fifth and sixth rays greatly elongate (Fig. 3B–C), reaching beyond the caudal base; and *ornithocephala* has only the sixth ray enlarged:

Both *Z. ornithocephala* and *Z. alleni* have the left and right supraorbital lateral-line canals connected with a single median pore (Fig. 4A–C). The left and right canals are nearly connected in *Z. robertsi* (Fig. 4D) and *Z. novaeguineae,* but are completely separated in *Z. kampeni* (Collette 1982:fig. 5B) and many marine species of *Zenarchopterus.*

*Comparative material.*—In addition to collecting the three type-specimens of *Z. ornithocephala,* Dr. Allen and his associates collected additional material of three of the other four species of freshwater *Zenarchopterus* in Papua New Guinea from September to November, 1982. This material is listed here as an appendix to the material listed in Collette (1982).

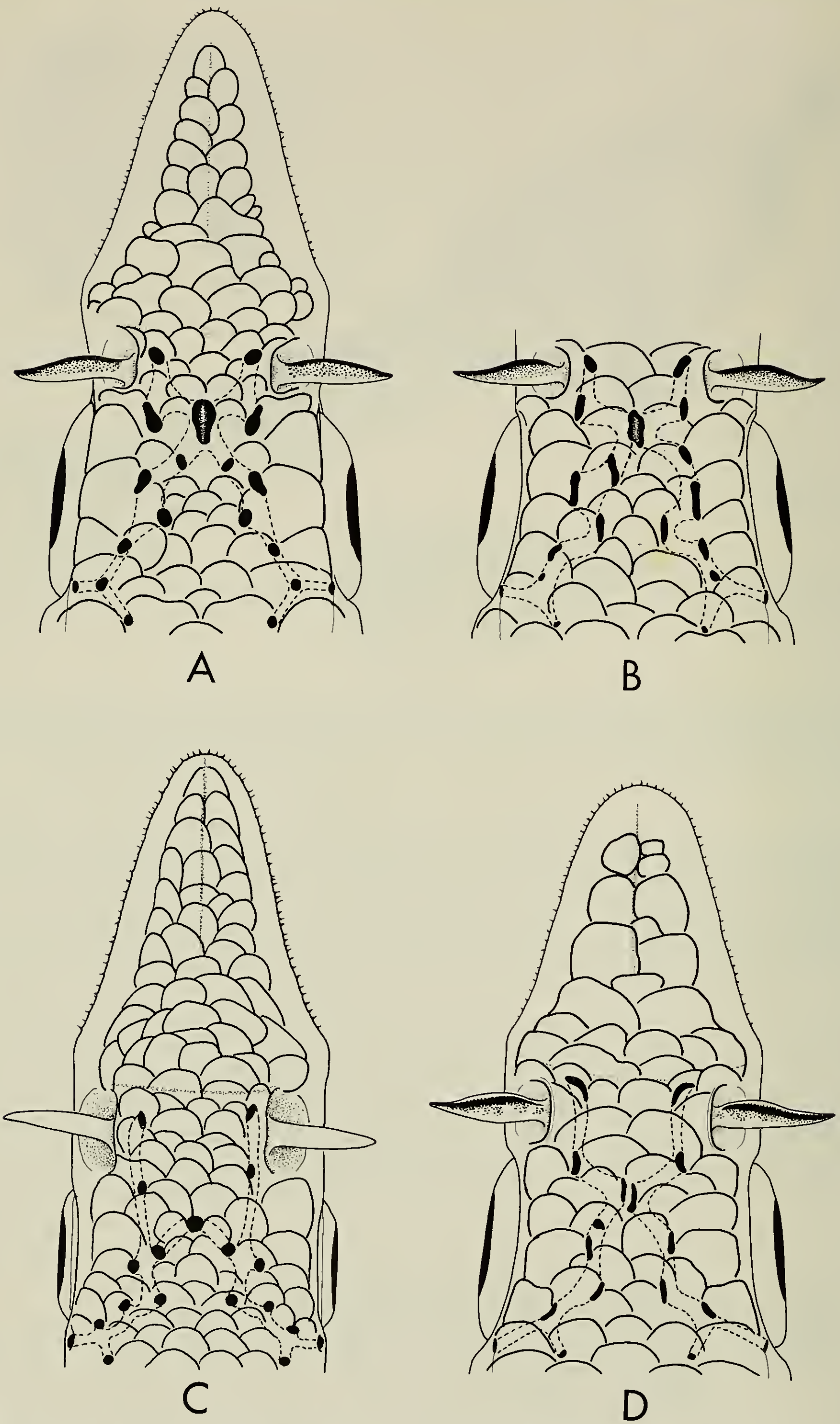

Fig. 4. Dorsal view of cephalic lateralis system in three freshwater species of *Zenarchopterus* from New Guinea. A, *Z. ornithocephala,* holotype, LBN 5419; B, *Z. ornithocephala,* paratype, USNM 266413; C, *Z. alleni,* holotype, ZMA 116.479. (Collette 1982:fig. 5A); D, *Z. robertsi,* paratype, USNM 219299.

*Z. kampeni.* Sepik R. WAM P-27847 (13, 28.9–125) and USNM 266411 (4, 113–144); Kwatit R. at junction with Sepik R.; 4°05′S, 143°06′E.

*Z. novaeguineae.* Oriomo R. WAM P-27815 (24, 41.1–118); Papua New Guinea; Oriomo R., 30 km upstream from mouth; 8°52′S, 143°11′E.

Fly R. WAM P-27812 (6, 51.5–148); trib. Nomad R., 1 km N of village; 6°18′S, 142°14′E.—USNM 266364 (1, 139); Nomad R., N of airstrip; 6°18′S, 142°14′E.—WAM P-27810 (1, 105); Hamami R. S of Nomad airstrip; 6°18′S, 142°14′E.—WAM P-27799 (4, 119–127); small creek 10 km S of Ningerum on Kiunga Rd.; 5°46′S, 141°08′E.—USNM 266363 (1, 113); Wai Somare R., 1 km S of Ningerum; 5°41′S, 141°09′E.—WAM P-27805 (1, 82.7); trib. of Ok Tedi R., 15 km N of Ningerum on Tabubil Rd.; 5°33′S, 141°16′E.

*Z. robertsi.* Kumusi R. WAM P-27790 (9, 65.5–128) and USNM 266412 (4, 96.2–125); Kaili Cr. 12 km E of Kokoda; 8°55′S, 147°47′E.

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# MORPHOMETRICS AND DISTINCTNESS OF THE HEDGEHOG GENERA (INSECTIVORA: ERINACEIDAE)

C. Brian Robbins and Henry W. Setzer

*Abstract.*—Five genera (*Erinaceus, Atelerix, Hemiechinus, Paraechinus, Aethechinus*) have been described in the hedgehog subfamily Erinaceinae. Using non-mensural characters, previous authors have recognized from one to five of these genera as valid. Population samples of the five named genera were compared using multivariate statistics on selected cranial measurements. Results of the statistical analyses, coupled with non-mensural characters, distribution, ecology, and fossil history, indicate that all five genera are distinct and all should be recognized.

The subfamily Erinaceinae includes five nominal genera: *Erinaceus* Linnaeus, 1758, *Atelerix* Pomel, 1848, *Hemiechinus* Fitzinger, 1866, *Paraechinus* Troussart, 1879, and *Aethechinus* Thomas, 1918. The status of these names ranges from the recognition of a single genus (*Erinaceus,* Dobson 1882), three genera (*Erinaceus, Hemiechinus,* and *Paraechinus*—see Corbet 1974, 1978; Honacki, Kinman, and Koeppl 1982), four genera (*Erinaceus, Hemiechinus, Paraechinus,* and *Atelerix*—see Dorst and Dandelot 1969), to all five as valid genera (Thomas 1918; Cabrera 1925; Allen 1939; Simpson 1945). A recent classification (Nowak and Paradiso 1983), although recognizing three genera (*Erinaceus, Hemiechinus,* and *Paraechinus*), subdivides *Erinaceus* into subgenera as: genus *Erinaceus,* with subgenera *Erinaceus* (one species) and *Atelerix* (four species, including two attributable to *Aethechinus.*

All categories above the species level include groups that are genetically and morphologically discontinuous between one another. Those taxa cannot be satisfactorily defined in absolute terms because of the possibility of the absence of a marked discontinuity between taxa of the same rank. However, a genus is generally regarded as containing one or more species phenetically separable from other genera by a decided gap between species clusters. For practical reasons, the more species in a species-group the smaller the gap needed to recognize it as a separate genus, and the smaller the number of species, the larger the gap needed to recognize it (Mayr 1969). The function of the genus is to group monophyletic (related) species and facilitate information retrieval.

Mayr (1969) gave the following criteria for delimiting and ranking taxa: (1) distinctness (size of gap)—measured in terms of phenetic distance and the biological significance of the difference; (2) evolutionary role (uniqueness of adaptive zone)—analyzed by its ecological significance and evolutionary history; (3) degree of difference—phenetically, the distance between means of two groups of species; (4) size of taxon—number of species; and (5) equivalence of ranking in related taxa.

Various combinations of characters could be used to construct a key to differentiate each of the five genera or to recognize four, three, two, or only one genus.

Because previous generic distinctions were based on non-mensural characters, we decided to compare samples of the named genera by using multivariate statistical analyses on selected cranial measurements to determine if another method would satisfactorily differentiate the genera.

In the following analyses we determine the degree of difference between groups, the type of scatter of a cluster, and whether or not there is equivalence of ranking in related taxa. The following questions were then asked and answered using results from the statistical analyses:

1) Are species clusters evident?
2) Are there gaps between the species clusters?
3) Are the species clusters of uniform density?
4) Are the species clusters large and heterogeneous?
5) Do the individual clusters include only specimens considered to be a part of the same genus (sensu stricto)?

It is also possible that a combination of mensural and non-mensural characters would better define the genera. Therefore, a sixth question was also asked:

6) Are species clusters (genera) better defined using results from statistical analyses as well as previously used non-mensural characters?

*Materials and methods.*—To assess the degree of difference (distinctness) of these five genera, specimens from several localities within the range of each genus were selected to include as many of their taxa as were available. Nine cranial measurements were taken and subjected to the NT-SYS multivariate statistical programs (Rohlf, Kishpaugh, and Kirk 1972) and the BMD computer programs (Dixon 1973). Character means of each sample were used when the sample size was greater than two. The standardized means or individual specimen measurements were used to compute matrices of average distance and correlation coefficients among the samples. The unweighted pair-group method using arithmetic averages (UPGMA) was used in the cluster analysis and presented as a phenogram. Non-metric multidimensional scaling (MDSCALE; Kruskal 1964a, b), were also provided by the NT-SYS programs. The BMD07M stepwise discriminant function analysis provided overall discrimination among the groups using the raw data from all individual specimens.

*Specimens used in the analyses.*—Species names are those recognized by Honacki *et al.* 1982. Subspecies names are included for those samples which have been named, by geographic area, in various publications. These are followed by country localities and sample size. Sample numbers used in Figs. 1 and 2 are indicated in parentheses.

*Erinaceus europaeus europaeus*—Germany, 10 (1); *E. e. hispanicus*—Spain, 3 (2); *E. concolor*—Turkey, 3 (3); *Paraechinus aethiopicus*—Morocco, 10 (4); Niger, 2 (6 and 7); Mauritania, 1 (5); *P. a. dorsalis*—Egypt, 4 (8); *P. a. deserti*—Egypt, 1 (11); *P. micropus*—W. Pakistan, 1 (9); *P. hypomelas*—Iran, 1 (10); *Aethechinus algirus*—Morocco, 11 (12); *A. frontalis*—South Africa, 17 and Namibia, 2 (13); *Hemiechinus auritus libycus*—Egypt, 12 (14); *H. a. aegyptius*—Egypt, 9 (15); *H. a. auritus*—Iran, 2 (16 and 17); *Atelerix albiventris albiventris*—Senegal, 22 (21); *A. a. spiculus*—Nigeria, 18 (19); *A. albiventris*—Ghana, 6 (20); Bourkina Fasso (Upper Volta), 10 (18).

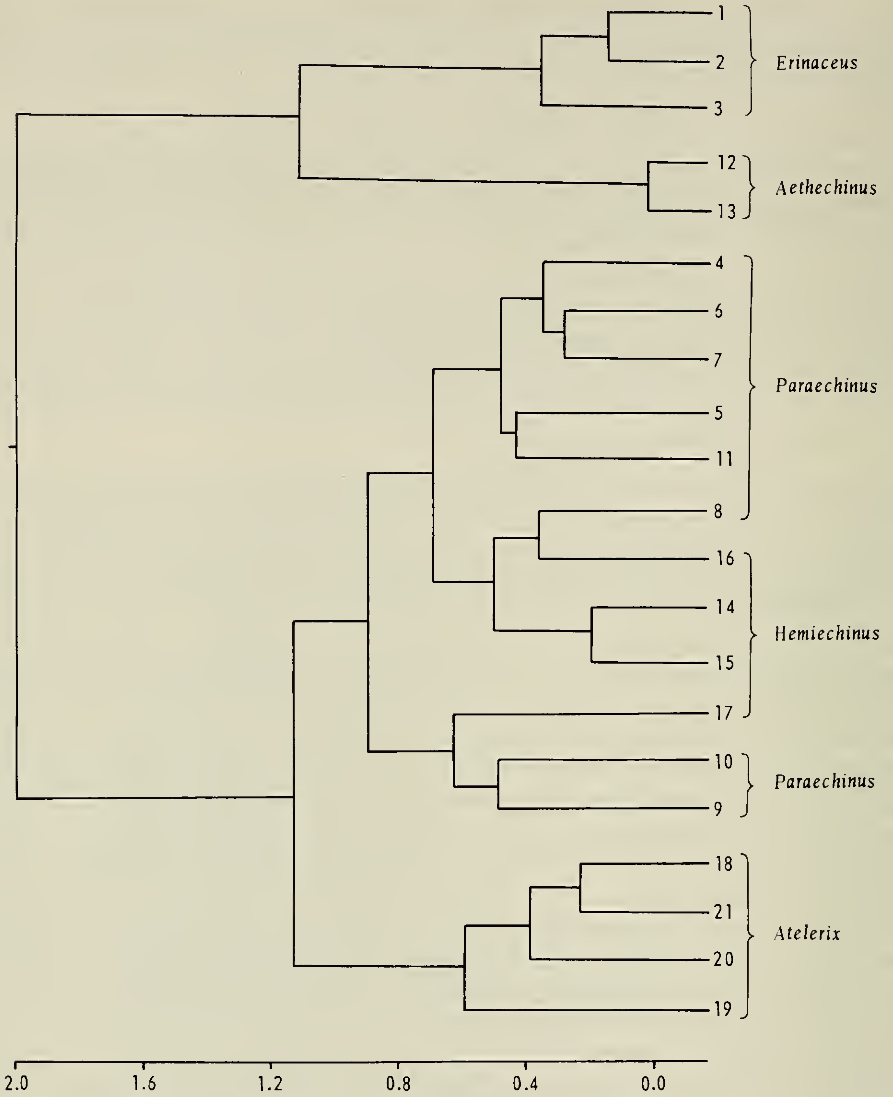

Fig. 1. Phenogram based on distance matrix of NT-SYS analysis of five genera of hedgehogs. Numbers refer to taxa and localities listed in the text. The cophenetic correlation is 0.898.

*Results.*—Some of the most common characters used by Anderson (1895), Miller (1912), Thomas (1918), Allen (1922), Cabrera (1925), and Corbet (1974, 1978) to compare or contrast the five genera are shown in Table 1. Morphological comparisons by Corbet (1974, 1978) led him to conclude that *Erinaceus, Atelerix,* and *Aethechinus* were congeneric (*Erinaceus*). Thus construed, *Erinaceus* incorporates all of the characters listed in Table 1 for *Erinaceus, Atelerix,* and *Aethechinus.* The remaining characters in Table 1 characterize *Hemiechinus* and *Paraechinus.*

*Erinaceus,* as defined by Corbet (1974, 1978), differs from both *Hemiechinus* and *Paraechinus* only by having a small postglenoid process. In addition, it differs

Table 1.—Morphological characters used to differentiate the five genera of hedgehogs.

| | *Erinaceus* | *Atelerix* | *Aethechinus* | *Hemiechinus* | *Paraechinus* |
|---|---|---|---|---|---|
| I3 and C—no. of roots | one | two | two | two | two |
| P3—size | normal | reduced or absent | normal | normal | reduced |
| Postglenoid process vs. mastoid process | smaller | smaller | smaller | same | larger |
| Pterygoids and bullae size | normal | normal | normal | normal | large |
| Hallux | normal | generally absent | normal | normal | reduced |
| Posterior palatal shelf | narrow | broad | broad | narrow | narrow |
| Spine-part on crown | present | present | present | absent | present |
| Ears | small | small | small | large | large |

from *Hemiechinus* by having a median spine-part on the crown of the head and from *Paraechinus* by having normal-sized pterygoids and bullae. *Hemiechinus* differs from the other two in lacking a median spine-part on the crown. It also differs from *Paraechinus* by having normal-sized pterygoids and bullae. *Paraechinus* is distinguishable from the other two genera by its inflated pterygoids and bullae.

Results of the UPGMA clustering analysis of specimens are shown as a phenogram in Fig. 1, which reveals two large and distinct clusters. *Erinaceus* and *Aethechinus* are clustered together and separated from the other three genera. Population samples of the taxa in *Erinaceus* and *Aethechinus,* as a part of the same large cluster, form distinct clusters of their own that show quite distinctive morphometric (cranial measurement) or phenetic distance between them. In the second or bottom cluster, *Atelerix* is distinct from both *Paraechinus* and *Hemiechinus.*

Figure 2, showing the MDSCALE projection, gives a better representation of the phenetic distance separating the five genera. The minimum spanning tree (Prim 1957) connects those samples closest in phenetic distance, yet shows the distances between the taxa compared. In this analysis, *Erinaceus, Aethechinus,* and *Atelerix* separate into distinct groups. The African samples of *Paraechinus* (numbers 4, 5, 6, 7, 8, 11) are also linked and clustered. The two samples of *Paraechinus* from Asia (9, 10) are linked but separated from the African samples by a specimen of *Hemiechinus* (17). The other three samples of *Hemiechinus* are linked.

A discriminant function analysis (Fig. 3) provided additional information for evaluating the morphometric differences between the five genera. The discriminant analysis shows that the degree of difference, as reflected by the distances between group means, is highly significant. The probability that all samples are allocated correctly to a particular group is $P \geq 0.90$. The probability for most is $P \geq 0.95$. The character vectors included in the figure (Power and Tamsitt 1973) show the cranial measurements and their relative contribution in the separation of the five clusters.

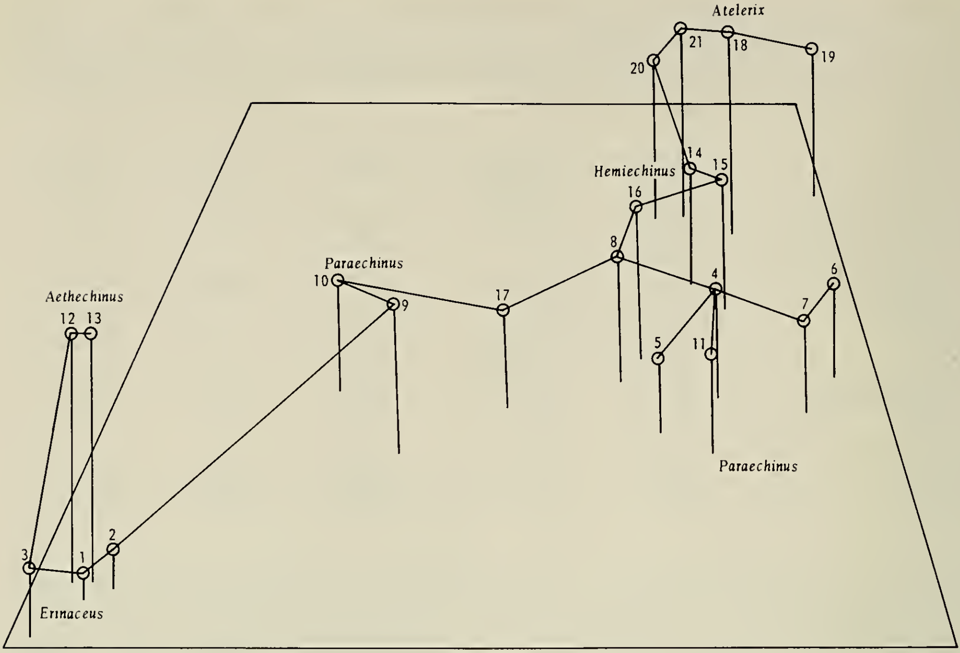

Fig. 2. Three-dimensional projection of MDSCALE analysis with minimum spanning tree for samples of hedgehog genera. For sample numbers refer to text. Stress is 0.033.

The distance between groups (size of gap) should be inversely proportional to the number of species in each group (size of taxon) in Fig. 3. For example, *Erinaceus* is represented by the fewest species but is separated from the other genera by the largest gaps and distance between group means. *Erinaceus* also has a dense species cluster. The degree of difference among the other genera is nearly equal. The distinctness of those genera, as reflected by distance (gap) between groups, varies. *Paraechinus* and *Hemiechinus* have homogeneous clusters and are separated by a decided gap. Both are separated from the other groups by even larger gaps. *Atelerix* and *Aethechinus* are closest in gap distance but the mean distance between their clusters is significant and they are well separated from the other genera. *Atelerix* has a dense and uniform cluster while the *Aethechinus* cluster is large, probably indicating greater heterogeneity.

The NT-SYS principal components analysis based on a correlation matrix (not figured) showed that cranial-size measurements (first component) separated *Erinaceus* and *Aethechinus* from the other three genera, of which *Atelerix* has the smallest skulls. *Erinaceus* was separated from *Aethechinus* in the second component, which was influenced positively by breadth of braincase and negatively by length of palatal shelf. Although *Erinaceus* has slightly larger breadth of braincase measurements than *Aethechinus,* its length of palatal shelf measurements are much smaller (see Table 1). *Paraechinus* has the largest breadth of braincase measurements relative to skull length, reflecting the inflated bullae in members of this genus. Except for *Aethechinus, Atelerix* has the longest length of palatal shelf measurements.

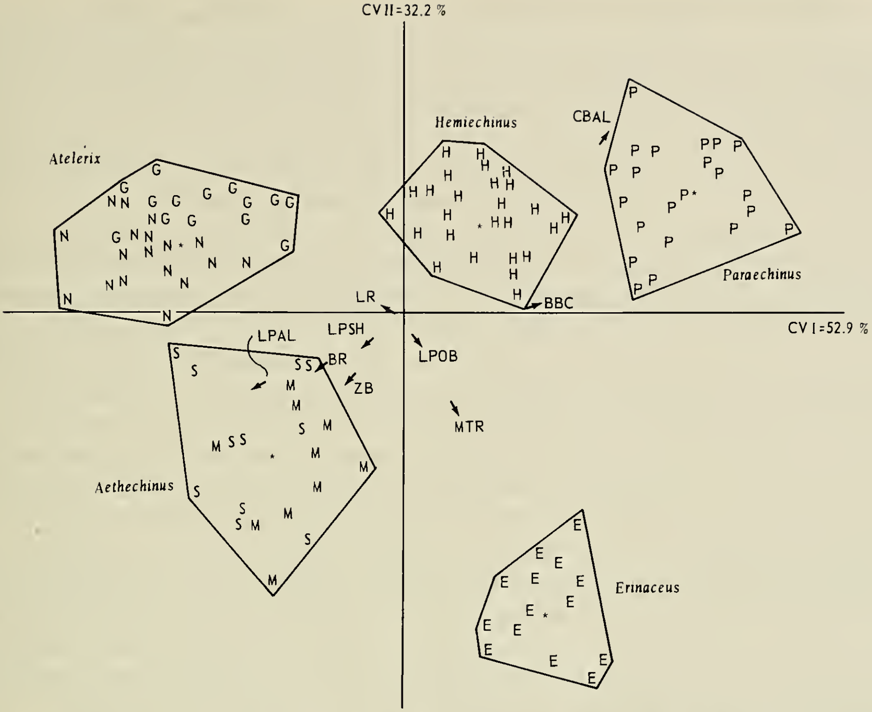

Fig. 3. Projection of the first two canonical variates in a discriminant analysis of samples of hedgehog genera. Arrows indicate vectors for the nine cranial measurements. Abbreviations are: CBAL—condylobasal length; LR—length of rostrum; MTR—alveolar length of upper molar tooth row; LPAL—length of palate; LPSH—length of palatal shelf; LPOB—least postorbital breadth; BR—breadth of rostrum; BBC—breadth of braincase; ZB—zygomatic breadth; N—Nigeria; G—Senegal; M—Morocco; S—southern Africa; CV I and CV II—canonical variates one and two; percent of cranial measurement variation accounted for by each is indicated.

*Discussion and Conclusions.*—The distinctiveness of each taxon based on the characters listed in Table 1 can be, as expected, subjective. The number of species recognized in each genus is also inconsistent among authors. *Erinaceus* is generally regarded as having one polytypic species, but Corbet and Hill (1980) recognized three species; *Paraechinus* contains three or four species; *Aethechinus* includes two or three species; *Hemiechinus* contains two or three species; and *Atelerix* contains several described taxa that need further study.

Butler (1978) summarized the distribution and fossil history of the five genera. He reports that *Erinaceus* is known from the Miocene to Recent in Europe, and Pleistocene to Recent in Asia in deciduous and Mediterranean woodland vegetation zones. *Atelerix* is known only from the Recent in Africa where it occurs throughout the savanna vegetation zones. *Hemiechinus* is known only from the Recent in southern Asia and northeastern Africa in semi-arid steppe or savanna regions. *Paraechinus* is known only from the Recent in southern Asia and northern Africa in desert regions. *Aethechinus* is recognized from the Recent in north and south African temperate to dry savanna habitats. These time and geographic ranges give an indication of evolutionary role, distribution, and ecological differences.

In Africa, four genera are geographically and ecologically separated. *Hemiechinus* is in the northeastern part where its range slightly overlaps that of *Aethechinus* in Libya. *Paraechinus* occurs in all of the North African deserts and slightly overlaps *Aethechinus* in Morocco and Algeria. *Atelerix* is found south of the Sahara desert in the savanna zones and does not co-occur with any other genus in the north. *Aethechinus* occurs again in southern Africa and may slightly overlap *Atelerix* in the northern part of its (*Aethechinus*) range.

*Erinaceus* is the only genus in Europe except for introduced *Aethechinus* which persists as localized populations in southern Spain and France. Three genera occur in Asia, with *Erinaceus* occupying the northernmost areas in the woodland steppe regions. It slightly overlaps *Hemiechinus* in some parts of its range but does not occupy the semi-arid steppe areas that *Hemiechinus* prefers. The desert-inhabiting genus *Paraechinus* slightly overlaps the range of *Hemiechinus* in some areas.

The five genera all have unique adaptive zones. Those that share similar ecologies are geographically separated. Different habitats and different distributions plus evidence from the fossil record (Butler 1978) indicate that these five also had different evolutionary histories. The differences in use of the environment are responsible for the width and distinctness of the gaps between the genera.

The six questions posed in the introduction can all be answered. Species clusters are evident; there are gaps between the clusters; four clusters are dense and uniform, the other is large and heterogeneous; each cluster includes only specimens considered to be a part of the same genus; and the species clusters are better defined using a combination of mensural and non-mensural characters.

*Paraechinus* and *Hemiechinus* are not clearly separated by the mensural data in Figs. 1 and 2. However, using non-mensural characters (Table 1), these distinctive genera are readily separable as was shown by Corbet (1974). This is supported by the data in Fig. 3 which show a decided gap and distance between group means. Using the results of these statistical analyses and the non-mensural characters from Table 1, five genera of hedgehogs are indicated. Morphological analyses also show that *Erinaceus* and *Aethechinus* are more closely related to each other and form a unit apart from the other three genera. If subgenera within *Erinaceus* (Nowak and Paradiso 1983) were justified, then they should be *Erinaceus* and *Aethechinus,* not *Erinaceus* and *Atelerix.* Nowak and Paradiso (1983) included species of *Aethechinus* with *Atelerix.* Morphologically, *Aethechinus* and *Atelerix* are not closely related. Their fossil records (Butler 1978) and geographic distributions suggest to us that European and Asian *Erinaceus* could have given rise to *Aethechinus,* which is now represented by separate species in northern and southern Africa.

Generic classifications using qualitative characters that recognize fewer than five genera need modification. Equivalence of ranking in related taxa, when applying unweighted non-mensural characters, can only result in the recognition of one or five genera. The results from the morphometric analyses of cranial measurements support the recognition of five genera (*Erinaceus, Aethechinus, Paraechinus, Hemiechinus,* and *Atelerix*) as given by Thomas (1918), Cabrera (1925), Allen (1939), and Simpson (1945). Recognition of five genera of hedgehogs also groups closely related species and avoids unnecessarily complicated arrangements resulting from using any other taxonomic grouping. Such an interpretation is possible using non-mensural morphological characters coupled with results of the statistical analyses.

*Erinaceus:* Relatively large animals with long and broad skulls; CBAL usually greater than 55 mm; I3 and C single rooted; P3 normal in size; postglenoid process smaller than mastoid process; pterygoids and bullae normal (not inflated); palatal shelf narrow; hallux well developed; a median spine-part present on crown of head; ears small, not projecting above head-spines.

*Hemiechinus:* Medium to large animals with medium to large skulls; CBAL ranges from 45 to 55 mm; I3 and C double rooted; P3 normal; postglenoid process same size as mastoid process; pterygoids and bullae normal; palatal shelf narrow; hallux well developed; median spine-part on crown of head absent; ears large, projecting above head-spines.

*Aethechinus:* Large animals with large skulls; CBAL ranges from 45 to 60 mm; I3 and C double rooted; P3 normal; postglenoid process smaller than mastoid process; pterygoids and bullae normal (not inflated); hallux well developed; palatal shelf broad; median spine-part on crown present; ears small.

*Paraechinus:* Medium animals with medium length but broad skulls; CBAL ranges from 40 to over 50 mm; I3 and C double rooted; P3 reduced in size; postglenoid process larger than mastoid process; pterygoids and bullae markedly inflated; hallux reduced; palatal shelf narrow; median spine-part on crown present; ears large, projecting well above head-spines.

*Atelerix:* Small animals with small skulls; CBAL usually less than 45 mm; I3 and C double rooted; P3 reduced or absent; postglenoid process smaller than mastoid process; pterygoids and bullae normal; palatal shelf broad; hallux usually absent, but if present then greatly reduced in size; median spine-part on crown present; ears small.

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# THE CORRECT IDENTITY OF THE PELAGIC AMPHIPOD *PRIMNO MACROPA*, WITH A DIAGNOSIS OF *PRIMNO ABYSSALIS* (HYPERIIDEA: PHROSINIDAE)

Thomas E. Bowman

*Abstract.*—Two large species of *Primno* are recognized: *P. macropa* Guérin-Méneville, an inhabitant of the Subantarctic biotic province, and *P. abyssalis* (Bowman), a resident of the Subarctic biotic province. *Primno macropa* is redescribed, and records from USNS *Eltanin* cruises mapped. It is suggested that *P. macropa* expanded its range into the North Pacific during a period of cooling. The North Pacific population became isolated when warming occurred and evolved into a distinct species, *P. abyssalis.*

In my revision of *Primno* (Bowman 1978) I identified as the type-species, *P. macropa* Guérin-Méneville, a large form that appeared to be confined to Subarctic water in the North Pacific. I made this identification with some misgivings, since the type-locality was "les mers du Chile." But I did so because the North Pacific form was the only one available to me that matched Guérin-Méneville's species in body length and in the form of pereopod 5. I had been unsuccessful in my attempts to obtain large specimens of *Primno* from the Southern Hemisphere. Recently, however, I received from Brain P. Boden specimens of a large form of *Primno* from the vicinity of Marion Island in the southern Indian Ocean. This form is very similar to the North Pacific form, but differs consistently in several details. I consider the two forms to be specifically distinct, and the Marion Island form to represent the true *Primno macropa.* Additional material of the true *P. macropa* has been identified in collections made during cruises of the USNS *Eltanin* for the U.S. Antarctic Research Program. Figure 2 shows the locations of these records. The North Pacific species identified as *Primno macropa* by Bowman (1978) is herein referred to *Primno abyssalis* (Bowman, in Fulton 1968).

### *Primno abyssalis* (Bowman, 1968)
Fig. 1A–K

*Euprimno abyssalis* Bowman, 1953:348–354, figs. 45–46, charts 114–116 [unpublished].—Bowman, in Fulton, 1968:104, 109.

*Primno macropa* Guérin-Méneville.—Thorsteinson, 1941:93–94, figs. 98–102.—Vinogradov, 1956:209.—Yoo, 1971a:59 [partim]; 1971b, passim; 1972a, passim; 1972b:174.—Sanger, 1973:20, 1974:7.—Lorz and Pearcy, 1975:1445–1446.—Bowman, 1978:3–8, figs. 1–2, 3a–c, 4.—Brusca 1981:43, fig. 15b.—Semenova, 1982:354–355 [partim], fig. 189.

*Euprimno macropus* (Guérin-Méneville).—Wailes, 1929:161; 1931:41; 1933:9.—Behning, 1939:363.

*Types.*—Holotype, adult ♀, 14 mm in length, Scripps Institution of Oceanography *Northern Holiday* expedition sta 12, 10 Aug 1951, 40°34′N, 147°54.5′W,

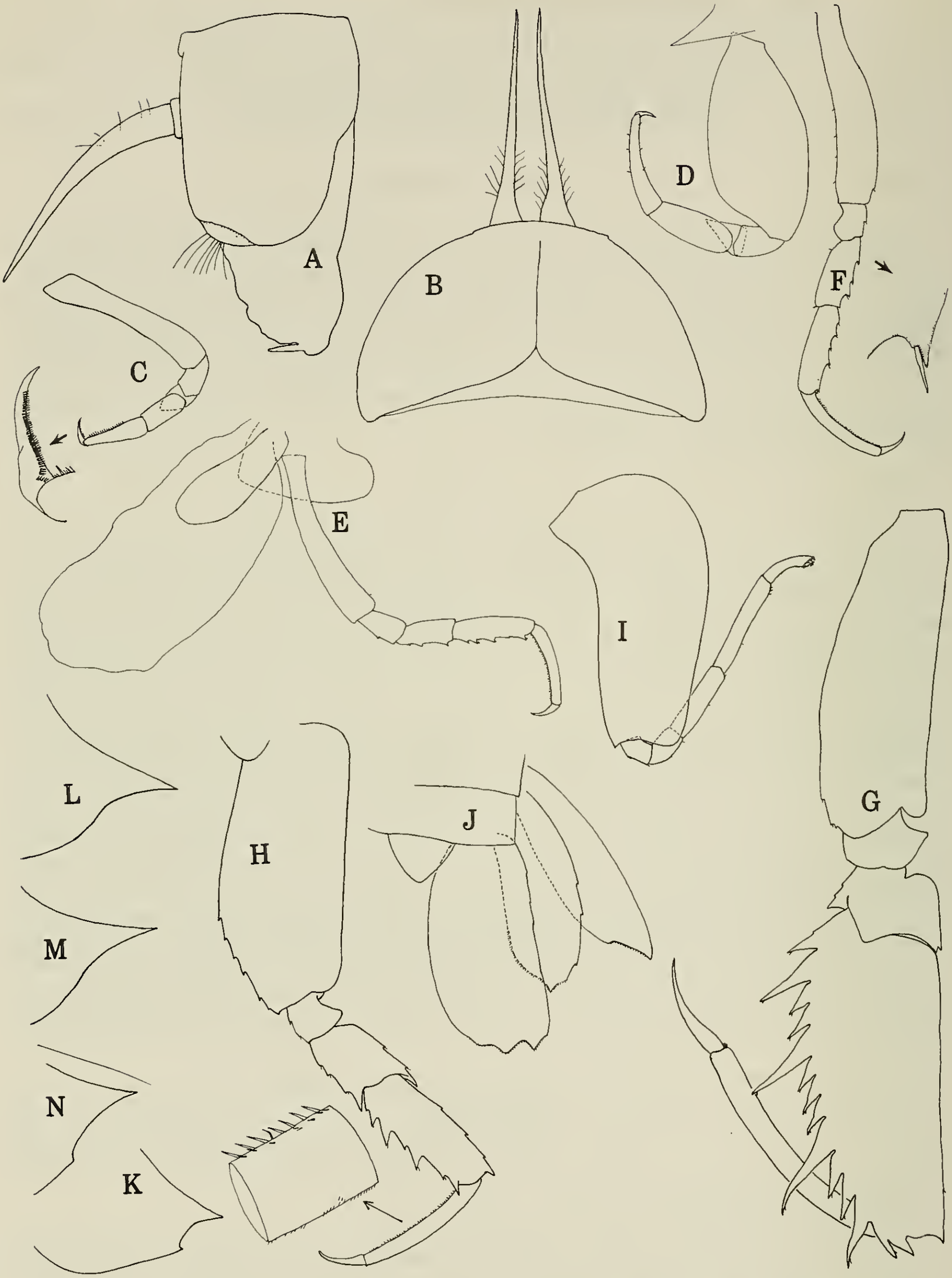

Fig. 1. A–K, *Primno abyssalis* ♀: A, Head, lateral; B, Head, dorsal; C–I, Pereopods 1–7; J, Telson and uropods; K, Posteroventral corner of pleonite 3. L–N, *Primno macropa*: Posteroventral corners of pleonite 3 of three different females.

Isaacs-Kidd midwater trawl, 1020-0 m, USNM 213613. Paratypes, 2 ♀, 14 mm in length, from same sample, deposited in collections of Scripps Institution of Oceanography.

*Etymology.*—From the Latin "abyssus" (bottomless depth) + the adjectival suffix "-alis," referring to the bathypelagic distribution of the species.

*Diagnosis* (emended from Bowman 1978).—Length up to 21 mm. Rostrum truncate, limited to space between antennae 1. Middorsal spines more pronounced than in other species of *Primno*. Pleonite 3 with shallow concavity ventral to posteroventral spine, with or without low defining notch. Antenna 1 only slightly longer than head. Rudimentary ♀ antenna 2 with few inconspicuous setae. Pereopod 5 carpus with proximal 1–2 teeth short; long teeth slightly shorter than width of carpus. Pereopod 6 basis slightly more than ⅓ as wide as long, narrowed proximally, proximal part of anterior margin concave; ischium, merus and carpus narrower than in other species of *Primno*; merus about ⅔ length of carpus. Pereopod 7 basis about as long as remaining segments combined. Uropod 3 with well developed medial shoulder.

*Distribution.*—Subarctic biotic province, North Pacific.

### *Primno macropa* Guérin-Méneville
Fig. 1L–N

*Primno macropa* Guérin-Méneville, 1836:4, pl. 17, fig. 1a–f.—Bovallius, 1887: 28.—?Spandl, 1927:168–169.—Barnard, 1930:424–425 [partim]; 1932:287–288 [partim].—Mackintosh, 1934, passim.—Hardy and Gunther, 1935, passim.—Hurley, 1955:172–174, figs. 219–235; 1969:33, map 7.—Vinogradov, 1962: 22.—Semenova, 1982:354–355 [partim].

*Primno menevillei* Stebbing, 1888:1447–1448, pl. 179B.

*Primno antarctica* Stebbing, 1888:1448–1451, pl. 209B.

*Euprimno macropus* (Guérin-Méneville).—Bovallius, 1889:400–407 [partim].—Walker, 1907:9.

*Euprimno macropa* Guérin-Méneville var. *menevillei* Stebbing.—Monod, 1926: 50–51, fig. 49.

*Material.*—Near Marion Island, Prince Edward Islands: Sta 6, no. 133, 46°52'S, 37°54'E, 100–0 m, 5 May 1983, 1 ♀; Sta 11d, 44°42'S, 22°30'W, 1000–500 m, 21 May 1983, 4 ♀; Sta 18, no. 41, 46°38'S, 38°05E, 100–0 m, 24 May 1983, 1 ♀. From collections of USNS *Eltanin* in the Southern Ocean: localities shown in Fig. 2 (complete station data available upon request).

*Diagnosis.*—Similar to *Primno abyssalis* but with the following differences: Body shorter, up to about 15 mm in length. Rostrum broad-truncate, conforming to contour of head, about 0.4 width of head. Middorsal spines slightly less well developed. Pleonite 3 with deeper concavity ventral to posteroventral spine, defined by a tooth. ♀ antenna 1 about ⅕ longer than head. Rudimentary ♀ antenna 2 with well developed cluster of delicate setae. Pereopod 6 not so slender; anterior margin of basis convex throughout length; merus about half length of carpus; posterior margin of propus with minute setae.

*Distribution.*—Subantarctic biotic province.

*Relationships.*—*Primno macropa* and *P. abyssalis* differ from the other species of *Primno* in their large size and in the pattern of teeth on the pereopod 5 carpus.

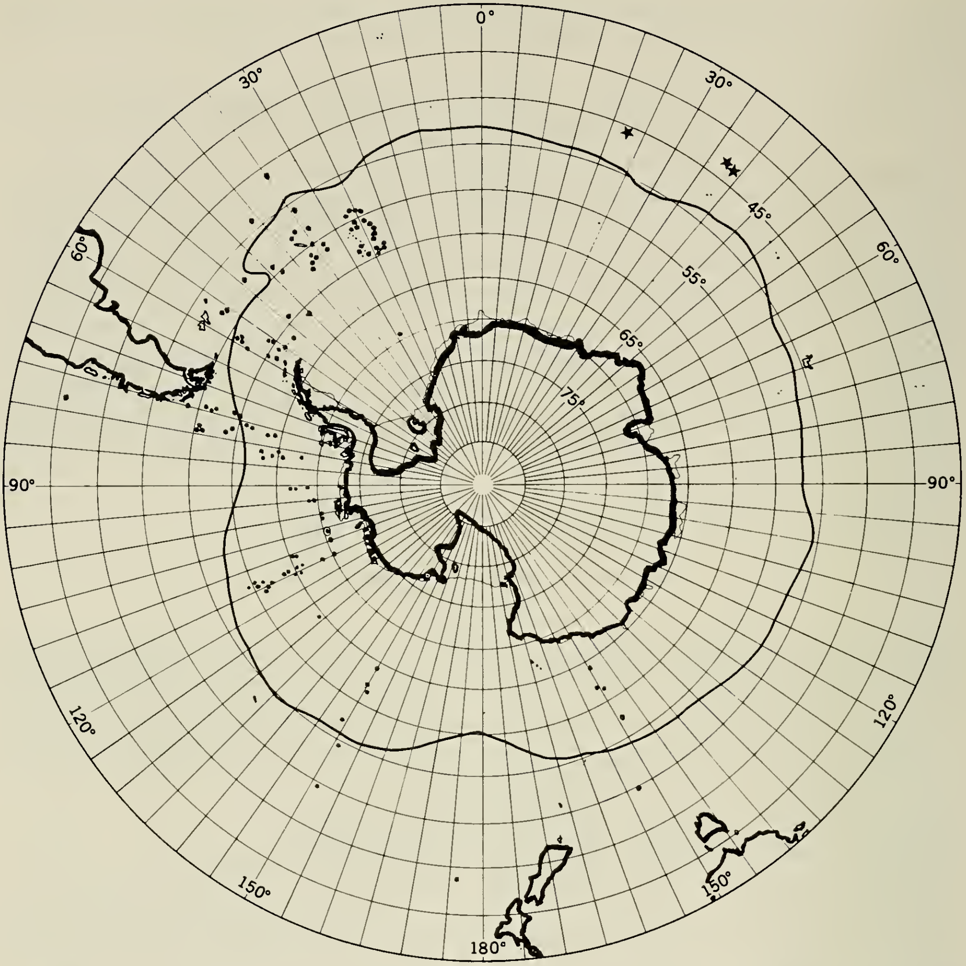

Fig. 2. Records of *Primno macropa* from cruises of USNS *Eltanin* (dots) and from Marion Island stations (stars).

They also live at greater depths and in higher latitudes than the other species. I suggest that *P. macropa* is the older of the two large species and gave rise to *P. abyssalis* as follows:

Originally *P. macropa* or its progenitor was limited to the Southern Hemisphere and there was no large *Primno* in the North Pacific. Cooling of the oceans by a few degrees during an ice age permitted *P. macropa* to expand its range into the North Pacific by way of the western coasts of South and North America. When the oceans warmed again the continuity was broken, leaving the North Pacific population isolated from that of the Southern Hemisphere. Since this isolation, the populations developed the small but constant differences that now require their recognition as distinct species. A number of species of zooplankton and nekton have a distribution pattern like that of *P. macropa-abyssalis* combined, occupying what McGowan (1974) calls the Subarctic and Subantarctic biotic province.

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# POLYCHAETE WORMS FROM A CAVE IN THE BAHAMAS AND FROM EXPERIMENTAL WOOD PANELS IN DEEP WATER OF THE NORTH ATLANTIC (POLYNOIDAE: MACELLICEPHALINAE, HARMOTHOINAE)

Marian H. Pettibone

*Abstract.*—*Pelagomacellicephala iliffei,* n. gen., n. sp. a macellicephalin polynoid is described from a cave in Middle Caicos Island, *Bathykermadeca turnerae,* n. sp. and *Bathybahamas charleneae,* n. gen., n. sp. also in the Macellicephalinae, and *Harmothoe ingolfiana* and *H. vagabunda,* n. sp. in the Harmothoinae are described from four experimental "wood islands" in deep water of the North Atlantic.

Of particular interest is a recent collection of some polynoid polychaetes from Conch Bar Cave, Turks and Caicos islands in the Bahamas, belonging to the Macellicephalinae, a subfamily of the Polynoidae known primarily from the deep sea, including bathyal and abyssal depths (Pettibone 1976). Four specimens were collected by Thomas M. Iliffe and Jill Yager in connection with their studies of cave faunas. They are referred, herein, to *Pelagomacellicephala iliffei,* n. gen., n. sp. The following comments on the habitat of the worms were kindly furnished by Dr. Iliffe.

The Turks and Caicos Islands are geologically and geographically a southeastward extension of the Bahamas. The Bahama Platform, including the Caicos Bank, consists of a cap of shallow water carbonates thicker than the surrounding ocean is deep (Dietz *et al.* 1970). This suggests that a shallow water depositional environment has been maintained in this region since at least the early Cretaceous. Slow subsidence, offset by deposition of coral and algal carbonates, has maintained the top of the platform nearly at sea level.

The Caicos Bank is a shallow water platform bordered by a series of islands extending along the northern and eastern margins. The major islands consist of a broad expanse of low lying flat land facing the interior of the platform, while a range or series of ranges of eolian carbonate hills 20 to 40 m in elevation fronts the seaward margin, parallel to the long axis of the islands. The youngest hills closest to the seashore are unconsolidated dunes consisting of reef-derived carbonate sand washed ashore and then blown inland by the prevailing trade winds. Those hills further inland are older, probably Pleistocene in age, and have been lithified into a hard eolian limestone. Caves are situated within these lithified dunes, while large circular collapsed shafts, called "blue holes" (Dill 1977), are found in shallow waters of the interior platforms.

Conch Bar Cave, reportedly in excess of 2.5 km long (Gregor 1981), is the largest and most significant cave in the Turks and Caicos group. The cave is developed in a coastal dune-derived hill (Conch Bar Hill) located 500 m inland from the open ocean. It consists of multiple levels, the lowest of which is permanently flooded with tidal brackish waters 10 or more meters deep. The four polynoids were collected from a broad shallow pool containing considerable amounts of organic detritus including leaves, twigs, and land snail shells in the sediments. Surface salinity in the pool was 23‰. Other animals found in the cave include the amphipod *Spelaeonicippe provo,* large numbers of the shrimps *Barbouria cubensis* and *Typhlatya garciae,* a new species of troglobitic mysid *Stygiomysis clarkei* described by Bowman *et al.* (1984) and several copepods now under study.

Another troglobitic polynoid was found inhabiting a sea water-flooded lava tube cave in the Canary Islands, the Jameos del Agua, collected by Wilkens and Parzefall (1974). It was described as *Macellicephala jameensis* in the Macellicephalinae by Hartmann-Schroder (1974), later revised and referred to a new genus, *Gesiella,* in the Harmothoinae by Pettibone (1976:64), and, still later, referred to a new subfamily, Gesiellinae, by Muir (1982:173). This extensive lava cave, despite being only 3000 to 5000 years old, contains fauna of both Tethyan and deep sea origins (Wilkens and Parzefall 1974; Iliffe *et al.* (1984).

A number of studies have pointed out the importance of plant remains of shallow-water or epipelagic origin (wood, leaves, fruit, sea grass, *Sargassum,* etc.) to the macrofauna of the deep sea, and these are summarized by Torben Wolff (1979). For instance, wood is used as a substrate and food for opportunistic boring bivalve mollusks, such as *Xylophaga.* Such macrofaunal herbivores are available as prey for predators, as dead remains for scavengers, and their fecal pellets can be utilized by deposit feeders. Polychaetes were found to be the dominant group, seeking shelter under the bark and in cavities of the wood.

Four species of deep-sea polynoids have been identified from wood panels that were submerged and later retrieved after one to three years at four permanent DSRV *Alvin* deep Atlantic bottom stations, in connection with the experimental studies being carried out by Ruth Turner on wood-boring mollusks (Pholadidae, Xylophagainae: *Xylophaga* and *Xylorado*). Turner (1973) found that after three and a half months some wood panels that had been pushed into the bottom sediment at a depth of 1830 meters were riddled by the burrows of the bivalve mollusks. These deep-sea wood-borers are opportunistic species and ". . . are the most important deep-sea organisms involved in converting woody plant material to available food sources (1) in the form of fecal pellets for detritus feeders, (2) as larvae or adults, exposed by distintegration of the wood, for predators, and (3) as dead remains for scavengers" (Turner 1973:1379).

In connection with the "wood-island" and panel experiments of Turner (1977, 1981), large "wood islands" (12 blocks of spruce, 30 cm on a side) were placed by DSRV *Alvin* at two Deep Ocean Stations (DOS) south and southeast of Woods Hole, Massachusetts, in 1830 and 3506 meters, one in the Tongue of the Ocean (TOTO, TOWER 3), the deep "fjord" in the shallow Great Bahama Bank, in 2066 meters, and one off St. Croix in 3995 meters. Around these "wood islands," a series of wood panels (60 by 15 by 3 cm) were pushed in the mud. When the areas were visited later, some panels were retrieved and replaced after variable lengths of time, from 9 months to three years. The panels were placed in retrieval boxes for fixation of the specimens at bottom temperature and pressure, assuring the best possible condition of the specimens. From the panels riddled by the boring xylophagids, a great variety of other organisms was collected, including detritus feeders and predators, and, among the latter, numerous polynoid worms.

Table 1.—Polychaetes identified from wood panels in North Atlantic.

| Species | DSRV *Alvin* "Wood Island" Stations | | | |
|---|---|---|---|---|
| | DOS-1 | DOS-2 | TOTO Tower 3 | St.-Croix |
| Polynoidae: | | | | |
| Macellicephalinae: | | | | |
| *Bathykermadeca turnerae,* n. sp. | 2 spec. | 10 spec.<br>(some young) | 33 spec.<br>(many young) | 51 spec.<br>(many young) |
| *Bathybahamas charleneae,* n. gen., n. sp. | | | 2 spec. | |
| Harmothoinae: | | | | |
| *Harmothoe ingolfiana* Ditlevsen | 372 spec.<br>(many young) | 184 spec.<br>(many young) | | |
| *Harmothoe vagabunda,* n. sp. | | | 7 spec. | 36 spec.<br>(many young) |
| Ampharetidae:* | | | | |
| *Decemunciger apalea* Zottoli | 69 spec.<br>(64 juv.) | 26 spec.<br>(10 juv.) | 1 spec.<br>(juv.) | |
| *Endecamera palea* Zottoli | | | | 18 spec. |

* See Zottoli (1982).

After preliminary sorting by Helene Ferranti and Charlene D. Long, assistants to Ruth Turner, the polynoid worms were sent to me for identification. From this collection of Polynoidae, four species were identified, two belonging to the usually deep water Macellicephalinae and two in the Harmothoinae. Zottoli (1982) reported on the polychaetes of the sedentary tube-dwelling family Ampharetidae, which were collected on some of the same panels.

The collection sites and species of Polynoidae and Ampharetidae are summarized below and in Table 1.

Locations of four experimental "wood islands":

1. Deep Ocean Station-1 (DOS-1), 110 miles south of Woods Hole, Massachusetts, 39°46′N, 70°41′W, in 1830 meters.
2. Deep Ocean Station-2 (DOS-2), 190 miles southeast of Woods Hole, Massachusetts, 38°18′24″N, 69°35′36″W, in 3506 meters.
3. Tongue of the Ocean, Bahama Islands (TOTO, TOWER 3), 24°53′12″N, 77°40′12″W, in 2066 meters.
4. Off St. Croix, Virgin Islands, 17°57′36″N, 64°48′36″W, in 3995 meters.

The types and additional specimens are deposited in the National Museum of Natural History, Smithsonian Institution (USNM). Types of *Harmothoe ingolfiana,* deposited in the Zoological Museum, Copenhagen (ZMC), were examined.

## Family Polynoidae

### Subfamily Macellicephalinae Hartmann-Schroder, 1971

Pettibone (1976:6–42) included seven genera in the subfamily Macellicephalinae, the type-genus *Macellicephala* McIntosh, 1876, and six new genera: *Bathycatalina, Bathyeliasona, Bathyfauvelia, Bathykermadeca, Bathykurila,* and *Bathyvitiazia.* Pettibone (1979:384–388) emended *Bruunilla* Hartman, 1971, and added it to the subfamily. Levenstein (1981:27–29) added *Bathypolaria* and *Bathymiranda.* Levenstein (1982b:1291–1296) added *Bathytasmania* and *Bathynotalia* and provided a key to the genera of the Macellicephalinae. However, her figure of the type-species of *Bathynotalia, B. perplexa,* shows the prostomium with lateral antennae (not mentioned in the text), in addition to the median antenna, palps and tentacular cirri (fig. e, in Levenstein 1982b). On this basis the genus is herein referred to Harmothoinae. Further, the prostomium of *Bathymiranda microcephala* Levenstein (1981, fig. 2a) lacks both lateral and median antennae and, on this account, is referred herein to Polaruschakovinae Pettibone, 1976.

*Diagnosis of Macellicephalinae.*—Body short, with relatively few segments (15–24). Prostomium bilobed; median antenna with distinct ceratophore and distal style; paired palps; without lateral antennae, with or without tapered frontal filaments; without eyes. Modified first or tentacular segment more or less fused to prostomium; tentaculophores lateral to prostomium, each with acicular process of variable development, with or without few setae and pair of dorsal and ventral tentacular cirri. Facial tubercle anterior and ventral to prostomium, more or less developed. Second or buccal segment with first pair of elytra, biramous parapodia and long ventral or buccal cirri attached basally on neuropodia lateral to ventral mouth. Muscular pharynx eversible, with 2 pairs of jaws and up to 9 pairs of papillae around opening. Parapodia long, biramous, both notopodia and neuropodia subconical with elongate acicular processes. Paired elytra and bulbous elytrophores relative few (7–12 pairs), on segments 2, 4, 5, 7, continuing on alternate segments to near end of body. Dorsal cirri with cylindrical cirrophores and distal styles, attached posterior to notopodia on segments 3, 6, 8, continuing on alternate and posterior segments lacking elytra. Dorsal tubercles on cirrigerous segments, corresponding in position to elytrophores, indistinct or more or less developed. Ventral cirri short, on ventral side of neuropodia on all segments. Pygidium variable in position and size, with dorsal anus and pair of anal cirri. Ventral nephridial or segmental papillae indistinct or variously developed on certain segments.

Three genera, each with a single species, are covered in this report: *Pelagomacellicephala iliffei,* new genus, new species; *Bathykermadeca turnerae,* new species; *Bathybahamas charleneae,* new genus, new species.

## *Pelagomacellicephala,* new genus

*Type-species.*—*Pelagomacellicephala iliffei,* new species. Gender: feminine.

*Diagnosis.*—Segments up to 21. Elytra and elytrophores 9 pairs, on segments 2, 4, 5, 7, 9, 11, 13, 15, and 17. Bilobed prostomium with rounded anterior lobes, without frontal filaments, with median antenna and palps, without lateral antennae or eyes. Tentaculophores of tentacular segment with 2 pairs of tentacular cirri, without projecting acicular process or setae. Dorsal cirri on non-elytra-bearing segments, with long styles. Dorsal tubercles on cirrigerous segments short, nodular. Parapodia long, biramous, both rami with projecting acicular processes, notopodia much shorter and smaller than neuropodia. Notosetae few, shorter and subequal in width to neurosetae, with double rows of close-set thickened serrations along one side. Neurosetae numerous, delicate, flattened, with serrate lateral borders. Ventral cirri short, but long on segment 2. Pharynx with pair of extra long middorsal and midventral papillae and 4 pairs of short lateral papillae; 2 pairs of jaws with basal teeth.

*Etymology.*—*Pelago,* from *pelagos,* Greek, sea, plus *macellicephala,* indicating the close relationship of this sea worm to the type-genus of the subfamily. Gender: feminine.

### *Pelagomacellicephala iliffei,* new species

Fig. 1

*Material examined.*—BAHAMAS: Turks and Caicos Islands, Middle Caicos Island, Conch Bar Cave, 28 Oct 1982, collected by hand with suction bottle while snorkeling in large 1 to 1.5 m deep tidal pool in totally dark section of cave, Thomas M. Iliffe and Jill Yager, collectors; holotype, USNM 96262, and 3 paratypes, USNM 96263-5.

*Description.*—Length of holotype (largest specimen) 9 mm, width 5 mm including setae, segments 21, last one small. Length of smallest young paratype (USNM 96264) 5 mm, width 2.5 mm, segments 19. Body flattened, tapered anteriorly and posteriorly, with long parapodia angled downward. Color: white, translucent, giving general appearance of pelagic polychaete.

Elytra and bulbous elytrophores 9 pairs, on segments 2, 4, 5, 7, 9, 11, 13, 15, and 17 (Fig. 1A, C). Elytra large, covering dorsum, delicate, transparent, showing "veins," without tubercles or papillae (Fig. 1G). Dorsal cirri on non-elytra-bearing segments; dorsal tubercles on cirrigerous segments from segment 8, short, nodular (Fig. 1B, D).

Prostomium deeply bilobed, with anterior lobes rounded; median antenna with small ceratophore in middle of prostomium, with very long, slender, smooth style; palps stout, long, tapered (Fig. 1A). Tentacular segment not distinct dorsally; tentaculophores lateral to prostomium, with 2 pairs of long dorsal and ventral tentacular cirri, those dorsal longer than ventral ones; bilobed facial tubercle anterior to prostomium (Fig. 1A). Second or buccal segment with first pair of large elytrophores, well-developed biramous parapodia and ventral or buccal cirri similar to tentacular cirri, attached to basal part of neuropodia lateral to ventral mouth (Fig. 1A). Pharynx with especially long middorsal and midventral papillae and 4 pairs of small papillae near lateral borders (Fig. 1H); 2 pairs of jaws with basal teeth (11–15) (Fig. 1I).

Parapodia biramous, as long as body width (Fig. 1A–D). Notopodia much shorter than neuropodia, subconical, with projecting acicular process on lower side. Notosetae few (up to 6), delicate, slightly curved, with 2 rows of close-set thickened serrations along one side and blunt tips (Fig. 1E). Neuropodia large, with projecting triangular acicular process, diagonally truncate supraacicular area and slightly rounded, truncate, subacicular area. Neurosetae numerous, forming fan-shaped bundle, delicate, fragile (many broken), flattened, serrate along lateral borders (Fig. 1F). Dorsal cirri with cylindrical cirrophores attached to posterodorsal side of notopodia; styles delicate, transparent, smooth, variable in length, some extending to tips of setae or far beyond (on small paratype, some dorsal cirri up to half length of animal) (Fig. 1D). Ventral cirri short, tapered, attached close to distal end of neuropodia (Fig. 1C, D).

Pygidium bulbous, enclosed by parapodia of posterior segments, with dorsal

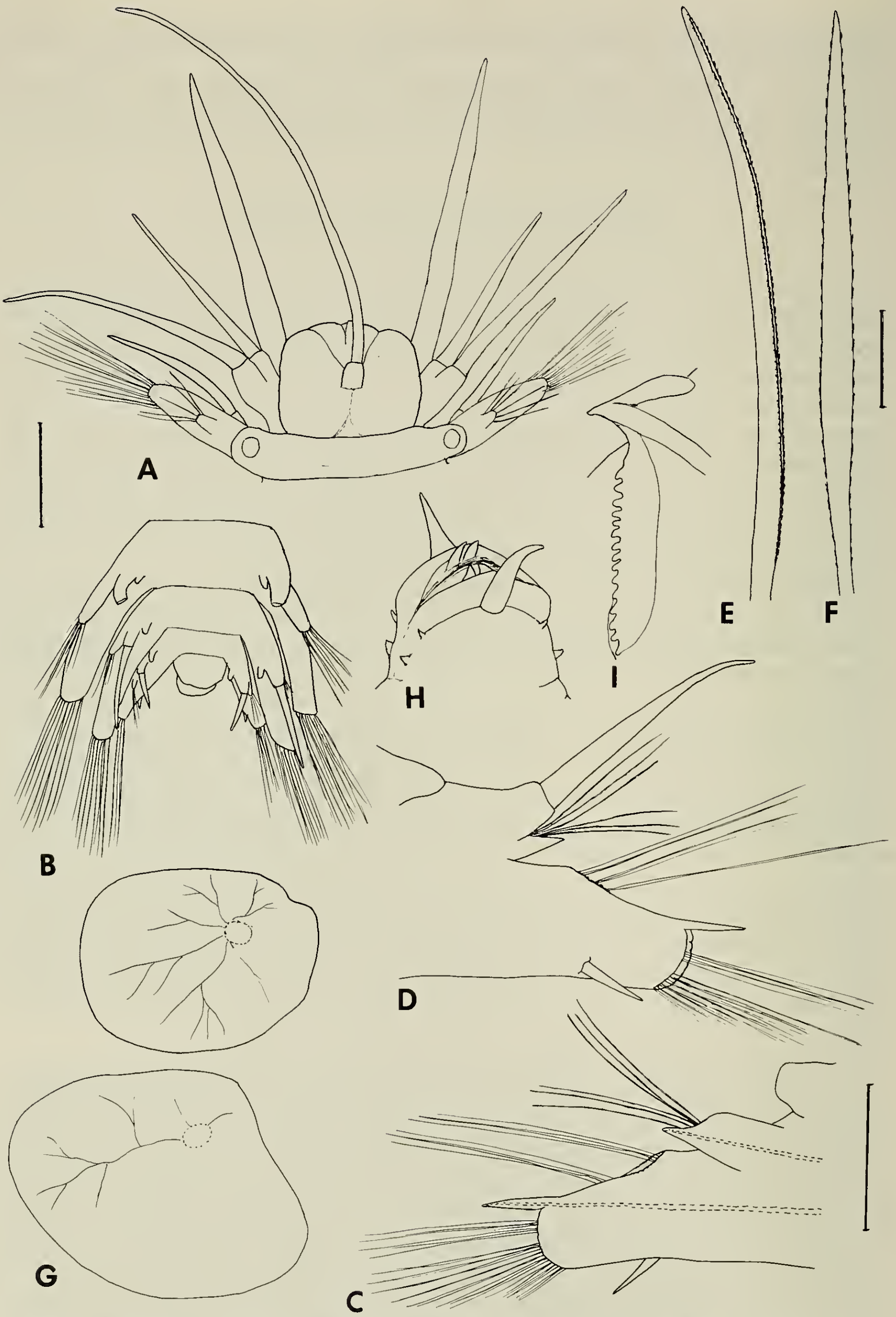

Fig. 1. *Pelagomacellicephala iliffei,* A–G, holotype, USNM 96262; H, I, paratype, USNM 96265: A, Anterior end, dorsal view; B, Posterior end, dorsal view, including cirrigerous segments 19–21; styles of dorsal cirri missing on segment 19; C, Right elytrigerous parapodium segment 9, anterior view, acicula dotted; D, Right cirrigerous parapodium segment 10, posterior view; E, Notoseta; F, Neuroseta; G, Two left elytra; H, Dorsal view of extended pharynx, turned slightly to right; I, Jaw. Scales: = 0.5 mm for A, B, G, H; 0.5 mm for C, D; 0.1 mm for E, F, I.

anus and rounded ventral lobe, anal cirri missing (Fig. 1B). Ventral segmental or nephridial papillae indistinct, none enlarged.

*Distribution.*—Known only from anchialine habitat of Conch Bar Cave, Middle Caicos, Turks and Caicos Islands, Bahamas. (See Introduction.)

*Etymology.*—The species is named for Thomas M. Iliffe, one of the collectors, in recognition of his interesting studies on cave faunas.

*Comparisons.*—The pharynx of *Pelagomacellicephala* differs from all other genera in the Macellicephalinae in having especially long middorsal and midventral papillae, small lateral papillae and jaws with a row of basal teeth. *Pelagomacellicephala iliffei* may be separated from the other two species of Macellicephalinae described herein according to the Key on page 142.

*Pelagomacellicephala iliffei* agrees in a number of respects with *Gesiella jameensis,* found in a lava tunnel cave in the Canary Islands: both are short-bodied, translucent, with 9 pairs of delicate elytra, similar parapodia, and lack eyes. The pharynx of *G. jameensis* is of the usual polynoid type, with 9 pairs of papillae and 2 pairs of jaws without basal teeth; the pharynx of *P. iliffei* is unique, as indicated above. The prostomium of *P. iliffei* lacks lateral antennae, placing it in the Macellicephalinae; *G. jameensis* has small lateral antennae inserted ventrally, placing it in the Harmothoinae (Pettibone 1976:60) or in Gesiellinae, based on the unique accessory filamentous organs on the cirrophores of the dorsal cirri (Muir 1982:173).

### *Bathykermadeca* Pettibone, 1976

*Type-species.*—*Macellicephala hadalis* Kirkegaard, 1956. Gender: feminine.

*Diagnosis.*—Segments 21. Elytra and elytrophores 9 pairs, on segments 2, 4, 5, 7, 9, 11, 13, 15, and 17. Prostomium deeply bilobed, conical anterior lobes with frontal filaments; ceratophore of median antenna inserted in anterior notch, with paired palps; without lateral antennae or eyes. Tentaculophores of tentacular segment lateral to prostomium, with 2 pairs of tentacular cirri and projecting acicular process, without setae. Dorsal cirri on non-elytra-bearing segments except segment 19 (lacks both elytra and dorsal cirri). Dorsal tubercles on cirrigerous segments inconspicuous or nodular. Parapodia biramous, both rami with elongate acicular processes, subequal in length. Notosetae subequal in length to and stouter than neurosetae, with 2 rows of spines and blunt tips. Neurosetae of 1 or 2 types. Posterior 4 segments somewhat modified and compressed. Pharynx with 7 pairs of dorsal and ventral papillae; 2 pairs of jaws with or without basal teeth.

A single species, *B. hadalis,* was previously referred to *Bathykermadeca,* as *Macellicephala hadalis* Kirkegaard, 1956, from South Pacific in the Kermadec Trench, in 6600–6720 meters. Additional records of this hadal species have been added by Levenstein (1978:165) from the Yap Trench in 8560–8720 meters, and by Levenstein (1982a:59) from the Japan Trench in 7350–7370 meters.

A new species from the North Atlantic is here added, *B. turnerae.*

### *Bathykermadeca turnerae,* new species

Figs. 2, 3

*Material examined.*—North Atlantic off St. Croix, Virgin Islands, 17°57′36″N, 64°48′36″W, 3995 m, R. D. Turner Panel Study. Panels submerged on *Alvin* dive

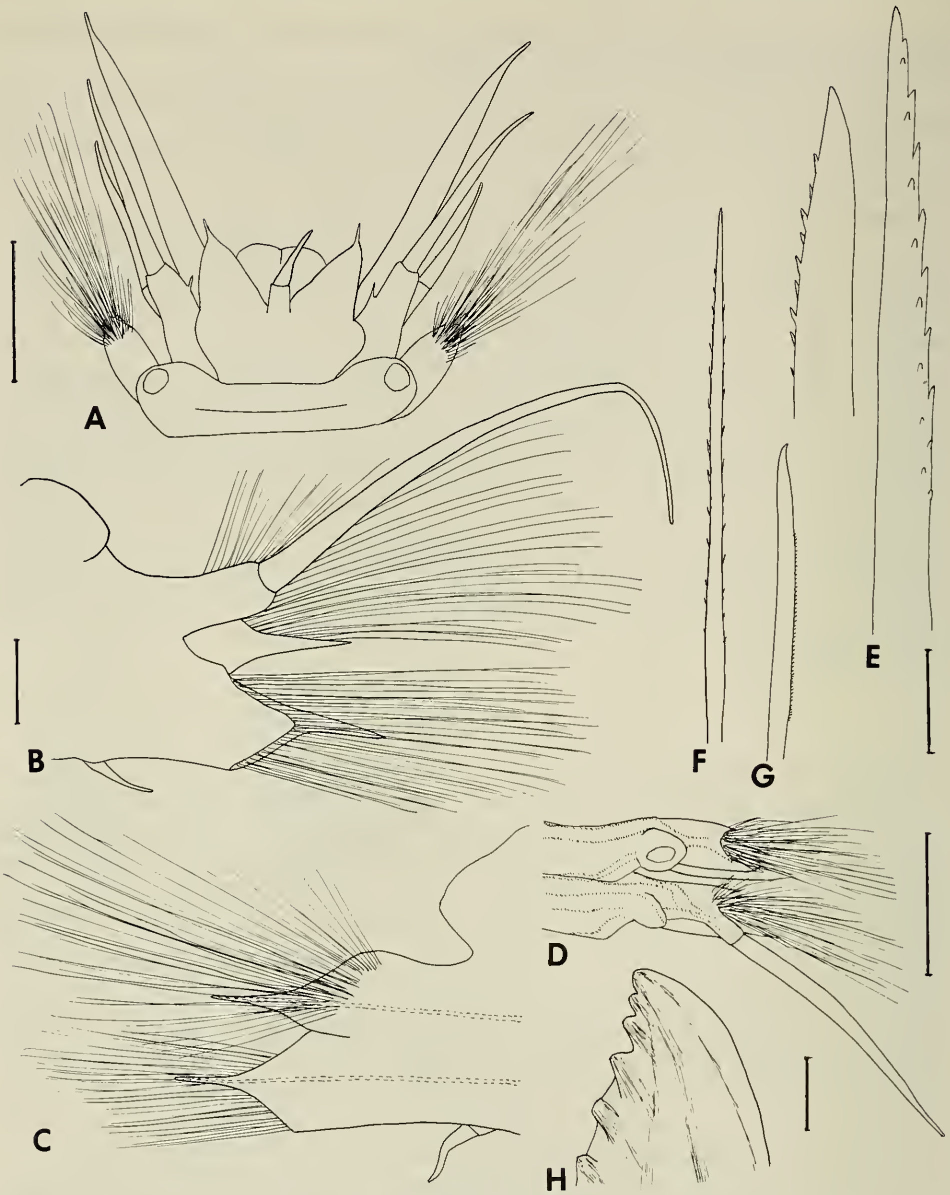

Fig. 2. *Bathykermadeca turnerae,* A, paratype, USNM 96246; B–G, holotype, USNM 96245; H, paratype, USNM 96247: A, Anterior end, dorsal view; B, Right cirrigerous parapodium, posterior view; C, Right elytrigerous parapodium, anterior view, acicula dotted; D, Right half of segments 7 and 8, dorsal view; E, Short and long notosetae; F, Supra-acicular neuroseta; G, Subacicular neuroseta; H, Jaw. Scales: = 1.0 mm for A; 0.5 mm for B, C; 2.0 mm for D; 0.1 mm for E–G; 0.1 mm for H.

873, 17 Dec 1978: P-4 removed on dive 1080, 7 Dec 1980, holotype (USNM 96245); P-5, P-13 removed dive 1079, 6 Dec 1980, 22 paratypes (USNM 96248); P-12 removed dive 1083, 7 Dec 1980, paratype (USNM 96246), 28 paratypes (USNM 96247).

North Atlantic, Bahamas, Tongue of the Ocean (TOTO), 24°53′12″N, 77°40′12″W, 2066 m, R. D. Turner Panel Study: Panel T-A submerged on *Alvin* dives 492, 493, 20, 21 Jan 1974; removed dive 751, 8 May 1977, paratype (USNM 69249).—Panel T-1 submerged dive 552, 19 Apr 1975; removed dive 753, 10 May 1977, paratype (USNM 96250).—Panel 4A/T86 submerged dive 563, 6 May 1975; removed dive 753, 10 May 1977, paratype (USNM 96251).—Panel T-16 submerged dive 564, 8 May 1975; removed dive 755, 12 May 1977, 4 paratypes (USNM 96253).—Panels T-17, T-18 submerged dive 564, 8 May 1975; removed dive 752, 9 May 1977, 8 paratypes (USNM 96254).—Panel T-20 submerged dive 564, 8 May 1975; removed dive 755, 11 May 1977, 4 paratypes (USNM 96255).—Panels T-37, T-56 submerged dives 752, 755, 9, 12 May 1977; removed dive 851, 11 Nov 1978, 8 paratypes (USNM 96256).—Panels T-15, T-36 submerged dives 752, 755, 9, 12 May 1977; removed dive 852, 12 Nov 1978, 5 paratypes (USNM 96252).—Panel T-85, no data, paratype (96257).

North Atlantic Deep Ocean Stations (DOS), R. D. Turner Panel Study: DOS-1, 110 miles south of Woods Hole, Massachusetts, 39°46′N, 70°41′W, 1830 m: Panel N-34 submerged on *Alvin* dive 597, 30 Aug 1975; removed dive 773, 29 Jul 1977, 2 paratypes (USNM 96258).—DOS-2, 190 miles SE of Woods Hole, 38°18′24″N, 69°35′36″W, 3506 m: Panel N-42 submerged dive 602, 6 Sep 1975; removed dive 792, 26 Sep 1977, 4 small paratypes (USNM 96259).—Panels N-45, N-62 submerged dives 657, 681, 10 Jun, 12 Aug 1976; removed dive 790, 23 Sep 1977, 5 small paratypes (USNM 96260: Panel N-95 submerged dive 817, 29 Jun 1978; removed dive 1026, 27 Jun 1980, paratype (USNM 96261).

*Description.*—Length of holotype (USNM 96245), largest specimen from off St. Croix, 17 mm, width including setae 11 mm, segments 21, last 2 very small. Largest paratype from Deep Ocean Station south of Woods Hole (USNM 96258) 14 mm long, 10 mm wide, with 21 segments. Smallest young paratype from off Bahamas (USNM 96255) 1 mm long, 1.2 mm wide, with 12 segments plus bulbous growing zone. Body oval, greatly flattened, tapering anteriorly and posteriorly, with very long parapodia and setae projecting posteriorly. No color. Dorsum with transverse ciliated bands, up to 4 per segment, continuing on bases of elytrophores and dorsal tubercles (Fig. 2D).

Elytrophores 9 pairs, large, bulbous, on segments 2, 4, 5, 7, 9, 11, 13, 15, and 17 (Figs. 2A, C, D; 3B). Elytra large, oval, covering dorsum, opaque white, without tubercles or papillae, sometimes with slightly undulate posterior border; first elytra with small anterior notch (Fig. 3G, H). Dorsal cirri and nodular dorsal tubercles on segments 3, 6, 8, 10, 12, 14, 16 (Fig. 2B, D). Parapodia of posterior segments (18–21) somewhat modified and compressed (Fig. 3A–F; see below).

Prostomium deeply bilobed, anterior lobes conical, with frontal filaments; median antenna with short cylindrical ceratophore and short tapered style; palps long, stout, tapered (Fig. 2A). Tentacular segment not distinct dorsally; tentaculophores with delicate acicular process on inner side; pair of long dorsal and ventral tentacular cirri, ventral ones shorter than dorsal; prominent bilobed facial tubercle anterior to prostomium (Fig. 2A). Second or buccal segment with first pair of large elytrophores, well-developed biramous parapodia and ventral or buccal cirri similar to tentacular cirri, with short cirrophores on basal part of neuropodia lateral to ventral mouth. Pharynx with 7 pairs of subequal papillae around opening; 2 pairs of dark reddish-striped jaws with 5 teeth on edge (Fig. 2H).

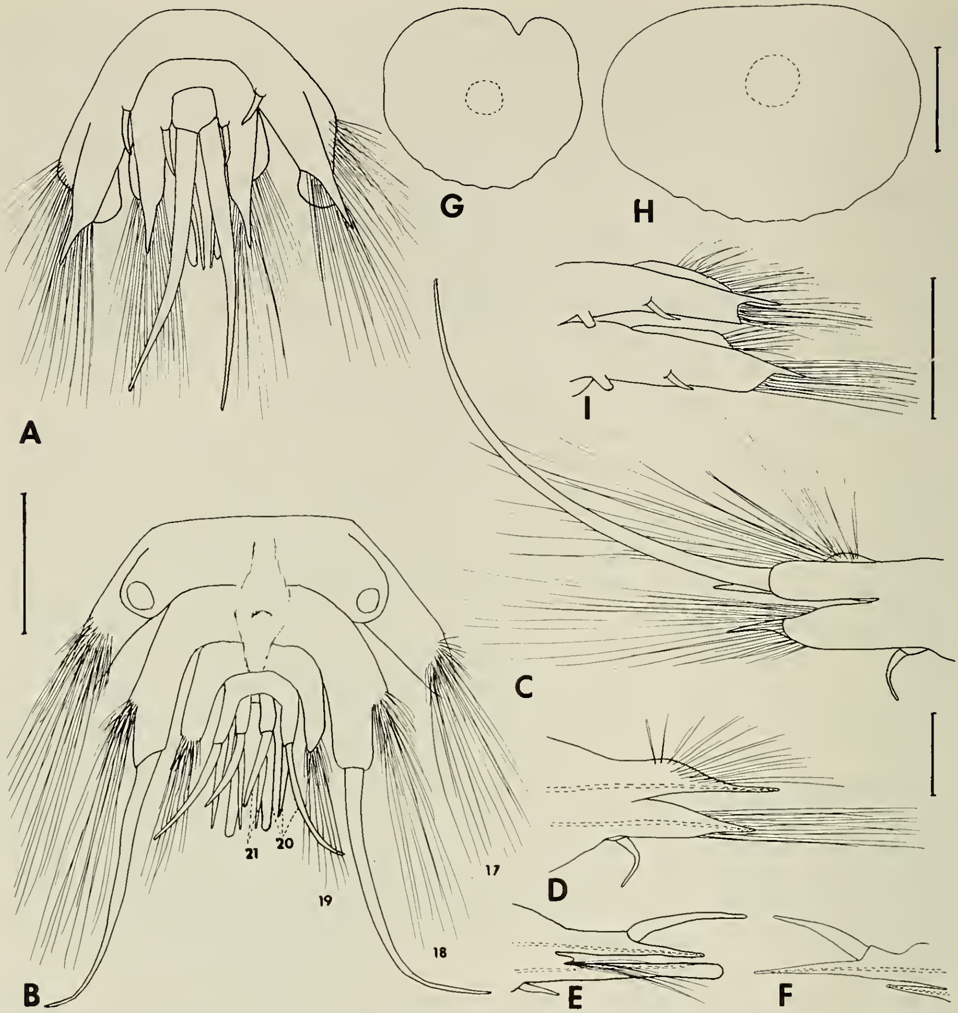

Fig. 3. *Bathykermadeca turnerae,* A–F, holotype, USNM 96246; G–I, paratype, USNM 96247: A, Ventral view posterior end including segments 18–21 (parapodia of 20 and 21 mostly hidden from view); B, Dorsal view posterior end including segments 17–21; C, Left cirrigerous parapodium of segment 18, posterior view; D, Left parapodium of segment 19, anterior view, acicula dotted; no elytrophore or dorsal cirrus present; E, Left parapodium of segment 20, anterior view, acicula dotted; F, Left parapodium of segment 21, posterior view, acicula dotted; G, First right elytron; H, Middle right elytron; I, Ventral view of left half of segments 12 and 13 showing segmental papillae. Scales: = 1.0 mm for A, B; 0.5 mm for C–F; 1.0 mm for G, H; 2.0 mm for I.

Parapodia long (Fig. 2B, C). Notopodia well developed, conical, with long projecting acicular process on lower side, almost as long as neuropodia. Notosetae numerous, forming radiating bundle, short to long, as long as and much stouter than neurosetae, acicular, nearly straight, with blunt bare tips and 2 rows of widely-spaced spines on distal part (Fig. 2E). Neuropodia subconical, with projecting acicular process on anterior lobe; posterior lobe shorter, rounded. Neurosetae very numerous, long, slender, of 2 types: supra-acicular ones with widely-spaced spines along lateral borders and tapered pointed tips (Fig. 2F); subacicular ones with numerous close-set spines along basal two-thirds and slightly hooked bare tips (Fig. 2G). Dorsal cirri with elongate cylindrical cirrophores attached on posterior sides of notopodia; styles long, slender, smooth, with tapered tips, extending beyond tips of setae (Fig. 2B). Ventral cirri short, tapered, attached on middle of neuropodia (Fig. 2B, C).

Segments posterior to elytrigerous segment 17 somewhat modified and compressed (Fig. 3A, B). Parapodia of segment 18 similar to more anterior cirrigerous parapodia with long dorsal cirri, except for absence of dorsal tubercles; parapodia long, directed posteriorly and enclosing shorter parapodia of segments 19–21 (Fig. 3A–C). Segment 19 lacking both elytrophores and dorsal cirri; small biramous parapodia enclosing still smaller parapodia of segments 20 and 21 (Fig. 3A, B, D). Parapodia of segment 20 with cirrophore of dorsal cirrus with short style, fused to projecting notopodial acicular process, without notosetae; neuropodium with tongue-like acicular lobe, rounded distally, with small bundle of slender neurosetae and small ventral cirrus (Fig. 3E). Notopodia of segment 21 similar to segment 20, neuropodia represented by small acicular lobe, lacking neurosetae and ventral cirrus (Fig. 3F).

Anal ridge visible on dorsal side of segments 17 to 19, with anal opening on segment 18 (Fig. 3B). Pygidium small squarish lobe between bases of parapodia 19 and ventral to parapodia of 20 and 21, with pair of long anal cirri (Fig. 3A). Four pairs of small segmental or nephridial papillae on ventral side of segments 12–15 (Fig. 3I).

*Distribution.*—North Atlantic, off St. Croix, Virgin Islands, off the Bahamas, and south and southeast of Woods Hole, Massachusetts, in depths from 1830 to 3995 meters, associated with wood panels. See Introduction.

*Etymology.*—The species is named for Dr. Ruth D. Turner, whose interesting *Alvin* Deep-sea Wood and Panel Experiments furnished the specimens on which this study is based.

*Comparisons.*—*Bathykermadeca turnerae* agrees in most respects with *B. hadalis* (Kirkegaard), including the presence of the four posteriormost segments being somewhat modified and compressed, and with both elytrophores and dorsal cirri lacking on segment 19. They may be separated, however, on the following characters:

| | *B. hadalis* (Kirkegaard) | *B. turnerae,* n. sp. |
|---|---|---|
| Dorsal tubercles | Inconspicuous | Nodular |
| Neurosetae | One type | Two types |
| Jaws | Without basal teeth | With basal teeth |
| Nephridial papillae | 6 large pairs on segments 12–17 | 4 small pairs on segments 12–15 |

*Bathykermadeca turnerae* may be separated from the other two species of Macellicephalinae described herein according to the Key on page 142.

### *Bathybahamas,* new genus

*Type-species.*—*Bathybahamas charleneae,* new species. Gender: feminine.

*Diagnosis.*—Segments 18. Elytra and elytrophores 8 pairs, on segments 2, 4, 5, 7, 9, 11, 13, and 15. Bilobed prostomium with blunt anterior peaks, without frontal filaments, with median antenna and palps, without lateral antennae or eyes. Tentaculophores of tentacular segment with 2 pairs of tentacular cirri and projecting acicular process, without setae. Facial tubercle trilobed. Dorsal cirri on non-elytra-bearing segments, with long styles; dorsal tubercles on cirrigerous segments with digitiform ciliated extensions. Parapodia long, biramous, both rami with projecting acicular processes, subequal in length. Notosetae numerous, subequal in length to and stouter than neurosetae, with single row of teeth. Neurosetae numerous, slender, of 2 types. Ventral cirri short, long on segment 2. Pharynx with 7 pairs of papillae; 2 pairs of jaws entire, without basal teeth.

*Etymology.*—*Bathy,* from *bathys,* Greek, deep, plus *bahamas,* referring to the locality in the deep Atlantic off the Bahama Islands plus s ending. Gender: feminine.

### *Bathybahamas charleneae,* new species
Fig. 4

*Material examined.*—North Atlantic, Tongue of the Ocean (TOTO) off the Bahama Islands, 24°53′12″N, 77°40′12″W, 2066 m, R. D. Turner Panel Study: Panel T-1 submerged *Alvin* dive 552, 19 Apr 1975; removed dive 753, 10 May 1977, paratype, USNM 96244.—Panel T-16 submerged dive 564, 8 May 1975; removed dive 755, 12 May 1977, holotype, USNM 96243.

*Description.*—Length of holotype 8 mm, width 6 mm including setae, segments 18. Paratype 9 mm long, 7 mm wide. Body oval, flattened dorsoventrally, with very long parapodia and setae extending laterally and posteriorly. Color: Anterior third of dorsum brownish; pharynx with dark brown lining. Dorsum with transverse ciliated bands, 2 per segment, extending onto elytrophores and dorsal tubercles.

Elytrophores large, bulbous, 8 pairs, on segments 2, 4, 5, 7, 9, 11, 12, and 15, with dorsal cirri on 3 posterior smaller segments (Fig. 4A, B). Elytra all missing. Dorsal tubercles on cirrigerous segments with digitiform ciliated extensions projecting laterally (Fig. 4C).

Prostomium deeply bilobed, with blunt anterior peaks; median antenna with large ceratophore in middle of prostomium, with long style; palps stout, long, tapered (Fig. 4A, H). Tentacular segment not distinct dorsally; tentaculophores lateral to prostomium, with prominent acicular process on inner side, without setae, with pair of long dorsal and ventral tentacular cirri; trilobed facial tubercle anterior to prostomium (Fig. 4A, H). Second or buccal segment with first pair of large elytrophores, well-developed biramous parapodia and ventral or buccal cirri similar to tentacular cirri, with short cirrophores on basal part of neuropodia lateral to ventral mouth (Fig. 4A). Pharynx with 7 pairs of subequal papillae around opening; 2 pairs of jaws without extra basal teeth (Fig. 4D).

Parapodia long, biramous (Fig. 4B, C). Notopodia round, with long projecting acicular process on lower side, almost as long as neuropodia. Notosetae numerous, forming radiating bundle, short to long, nearly as long as and stouter than neurosetae, slightly curved, with blunt tips and single row of widely-spaced teeth along one side (Fig. 4E). Neuropodia conical, with long projecting acicular process on anterior lobe; posterior lobe slightly shorter, rounded. Neurosetae numerous, long, slender, of 2 types: supraacicular ones slightly stouter, flattened, with widely-

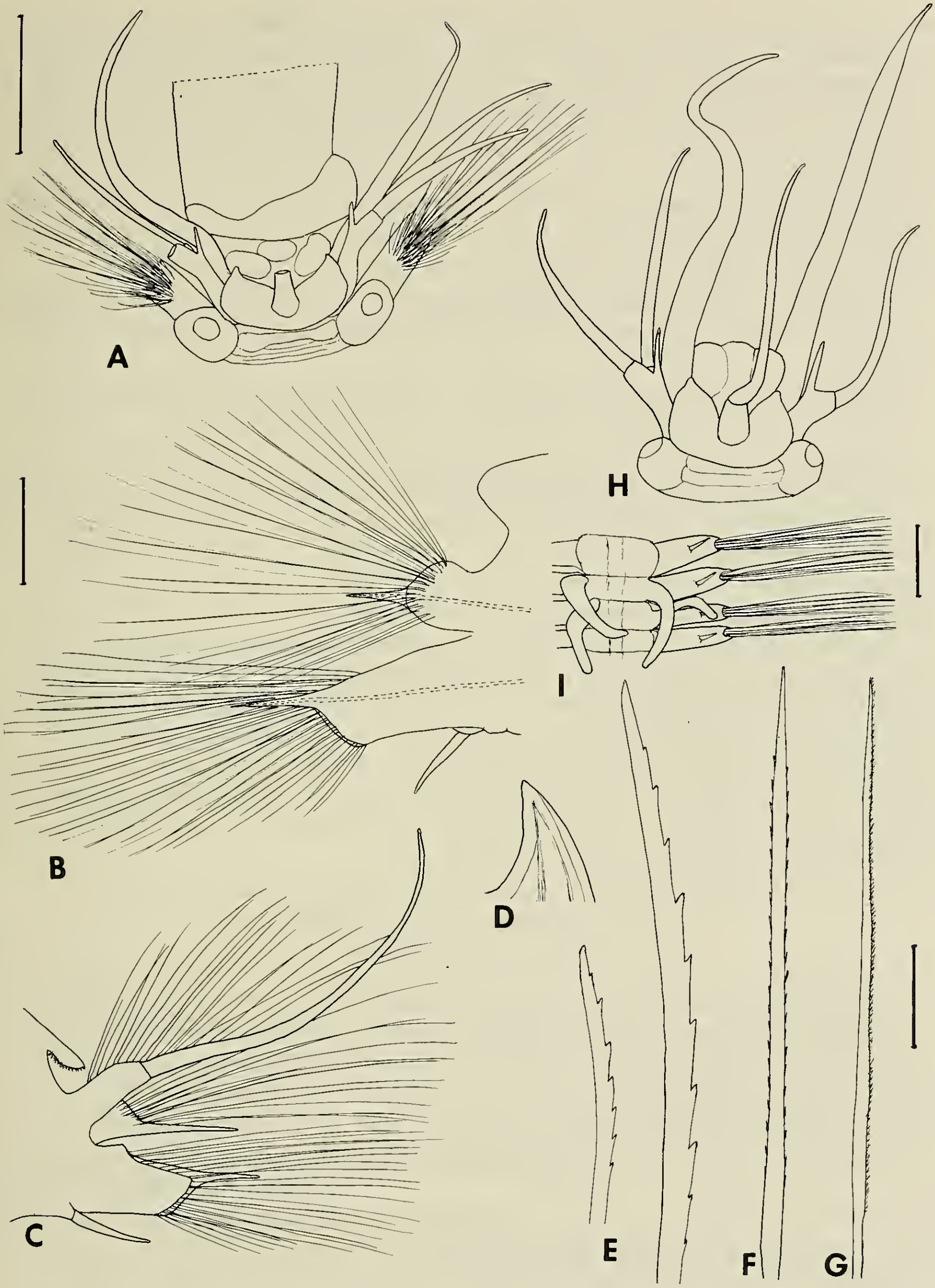

Fig. 4. *Bathybahamas charleneae*, A–G, holotype, USNM 96243; H, I, paratype, USNM 96244: A, Dorsal view anterior end, pharynx completely extended, only basal part shown; styles of median antenna and left dorsal tentacular cirrus missing; B, Right elytrigerous parapodium, anterior view, acicula dotted; C, Right cirrigerous parapodium, posterior view; D, Isolated jaw; E, Short and long notosetae; F, Supra-acicular neuroseta; G, Subacicular neuroseta; H, Dorsal view anterior end, pharynx partially extended; right ventral tentacular cirrus missing; parapodia of segment 2 not shown; I, Ventral view of segments 11–14 showing elongate papillae on 12 and 13. Scales: = 1.0 mm for A, H; 0.5 mm for B, C; 0.1 mm for D–G; 1.0 mm for I.

spaced serrations on lateral sides and pointed bare tips (Fig. 4F); subacicular neurosetae slender, with numerous faint, fine, close-set hairs or spines along one side, tapering distally with delicate hairs (Fig. 4G). Dorsal cirri with elongate cylindrical cirrophores on posterior side of notopodia; styles long, slender, extending beyond setae (Fig. 4C). Ventral cirri short, tapered, in middle of neuropodia (Fig. 4B, C).

Pygidium small lobe nearly hidden by parapodia and setae of posterior segments. Small ventral segmental papillae on segments 6–15 on holotype. Paratype with 2 pairs of elongate ventral papillae on segments 12 and 13 (Fig. 4I).

*Distribution.*—North Atlantic off the Bahamas, in 2066 meters depth, associated with wood panels and with much more abundant polynoid, *Bathykermadeca turnerae.*

*Etymology.*—The species is named for Charlene D. Long, who made preliminary identifications of this and many other polynoid polychaetes.

*Comparisons.*—*Bathybahamas* differs from the four previously described genera of the Macellicephalinae also possessing 8 pairs of elytra; i.e. *Bruunilla* Hartman, 1971 (emended Pettibone 1979), *Bathyeliasona* Pettibone, 1976, *Bathyvitiazia* Pettibone, 1976, and *Bathypolaria* Levenstein, 1981, in having neurosetae of 2 types, instead of a single type, in having notopodia of the biramous parapodia subequal in length to the neuropodia, instead of considerably shorter, and in having dorsal tubercles with digitiform branchial processes, instead of lacking them. This latter feature is present also in *Bathyfauvelia* Pettibone, 1976 (with 9 pairs of elytra) and *Bathycatalina* Pettibone, 1976 (with 12 pairs of elytra) (see Key below). *Bathybahamas* lacks (1), the characteristic wing-like structure on the ventral side of the lower lip of *Bruunilla,* (2), the keel-like pygidium of *Bathypolaria,* (3), the jaws with basal teeth of *Bathyvitiazia* and *Bruunilla* and (4), the different type of notosetae of *Bathyeliasona.* The five genera with 8 pairs of elytra can be separated according to the following Key.

## Key to the Genera of Macellicephalinae with 8 Pairs of Elytra

1. With pair of wing-like structures on ventral side of segments 2 and 3 (lower lip); trilobed facial tubercle (fig. 1b, in Pettibone 1979). Prostomium rounded, without anterior projections and frontal filaments (fig. 1a, in Pettibone 1979). Jaws with basal teeth (fig. 2c, in Pettibone 1979). Notopodia much shorter than neuropodia (fig. 2a, b, in Pettibone 1979) .. ...................... *Bruunilla* Hartman, 1971 (emend. Pettibone, 1979)
*B. natalensis* Hartman, 1971
(Mozambique Basin, 4886–5068 m depth)

– Without pair of wing-like structures on ventral side on lower lip ...... 2

2. Dorsal tubercles with lateral digitiform branchial extensions (Fig. 4C). Notopodia subequal in length to neuropodia (Fig. 4B, C). Neurosetae of 2 types (Fig. 4F, G). Prostomium with projecting blunt peaks, without frontal filaments; facial tubercle trilobed; tentaculophores with prominent acicular process, without setae (Fig. 4A, H). Jaws of pharynx without basal teeth (Fig. 4D) ............................. *Bathybahamas,* new genus
*B. charleneae,* new species
(Off Bahamas, 2066 m depth)

– Dorsal tubercles indistinct, not forming digitiform branchial structures. Notopodia much shorter than neuropodia. Neurosetae of single type ... 3

3. Prostomium with projecting anterior lobes and frontal filaments; tentaculophores with transverse row of setae (fig. 14a, b, in Pettibone 1976). Jaws of pharynx without basal teeth. Neurosetae flattened, greatly expanded, with close-set lateral serrations (fig. 13e, in Pettibone 1976 .... ........................................ *Bathyeliasona* Pettibone, 1976  
*B. abyssicola* (Fauvel, 1913)  
(Bay of Biscay, 4380 m depth)

– Prostomium rounded, without projecting anterior lobes and frontal filaments; tentaculophores without setae (fig. 20a in Pettibone 1976; fig. 1a in Levenstein 1981). Neurosetae not greatly expanded, with widely spaced spines along lateral sides (fig. 20h in Pettibone 1976; fig. 1e in Levenstein 1981) ........................................................ 4

4. Jaws of pharynx with numerous teeth (fig. 20c in Pettibone 1976). Segments 17. Notosetae slender, delicate, flattened, with serrations along lateral borders (fig. 20g in Pettibone 1976). Pygidium oval (fig. 20b in Pettibone 1976) ........................... *Bathyvitiazia* Pettibone, 1976  
*B. pallida* (Levenstein, 1971)  
(Kamchatka Trench, 3816 m depth)

– Jaws of pharynx without teeth. Segments 15. Notosetae thick, toothed along one side (fig. 1d in Levenstein 1981). Pygidium prominent, keellike (fig. 1b in Levenstein 1981) ........... *Bathypolaria* Levenstein, 1981  
*B. carinata* Levenstein, 1981  
(Canadian Arctic, 2750–3920 m depth)

## Key to Macellicephalinae with Dorsal Tubercles Forming Cirriform Ciliated Branchial Structures

1. Notopodia shorter than neuropodia (fig. 21e in Pettibone 1976). Elytra 9 pairs, segments 19–21. Neurosetae of single type, flattened, paddle-like (fig. 22e in Pettibone 1976). Notosetae with numerous spinous rows (fig. 22d in Pettibone 1976) .................... *Bathyfauvelia* Pettibone 1976  
*B. affinis* (Fauvel, 1914)  
(Off Madeira, 0–2380 m depth)

– Notopodia subequal in length to neuropodia (Fig. 4B, C; fig. 23c in Pettibone 1976) ................................................ 2

2. Elytra 12 pairs, segments 24. Neurosetae of single type, flattened, paddlelike (fig. 23e in Pettibone 1976). Notosetae with numerous spinous rows (fig. 23d in Pettibone 1976) ............... *Bathycatalina* Pettibone, 1976  
*B. filamentosa* (Moore, 1910)  
(Off Santa Catalina Is., 611–1097 m depth)

– Elytra 8 pairs, segments 18. Neurosetae of 2 types, not flattened, paddlelike (Fig. 4F, G). Notosetae serrated along edge (Fig. 4E) ............. ........................................ *Bathybahamas,* new genus  
*B. charleneae,* new species  
(Off Bahamas, 2066 m depth)

### Key to Three Species of Macellicephalinae from North Atlantic Reported Herein

1. Elytra 8 pairs. Segments 18. Dorsal tubercles with lateral digitiform ciliated extensions (Fig. 4C). Prostomium with blunt anterior peaks, without frontal filaments, with long median antenna (Fig. 4H). Tentaculophores with projecting acicular process, without setae; facial tubercle trilobed (Fig. 4A, H). Parapodia with notopodia and neuropodia subequal in length (Fig. 4C). Pharynx with 7 pairs of subequal papillae; jaws without basal teeth. Without long ventral segmental papillae or with 2 pairs of elongate papillae on segments 12 and 13 (Fig. 4I) . . *Bathybahamas charleneae,* n. gen., n. sp.

– Elytra 9 pairs. Segments 19–21. Dorsal tubercles short, nodular (Figs. 1D, 2B, D). Facial tubercle bilobed (Figs. 1A, 2A). Jaws of pharynx with basal teeth (Figs. 1I, 2H) .............................................. 2

2. Prostomium with conical anterior lobes with frontal filaments, with short median antenna (Fig. 2A). Tentaculophores with small acicular process, without setae (Fig. 2A). Parapodia with notopodia and neuropodia subequal in length (Fig. 2C). Pharynx with 7 pairs of subequal papillae; jaws with basal teeth (Fig. 2H). Posterior segments (18–21) modified and compressed, without elytra or dorsal cirri on segment 19 (Fig. 3B, D). Four pairs of ventral segmental papillae on segments 12–15 (Fig. 3I) ........ ........................................ *Bathykermadeca turnerae,* n. sp.

– Prostomium with rounded anterior lobes, without frontal filaments, with long median antenna (Fig. 1A). Tentaculophores without acicular process or setae (Fig. 1A). Parapodia with notopodia much shorter than neuropodia (Fig. 1C). Pharynx with 5 pairs of papillae, median ones extra long, lateral ones small; jaws with more numerous basal teeth (11–15) (Fig. 1H, I). Posterior segments not modified, with dorsal cirri on segment 19 (Fig. 1B). Ventral segmental papillae indistinct, none enlarged ............. .............................. *Pelagomacellicephala iliffei,* n. gen., n. sp.

## Subfamily Harmothoinae Horst, 1917

### Genus *Harmothoe* Kinberg, 1856

*Type-species.—Harmothoe spinosa* Kinberg, 1856. Gender: feminine.

*Diagnosis.*—Segments up to 45. Elytra and elytrophores 15 pairs, on segments 2, 4, 5, 7, alternate segments to 23, 26, 29, and 32. Dorsal cirri on non-elytra-bearing segments. Nodular dorsal tubercles on cirrigerous segments. Elytra with microtubercles, with or without macrotubercles. Bilobed prostomium with cephalic peaks, 3 antennae and paired palps; lateral antennae with distinct ceratophores, inserted ventral to ceratophore of median antenna; usually with 2 pairs of eyes. Tentaculophores of tentacular segment lateral to prostomium, with small acicular process, with or without setae, with 2 pairs of tentacular cirri. Parapodia biramous, both rami with elongate acicular processes; neuropodia usually with supra-acicular digitiform process. Notosetae as stout as or stouter than neurosetae, with well-marked spinous rows and blunt to pointed tips. Neurosetae with elongate spinous regions, with tips slightly hooked, at least some with secondary subterminal tooth. Pharynx with 9 pairs of papillae and 2 pairs of hooked jaws, without basal teeth.

Table 2.—Records of *Harmothoe ingolfiana* from Deep Ocean Stations (DOS).

| Panel | Submerged *Alvin* dive | Removed *Alvin* dive | Number specimens | USNM cat. no. |
|---|---|---|---|---|
| DOS-1 | | | | |
| N24, N27 | 597 30 Aug 75 | 658 15 Jun 76 | 20 | 81248 |
| N26, N28 | 597 30 Aug 75 | 685 17 Aug 76 | 14 | 81231 |
| N28 | 597 30 Aug 75 | 794 28 Sep 77 | 11 | 81232 |
| N34 | 597 30 Aug 75 | 773 29 Jun 77 | 39 | 81250 |
| N35 | 597 30 Aug 75 | 834 18 Sep 78 | 9 | 81233 |
| N47 | 658 15 Jun 76 | 774 30 Jul 77 | 18 | 81234 |
| N54 | 658 15 Jun 76 | 794 28 Sep 77 | 10 | 81235 |
| N74 | 774 30 Jul 76 | | | |
| N54 | 658 15 Jun 76 | 794 28 Sep 77 | 21 | 81236 |
| N65 | 685 17 Aug 76 | 773 29 Jul 77 | 10 | 31237 |
| N67 | 685 17 Aug 76 | 776 1 Aug 77 | 15 | 81238 |
| N72 | 773 29 Jul 77 | 834 18 Sep 78 | 160 | 81251 |
| N99 | 834 18 Sep 78 | 1026 27 Jul 80 | 45 | 81239 |
| DOS-2 | | | | |
| N31, N39 | 601 5 Sep 75 | 777 3 Aug 77 | 100 | 81249 |
| N37 | 601 5 Sep 75 | 681 13 Aug 76 | 4 | 81240 |
| N40 | 601 5 Sep 75 | 657 10 Aug 76 | 10 | 81241 |
| N42 | 602 6 Sep 75 | 792 26 Sep 77 | 1 | 81242 |
| N44 | 657 10 Jun 76 | 790 23 Sep 77 | 4 | 81243 |
| N45 | 657 10 Jun 76 | 790 23 Sep 77 | 5 | 81244 |
| N62 | 681 13 Aug 76 | | | |
| N50 | 657 10 Jun 76 | 778 4 Aug 77 | 11 | 81245 |
| N63 | 681 13 Aug 76 | | | |
| N60 | 681 13 Aug 76 | 817 29 Jun 78 | 5 | 81246 |
| N82, N83 | 790 23 Sep 77 | 1031 3 Aug 80 | 43 | 81252 |
| N95 | 817 29 Jun 78 | 1026 17 Jul 80 | 1 | 81247 |

Two species of *Harmothoe* are covered in this report: *H. ingolfiana* Ditlevsen, 1917, and *H. vagabunda*, new species.

### *Harmothoe ingolfiana* Ditlevsen
Fig. 5

*Harmothoe ingolfiana* Ditlevsen, 1917:32, pl. 1: figs. 12, 14, pl. 2: fig. 15, text-fig. 15a–d.—Wesenberg-Lund, 1950:8.—Wolff, 1979:117, 120, 123–124.

*Material examined.*—North Atlantic, south of Iceland, 61°30′N, 22°30′W, 1836 m, *Ingolf*-Exped. sta 67, 10 syntypes (ZMC).

North Atlantic Deep Ocean Stations (DOS), R. D. Turner Panel Study: DOS-1, 110 miles south of Woods Hole, Massachusetts, 39°46′N, 70′41′W, 1830 m, 372 specimens, including many young (USNM; see Table 2). DOS-2, 190 miles southeast of Woods Hole, 38°18′24″N, 69°35′36″W, 3506 m, 184 specimens, including many young (USNM; see Table 2).

*Description.*—Length of complete syntype 12 mm, width with setae 5 mm, segments 36. Length of incomplete syntype of 16 segments 9 mm, width 8 mm. Three specimens from DOS-1 (USNM 81248) 32–33 mm long, 13–15 mm wide, segments 38–39. No color.

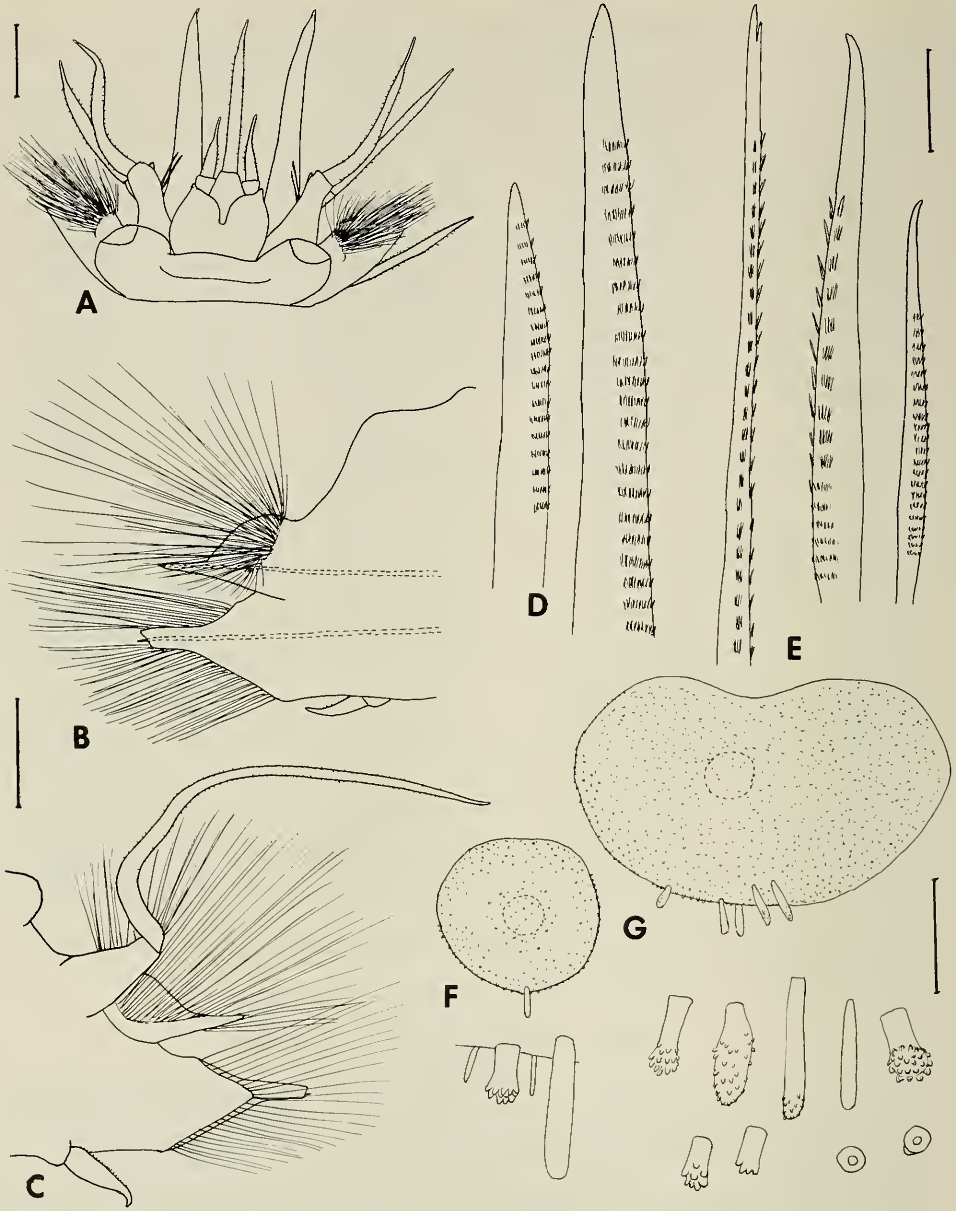

Fig. 5. *Harmothoe ingolfiana,* USNM 81248: A, Anterior end, dorsal view; B, Right elytrigerous parapodium, anterior view, acicula dotted; C, Right cirrigerous parapodium, posterior view; D, Short and long notosetae; E, Upper, middle and lower neurosetae; F, First elytron, with detail of microtubercles, macrotubercles and papillae; G, Middle left elytron with detail of same. Scales: = 1.0 mm for A; 1.0 mm for B, C; 0.1 mm for D, E; 2.0 mm for F, G.

Body flattened, subrectangular, tapered slightly anteriorly and posteriorly. Elytra 15 pairs, large, covering dorsum, circular, oval to subreniform in shape, densely covered with small, conical microtubercles, becoming larger near lateral and posterior borders, with multispinous tips; some elytra with few macrotubercles near posterior border, cylindrical to oval, smooth or spinous distally (Fig. 5F, G; pl. 1: figs. 12, 14, in Ditlevsen 1917). Elytrophores large, bulbous (Fig. 5A, B). Dorsal cirri on non-elytra-bearing segments; dorsal tubercles on cirrigerous segments nodular (Fig. 5C).

Prostomium bilobed, with cephalic peaks; median antenna with stout ceratophore in anterior notch, with long style, minutely papillate; lateral antennae with short stout ceratophores inserted ventrally, with short styles, minutely papillate; palps stout, tapered, smooth; without eyes (Fig. 5A; pl. 2: fig. 15, in Ditlevsen 1917). Tentaculophores lateral to prostomium, with small acicular process, 2–3 setae and dorsal and ventral tentacular cirri similar to median antenna (Fig. 5A). Facial tubercle not distinct, with facial ridge. Second or buccal segment with first pair of large elytrophores, biramous parapodia and long ventral buccal cirri inserted basally on neuropodia lateral to ventral mouth, similar to tentacular cirri (Fig. 5A).

Parapodia biramous (Fig. 5B, C; text-fig. 14, in Ditlevsen 1917). Notopodia smaller than neuropodia, rounded, with acicular process on lower side. Notosetae numerous, forming radiating bundle, short to long, stouter and as long or longer than neurosetae, straight, sword-shaped, reddish amber-colored, with prominent transverse spinous rows and rather long bare tapered tips (Fig. 5D; text-fig. 15a, in Ditlevsen 1917). Dorsal cirri with cylindrical cirrophores on dorsoposterior side of notopodia; styles slender, extending beyond setae, with scattered micropapillae (Fig. 5C). Neuropodia conical, with presetal acicular process, with only small supra-acicular extension (without digitiform supra-acicular process, as usual in *Harmothoe*). Upper neurosetae more slender, with longer spinous regions and bifid tips; middle and lower neurosetae stouter, with entire bare tips and shorter spinous regions (Fig. 5E). All neurosetae with bifid tips in smaller specimens (text-fig. 15b–d, in Ditlevsen 1917). Ventral cirri short, subulate, with micropapillae on upper part (Fig. 5B, C).

Pharynx with 9 pairs of papillae and 2 pairs of hooked jaws. Nephridial papillae small, beginning on segment 6. Pygidium small, bulbous, with pair of anal cirri.

*Distribution.*—North Atlantic, south of Iceland to off New England, in 1830 to 3506 meters depth. In burrows of wood-boring bivalves (Xylophagainae).

*Remarks.*—The original material of *H. ingolfiana,* described by Ditlevsen (1917), was collected from *Ingolf*-Expedition station 67 south of Iceland in 1783 meters (975 fms), corrected by Wesenberg-Lund (1950:8) to 1836 meters. Ditlevsen (1917:33) remarked "that it is a pronounced deep-sea form, is beyond doubt." In connection with his study on "Macrofaunal Utilization of Plant Remains in the Deep Sea," Wolff (1979:117, 120, 123–124) reported that "A log of pine wood, several meters long, was collected at 1800 m in the North Atlantic (K. W. Ockelmann, pers. comm.)" and "A *Xylophaga*-bored piece of a pine log, c. 15 × 35 cm, from *Ingolf* st. 67 in the North Atlantic (1836 m)" contained a number of polychaetes with preliminary identifications by the late A. Eliason. Among them was *Harmothoe ingolfiana,* described by Ditlevsen from the same *Ingolf* station. Thus it appears safe to assume that the syntypes of *H. ingolfiana* were associated with the boring bivalves (*Xylophaga*) in wood. The numerous specimens, from young to adult, identified as *H. ingolfiana* in the wood panel study by Ruth Turner in the North Atlantic, indicate that it is an opportunistic species, using the wood and animal associates as a substrate, as well as a source of food. Numerous specimens of the ampharetid polychaete, *Decemunciger apalea,* were described by Zottoli (1982) from the same wood panels.

### *Harmothoe vagabunda,* new species
Fig. 6

*Material examined.*—North Atlantic, Tongue of the Ocean (TOTO), off Bahama Islands, 24°53′12″N, 77°40′12″W, 2066 m, R. D. Turner Panel Study, submerged on *Alvin* dive 564, 8 May 75; panels T-16, T-17, T-20 removed on dives 752, 754, 9–12 May 77, 7 paratypes, USNM 81227–81229.

Off St. Croix, Virgin Islands, 17°57′36″N, 64°48′36″W, 3995 m, R. D. Turner Panel Study, submerged on *Alvin* dive 873, 17 Dec 78; P-3 removed on dive 1080, 7 Dec 80, paratype (USNM 81226); P-5, P-13 removed on dive 1079, 6 Dec 80, 20 small paratypes, USNM 81225. *Alvin* dives 875, 876, 19, 20 Dec 78, picked up pieces of "wild" wood, about 5 and 6 feet long, holotype, USNM 81223 and 15 paratypes, USNM 81224.

*Description.*—Length of holotype from off St. Croix (USNM 81223) 13 mm, width with setae 6 mm, segments 35; paratype (USNM 81224) 9 mm long, 4 mm wide, with 34 segments. Length of paratype from off Bahamas (USNM 81228) 10 mm, width 5 mm, segments 31, last 4 smaller, regenerating. No color.

Body flattened, slightly tapered anteriorly and posteriorly. Elytra 15 pairs, large, covering dorsum, oval, soft, opaque white, nearly covered with conical microtubercles, low, oval on anterior part; some scattered cylindrical papillae on surface and on lateral borders but without long fringe of papillae (Fig. 6F). Elytrophores large, bulbous (Fig. 6A, B). Dorsal cirri on non-elytra-bearing segments; dorsal tubercles nodular (Fig. 6C).

Prostomium bilobed, rounded, with cephalic peaks very small or indistinct; median antenna with large ceratophore in anterior notch, with style about 2 times longer than prostomium having scattered short papillae and slender tip; lateral antennae with rather large bulbous ceratophores inserted ventrally, with styles short and subulate; palps stout, tapered, slightly longer than median antenna; without eyes (Fig. 6A). Tentaculophores lateral to prostomium, with small acicular process and 2–4 setae on inner side; dorsal tentacular cirri about same length as median antenna, ventral ones shorter; raised facial ridge but without distinct facial tubercle. Second or buccal segment with pair of large bulbous elytrophores, biramous parapodia and long ventral buccal cirri inserted basally on neuropodia lateral to ventral mouth, similar to tentacular cirri (Fig. 6A).

Parapodia biramous (Fig. 6B, C). Notopodia smaller than neuropodia, rounded, with acicular process on lower side. Notosetae numerous, forming radiating bundle, short to long, much stouter than and slightly shorter than neurosetae, slightly curved, with spinous rows and tapered pointed bare tips (Fig. 6D). Dorsal cirri with cylindrical cirrophores on dorsoposterior side of notopodia; styles slender, extending beyond setae, with scattered short papillae and slender terminal filament (Fig. 6C). Neuropodia conical with longer presetal acicular process; postsetal lobe shorter, rounded. Neurosetae numerous, forming fan-shaped bundle. Upper neurosetae longer, more slender, with longer spinous regions and bifid split tips; lower neurosetae shorter, stouter, with tips slightly curved, with slender secondary tooth (Fig. 6E). Ventral cirri short, tapered (Fig. 6B, C).

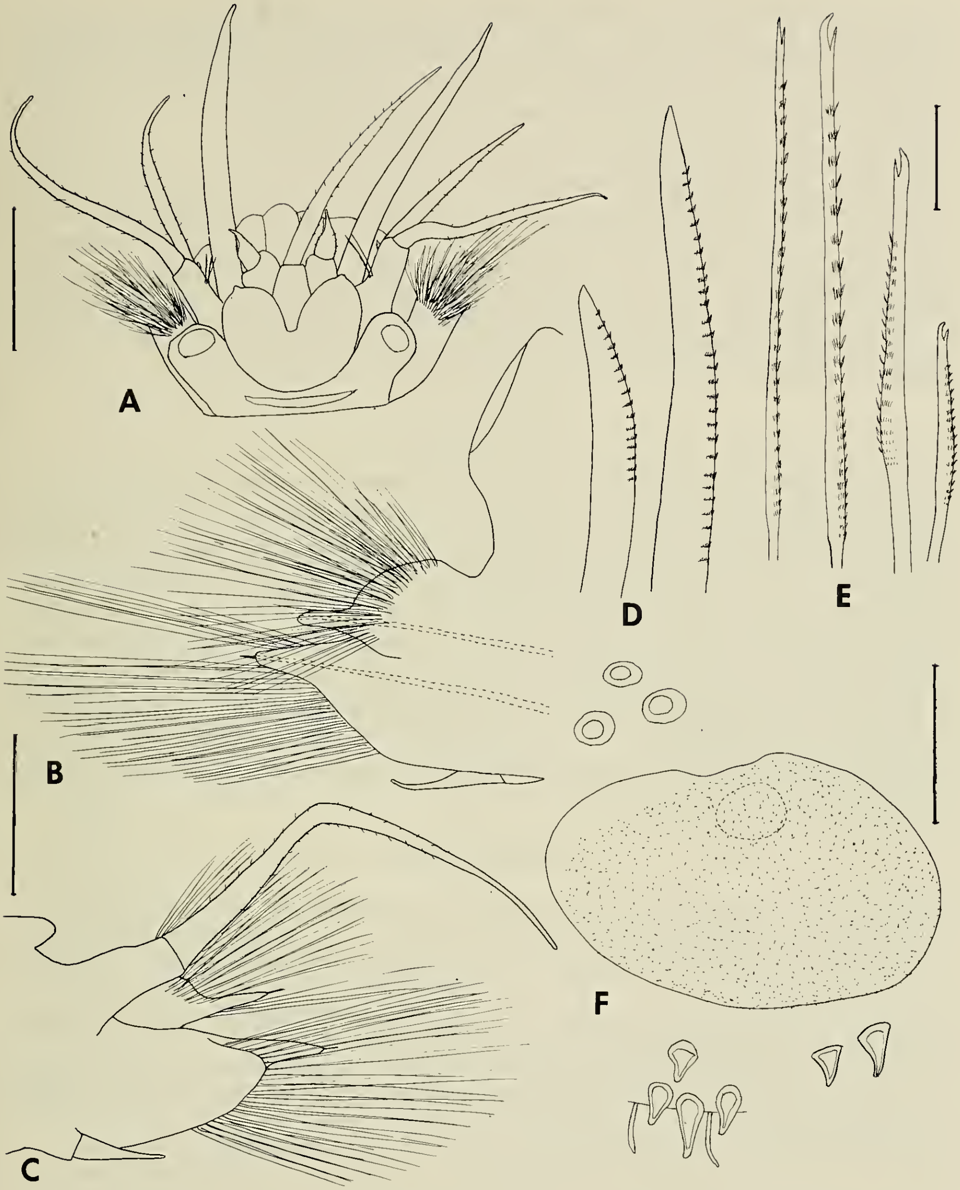

Fig. 6. *Harmothoe vagabunda,* holotype, USNM 81223: A, Dorsal view anterior end, pharynx partially extended; B, Right elytrigerous parapodium, anterior view, acicula dotted; C, Right cirrigerous parapodium, posterior view; D, Short and long notosetae; E, Upper, middle and lower neurosetae; F, Right elytron, with detail of some microtubercles and papillae. Scales: = 1.0 mm for A; 0.5 mm for B, C; 0.1 mm for D, E; 1.0 mm for F.

Pharynx with 9 pairs of black papillae and 2 pairs of hooked jaws. Ventral nephridial papillae small, beginning on segment 6. Pygidium small, with pair of anal cirri.

*Distribution.*—North Atlantic off Bahamas in 2066 meters depth and off St.

Croix, Virgin Islands, in 3995 meters depth. In burrows of marine wood-boring bivalves (Xylophagainae), along with more numerous polynoids *Bathykermadeca turnerae.* The ampharetid polychaete *Endecamera palea* was described by Zottoli (1982) from the same "wild" wood at the St. Croix station.

*Etymology.—vagabunda,* from Latin *vagabundus,* wandering, referring to its association with sunken pieces of wood.

*Comparisons.*—Both the deep-sea *H. vagabunda* and *H. ingolfiana* lack eyes and the neuropodia lack distinct digitiform supra-acicular processes, contrary to the usual condition in species of *Harmothoe. Harmothoe ingolfiana* has distinct cephalic peaks; they are very small or lacking in *H. vagabunda.* The elytra of the former have microtubercles that are spinous-tipped, with some macrotubercles present; the microtubercles are only conical in *H. vagabunda.*

## Acknowledgments

I appreciate the opportunity to work up the cave polynoids received from Dr. Thomas M. Iliffe, as a part of his study on cave faunas, and the detailed information he provided on the cave habitat. I also appreciate being a part of the interesting wood and panel experiments being carried on by Dr. Ruth D. Turner in the deep North Atlantic. The collection of specimens from caves in the Turks and Caicos islands was supported in part by a National Science Foundation Grant (BSR 8215672) to Thomas M. Iliffe. The study conducted on *Alvin* "wood islands" by Ruth Turner was supported by an Office of Naval Research grant to Harvard University. My thanks go to Dr. J. B. Kirkegaard of the Zoologisk Museum, Copenhagen, for the loan of types. The manuscript benefited from the reviews of Thomas E. Bowman and Meredith L. Jones.

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# AN ADDITIONAL NEW SCALE WORM (POLYCHAETA: POLYNOIDAE) FROM THE HYDROTHERMAL RIFT AREA OFF WESTERN MEXICO AT 21°N

Marian H. Pettibone

*Abstract.*—A unique polychaete, *Branchiplicatus cupreus,* n. gen., n. sp., from the hydrothermal vent area at 21°N off western Mexico is described and referred to a new subfamily of Polynoidae, Branchiplicatinae. Branchiae are well developed and of an unusual type. The prostomium is truncate, rather than bilobed, as is usual in the Polynoidae.

This is the fourth contribution dealing with the unusual polynoid polychaetes collected from hydrothermal vents off the Galapagos and on the East Pacific Rise off western Mexico at 21°N (Pettibone 1983, 1984a, b). The polynoids described herein were collected by the OASIS group of Scripps Institution of Oceanography during four *Alvin* dives in April–May 1982 in 2612–2633 meters at 21°N. They were a part of the numerous polynoid polychaetes sent to me by J. F. Grassle and I. Williams of the Woods Hole Oceanographic Institution (WHOI). The specimens were retrieved from washes of other invertebrates, including the vestimentiferans *Riftia pachytila* Jones, 1981, the giant clams *Calyptogena magnifica* Boss and Turner, 1980, and the ampharetid polychaetes *Alvinella pompejana* Desbruyères and Laubier, 1980. Other described polynoids collected from some of the same dives include *Lepidonotopodium fimbriatum* Pettibone, 1983, and *L. riftensis* Pettibone, 1984b. This is the second branchiate species of Polynoidae to be described from the hydrothermal vent areas, the first being *Branchipolynoe symmytilida* Pettibone, 1984a, commensal in the mantle cavities of the Galapagos deep-sea vent mussels.

The types are deposited in the National Museum of Natural History, Smithsonian Institution (USNM). This is OASIS Expedition Contribution number 25.

## Family Polynoidae

### Branchiplicatinae, new subfamily

### *Branchiplicatus,* new genus

*Type-species.*—*Branchiplicatus cupreus,* new species. Gender: masculine.

*Diagnosis.*—Body elongate, flattened, tapered posteriorly, segments up to 35, first achaetous. Elytra and elytrophores 12 pairs on segments 2, 4, 5, 7, 9, 11, 13, 15, 17, 19, 21, and 23. Dorsal cirri on non-elytra-bearing segments, with short cirrophores and long styles. Branchiae well developed on segments posterior to segment 2, of unique type formed of elongate folded sacs with ciliated bands and attached by broad base to lateral sides of flattened elytrophores and of dorsal tubercles on cirrigerous segments. Prostomium truncate anteriorly, not bilobed, fused to tentaculophores of first or tentacular segment, with long median antenna and pair of long palps; without lateral antennae or eyes. Tentaculophores without setae, with 2 pairs of tentacular cirri; without facial tubercle. Second or buccal segment with first pair of elytra, biramous parapodia and long ventral buccal cirri. Parapodia biramous, both rami with projecting acicular processes and numerous long, copper-colored setae. Notosetae much stouter than neurosetae, smooth or with double rows of spines. Neurosetae of 2 types. Ventral cirri short. Pharynx with 5 pairs of unequal papillae; 2 pairs of jaws with edges minutely denticled. Without distinct segmental ventral papillae.

*Etymology.*—*Branchi,* from *branchia* (Greek) gills, plus *plicatus,* from *plicatus* (Latin) fold, referring to the unusual type of folded branchiae. The specific name *cupreus,* from *cuprum* (Latin) copper, referring to striking copper-colored setae.

### *Branchiplicatus cupreus,* new species
Figs. 1–4

*Material examined.*—Pacific Ocean off western Mexico, 20°50′N, 109°06′W, OASIS *Alvin* dives in 1982: Dive 1214, 20 Apr, 2633 m, vestimentiferan wash, holotype (USNM 97219) and 21 paratypes (11 young; USNM 97220-2, 97226).—Dive 1219-10A & B, 25 Apr, 2612 m, *Riftia* and *Calyptogena* wash, fine fraction, 2 paratypes (USNM 97223).—Dive 1221-15, 4 May, 2618 m, *Riftia* and *Calyptogena* wash, coarse fraction, 1 young paratype (USNM 97224).—Dive 1226-7, 10 May, 2616 m, *Riftia, Calyptogena* and *Alvinella* wash, paratype (USNM 97225).

*Description.*—Length of holotype (USNM 97219) 50 mm, width with setae 15 mm, segments 35, last one small. Length of paratype (USNM 97221) 45 mm, width 19 mm, segments 34. Length of small paratype (USNM 97223) 13 mm, width 6 mm, segments 31. Body elongate, flattened ventrally, slightly arched dorsally, tapering slightly anteriorly and more so posteriorly (Fig. 1). No color but with striking long copper-colored setae.

Prostomium truncate anteriorly, extending posterolaterally and fused to tentaculophores of first or tentacular segment (Fig. 2A). Median antenna with ceratophore attached to middle of prostomium, with long tapered style; palps stout, long, tapered; without lateral antenna or eyes. Tentaculophores without setae, with 2 pairs of long slender tentacular cirri, dorsal ones subequal in length to palps, ventral ones slightly shorter (Fig. 2A). Tentacular segment not visible dorsally, forming upper and lateral lips of ventral mouth (Fig. 2A, B). Second or buccal segment with first pair of bulbous elytrophores, elytra, biramous parapodia, and long ventral buccal cirri similar to tentacular cirri and attached on bulbous cirrophores on bases of neuropodia lateral to lower lip and ventral mouth (Fig. 2A, B, G; 3A). Large muscular eversible pharynx with 5 pairs of papillae around opening, median pair longer with tapered tips, adjacent lateral pairs similar in shape but shorter, and lateral pairs shorter, rounded (Fig. 2D, E). Two pairs of large dark jaws with edges serrated or minutely denticled (about 20 teeth; Fig. 2E, F). Subdistally, pharynx with diagonal rows of small papillae on dorsal, ventral and lateral surfaces.

Elytra 12 pairs, on segments 2, 4, 5, 7, 9, 11, 13, 15, 17, 19, 21 and 23, with dorsal cirri on non-elytra-bearing segments, including up to 12 posterior segments. Elytra (Figs. 1; 2G, H; 4C) large, oval, covering dorsum except for posterior segments. Elytra stiff, smooth, opaque, with "veins"; first pair of elytra on segment

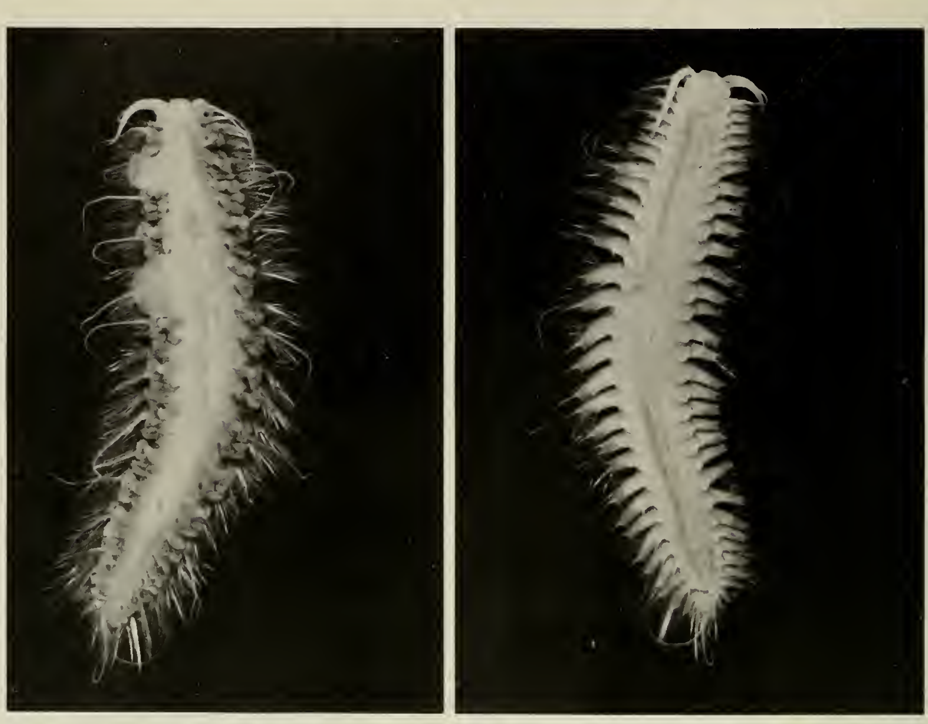

Fig. 1. *Branchiplicatus cupreus,* paratype, USNM 97220: Dorsal view, left; ventral view, right; only 2 elytra remain. 2×.

2 with anterior notch (Fig. 2G); posterior 12th pair on segment 23 elongate-oval, covering several posterior smaller segments (Fig. 4C). Posterior border of elytra with variable number of small round tubercles not sharply set off surface (Fig. 2G, H); elytral surface with minute sensory papillae. On small paratype (USNM 97223), tubercles scarcely demarcated and lacking on first and last pairs (Fig. 4C).

Elytrophores, from segment 4 on, flattened, directed posterolaterally, with flattened extensions on anterior and posterior sides, and with branchiae attached on lateral sides (Figs. 2C; 3D). Dorsal tubercles, corresponding in position to elytrophores on cirrigerous segments, also flattened, with anterior and posterior extensions, and with branchiae attached on lateral sides (Figs. 2C; 3B, C; 4A).

Branchiae begin on segment 3 and continue posteriorly (Figs. 2A, C; 3B–D; 4A). Branchiae of unique type, formed of flattened elongate sacs, deeply folded and convoluted, attached by broad bases to lateral sides of elytrophores and dorsal tubercles and to dorsal sides of notopodia and dorsal cirrophores; surfaces of branchiae with transverse ciliated bands. Branchiae on elytrigerous segments with extra lobe on posterior side; branchiae on cirrigerous segments formed of equal-sized anterior and posterior flattened sacs fused basally.

Parapodia biramous (Figs. 3A–D; 4A). Notopodia shorter than neuropodia, rounded, with projecting acicular process on lower side and with short bract on anterior side. Cirrophores of dorsal cirri cylindrical and fused on lower side to anterior notopodial bract; styles of dorsal cirri long, slender, extending far beyond setae (Figs. 3B, C; 4A). Notosetae numerous, forming radiating bundles, short to

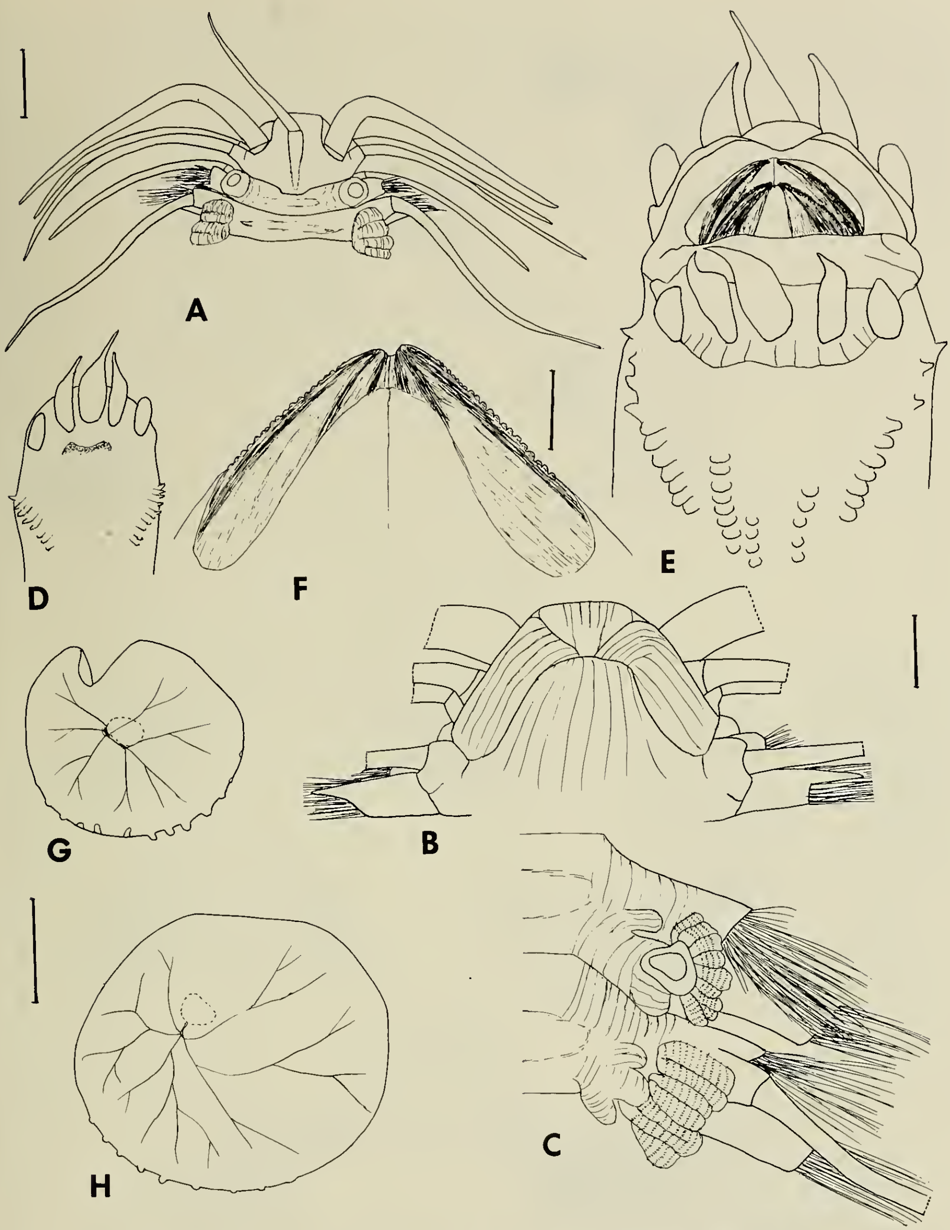

Fig. 2. *Branchiplicatus cupreus,* A–C, holotype, USNM 97219; D–H, paratype, USNM 97221: A, Dorsal view anterior end; B, Ventral view anterior end, bases of palps and cirri only shown; C, Dorsal view right parapodia of segments 11 and 12; distal end of style of dorsal cirrus not shown; D, Dorsal view anterior end of extended pharynx; E, Ventral view of same; F, Dorsal jaws; G, First left elytron (segment 2); H, Left elytron 6 (segment 11). Scales = 2.0 mm for A, D; 1.0 mm for B, C, E; 0.5 mm for F; 2.0 mm for G, H.

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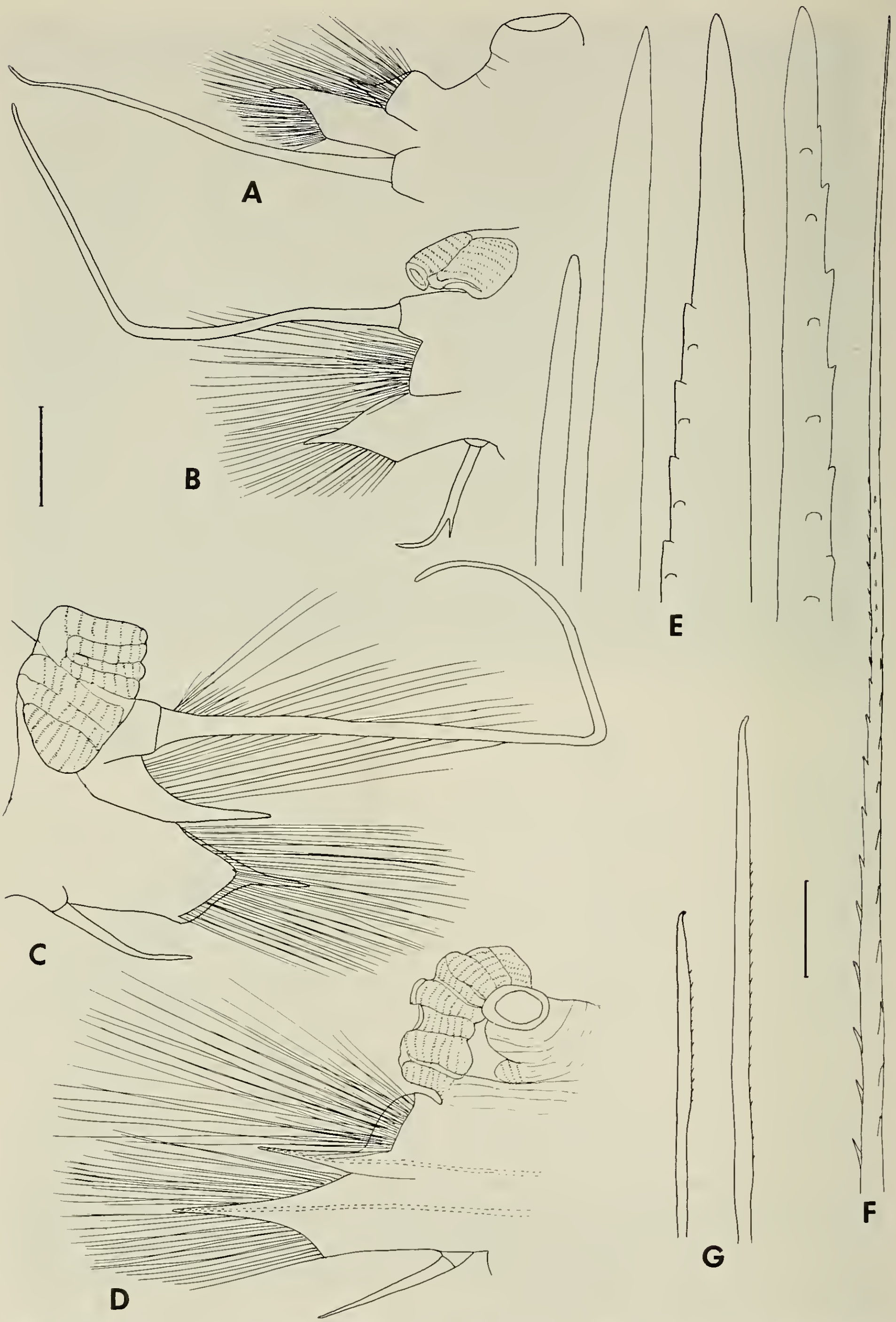
Fig. 3. *Branchiplicatus cupreus,* paratype, USNM 97221: A, Right elytrigerous parapodium segment 2, anterior view; B, Right cirrigerous parapodium segment 3, anterior view, ventral cirrus with



abnormal split tip; C, Right cirrigerous parapodium segment 14, posterior view; D, Right elytrigerous parapodium segment 15, anterior view, acicula dotted; E, Four short and long notosetae; F, Supra-acicular neuroseta; G, Middle and lower subacicular neurosetae. Scales = 1.0 mm for A–D; 0.1 mm for E–G.

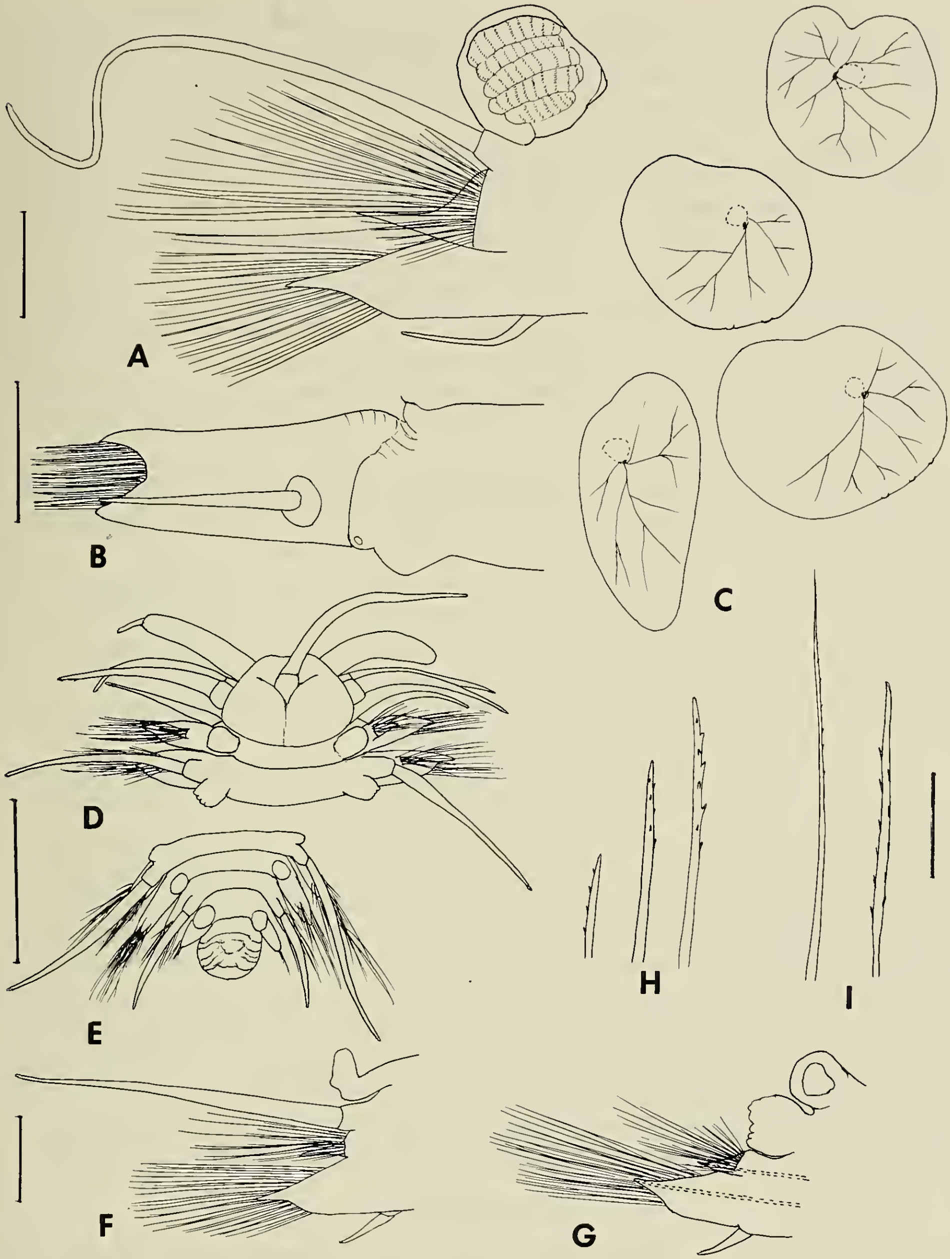


Fig. 4. *Branchiplicatus cupreus,* A, B, paratype, USNM 97221; C, small paratype of 31 segments, 13 mm long, USNM 97223; D–I, young paratype of 15 segments, 2.5 mm long, USNM 97222: A, Right cirrigerous parapodium segment 25, anterior view; B, Ventral view of left parapodium segment 20 showing nephridial opening; C, Right 1st, 2nd, 6th and 12th elytra (segments 2, 4, 11, 23); D, Dorsal view anterior end, elytra missing; E, Dorsal view posterior end; F, Right cirrigerous parapodium segment 8, anterior view; G, Right elytrigerous parapodium segment 9, anterior view, acicula dotted; H, Three short and long notosetae; I, Upper and lower neurosetae. Scale = 1.0 mm for A, C; 1.0 mm for B; 0.5 mm for D, E; 0.2 mm for F, G; 0.1 mm for H, I.

long, some as long as neurosetae. Notosetae numerous, forming radiating bundles, short to long, some as long as neurosetae. Notosetae much stouter than neurosetae, acicular, smooth or with double rows of spines near distal bare tips (Fig. 3E). Neuropodial presetal lobes conical, with projecting acicular process; postsetal lobes shorter, rounded. Neurosetae very numerous, slender, forming fan-shaped bundles. Supra-acicular neurosetae with 2 rows of prominent spines, tapering to long bare capillary tips (Fig. 3F). Subacicular neurosetae more slender, with shorter spines and slightly hooked bare tips (Fig. 3G). Ventral cirri short, tapered (Fig. 3B–D).

Dorsal anal ridge and anus enclosed in branchiae and parapodia of few posterior segments (32–35). Small rectangular ventral pygidium between parapodia of segments 34 and 35, with pair of long anal cirri (sometimes one short or both missing). No distinct nephridial or segmental papillae but ventral bases of neuropodia somewhat inflated with slightly projecting opening (not always visible; Fig. 4B).

Young paratypes (USNM 97226) ranging in size from 5 mm in length, 3 mm in width, with 19 segments, last 2 very small, to 1 mm in length, 1 mm in width, with 10 segments plus growing region. Young paratype (USNM 97222; Fig. 4D–I) of 15 segments plus growing zone, 2.5 mm long, 2 mm wide, with 8 pairs of elytrophores (elytra missing). Developing flattened branchiae beginning on segment 3 (Fig. 4D–G). Prostomium with slight anterior notch, instead of truncate; palps cylindrical, with terminal filament, instead of tapered; median antenna closer to anterior end (Fig. 4D). Parapodia similar in shape to adults (Fig. 4F, G). Notosetae of same type but more slender (Fig. 4H). Neurosetae also more slender; lower ones with more prominent spines (Fig. 4I).

*Remarks.*—The unique folded type of branchiae in *Branchiplicatus* separates the genus and subfamily from the other subfamilies of Polynoidae. The presence of branchiae is an unusual feature in the Polynoidae, as mentioned in the description of *Branchipolynoe symmytilida* in Branchipolynoinae (Pettibone 1984a). In the latter group the well-developed branchiae are arborescent, rather than of the unique type in *Branchiplicatus.* The truncate, rather than bilobed prostomium also sets *Branchiplicatus* apart in the Polynoidae. There appears to be a greater fusion of the prostomium with the first or tentacular segment. The pharynx also differs from the other subfamilies in having five pairs of unequal papillae and two pairs of large serrated jaws. Branchiplicatinae agrees with the subfamilies Macellicephalinae, Lepidonotopodinae, and Branchipolynoinae (Pettibone 1976; 1983; 1984a) in having prostomia with median antenna only and lacking lateral antennae, but in these subfamilies, the prostomium is bilobed, rather than truncate.

## Acknowledgments

I wish to thank J. F. Grassle and I. Williams of the Woods Hole Oceanographic Institution for the material on which this study is based, as well as the members of the OASIS Expedition in 1982 of the Scripps Institution of Oceanography. The manuscript benefited from the reviews of Fenner A. Chace, Jr., Nancy J. Maciolek, and James A. Blake. Mr. Michael Carpenter kindly photographed the paratype.

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# THE OLIGOCHAETA OF GEORGES BANK (NW ATLANTIC), WITH DESCRIPTIONS OF FOUR NEW SPECIES

Dale Davis

*Abstract.*—Thirty-two oligochaete species are recorded from benthic grab samples taken southeast of Massachusetts (Georges Bank). Taxonomic notes are provided for all species not previously dealt with in earlier papers (Erséus and Davis 1984; Erséus 1984a; Davis 1984). Four of the species, *Phallodrilus dorsospermatheca, Phallodrilus christeri, Adelodrilus bacrionis,* and *Uniporodrilus vestigium* are new to science and described herein. Some aspects of sediment-species relationships, life histories, and geographical distributions are discussed.

During the Georges Bank Benthic Infauna Monitoring Program, 32 species of marine Oligochaeta were encountered (Table 1). Of these 32, 11 are known to be new species. All members of the genus *Adelodrilus,* except *A. bacrionis,* n.sp., from Georges Bank were previously treated by Erséus and Davis (1984). Several species of *Phallodrilus* have been dealt with by Erséus (1984a), and *Olavius cornuatus* has been described by Davis (1984).

Cook (1969, 1971) studied the Oligochaeta of Cape Cod Bay, Massachusetts. His work was very thorough and is commonly used for reference when studying oligochaetes in shallow waters along the northeast coast of the U.S. Cook (1970a, b) also made significant contributions to the knowledge of deep-sea oligochaetes from the northwest Atlantic. Several other publications (Brinkhurst 1965, 1966; Brinkhurst and Jamieson 1971; Brinkhurst and Baker 1979; Lasserre 1971; Cook and Brinkhurst 1973) are useful for identification of marine oligochaetes from the northwest Atlantic, but are concerned again mostly with shallow-water forms.

Only in the last few years have publications (Erséus 1979a, b, 1983a; Baker and Erséus 1979) dealt with the oligochaetes from the continental shelf of the northeast U.S. The material from the Georges Bank Monitoring Program provides a significant contribution to the knowledge of marine oligochaetes from this area.

## Materials and Methods

All samples were taken in the course of the Georges Bank Benthic Infauna Monitoring Program performed by Battelle New England Marine Research Laboratory for the U.S. Department of the Interior, Minerals Management Service (Final Report for year one available through the National Technical Information Service). Starting in July 1981, samples were taken in February, May, July, and November of each year through May of 1984. Samples were taken with a 0.04 $m^2$ Van Veen grab. The samples were subsequently sieved through a 300 $\mu$m screen and fixed in 10% formalin. In the laboratory, the samples were resieved through a stack of 500 $\mu$m and 300 $\mu$m screens and transferred into 70% isopropanol for processing and storage. Oligochaete specimens were stained in Harris haematoxylon or paracarmine and mounted in permanent mounting media on

Table 1.—List of species from Georges Bank.

Tubificidae

*Adelodrilus anisosetosus* Cook, 1969*
*A. bacrionis,* n. sp.
*A. correptus* Erséus and Davis, 1984*
*A. cristatus* Erséus, 1983*
*A. inopinatus* Erséus and Davis, 1984*
*A. multispinosus* Erséus, 1979*
*A. pilatus* Erséus and Davis, 1984*
*Phallodrilus biprostatus* (Baker and Erséus, 1979)*
*P. boeschi* Erséus, 1984*
*P. coeloprostatus* Cook, 1969*
*P. davisi* Erséus, 1984*
*P. dorsospermatheca,* n. sp.
*P. christeri,* n. sp.
*P. flabellifera* Erséus, 1984*
*P. parviatriatus* Cook, 1971
*Phallodrilus,* sp. A
*Olavius cornuatus* Davis, 1984*
*O. tenuissimus* (Erséus, 1979)
*Uniporodrilus vestigium,* n. sp.
*Bathydrilus longus* Erséus, 1979
*Heterodrilus occidentalis* Erséus, 1981
*Limnodriloides barnardi* Cook, 1974
*L. medioporus* Cook, 1969
*Tubificoides intermedius* (Cook, 1969)
*Tubificoides,* sp. A
*Tubificoides,* sp. B

Enchytraeidae

*Marionina welchi* Lasserre, 1971
*Grania,* sp. A
*Grania,* sp. B
*Grania,* sp. C
*Grania,* sp. D

Family unknown

Oligochaeta, n. fam., sp. A

* Denotes species which have been dealt with in previous publications.

glass slides. The type-series of the new species are deposited at the United States National Museum of Natural History (USNM), Washington, D.C.

## Area Studied

Figure 1 is a map of the area southeast of Massachusetts showing Georges Bank and the surrounding area where the samples were taken. Station 5 was the location of a drilling platform and was designated as the "site-specific station." Station 5 consisted of an array of 29 stations (5-1 to 5-29) located around the drill site. The remainder of the stations were located at key sites on Georges Bank and were designated as "regional stations."

## Systematics

### *Adelodrilus bacrionis,* new species

Figs. 2, 3

*Holotype.*—USNM 97236.

*Type-locality.*—Georges Bank, SE of Massachusetts, USA, sta. 5-28, 40°39.5′N, 67°41.9′W, 75 m, medium to coarse sand, Nov 1983.

*Paratypes.*—USNM 97237–97238. Two specimens from off Massachusetts (Georges Bank), sta. 2, 40°59.0′N, 66°55.8′W, 71 m, medium to coarse sand, Nov 1983.

*Other material examined.*—Five specimens from off Massachusetts (Georges Bank): 4 from type-locality, one from sta. 5-3, 40°39.8′N, 67°46.1′W, 78 m, medium to coarse sand, Nov 1981.

*Etymology.*—The name *bacrionis* is Latin for "ladle," referring to the shape of the giant penial setae of this species.

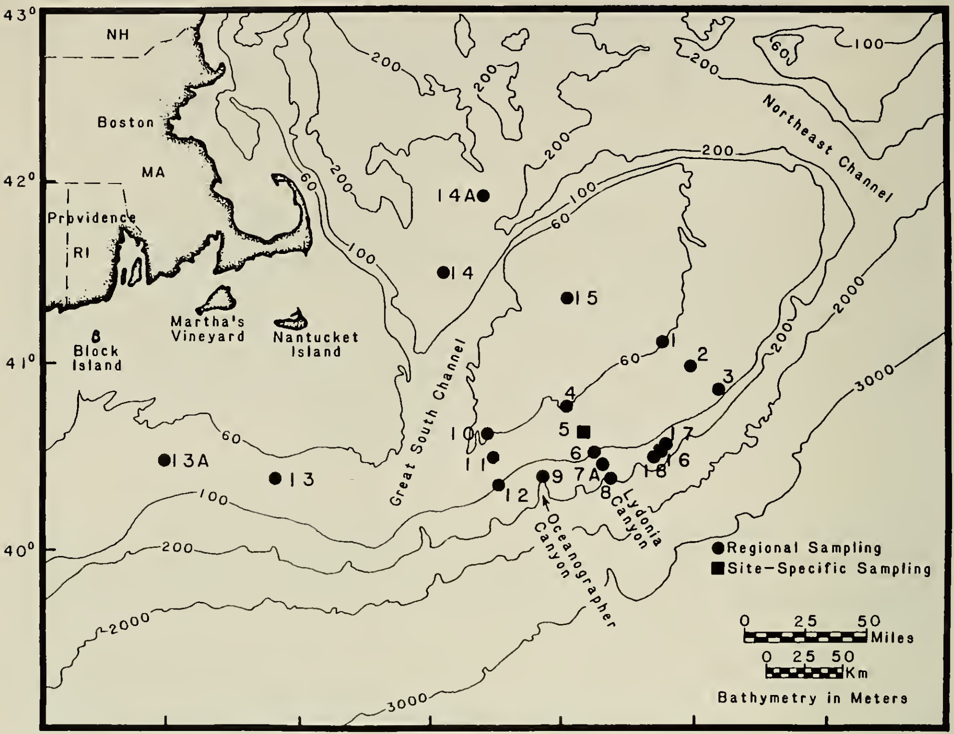

Fig. 1. Map showing positions of sampling stations.

*Description.*—Length 1.9–3.0 mm, 26–33 segments; diameter: 90–151 μm anteriorly, 116–148 μm at segment XI, 62–142 μm posteriorly. Clitellum not observed in these specimens. Secondary annulation weak, 3–4 annuli per segment. Prostomium conical and rounded. Somatic setae (Fig. 3C) similar throughout except ventral setae of segments IX and X in mature specimens. Somatic setae slightly sigmoid; bifid with small, short teeth; upper tooth smaller than lower tooth; 41–59 μm long, 1.5–1.8 μm thick, 2–4 per bundle anteriorly; 32–48 μm long, 1.4–1.8 μm thick, 2–3 per bundle except in specimens in transition stage where normal somatic setae may still be present to give 3–5 per bundle; one or two setae of a modified bundle bifid, slightly enlarged, 41–63 μm long, 1.8–2.5 μm thick; one seta of modified bundle sharply single pointed, larger than bifid setae of same bundle, 48–68 μm long, 2.7–3.2 μm thick. Ventral setae of XI highly modified into penial bundles, each containing: (1) one giant seta (Figs. 2:gs, 3A) with long, slightly sigmoid shaft much widened and cupped ectally to form ladle shape; 120–146 μm long, 10.0–10.8 μm thick at middle (much wider ectally); (2) one medium-sized, simple-pointed seta (Figs. 2:is, 3B) with 90 degree bend in middle and near ental end, slightly curved ectally, 86–98 μm long, 3.6–4.5 μm thick at middle; (3) 4–7 thin ectally hooked, small setae (Fig. 2:ss) 29–33 μm long, 0.9–1.1 μm thick. Giant and intermediate penial setae parallel and small penial setae perpendicular to long axis of worm. Ectal ends of penial setae located within deep, folded copulatory sacs.

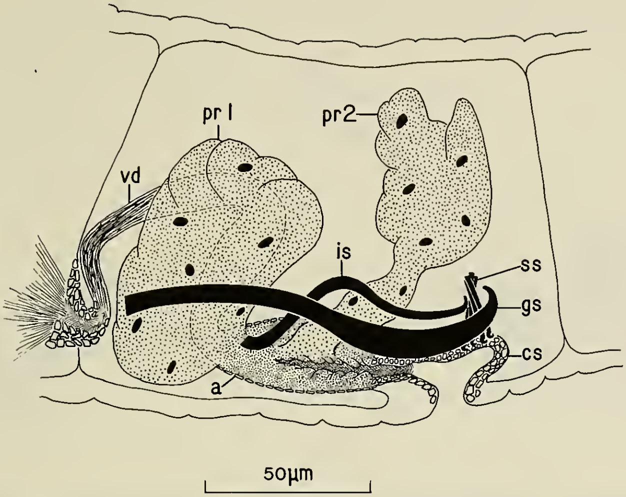

Fig. 2. *Adelodrilus bacrionis,* lateral view of male genitalia in segment XI. a, atrium; cs, copulatory sac; gs, giant penial seta; is, intermediate penial seta; pr1, anterior prostate gland; pr2, posterior prostate gland; ss, small penial setae; vd, vas deferens.

Pharyngeal glands small and lobed, located in V and anterior part of VI. Male genitalia (Fig. 2) paired in XI. Vas deferens thin-walled and broadly dilated; 5–18 $\mu$m wide, about 150 $\mu$m long; filled with random sperm; entering apex of atrium. Atrium elongate-oval; 54–75 $\mu$m long, 23–34 $\mu$m wide; thin outer lining; thick, granulated and ciliated inner epithelium; opening into inner end of copu-

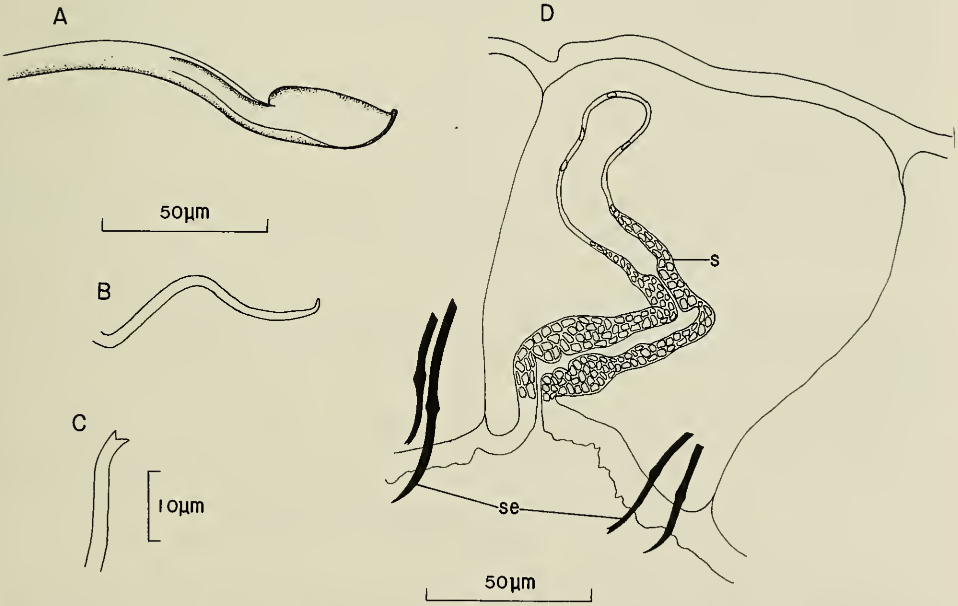

Fig. 3. *Adelodrilus bacrionis*: A, Giant penial seta; B, Intermediate penial seta; C, Somatic seta; D, Lateral view of segment X. s, spermatheca; se, ventral setae of segments IX and X.

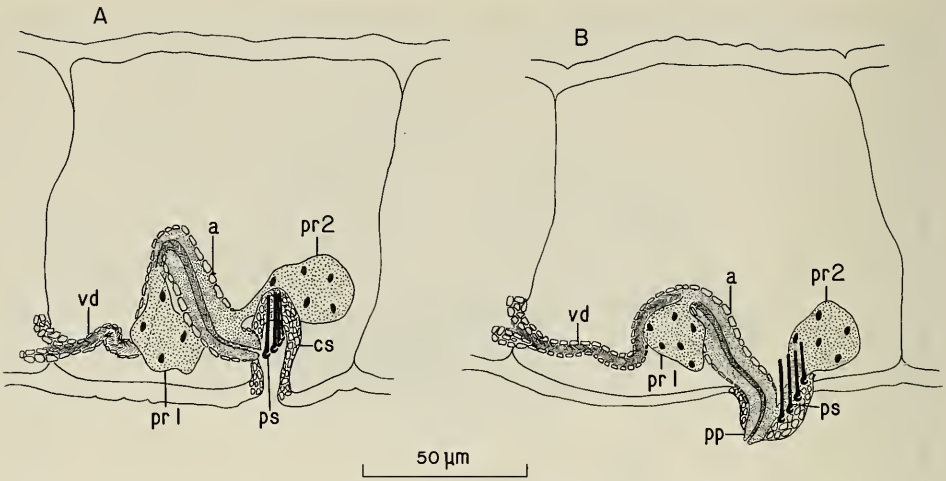

Fig. 4. *Phallodrilus dorsospermatheca*: A, Lateral view of male genitalia in segment XI, with pseudopenis retracted; B, Lateral view of male genitalia in segment XI, with pseudopenis everted. pp, pseudopenis; ps, penial setae; other abbreviations as for Fig. 2.

latory sac. Anterior prostate gland large, somewhat lobed; positioned anterior and dorsal to atrium; attached to ental end of atrium, near entrance of vas deferens. Posterior prostate smaller than anterior prostate; also somewhat lobed; positioned dorsal and posterior to atrium, attached by long stalk to middle to ectal part of atrium. Male pores paired; located in line with ventral setae in posterior part of XI. Spermathecae (Fig. 3D) long and narrow, with 90 degree bend at point where duct enters ampullae; ducts long and hollow, 41–59 $\mu$m long, 18–23 $\mu$m wide; ampullae thin-walled and elongate, 33–59 $\mu$m long, 14–23 $\mu$m wide. Sperm in random masses. Spermathecal pores paired, in line with ventral setae in X near intersegmental furrow IX/X.

*Remarks.*—This species is closely related to *Adelodrilus cooki* Erséus, 1978, and *A. pilatus* Erséus and Davis, 1984. All three species share the following characteristics: single-pointed setae in the ventral bundles of IX and X, spoon-shaped giant penial setae accompanied by intermediate penial setae, and small penial setae. It is also likely that *A. pusillus* Erséus, 1978, *A. kiselevi* (Finogenova, 1972), and *A. correptus* Erséus and Davis, 1984, are closely related to this group but these species do not have the modified setae in the ventral bundles of IX and X. *Adelodrilus bacrionis* is most easily distinguished from the other species in this group by the geniculate shape of both the intermediate penial setae and the spermathecae.

*Habitat.*—Sublittoral, medium to coarse sand, 71–78 m.

*Distribution.*—Northeast coast of the U.S.: off Massachusetts (Georges Bank).

### *Phallodrilus dorsospermatheca,* new species

Figs. 4, 5

*Holotype,*—USNM 97233.

*Type-locality.*—Georges Bank, SE of Massachusetts, USA, sta. 2, 40°59.0′N, 66°55.8′W, 71 m, medium sand, Feb 1984.

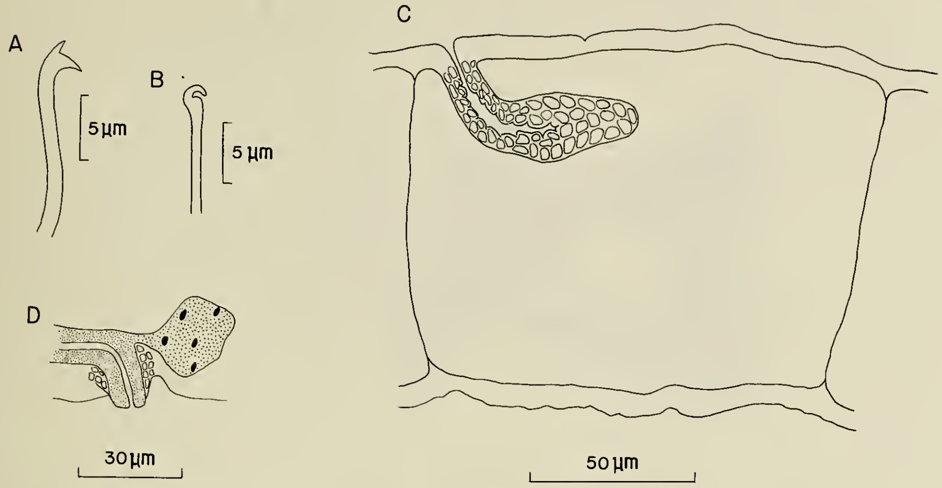

Fig. 5. *Phallodrilus dorsospermatheca*: A, Somatic seta; B, Penial seta; C, Lateral view of spermatheca in segment X; D, Pseudopenis partially everted.

*Paratypes.*—USNM 97234–97235. Two specimens from off Massachusetts (Georges Bank), both from type-locality.

*Other material examined.*—Three specimens from off Massachusetts (Georges Bank), all from type-locality.

*Etymology.*—The name *dorsospermatheca* refers to the dorsal position of the spermatheca.

*Description.*—Length 3.8–5.3 mm, 34–38 segments; 66–99 µm wide anteriorly, 84–99 µm wide at segment XI, 55–90 µm wide posteriorly. Clitellum not observed in specimens examined. Secondary annulation very weak or not present. Prostomium conical and rounded, 1½ times long as wide. Somatic setae (Fig. 5A) similar in shape throughout, sigmoid, bifid, upper tooth thinner and shorter than lower tooth; 30–36 µm long, 1.5–1.8 µm thick, 3–4 per bundle anteriorly; 28–33 µm long, 1.5–1.8 µm thick, (1)–2–(3) per bundle posteriorly. Ventral setae of segment XI modified into penial bundles (Fig. 4:ps), each containing 4 setae. Penial setae (Fig. 5B) straight, single pointed, ectally hooked and clubbed, about 22 µm long, 1 µm thick (very difficult to establish exact size); situated perpendicular to long axis of worm.

Pharyngeal glands located in segments V and VI and anterior part of VII. Male genitalia (Fig. 4) paired in segment XI. Vas deferens (Fig. 4:vd) short, thin-walled, ciliated; 70–75 µm long, 4.5–6.3 µm wide; entering atrium apically. Atrium (Fig. 4:a) straight and elongated, nearly erect; moderately thick outer lining; thick, granulated and ciliated inner epithelium; opening into small, simple copulatory sac (Fig. 4:cs); ectal tip capable of being protruded to form short, thick pseudopenis (Fig. 4:pp). Anterior prostate gland (Fig. 4:pr1) small, compact; situated ventral to atrium; attached to ental end of atrium, near entrance of vas deferens. Posterior prostate (Fig. 4:pr2) small, compact; situated directly posterior to atrium; attached to atrium ectally by short stalk. Male pores paired; in line with ventral setae in posterior part of segment XI. Spermathecae (Fig. 5C) small, elongated (probably not completely formed); duct 5–6 µm long, 6–7 µm wide; ampullae 18–36 µm

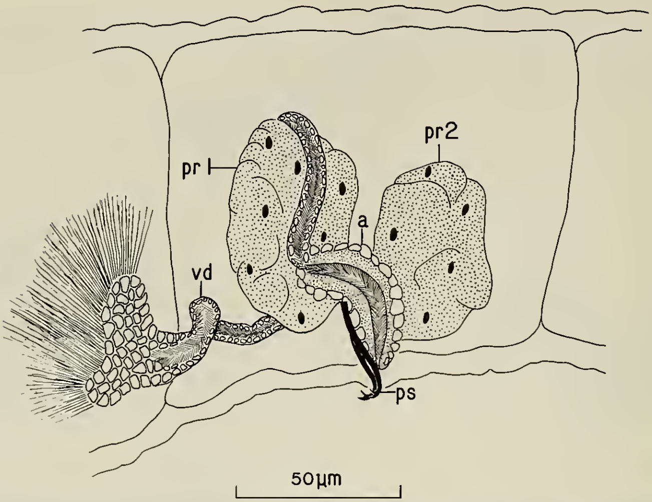

Fig. 6. *Phallodrilus christeri,* lateral view of male genitalia in segment XI. Abbreviations as for Fig. 4.

long, 12–14 µm wide. No sperm observed. Spermathecal pores paired, in line with dorsal setae in anterior part of segment X.

*Remarks.*—As discussed by Erséus (1984a), many species of *Phallodrilus* (*P. coeloprostatus* Cook, 1969; *P. biprostatus* (Baker & Erséus, 1979); *P. parviatriatus* Cook, 1971; and others) from the northwest Atlantic share the feature of small, ectally hooked and clubbed penial setae. *Phalladrilus dorsospermatheca,* which also shares this feature, further supports the view of Erséus that these species are a monophyletic group which has evolved and radiated in the northwest Atlantic.

*Phallodrilus dorsospermatheca* is also similar to *P. minutus* Hrabě, 1973. Both species are small overall with small genitalia, similar penial setae, and spermathecal pores which are more dorsally positioned than those of most other members of the genus *Phallodrilus.* The shape of the protruded pseudopenis shown in the redescription of *P. minutus* (Erséus and Kossmagk-Stephan 1983; Fig. 1:pp) very closely resembles the partly protruded pseudopenis (Fig. 5D) of *P. dorsospermatheca.*

*Phallodrilus dorsopermatheca* differs from *P. minutus* in having smaller and more sharply hooked penial setae and spermathecal pores situated in line with the dorsal setae instead of more laterally.

*Habitat.*—Sublittoral, medium sand, 71 m.

*Distribution.*—Northeast coast of U.S.: off Massachusetts (Georges Bank).

### *Phallodrilus christeri,* new species

Figs. 6, 7

*Holotype.*—USNM 97239.

*Type-locality.*—Georges Bank, SE of Massachusetts, sta. 5-1, USA, 40°39.5′N, 67°46.2′W, 79 m, medium to coarse sand, Nov 1983.

*Paratypes.*—USNM 97240–97241. Two specimens from off Massachusetts

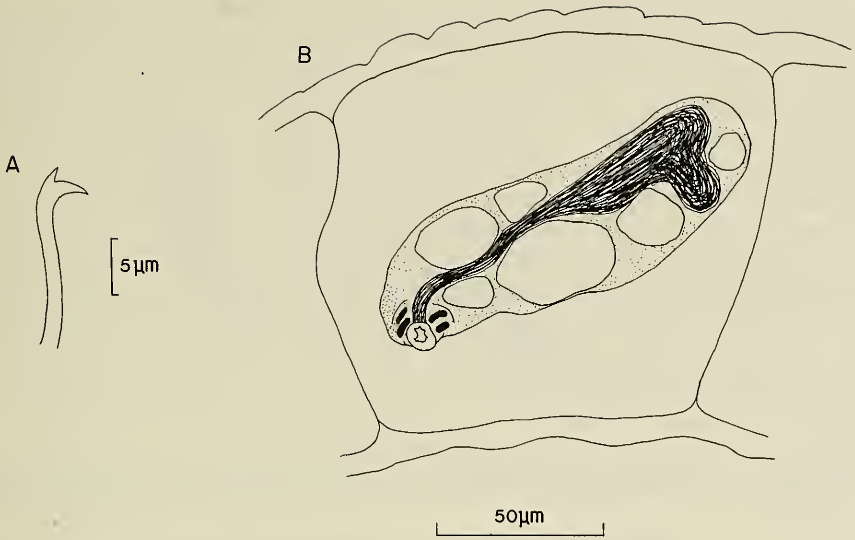

Fig. 7. *Phallodrilus christeri*: A, Somatic seta; B, Lateral view of spermatheca in segment X.

(Georges Bank): one from type-locality; one from sta. 5-18, 40°39.6′N, 67°47.6′W, 80 m, medium to coarse sand, Nov 1984.

*Other material examined.*—Four specimens from off Massachusetts (Georges Bank): three from sta. 5-4, 40°39.5′N, 67°46.5′W, 79 m, medium to coarse sand, May 1983; one from sta. 5-18, 40°39.6′N, 67°47.6′W, 80 m, medium to coarse sand, Nov 1983.

*Etymology.*—This species is named for Dr. Christer Erséus (University of Göteborg, Sweden) who has made many important contributions to the study of marine oligochaetes.

*Description.*—Length 4.0–6.9 mm, 44–50 segments; 67–132 µm wide anteriorly, 134–142 µm wide at segment XI, 55–143 µm wide posteriorly. Clitellum extending over X and XI. Secondary annulation strongly developed, 4–6 annuli per segment. Prostomium conical and rounded, 1½ times longer than wide. Somatic setae (Fig. 7A) similar throughout; bifid, slightly sigmoid, with upper tooth smaller than lower tooth; 38–42 µm long, 1.0–1.5 µm thick, 2–3 per bundle anteriorly; 38–41 µm long, 1.0–1.5 µm thick, 2 per bundle posteriorly. Ventral setae of XI modified into penial bundles (Fig. 6:ps) with each containing 2 setae. Penial setae bifid; long, thin teeth equal in length; upper tooth thicker than lower tooth; shaft slightly sigmoid, sharply curved ectally; 38–48 µm long, 1.5–1.8 µm thick. Penial setae perpendicular to long axis of worm.

Pharyngeal glands small, compact; located in posterior part of III. Male genitalia (Fig. 6) paired in XI. Vas deferens (Fig. 6:vd) moderately thick-walled and ciliated; 150–180 µm long, 6.5–9.0 µm wide; entering atrium ectally. Atrium (Fig. 6:a) small, oval to comma-shaped; moderately thick outer lining; thick, granulated and ciliated inner epithelium; 41–62 µm long, 15–17 µm wide; opening directly to outside through male pore; ectal tip slightly protrusible to form small pseudopenis. Anterior prostate gland (Fig. 6:pr1) small and compact; positioned anterior to atrium; entering atrium entally near entrance of vas deferens. Posterior prostate gland (Fig. 6:pr2) also small and compact; positioned posterior to atrium; entering atrium ectally. Male pores paired; located in line with ventral setae in middle of segment XI. Spermathecae (Fig. 7B) large and oval; duct very short, 9–14 μm long, 9–10 μm wide; ampullae with very thick and glandular walls, 54–128 μm long, 23–37 μm wide, actual lumen small, filled with random sperm. Spermathecal pores paired, in line with ventral setae in anterior part of X.

*Remarks.—Phallodrilus christeri* does not seem to be closely related to any single species, but instead, shares features of several species. The basic shape and structure of the atria are common in this genus. The bifid penial setae are found in only three other species (*P. aquaedulcis* Hrabě, 1960; *P. vulnus* Erséus, 1983b; and *P. cristolatus* Erséus, 1983b), but this is the only feature these species share with *P. christeri.* The male genitalia and the histology of the spermathecae of *P. postspermathecatus* Erséus, 1980, are similar to the new species, but the spermathecae are located in segment XII and the penial setae are not bifid.

*Habitat.*—Sublittoral, medium to coarse sand, 79–80 m.

*Distribution.*—Northeast coast of the U.S.: off Massachusetts (Georges Bank).

### *Phallodrilus parviatriatus* Cook, 1971

*Phallodrilus parviatriatus* Cook, 1971:204–207, fig. 1.—Erséus, 1979c:190.

*Type-material.*—USNM 42015–42017; National Museum of Natural Sciences, Ottawa, Canada, 3413.

*Type-locality.*—Cape Cod Bay, Massachusetts, USA, 41°54.0′N, 70°8.6′W, 17.1 m.

*New material examined.*—Four specimens from off Massachusetts (Georges Bank): one from sta. 5-4, 40°39.5′N, 67°46.5′W, 79 m, medium to coarse sand, Jul 1981; one from sta. 5-22, 40°39.5′N, 67°43.3′W, 77 m, medium to coarse sand, Jul 1981; two from sta. 5-28, 40°39.5′N, 67°41.9′W, 75 m, medium to coarse sand, Feb 1983.

*Remarks.*—The new material conforms in all ways to the original description (Cook 1971) and represents a slight depth extension from 41 m to 79 m.

*Habitat.*—Subtidal, medium to coarse sand, 17–79 m.

*Distribution.*—Northeast coast of the U.S.; New Jersey, Massachusetts (Cape Cod Bay and Georges Bank).

### *Olavius tenuissimus* (Erséus, 1979c)

*Phallodrilus tenuissimus* Erséus, 1979c:199–200, fig. 20.
*Olavius tenuissimus.*—Erséus, 1984a.

*Type-material.*—USNM 56208–56212.

*Type-locality.*—Off Miami, Florida, USA, 25°43.0′N, 80°10.2′W, 3 m.

*New material examined.*—Seven specimens from off Massachusetts (Georges Bank): five from sta. 9, 40°26.7′N, 68°09.8′W, 141 m, fine to medium sand, three collected Feb 1982, two collected Nov 1983; two from sta. 12, 40°22.2′N, 68°30.2′W, 103 m, fine to coarse sand, Nov 1983.

*Remarks.—Phallodrilus tenuissimus* was thoroughly described by Erséus (1979c). Although the new material examined conforms to the original description, nearly all measurements tended to be in the low end of the size range reported by Erséus.

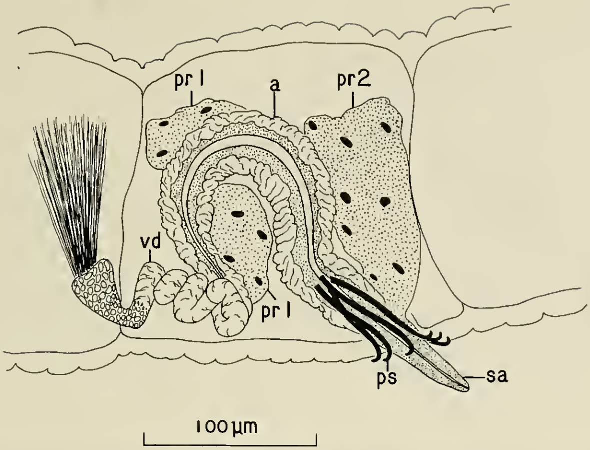

Fig. 8. *Uniporodrilus vestigium,* lateral view of male genitalia in segment XI. sa, styliform atrium; other abbreviations as for Fig. 4.

In the original description, Erséus (1979c) noted that the size of the penial setae varied between material from different localities. As for the other characteristics in the new material, the penial setae tended to be shorter than average (38–51 µm as compared to 41–74 µm in the original description). All specimens in the new material have only one penial seta per "bundle." All of the material from the original description was found at shallow depths (less than 10 m) while the new material was found only at depths greater than 100 m.

The new material represents a considerable range extension (and depth extension) northward from North Carolina to off Massachusetts (Georges Bank).

*Habitat.*—Subtidal, fine to coarse sand, 0.5–141 m.

*Distribution.*—East coast of U.S.: Florida, North Carolina, Massachusetts (Georges Bank), Bermuda.

### *Uniporodrilus vestigium,* new species
Figs. 8, 9, 10

*Holotype.*—USNM 97247. Whole mounted specimen.

*Type-locality.*—Georges Bank, SE of Massachusetts, USA, sta. 5-1, 40°39.5'N, 67°46.2'W, 79 m, medium to coarse sand, Jul 1983.

*Paratypes.*—USNM 97248–97250. One sectioned specimen, two whole mounted specimens from off Massachusetts (Georges Bank): sectioned specimen from sta. 5-11, 40°39.2'N, 67°46.6'W, 80 m, medium to coarse sand, May 1983; whole mounted specimens from type-locality, one collected May 1983.

*Other material examined.*—Two sectioned specimens, three whole-mounted specimens from off Massachusetts (Georges Bank): one sectioned specimen from type-locality; one sectioned specimen from sta. 5-11, 40°39.2'N, 67°46.6'W, 80 m, medium to coarse sand, Jul 1983; one whole mounted specimen from type-locality; one from sta. 5-3, 40°39.8'N, 67°46.1'W, 78 m, medium to coarse sand, May 1983; one from sta. 5-20, 40°38.5'N, 67°46.1'W, 78 m, medium to coarse sand, Nov 1982.

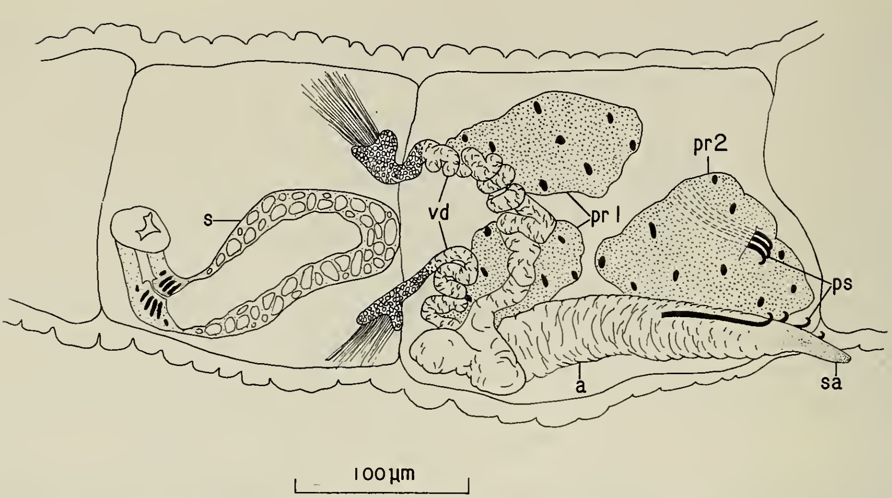

Fig. 9. *Uniporodrilus vestigium,* ventral view of spermatheca and male genitalia in segments X and XI. s, spermatheca; other abbreviations as for Fig. 8.

*Etymology.*—The name *vestigium* is Latin for "footprint," or something left behind. This refers to one bundle of penial setae which is "left behind" after the atrium from that side of the worm has disappeared.

*Description.*—Length 5.5–7.1 mm, 48–54 segments; nearly uniform width throughout, 205–223 µm wide at segment XI. Clitellum extending over XI and XII. Prostomium conical and rounded, slightly longer than wide. Secondary annulation strongly developed, 6–7 annuli per segment. Somatic setae (Fig. 10A) similar throughout, slightly sigmoid, bifid with upper tooth smaller than lower tooth; 35–51 µm long, 1.8–2.0 µm thick, 2–3 per bundle anteriorly; 33–42 µm long, 1.5–1.8 µm thick, 2 per bundle posteriorly. Ventral setae of segment XI modified into penial bundles (Figs. 8–9:ps), each containing 4–6 setae. Penial setae slightly sigmoid, single pointed and ectally hooked; 70–78 µm long, 2.0–2.5 µm thick; situated slightly oblique to parallel to long axis of worm.

Pharyngeal glands small, located in segment V and anterior part of segment VI. Male genitalia (Figs. 8–9): sperm funnels, vasa deferentia, and anterior prostate glands paired; atrium and posterior prostate gland unpaired; in segment XI. Vasa deferentia (Figs. 8–9:vd) highly coiled, with thick muscular walls; vas deferens of side lacking atrium longer than other side, running under nerve cord and entering atrium apically, approximately 380 µm long; vas deferens of atrium side entering atrium apically near entrance of other vas deferens, approximately 270 µm long. Atrium (Figs. 8–9:a) large, horseshoe-shaped, with thick, very muscular outer lining and thick, granulated inner epithelium; 250–345 µm long, 72–77 µm wide. Ectal tip of atrium styliform (Figs. 8–9:sa) and capable of protruding through body wall.

Anterior prostate glands (Figs. 8–9:pr1) small; one on atrium side of worm, entering atrium entally; one on side lacking atrium, possibly vestigial, attachment to atrium not seen. Posterior prostate gland (Figs. 8–9:pr2) very large, extending over both sides of worm, attached to ectal end of atrium. Male pore unpaired, located in line with ventral setae of atrium side of worm in posterior part of

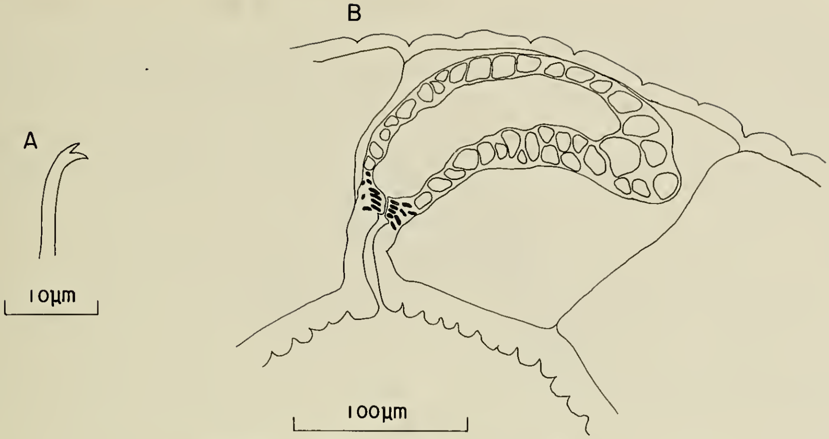

Fig. 10. *Uniporodrilus vestigium*: A, Somatic seta; B, Spermatheca.

segment XI. Spermatheca (Figs. 9:s, 10B) unpaired, very large; duct moderately long and hollow, with first ¾ having wide lumen to act as vagina to receive styliform atrium, last ¼ constricted, 50–55 µm long, 23–32 µm wide; ampullae elongate-oval, sometimes slightly curved, with walls very thick containing large glandular spheres and smaller, yellowish spheres probably containing lipids, 145–230 µm long, 62–80 µm wide, walls up to 20 µm thick. Sperm in random masses. Spermathecal pore unpaired, mid-ventral or slightly to one side; in segment X near intersegmental furrow of IX/X.

*Remarks.*—*Uniporodrilus vestigium* is closely related to *U. granulothecus* Erséus, 1979b. The new species differs in having only one posterior prostate gland, the male pore being in line with the ventral setae instead of being mid-ventral, and the spermathecal pore in segment X instead of segment IX. The new species also has a more muscular atrium and vasa deferentia and fewer penial setae.

With the addition of this species, the generic description of *Uniporodrilus* Erséus, 1979b, is slightly modified to include species with the spermathecal pore in segment X, the male pore in line with the ventral setae, and one posterior prostate gland. If other species of this genus are found, it is likely that these characteristics will be highly variable. The most important generic characteristics are the unpaired atrium and spermatheca.

*Habitat.*—Sublittoral, medium to coarse sand, 78–80 m.

*Distribution.*—Northeast coast of the U.S.: off Massachusetts (Georges Bank).

### *Bathydrilus longus* Erséus, 1979d

*Bathydrilus longus* Erséus, 1979d:144–145, fig. 9.

*Type-material.*—USNM 55693–55700.

*Type-locality.*—Continental shelf off the coast of New Jersey, USA, NW Atlantic, 30°06.6′N, 72°59.0′W, 70 m.

*New material examined* (new records). Four specimens from off Massachusetts (Georges Bank): two from sta. 16, 40°34.2′N, 67°12.3′W, 138 m, medium to coarse sand, Nov 1983; one from sta. 12, 40°22.2′N, 68°30.2′W, 103 m, medium to coarse sand, Nov 1983; one from sta. 7, 40°28′N, 67°43.2′W, 165 m, medium to coarse sand, Jul 1981.

*Remarks.*—*Bathydrilus longus* was thoroughly described by Erséus (1979d). The new specimens conform in most respects to the original description, with two notable exceptions. In two of the specimens examined, the male pores appeared to be located in the anterior part of segment XII. It was very difficult to establish the exact position of the septum between segments XI and XII but it was clear in these two specimens that the male pores are situated more posteriorly than depicted in the illustration for the original description (Erséus 1979d, fig. 9).

The other exception to the original description is the length of the atrium. Three of the specimens examined have atria with lengths of 270–320 μm, which is considerably longer than the originally reported lengths of 185–250 μm long.

This material represents a slight range extension northward from off New Jersey to off Massachusetts. This material was also found at slightly deeper depths of 103–165 m as compared to 70–91 m for the type material.

*Habitat.*—Sublittoral, medium to coarse sand, 70–165 m.

*Distribution.*—Northeast coast of the U.S.: off New Jersey and Massachusetts (Georges Bank).

### *Heterodrilus occidentalis* Erséus, 1981

*Heterodrilus occidentalis* Erséus, 1981:121, fig. 11.

*Type-material.*—USNM 60606–60610.

*Type-locality.*—Near Beaufort, North Carolina, USA, 34°41′58″N, 76°37′20″W, 5 m.

*New material examined* (new records).—Three specimens from off Massachusetts (Georges Bank): two from sta. 15, 41°27.5′N, 68°00.7′W, 38 m, fine to medium sand, Jul 1981; one from sta. 16, 40°34.2′N, 67°12.3′W, 138 m, medium to coarse sand, Nov 1981.

*Remarks.*—The new material conforms in all ways to the original description (Erséus 1981). These records represent a slight range extension northward from New Jersey to off Massachusetts. One of the new specimens was found at 138 m, which is a considerable depth extension from 24 m.

*Habitat.*—Subtidal, fine to coarse sand, 4.5–138 m.

*Distribution.*—East coast of U.S.; North Carolina, New Jersey, and Massachusetts (Georges Bank).

### *Limnodriloides medioporus* Cook, 1969
Fig. 11

*Limnodriloides medioporus* Cook, 1969:21–22, fig. 7; 1970b:980; 1971:212; 1974, 131.—Brinkhurst and Jamieson, 1971:530, fig. 8.24 A–C.—Erséus, 1982:225–226, fig. 9.

*Type-locality.*—Cape Cod Bay, Massachusetts, USA, 41°54.9′N, 70°15.12′W, 36.5 m.

*New material examined.*—Six specimens from off Massachusetts (Georges Bank): four from sta. 13, 40°29.5′N, 70°12.6′W, 67 m, silt to very fine sand, Nov 1983; one from sta. 13A, 40°30.0′N, 71°00.5′W, 78 m, silt, Nov 1983; one from sta. 7A, 40°32.15′N, 67°44.2′W, 165 m, silt to very fine sand, Feb 1984.

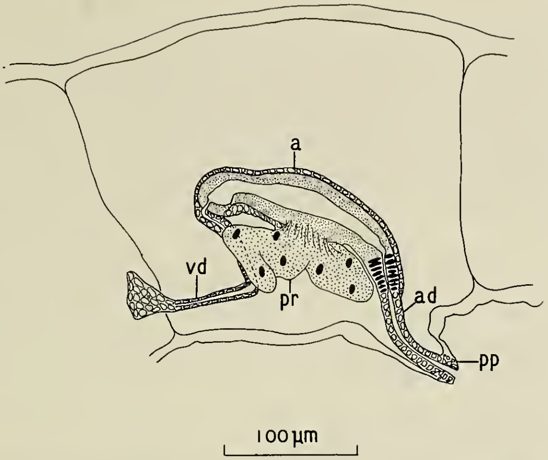

Fig. 11. *Limnodriloides medioporus,* lateral view of male genitalia in segment XI, with pseudopenis everted. pr, prostate gland; ad, atrial duct; other abbreviations as for Fig. 4.

*Remarks.*—The specimens examined here conform in every way to the original description with one minor exception. The original description (Cook 1969) states that there are two somatic setae per bundle posteriorly. In the new material, there were occasionally only one or up to three per bundle. The median pore is often not visible, depending on whether the penes are everted or not. These can vary from the relaxed state, as in the original description (Cook 1969, fig. 7), to the fully everted position (Fig. 11). In many cases, the penes will be only partially everted so the median pore disappears, which is confusing for identification purposes.

*Habitat.*—Subtidal silt to medium sand, 18–97 m.

*Distribution.*—Northeast coast of U.S., Massachusetts through New Jersey.

### *Limnodriloides barnardi* Cook, 1974

*Limnodriloides barnardi* Cook, 1974:134–135, fig. 5.—Erséus 1976:32–33, fig. 3; 1982:232–234, not fig. 13.

*Limnodriloides winckelmanni* Michaelsen, 1914:—Jamieson, 1977:338, not fig. 2.

*Type-material.*—USNM 48730–48731.

*Type-locality.*—Bahía de San Quintín, Pacific coast of Mexico, less than 2 m.

*New material examined* (new records).—Three specimens from off Massachusetts (Georges Bank); all from sta. 12, 40°22.2′N, 68°30.2′W, 103 m, medium to coarse sand, Nov 1983.

*Remarks.*—*Limnodriloides barnardi* was thoroughly described by Cook (1974) and subsequently reviewed by Erséus (1982). The new material examined conformed closely to the material examined by Erséus from the northern localities along the U.S. east coast.

In the specimens studied here, the male and spermathecal pores were located very close together. The male pores were so close together in one specimen that they formed an I-shaped common median bursa. The spermathecal setae were also smaller than those of the type-material (65–77 μm compared to 110–120 μm), but were all located posterior to the spermathecal pores.

This material represents a slight northward range extension on the east coast of the U.S. from New Jersey to off Massachusetts (Georges Bank).

*Habitat.*—Subtidal, silt to coarse sand, 0.5–150 m.

*Distribution.*—Massachusetts, New Jersey, Maryland, Virginia, North Carolina, East coast of Florida, Bahamas, Bermuda, and Pacific coast of Mexico.

### *Tubificoides intermedius* (Cook, 1969)

*Peloscolex intermedius* Cook, 1969:11–12, fig. 2.—Brinkhurst and Jamieson, 1971: 512–513, fig. 8.22 K, L.—Holmquist, 1978: fig. 6B.

*Tubificoides intermedius* Brinkhurst and Baker, 1979:1559, fig. 7.

*Type-material.*—USNM 38259–38262.

*Type-locality.*—Cape Cod Bay, Massachusetts, USA, 41°55.75′N, 70°21.07′W, 42.6 m.

*New material examined.*—Three specimens from off Massachusetts (Georges Bank); all from sta. 13, 40°29.5′N, 70°12.6′W, 67 m, silt to very fine sand, one collected Nov 1982, two collected Nov 1981.

*Remarks.*—The new material examined here conforms in most ways to the original description (Cook 1969); however, as mentioned by Brinkhurst and Baker (1979), the illustration in the original description (Cook 1969, fig. 2) is not accurate. The illustration by Holmquist (1978, fig. 6B) very accurately depicts the male genitalia as seen in a whole mount in the material examined here.

*Habitat.*—Subtidal, silt to very fine sand, 7–67 m.

*Distribution.*—Northeast coast of U.S.; Massachusetts (Cape Cod Bay and Georges Bank),

### *Marionina welchi* Lasserre, 1971

*Marionina welchi* Lasserre, 1971:453–454, fig. 2.

*Type-material.*—USNM 43479–43481.

*Type-locality.*—Cape Cod Bay, Massachusetts, USA, 41°54.00′N, 70°08.40′W, 17 m.

*New material examined* (new records).—Six specimens from off Massachusetts (Georges Bank): one from sta. 5-10, 40°39.4′N, 67°46.9′W, 80 m, medium to coarse sand, Jul 19-14, 40°39.5′N, 67°44.7′W, 79 m, medium to coarse sand, Jul 1981; one from sta. 5-2, 40°39.6′N, 67°45.8′W, 78 m, medium to coarse sand, May 1982; one from sta. 5-1, 40°39.5′N, 67°46.2′W, 79 m, medium to coarse sand, Nov 1983; two from sta. 5-18 40°39.6′N, 67°47.6′W, 80 m, medium to coarse sand, Nov 1983.

*Remarks.*—The new material conforms in every way to the original description (Lasserre 1971). *Marionina welchi* was previously known only from Cape Cod Bay, Massachusetts. Although the new material does not represent a geographical range extension, it certainly represents a considerable habitat extension.

*Habitat.*—Subtidal, medium to coarse sand, 14.6–80 m.

*Distribution.*—Northeast coast of U.S.; Massachusetts (Cape Cod Bay, Georges Bank).

### Unidentified Material

This group, with the exception of *Phallodrilus* sp. A, represents species which have not been identified because of problems within their respective taxonomic groups. *Phallodrilus,* sp. A has been confirmed to be a new species by Erséus (pers. comm.), but there was only one specimen found during the program. This species will be described by Erséus if it is determined that a complete description can be obtained from this one specimen.

The genus *Tubificoides* is in dire need of revision, which often makes identifications questionable. This is the case for *Tubificoides,* sp. A and B. Species A is similar to *T. maureri,* but the opening in the penial sheath seems to be more lateral in *T. maureri.* Species B keys out to be *T. apectinatus* using the key to the species of *Tubificoides* by Brinkhurst and Baker (1979). The problem lies in the difference between the original description (Brinkhurst 1965:133–134, fig. 5, O–T) and the description by Brinkhurst and Baker (1979:1559, fig. 9). There is a considerable difference in the shape of the penial sheath in these two descriptions, making it difficult to know which is correct. These problems will probably not be remedied until the revision of this genus is complete.

Four new species of *Grania* were found from Georges Bank and confirmed by Erséus (pers. comm.). The descriptions of these species will be included in a revision of the genus *Grania,* which is currently being undertaken by Erséus and Coates (Erséus, pers. comm.).

The species designated as Oligochaeta, n. fam., sp. A, represents what is probably a new family, which has been found in other material from along the east and west coasts of the U.S. and the Caribbean (Erséus, pers. comm.). The material from Georges Bank, along with material from the other locations, is currently being worked out by Erséus (pers. comm.).

## Discussion

No specific data were recorded on life history or sediment-species relationships during the Georges Bank Monitoring Program; however, many obvious trends were observed which were consistent throughout the three-year program and should be noted. It should be emphasized that these observations are not based on quantitative data.

### Sediment-Species Relationships

The sediment at Station 5 consisted mainly of medium to coarse sand, a feature shared by only two other stations (2 and 16). All other stations had a higher percentage of fine sand, except Stations 13, 13A and 14A, which were predominantly silt. This "medium to coarse sand" habitat is obviously preferred by most oligochaetes. In the three stations with this sediment type, there were generally about 50 to 75 specimens per sample with up to 20 species present. In the stations with higher percentages of fine sand, there were rarely more than 25 specimens per sample and generally not more than five species present. In the stations with high amounts of silt, there were large numbers of only one to three species.

The medium to coarse sand sediments were dominated by members of the subfamily Phallodrilinae; *Phallodrilus, Adelodrilus,* and *Uniporodrilus. Bathydrilus* is the only member of this subfamily that was not found in the coarse sediment, which may be an indication of its relationship to the Phallodrilinae. All species of the family Enchytraeidae reported herein were also found in the coarse sediments.

The finer sediments were dominated by *Limnodriloides medioporus* and *Tubificoides,* sp. A. *Bathydrilus longus, Heterodrilus occidentalis, Limnodriloides barnardi,* and the gutless Phallodrilinae occurred repeatedly at specific stations without any apparent relationship to sediment type.

The stations with silty sediments always had large numbers (up to 300 per sample) of *Limnodriloides medioporus* which were usually accompanied by a few specimens of *Tubificoides intermedius* and/or *Tubificoides,* sp. B.

## Life Histories

Sexually mature specimens of many of the species were found in all samples suggesting that they are capable of reproducing year-round. It was quite apparent that the number of sexually mature specimens for all species was higher in the November samples; however, *Adelodrilus pilatus* seemed to be the only species that was sexually mature exclusively in November.

There are obviously some species with a much lower number of sexually mature individuals than juveniles at any time of the year when compared to the "usual number," which can be shown by example. *Tubificoides,* sp. B was relatively common in nearly all samples from Station 13A, but only three sexually mature specimens were found during the entire program. For most species, there were usually at least a few sexually mature individuals in every sample.

## Geographical Distribution

Nearly all of the species from Georges Bank are limited in their distribution to the northeast coast of the United States. The distribution of *Olavius tenuissimus* extends south to Florida and Bermuda and *Limnodriloides barnardi* may be cosmopolitan in its distribution, being found from the east and west coasts of North America.

The unidentified species such as *Tubificoides,* sp. B and the *Grania* complex may be more widely distributed if they turn out to be known species.

## Acknowledgments

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# PENAEOID SHRIMP FAUNA FROM TROPICAL SEAGRASS MEADOWS: SPECIES COMPOSITION, DIURNAL, AND SEASONAL VARIATION IN ABUNDANCE

Raymond T. Bauer

*Abstract.*—The motile invertebrate epifauna of seagrass (*Thalassia testudinum*) meadows at Dorado, north coast of Puerto Rico, was sampled monthly during the day and at night for a year. The penaeoid shrimp component of the mobile epifauna was dominated by two small sicyoniids, *Sicyonia parri* (65% of N) and *S. laevigata* (21% of N). *Metapenaeopsis goodei, M. martinella,* and *M. smithi* were much less numerous. All penaeoid shrimps were collected in significantly higher numbers at night. Laboratory observations indicate that all species burrow just under the bottom during the day but are active at night. The nocturnal emergence of these penaeoids and their increased susceptibility to capture at and after dusk was documented by sampling which began before and ended after sunset; numbers of shrimp taken increased dramatically with increasing darkness. *Sicyonia parri* and *S. laevigata* showed significantly higher abundances in spring and summer months at one of two replicate sampling sites while *Metapenaeopsis* juveniles exhibited a similar pattern at both sites. There was no evidence of seasonality in *Metapenaeopsis* adults.

In recent years various investigators have conducted sampling programs in subtropical and tropical seagrass meadows dominated by turtlegrass, *Thalassia testudinum* (Bauer, in press; Greening and Livingston 1982; Gore *et al.* 1981; Heck 1976, 1977, 1979; Thorhaug and Roessler 1977; Hooks *et al.* 1976). The results of these studies on community structure show that, as in seagrass meadows in temperate areas (Heck and Orth 1980a, b; Kikuchi and Pérès 1977; Kikuchi 1966), the motile invertebrate epifauna sampled by pushnets, epibenthic dredges, otter trawls, and drop net techniques is dominated numerically by decapod crustaceans such as caridean shrimps, penaeoid shrimps, paguroid crabs, and brachyuran crabs. Kikuchi (1966, 1974) and Reid (1954) reported that decapods, e.g., shrimps, are preferred food items of fishes foraging over seagrass beds. Initially, analyses of community structure, i.e., species composition and relative abundance, were carried out on collections taken during daylight hours. More recently, Bauer (in press), Leber and Greening (ms), and Greening and Livingston (1982) have demonstrated that the *Thalassia* epifaunal community is "awake" at night; more species are collected at night and individual species abundances are significantly higher in night samples.

Penaeoid shrimps are often a numerically important component of the motile epifauna in *Thalassia* meadows (Greening and Livingston 1982; Gore *et al.* 1981; Heck 1976, 1977). In a year-long monthly sampling program conducted in seagrass beds at Dorado, north coast of Puerto Rico, penaeoids frequently comprised 10–15% of the total number of individuals in a monthly night sample (range: 1–41%).

The purpose of this report is to describe the species composition of the penaeoid fauna from these seagrass meadows, to compare estimates of abundance based on day and night sampling, and to describe seasonal variations in abundance of the numerically dominant species.

## Methods

The seagrass meadows sampled were located in a cove just east of the Dorado Balneario (public beach) near Dorado (18°29′N, 66°15′W), on the north coast of Puerto Rico. These grassbeds are described by Bauer (in press); further details on study areas, methods used, and sampling information can be obtained from that report. A shallow rocky reef protects the beds from the normal 2–6′ (0.6–1.8 m) ocean swells characteristic of the north coast. The Dorado grassbeds have the form of a terrace raised approximately 1 m above the surrounding sand bottom. Two species of seagrasses, *Thalassia testudinum* and *Syringodium filiforme,* were the primary vegetation; *T. testudinum* was dominant in blade density throughout the investigation. A variety of species of attached benthic algae occurred in the grassbeds but were never extremely abundant; drift algae (e.g., Greening and Livingston 1982; Gore *et al.* 1981) were not present in noticeable quantity during the study period.

Two areas within the Dorado seagrass meadows were delimited as replicate sampling sites. The two sites were 40 m apart and almost separated by the surrounding sand bottom. The median water depth at Site 1 varied from 0.7–1.0 m (depending on tidal height) while Site 2 was somewhat shallower (0.4–0.7 m). Sediments under Site 1 were muddy sand; those at Site 2 were similar but scattered coral rubble also occurred there. These grassbeds were relatively level and free of holes so that uninterrupted runs of the pushnet could be taken.

A 0.5-m wide pushnet with a 1.0-mm mesh liner sewn into the net bag was used to sample the mobile invertebrate epifauna. A sample unit was a 10 m run so that each sample covered an area of 5 $m^2$. Collecting took place when the tidal level was lower than 0.2 m. A small part of Site 2 was exposed by the lowest tides; samples were not taken when this area was exposed. Night collections were usually made at new moon to first quarter or before moonrise at other lunar phases; the only quantitative field work reported here done under the light of full moon was in March 1982.

Monthly day and night sampling was conducted from February 1982 to February 1983. Each month, 10 day and 10 night samples were taken at each of the two sites. A map of each site was divided into areas the size of a sample unit, 10 m × 0.5 m. These units were numbered and sample locations were chosen by using a random numbers table. In the field, one end of these randomly selected units was located by measurements from reference markers. The median speed at which the net was pushed varied from 0.7–0.9 m/sec. After a pushnet run, all material was removed from the net and placed in a plastic bag with 37–40% formaldehyde added to make an approximately 10% formalin solution. In the laboratory, animals were sorted out and placed in 70% ethanol for permanent storage.

Day samples were those taken between sunrise and sunset; night collections were conducted between sunset and sunrise. The time of day or night field work varied with low tide periods during which such work was carried out. Because of the timing of tides, three sets of samples took place across the night–day or day–night transition; since I report variations in individual sample abundance with time for these particular samples, time of field work will be given in greater detail for them. May Site 1 day samples began at 1725 Atlantic Standard Time and ended at 1925; sunset was at 1833 and darkness (when flashlight became necessary to read and record data) fell at approximately 1900. The May Site 2 night collections were from 1830 to 2000; the time of sunset and darkness was the same as for May Site 1 day. The June Site 1 night samples were from 0440 to 0555; sunrise was at 0522. In June at Site 2 there were two day (just after sunrise and during the afternoon) and no night samples. Bad weather prevented field studies in February 1982 at Site 1 and caused termination of work in July at Site 1 after only 3 samples. April Site 1 day and Site 2 night collections had to be discarded because of poor preservation.

Water temperature varied from 26–30.5°C and salinity from 34–36‰ during the study period (measured monthly during field work).

Observations on day-night activity were carried out on captive animals in recirculating aquaria with sand bottom in which *Thalassia* plants were imbedded. Shrimps were maintained under either a variable day-night light cycle which coincided with working hours or a 12 hr day:12 hr night cycle controlled by a timer. "Daylight" was fluorescent light; night observations were made under constant red light, with flashlight with and without red filter, by flash photography, or by turning on day lights during a dark cycle.

The classification of dendrobranchiate shrimps given by Pérez Farfante (1977, 1978) is followed in this report.

## Results

*Species composition.*—Approximately 7500 dendrobranchiate shrimps were captured (Table 1). Almost all individuals were species in the superfamily Penaeoidea. Two members of the family Sicyoniidae, *Sicyonia parri* (Burkenroad) and *S. laevigata* Stimpson comprised 85.9% of the total collected (Table 1). Three *Metapenaeopsis* species (Penaeidae), *M. smithi* Schmitt, *M. martinella* Pérez Farfante, and *M. goodei* (Smith) were much less abundant (Table 1). I grouped all juvenile (without the well developed petasma or thelycum needed for species identification) *Metapenaeopsis* together; these juveniles accounted for 9.3% of the total number of shrimps. The genus *Penaeus* was represented by only 31 late postlarvae. Only four specimens of the superfamily Sergestoidea, family Sergestidae (*Lucifer faxoni* Borradaile) were taken in the samples.

*Diel variation in abundance.*—All penaeoid species were much more abundant in night samples than in day collections. At both sites, the mean number of *Sicyonia parri* per square meter of sampling effort was significantly higher than the day mean (95% confidence limits of day and night means do not overlap) (Fig. 1). In 3 of 13 months, no individuals of this species were captured during the day at Site 1. Estimates of monthly abundance based on night samples ranged from 1–14/m$^2$ (monthly means). *Sicyonia laevigata* followed a similar pattern of consistently higher mean numbers of individuals in samples taken at night (Fig. 2). On six of 27 occasions, there were no *S. laevigata* taken during daylight hours.

Table 1.—Species composition and relative abundance of dendrobranchiate shrimps from Dorado, Puerto Rico, seagrass meadows (totals of 13 months, both sites, day + night).

| Rank | Species | Number collected (and % of total) |
|---|---|---|
| 1. | *Sicyonia parri* | 4827 (64.7%) |
| 2. | *S. laevigata* | 1582 (21.2%) |
| 3. | *Metapenaeopsis* juveniles | 693 (9.3%) |
| 4. | *M. smithi* | 210 (2.8%) |
| 5. | *M. martinella* | 70 (0.9%) |
| 6. | *M. goodei* | 42 (0.6%) |
| 7. | *Penaeus* sp. (late postlarvae) | 31 (0.4%) |
| 8. | *Lucifer faxoni* | 4 (0.1%) |

Estimates of mean density based on nocturnal samples ranged from 0.3–3.0/m$^2$. Relatively few adult *Metapenaeopsis goodei, M. smithi,* and *M. martinella* occurred in the samples (Table 1). To analyze day–night variation in *Metapenaeopsis,* adults of all three species were grouped (Fig. 3). *Metapenaeopsis* adults were taken in only 1 of 27 day sampling periods. Mean abundance in night samples varied from 0.08–0.80/m$^2$. *Metapenaeopsis* juveniles were also primarily night collectable (Fig. 4); the mean number/m$^2$ in monthly night collections ranged from 0–2.4.

Three sets of samples were taken during the day to night or night to day transition; the changes in numbers of shrimps taken with increasing darkness or increasing light gives another view of diel variation in their collectability. Two day to night sample sets taken in May 1982, demonstrate the dramatic increase in numbers of *Sicyonia parri* and *S. laevigata* with increasing darkness (Fig. 5). The positive correlation between shrimps/sample and sample number (increasing sample number = increasing darkness) is statistically significant for both species (Table 2). Numbers of *Metapenaeopsis* adults + juveniles) per sample were positively correlated with higher sample numbers at Site 2 but not at Site 1 (Table 2). In June at Site 1, night to day collections were made and a decrease in numbers of *Sicyonia parri* and *S. laevigata* with time (higher sample numbers = increasing light) was demonstrated (Fig. 6). The negative correlation between shrimp abundance and sample number was significant for *S. parri* but not for *S. laevigata* (Table 2). *Metapenaopsis* juveniles and adults occurred in low densities during the first five samples taken before light and only 1 individual was collected in the last five pushnet runs near or after sunrise. This decline in *Metapenaeopsis* numbers was significant (Table 2).

### Seasonal Variation in Abundance (Night Samples)

To look at possible differences in monthly abundances, a one-way ANOVA, using the log (x + 1) transformation, was done on monthly night mean densities for *Sicyonia parri, S. laevigata, Metapenaeopsis* adults, and *M.* juveniles for each site. Differences between individual monthly means were determined with the Student-Newman-Keuls test, using the $P = 0.05$ level of significance (Table 3).

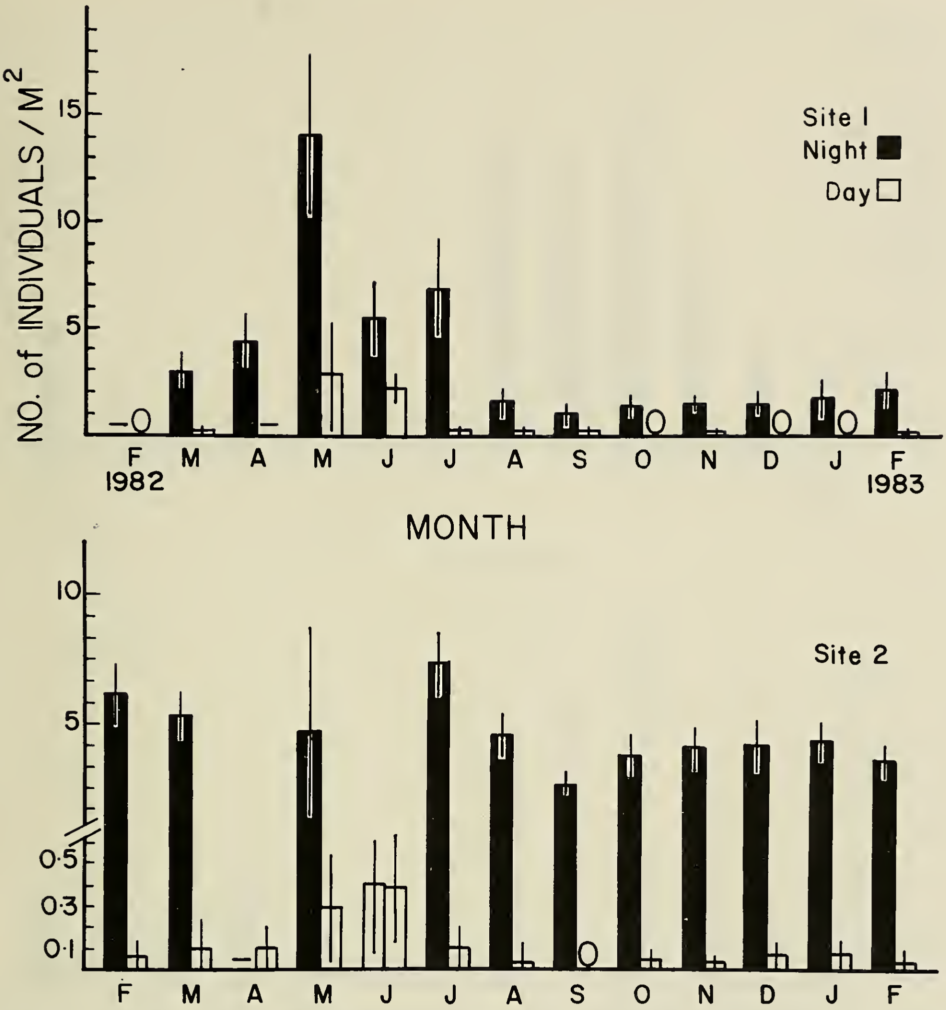

Fig. 1. Monthly day and night abundances of *Sicyonia parri.* Bars represent mean number of individuals captured per square meter of sampling effort; vertical lines are the 95% confidence limits on the means. A dash (—) signifies no sampling for that period; a zero (0) means that no individuals were taken. Black bars are night means; clear bars represent day means.

For *S. parri* at Site 1, abundances in April, May, June, and July were significantly higher than in the remaining months; at site 2, a similar pattern was not obvious (Fig. 1, Table 3). The trends in abundance of *S. laevigata* were similar to *S. parri* at Site 1, with May, June, and July means forming a group distinctly greater than the other months. Although there were significant differences at site 2 in *S. laevigata* ($P < 0.001$), groups of similar means were highly overlapping, and a pattern of highs and lows similar to Site 1 is not apparent (Table 3). Mean abundances of *Metapenaeopsis* adults were highly overlapping at Site 1 (Fig. 3, Table 3) and monthly means were not significantly different at Site 2 ($P \gg 0.10$). However, seasonal differences were present in *Metapenaeopsis* juveniles (Fig. 4, Table 3).

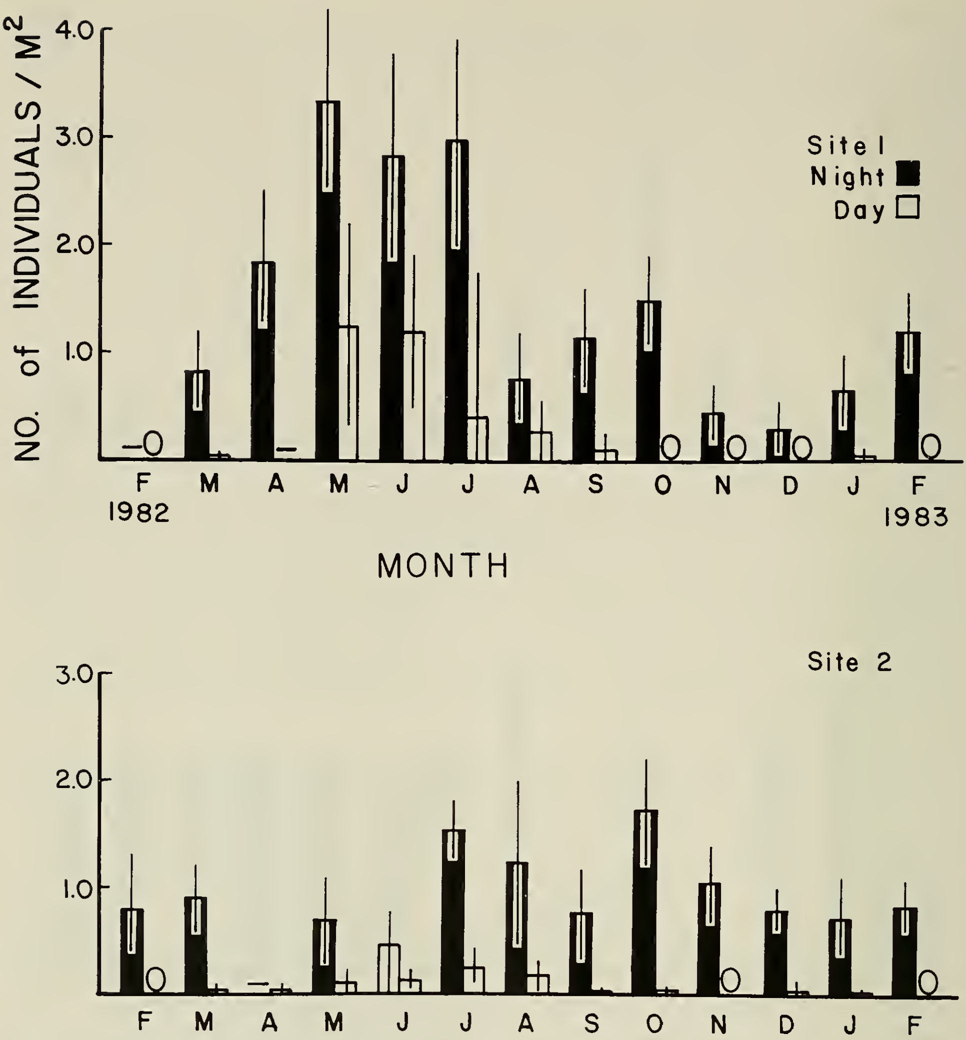

Fig. 2. Monthly day and night abundances of *Sicyonia laevigata*. Symbols same as Fig. 1.

At Site 1, May, August, and September means were significantly higher than all others; at Site 2, August, September, October were months of peak abundance.

*Laboratory observations on diel activity.*—Both *Sicyonia* species were nocturnally active in laboratory aquaria with sand bottom and *Thalassia*. During the daylight cycle, these shrimps remained buried just under the sandy surface. At night (complete darkness or red light) the sicyoniids emerged from the sand onto the surface of the aquarium bed; some individuals walked over the sand while many crawled up or clung to various parts of seagrass leaves. *Sicyonia* spp. could be made to burrow during a night cycle simply by turning on day (fluorescent) lights; emergence could be evoked during a day cycle within a short time by turning off lights. The few observations made on *Metapenaopsis* spp. indicated night emergence-day burrowing behavior similar to *Sicyonia* species. *Metapenaeopsis* individuals were not seen climbing seagrass leaves as did the sicyoniids.

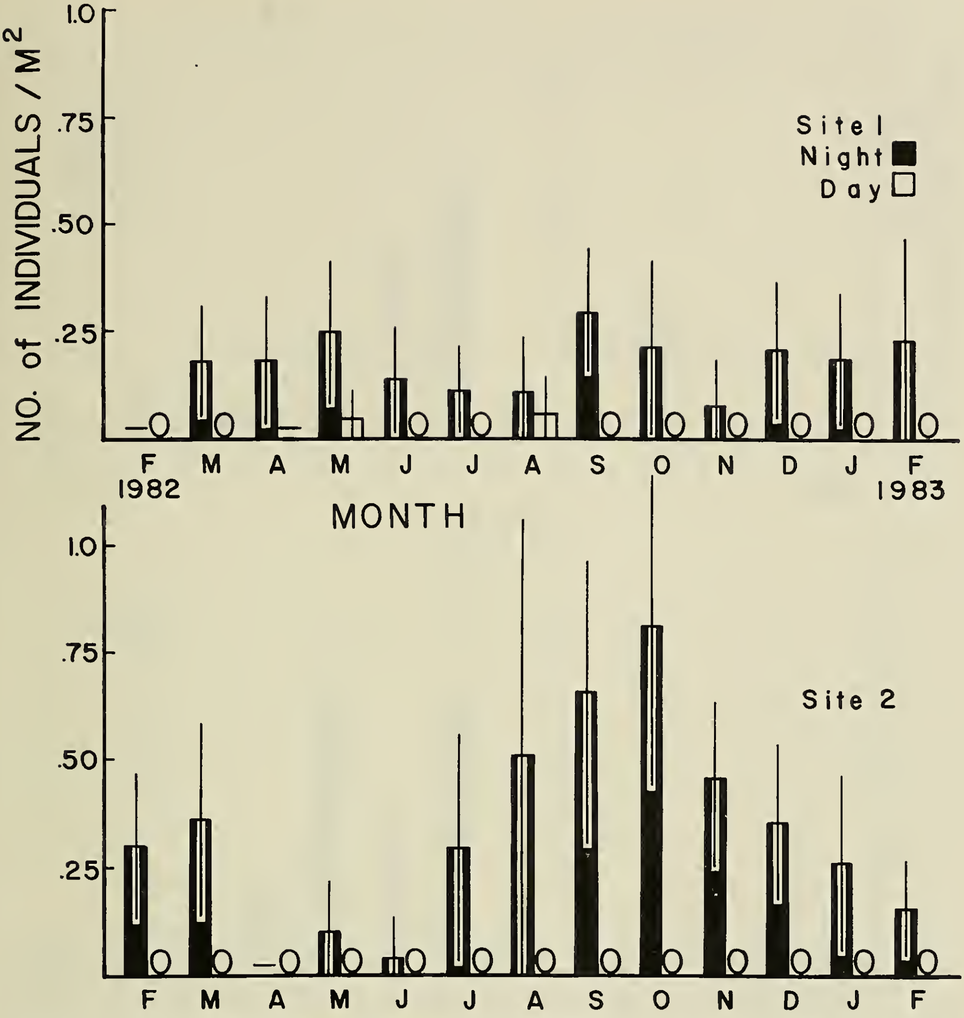

Fig. 3. Monthly day and night abundances of *Metapenaeopsis* adults (*M. goodei, M. smithi* and *M. martinella* grouped together). Symbols same as Fig. 1.

## Discussion

The penaeoid shrimp fauna collected from seagrass beds at Dorado, north coast of Puerto Rico, was dominated numerically by *Sicyonia parri* and *S. laevigata.* Conspicuous by their scarcity were members of the genus *Penaeus*; of nearly 7500 penaeoid shrimps collected, only 31 *Penaeus* (late postlarvae) occurred in the samples. In other studies on seagrass mobile invertebrate epifauna, sicyoniids were quite rare or absent while either *Penaeus duorarum* (Florida) or *P. notialis* (Caribbean) was one of ten most abundant invertebrate species (Greening and Livingston 1982; Gore *et al.* 1981; Heck 1976, 1977).

If appearance in local fisheries is some indication of population abundances, then *Penaeus* spp. may be rare not only on the north coast but in other areas of Puerto Rico as well. Although Suárez Caabro (1979) does include "*Penaeus* spp."

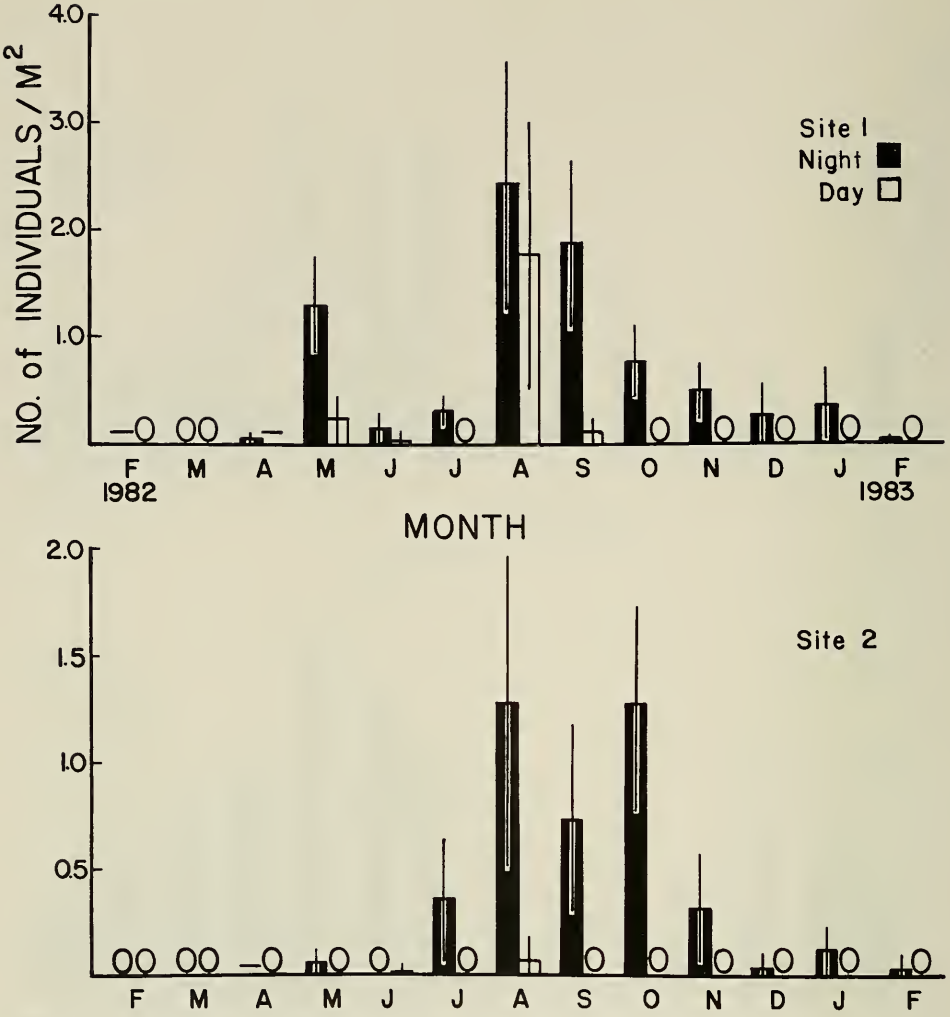

Fig. 4. Monthly day and night abundances of *Metapenaeopsis* juveniles. Symbols same as Fig. 1.

in the list of 130 species taken in local fisheries of Puerto Rico, no further information is given by him. Furthermore, Weiler and Suárez Caabro (1980) do not list penaeoids in their report on species composition and catch records of Puertorican fisheries. An occasional local fishery for *Penaeus* spp. is known from southwest Puerto Rico (Laguna Joyuda, Boquerón) (Roger Zimmerman, pers. comm.). Three species, *P. schmitti, P. subtilis,* and *P. notialis,* contribute to this fishery (Allan Stoner, pers. comm.). I have collected only a very few specimens of *Penaeus* spp. in other seagrass beds on the north coast (Luquillo platform, Condado Lagoon). Schmitt (1935) collected a few specimens of *Penaeus brasiliensis* on the north coast. In summary, shrimps of the genus *Penaeus* do occur in Puerto Rico but there is no indication of large populations. Brackish water mangrove areas and seagrass meadows are available as juvenile habitats on the north coast and the rest of the island. The factor or combination of factors which

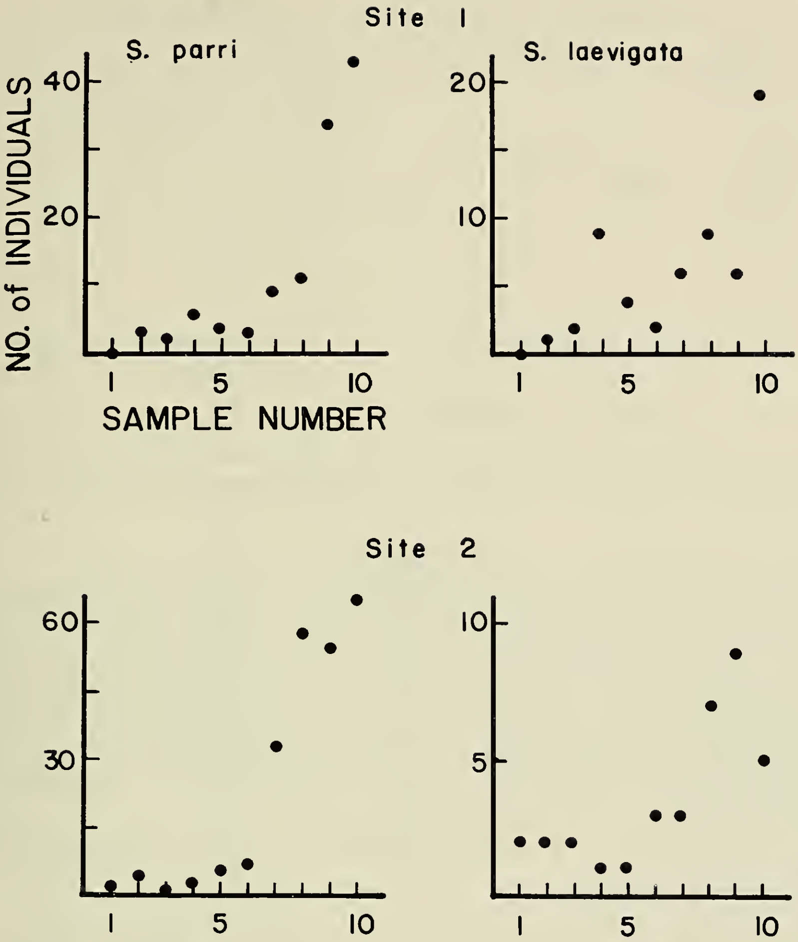

Fig. 5. Increase in numbers of *Sicyonia parri* and *S. laevigata* taken with increasing darkness (higher sample numbers) in collections beginning before and ending after sunset (May 1982).

prevent the occurrence of large populations of *Penaeus* spp. around Puerto Rico are not known; on the north coast, the narrowness of the insular shelf (a few kilometers) could be one possible factor.

Both the *Sicyonia* and the *Metapenaeopsis* species from the Dorado seagrass beds were nocturnally active. The laboratory observations indicated that, in the presence of daylight, *S. parri, S. laevigata,* and *Metapenaeopsis* species burrow just under the bottom sediments. In darkness they emerge from daytime hiding places to walk over the bottom and, in the species of *Sicyonia,* to climb up the seagrass blades. Field evidence confirms the nocturnal activity of these species. The numbers of *Sicyonia* spp. taken in night collections were always much higher than in the day; the nighttime presence of these shrimps on the seagrass beds and especially their habit of climbing seagrass leaves makes them susceptible to push-net capture at night. Their emergence from day burial at dusk is confirmed by samples begun before and terminating after sunset; the increase in numbers of

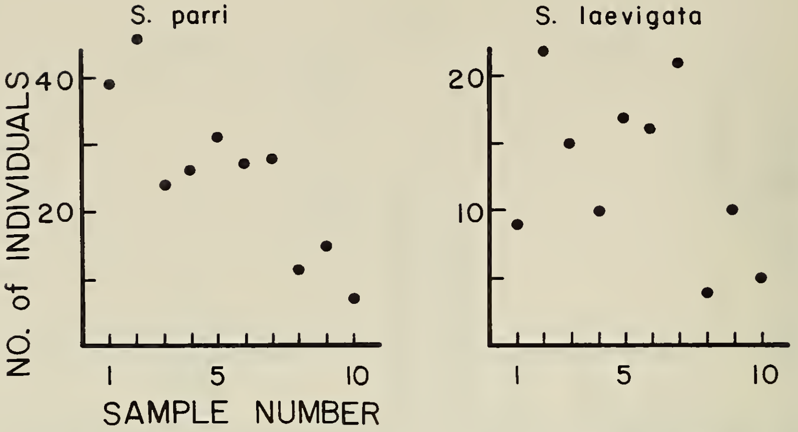

Fig. 6. Decline in numbers of *Sicyonia parri* and *S. laevigata* taken with increasing light (higher samples numbers) in collections beginning before and ending after sunrise (June 1982, Site 1).

sicyoniids per sample with increasing darkness was dramatic. Their return to beneath the surface at dawn was documented by the capture of fewer and fewer individuals with increasing light in collections that took place over the night–day transition. That the sicyoniids were actually burying themselves in the seagrass meadow sediments (instead of migrating elsewhere or avoiding the net during the day) is confirmed by some day observations in which I dug and screened bottom sediments from the seagrass beds; sicyoniids occurred beneath the surface in these sediments. Both laboratory and field evidence show that *Metapenaeopsis* spp. are active at night and burrow during the day.

Several investigators have made observations on the nocturnal behavior of

Table 2.—Correlations of number of individuals/sample and sample number (=increasing time) in collections beginning before and ending after sunset or sunrise. The Spearman rank correlation coefficient ($r_s$) is calculated for the possible correlation for each species or group. The probability is given for the one-sided hypothesis: no positive correlation (day to night samples) or no negative correlation (night to day). The null hypothesis is rejected when $P < 0.05$. (S) = significant test; (NS) = nonsignificant.

| Species | $r_s$ | Probability |
|---|---|---|
| | May Site 1 (day to night) | |
| *Sicyonia parri* | +0.918 | <0.001 (S) |
| *S. laevigata* | +0.797 | $0.005 > P > 0.001$ (S) |
| *Metapenaeopsis* spp. | +0.312 | >0.10 (NS) |
| | May Site 2 (day to night) | |
| *Sicyonia parri* | +0.912 | <0.001 (S) |
| *S. laevigata* | +0.788 | $0.005 > P > 0.001$ (S) |
| *Metapenaeopsis* spp. | +0.670 | $0.025 > P > 0.01$ (S) |
| | June Site 1 (night to day) | |
| *Sicyonia parri* | −0.770 | $0.01 > P > 0.005$ (S) |
| *S. laevigata* | −0.360 | >0.10 (NS) |
| *Metapenaeopsis* spp. | −0.684 | $0.025 > P > 0.01$ |

Table 3.—Comparison of monthly mean abundances (night samples). Months are listed in order of increasing means. Vertical lines join months whose means are not significantly different (Student-Newman-Keuls test, $P > 0.05$). There were no significant differences between means for *Metapenaeopsis* adults at Site 1 (one-way ANOVA, $P \gg 0.10$). Months of zero abundance are not listed below. (*S.* = *Sicyonia*; *M.* = *Metapenaeopsis*).

| *S. parri* | *S. laevigata* | *M.* juveniles | *M.* adults |
|---|---|---|---|
| | | Site 1 | |
| Sept | Dec | Feb 83 | — |
| Oct | Nov | April | |
| Aug | Jan | June | |
| Dec | Aug | Dec | |
| Nov | March | July | |
| Jan | Sept | Jan | |
| Feb 83 | Feb 83 | Nov | |
| March | Oct | Oct | |
| April | April | May | |
| June | June | Sept | |
| July | July | Aug | |
| May | May | | |
| | | Site 2 | |
| Sept | May | Feb 83 | May |
| May | Jan | Dec | Feb 83 |
| Feb 83 | Sept | May | Jan |
| Oct | Feb 82 | Jan | July |
| Nov | Dec | Nov | Feb 82 |
| Dec | Feb 83 | July | March |
| Jan | March | Sept | Dec |
| Aug | Nov | Aug | Aug |
| March | Aug | Oct | Nov |
| Feb 82 | July | | Sept |
| July | Oct | | Oct |

various penaeoid species. Cobb *et al.* (1973) reported that *Sicyonia brevirostris* were much more abundant at night and that gut content analyses also indicated nocturnal activity. Pérez Farfante (1971) noted that the few data available indicated that *Metapenaeopsis goodei, M. smithi,* and *M. martinella* were night active. Several *Penaeus* spp., e.g., *P. aztecus* and especially *P. duorarum* make shallow day burrows which they leave at night (Wickham and Minkler 1975; Pérez Farfante 1969; Fuss 1964; Williams 1958). Light intensity has been shown to be the most important factor mediating activity in these *Penaeus* species (Bishop and Herrnkind 1976; Wickham and Minkler 1975; Fuss and Ogren 1966). In the laboratory, I could cause emergence of *Sicyonia* spp. during the day by simply turning off the lights for 20–30 minutes. When lights were turned on again, the shrimps began burrowing within a very few minutes.

Seasonal variations in abundance of *Sicyonia* and *Metapenaeopsis* spp. were not as notable as those of the nine most numerous caridean species from the same meadows (Bauer, in press). The carideans had marked population highs in late spring and summer with a smaller peak in December and January; abundance peaks and troughs were very highly correlated statistically. Seasonal differences in abundance were found in *Sicyonia parri* and *S. laevigata* at Site 1, with significantly higher densities in late spring and summer months; this pattern was not apparent at Site 2. When sorting the samples from the field, it was obvious that large numbers of *Sicyonia* juveniles arrived at the seagrass meadows in May and June, perhaps accounting for higher *Sicyonia* abundances in that period. These observations need to be verified by size-frequency analysis of monthly collections (now in progress). *Metapenaopsis* adults showed little seasonal variation in numbers. However, recruitment of *Metapenaeopsis* juveniles was not continuous; sharp increases in numbers occurred from August and September or October at both sites.

Penaeoid species were less abundant than caridean shrimps at the Dorado seagrass meadows. *Sicyonia parri* total abundance was a little higher than that of *Hippolyte curacaoensis,* the fifth ranked caridean; *S. laevigata* was intermediate in total captured between the seventh and eight ranked carideans, *Processa bermudensis* and *P. riveroi,* respectively (Bauer, in press). *Metapenaeopsis* spp. were comparatively rare. I consider the *Sicyonia* night abundances reported here to be good estimates of population densities. *Sicyonia* spp. are heavily armored, robust, benthic species; I know of no reports of night swimming away from the bottom for *Sicyonia* spp. In addition, the small mesh (1 mm) used in the pushnet assured that the small adults and juveniles were taken. *Sicyonia parri* and *S. laevigata* are small sicyoniids (maximum sizes given in Williams 1984). Juveniles and small males with 2–4 mm carapace length were at times quite numerous; shrimps of this size can easily slip through the 6–7 mm mesh of trawls and scrapes generally used in seagrass sampling studies (e.g., Greening and Livingston 1982; Heck 1976, 1977, 1979). Bauer (in press) also found that densities of carideans (similar in size or smaller than sicyoniids) estimated by fine mesh pushnet samples were much higher than in studies using trawls or scrapes with larger mesh and equal to caridean densities taken by drop net (Gore *et al.* 1981).

*Metapenaeopsis* abundances might be underestimated in pushnet samples, even those taken at night. Wheeler (1937, cited in Pérez Farfante 1971) reported that *M. goodei* was collected near the water surface at night. If this is normal behavior (i.e., not a case of shrimps being attracted by a bright artificial light) and members of these species do swim off the bottom at night, then estimates of abundance would be in error.

In summary, penaeoid shrimps of the genera *Sicyonia* and *Metapenaeopsis* are very nocturnal and therefore susceptible to pushnet capture at night. Quantitative sampling for analysis of community structure or life history must take place at night to include these species and to estimate their relative abundances and densities. In addition, a small mesh net should be used in collecting to include the juveniles and small adults of these penaeoids.

## Acknowledgments

I am grateful to the many University of Puerto Rico students who have helped in field sampling, sorting of samples, and preparation of illustrations. Financial support for students and for equipment was provided by University of Puerto Rico OCEGI grants. I thank Dr. Isabel Pérez Farfante for her help in species identifications and for providing me with valuable literature references. The editorial suggestions of Drs. Isabel Pérez Farfante, Fenner A. Chace, Jr., and Roger Zimmerman were quite helpful.

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# TWO NEW SPECIES OF TWO NEW GAMMARIDAN GENERA (CRUSTACEA: AMPHIPODA) FROM THE FLORIDA KEYS

James Darwin Thomas and J. Laurens Barnard

*Abstract.*—Two new species of the new genera *Anamaera* (*A. hixoni*) and *Spathiopus* (*S. looensis*), both belinging to the section Gammarida of Amphipoda, are described from the Florida Keys. *Anamaera* is a new genus close to *Maera, Ceradocus,* and *Ceradomaera,* but has an unique combination of minor character expressions. Males of *Spathiopus* have an unusual paddle-shaped antenna 2 but otherwise *Spathiopus* appears to be an apomorph of *Elasmopus.*

The new taxa described herein were collected at Looe Key Reef, off Big Pine Key in the Florida Keys. Looe Key Reef is now a National Marine Sanctuary of the United States of America and the amphipods described herein were collected while compiling a faunal list of the Sanctuary.

## Section Gammarida

The reader is referred to Barnard and Barnard (1983) for a discussion of classification in this group and the advisability of omitting commitment to superfamilies and families until more studies on morphology, behavior, and genetics have been completed. These genera would probably be assignable to the hadzioid (=melitoid) family group depicted by Bousfield (1978, 1983) but we cannot find any characters to separate that group from others, except Anisogammaridae, in the greater Gammarida (section) group of Gammaridea. Anisogammaridae have accessory gills and are quite distinctive. Crangonyctoids (with or without sternal gills and with or without paddle calceoli), melitoids-hadzioids (without gill 7), gammaroids (with or without gill 7) and other groups in Gammarida are as yet not well described and are poorly defined.

*Legends.*—Capital letters denote main parts in the following list; lower case letters to left of capital letters or in body of figure indicate modifications as follows; lower case letters to right of capital letters indicate specimens described in captions: A, antenna; B, body; C, coxa; D, dactyl; F, accessory flagellum; G, gnathopad; H, head; I, inner plate or ramus; J, prebuccal; K, lacinia mobilis; L, labium; M, mandible; O, outer plate or ramus; P, pereopod; Q, incisor; R, uropod; S, maxilliped; T, telson; U, labrum; V, palp; W, pleon; X, maxilla; Z, gill; a, aberrant; f, flat; left, lateral; m, medial; n, dissected; o, opposite; r, right; s, setae removed.

## Family Gammaridae (classical sense)

### *Spathiopus,* new genus

*Diagnosis.*—Body lacking dorsal teeth. Rostrum obsolete. Antenna 1 longer than antenna 2, article 2 longer than 1, article 3 short, secondary flagellum

2-articulate, calceoli absent. Article 5 of antenna 2 shorter than article 4, flagellum in male flat from side view but articles expanded into broad paddle from dorsoventral views. Mandibular incisors weakly toothed, laciniae mobilae toothed, rakers present, molars triturative, molar surface with large accessory knobs or "choppers," palp article 3 falcate. Inner lobes of lower lip fleshy. Medial margins of inner plates on maxillae almost naked, apex of inner plate on maxilla 1 with about 4 setae, palp 2-articulate. Maxillipeds ordinary but inner plates lacking stout thick spines, dactyl weakly unguiform, with large nail. Anterior coxae of medium length, none strongly reduced in size, coxa 4 weakly excavate posteriorly. Gnathopod 1 of melitid form (see Barnard & Barnard 1982 for definition), thus wrist elongate, setose and poorly lobed, hand shorter, subrectangular, palm short and weakly oblique; gnathopod 2 of male enlarged, subchelate, wrist short and lobate, hand elongate, large, palm oblique. Pereopods short. Epimera and pleopods well defined and ordinary. Uropods 1–3 short, stout, spinose, outer ramus of uropod 3 with minute second article. Telson fully cleft, all major spines apical. Gills present on coxae 2–6, thin oostegites present on coxae 2–5.

*Type-species.*—*Spathiopus looensis,* new species.

*Etymology.*—Named for the spatulate condition of the flagellum of antenna 2. This condition is present in both sexes, but is best developed in adult males.

*Relationship.*—This genus appears to be an apomorph of various species in *Elasmopus* Costa as it differs substantially only in the expansion of the articles on the flagellum of antenna 2. This unusual character is also accorded generic status in the *Gammaropsis-Audulla* pair of genera in the Corophioidea and probably indicates a special function associated with the structure.

### *Spathiopus looensis,* new species

Figs. 1–3

*Description*: Holotype male "g" 4.31 mm.—Eyes ovate, small, brown in alcohol, with halo of free ommatidial elements around pigment core. Lateral cephalic lobes with small notch below eyes. Article 1 of peduncle of antenna 1 with line of 3 ventral spines. Flagellum shorter than peduncle, aesthetascs absent.

Labrum broadly heart-shaped, epistome unproduced. Right and left rakers 3 and 3 (first left raker complex), each molar with spinose protrusion and major seta, palp article 3 with DE setae. Each outer lobe of lower lip with cone. Inner plate of maxilla 1 with 2 large and 3 small apical or outer setae, outer plate narrow, with 7 spines, palp broader than outer plate and with densely armed apex, palps symmetrical. Inner plate of maxilla 2 narrower than outer, with 1–2 apicomedial setae. Inner plate of maxilliped with falcate ventral coupling hook, outer plate with medial and apical spines, article 3 with serrate apical hook.

Coxa 1 extended forward anteroventrally. Gnathopod 1 as illustrated, article 4 of gnathopod 2 with lobe underriding article 5, latter also with weak apical lobe pointing distad, palm or hand densely setose and smooth, merging evenly with posterior margin of hand, dactyl short, medial surface with longitudinal ridge confining dactyl override, ridge sinuous and unevenly serrate. Pereopods 3–4 of similar structure but pereopod 4 smaller, article 5 with pair of large apicoposterior spines, apicalmost pair of spines on article 6 slightly smaller than preceding spine pairs, dactyl with 3 setules at declivity. Article 2 of pereopods 5–7 pyriform,

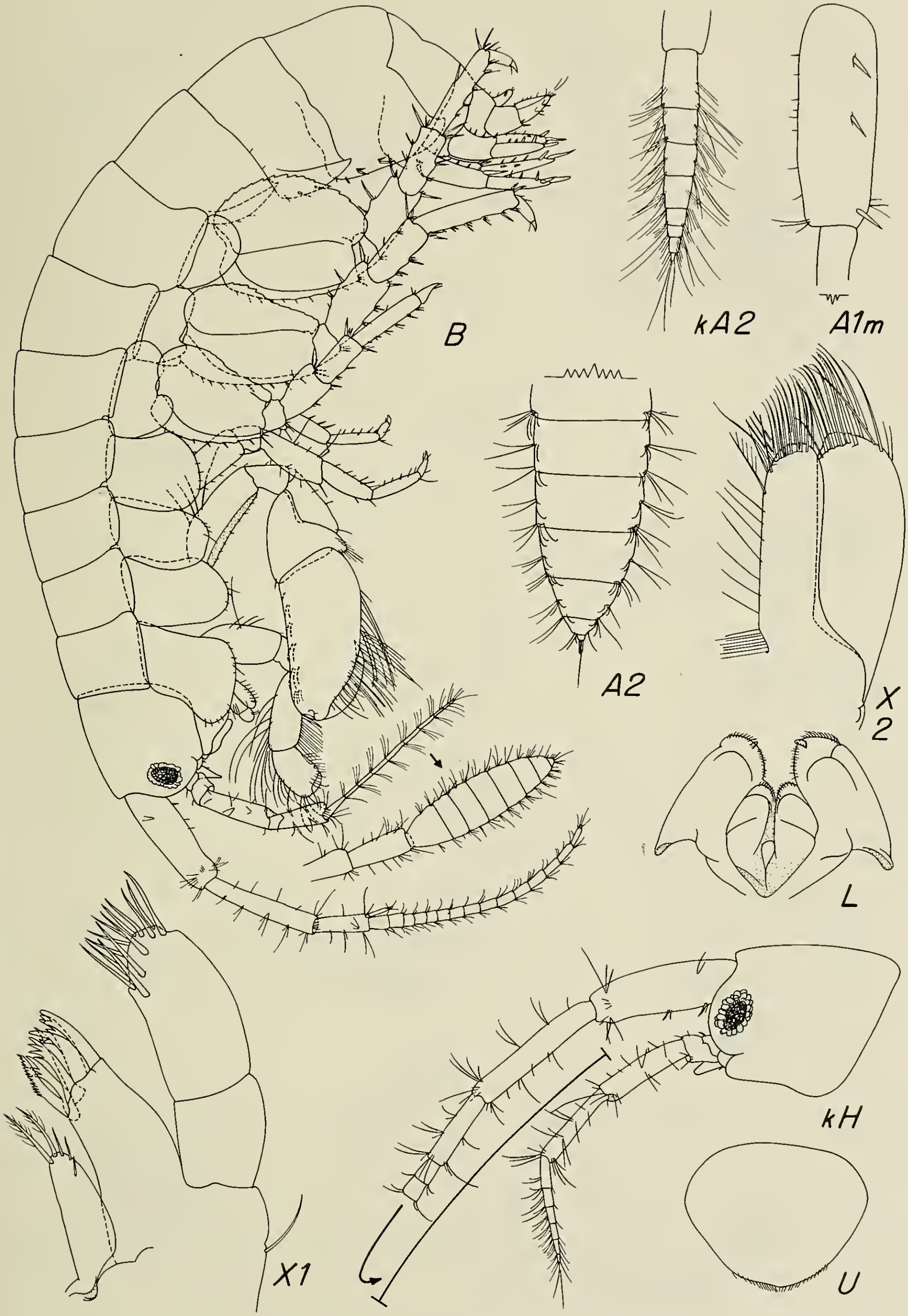

Fig. 1. *Spathiopus looensis.* Unattributed figures = holotype male "g" 4.31 mm; i = male "i" 4.77 mm; k = female "k" 4.47 mm.

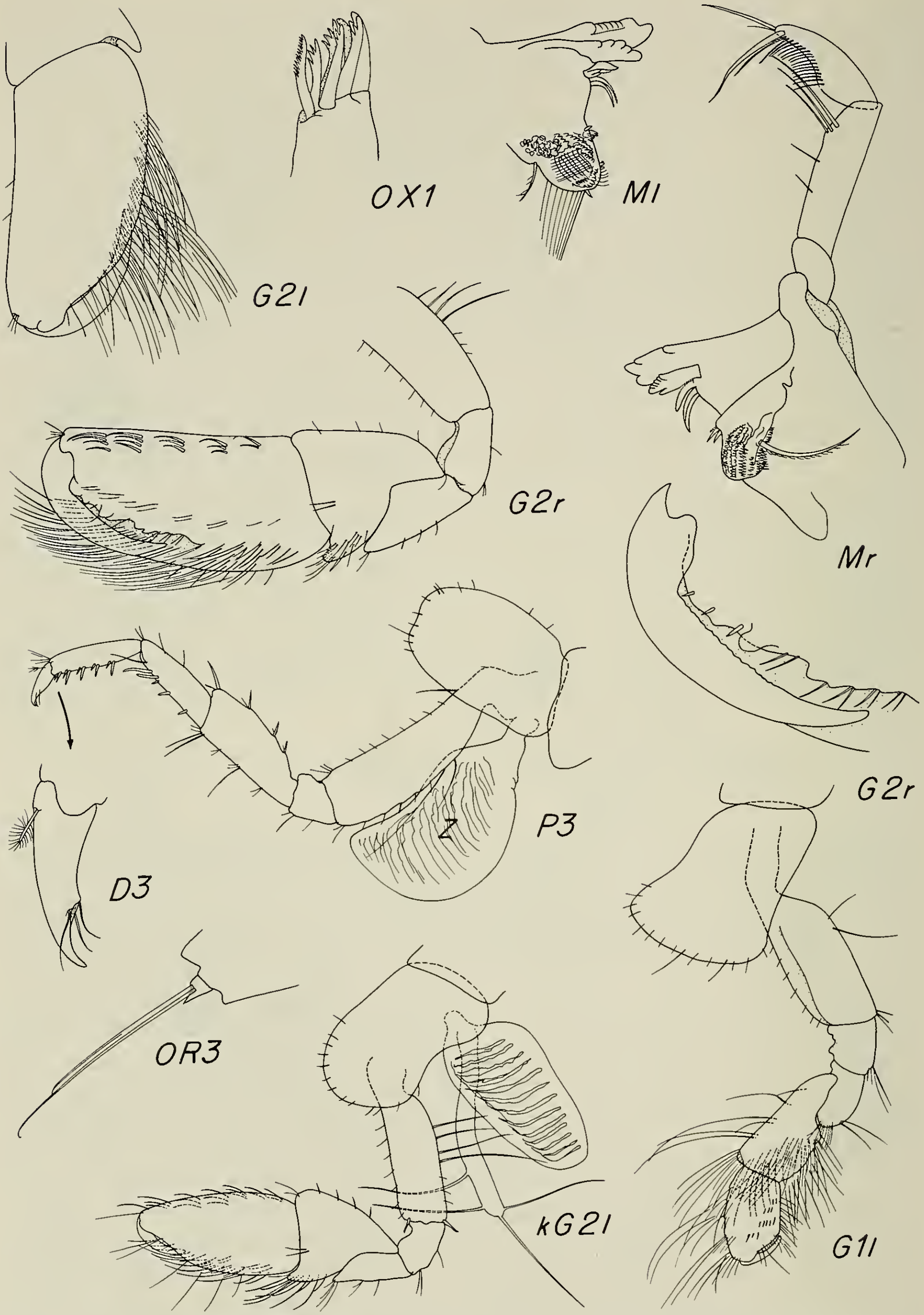

Fig. 2. *Spathiopus looensis.* Unattributed figures = holotype male "g" 4.31 mm; k = female "k" 4.47 mm.

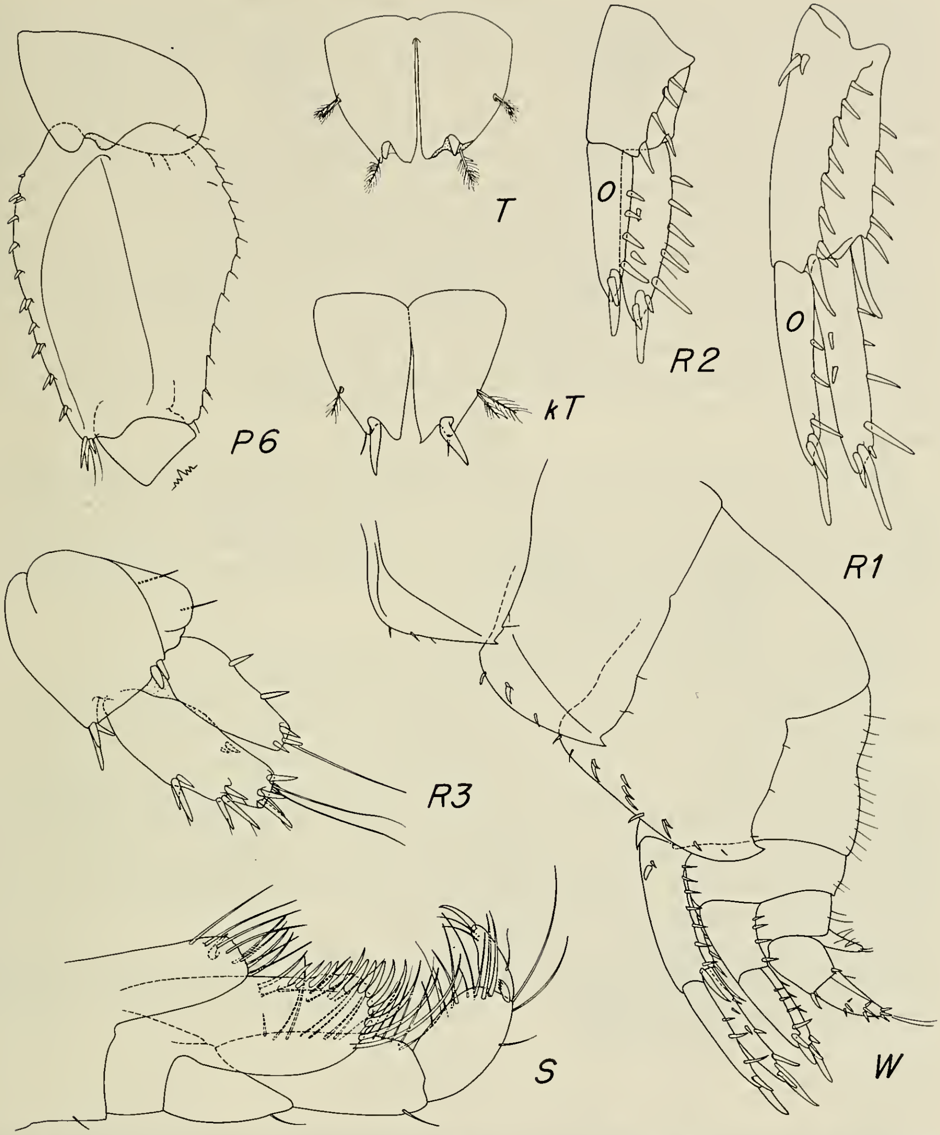

Fig. 3. *Spathiopus looensis.* Unattributed figures = holotype male "g" 4.31 mm; k = female "k" 4.47 mm.

tapering apically, weakly lobate, face with outer ridge (pereopod 5) or ridges (pereopods 6–7). Gills on coxae 2–6, that on coxa 3 longest, those on coxae 2–4 subequal, club-shaped, flat, that of coxa 5 similar but smaller, that of coxa 6 smallest and almost orbicular.

Epimera 1–3 with small sharp posteroventral tooth, margin above with 1–2 setule notches, ventral spine formula of epimeron 1 = 1-1-1, on face of eipmeron 2 = 1-1-1, on epimeron 3 = 1-1-2-3-2-1-1. Urosomite 1 with ventral spine, basal face of uropod 1 with pair of spines, dorsal margin of peduncle with 7 short spines, apex with a single large spine, similar large spine medially, peduncle of uropod 2 with 4 short dorsolateral spines, rami of uropods spinose like *Elasmopus*. Uropod 3 short, peduncle expanded and plate-like, inner ramus slightly smaller than outer, with 2 medial spines, outer ramus lateral spine formula = 3-3, apical spines =4, apical spines on inner ramus = 3; article 2 on outer ramus with 2 setae. Telson short, broad, lobes tapering but apically notched, inner wing sharp, each notch with stout (abnormally stunted) spine, lateral margins each with pair (or abnormally one seta) of setules, each lateral apical wing with setule.

Female "k" 4.47 mm.—Like male but flagellum of antenna 2 only weakly expanded and only scarcely longer than article 4 of peduncle, article 5 of peduncle not shortened; gnathopod 2 much smaller than male and hand lacking medial ridge. Armament formula on epimeron 2 = 1-2-1-2, epimeron 3 = 1-2-3-3-2-1. Ventral facial spines on outer ramus of uropod 3 reduced to 1. Oostegites thin, setal formula of oostegites 1–4 = 2-2-3-3, anterior, 1-2-2-1 distal, and 1-2-1-2 posterior.

*Variations.*—Adults relatively uniform, male "i" like holotype but telsonic spines not stunted and normally long as shown for female telson. Male "h" telson also normal, spine count on epimeron 2 = 1-3-1-0, epimeron 3 = 1-3-4-2-3-0. Telson normal (with lateral setae in pairs but many specimens with setae reduced to one on one side or the other).

*Etymology.*—Named for the type-locality.

*Holotype.*—USNM 195127, male "g" 4.31 mm, illustrated.

*Type-locality.*—Florida Keys, Looe Key Reef, 9 Oct 1983, in backreef area, in algae-covered rubble in sand, 1 m, station LKR4H, coll. J. D. Thomas.

*Material.*—The type-locality, male "h" 3.96 mm (observed), male "i" 4.77 mm (observed), female "k" ovigerous 4.47 mm (illustrated) and 8 other specimens. Same area, 7 m, 8 Oct 1983, station LKFR4C, coll. J. D. Thomas (4). Biscayne Bay, Ragged Keys, 1200 feet west of marker no. 5 in channel between two keys, 2 m, 8 Apr 1982, coll. Iver M. Brook and J. D. Thomas (10); same area, Oct 1982, coll. Biosystems, Inc. Station # 16 (30).

*Distribution.*—Florida, Biscayne Bay south to Looe Key Reef, 1–7 m, occurring primarily in backreef areas of coral reefs in rubble, and in other shallow protected areas adjacent to deeper water where algae covered rocky substrates are available.

### *Anamaera,* new genus

*Diagnosis.*—Body lacking dorsal teeth. Rostrum weak. Antenna 1 longer than antenna 2, article 2 longer than 1, article 3 short, secondary flagellum 3–5-articulate, calceoli absent. Article 5 of antenna 2 shorter than article 4, flagellum cylindrical. Mandibular incisors strongly toothed, laciniae mobiles toothed, rakers present, molars triturative, palp article 3 linear, about as long as article 2, with A, D and E setae sparse. Inner lobes of lower lip fleshy. Medial margins of inner plates on maxillae naked, at best bearing hair-like armaments. Apex of inner plate on maxilla 1 with about 5 setae, palp 2-articulate. Maxillipeds ordinary but inner plates lacking stout thick spines, dactyl weakly unguiform, with large nail.

Anterior coxae of medium length, none strongly reduced in size, coxa 2 largest, coxae 1–4 weakly excavate posteriorly, coxa 1 with anteroventral tooth and posteroventral cusp. Gnathopod 1 of melitid form (see Barnard and Barnard 1983,

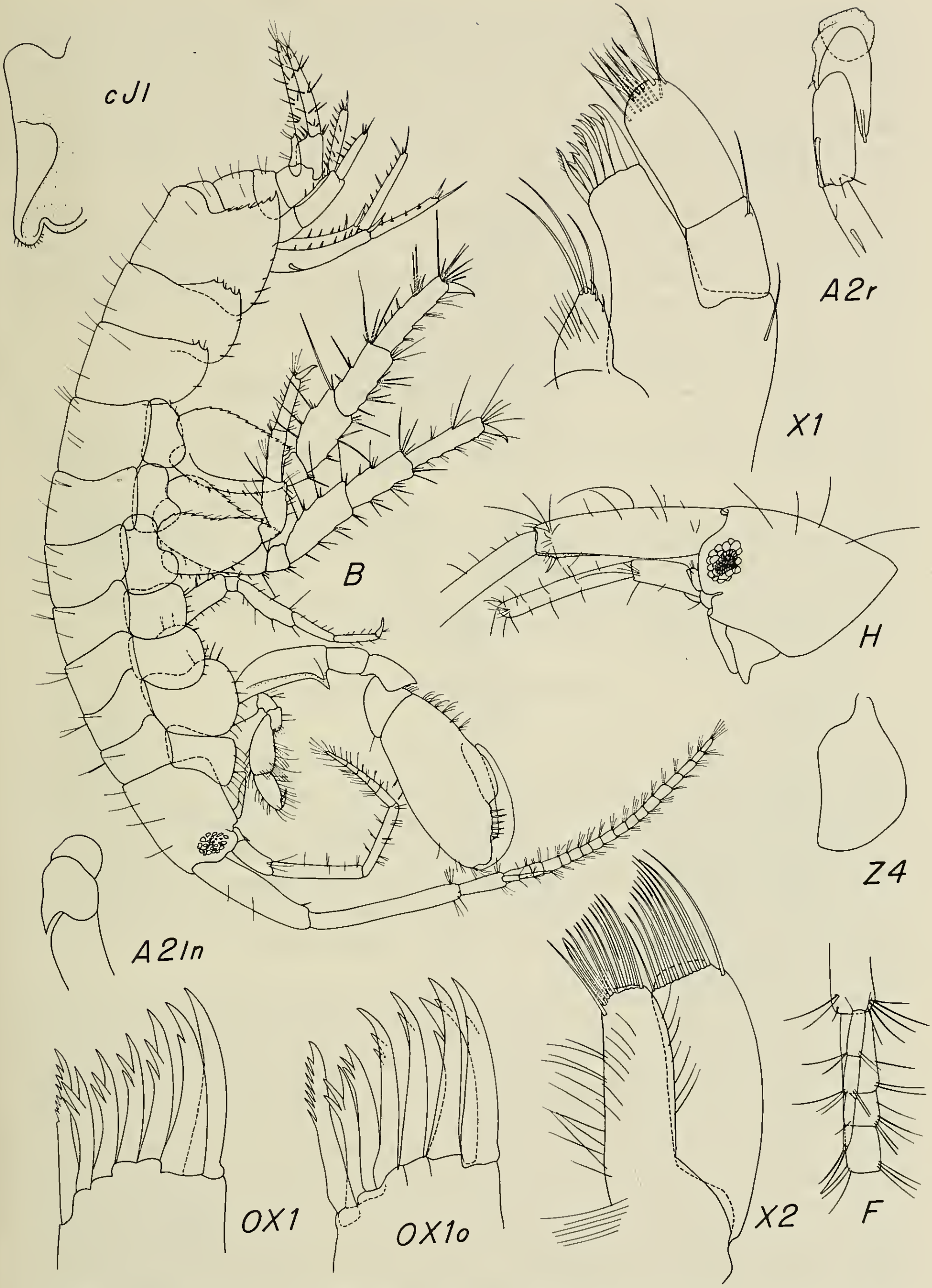

Fig. 4. *Anamaera hixoni.* Unattributed figures = male holotype "a" 5.22 mm; c = female "c" 4.04 mm; d = female "d" 3.10 mm.

for definition), thus wrist elongate, setose and poorly lobed, hand shorter, subrectangular, palm short and oblique; gnathopod 2 of male asymmetrical, one side enlarged, subchelate, wrist short and lobate, hand elongate, large, palm oblique and continuous with hind margin of hand; other side small like gnathopod 1 and similar, wrist elongate, unlobed, hand somewhat broader and longer than on gnathopod 1, palm oblique, anterior margin of hand more setose, posterior setae more curved apically. Pereopods short.

Epimera serrate behind. Pleopods well defined and ordinary. Uropods 1–3 long, slender, spinose, basal face of uropod 1 with spine, peduncle of uropod 3 scarcely elongate, rami equiramous though outer ramus with minute second article. Telson fully cleft, lobes pointed, cuspidate, with apical and dorsofacial spines. Gills present on coxae 2–6, thin oostegites present on coxae 2–5.

*Type-species.—Anamaera hixoni,* new species.

*Etymology.*—Named for the concept as "variant Maera," thus "ana" reflecting Greek "again."

*Relationship.*—Differing from *Maera* Leach in the asymmetry of male gnathopod 2.

Differing from *Ceradocus* Costa in the long article 3 of the mandibular palp, lack of tooth on article 1, the poorly setose medial margins of maxillae 1–2, and the absence of dorsal body serrations.

Differing from *Ceradomaera* Ledoyer, 1973 in the lack of dorsal teeth on the pleon and the long article 3 of the mandibular palp.

### *Anamaera hixoni,* new species

Figs. 4–7

*Description*: Holotype male "a."—Body generally similar to *Elasmopus* and *Maera,* sparsely setose dorsally, with long antenna 1 and short antenna 2. Head with anteroventral notch and sinuous tooth below, eye of medium size, with brownish purple core surrounded by clear apices of ommatidia. Article 1 of antenna 1 about as long as head, flagellum shorter than peduncle. Gland cone of antenna 2 very long (aberrantly short and regenerant on left side in holotype and other specimens but normally long on both sides), flagellum about as long as article 4 of peduncle.

Epistome produced upward and forward slightly, upper lip from anterior view with truncate, almost smooth ventral margin. Mandibles bulky, with large inner vertical keel bearing small but strongly triturative molar ventrally, each molar with plumose seta, incisors toothed, right lacinia mobilis bifid and complexly mutltitoothed, left lacinia mobilis flattened and 4-toothed, rakers about 7, palp article 1 scarcely elongate, article 2 of medium length, article 3 linear, about as long as article 2, with 1 A seta, 4 D setae and 2 E setae. Mandibular lobes of lower lip weak, broad, obtuse. Inner plate of maxilla 1 small, longer than broad, with 2–3 long apical and 3-2 small apicolateral setae; outer plate narrow, with 11 spines (some hidden in illustrations), palp broad, 2-articulate, with 2 ranks of apical and subapical armaments, right and left sides symmetrical. Plates of maxilla 2 erect, long, slender, inner narrower, armed medially only with thin hair-like armaments, no orthodox setae medially. Inner plate of maxillipeds excavate, with long lateral and small medial cusp, no stout apical spines, with several medial

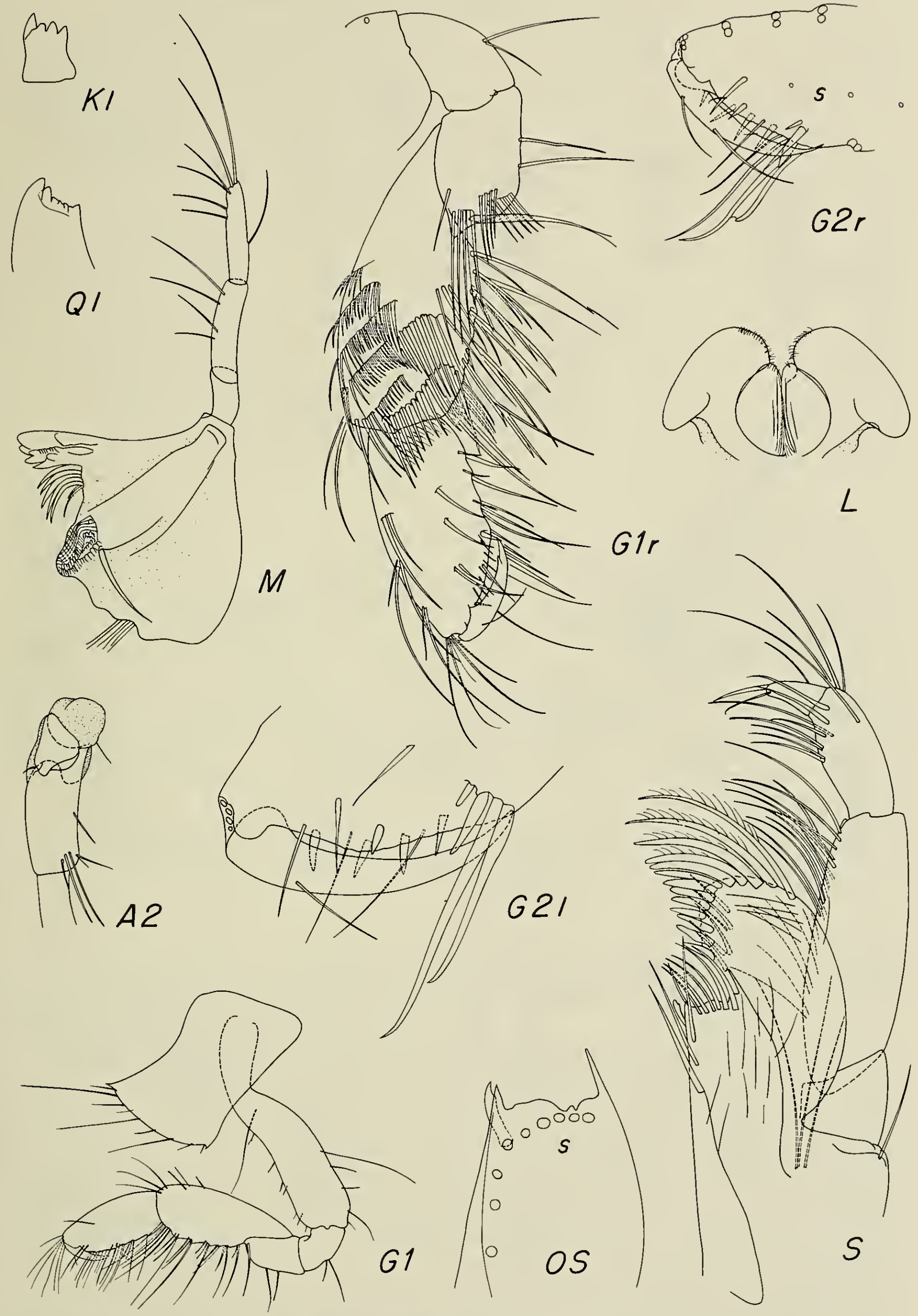

Fig. 5. *Anamaera hixoni.* All figures = male holotype "a" 5.22 mm.

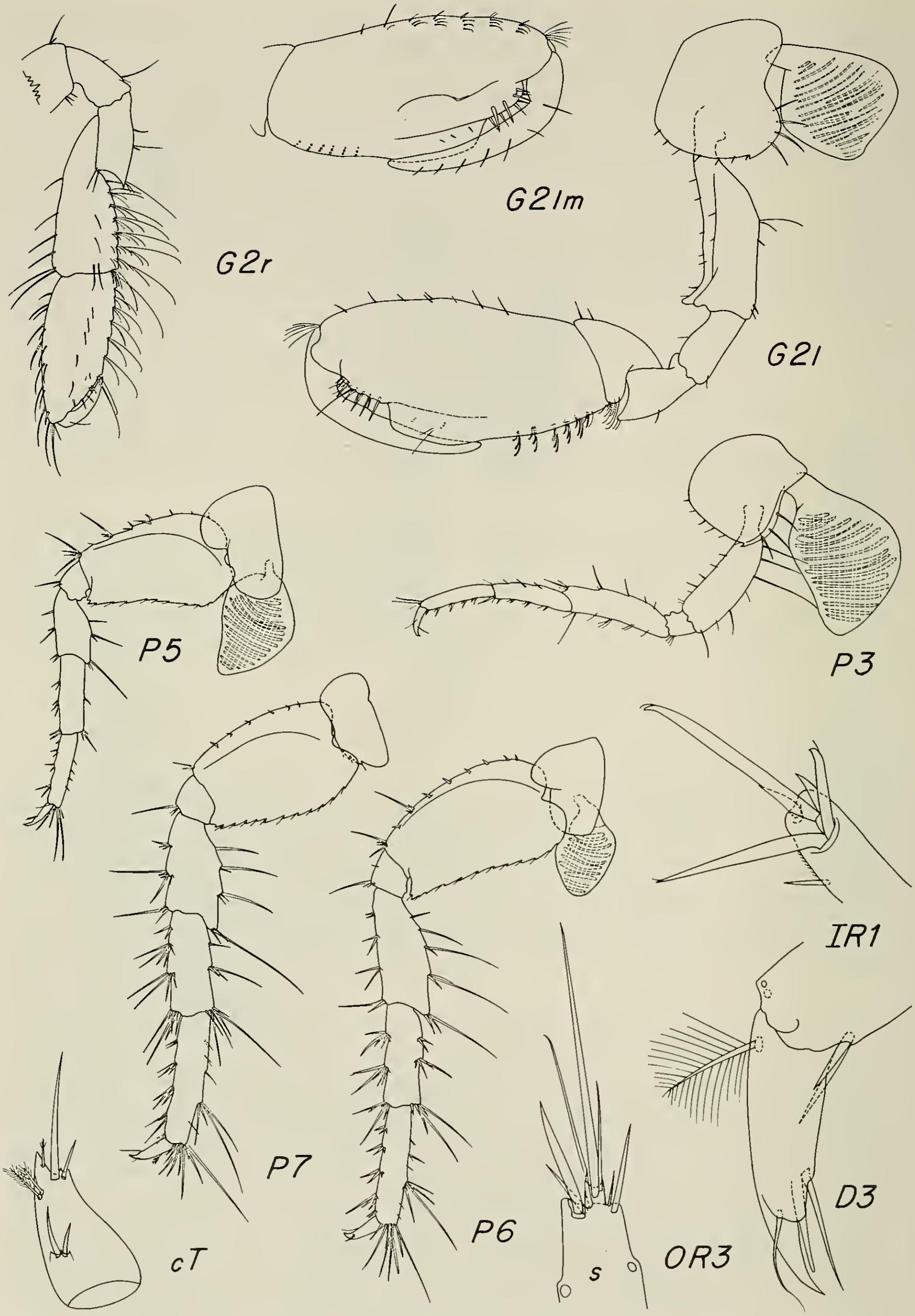

Fig. 6. *Anamaera hixoni.* Unattributed figures = male holotype "a" 5.22 mm; c = female "c" 4.04 mm.

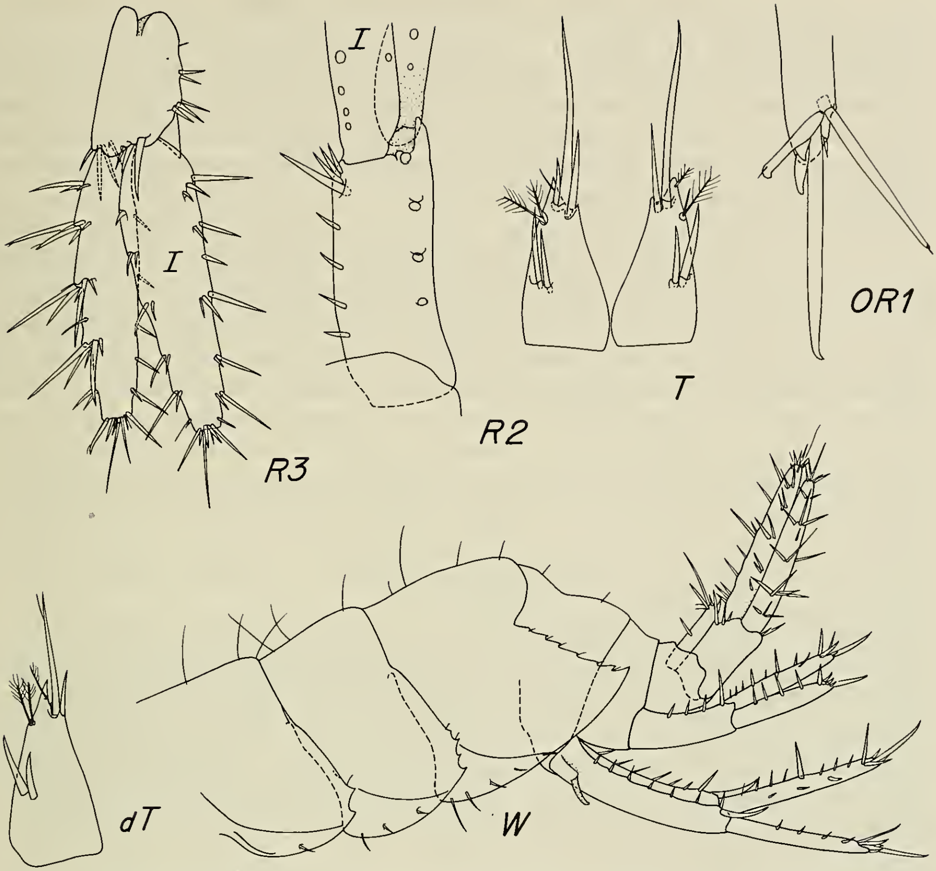

Fig. 7. *Anamaera hixoni.* Unattributed figures = male holotype "a" 5.22 mm; d = female "d" 3.10 mm.

and apical setae, outer plate large, with blunt medial spines and many apical spines becoming thinner apicad, palp slender, elongate, dactyl stubby-unguiform, nail strong, with 1+ accessory nail(s).

Coxa 1 with anterior excavation and anteroventral sharp cusp pointing forward, coxa 2 much larger, anterior margin straight, but posterior excavate, thus ventral half of coxa appearing swollen, coxa 3 similar but much smaller, coxa 4 somewhat more quadrate, coxae 5–7 scarcely but successively shorter, ordinarily lobate, coxae 1–4 with short ventral setae, coxae 2–3 with 4 and 3 posterior spines.

Article 5 of gnathopod 1 with very dense medial comb of spines. Article 2 of larger male gnathopod bearing anteroapical pair of cusps representing terminus of inner and outer anterior keels, article 3 of gnathopod 2 slightly elongate, article 4 with sharp posterodistal cusp pointing distally; palm of larger male gnathopod with distal spinose margin bearing inner and outer rows of 5 and 4 spines, then adjacent acclivity with flat topped smooth proximal lobe bearing few largely facial setae, dactyl simple (with marginal setae), extending halfway along palmar-hand margin, proximal part of this margin with setal tufts. Palm of smaller gnathopod

2 short, oblique, with sparse short spines and defined by row of 4 long and short setal-spines in tandem cluster.

Coupling spines of pereopods 3–7 small, slightly uneven, simple, dactyls with acclivity marked by whip, bearing 2 other setules, one marginal, one facial; article 2 of pereopods 5–7 weakly expanded, with one facial ridge, posteroventrally lobate subsharply, posterior margins with medium serrations, some spines of articles 4–6 as long as or longer than article 5.

Epimera 1–3 each with lateral ridge, formula of ventrofacial spines on epimera 1-3 = 1-3-5, formula of posterior serrations (counted as points) = 2-4-7. Pleonites dorsally smooth, pleonite 4 weakly humped dorsally. Basofacial spine of peduncle on uropod 1 attached to raised lateral plaque, each peduncular apex with large spine, medial margin with 8 smaller spines (otherwise as illustrated), medial margin of peduncle on uropod 2 with 4 spines in tandem but apically with row of 4 or 5 spines forming fan and attached in dorsoventral row (otherwise as illustrated), apices of outer rami on uropods 1–2 alike, with 4 large and one tiny spines, of inner rami with 5 large spines. Uropod 3 overextending uropods 1–2, peduncle complexly spinose, outer ramus slightly shorter than inner, both rami complexly spinose. Telson with middorsolateral pair of spines, each obliquely excavate, apex with pair of long spines, sharp apex with lateral setule, also pair of setules proximal and lateral to apex.

Female "c" 4.04 mm.—Generally like male but both sides of gnathopod 2 small, like small version of male gnathopod 2 (not therefore reillustrated). Antennae, gnathopod 1 and epimera like male. Some spines on coxae 2–3, uropod 3 and telson either longer or shorter than shown for male but these differences proved not to be of sexual value, merely individual variation in both sexes. (Telson illustration therefore to be discounted.) Oostegites long and thin, on coxae 2–5, apical setal formula = 3-3-3-4, anterior setae = 2-1-1-0, posterior setae = 1-1-1-0, posterior setules = 1-1-1-6.

*Variations.*—Either right or left gnathopod 2 of male enlarged. Males and females found to vary in spine lengths especially on telson and uropod 3.

Young female "d" with 3 articles in accessory flagellum, 4 in flagellum of antenna 2. Spine count on coxae 2-3 = 4-3. Spine count on epimera 1,2,3 = 1-3-4, posterior points on epimera 1,2,3 = 2-2-5. Apex of each telsonic lobe with 2 spines, outer long, inner short; each dorsal spine pair with outer longer than inner.

Male "e" also with left gland cone stunted and probably regenerant as in holotype. Gnathopod 2 apical spine area of palm with 4 and 4 spines; coxa 2 with 5 posterior spines, coxa 3 with 3.

Male "f" with apical spine area on male gnathopod 2 palm bearing 8 and 6 spines. Spine counts on epimera 1,2,3 = 1-3-5.

*Illustrations.*—Views of holotype gland cone on antenna 2 showing left views on left antenna 2 (gland cone stunted) and right antenna 2 (from medial view) intact and then a left dissected view to show dorsal tooth of article 2 seen only medially.

*Color.*—Body white and wine-rose, rose color forming diffused blotches, bands and spots as follows: core of eye; base of rostrum between eyes; scattered dorsal diffusion on pereonites 1–7, on pereonites 1–2 occurring middorsally and extending laterally as blotches, on pereonites 3–7 occurring as band at posterior margin; oblique slashed from belly of pleonites 1–3 showing through epimera;

light dorsal transverse band each on pleonites 1–3; basal blotch each in peduncles of uropods 2 and 3 and each lobe of telson.

*Food.*—Stomach contents include substantial volumes of sand grains and broken pieces of filamentous algae and other brown, green and ochraceous minute particles of organic matter.

*Etymology.*—Named in honor of Ray F. Hixon (10 June 1947 to 19 Mar 1984), a rare and extraordinary person who spent many hours in the waters of Biscayne Bay and the Florida Keys.

*Holotype.*—USNM 195126, male, "a" 5.22 mm (illustrated).

*Type-locality.*—JDT LKR 4H, Florida Keys, Looe Key, 1 m, 9 Oct 1983, algae covered rubble on sand, coll. J. D. Thomas.

*Material.*—Type-locality, female "b" 3.72 mm, female "c" 4.04 mm, young female "d" 3.10 mm. Biscayne Bay, Florida, Ragged Keys, in channel between two keys, 2 m, coll. Iver M. Brook and J. D. Thomas, male "e" 4.28 mm, male "f" 4.50 mm.

*Distribution.*—Florida from Biscayne Bay south to the Lower Florida Keys, 1–2 m.

## Acknowledgments

We thank Dr. Pat McLaughlin, whose specimens were collected by Biosystems Research Inc., as part of the Biscayne Bay Restoration and Enhancement Program under the direction of the Dade County Department of Environmental Resources Management, and funded by the Florida Department of Environmental Regulation. The first author was also supported by grants from the National Science Foundation (DEB8121128) and a contract from the Sanctuary Programs Division, Office of Ocean and Coastal Resource Management, NOAA. Both authors received support from the Scholarly Studies Program of the Smithsonian Institution, for which we thank Dr. David Challinor. We thank Carolyn Cox Lyons of New York City for inking our plates.

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# THREE NEW SPECIES OF THREAD SNAKES (SERPENTES: LEPTOTYPHLOPIDAE) FROM HISPANIOLA

Richard Thomas, Roy W. McDiarmid, and Fred G. Thompson

*Abstract.*—Three new species of thread snakes of the genus *Leptotyphlops* are described from Hispaniola as: *L. calypso* from the Samaná Peninsula, and *L. asbolepis* from the Sierra Martín García, Dominican Republic, and *L. leptepileptus* from the Massif de la Selle, Haiti. These three species together with *L. bilineatus* and *L. pyrites* form a distinct group of *Leptotyphlops* that is restricted to the West Indies. All five species are compared and a key to the seven species of the genus known from the West Indies is presented.

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The first collection of a leptotyphlopid from Hispaniola (Thomas 1965) resulted in increased field effort to secure additional specimens of these secretive snakes. Further collecting yielded species of this genus different from *Leptotyphlops pyrites* Thomas from three widely scattered points on the island (Fig. 1): The Samaná Peninsula and the Sierra Martín García in the Dominican Republic and the north slopes of the La Selle Massif in Haiti. The snakes from each of these localities not only are distinct from *L. pyrites* but also from one another. Field work during the past few years also has extended the known range of *L. pyrites* from the vicinity of the type-locality near Pedernales, Dominican Republic, west into Haiti along the south coast and north into the Valle de Neiba.

Thomas (1965) considered *Leptotyphlops bilineatus* Schlegel of the Lesser Antilles and *L. pyrites* to be the only known members of a distinct Antillean group. The defining feature of this "*bilineatus* group" was the presence of two subocular supralabial scales that prevent the ocular scale from extending to the labial margin. In all other members of the family, a single scale called the oculolabial (ocular of Klauber 1940) covers the eye and extends to the labial border. The two original species in the group also had a similarly striped color pattern. The three new species described herein are members of the *bilineatus* group that depart significantly in certain features from *L. bilineatus* and *L. pyrites.*

We continue to use the term "*bilineatus* group" as a convenient means of designating those species of *Leptotyphlops* having the subocular supralabial scales. That all of the known members are restricted to the West Indies suggests that we may be dealing with a monophyletic radiation. However, it is also possible that the group is non-monophyletic and represents remnants of an old, formerly more widespread group within the genus, whose only relicts happen to be West Indian. Following this interpretation, the presence of subocular supralabial scales could well be a plesiomorphous character. An osteological study under way (Thomas) may clarify relationships within the genus and shed light on the nature of the *bilineatus* group.

## Methods and Terminology

We use certain conventions of description and measurement that should be noted.

Fig. 1. Map of Hispaniola showing localities for *Leptotyphlops* species.

(1) With reference to most scales, length refers to the greatest anterior-posterior measurement, and width refers to the greatest transverse measurement, even if the transverse dimension is the greater. When this convention is not used, as with a diagnonally placed scale, the "length" is measured along the major axis and is so stated. Height is the greatest vertical measurement when the surface of the scale is largely lateral. All measurements were made with dial calipers unless otherwise noted.

(2) Supranasal and infranasal scales are equivalent to upper and lower nasals as used by Klauber (1940). Prefrontal, frontal, interparietal, and interoccipital in some instances are designated PF, F, IP, and IO, respectively.

(3) When the rostral is described as protuberant, it has a distinct central bulge, i.e., in transverse section the edges of the rostral scale would be seen to lie flat against adjacent scales and the central part to arch outward (Fig. 2). The resulting dorsal outline of the head may be almost trilobed. An extreme of protuberance is seen in the ogival outline of the head of *Rhinoleptus* (Orejas-Miranda *et al.* 1970, figs. 2 and 3). The protuberance we describe does not result from a preshedding condition such as has been seen in some typhlopids (Richmond 1961).

(4) A decurved snout describes a condition in which the ventral surface of the snout is straight (horizontal), or even slightly concave, and the bulge in the rostral drops slightly below this plane.

(5) Scale row reductions are described in two ways. First, the number of midventral scales anterior to the anal scale was recorded at the point at which scale rows fuse. Scale rows were counted left to right and ventral to dorsal with the midventral row being 0; thus one could have a reduction formula of 20 (2 + 3)/16 (2 + 3). Second, the distance in millimeters (Z) anterior to the vent was measured at the last reduction step (13 rows to 12 rows at ventral 16). The point of reduction is then expressed as a percentage of snout-vent length (SVL) computed by $[1 - (Z/SVL)] \times 100$. This is much more informative than standard scale row reduction formulae, which are of dubious comparative value when longitudinal counts differ.

(6) Head width was measured at the level of the parietals using an ocular micrometer mounted in a dissecting microscope.

(7) Rostral width was measured at the widest point on the snout and length from the supranasal-infranasal suture to the midpoint on the posterior edge.

(8) Midbody diameter (MBD) was measured to the nearest 0.1 mm transversely so that the relatively rigid axial muscle mass and rib cylinder rather than the softer visceral mass defined the body diameter.

(9) Total length was measured along a ruler to the nearest millimeter (mm), and tail length to the nearest 0.1 mm from the posterior cloacal lip to the tip of the caudal spine. SVL was obtained by subtracting tail length from total length and rounding to the nearest mm.

(10) A major dichotomy in eye size and morphology exists in this group of leptotyphlopids and is not the result of preservation techniques, age in preservative, or pre-molting opacity. This character is used in the diagnoses. In large-eyed species the eyes are equal to about ⅓ the distance from the anterior border of the naris to the posterior margin of the eye; they are close to the surface and are surrounded by a distinct, clear orbital space. The ocular scale bulges slightly outward over the orbit, and that area lacks scale organs. In the small-eyed species the eye is about ⅛ the naris-to-eye distance and visible only as a small black dot well beneath the scale surface. There is no evident orbital space nor brille-like differentiation of the ocular. Scale organs are randomly distributed over the surface of the ocular.

(11) All scale organs that we discerned in these leptotyphlopids are small tubercles, some more flattened than others (flattening is probably an artifact of preservation). Orejas-Miranda *et al.* (1977) showed that differences in the density of scale organs on the heads of some leptotyphlopids may be of taxonomic value. We did not count scale organs because among the new species no great variation in scale organ density was observed. The species we describe have scale organs scattered over the head. They are concentrated on the snout and infralabials, become sparse on the posterior head region, and are largely absent behind the parietals. The scale organs appear to be more numerous in the large-eyed, heavily pigmented members of the group (*bilineatus* and *pyrites*) than in the new species.

(12) All specimens were sexed; if hemipenes were not everted, sex was determined by dissection of hemipenes or dissection of gonads.

(13) Data for holotypes listed in [ ] in description sections for each species.

(14) Statistics were done on an Apple computer using the program "Quickstat" by C. Richard Tracy.

Specimen citations reference the following museums: UF—University of Florida, Florida State Museum; USNM—National Museum of Natural History. Some additional specimens in the collection of Richard Thomas (RT) and in the Albert Schwartz Field Series (ASFS) will be deposited in other museums.

## *Leptotyphlops calypso,* new species

Figs. 2, 3

*Holotype.*—USNM 236659, adult male, taken 6.5 km S Las Galeras, Provincia de Samaná, Dominican Republic, on 22 Feb 1975, by Roy W. McDiarmid.

*Paratypes.*—(all from Provincia de Samaná, Dominican Republic). RT 8859,

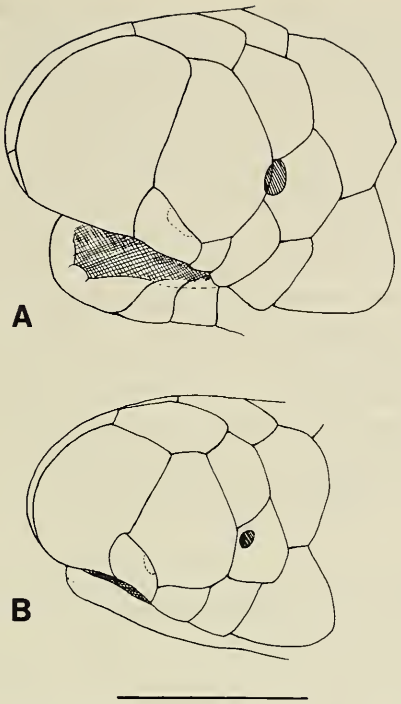

Fig. 2. Anterolateral view of the heads of A, *Leptotyphlops calypso* (USNM 236658, paratype) and B, *L. leptepileptus* (ASFS V49850, paratype) showing differences in snout and rostral shape. Line = 1 mm.

USNM 236658, adult males, ca. 4 km S Las Galeras, 8 Aug 1981, R. Thomas.—RT 8883, juvenile male, ca. 5 km S Las Galeras, 12 Aug 1981, Sra. Matías.

*Diagnosis.*—A relatively slender (SVL/MBD 73–87), unpigmented (pink in life), small-eyed *Leptotyphlops* of the *bilineatus* group having 4 supra- and 4 infralabials, third supralabial in subocular position; high number of middorsal scales (370–380); far posterior reduction from 14 to 12 scale rows (96–97% SVL) by fusion of rows 2 and 3; rostral moderate; snout broadly rounded, not protuberant; supranasal rhomboidal; ocular small, hexagonal; temporal-parietal suture length equal to ½ or less the parietal-occipital suture; anal and ventral tubercles in males; external anal spurs in at least some males; pelvic girdle including ilium, ischium, pubis and femur present.

*Distribution.*—Known only from the area between 4 and 6.5 km S Las Galeras on the Samaná Peninsula of the Dominican Republic (Fig. 1).

*Description.*—(all specimens male, N = 4) (Figs. 2 and 3, Tables 1 and 2). SVL 124–190 [166] mm ($\bar{x}$ = 166.5 mm); tail 5.8–8.9 [7.7] mm ($\bar{x}$ = 7.8 mm); MBD 1.7–2.2 [1.9] mm ($\bar{x}$ = 2.0 mm); SVL/MBD 73–87 [87] ($\bar{x}$ = 82.8). Head parallel-sided, tapering anterior to slight temporal bulge (head width 1.88–2.14 mm; $\bar{x}$ = 2.001 mm); snout somewhat truncate in dorsal aspect, broadly rounded in lateral aspect with nearly vertical anterior face, not protuberant or decurved. Eye small (equal to ⅙ to ⅛ distance from anterior border of naris to posterior border of eye), deeply embedded, no clear orbital space. Rostral moderate in width, parallel-

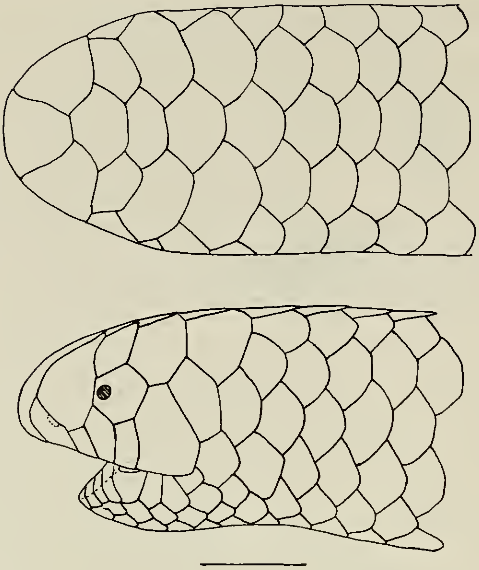

Fig. 3. Dorsal and lateral views of the head of *Leptotyphlops calypso* (RT 8859, paratype). Line = 1 mm.

sided ventrally, expanding slightly on tip of snout and tapering posteriorly to a narrow, truncate margin; virtually all of rostral visible in frontal view. Prefrontal large, hexagonal, slightly broader than long; frontal smaller, hexagonal, distinctly broader than long; interparietal larger (PF > IP > IO > F). Supranasal roughly rhomboidal, narrowest dorsomedially, broadly curved on posteroventral edge, not angled; ventralmost point a broad wedge between infranasal and first supralabial. Infranasal large, mostly visible in lateral view, extending dorsally to a level just below eye; free edge extending from widepoint of rostral posteroventrally, suturing with supranasal and first supralabial; naris under edge of infranasal just anterodorsal to supranasal-first supralabial suture. Ocular small, hexagonal, about 1.3 times higher than long, with a short supranasal suture. Supraocular large, elongate, about twice as long (major axis) as wide, pentagonal, almost a parallelogram, extending ventrally to just above eye. Parietal and occipital large and blocklike, occipital larger than parietal; both about 1.6 times wider than long and spanning two paramedian scale rows; occipital slightly emarginate on distal free edge. Temporal inserting between parietal and occipital for distance equal to ½ or less the length of parietal-occipital suture. Four supralabials, first suturing dorsally with supranasal, second picketlike with dorsal apex inserted between supranasal and ocular, third abutting dorsally on ocular, fourth large and subtriangular, most of its area posterior to ocular, in contact with posteroventral edge of ocular, parietal, temporal, and first scale of dorsal row 3. Mental scale with median ventral notch, each winglike lobe extending posterolaterally inside labial margin along posterior median edge of first infralabial; postmental cycloid. Infralabials 4, the fourth large, oval, platelike. Middorsal scales 375–380 [379] ($\bar{x}$ = 377.5); subcaudal scales 19–20 [20] ($\bar{x}$ = 19.5). Scale rows 14, reducing to 12 at

96–97% [96] SVL by fusion of scale rows 2 and 3 (aberrantly 3 and 4 on right side of RT 8883) [20 (2 + 3) and 16 (2 + 3) midventral scales anterior to vent]; caudal scale rows 12. Anal scale roughly pentagonal with posterior median apex. Prominent spur visible externally on each side of vent beneath scale in two specimens (the holotype and USNM 236658). Tubercular scale organs present (except in RT 8883, a juvenile) around cloaca and anteriorly on 3 ventralmost scale rows for distance of up to nearly ⅓ SVL. Pigmentation lacking (pink in life).

*Variation.*—As all specimens are males, no sexual dimorphism is evident. The tuberculation of the scales around the vent and along the ventral surface is most extensive in RT 8859 and USNM 236658, somewhat less so in the holotype, and absent in the juvenile (RT 8883). The anal tubercles and claws likely are secondary sexual characteristics. The juvenile and one adult (RT 8859) lacked externally visible spurs, but the adult, which was cleared and stained, has internal spurs. During removal of the skin an opening to the exterior was evident. An examination of radiographs of the juvenile (RT 8883) reveals a much less developed pelvic girdle rudiment (only ilial and ischial elements ossified) and no obvious internal spurs.

Some abnormal fusions of head scales were noted. In the holotype the fourth supralabial on the left is partly fused with the temporal. In RT 8883, supralabials 1 and 2 on the right are fused, as are supralabials 3, 4, and the temporal; the left side of the head is damaged, and the supralabial condition cannot be ascertained.

*Remarks.*—All specimens were collected along the road south of Las Galeras that parallels a prominent limestone ridge. The area is a mixture of open pasture and mixed mesic cultivation (bananas, yams, coffee, corn, coconuts, papayas) interspersed with some scrubby to semi-wooded habitat. The holotype and two other specimens (RT 8859, USNM 236658) were taken from beneath very large limestone rocks in an open pasture; a third specimen was beneath the same rock with one of the paratypes but escaped. The juvenile was found crawling on the floor of an outdoor kitchen.

*Etymology.*—*Calypso* is a proper noun that derives from the Greek verb "to hide" (*kalypto,* "I hide"); this new species is certainly well hidden in nature, as those of us who have looked for it can attest. Furthermore, Calypso, the nymph who sequestered Odysseus on Ogygia, was in island creature; and calypso, as a music form, has West Indian associations, even if not in the Hispaniolan traditions.

### *Leptotyphlops asbolepis,* new species
Fig. 4

*Holotype.*—UF 54802, adult female, taken on the west slope of Loma del Aguacate, 350 m, Sierra Martín García, Provincia de Barahona, Dominican Republic, on 29 Jan 1976, by Fred G. Thompson.

*Paratype.*—USNM 236660, adult male, same data as holotype.

*Diagnosis.*—A relatively stout (SVL/MBD 56–60), small-eyed, uniformly pigmented *Leptotyphlops* of the *bilineatus* group having 4 supra- and 4 infralabials, third supralabial in subocular position; relatively low middorsal scale number (302–342); far posterior reduction from 14 to 12 scale rows (98–99% SVL) by fusion of rows 2 and 3; rostral moderate in size; snout slightly decurved and protuberant; rhomboidal supranasal; small to large, hexagonal ocular; temporal-parietal suture length equal to or slightly less than length of parietal-occipital suture; no anal or ventral tubercles; no anal spurs; no pelvic girdle.

*Distribution.*—Known only from the type locality (Fig. 1).

*Description.*—(Fig. 4, Tables 1 and 2). SVL 135–[156] mm; tail 6.6–[6.8] mm; MBD 2.3–[2.5] mm; SVL/MBD 56–[60]. Head slightly broader than neck (1.97–2.01 mm; $\bar{x} = 1.99$ mm), tapering towards snout from slightly swollen temporal region; snout somewhat protuberant, rounded in lateral aspect, slightly decurved. Eye small (equal to ca. ⅛ distance from anterior edge of naris to posterior margin of eye), deeply embedded, no clear orbital space. Rostral moderately wide, parallel-sided ventrally, expanding on tip of snout, where slightly protuberant, and tapering to truncate posterodorsal margin; ventral portion nearly horizontal. Prefrontal, frontal, and interparietal subhexagonal, wider than long, increasing in size in that order; interoccipital smaller than interparietal, cycloid, isomorphic with succeeding middorsal scales. Supranasal roughly rhomboidal, narrowest dorsomedially, broadly curved on posteroventral edge, not angled, ventralmost point a broad wedge between infranasal and first supralabial. Infranasal large, mostly visible in lateral aspect, extending dorsally to point just above level of eye; posterior edge extending from wide point of rostral posteroventrally, contacting supranasal and first supralabial; naris under edge of infranasal about midway along infranasal-supranasal suture. Ocular small to large, about 1.2 to 1.6 times higher than long, hexagonal, with long supranasal suture. Supraocular small, a short pentagon, about 1.5 times longer (major axis) than wide, extending ventrally to point well above eye. Parietal and occipital large, about twice as wide as long, each spanning 2 dorsal scale rows; parietal somewhat emarginate on distal free edge; occipital markedly to moderately emarginate. Temporal inserted between parietal and occipital a distance greater than ½ parietal-occipital suture. Four supralabials, second picketlike with dorsal apex inserted between supranasal and ocular, third abutting dorsally on ocular, fourth large and subtriangular, most of its area posterior to ocular, in contact with posteroventral edge of ocular, parietal, temporal, and first scale of row 3. Mental with median ventral notch, each winglike lobe extending posterolaterally inside labial margin along posterior median edge of first infralabial; postmental cycloid. Infralabials 4, fourth large, oval and platelike. Middorsal scales 302–[342]; subcaudals [18]–19. Scale rows 14, reducing to 12 at 8 and 6 and [7 and 4] midventral scales anterior to vent at 98–[99]% SVL by fusion of rows 2 and 3; caudal scale rows [12]. Anal scale roughly pentagonal with posterior median apex. No anal spurs. Tubercular scale organs scattered over head, largely absent posterior to occipitals, concentrated on rostral and infralabials; no scale organs evident around vent. Pigmentation relatively uniform and dense over body but with some unpigmented patches; coloration faintly lineate due to slightly denser melanophores at centers of scales; head unpigmented, pigmentation beginning about level of occipitals.

*Variation.*—The difference of 40 middorsal scales between the type and the paratype is probably the result of sexual dimorphism, as is also the relative difference in tail length (see following description for evidence on sexual dimorphism in these snakes). The other main difference between the type and the paratype is in the size of the ocular scale. Because sexual dimorphism in this character is unknown in other species of *Leptotyphlops,* most likely this represents extremes of variation.

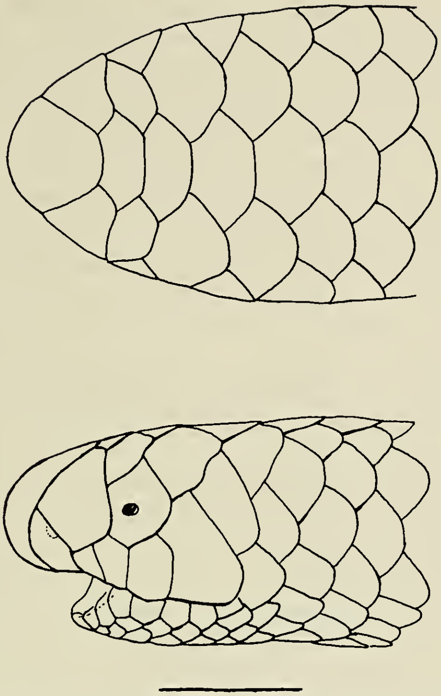

Fig. 4. Dorsal and lateral views of the head of *Leptotyphlops asbolepis* (UF 54802, holotype). Line = 1 mm.

*Remarks.*—The two specimens of *L. asbolepis* were collected under limestone boulders in a mesic forest zone reached by trail up the mountainside from La Salina (Puerto Alejandro) on the east side of the Bahia de Neiba.

*Etymology.*—From the Greek, *asbolos,* "soot," and *lepis,* "scale," in reference to the darker, more uniform coloration of this species.

### *Leptotyphlops leptepileptus,* new species
Figs. 2, 5

*Holotype.*—USNM 236661, adult female, taken at Soliette, 5 km airline NW Fond Verettes, 366 m, Département de l'Ouest, Haiti, one of series collected on 19 Jul 1978, by native collectors and Richard Thomas.

*Paratypes.*—(all same locality as holotype) RT 5596, juvenile male, 5614, female, 19 Jul 1978, native collectors and Richard Thomas.—RT 5682–5685, 5696–5715, USNM 236662–71, 19 males, 15 females, native collectors, 23 Jul 1978.—ASFS V49834–70, 13 males, 23 females, 1 undetermined, native collectors, 13 Jul 1979.

*Diagnosis.*—Relatively slender (SVL/MBD 72–94), small-eyed, silvery tan or piebald *Leptotyphlops* of the *bilineatus* group having 3 supra- and 3 infralabials, second supralabial in subocular position; high number of middorsal scales (377–

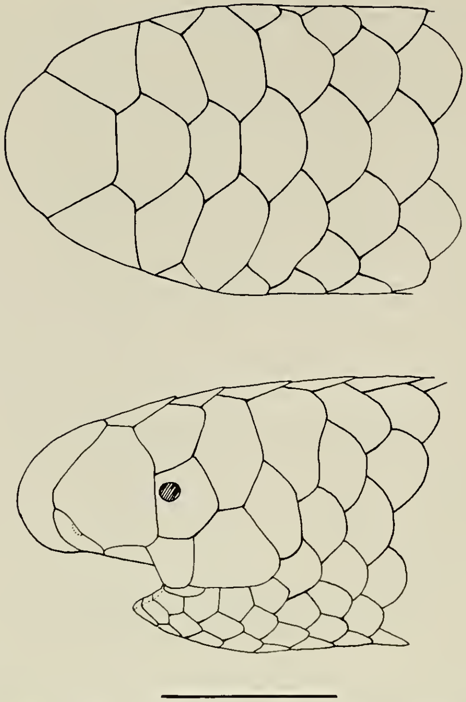

Fig. 5. Dorsal and lateral views of the head of *Leptotyphlops leptepileptus* (USNM 236661, holotype). Line = 1 mm.

414); far posterior reduction from 14 to 12 scale rows (84–95% SVL) by fusion of rows 0 and 1; large, protuberant rostral; slightly decurved snout; triangular supranasal; small, pentagonal ocular; temporal-parietal suture length equal to ½ or less length of parietal-occipital suture; no anal or ventral tubercles; no anal spurs; pelvic vestiges usually absent.

*Distribution.*—Known only from the type-locality, an intermontane valley on the north slopes of the Massif de la Selle of Haiti (Fig. 1).

*Description.*—(Figs. 2 and 5, Tables 1 and 2). SVL: males (juveniles of 102, 105 mm excluded) 144–174 mm, $\bar{x}$ = 156.03 mm, SE = 2.548 mm (N = 29); females 140–198 [184] mm, $\bar{x}$ = 172.88 mm, SE = 4.275 mm (N = 41); tail length: males 5.0–7.4 mm, $\bar{x}$ = 6.80 mm, SE = 0.013 mm (N = 32); females 5.8–7.4 [7.1] mm, $\bar{x}$ = 6.87 mm, SE = 0.008 mm (N = 40); MBD 1.4–2.3 [2.1] mm, $\bar{x}$ = 1.99 mm, SE = 0.176 mm (N = 74); SVL/MBD 72–94 [87.6]. Head narrow (1.45–1.68 mm, $\bar{x}$ = 1.60 mm, SE = 2.121 mm, N = 72), parallel-sided with slight temporal bulge, tapering anterior of eyes to somewhat protuberant, decurved snout. Eye small (⅙ to ⅛ distance from naris to eye), deeply embedded, no clear orbital space. Rostral large, covering about ½ snout anterior to eye in dorsal aspect, tapering posteriorly to truncate margin, protuberant on snout tip; parallel-sided ventrally, widening gradually onto front of snout; ventral portion horizontal, somewhat concave, not completely visible in frontal view. Prefrontal very large, subhexagonal to nearly cycloid; frontal smaller (shorter), hexagonal; interparietal and interoccipital larger than frontal, smaller than prefrontal, cycloid (in general $PF \geq = IP > IO \geq = F$). Supranasal large, subtriangular, posterior edge forming nearly right angle with nearly horizontal ventral edge; ventralmost point at apex of broad angle between nasal and first supralabial. Infranasal small, surface largely ventral, mostly not visible in lateral aspect; dorsal tip extending to just below level of eye; posterior edge extending from widepoint of rostral posteroventrally, contacting supranasal-first labial suture. Supraocular an elongate, irregular pentagon (almost a parallelogram), about twice as wide as long (major axis), ventral end inserted between supranasal and ocular and extending to point above eye for distance equal to about ½ eye diameter. Parietal and occipital large, less than twice as wide as long, each spanning two paramedian rows of dorsal scales; occipitals slightly smaller than parietals, emarginate on distal half of free edge. Temporal inserting between parietal and occipital a distance ⅓ to ½ length of parietal-occipital suture. Three supralabials, surface of first nearly ventral (transverse); dorsal edges of second and third partially abutting ventral edge of ocular, both occluding ocular from labial border; second in short contact with supranasal and third with parietal, temporal, and first scale of row 3. Infralabials 3, third large, oval, platelike. Middorsal scales 377–414 (males 377–395, $\bar{x} = 385.22$, SE = 0.866, N = 32; females 393–414 [411], $\bar{x} = 404.95$, SE = 0.773, N = 41). Subcaudals 17–22 (males 18–22, mode 20; females 17–21 [19], mode 20). Reduction from 14 to 12 scale rows occurring at 84–97% [92] SVL by fusion of scale rows 0 and 1 [31 (0 + 1)/31 (0 + 1) midventral scales anterior to vent]; scale rows of tail 12. Anal scale roughly pentagonal with median posterior apex. No anal spurs; no pelvic girdle, pelvic vestiges occasionally present. Head unpigmented; brown (silvery in life) body pigmentation beginning on neck and becoming uniform over all of body except anal scale; variant pigmentation (20%) with irregular unpigmented and more darkly pigmented blotches randomly distributed over body. Hemipenes simple, everted organs expanded basally, tapering towards tip, no ornamentation and no complex structures; size minute, about 1 mm long in largest specimens. Sulcus spermaticus entering organ on medial surface, proceeding distad about ½ length, then spiralling counterclockwise ¼ turn (apical aspect) and continuing to tip of organ.

*Variation.*—Pronounced sexual dimorphism exists in middorsal counts, SVL, tail length as a percentage of body length, and reduction level (% SVL). Differences between means of these characters were all significant at $P < 0.000001$ when tested with the t-test. Subcaudal counts have the same mode in both sexes, but the range of counts for males was higher than that for females. The piebald color morph occurs in both sexes. Variants from the standard configuration of head scales include a small, supernumerary scale separating the third supralabial from contact with the parietal (USNM 236662 bilateral; RT 5705, right side), the wedge-insertion of the second supralabial between the ocular and supranasal (ASFS V49854, left side), and 4 supralabials (bilateral) in USNM 236662, although in this specimen the second supralabial does not insert between the supranasal and the ocular, as it does in the species of this group for which four supralabials is the normal condition. Only one of 35 x-rayed and two cleared and stained specimens had a trace of a pelvic rudiment. In that male (RT 5713) a pair of small, opaque elements (ischial remnants?) lying lateroventrally below the second vertebrae anterior to the cloaca is obvious in the radiograph. None of the hemipenes appears completely everted, although many are nearly so; they are minute, none measuring more than 1 mm in length.

*Remarks.*—The type-locality is a settlement along the valley of the Rivière Soliette, tree-lined and shady compared to the more open cultivation-scrub mosaic of the surrounding limestone hills. Some specimens were collected from piles of stream-worn cobbles in a shady (mango) rest area along the road. Unfortunately, we have no way of knowing how far away and into what different habitats, if any, the Haitian collectors ranged to collect the balance of the specimens.

*Etymology.*—*Leptepileptus* is from the Greek meaning extremely thin, literally "thin-upon-thin."

*Comparisons and Discussion.*—The three species we describe obviously are more closely related to one another than to the other two species within the *bilineatus* group. They are small-eyed, small-headed, relatively long-snouted, slender, lightly (or not at all) pigmented snakes with high numbers of middorsal scales and scale row reduction occurring on the body. In contrast, *Leptotyphlops bilineatus* and *L. pyrites* are shorter, stouter, larger-headed, larger-eyed, shorter-snouted, boldly patterned snakes with lower middorsal scale counts and no scale row reduction on the body. Among our trio of new species, the differences are nevertheless pronounced. *Leptotyphlops leptepileptus* has a strikingly narrower head (Fig. 6) and broader rostral scale (Fig. 7); it also is unique among the three in having three supra- and infralabial scales and a scale row reduction by fusion of rows 0 and 1. The large, triangular, last supralabial (3 in *leptepileptus,* 4 in *calypso* and *asbolepis*) partly extends beneath the ocular in *L. leptepileptus,* whereas its area is largely posterior to the ocular in *L. calypso* and *L. asbolepis.* In *L. leptepileptus* the rostral is larger and more protuberant, and the snout is more decurved and depressed (more transversely oval in cross section); as a reflection of this, the infranasal and first supralabial are more nearly transverse in position than they are in the other two species. The ocular distance is notably shorter in *L. leptepileptus* (Fig. 8). The lateral head scale differences between *L. leptepileptus* and the other species are largely attributable to the lack of equivalent supralabials. The second supralabial in the 4-labial species inserts wedge-like between the supranasal and the ocular and accounts for the more rhomboidal shape of the supranasal by putting an extra facet on the posteroventral margin of the supranasal. Likewise the ocular becomes more hexagonal by the second supralabial insertion. The large, triangular, last supralabial is largely excluded from the subocular space in the 4-labial species but occupies part of the sub-ocular space in *L. leptepileptus.* Therefore, the differences are not easily viewed as the result of simple fusion of one supralabial with another to get from the 4- to the 3-supralabial condition (or simple splitting, if the reverse was the sequence). Other aspects of shape differences among the species are obvious by comparison of Figs. 3, 4, 5, and 9 and Table 1.

The absence of pelvic vestiges in *L. asbolepis* and most *L. leptepileptus* is a feature undocumented in other species of the genus (List 1966), although Tihen (1945) reported a personal communication from Leonard Laufe that some (unspecified) species lack them. Examination of three specimens of *L. bilineatus* (USNM 119168 and USNM 222954, radiographs; USNM 236657, cleared and stained) and one specimen of *L. pyrites* (RT 7600, cleared and stained) failed to reveal pelvic vestiges in these species as well. Based on our preliminary findings, it appears that the *bilineatus* group has species which clearly document an evo-

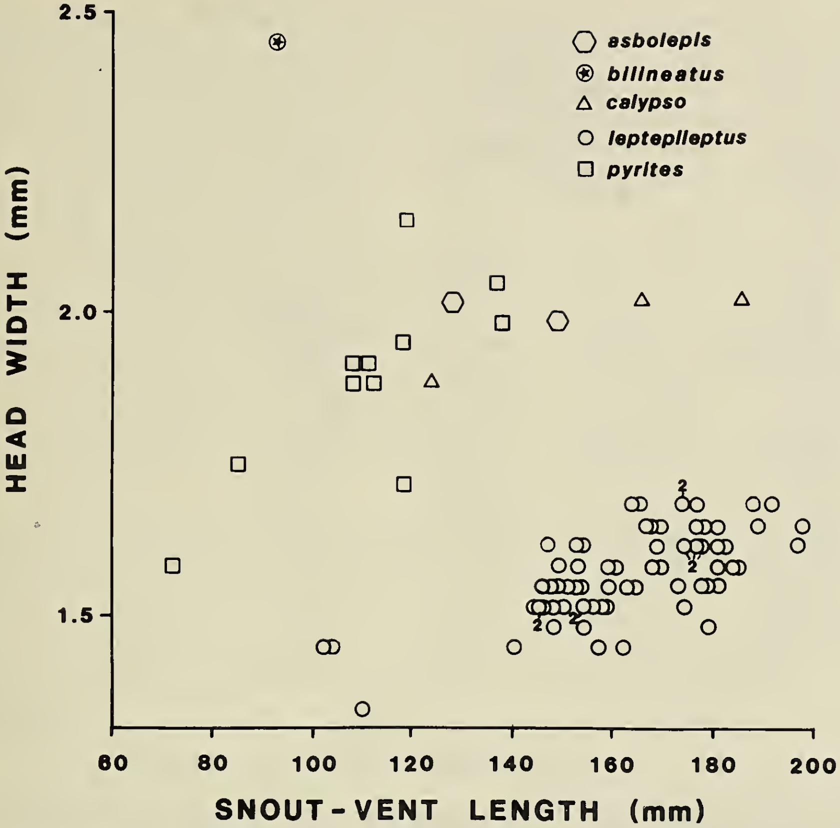

Fig. 6. Scatter diagram of head width versus snout–vent length for *bilineatus* group *Leptotyphlops*. Numbers indicate symbols representing more than one specimen.

lutionary transition including forms with well developed pelvic girdles and external anal spurs (*L. calypso*), species in which a pelvic vestige is only rarely present (*L. leptepileptus*), and species which seemingly lack pelvic vestiges completely (*L. asbolepis, L. bilineatus, L. pyrites*). A comparison of the single juvenile of *L. calypso* to adults of that species indicates a sequential pattern of ossification of the pelvic girdle with posterior elements (ilium and ischium) appearing before the anterior and lateral components. Thus, one can envision a reduction and ultimate loss of pelvic girdle components in West Indian species of *Leptotyphlops* through modification of the developmental process. This interpretation is strengthened by the detection of an ossified ischial vestige in only one specimen of *L. leptepileptus* whereas all others (36) examined have lost the girdle completely. These findings suggest the value of a detailed examination of the sexual and ontogenetic changes in pelvic girdle components during development and growth of *Leptotyphlops.*

*Leptotyphlops calypso* has a more rounded and swollen snout with an almost flat, ramlike anterior surface but narrow rostral. The prominent perianal and ventral tubercles in *L. calypso,* if consistent (presumably in adult males only), are

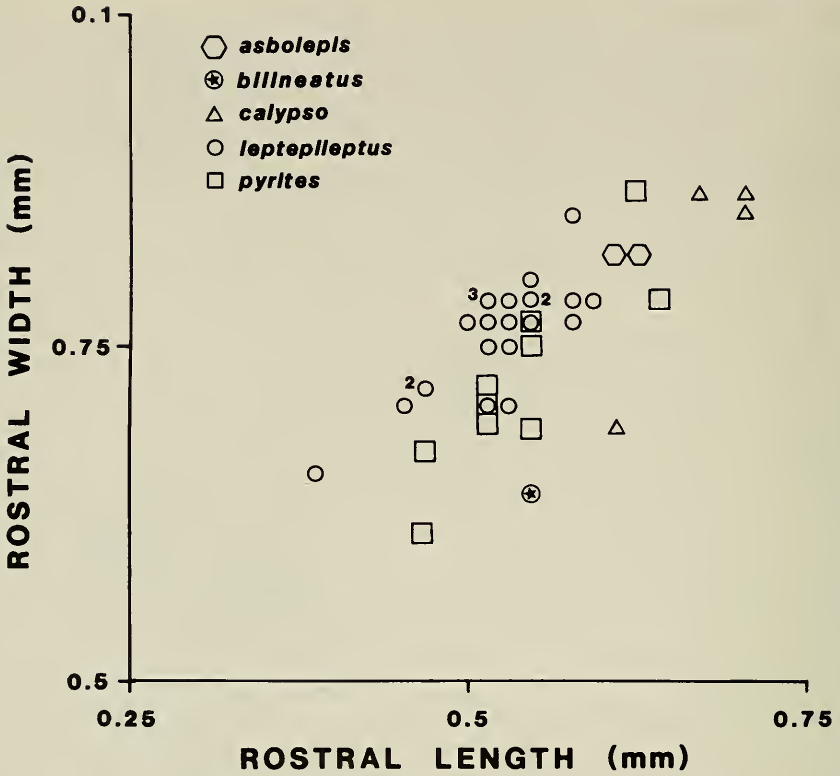

Fig. 7. Scatter diagram of rostral scale width versus rostral scale length for the *bilineatus* group *Leptotyphlops.* Numbers indicate symbols representing more than one specimen.

probably unique (the small sample of *L. asbolepis* precludes our being sure). Since we have but one male *L. asbolepis,* we also cannot be sure that anal spurs do not exist in that species. However, the absence of a pelvic vestige in *L. asbolepis* suggests that anal spurs may be absent. The claws reported for *L. humilis* and *L. nigricans* by List (1955) seem much less well developed than those of *L. calypso.* List noted the possibility that claws emerge to the surface during the breeding season only.

*Leptotyphlops asbolepis,* although amply distinct in combination of characters (Tables 1 and 2), lacks strikingly unique features; it is the most darkly pigmented of the three and is intermediate in rostral size and snout shape between *L. calypso* and *L. leptepileptus.* The extent to which the temporal inserts between the parietal and occipital is very distinctive, and the supraocular is also small compared to that of the other species.

One result of our collecting has been the acquisition of more material of *Leptotyphlops pyrites.* Originally known only from the xeric to semixeric lowlands of the western Barahona Peninsula of the Dominican Republic, we now have taken it in the southeastern coastal plain of Haiti. The habitat at the localities east of Belle-Anse is xeric limestone scrub and remnant woods, similar to some of the area near the type-locality. At Mare Geoffrey, 19 km W Thiote, the habitat is more mesic. At this locality the road crosses a dry (no doubt intermittent) river

Table 1.—Comparison of the head shape and scalation among the five species of the *bilineatus* group of *Leptotyphlops.*

| | *calypso* | *asbolepis* | *leptepileptus* | *pyrites* | *bilineatus* |
|---|---|---|---|---|---|
| Rostral | narrow, nonprotuberant | intermediate, slightly protuberant | broad, protuberant | narrow, nonprotuberant | narrow, nonprotuberant |
| Snout | swollen, blunt | intermediate | depressed, decurved | short, blunt | short, blunt |
| Supraocular | moderate | small | large | moderate | moderate |
| Ocular | hexagonal, short anterior suture | hexagonal, short anterior suture | pentagonal, long anterior suture | hexagonal, short anterior suture | hexagonal, short anterior suture |
| Infranasal | large, high; surface lateral | large, high; surface lateral | small, low; surface largely ventral | large, high; surface lateral | large, high; surface lateral |
| First labial | surface largely lateral | surface largely lateral | surface largely ventral | surface largely lateral | surface largely lateral |
| Last labial | largely posterior to ocular | largely posterior to ocular | partly beneath ocular | largely posterior to ocular | largely posterior to ocular |
| Parietal-occipital suture | long | short | long | long | long |

bed with steep banks of river cobble substratum and sparse, low, scrubby growth with some trees. We found seven *L. pyrites* together in loose soil and gravel around the roots of a small leguminous tree; two others were found in somewhat more exposed situations, one under a rock and one in a piece of abandoned termite

Table 2.—Comparison of major diagnostic characteristics among the five species of the *bilineatus* group of *Leptotyphlops.*

| | *calypso* | *asbolepis* | *leptepileptus* | *pyrites*[1] | *bilineatus* |
|---|---|---|---|---|---|
| SVL-maximum (mean) | 190 (167) | 156 (146) | 198 (164) | 138 (115) | 108 (90) |
| SVL/MBD | 73–87 | 56–60 | 72–94 | 43–64 | 35–41 |
| Middorsals | 370–380 | 302–342 | 377–414 | 262–287 | 170–189 |
| Reduction level (% SVL) | 96–97 | 98–99 | 84–95 | —[2] | —[2] |
| Rows fused in reduction | 2 + 3 | 2 + 3 | 0 + 1 | —[2] | —[2] |
| Labials | 4 | 4 | 3 | 4 | 4 |
| Eye size | small | small | small | large | large |
| Color | unpigmented | uniform except head | uniform or piebald except head | dark with stripes | dark with stripes |
| Anal spurs | + | − | − | − | − |
| Anal tubercles | + | − | − | − | − |

[1] Data in part from Thomas (1965).

[2] Reduction occurs posterior to vent.

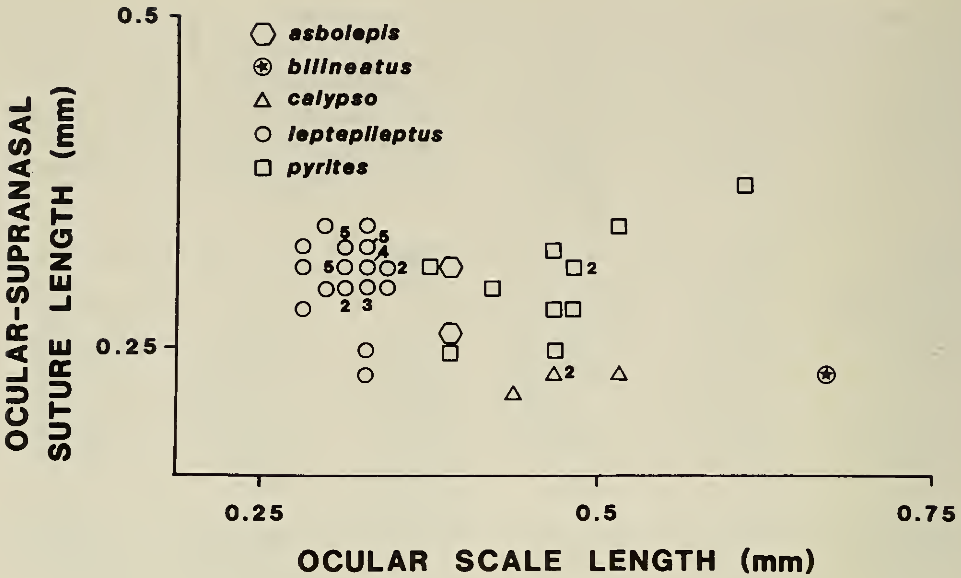

Fig. 8. Scatter diagram of length of the ocular-supranasal suture versus maximum length of ocular scale for the *bilineatus* group *Leptotyphlops*. Numbers indicate symbols representing more than one specimen.

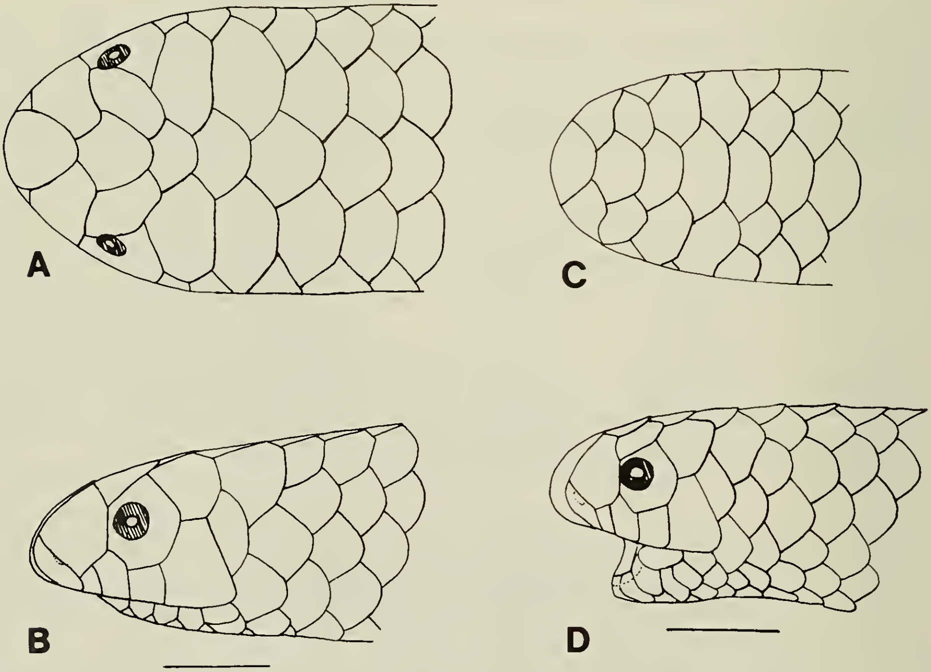

Fig. 9. Dorsal and lateral head views of *Leptotyphlops bilineatus* (A and B, USNM 236657) and *L. pyrites* (C and D, RT 7607). Line = 1 mm.

nest under a rock. Three specimens from 6 km NW Duvergé in the Valle de Neiba (Dominican Republic) extends the known range about 50 km to the northeast of the type-locality and across the Sierra de Baoruco. At this locality the habitat was extremely xeric; the snakes were found under palm trunk cuttings.

In meristic characters none of the new *L. pyrites* material departs significantly from those of the hypodigm, although one Duverge specimen (RT 4423) is at the upper extreme in middorsal scales (287). The Haitian specimens are darker than the Dominican specimens, the bold dorsal-zone striping being much obscured. In contrast, the three Valle de Neiba snakes lack the median and paramedian dorsal stripes, having only a pale median dorsal band. These individuals also appear to differ from topotypical *L. pyrites* in the shape and proportional relationships of certain head scales. Without more specimens the significance of this variation is difficult to assess.

*Specimens examined.—Leptotyphlops bilineatus,* Martinique: USNM 119168, Martinique: USNM 236657, Plage du Diamant.—St. Lucia: Anse-La-Raye: USNM 222954, 0.1 mi E of Anse Galet River. *Leptotyphlops pyrites,* Haiti: Département de l'Ouest: RT 7201, 9.6 km E Belle-Anse; RT 7222, 11.2 km E Belle-Anse; RT 7600–7608, RT 7692, 19.5 km W Thiote, 600'.—Dominican Republic, Provincia de Independencia: RT 4423 9125, 9126, 6 km W Duvergé.

## Key to West Indian Speices of *Leptotyphlops*

1. Ocular scale excluded from labial border by supralabials ............ 2

– Ocular (oculolabial) extends to labial border ........................ 6

2. Middorsal scales fewer than 290; eye large, obvious, equal to ⅓ distance from anterior border of naris to posterior margin of eye; striped color pattern ........................................................ 3

– Middorsal scales more than 300; eye small, indistinct, equal to ⅛ the distance from anterior border of naris to posterior margin of eye; generally uniform color pattern ........................................ 4

3. Middorsal scales 170–189; small size, maximum snout–vent length 108 mm; known from Barbados, Martinique and St. Lucia .......... *bilineatus*

– Middorsal scales 262–287; medium size, maximum snout-vent length 138 mm; known from several localities on southern coastal plain of Hispaniola ........................................................ *pyrites*

4. Three labial scales; middorsal scales 377–414; scale row reduction by fusion of rows 0 + 1; known only from the Massif de la Selle in Haiti ........................................................ *leptepileptus*

– Four labial scales; middorsal scales fewer than 380; scale row reduction by fusion of rows 2 + 3 ........................................ 5

5. Middorsal scales 302–342; body uniformly pigmented; anal tubercles and spurs absent; known only from the Sierra Martín García, Dominican Republic ........................................................ *asbolepis*

– Middorsal scales 370–380; body unpigmented; anal tubercles and spurs present in most males; known only from the tip of the Samaná Peninsula, Dominican Republic ........................................ *calypso*

6. Uniformly dark above, no light spot on snout or tail tip; known only from Watling Island (=San Salvador), Bahamas ...................... *columbi*

– Usually with longitudinal dark stripes on each dorsal scale row, distinct light spot on snout and tail tip; known from Bay Islands of Honduras, Swan Islands, Providence and San Andres Islands .............. *goudotii*

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# A NEW SKINK (REPTILIA: SAURIA: *LEIOLOPISMA*) FROM FIJI

George R. Zug

*Abstract.*—A new lizard, *Leiolopisma alazon,* is described from the southernmost island cluster, Ono-i-Lau, of Fiji. This species represents the first record of *Leiolopisma* from the Fijian Islands. *Leiolopisma alazon* shows no evidence of close relationship with its nearest geographic congeners on New Caledonia. Instead, *L. alazon* does show a relationship to the New Zealand "leiolopisma" skinks and is most similar to the species of *Cyclodina,* except by its possession of a transparent palpebral disc in each lower eyelid. To facilitate comparison with New Caledonian *Leiolopisma,* the latter were studied and five species groups are tentatively recognized.

The skinks of the Fiji Islands have long been known to represent three genera: *Cryptoblepharus, Emoia,* and *Lipinia.* A fourth genus, *Eugonglylus,* may occur in the Fijian group, but its presence remains unconfirmed. Thus, the discovery of a different lygosomine skink in the Ono-i-Lau group was a great surprise, particularly since the new species was found on only the smallest island of the three searched in this group.

The new skink possesses an alpha palate, 11 premaxillary teeth, and toes covered dorsally by a single row of scales, characters of Greer's (1974) group II skinks. It can further be recognized as a member of the genus *Leiolopisma* by moveable lower eyelids with a large transparent palpebral disc in each lid and well developed prefrontal scales. *Leiolopisma* is predominantly a Southwest Pacific group with species on Lord Howe Island, New Caledonia, New Hebrides, New Zealand and Chatham Islands, Australia, and Tasmania (Greer 1979). Because the specimens from Ono-i-Lau differ in several features from the other species of *Leiolopisma,* the Ono-i-Lau population is described as:

### *Leiolopisma alazon,* new species
Figs. 1, 2

*Holotype.*—USNM 230000, adult male; Fiji, Ono-i-Lau, Yanuya Island, 20°37′S 178°41′W, coll. George R. Zug, 29 Apr 1982.

*Paratopotypes.*—USNM 229989 (cleared and stained), USNM 229990–9999 (alcoholics), juveniles, females, and males with same collection data as holotype.

*Diagnosis.*—This skink is a small *Leiolopisma* with an adult snout-vent length (SVL) of 45–65 mm, a robust elongate body, short but well developed limbs, a pair of frontoparietal scales, prefrontals not in contact, smooth dorsal scales, 34–37 scale rows around midbody, and an orange to red tail in adults. These features, singly or in combination, distinguish this species from all currently recognized *Leiolopisma* species. The Australian species *L. duperreyi, L. greeni, L. metallicum, L. ocellatum, L. palfreymani, L. platynotum, L. pretiosum,* and *L. trilineatum* possess a single (fused) frontoparietal scale; *L. baudini, L. coventryi, L. en-*

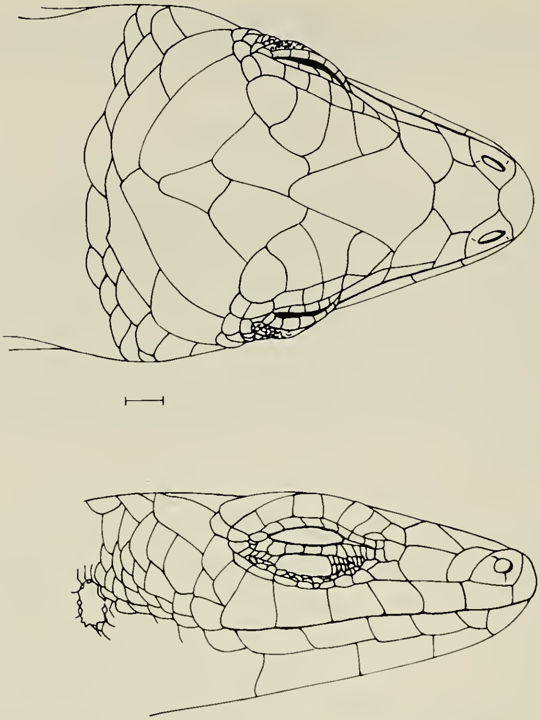

Fig. 1. Dorsal and lateral view of the head of *Leiolopisma alazon.* Based on the holotype, USNM 230000. Inset 1 mm.

*trecasteauxii,* and *L. zia,* have fewer than 34 scale rows around midbody; *L. spenceri* has supernasals; adult *L. lichenigerum* has SVL greater than 75 mm. No New Zealand *Leiolopisma* possesses a uniform reddish or orangish tail dorsally. The majority, *L. acrinasum, L. chloronoton, L. fallai, L. gracilicorpus, L. grande, L. homalonotum, L. infrapunctatum, L. lineoocellatum, L. nigriplantare, L. otagense,* and *L. suteri* also have adult SVL greater than 75 mm. *Leiolopisma fasciolare,* known only from the original description, has 27 scale rows around midbody. The majority of the New Caledonian species, *L. austrocaledonicum, L. deplanchei, L. euryotis, L. novacaledonicum, L. steindachneri, L. tricolor,* and *L. variabile,* have a single frontoparietal. *Leiolopisma greeri* and *L. nigrofasciolatum* have large prefrontals broadly in contact medially.

*Description of holotype.*—Adult male of 60.4 mm SVL and 46 mm tail length (regenerated); general habitus of elongate and robust body, head triangular in outline, depressed and rounded snout, limbs short but well formed, robust and subcylindrical tail gradually tapering to point. Head length (tip of snout to ear opening) 12.4 mm, head width (at angle of jaw) 9.0 mm, snout to naris distance 1.1 mm, axilla to inguen (trunk) length 34.8 mm, hindlimb length 16.0 mm. Forelimb (length, 12.3 mm) shorter than hindlimb; no overlap when adpressed.

Rostral wider than high, in broad contact with frontonasal; prefrontals moderate-sized, paired, and widely separated by frontal-frontonasal contact; frontonasal octagonal, width and length subequal, in broad contact with frontal; frontal

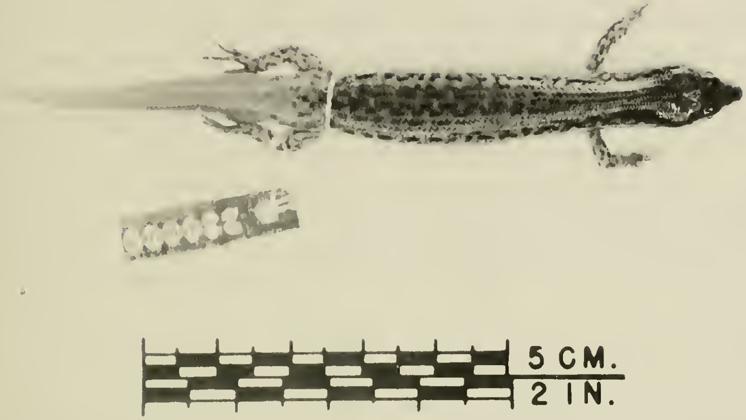

Fig. 2. Dorsal view of *Leiolopisma alazon* (USNM 230000).

truncated rhomboidal, length twice width, in broad contact with frontoparietals; frontoparietals paired, somewhat rhomboidal, length slightly greater than width, bordering interparietal and parietals posteriorly; interparietal large, approximately half area of frontoparietal, rhomboidal, width approximately two-thirds length; parietals paired, trapezoidal, length two to three times width, bordered posteriorly by pair of large nuchal scales and upper secondary temporal scales. Nasal large, obovate, grooved, naris circular and nearly centered in scale; anterior loreal higher than wide; posterior loreal wider than high; upper and lower preoculars large, contiguous with row of small, distinct suboculars separating labials from lower eyelid scales. Four large supraoculars on each side; 9 supraciliaries; 10 upper eyelid scales; anteriorly an accessory supraciliary between second supraciliary, eyelid, and upper preocular; 3–4 postoculars; lower eyelid with large palpebral disc, 1.1 mm in maximum length; primary temporal and pair of secondary temporals on each side; upper secondary temporal largest and on posterior border of parietal. Supralabials 7, fifth beneath eye, sixth highest; infralabials 6; mental semicircular; postmental large and pentagonal; 3 pairs of chinshields, first pair largest and only pair in contact medially. Ear openings vertically elliptical, 0.6 × 1.3 mm.

Dorsal scales smooth, in 70 transverse rows from base of tail to nuchals; 36 rows of scales around midbody; ventral scales slightly larger than dorsals and laterals; preanals slightly larger than preceding scales; 14 smooth lamellae beneath fourth finger; 21 smooth lamellae beneath fourth toe. Finger lengths, 3 = 4 > 2 > 5 > 1; toes, 4 > 3 > 2 > 5 > 1.

In life, dorsum with brownish olive ground color, spotted with light golden or beige and dark brown scales; labial and mental area with dark brown streaks or spots; venter golden beige; tail rufous orange above and below. In alcohol, dorsum brown with scattering of dark brown and beige spots; dark brown spots concentrated dorsolaterally to give impression of stripe from posterior edge of eye to inguen; sides light brown, rapidly grading to cream colored venter; head brown dorsally with few dark specks, upper and lower lips with dark brown bars that extend onto chinshields; limbs beige with numerous dark brown spots dorsally; tail orangish beige dorsally and laterally, cream ventrally.

*Variation.*—The paratopotypic specimens are all smaller than the holotype. The two females (USNM 229990, 229998) are 48.1 and 42.7 mm SVL, respectively; both appear mature or are maturing because each contains small, but vitellogenic, follicles. The remaining specimens are males, ranging from 26.9 to 57.7 mm SVL. The smallest may be a hatchling/newborn, since it possesses a ventral scale aberration which may be a yolk-sac scar. Two males (51.3 and 57.7 mm SVL) have large testes and epididymides and are presumed mature. The other males (33–49 mm SVL) are immature with small testes. In all specimens, original or completely regenerated tails are equal to body length or slightly longer, robust, cylindrical with gradual taper to the tip. The head is triangular on all specimens with a head width to head length proportion of 0.67–0.74. The limbs are well formed and short. The hindlimb and forelimb when adpressed to trunk remain widely separated. Trunk length (measured between fore- and hindlimbs) is approximately half the snout–vent length (48–58%, mean 53%).

Dorsal head scale pattern is relatively invariable; the differences are minor shape and positional alterations. Only the supraciliaries vary in number, 8–9; 8 supraciliaries is the modal number with 9 resulting from a division of the second supraciliary. The lateral head scales are somewhat more variable in size, shape, and position. The upper eyelid bears 8–11 scales, mode 10. The nasal retains the obovate to parallelogram shape; naris is typically central, but in some individuals, the naris is shifted anteroventrally toward inferior border; posterodorsal and medioventral grooves extend from the naris in a few individuals, never creating a distinct division of the nasal, ventral groove most prominent when present. Anterior and posterior loreals are higher than wide and wider than high, respectively, as in the holotype, although the width of the anterior loreal varies from approximately two-fifths to half of the height and, in the posterior loreal, the shape is rectangular to weakly trapezoidal. The preoculars are paired in all specimens, the upper usually equal in size to lower, occasionally smaller. The subocular row is complete in all individuals; although in two individuals, the suboculars above the fifth supralabial are only slightly larger than the scales covering the lower eyelid. The suboculars grade imperceptibly into the postoculars; one postocular is always wedged between the last two supraciliaries. Similarly, there are one or two small scales wedged between the first and second supraciliaries and the anterior upper eyelid scales. Of the temporals the size ranking of small to large is invariably primary, lower secondary, and upper secondary. There are 7 supralabials, fifth beneath orbit, and 5–7 infralabials, mode 6, in all specimens. Ear opening is elliptical and subequal to palpebral disc of lower eyelid in all. Low rounded auricular scales are barely evident along anterior margin, 2 or 3 in number.

All body scales are smooth. The dorsal scales lie in 71–77 transverse rows, mean 73.8, from base of tail to nuchals. There are 34–37, mode 34, scales around midbody. The fourth finger bears 12–15 lamellae, mode 15, the fourth toe 20–23 lamellae, mode 22.

In life, all individuals had the same coloration and general pattern as the holotype; however, there was a single striking difference in tail color. USNM 22989–95 had tails in shades of salmon, 229996–99 in shades of beiges; these colors were as evident ventrally as dorsally. Tail color differences have no association with size (age), sex, or reproductive condition. In alcohol, dorsal ground colors range from tan to brown with a various density of dark brown spotting. In all, there is a concentration of these spots into an interrrupted dorsolateral stripe on each side. In individuals less than 55 mm SVL, these dark spots are dense and arranged into ragged-edged, irregular transverse bars.

*Etymology.*—The name "alazon" is Greek (neuter) for wanderer or rover. It is used in allusion to this species wandering from the common geographic track (New Caledonia through New Zealand to Australia) of Pacific *Leiolopisma* as well as to its dispersal to the remote Ono-i-Lau group.

## Ecological Observations

Yanuya Island is a small coral island, probably less than a hectare in area, in the Ono-i-Lau cluster. It is a fairly flat island with only scattered, irregularly spaced limestone outcrops, of 2–4 m in height. The entire island is covered by forest; the canopy is nearly closed at approximately 10 m. The island serves as a rookery area for brown boobies and sooty terns. Presumably, the rookery accounts for the presence of a sandy humus-like soil and the reported presence of "plenty snakes," presumably the boid *Candoia bibroni.* The forest floor had a light scattering of leaves and fallen limbs. All but one of the *Leiolopisma alazon* were in or under rotten logs; the single exception was a juvenile caught resting on a blade of grass.

The smallest specimen (26.9 mm SVL) appears to have a yolk-sac scar and, hence, may have been recently hatched or born. However, in "leiolopisma" of similar adult size (e.g., *Lampropholis delicata* & *quichenoti*; Clarke 1965), one week old juveniles have 17–20 mm SVL. Since none of the females were gravid or pregnant, it is impossible to declare this species as ovi- or viviparous. Both females (42.7 and 48.1 mm SVL) possess small, but clearly vitellogenic follicles. The smallest male with well developed testes and epididymides is 51.3 mm SVL; a male of 49.3 mm SVL has small testes and is likely immature. These data suggest a sexual dimorphism in body size with females maturing at a smaller size than males.

Three other lizard species were seen or captured on Yanuya: *Cyrtodactylus pelagicus, Emoia cyanura,* and *Emoia* cf. *samoensis* complex. *Emoia cyanura* was the most abundant of the Yanuya lizards. *Cyrtodactylus* is the only species sharing the same microhabitat as *Leiolopisma,* but the two were not found under the same logs.

*Leiolopisma* was not found on either of the two other larger islands visited in the Ono-i-Lau cluster. Davora Island lacks a humus-like soil, having only a fine coral rubble with a dead leaf cover; *Lipinia noctua, Cryptoblepharus,* and *Emoia* *cyanura* were present. Estad Island is a sand island with partially humus-like soil; only *Emoia cyanura* was observed.

## Distribution and Relationships With Other Oceanic *Leiolopisma*

The occurrence of a *Leiolopisma* in the southern Fijian Lau group seems anomalous, but then the distribution of the genus *Leiolopisma* is a peculiar one. The occurrence of the type-species of *Leiolopisma* (*L. telfairi*) on Round Island of the Mauritius group in the western Indian Ocean with all other representatives in the Southwest Pacific makes little zoogeographic sense, no matter how ardent a supporter one is of long distance dispersal or vicariance. On zoogeographic grounds, *Leiolopisma* currently appears to be a polyphyletic group and with further study is likely to be divided into the West Indian Ocean *Leiolopisma* and a Southwest Pacific group of one or more genera[1]; however, such a taxonomic reshuffling is well beyond the scope of the present study. Considering only the distribution of the Pacific *Leiolopisma,* the pattern still remains unique among the Pacific herpetofauna, since it is J-shaped incorporating the New Caledonian cluster southward to New Zealand and westward to center on southeastern Australia and Tasmania. Within each of the aforementioned areas, the genus has undergone great diversity. The origin of this pattern has been variously explained. Although Brown (1956) does not address this pattern directly, he does suggest that the Loyalty and New Caledonian fauna derive largely from the Australian region. Towns (1974) treats the origin of the New Zealand skink fauna and recognizes four possible dispersal routes: 1) Australia-Tasmania track; 2) Fiji-Tonga-Kermadec track; 3) New Caledonia-Norfolk track; 4) Australia-Lord Howe track. Towns' analysis does not eliminate any of these tracks as a possible dispersal route and, although he seems to favor the two Australian tracks, he also advocates the Fiji-Kermadec track for the *Leiolopisma suteri-lichenigerum* group. Greer (1974) labels the *Leiolopisma* pattern as relictual; he further suggests that the diversity of *Leiolopisma* at the periphery of the major radiation of skinks may result from *Leiolopisma* being at a competitive disadvantage with the more advanced skink genera. However, he also suggests Australia as the source area for the eastward dispersal of *Leiolopisma* into the Southwest Pacific. Hardy (1977) proposes the Sulawesi-New Guinea region as the source area for the ancestral *Leiolopisma* stock which, with multiple invasions, entered Australia and New Caledonia; New Zealand in turn received multiple invasions from these two source areas. Only Hardy's interpretation is based on hypotheses of interspecific relationships and, hence provides rational estimates of vicariance tracks or dispersal pathways. The presumed close relationship of the Australian *L. coventryi* and *L. entrecasteauxii* with the New Zealand *Leiolopisma* species and with the New

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[1] Recently Greer (1979) split Pacific *Leiolopisma* into two genera, the alpha palate *Leiolopisma* and the beta palate *Lampropholis.* Earlier Hardy (1977) divided the New Zealand *Leiolopisma* species into the scaly eyelid *Cyclodina* and the palpebral disc eyelid *Leiolopisma.* Other genera are likely to be recognized in the future, because, even now, the division of "leiolopisma" skinks is uncertain. Greer (1979) does not recognize *Cyclodina* or *Pseudemoia.* My usage of *Leiolopisma,* thus, straddles the recommendations of Hardy and Greer. I anticipate that in the future *alazon* will be re-assigned to a currently unrecognized genus, such as *Oligosoma.*

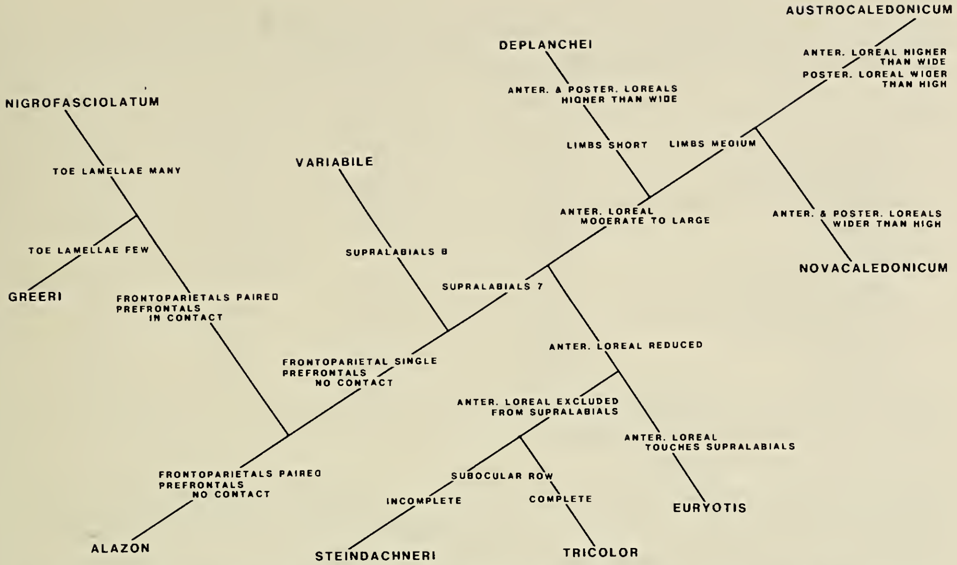

Fig. 3. Taxon and character phenogram of the major species/forms of New Caledonian *Leiolopisma* and *L. alazon*. The resulting clusters of species/forms likely indicate some degree of relationship; however, hypotheses of relationships require the establishment of character state polarities and an analysis of a wider array of morphological characters.

Caledonian *L. nigrofasciolatum* suggested to Hardy that the Southwest Pacific *Leiolopisma* had their initial center of divergence in New Caledonia and one stock reached Australia via the Eastern Australian Current, and another stock reached New Zealand by the tropical cyclone trackway. If dispersal of *Leiolopisma* is aided by oceanic currents and/or cyclonic storms, only the latter seems likely to have placed *Leiolopisma* in the southern Lau group of Fiji, since the general flow of ocean currents is westward and southwestward through the Fijian islands. The storm track would have to have been a highly irregular one to have crossed the New Caledonian and Loyalty region and then traveled 1300 km east-northeast to the Lau islands.

Such an interpretation of the presence of *Leiolopisma alazon* in Ono-i-Lau is highly speculative, but seems more reasonable than an upcurrent dispersal of 1450 km from New Zealand. If this interpretation is correct, the closest relatives of *L. alazon* should be with the New Caledonian species; however, such a relationship is not strongly supported by the evidence (external morphology) currently available to me.

From a strictly phenetic viewpoint, I recognize five species groups of New Caledonian *Leiolopisma* (*nigrofasciolatum, variabile, euryotis, deplanchei,* and *austrocaledonicum* groups; Fig. 3 and Tables 1 and 2). Note that this arrangement is very tentative, since I have not examined representatives of all species and have, of necessity, relied on literature descriptions. The *nigrofasciolatum* group shares with *alazon* paired frontoparietal scales and high numbers of dorsal trunk and midbody scale rows; otherwise, they are very dissimilar owing to the strikingly different body form of a long thin trunk, pointed head, and long slender limbs of

Table 1.—Character matrices for Fijian and New Caledonian *Leiolopisma.* Body measurements and proportions (means). Abbreviations: BL, body length; HbL, hindlimb length; HL, head length.

| Taxon | Minimum adult SVL (mm) | HL/SVL | HbL/SVL | HbL/BL |
|---|---|---|---|---|
| alazon | 45–50 | 0.21 | 0.29 | 0.56 |
| austrocaledonicum | 40 | 0.20 | 0.43 | 0.86 |
| deplanchei | 35 (?) | 0.20 | 0.29 | 0.60 |
| euryotis | 35 (?) | 0.21 | 0.42 | 0.82 |
| greeri* | 60 | ? | ? | ? |
| nigrofasciolatum | 80 | 0.20 | 0.41 | 0.82 |
| novaecaledonicum* | 60 | 0.21 | 0.39 | ? |
| steindachneri | 50 (?) | 0.25 | 0.47 | 1.08 |
| tricolor | 45–50 | 0.22 | 0.44 | 1.01 |
| variabile | 80 | 0.23 | 0.57 | 1.33 |

* Data derived from original description.

*nigrofasciolatum* group members. *Leiolopisma variabile* shows no similarity to *L. alazon*; in fact, *L. variabile* is unlike any other New Caledonian *Leiolopisma. Leiolopisma variabile* shares body size and shape with *L. nigrofasciolatum,* but its meristic characters are strikingly different, particularly such features as the granular-scale patch on the posterior surface of the thigh and the high number of fourth toe lamellae. The *euryotis* group is a monothetic group based on the reduction of the anterior loreal, and as such, *L. alazon* does not belong with this group. It is further excluded from the *euryotis* group by differences in habitus and associated scale characters, e.g., dorsal scale rows and fourth toe lamellae (see Tables 1 and 2). *Leiolopisma deplanchei*[2] and *L. alazon* have little in common aside from body shape and relative limb length. The *austrocaledonicum* group is a diverse complex of species and populations; they share general features such as loreal shape and number of supralabials with *L. alazon,* but differ in many other features including habitus.

Since *Leiolopisma alazon* has no obvious affinities with the New Caledonian *Leiolopisma,* a brief comparison with the New Zealand leiolopismine skinks is appropriate. Considering New Zealand as a "source" area, however, assumes a much more ancient arrival of *Leiolopisma* into the Lau group and a biogeographical explanation based on vicariance rather than long-distance dispersal (Springer 1982). Such an explanation suggests an arrival (in the Fiji area, not the Lau group specifically) time of 20–50 million years ago during the formation of the Melanesian marginal sea (Crook and Belbin 1978). This interpretation would indeed make *Leiolopisma* an old lineage, but this is not discordant with its presumed primitiveness relative to other lygosomine skinks (Greer 1974) or the age of many extant genera of lizards (Estes 1983).

The New Zealand "leiolopisma" skinks possess primitive traits relative to most of their Australian and New Caledonian congeners (Hardy 1977). *Cyclodina* has

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[2] *Leiolopisma deplanchei* Bavay (1869:23) is a small lizard with an elongated cylindrical trunk and short limbs, and it is the *L. deplanchei* referred to herein. *Leiolopisma deplanchei* Bocage (1873:229) is a junior homonym and refers to a large lizard with long limbs; the original description suggests that Bocage's name is a junior synonym of *L. nigrofasciolatum* Peters (1869). Roux (1913:115) similarly identified *deplanchei* Bocage as a synonym of *nigrofasciolatum* Peters.

Table 2.—Head and body scalation. The taxa (given in abbreviated form) are arranged in the same order as the preceding table.

| Characters | ala | aus | dep | eur | gre | nig | nov | ste | tri | var |
|---|---|---|---|---|---|---|---|---|---|---|
| Frontoparietal | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 |
| Prefrontals | | | | | | | | | | |
| Size (S, M, L) | M | S, M | M | M | L | L | L | L | L | L |
| In contact | – | – | – | – | + | + | – | – | – | – |
| Nasals divided | – | + | ± | – | – | – | – | – | + | + |
| Naris central | + | – | + | + | + | – | + | + | + | – |
| Loreals | | | | | | | | | | |
| Anterior | h > w | h > w | h > w | h > w | w > h | w > h | w > h | reduced | | h = w |
| Posterior | w > h | w > h | h > w | h = w | w > h | w > h | w > h | h = w | h = w | w > h |
| Preoculars | 2 | 2 | 2 | 2 | 2 | 1–3 | 2 | 2 | 2 | 2 |
| Subocular row | comp | inc | inc | comp | inc | inc | inc | inc | comp | inc |
| Supraciliaries | 8–9 | 7–8 | 8 | 8 | ? | 9–10 | 8 | 8 | 8–9 | 8 |
| Temporals | | | | | | | | | | |
| Primary | 1 | 1 | 1 | 1 | ? | 2–3 | 1 | 1 | 1 | 1 |
| Secondary | 2 | 2 | 2 | 2 | ? | ≥3 | 2 | 2 | 2 | 2 |
| Supralabials | | | | | | | | | | |
| Modal # | 7 | 7 | 7 | 7 | 8 | 9 | 7 | 7 | 7 | 8 |
| In orbit | V | V | V | V | VI | VII | V | V | V | VI |
| Infralabials | 5–7 | 6–7 | 6 | 6 | ? | 8–10 | 6 | 6 | 6–7 | 6–8 |
| Nuchals | pr | pr | pr | pr | pr | pr | pr | pr | none | pr |
| Dorsal scale rows | 71–75 | 55–61 | 48–49 | 50 | ? | 78–95 | ? | 51–55 | 63–66 | 45–54 |
| Midbody scale rows | 34–37 | 25–33 | 28 | 34 | 35 | 34–39 | 32 | 34–35 | 38–42 | 35–39 |
| Fourth finger lamellae | 12–15 | 15–19 | 13–14 | 18 | ? | 21–25 | ? | 21–22 | 17–20 | 21–25 |
| Fourth toe lamellae | 20–22 | 24–32 | 25–28 | 32 | 23 | 30–35 | 22 | 37–39 | 29–33 | 37–42 |
| Keels on dorsal scales | 0 | 3–4 | 0 | 3 | 0 | 0 | 3–5 | 0 | 3–5 | 3 |
| Preanals enlarged | + | + | – | – | + | – | – | – | – | – |

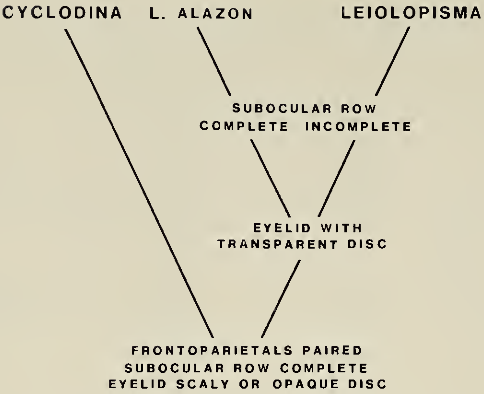

Fig. 4. Phenetic relationships of New Zealand "leiolopisma" and *L. alazon.* Hardy's dendrogram (1979:fig. 2) suggests *Cyclodina* as a derived form owing to chromosome morphology. Pericentric inversion of chromosome pairs 7 and 8 would support the close relationship of *L. alazon* with *Cyclodina.*

a scaly, opaque lower eyelid and paired frontoparietals; two characters assumed to be primitive for "leiolopisma" skinks. Although *L. alazon* does not share the eyelid character, it does have paired frontoparietals. Furthermore, *L. alazon* shares numerous other characters with the species of *Cyclodina*: moderate to large prefrontals, large anterior and posterior loreals, complete subocular row beneath eye, high numbers of dorsal and midbody scale rows, low number of fourth toe lamellae, habitus, and general coloration, particularly orange tinted tails. Overall, *L. alazon* appears to be most similar to *C. whitakeri.* In contrast, *L. alazon* shares fewer features with the New Zealand *Leiolopisma*; the transparent palpebral disc of the lower eyelid is the most noticeable exception. The New Zealand *Leiolopisma* have larger body sizes (>70 mm SVL) and incomplete subocular rows; most tend to have slender bodies and longer limbs. Nonetheless, some species, e.g., *L. lineoocellatum* and *L. suteri* do share similar scale counts and habitus with *L. alazon.* Thus, the data suggest the derivation of *L. alazon* from a New Zealand "leiolopisma" stock (Fig. 4).

The greater similarity of *L. alazon* to the New Zealand *Cyclodina* than to the New Zealand *Leiolopisma* emphasizes the need for a re-evaluation of the relationships of the "leiolopisma" skinks. The diversity of the New Caledonian *Leiolopisma* and the apparent structural divergence of the different species and species groups similarly encourages such a re-evaluation.

## Acknowledgments

The specimens of the new species were collected during a herpetological and ichthyological survey of Fiji sponsored by the Max and Victoria Dreyfus Foundation and the Smithsonian Scholarly Studies Program, with logistic support from the Marine Laboratory of the Fijian Ministry of Agriculture and Fisheries and the School of Natural Resources, The University of the South Pacific. The support from these institutions and associated individuals is much appreciated. I also wish to thank my colleagues on the "Blue Dolphin" for their companionship and cooperation during the Lau voyage, C. A. Ross for his assistance and encouragement in the analysis of the *Leiolopisma,* and W. C. Brown, R. I. Crombie, G. S. Hardy, W. R. Heyer, R. Sadlier, and V. G. Springer for their constructive reviews of the manuscript. Colleagues in other museums have been most helpful in loaning specimens; I wish to thank E. N. Arnold (British Museum (Natural History)), E. J. Censky and C. J. McCoy, Jr. (Carnegie Museum of Natural History), H. K. Voris (Field Museum of Natural History), P. Alberch and J. P. Rosado (Museum of Comparative Zoology, Harvard University), E. R. Brygoo (Muséum National d'Histoire Naturelle), and D. M. Harris and A. G. Kluge (University of Michigan, Museum of Zoology).

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# *HALOPHILA DECIPIENS,* AN UNREPORTED SEAGRASS FROM THE PHILIPPINES

Ernani G. Meñez and Hilconida P. Calumpong

*Abstract.*—*Halophila decipiens* Ostenfeld is reported for the first time from the Philippines. This report and a previous one from the Gulf of Siam represent the only distribution records of the species in the northern Pacific.

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On July 29, 1983 and April 11, 1984, the authors visited an artificial reef site at Sumariling Beach, Siaton, Negros Oriental, Philippines (Fig. 1B) for purposes of collecting seaweeds and seagrasses for systematic study. Among their collections were fertile specimens of an unreported seagrass, *Halophila decipiens* Ostenfeld (Hydrocharitaceae). The discovery of *H. decipiens* in the Philippines is a new distribution record. Additionally, this record and a previous one from the Gulf of Siam represent the only locations in the northern Pacific.

The specimens are cited according to the senior author's field number and are deposited in the U.S. National Herbarium, Smithsonian Institution, Washington, D.C., in the Silliman University Herbarium, Central Philippines, in the Rijksherbarium, Leiden, Netherlands, and in the Philippine National Herbarium.

### *Halophila decipiens* Ostenfeld, Bot. Tidsskr. 24:260. 1902.
Figs. 2, 3

*Description.*—Plants monoecious, pale green, with long, thin rhizomes not more than 1 mm in diameter; internodes 5–40 mm long; usually one long root present below each erect shoot. Erect shoot short, bearing a pair of leaves borne on each node. Leaves petiolate, the petioles triquetrous, 5–10 mm long, enveloped by a pair of transparent, orbicular to ovate-elliptic stipules having only the dorsal surface hairy and the apex emarginate. Leaf blades oblong, oval or elliptic, round at the apex, the base shortly attenuate or cuneate, 6–10 mm wide, up to 22 mm long, the margins minutely serrate; lateral veins 6–9 pairs, a few occasionally forked, the midrib connected to the intramarginal vein at the top; both surfaces of leaf blade beset with minute, unicellular hairs. Spathes arising between a pair of leaves, ovate, obovate, or elliptic, occasionally slightly apiculate, transparent and scarious, up to 7 mm long and 6 mm wide, with an uneven margin, only the dorsal surface densely hairy, enclosing 1 male and 1 female flower. Hooded perianth segments 3, enclosing a long-pedicelled staminate flower up to 3.5 mm long and 0.3 mm in diameter consisting of 3 oblong, sessile anthers, each with a thin membranous cover. Pistillate flower subsessile, with an elliptic to ovoid ovary, up to 2.5 mm long and 1 mm in diameter; hypanthium 2–4 mm long; styles 3, up to 12 mm long. Fruits ovoid to subglobose, 4 mm long and 2.5 mm in diameter, beaked.

*Natural history.*—Specimens of *Halophila decipiens* from the Philippines were collected by SCUBA diving in a bay, 1.5 km from a river outlet, at depths of 11 to 23 meters. During the rainy season, in June to August, the water in the bay

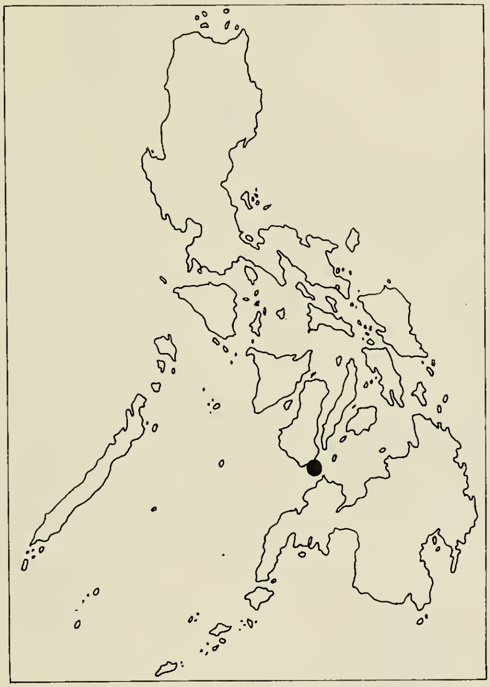

Fig. 1. *Halophila decipiens.* A, World distribution; B, Philippine distribution.

becomes turbid due to agitation of the bottom; otherwise it is clear. The plants grew in soft mud mixed with fine sand. They were observed growing with fertile *Halophila minor* and *H. spinulosa* at 11 meters, but with *H. minor* only at 13, 17, and 20 meters. Pure stands of *H. decipiens* were found at 23 meters depth. The plants thrive in sheltered areas on soft mud, sand-mud, and sandy substrates, usually in deep waters. They have been collected from an estuary in New Caledonia, mangrove-swamps on Guadeloupe and Puerto Rico, at the entrance of a river in Queensland, in a creek at Kingston Harbor in Jamaica, and at reef sites

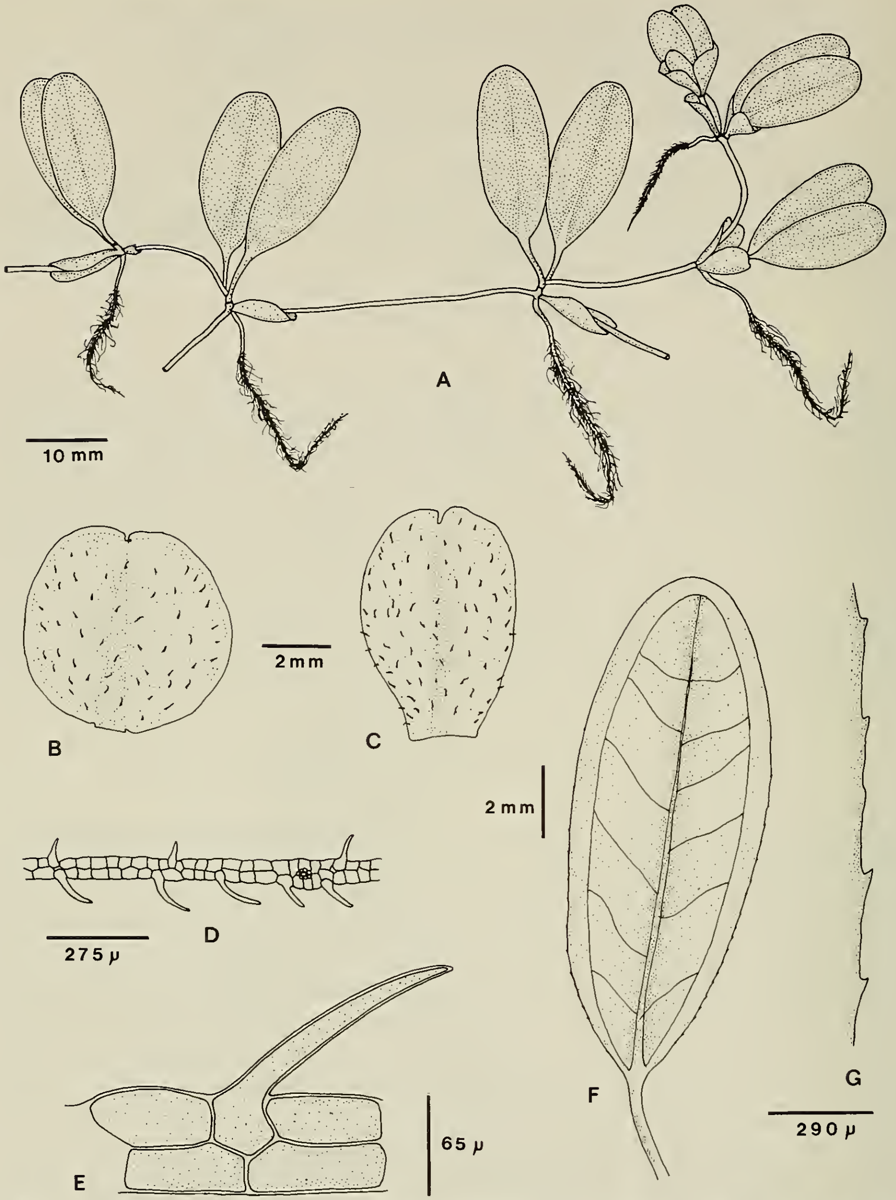

Fig. 2. *Halophila decipiens.* A, Habit of sterile specimen; B–C, Stipules, with hairs on dorsal surface; D, Cross-section of leaf showing hairs on both surfaces; E, Magnified hair on leaf surface; F, Leaf, showing lateral veins and serrate margins; G, Magnified serrate margin of a leaf.

in Queensland and Puerto Rico. Den Hartog (1970) considers *H. decipiens* pantropical.

*Range.*—*Halophila decipiens* occurs in the Seychelles, Cargados Carajos, India, Sri Lanka, Thailand, Indonesia, Queensland, New South Wales, New Caledonia, Tahiti, Jamaica, Puerto Rico, Virgin Islands, Guadeloupe, St. Vincent, Marti-

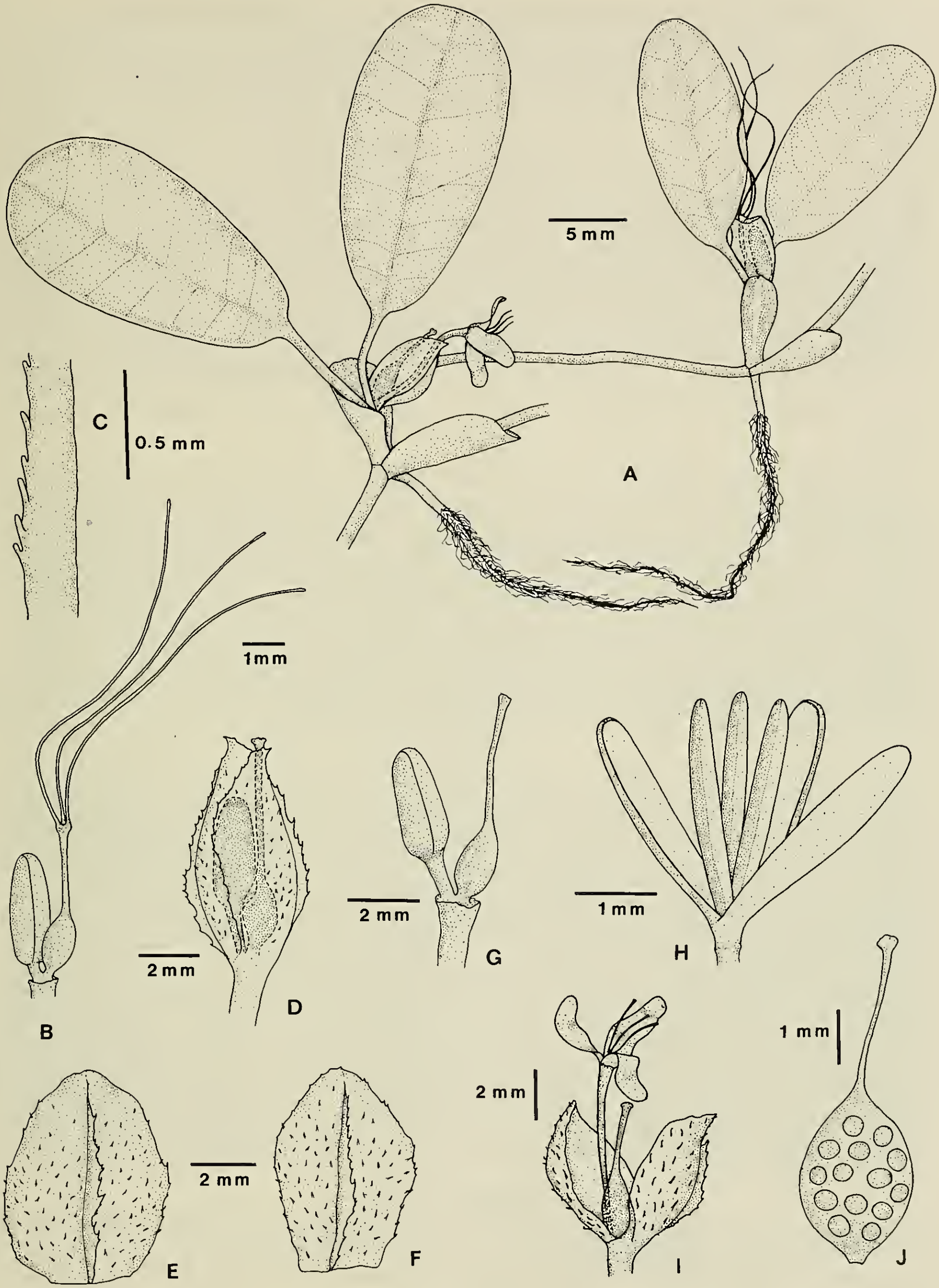

Fig. 3. *Halophila decipiens.* A, Habit of a fertile specimen with male and female flowers; B, Male and female flowers without the spathe; C, Magnified portion of a style with papillae; D, Male and female flowers enclosed by spathe; E–F, Spathes with keels and hairs; G, Mature flowering stage, showing female flower after the styles have fallen off and a male flower; H, Male flower with three anthers enclosed by three perianth segments; I, Spathe enclosing beaked fruit and male flower after anthesis, the latter showing long pedicel, perianth segments and persistent connective tissues; J, Beaked fruit, showing subglobose seeds.

nique, Barbados, Tobago, Trinidad, Curaçao, Venezuela, Colombia, Panama, and Costa Rica. These distribution data are from den Hartog's (1970) publication.

*Remarks.*—There are four species of *Halophila* previously recorded (Meñez, Phillips and Calumpong 1983) from the Philippines. *Halophila ovalis, H. minor,* and *H. decipiens,* which constitute 50% of the known taxa in section *Halophila,* occur in the Philippines. Since these three species are similar in having erect shoots with one pair of leaves, their taxonomic distinctions are based primarily on leaf morphology and whether they are monoecious or dioecious. *Halophila minor,* probably the smallest of the three species, and *H. ovalis,* the largest, are characterized by having entire leaf margins and no hairs on the leaf surfaces. *Halophila decipiens* has serrate leaf margins and hairs on both surfaces of the leaf blade. In addition, the latter has 6–9 pairs of lateral veins; *H. minor* has 4–7, and *H. ovalis* has 12–22. *Halophila decipiens* is monoecious and occurs in deeper waters, while *H. minor* and *H. ovalis* are dioecious and are found in shallower waters.

Due to the great variability in the morphology of taxa in section *Halophila* (i.e., leaf size and shape, plant size, and venation), which is probably influenced by the environment, taxonomic confusion apparently still exists. McMillan and Williams (1980), in their study of isozymes, demonstrated that leaf shape and venation patterns of taxa in section *Halophila* are correlated with their isozyme variations.

*Specimens studied.*—83 EM-1, Sumariling Beach, Siaton, Negros Oriental, Philippines, soft mud mixed with fine sand, silty bottom, 23 m deep, 29 Jul 1983; 84 EM-1, Sumariling Beach, Siaton, Negros Oriental, Philippines, soft mud mixed with fine sand, silty bottom, 11–20 m deep, 11 Apr 1984.

## Acknowledgments

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# REDESCRIPTION OF *HETEROCARPUS LAEVIS* A. MILNE EDWARDS (CRUSTACEA: DECAPODA: PANDALIDAE)

Brian Kensley and William Tobias

*Abstract.*—*Heterocarpus laevis* was figured by A. Milne Edwards in 1883, based on material from Martinique. One other specimen has been recorded from off the Cayman islands. No written description was provided, and the species has not been recorded since. Based on fresh material from St. Croix, U.S. Virgin Islands, the species is figured and redescribed. *Heterocarpus laevis* is unique in this genus, for lacking lateral carapace carinae.

A deepwater shrimp trapping survey was conducted by the second author at selected sites off St. Croix, U.S. Virgin Islands, in August 1982, as part of the Virgin Islands Fishery Development and Demonstration Project.

Twenty-four hour-sets were made with polyethylene traps (Fathoms Plus, San Diego, California), 73 cm wide by 87 cm long by 30 cm high, baited with blue runner (*Caranx crysos*). Trap mesh size was reduced to 1.3 cm with an internal plastic netting. Each set consisted of six traps spaced at 20 m intervals with 5 kg weights before the first and after the last trap.

Several deepwater shrimps and other invertebrate species were obtained from a depth of 460 m in the Salt River Canyon, off the north coast of St. Croix. These specimens were submitted to the first author for identification. Among these were six specimens which proved to be *Heterocarpus laevis.*

In April 1883, Alphonse Milne Edwards published a set of 44 plates of new or rare crustaceans from various sources, including the *Blake,* and *Travailleur* and *Talisman* expeditions. Among these was *Heterocarpus laevis,* taken by the Blake Expedition in 169 fathoms (309 m) off Martinique in the Caribbean Sea. The plate included a lateral view of an entire animal, plus enlarged figures of the first antenna, the antennal scaphocerite, and the shorter pereopod 2. No written description was published. Faxon (1896) recorded a second specimen, taken by the *Blake* Expedition from 297 fathoms (543 m) off Cayman Brac in the Cayman islands. This lack of description and rarity of records prompted the present paper.

## Family Pandalidae

### Genus *Heterocarpus* A. Milne Edwards

### *Heterocarpus laevis* A. Milne Edwards, 1883

Figs. 1–3

*Heterocarpus laevis* A. Milne Edwards, 1883 [unnumbered plate, no. 28 in sequence].—Faxon, 1896:161.—De Man, 1920:109.

*Material.*—Salt River Canyon, St. Croix, U.S. Virgin Islands, 460 m, coll. W. J. Tobias, 19 Aug 1982, sample #004.

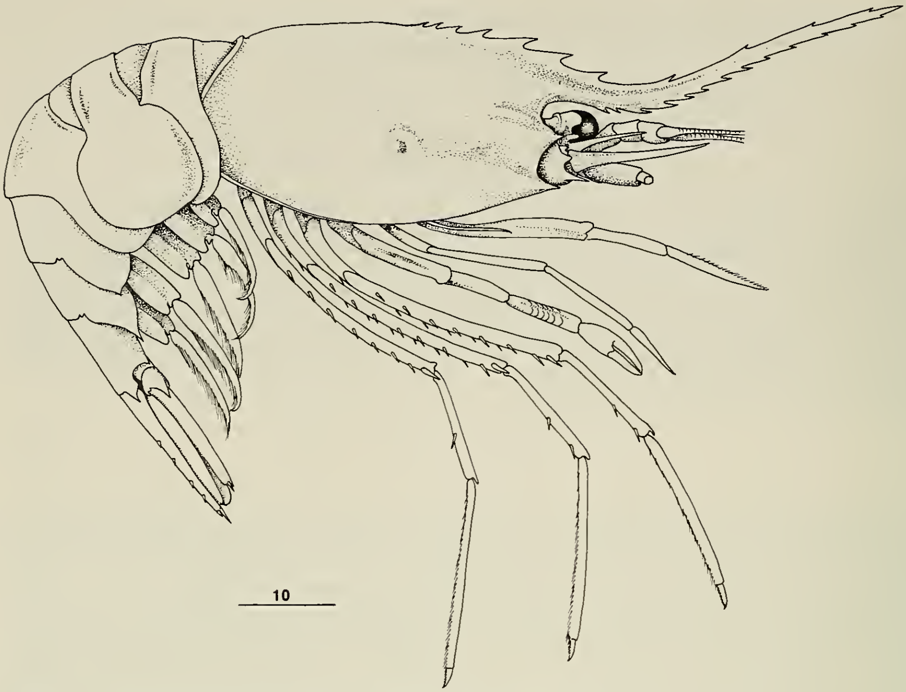

Fig. 1. *Heterocarpus laevis:* Male in lateral view. Scale in mm.

| | Carapace length | Rostral length | Abdominal length | Rostral formula |
|---|---|---|---|---|
| ♂ | 31.4 | 35.9 | 54.5 | 13/13 |
| ♂ | 31.9 | 33.5 | 54.0 | 11/12 |
| ♀ | 29.9 | – | 55.5 | – |
| ♀ | 30.2 | 37.0 | 56.0 | 12/12 |
| ♀ | 30.6 | 38.8 | 55.0 | 13/12 |
| ♀ | 33.3 | 39.9 | 59.9 | 12/13 |

*Description.*—Rostrum ⅕–⅐ longer than carapace, directed oblique-dorsally, with lateral carina in basal ⅓–½, with 12–13 ventral teeth almost reaching apex; with 11–13 dorsal teeth extending almost to apex, including 6 or 7 teeth posterior to orbital margin. Carapace with middorsal carina becoming obsolete in posterior ⅕; strong antennal spine barely overreaching strong branchiostegal spine, both spines with obscure rounded buttress; carapace lacking lateral carinae; rostral base and anterior carapace around antennal and branchiostegal spines finely pubescent, hairs short, almost scale-like.

Abdominal somites 1 and 2 dorsally rounded; somite 3 with middorsal elongate raised area, but not forming true carina; somites 4–6 dorsally rounded. Pleura 1–3 ventrally rounded; pleuron 4 with small posteroventral tooth; pleuron 5 posteroventrally produced into acute spine; somite 6⅗ length of telson.

Telson (Fig. 3b) with broad shallow middorsal groove becoming obsolete pos-

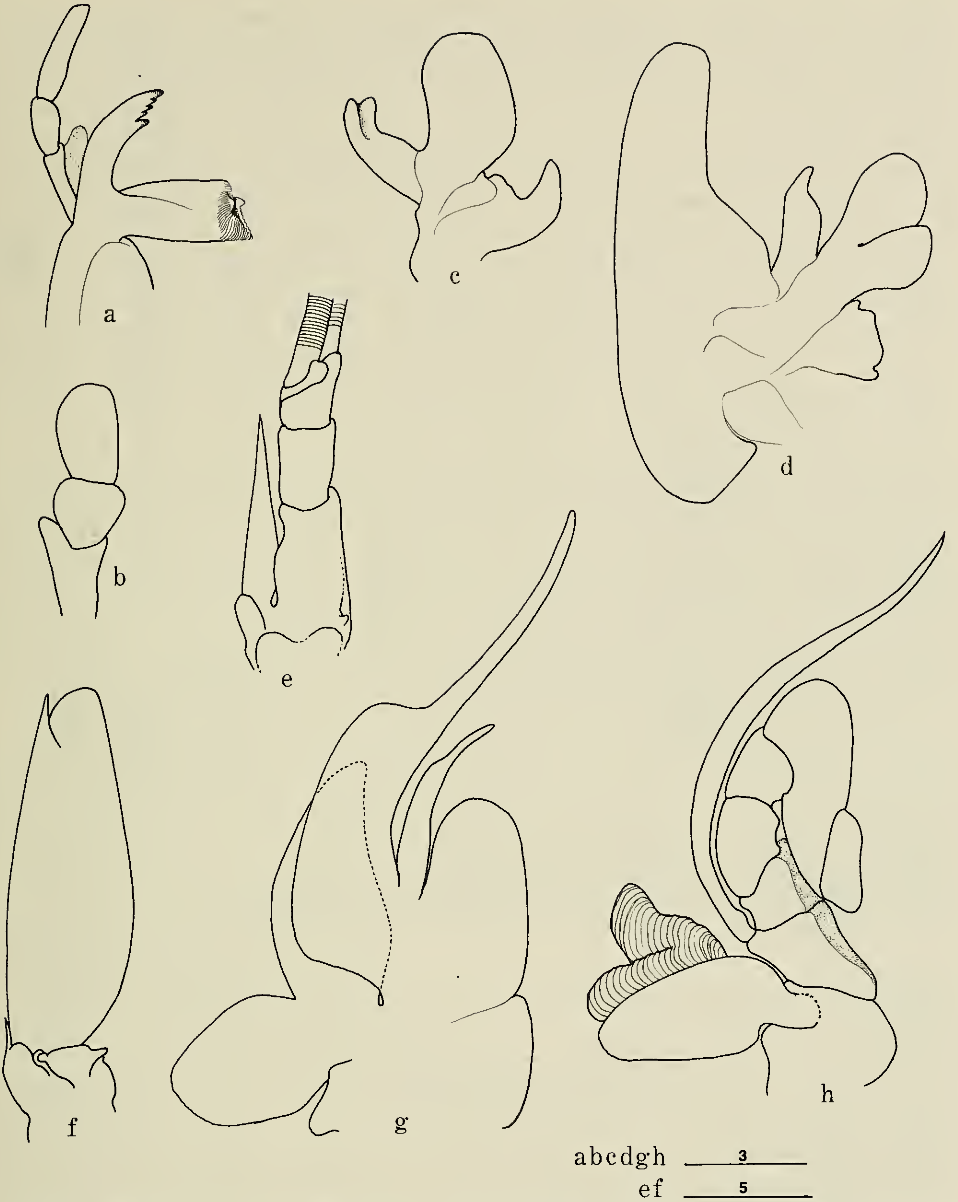

Fig. 2. *Heterocarpus laevis:* a, Mandible; b, Mandibular palp; c, Maxilla 1; d, Maxilla 2; e, Antenna 1 peduncle; f, Antennal scaphocerite; g, Maxilliped 1; h, Maxilliped 2. Scales in mm.

teriorly; 5 pairs dorsal spinules; posterior margin acutely triangular, with 2 pairs elongate spines internal to last of dorsal spinules.

Eyes with spherical cornea much broader than stalk; ocellus lacking. Antenna 1, (Fig. 2e) stylocerite elongate-slender, reaching at least to midlength of external margin of 3rd peduncle article. Antenna 2, scaphocerite blade (Fig. 2f) just overreaching distolateral spine; distal margin broadly rounded. Mouthparts as figured.

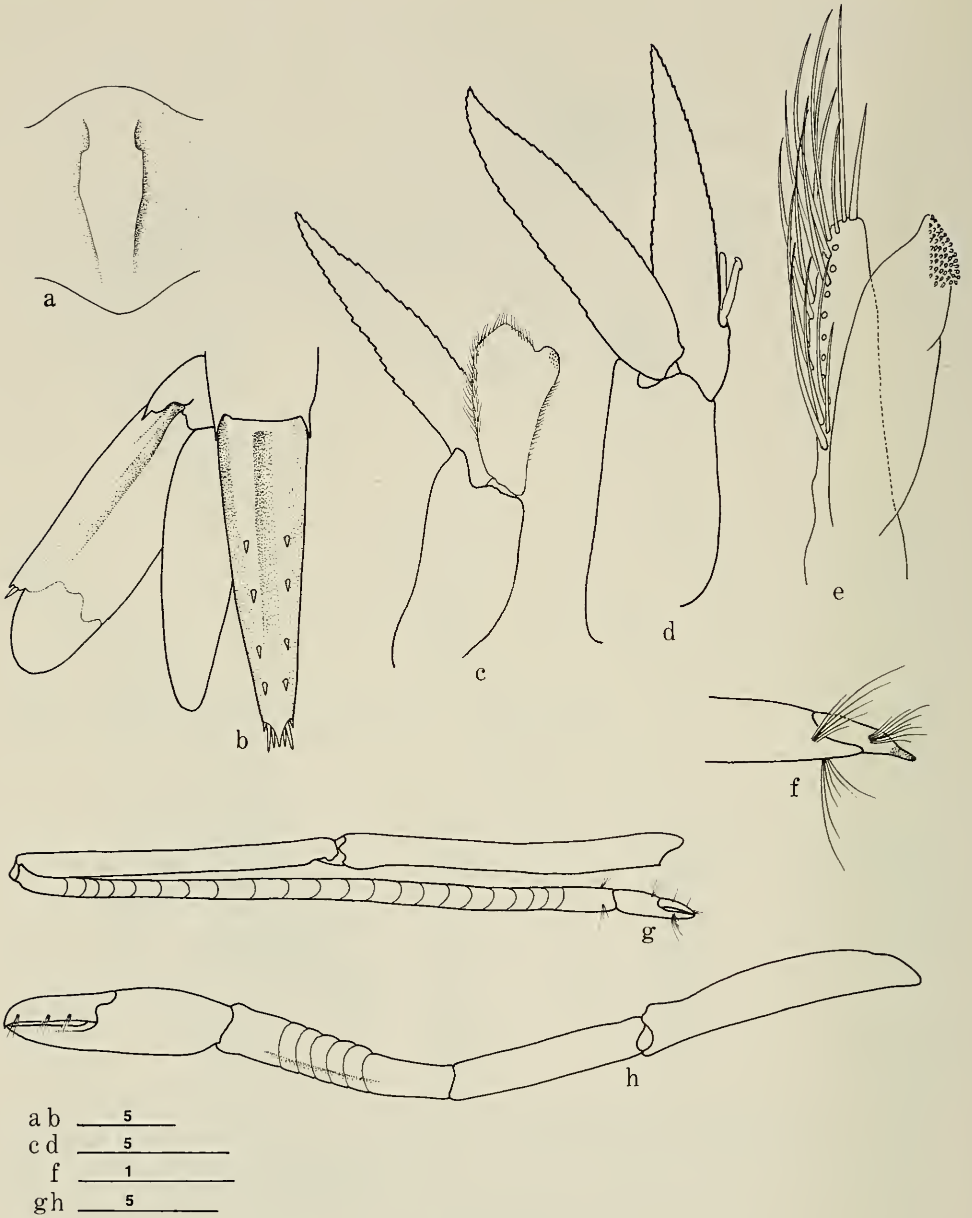

Fig. 3. *Heterocarpus laevis:* a, Abdominal somite 3 in dorsal view; b, Telson and left uropod; c, Male, pleopod 1; d, Male, pleopod 2; e, Appendix masculina and appendix interna, further enlarged; f, Chela of pereopod 1; g, Longer pereopod 2; h, Shorter pereopod 2. Scales in mm.

Mandibular palp, (Fig. 2a, b) basal article lobed at inner distal angle; 2nd article broad, about ⅔ length of 3rd article. Maxilliped 2, (Fig. 2h) terminal article of endopod twice wider than long, set obliquely on penultimate article. Maxilliped 3 overreaching scaphocerite by half of terminal article; latter armed with rows of short spines, tipped with small corneous spine.

Pereopods 1–4 with strap-shaped epipods. Pereopod 1 reaching just beyond scaphocerite; dactylus (Fig. 3f) less than 1 mm in length, set obliquely on propodal apex, with single apical spine; propodus basally broader than distally, with rows of setae on proximomesial surface, ⅔ length of carpus; latter only slightly shorter than merus; ischium with row of 8 or 9 short spines on posterodistal margin. Pereopod 2, shorter leg reaching distal ⅔ of scaphocerite; chela subequal to carpus in length, fingers with entire cutting edges, subequal to palm in length; carpus of 6 or 7 articles, proximal and distal articles longer than intervening 4 or 5 subequal articles; ischium with carinate posterior margin; longer leg overreaching scaphocerite by chela and distal ⅓ of carpus; latter of 20–23 articles, subequal in length to merus and ischium together. Pereopod 3 extending beyond scaphocerite by length of dactylus and propodus; dactylus ⅐ length of propodus, with 5 spines on posterior margin; propodus bearing short scattered spines on posterior surface; carpus with strong spine near laterodistal margin, another just distal to midlength, 14–16 short irregularly spaced spines on mesial and posterior surfaces; merus with 8 or 9 large lateral spines, 7 large mesial spines; ischium with 2 spines on posterior surface. Pereopod 4 overreaching scaphocerite by dactylus and ⅚ of propodus; dactylus ⅛ length of propodus; carpus with 1 or 2 strong posterolateral spines, several small scattered spines on posteromesial surface; merus with 8 spines on lateral surface, 7 on mesial surface; ischium with 2 spines on posterior surface. Pereopod 5 overreaching scaphocerite by dactylus and ⅗ of propodus; dactylus ⅑ length of propodus; carpus with single lateral spine at about midlength; merus with 8 posterolateral spines, and single mediodistal spine; ischium unarmed.

Pleopod 1 in male, (Fig. 3c) endopod about ½ length of exopod, distally broadened, with low mesial lobe bearing hooks; distal and lateral margins setose. Pleopod 2 (Fig. 3d) in male, appendix interna and appendix masculina subequal in length; appendix interna with distal triangular area bearing hooks; appendix masculina bearing about 25 spines of varying lengths on distal and lateral margins. Outer ramus of uropod (Fig. 3b) with groove on outer surface proximally well defined, becoming obsolete distally; distolateral fixed spine at distal ¾; both rami just falling short of telsonic apex.

*Remarks.*—Several differences between Milne Edwards' figure (1883) and the Virgin Islands material are noted:

The stylocerite is shorter in the original figure, than in the present material; no spines are shown on the merus of pereopod 5; the uropodal rami overreach the telsonic apex by a short distance; the scaphocerite is shown as being parallel-sided for most of its length. In spite of these differences, the overall closeness in the general form, and the agreement in the number of articles in the carpi of the second pereopods, make the identity of the present material unmistakable.

*Heterocarpus laevis* is unusual in being the only species in the genus lacking lateral carapace carinae.

The present material was captured along with several specimens of *Plesionika edwardsii* and *Plesionika* sp.

## Acknowledgments

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# *LUCAYARINA CATACUMBA*, NEW GENUS, NEW SPECIES, A BAHAMIAN SEA-CAVE AMPHIPOD (CRUSTACEA: AMPHIPODA: LYSIANASSIDAE)

Janice Clark and J. L. Barnard

*Abstract.*—A new genus of lysianassid amphipod, analogue of the Indo-Pacific *Glycerina*, is described from 2 sea-caves (blue holes) in the Bahamas Islands. *Lucayarina* differs from*Glycerina* in having article 2 of pereopods 5–7 indentured (in contrast to pereopod 5 only in *Glycerina*), the short article 3 and absence of dactylar shroud on gnathopod 1.

## Legend

Capital letters denote main parts in following list; lower case letters to left of capital letters or in body of figure indicate modifications as per following list; lower case letters to right of capital letters indicate specimens described in captions: A, peduncle; B, body; C, coxa; D, dactyl; E, male duct; G, gnathopod; H, head; I, inner plate or ramus; J, prebuccal; K, male pores sternite 7; L, labium; M, mandible; N, pereon; O, outer plate or ramus; P, pereopod; R, uropod; S, maxilliped; T, telson; V, palp; W, pleon; X, maxilla; Y, gill; Z, pleopod; a, aberrant; f, flat; l, left; o, opposite; r, right; s, setae removed.

## Family Lysianassidae

### *Lucayarina*, new genus

*Type-species.*—*Lucayarina catacumba*, new species.

*Diagnosis.*—Head deeper than long, rostrum short, ocular lobe produced and gently rounded, lower antennal sinus weak. Eyes bilateral.

Antenna 1 slender, rather long; first article of peduncle slightly inflated, lacking tooth, longer than 2 and 3 combined; first flagellar article elongate, in female half, in male as long as article 1 of peduncle, with dense cover of aesthetascs in transverse rows on lateral surface; calceoli absent in material at hand. Accessory flagellum well developed, with 5 or 6 articles, article 1 as long as 2 and 3 combined. Antenna 2 with article 4 slightly longer than 5, flagellum shorter than peduncle.

Epistome slightly concave, distinctly separated from evenly rounded upper lip.

Mandible with rakers but no lacinia mobilis on either side, incisor with only one weak inner hump, remaining edge straight and smooth; molar prominent, slightly rounded, triturative, lacking major seta; palp moderately strong, attached very slightly proximal to base of molar, article 1 short, article 2 setose distally, article 3 shorter than 2, weakly falciform, with D and E setae.

Lower lip with simple, broadly rounded outer lobes, inner lobes absent.

Maxilla 1 with well developed inner plate bearing 1–2 major apical setae; outer plate with oblique apical margin bearing 11 denticulated spines weakly divided into 3 sets of 5, 5, plus 1 weakly discontiguous medial subapical spine; palp 2-articulate, almost reaching apex of outer plate, article 2 with 4 spine-teeth and several midapical serrations. Maxilla 2 with inner plate slightly shorter, more pointed and much narrower than outer plate, apical armaments stout, inner plate with setae on apicomedial margin.

Maxillipeds with inner plate subrectangular, bearing 3 short apical spines and plumose setae apically, with plumose setae medially; outer plate squamiform, with 2 rows of spines ventrally, inner marginal row being shorter and truncated (with ragged, possibly worn ends); palp 4-articulate, article 2 reaching to apex of outer plate, dactyl long, unguiform, with outer long and inner short setules, short apical nail barely distinct.

Coxae 2–4 of same length, coxa 1 shorter and weakly bent forward; coxa 4 with ordinary posterior excavation and strong ventral lobe. Oostegites and gills on legs 2–6; brood plates of female slender, with setae apically (generally setae rudimentary). Gills saclike, not pleated, with much smaller auxiliary lobe attached proximally.

Gnathopods ordinary; gnathopod 1 simple, subequal in length to gnathopod 2, article 3 short, article 5 slightly shorter than 6, hand spinose, dactyl ordinary, not shrouded in setae; gnathopod 2 minutely chelate (or parachelate). Pereopods 3–4 article 6 with short spines posteriorly, locking spines large. Article 2 of pereopods 5–7 deeply serrate posteriorly; no pereopods prehensile.

Pleopods normal, peduncles poorly setose, with rami of subequal length; peduncle with 2 mediodistal denticulate coupling-hooks. Epimeron 3 dominant, only epimeron 2 ventroapical corner somewhat sharply produced.

Uropods 1 and 2 well developed, styliform, no ramus with special notch; uropod 3 biramous, peduncle box-like, both rami broadly lanceolate and shorter than peduncle, outer ramus 2-articulate, inner ramus shorter than outer. Telson slightly longer than broad, deeply cleft.

*Description.*—Antennal article 3 with lateral-distal row of spines. All coxae moderately setose. Only gill 6 subordinate (crenulation distally).

*Relationship.*—This genus closely resembles *Glycerina* Haswell, 1882, (=*Glycera* Haswell, 1879) which has two known species, the type-species *G. tenuicornis* (Haswell, 1879), (? = *G. affinis* Chilton, 1885, said to be *Amaryllis macrophthalmus* by Stebbing, 1910), and *G. teretis* Andres, 1981. Another taxon, *Lysianassa woodmasoni* Giles, 1890, was made a synonym of *G. tenuicornis* by Pirlot (1936). If this composition is accepted, *G. tenuicornis* would have a distribution from southeastern Australia to India and Indonesia in 0–141 m; (*G. affinis* occurs southeastern Australia in shallow water), and *G. teretis* from the Red Sea in 1869 m. One must note that no modern record of *Glycerina* from India has been published and *Glycerina* from Australia has never been properly described, and therefore identifications in Indonesia and India are suspect. Despite this, the known characters of *Glycerina* are adequate to distinguish our new genus.

*Lucayarina* differs from *Glycerina* in the short article 3 and the absence of the inner dactylar setal shroud on gnathopod 1 and the deep tooth-like serrations of article 2 on pereopods 6–7; these teeth are present in *Glycerina* only on pereopod 5. If we can take Pirlot's (1936) and Andres' (1981) accounts as typically descriptive of *Glycerina* (note that the Australian specimens have not been described properly) then *Lucayarina* also differs from *Glycerina* in the unpleated gills, the lack of special notch on the inner ramus of uropod 2, the strongly setose article 2 of the mandibular palp, the thinner outer plate of the maxilliped, the contiguous and apical placement of the spines on the outer plate of maxilla 1, and the absence of a tooth on article 1 of antenna 1. Dr. Andres believes the short article 3 of gnathopod 1 prevents any close affinity to be ascribed between *Glycerina* and *Lucayrina*: Dr. Lowry notes the different kind of spines present on the outer plate of maxilla 1 compared with *Glycerina*, differences in the mandibular molar, and strong differences in the setal shroud of gnathopod 1.

J. L. Barnard (1969) did not notice the weak similarity of *Glycerina* to the scopelocheirid genera typified by *Scopelocheirus* Bate, although he did note this for a similar genus *Ichnopus* Costa. Scopelocheirids are typified by a shroud of propodal and/or dactylar setae hiding the dactyl of gnathopod 1; in *Ichnopus* and *Glycerina* these setae are weakly developed on the posterior margin of the dactyl. In *Lucayarina* these setae are absent or very weakly represented (no more so than in non-scopelocheirid members of Lysianassidae). *Ichnopus* and *Glycerina* closely resemble each other in this character but *Lucayarina* lacks these setae. We leave the problem of the significance of this character and its higher taxonomic value to our colleagues now studying the internal divisions of Lysianassidae. *Lucayarina* otherwise differs from *Ichnopus* in the unpleated gills, the presence of deep teeth on article 2 of pereopods 5–7 (although the serrations of *Ichnopus pelagicus* Schellenberg, 1926, are said to be slightly enlarged), in the lack of a tooth on article 1 of antenna 1, the contiguous and apically placed spines on the outer plate of maxilla 1, the presence of rakers on both left and right mandibles (which needs study in *Ichnopus*), and the non-attenuate, non-hooked apex of the mandibular palp. Dr. Andres believes that the dense medial setation on the inner plate of maxilla 1 prevents any close relationship to be ascribed between *Lucayarina* and, for example, *Scopelocheirus*.

*Lucayarina* differs from *Aroui* Chevreux (1911) in the presence of pereopodal teeth, the poorly setose inner plate of maxilla 1, the non-paddle-shaped plates of maxilla 2, and the unpleated gills. Dr. Andres believes the slightly elongate article 3 on gnathopod 1 and the presence of a lacinia mobilis in *Aroui* prevent any affinity being ascribed between *Aroui* and *Lucayarina*.

*Lucayarina* differs from *Menigratopsis* Dahl (see Just 1976 for careful redescription) in the toothed pereopods, the absence of left lacinia mobilis, the well armed article 6 of pereopods 3–7, with locking spines, and the diverse extension of plates on maxilla 2; characters also noted by Drs. Andres and Lowry include the triturative molar, lack of calceoli, lack of accessory lobes on gills, and armament differences on palp of maxilla 1 and outer plate of maxilliped.

*Etymology.*—Word combination of Lucaya from the main tribe of Arawak Indians inhabiting the Bahamas before being exported and extirpated; and part of *Glycerina*; feminine.

### *Lucayarina catacumba*, new species
Figs. 1–5

*Description of female "a" 4.35 mm.*—Head about 60% as long as wide, rostrum about 20% as long as remainder of head; ocular lobes mammilliform; eyes long, oval, capsule absent, pigment absent in alcohol.

Antenna 1 as long as antenna 2; second and third articles short, article 3 with 8 medium and 1 long aesthetascs, primary flagellum slender, longer than peduncle, with 11 articles, article 1 almost 1.4 times as long as article 3 of peduncle, formula

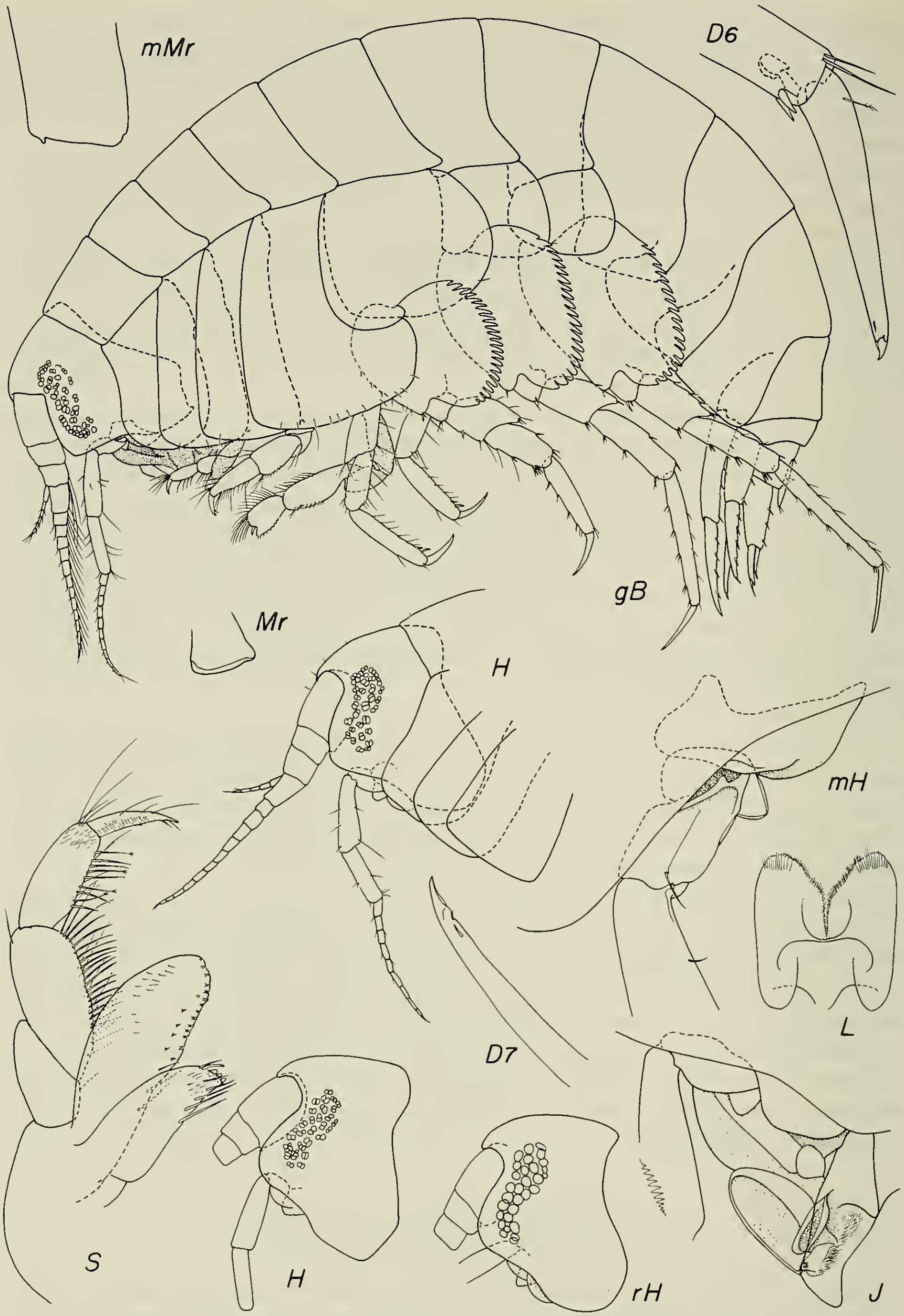

Fig. 1. *Lucayarina catacumba,* unattributed figures = female "a"; g = female "g"; m = male "m"; r = female "r."

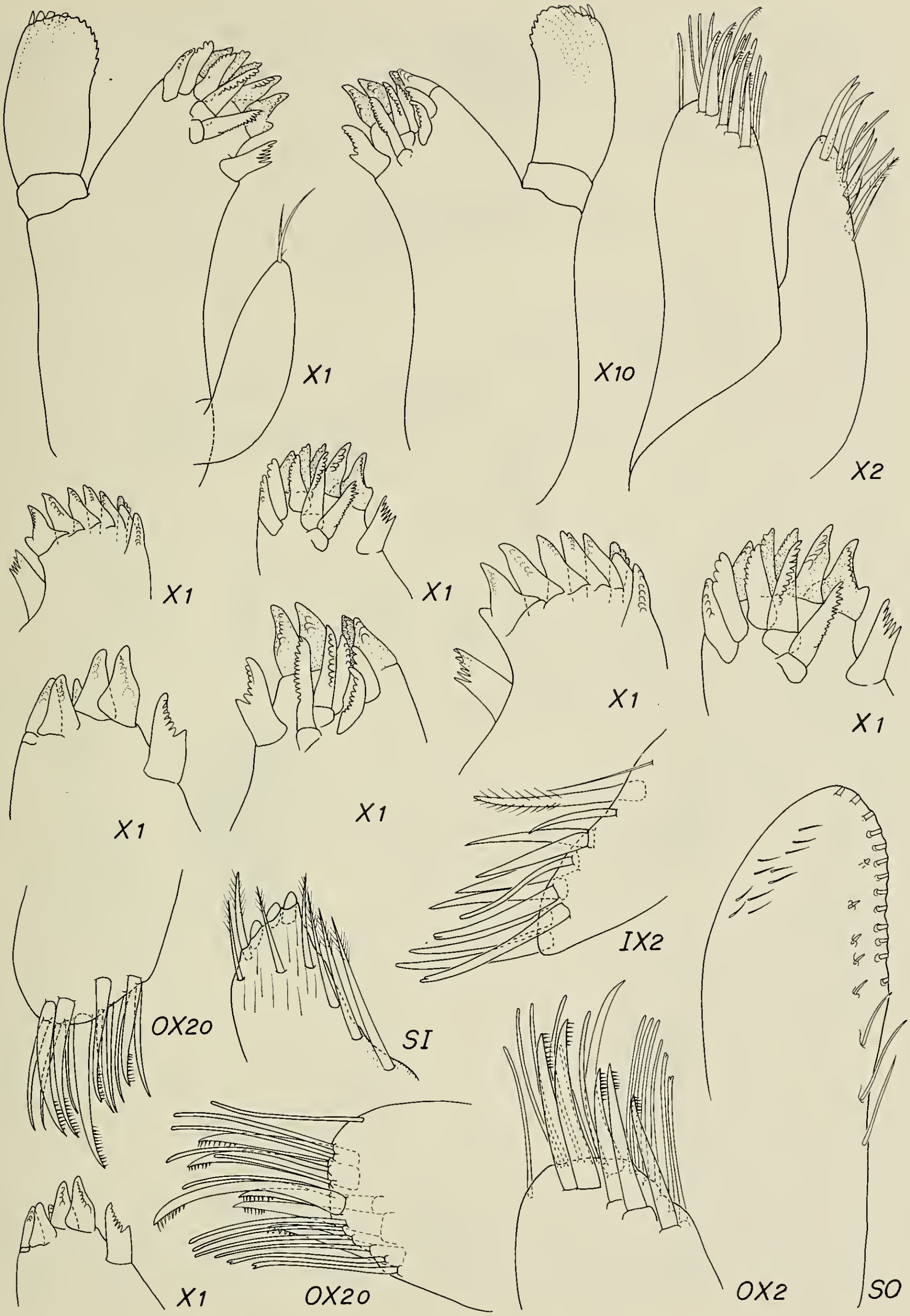

Fig. 2. *Lucayarina catacumba,* all figures = female "a." Views of outer plate of maxilla 1 based on both sides of appendage from various aspects.

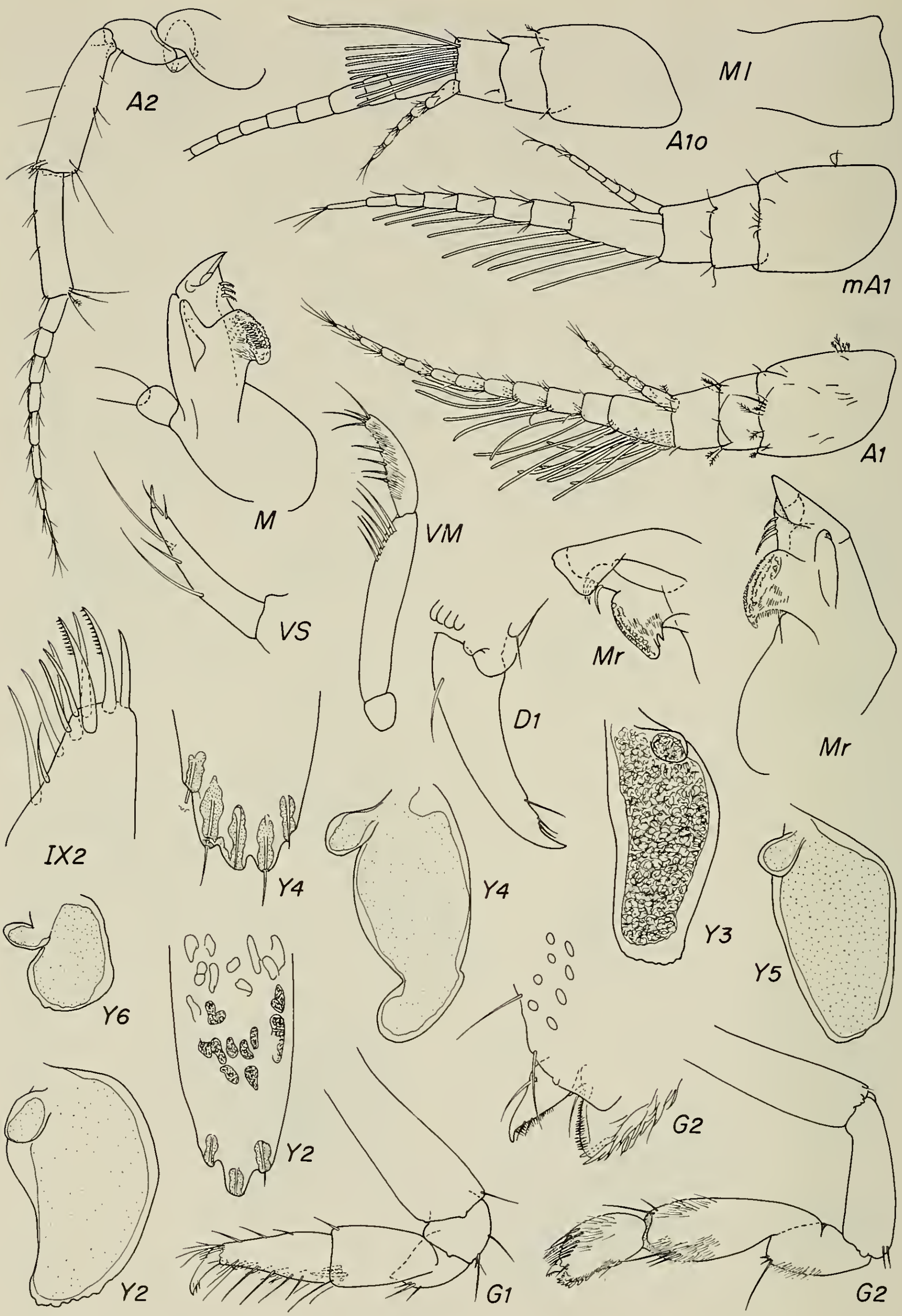

Fig. 3. *Lucayarina catacumba,* unattributed figures = female "a"; m = male "m."

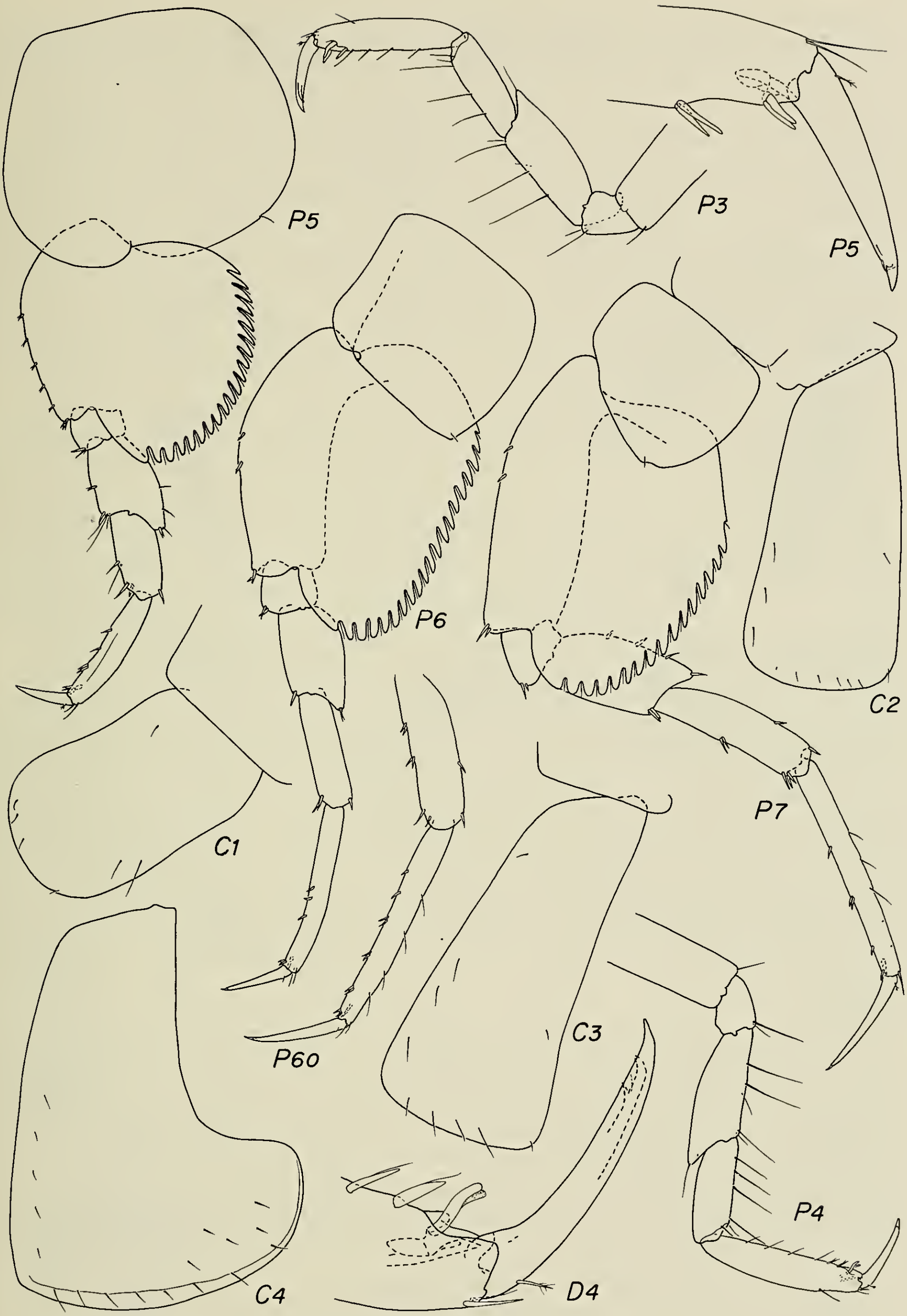

Fig. 4. *Lucayarina catacumba,* all figures = female "a."

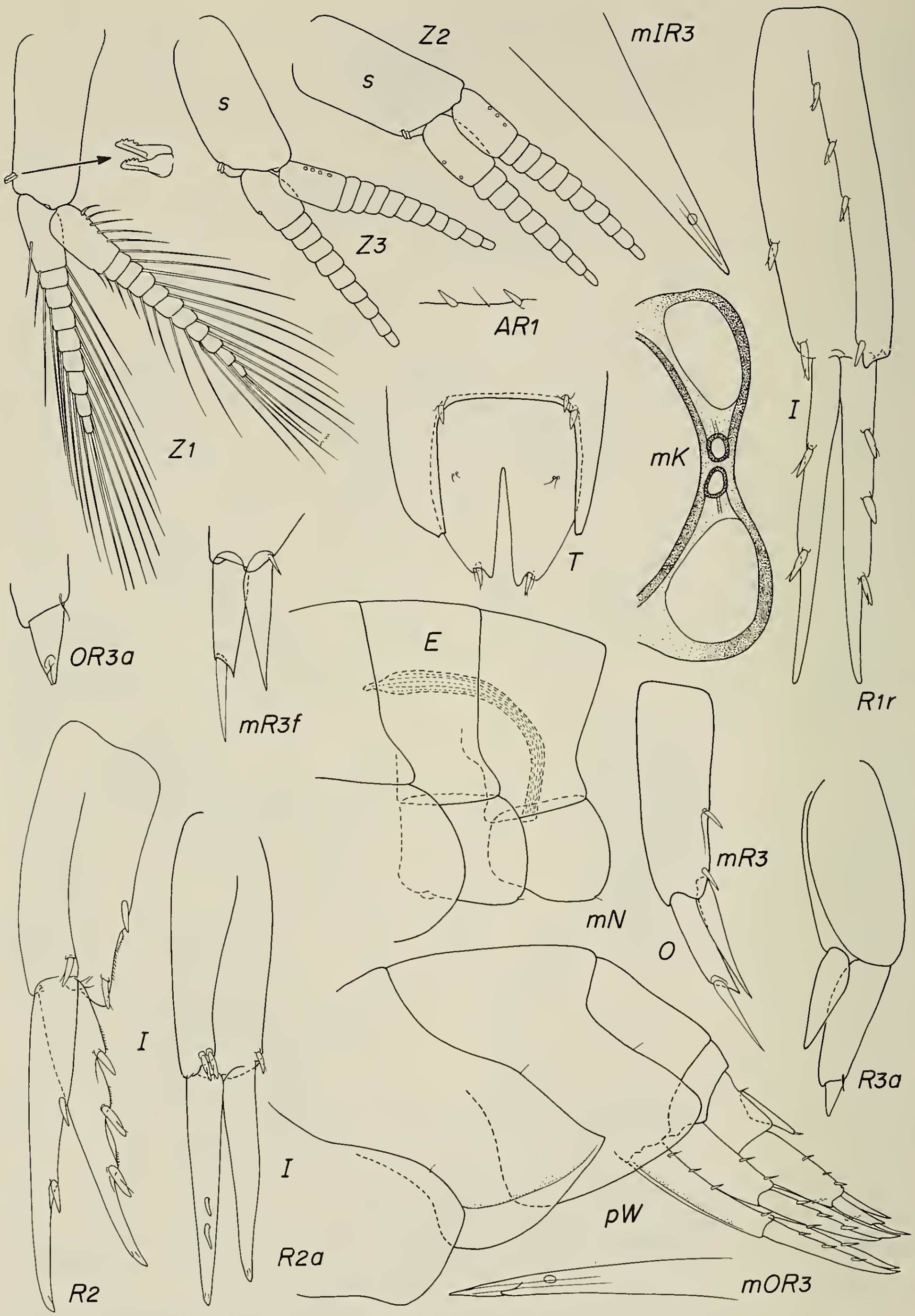

Fig. 5. *Lucayarina catacumba,* unattributed figures = female "a"; m = male "m"; p = female "p."

of long aesthetascs = 9-2-2-2-1-0-0-0-0-0-0, some aesthetascs on article 1 emerging from telescoped part, accessory flagellum 5-articulate. Article 3 of antenna 2 with 3 ventral setules; flagellum with 8–9 articles (left and right respectively).

Upper lip and epistome both protuberant and separated by line of articulation.

Mandible with raker row composed of 3 strongly curved spines; incisor with protrusion on lateral corner and notch on medial corner; palp article 2 moderately thin with mediodistal row of 6 setae; article 3 much shorter than 2, distally tapering, with comblike row of 4 D setae on medial edge and 4 apical E setae. Inner plate of maxilla 1 moderately long, thin, apex rounded with 2 apical setae and one setule; outer plate with 11 apical spines, 5 set facially and 1 offset medially; article 1 of palp ¼ length of article 2, palp broad, long, apex of article 2 with 4 lateral spine teeth and 8 medial cusps. Inner plate of maxilla 2 thinner and shorter than outer, with 3 thick medial setae, 3 thin medial setae, 3 apical setae (2 plain, 1 toothed) and 1 facial toothed seta (R = 4 medial setae and one facial bifid seta). Maxilliped with inner plate reaching just beyond middle of outer plate, with 3 short stout apical spines; outer plate with row of short blunt spines on medial margin, plus ventrofacial row of short pointed spines and 3 basomedial longer setae; lateral face with series of 'ghost' setae (2 uneven rows = 11 setae), palp article 2 longer than others, article 3 with facial pubescence towards apex, dactyl digitiform, ¾ as long as article 3, faintly curved, with stout nail inserted apically and with 3 long outer and 2 short inner accessory setae.

Coxae 2–4 extending subequally; coxa 1 quadrate, ventral margin with 3 setules, one setule set in notch at apicoventral corner, 2 (right side = 1) posterior facial setae and one facial seta toward anterodorsal corner; coxa 2 rectangular, expanding distalwards, anterior facial margin with 3 setae (right with 2), ventrally with 6 setae, one seta set in notch at apicoventral corner, one seta set facially at posterior margin; coxa 3 similar to 2, but apicoventral corner produced, 3 (right side = 2) anterior margin setae set facially, 4 along ventral margin, one setule set in notch at apicoventral corner, one posterior facial marginal seta, one setule set facially in anterodorsal corner; coxa 4 produced posterodistally, excavation above lobe large, anterior margin with 5 (R = 4) facial setae, ventral with 8, 5 facial setae scattered on produced posteroventral lobe. Oostegites with rudimentary apical setae.

Gnathopod 1 article 6 tapering distally, with short spines and medium setae on posterior margin; dactyl with 3 subapical setules; gnathopod 2 stouter than 1, article 5 nearly twice as long as 6, subquadrate, almost twice as long as broad. Pereopods 3 and 4 article 2 slender, as long as 3, 4 and 5 combined; article 4 shorter than 6, distally wider than 5, with anterodistal apex greatly produced; dactyl strong, curved, with weak nail and 2 setules; locking spines weakly S-shaped. Pereopod 5 shorter than 6 and 7; pereopod 6 slightly smaller than 7; article 2 produced posterodistally; article 4 broader than 5; article 6 longer than 3 and 4 combined.

Each epimeron with one setule on posterior edge. Each pleopod with pair of locking spines, articles of outer and inner rami on pleopods 1–3 = 11 and 9, 11 and 9, 11 and 10, basal setal formulas on rami (running from lateral to medial on each ramus) = 6-2-1-2, 4-1-1-3, 5-1-1-2.

Urosomite 3 with winglike plaque surrounding base of telson on each side, with 1 or 2 small spines at the corners of joint between telson and urosomite. Uropod

1 rami of equal length and as long as outer ramus of uropod 2; rami slightly shorter than peduncle, outer with 3, inner with 2 marginal spines. Uropod 2 rami of subequal length, both longer than peduncle, outer with 3, inner with 2 marginal spines; [left uropod 2 aberrant, see Fig. 5]. Uropod 3 (aberrant in female "a," see Fig. 5, following description from normal female) peduncle with 2–3 spines, rami lanceolate, outer ramus not as long as peduncle, article 2 spiniform, about 70% as long as article 1, medioapical corner of article 1 sharply produced; inner ramus slightly exceeding apex of article 1 of outer ramus; only armament of rami formed by one seta at medial base of inner ramus.

Telson with slightly convex lateral margins, tapering towards notched apices, each lobe bearing short terminal spine and setule set in notch, and pair of dorsal penicillate setules near midlateral margins.

Male "m"—3.87 mm. (Figs. 1, 3, 5): Antenna 1 flagellum with 8 articles, accessory flagellum with 6; formula of aesthetascs = (5 groups), 2,2,2,2,0,0,0. Uropod 3 peduncle with 2 dorsal spines (right with 3); pereonite 7 with 2 sternal pores and conspicuous duct running from base of coxa 7 through body to pereonite 5.

Female "r" 3.71 mm (Andros): Description based only on differences from holotype; parentheses show comparison to holotype when item is more, otherwise all statements concern "fewer": Unlike holotype, eyes with ommatidia (facets) mostly solid, not divided, inner ends not atrophied nor vermiform.

Antenna 1 article 3 with 7 medium and 1 long aesthetascs; primary flagellum with 9 articles; formula of long aesthetascs = 8-2-2-2-2-2-1-1-0-1-0 (more than holotype). Antenna 2 article 4 with 1 dorsal seta, article 5 with 1 ventral seta (more than holotype); flagellum on both right and left sides with 8 articles (similar to holotype).

Mandible palp article 2 with mediodistal row of 5 setae; article 3 with comblike row of 3 D setae on medial edge.

Maxilliped outer plate ventrofacial row with 4 short, pointed spines and 2 basomedial longer setae; lateral face with 14 "ghost" setae.

Coxa 2 lacking facial seta toward anterodorsal corner; coxa 3 with 3 setae along ventral margin and no facial setae on posterior margin or anterodorsal corner; coxa 4 with 3 facial setae on anterior margin and 2 facial setae on posteroventral lobe.

Gnathopod 1 article 6 with 2 anterior setae. Pereopod 3 articles 4 and 5 posterior margins each with 1 long seta; pereopod 4 articles 4 and 5 posterior margins each with 2 long setae; article 6 anterior margin naked, posterior margin with 3 medium setae and 1 short spine; pereopod 5 article 4 anterior margin naked; pereopod 6 article 6 posterior margin with 2 setae, anterior margin with 3 pairs of short spines and a single proximal spine.

Articles of outer and inner rami on pleopods 1–3 = 10 and 9, 9 and 8, 9 and 8.

Uropod 2 peduncle with 3 dorsomedial spines (more than holotype).

Holotype female "n" 3.90 mm.—Uropods 1–3 normal.

Female "p" 4.0 mm (Fig. 5). Epimera 2 and 3 with single setule on posterior edge.

*Remarks.*—The Andros material thus appears to differ only slightly from the Grand Bahama material in the eyes and variations in spines and setae.

*Holotype.*—USNM 195132, female "n" 3.90 mm.

*Type-locality.*—Grand Bahama Island, Cemetery Cave (a blue hole offshore 30+ m), 25 Oct 1982, 15 m depth, "red amphipods," on lobster carcass, coll. Thomas M. Iliffe and Dennis Williams.

*Other material.*—Type-locality, female "a" 4.35 mm (main illustrations), female "g" 5.37 mm (whole mount), male "m" 3.87 mm (illustrated), female "p" 4.0 mm (illustrated), female "q" 4.12 mm, male "s" 3.84 mm, female "t" 3.12 mm, and 250 other specimens, no apparent terminal males present; Andros Island, British Blue Holes Expedition, 1981–82, blue hole no. 31, from lobster carcass 100 m horizontal locus, depth of 15 m, Dr. George F. Warner, University of Reading, England, female "r" 3.71 mm (compared fully to holotype, head illustrated), and 30 other specimens.

*Etymology.*—Catacumba from the Latin for "underground burial gallery" or "ad catacumbas" "at the canyon" "at which one of the longest catacombs is situated"; feminine.

*Distribution.*—Sea caves in the Bahamas Islands.

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We thank the collectors of the material and especially Jill Yager, of Grand Bahama Island, who sent us the Cemetary Cave material and Dr. Thomas M. Iliffe, of Bermuda Biological Station, for information about the localities. Dr. J. K. Lowry of the Australian Museum, Dr. Jean Just of the Zoological Museum, University of Copenhagen, and Dr. H. G. Andres of Hamburg University kindly offered comments on the manuscript. Linda B. Lutz of Mobile, Alabama, inked our drawings and prepared the plates for publication. We thank Patricia Bell Crowe for laboratory assistance.

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# NEW SPECIES OF ISOPODA FROM THE FLORIDA MIDDLEGROUNDS (CRUSTACEA: PERACARIDA)

Allan Hooker

*Abstract.*—Six new species of isopods, five asellotes and one anthurid, are described from the Florida Middlegrounds in the northeastern Gulf of Mexico. One is described as a new genus, viz. *Mexicope kensleyi.* The other five species described are: *Pleurocope floridensis, Munnogonium wilsoni, Janira biunguicula, Gnathostenetrioides pugio,* and *Mesanthura hopkinsi.* The specimens were all collected from artificial habitats of mostly man-made materials.

Isopod crustaceans may be an important part of the macro-epifauna and macroinfauna of various marine habitats. The state of our knowledge of these links in the food-web of the macro- and megafauna of the western Atlantic, Caribbean, and Gulf of Mexico waters is generally limited to faunal checklists and inventories which usually deal with specific localities, e.g., Menzies and Frankenberg 1966, Hudson *et al.* 1970, Rouse 1970. There are also several regional reports and monographic accounts. Of these, the most comprehensive is that from Puerto Rico (Menzies and Glynn 1968).

As part of a survey of the biota of the Florida Middlegrounds, members of the Dauphin Island Sea Lab participated in an inventory of the area's epibenthic fauna between June 1978 and January 1981. A large majority of the diminutive asellote isopods of this study were collected in artificial habitats placed on and retrieved from a hermatypic coral reef at a depth of approximately 30 meters. Habitat placement and retrieval was accomplished by means of SCUBA. The anthurid species was found in vacuum samples collected by the submersible research vessel *Diaphus.*

The six new isopods are described and illustrated. Where practical, artificial dichotomous keys are presented.

## Materials and Methods

All the specimens of this study were collected from the Florida Middlegrounds at 28°35′N, 84°16′W (see Fig. 1). A component of the West Florida shelf, 150 Km south of the north Florida coast and 160 km northwest of Tampa Bay, the Middlegrounds are influenced by the Caribbean-derived Loop Current, Florida Bay waters, and the West Florida Estuarine Gyre (Austin and Jones 1974). The area is characterised by coral reefs, projecting discontinuously from the bottom, not exceeding depths of 55 m (Jordan 1952). An abundant invertebrate community is supported by the area's reefs (Hopkins *et al.* 1977) among which are this study's isopods.

Nearly all the new species were obtained from artificial habitat cryptofaunal samples; however, selected sponges (especially *Agelas dispar*) and corals (especially *Madracis decactis*) played host to several of the collected specimens. *Agelas dispar* was found to host up to ten species of isopods, while *Madracis decactis* up to 14

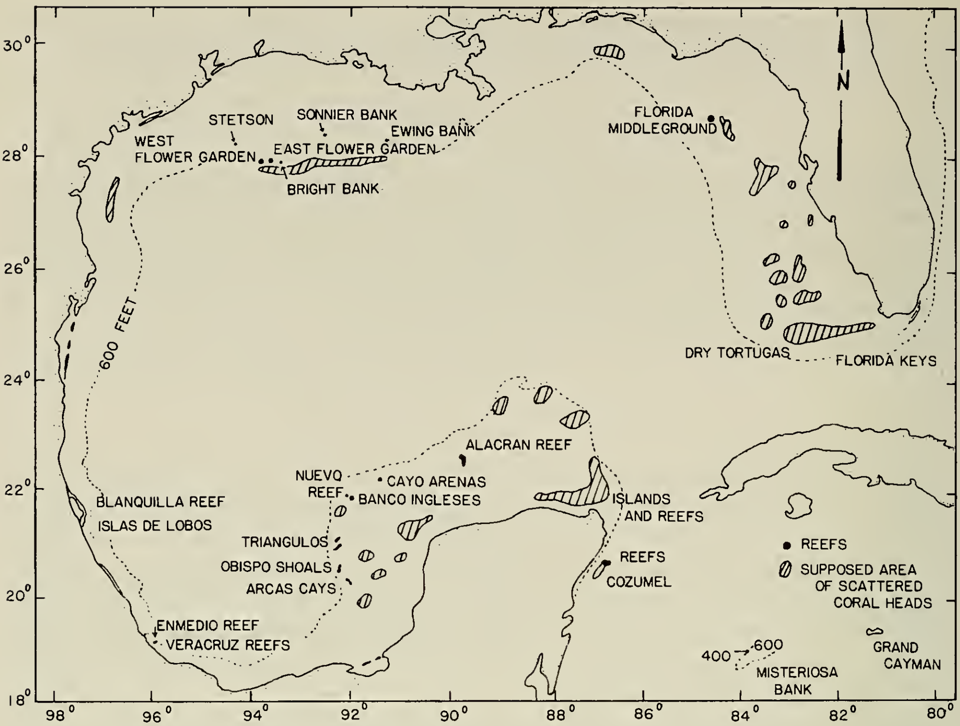

Fig. 1. The Gulf of Mexico, showing the Florida Middlegrounds and other known reef locations (after Bright and Pequegnat 1974).

species (see Table 1). The unexpectedly large numbers of specimens found in the artificial habitats may be due to the extra effort expended in picking and sorting as against the same effort involved in picking and sorting naturally occurring samples.

Attempting to maximize internal heterogeneity, artificial habitats contained predetermined quantities of PVC tubing of two diameters, oyster shell, plastic straws, trawl netting, plastic swizzle sticks, fibreglass insulation, and plastic meshed "scrubbies," enclosed in vinyl-clad hardware cloth (1 cm × 1 cm mesh), structurally strengthened externally by a plastic milk case. Figure 2 is a cross-sectional view of such an artificial habitat.

Habitats were placed on the reef's rubble, and anchored by railroad iron sections. Habitat retrieval occurred at regular intervals corresponding to scientific cruises to the Middlegrounds. Retrieval consisted of enclosing the habitats in cloth bags, floating them to the surface by means of lift bags, and surface recovery. Both habitat placement and retrieval were accomplished by means of SCUBA.

On retrieval, intact individual habitats were fixed in 10% formalin, and transported to the laboratory. All the habitat substrates were rinsed over a 0.5 mm mesh sieve, the resulting animals and rubble stored in 70% anhydrous alcohol. The reef rubble found in nearly all the habitats was probably a result of habitat settling and storm-induced disturbance. No attempt was made to determine which of the internal microhabitat substrates was favored by the asellotes. The single

Table 1.—Distinguishing characters of Pleurocopidae, *Mexicope,* Abyssianiridae, *Janira,* and *J. biunguiculus.* Explanation of abbreviations: a, absent; am, ambulatory; b, biramous; c, covered; dil, dilated; e, expanded; ep, exposed; l, lacking; m, modified; n, non-expanded; nr, normal; ns, non-stalked; p, present; ps, parallel-sided; s, stalked; sag, sagittate; su, subchelate; u, uniramous; v, varied; ?, unknown or uncertain.

| | *Mexicope* (unassigned) | *Pleurocope* (Pleurocopidae) | *Prethura* (Pleurocopidae) | *Santia* (Pleurocopidae) | Kuphomunna (Pleurocopidae) | *Abyssianira* (Abyssianiridae) | *Janira* (Janiridae) | *Janira biunguiculus* |
|---|---|---|---|---|---|---|---|---|
| Ant. I peduncular segments | 2 | 2 | 2 | 1,2,3 | 2 | 4(?) | 3,4 | 1 |
| Ant. I flagellar articles | 7 | 4 | 3 | 3,4,5 | 3 | 2(?) | v | 5 |
| Ant. I aesthetascs | p | p,l | l | 1–3 | 1 | ? | 0,2(?) | 2 |
| Ant. II peduncular segments | 6 | 6 | 6 | v | 5 | ? | 6 | ? |
| Ant. II flagellar articles | 13 | 6,7 | 8 | v | 15 | ? | v | ? |
| Ant. II aesthetascs | 0 | 1 | 0 | 0 | 0 | ? | 0 | ? |
| Ant. II peduncular scale | p | l | l | l | l | l | p | p |
| Length of Ant. I vs Ant. II | II>I | I>II | II>I | II>I | II>I | ? | II>I | ?(II>I) |
| Maxillipedal palp seg. 1–3 | n | n | n | n | n | e | e | e |
| Maxilla I | b | u | b | b | b | b | b | b |
| Mandibular palp | l | l | l | p,l | l | p | p | p |
| Molar process | m | m | nr | nr | nr | nr | nr | nr |
| Eyes | p | p | p | p | p | a | p | p |
| Eye location | s | s | s | s | s | – | ns | ns |
| Uropods | b | b | m | b,u | b | b | b | b |
| Pereopod I | am | su | su | su | su | su | am,su | am |
| Claws on Prp. II–VII | 2 | 1 | 2 | 2 | 2 | 2 | 3,2(?) | 2 |
| Epimera (dorsally) | 1–7 | 2–3,5–6 | 0 | 0 | 5–7 | 1–7 | 1–7,2–7 | 1–7 |
| Pleonal segments | 2 | 1,2 | 2 | 1,2 | 1 | 2 | 2 | 2 |
| Male Plp. I distally | ps | ps | ps | ps | dil | sag | v | ps |
| Male Plp. II | nr | nr | e | nr | nr | nr | nr | nr |
| Anus | c | ep | ? | ep | ep | c | ? | ep |

species of anthurid was found in bottom vacuum samples provided by a minisubmersible research vessel.

## Systematics

### Infraorder Asellota

### Family Pleurocopidae

### *Pleurocope floridensis,* new species

Figs. 3, 4

*Description.*—Body broad, ovate, nearly twice longer than wide; broadest at pereonites 3 and 4. Dorsum covered with numerous minute tubercles. Cephalon about 1½ times wider than long, widest at eyestalk origin. Eyestalks projecting laterally nearly to spine of second pereonite, with 3 light-brown ommatidia; preocular lobes absent. Frontal margin slightly convex. Coxal plates dorsally visible on pereonites 2–3 and 4–7. Pereonites 2–4 subequal in length; slightly longer than subequal pereonites 1, 5–7; pereonites 5–7 narrower than preceding segments; coxal plates of pereonites 2, 3, 5 and 6 each with single lateral spine, tipped with 2 elongate simple setae. Pleotelson twice longer than broad, slightly raised at uropodal insertion, posteriorly tapering, elongate; 2 spines on each ventrolateral

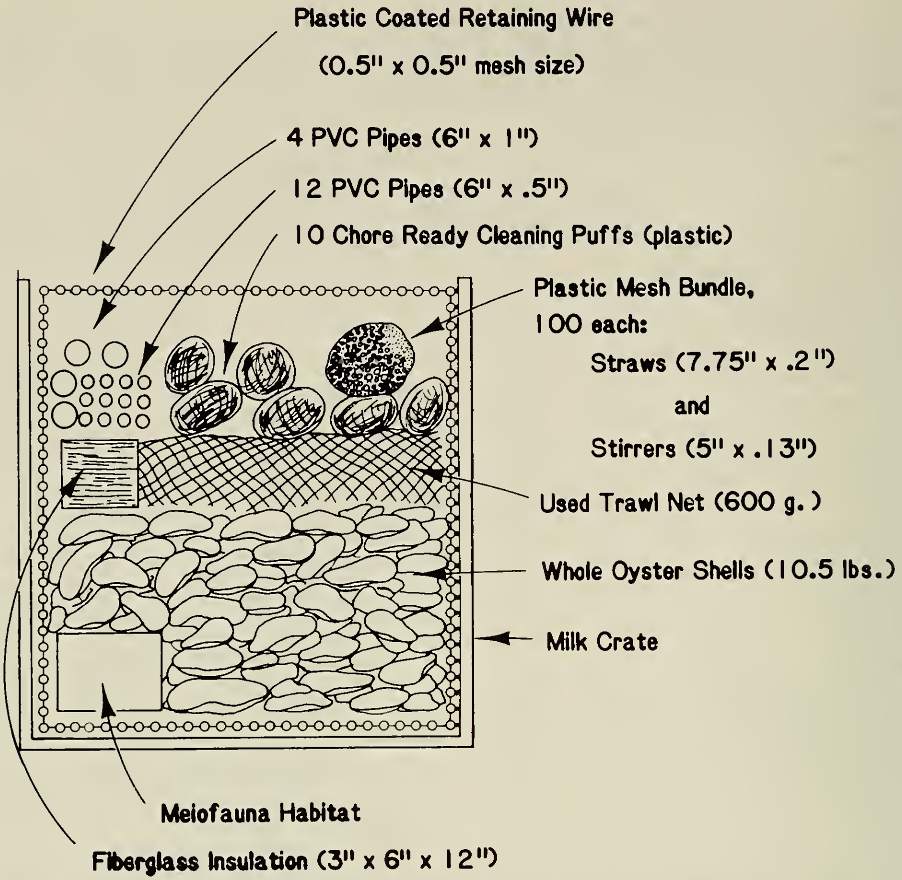

Fig. 2. Schematic cross-sectional view of artificial habitat utilized in the Florida Middlegrounds.

margin; 10–12 elongate articulate setae arising from each distal ventrolateral margin, several extending beyond pleotelsonic apex. No anterior pleonite visible.

Antennular peduncle 2-segmented, first segment slightly longer than second; flagellum of 4 articles, third longest, bearing 2 terminal aesthetascs; fourth article with 1 aesthetasc and elongate seta. Antenna reaching to midpoint of antennular flagellum, with 6-segmented peduncle, third segment strongly produced mesially, forming lobe tipped with row of 5 robust setae; fifth and sixth segments subequal in length, together equal to previous 4 segments together; flagellum half length of peduncle, of 6 articles, terminal article bearing 2 setae and 1 apical aesthetasc.

Mandible lacking palp; rudimentary lacinia mobilis on left mandible; molar process highly modified, conical, directed distally, incisor also modified, an elongate extension with several clefts.

Inner lobe of maxilla 1 rudimentary; outer lobe with 8 or 9 spines. Maxilla 2 biramous, inner ramus supporting 4 terminal setae; both lobes of outer ramus tipped with 2 setae. Maxilliped with narrow 5-segmented palp; epipodite distally rounded; broad endite with 2 coupling hooks, and setules fringing entire concave distal margin.

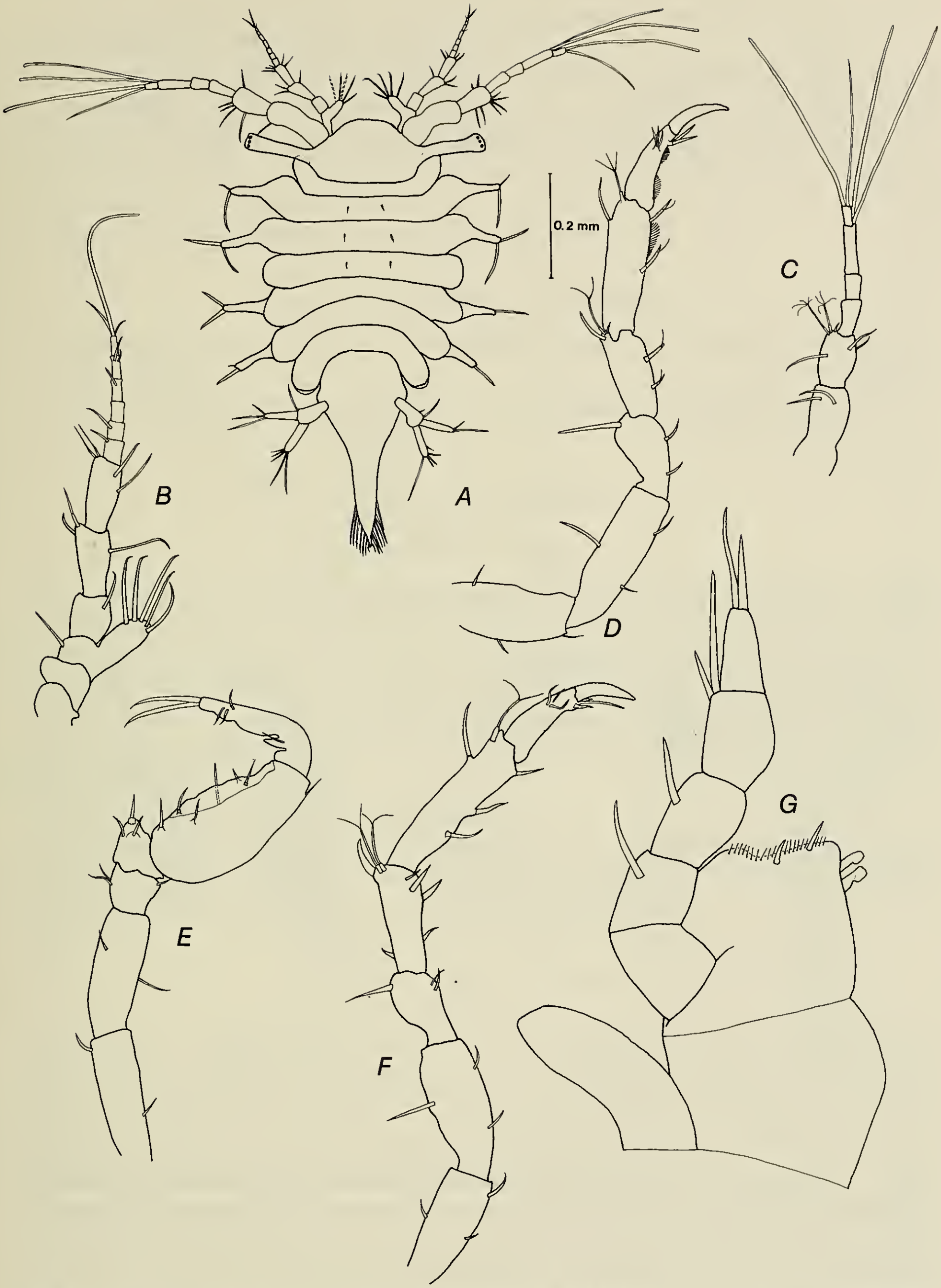

Fig. 3. *Pleurocope floridensis*: A, Holotype ♂, dorsal view; B, Antenna 2; C, Antenna 1; D, Pereopod 2; E, Pereopod 1; F, Pereopod 7; G, Maxilliped.

Pereopod 1 prehensile, dactyl with 2 elongate spines distally and lanceolate process on proximal inner margin; propod nearly oval; merus and carpus shortest segments, subequal in length. Dactyl of pereopod 2 with single claw, bearing setules on penultimate and ultimate articles.

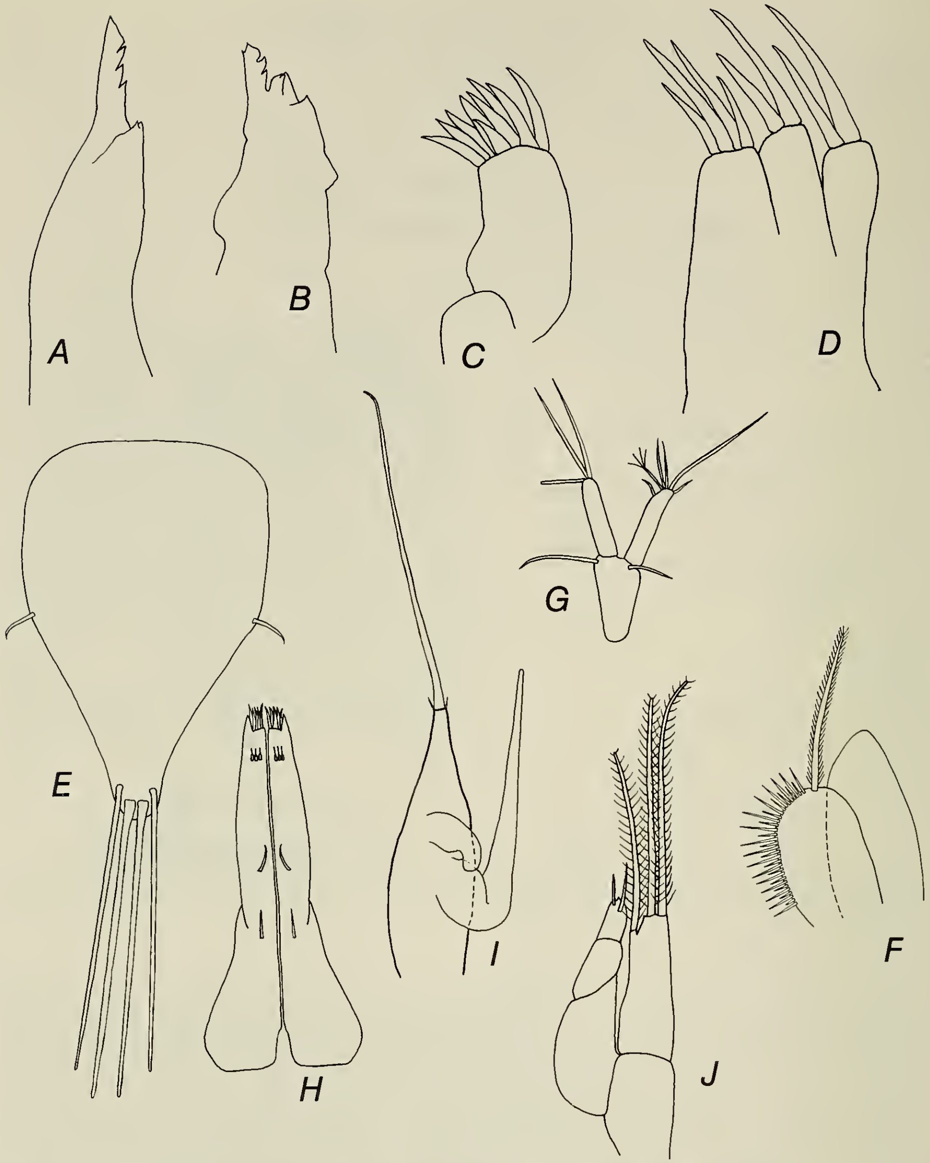

Fig. 4. *Pleurocope floridensis*: A, Right mandible; B, Left mandible; C, Maxilla 1; D, Maxilla 2; E, Operculum ♀; F, Pleopods 4 and 5 ♂; G, Uropod; H, Pleopod 1 ♂; I, Pleopod 2 ♂; J, Pleopod 3 ♂.

Uropods pedunculate, inserted dorsolaterally; peduncle expanded distally; lengths of peduncle, exopod, and endopod subequal. Rami of pleopod 1 fused proximally, elongate, widest proximally, with single spine on outer distal margin, apex bearing several setae. Pleopod 2 with long, slender endopod; exopod tapering distally, tipped with elongate spine. Endopod of pleopod 3 slightly longer than exopod, bearing 2 simple setae apically; outer branch tipped with 3 plumose setae.

Female: Body broader than male. Sexual dimorphism not apparent in gnathopod. Brood pouch of 3 pairs of oostegites.

*Material.*—Holotype male TL 1.15 mm, United States National Museum, catalog number 184943. Allotype female TL 0.96 mm, USNM 184944. Paratypes deposited in Dauphin Island Sea Lab Museum, catalog number 6183-1507.

*Etymology.*—The specific epithet *floridensis* refers to the locality where the asellote was collected.

*Remarks.*—See Remarks section for *Mexicope kensleyi.*

## Key to the Species of *Pleurocope*

1. Dorsum with long setae; pleon of two segments; uropodal rami longer than peduncle .......... *P. dasyura*
– Dorsum without long setae; pleon of one segment; uropodal peduncle as long as rami .......... *floridensis*

## Family Incertae Sedis

### *Mexicope,* n. gen.

*Diagnosis.*—Eyes present; frontal margin of head straight; antennulae normal; scale present on antennal peduncle. Pleon 2-segmented, second segment as wide as long, with lateral serrations. Epimera spiniform, present on pereonites 1–7. Mandibular palp lacking; molar process conical, setiferous; maxillipedal palp 5-segmented, all segments subequally wide. Pereopod 1 ambulatory; all pereopodal dactyli biunguiculate. Uropoda elongate, biramous. Male pleopod 1 distally bilobed, both lobes setiferous.

*Type-species.—Mexicope kensleyi,* n. sp.

*Etmyology.*—The generic epithet *Mexicope* is a combination of the prefix *Mexi-*, indicating the Gulf of Mexico, and the suffix *-cope* derived from Pleurocopidae, the family to which *Mexicope* shows most similarities.

### *Mexicope kensleyi,* new species
Figs. 5, 6

*Description.*—Female: Body nearly 3 times longer than wide, widest at pereonites 3 and 4. Head extending laterally, as wide as epimera of pereonite 1; preocular spines present; eyes dorsal, black, borne on small lobes. Pereonites 1–7 with spiniform coxae; coxae of pereonites 2–7 with recurved setae. Pleon with simple setae laterally and fringed setae apically; pleonite 1 free.

Antennule extending to proximal end of antennal peduncle segment 6; distal segment of 2-jointed peduncle with several plumose setae; flagellum of 7 articles, article 5–7 each with single terminal aesthetasc. Antenna heavily setose; peduncle 6-segmented, third segment with seta-bearing squama, fifth segment slightly longer than preceding 4 segments together; flagellum slightly longer than peduncle, first article longest, remaining 12 articles subequally long, together about twice length of first article.

Mandible lacking palp, with conical setiferous molar process; left mandible with quadridentate lacinia, quadridentate incisor molar process, row of 1 simple and 6 dentate spines. Maxilla 1 inner ramus short, outer ramus with 11 spines. Maxilla

Fig. 5. *Mexicope kensleyi*: A, Holotype ♀, dorsal view; B, Left mandible; C, Right mandible; D, Antenna 1; E, Maxilla 1; F, Maxilliped; G, Maxilla 2; H, Antenna 2; I, Pereopod 1; J, Pereopod 2; K, Pereopod 7.

2, inner ramus supporting 4 spines distally, inner lobe of outer ramus with 2 dentate spines and 2 fringed setae terminally, outer lobe with 4 fringed setae.

Maxilliped with 5-segmented palp, segments subequally wide, terminal segment

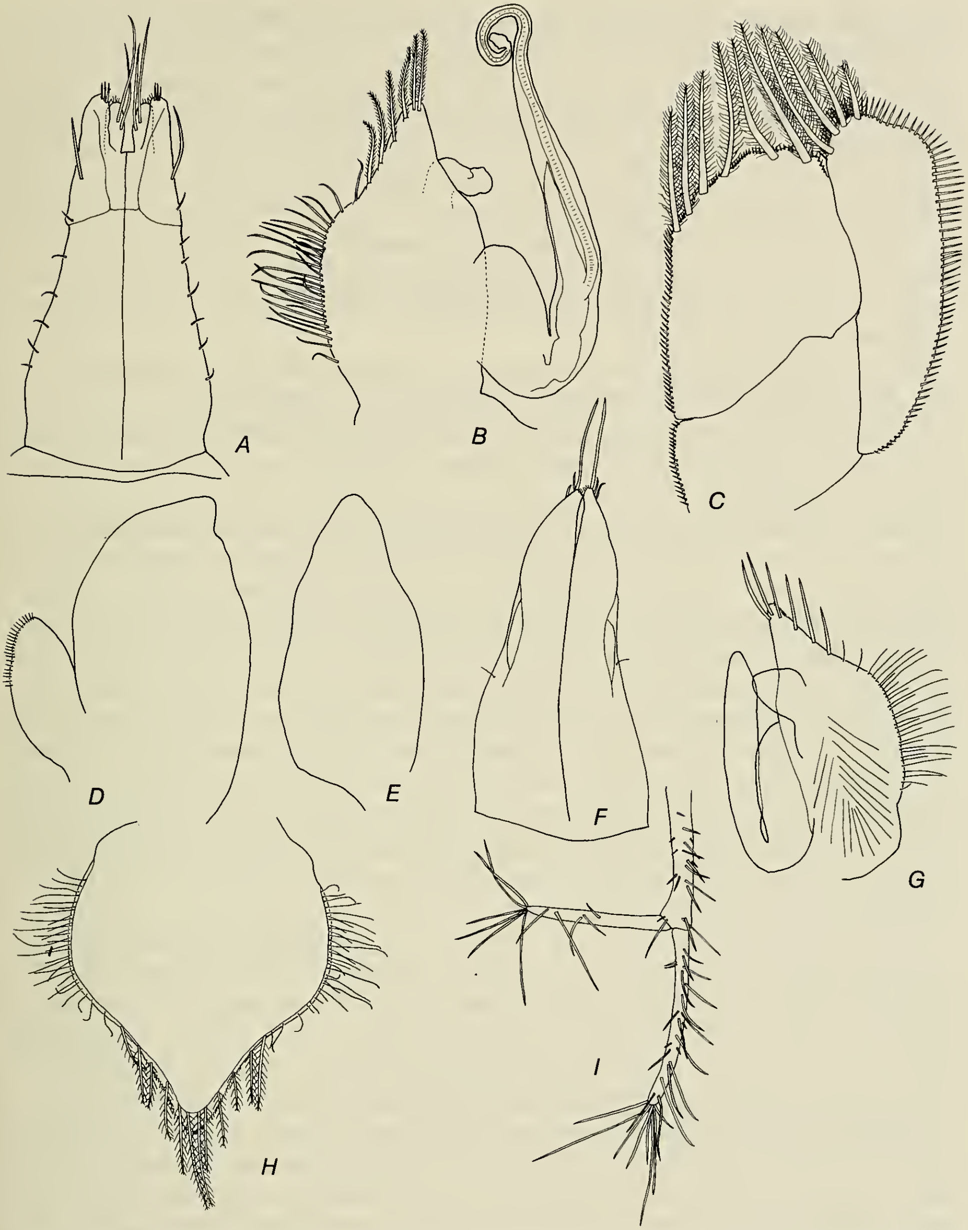

Fig. 6. *Mexicope kensleyi*: A, Pleopod 1 ♂; B, Pleopod 2 ♂; C, Pleopod 3 ♂; D, Pleopod 4 ♂; E, Pleopod 5 ♂; F, Pleopod 1, immature ♂; G, Pleopod 2, immature ♂; H, Operculum ♀; I, Uropod.

bearing several setae distally. Endite broad, outer margin rounded; inner margin with 2 coupling hooks prominent tooth distally; bearing numerous setules on distal third. Epipodite small, narrowly rounded apically.

Pereopod 1 ambulatory; subequally long basis and propodus longest segments; merus bulbous; dactyl with 2 claws. Pereopod 2 with biunguiculate dactyl, carpus, and propodus equally long. Pereopod 7 longest, similar to pereopod 2.

Uropoda elongate, setiferous, biramous, peduncle and exopod subequal in length, endopod slightly longer.

Operculum as broad as long; distal half of lateral margin somewhat excavate, proximal half bearing numerous narrow setae; 12 prominent feather setae along distal subacute margin.

Male: Pleopod 1 rami fused proximally, bearing several short setae and single elongate seta laterally; bilobed distally, outer lobe with 3 setae and several setules terminally; inner lobe bearing several setules apically and 2 elongate setae medially. Pleopod 2 sympod with alternating long and short setae along outer margin, 6 plumose setae on outer distal third; endopod coiled distally, with flared stylet, exceeding length of sympod.

*Material.*—Holotype female TL 2.95 mm, USNM 184940. Allotype male TL 1.66 mm, USNM 184941. Paratypes DISL Museum 6183-1506.

*Etymology.*—The specific name *kensleyi* is for Brian Kensley, of the National Museum of Natural History (Smithsonian Institution), for the assistance and guidance he has given me.

*Remarks (Pleurocope floridensis* and *Mexicope kensleyi).*—Consistently challenging to taxonomists, the genus *Pleurocope* has undergone five different family assignments since its inception by Walker in 1901. Describing *P. dasyura* from the Mediterranean Sea, Walker (1901) placed his genus in the family Munnidae. Wolff (1962:64) reassigned *Pleurocope* to the family Dendrotionidae with hesitancy and noted its exceptional characters in the family diagnosis. Facilitated by several fresh specimens of *P. dasyura,* Fresi and Schieke (1972) re-evaluated *Pleurocope,* and felt it necessary to erect a new family, Pleurocopidae. Wilson (1980) argued that the cephalic appendages Fresi and Schieke (1972) cite as basis for the erection of Pleurocopidae are ". . . specializations not of familial significance . . ." and placed *Pleurocope* in the family Antiadidae. Finally, recent efforts (Kensley, 1982) to rectify nomenclatural and priority problems will place the genus in the family Pleurocopidae.

After comparing *Pleurocope* and the other pleurocopid genera, *Kuphomunna* Barnard, 1914, *Santia* Sivertsen and Holthuis, 1980 (=*Antias* Richardson, 1906), and *Prethura* Kensley, 1982, the heterogeneity of this family becomes immediately apparent. Kensley (1982), citing the diverse nature of the family's constituent genera, is admittedly hesitant in grouping this foursome, which he believes need to be studied in greater detail in order to establish taxonomic relationships.

*Pleurocope floridensis* can be distinguished from *P. dasyura* Walker by its single segmented pleon, short dorsal setae, and subequally long uropodal peduncle and rami. A third member of the genus is presently being described by Wilson and Carter (Wilson, pers. comm.). *P. floridensis* differs from it by possessing only five robust setae along the mesial margin of the second antenna's third segment.

The new monotypic genus, *Mexicope,* also offers taxonomic difficulties. Its unique combination of diagnostic attributes does not fit readily into any existing family. Both Wilson (pers. comm.) and Kensley (pers. comm.) feel *Mexicope* is most closely related to the family Pleurocopidae, even though it shares several characters with the Janiridae. The new genus, however, differs significantly from its pleurocopid allies by possessing peduncular scales on its antennae, a conical setiferous molar process, and an ambulatory first pereopod. *Mexicope* can also be distinguished from the janirids by its nonexpanded maxillipedal palp segments

1–3, absence of a mandibular palp, modified molar process, and stalked eyes. Table 2 compares the distinguishing characters of *Mexicope,* the genera of Pleurocopidae, and the genus *Janira.*

Because of this overlapping of familial features and because of the present vagueness of family and generic diagnoses of the Janiridae and Pleurocopidae, *Mexicope* is not assigned a familial position.

## Family Paramunnidae

### *Munnogonium wilsoni,* new species

Figs. 7, 8

*Description.*—Male: Body pear-shaped, widest at pereonite 3, nearly twice longer than wide. Frontal margin of head broadly rounded; black eyes on short lateral projections; coxal plates dorsally visible on pereonites 2–7. Pleotelson as long as broad, laterally dentate to point of uropodal insertion, posteriorly rounded.

Antennular peduncle 2-segmented, second segment expanded distally; first and fourth articles of flagellum subequally long, latter bearing single elongate aesthetasc and several setae apically.

Third segment of antennal peduncle elongate, with seta-bearing scale; sixth peduncular segment slightly longer than fifth segment, with several setae distally. Flagellum of 6 or 7 segments, each article slightly shorter than the preceding one.

Mandibles with strong, truncate molar process; palp reduced to glabrous scale; left mandible with 4-toothed incisor, lacinia mobilis trifid, 4 elongate simple setae; incisor of right mandible 5-toothed, spine row of 2 serrate setae and 3 simple setae. Inner ramus of maxilla 1 with 1 plumose and 3 elongate simple setae; 8 terminal spines on outer ramus, single spine arising from body of outer ramus. Maxilla 2, inner ramus broad, bearing several elongate simple setae and 1 feather seta along distal margin, with several rows of setules of distal half; inner lobe of outer ramus with 3 elongate simple setae terminally, outer lobe carrying 1 feather seta and 2 elongate simple setae.

Maxillipedal epipodite extending to first palp segment; palp 5-segmented, joints 1–3 expanded; endite setose along distal margin, 2 coupling hooks along inner margin.

Pereopod 1 subchelate; dactyl with terminal and accessory claws; carpus with 2 prominent sensory spines inferiorly; basis longest article, subequal in length to ischium and merus together. Single claw on dactyl of pereopod uni-unguiculate; basis and ischium subequally long.

Uropodal protopod not visible dorsally; endopod twice longer than exopod, both rami apically setose.

Pleopod 1 sagittate, lateral corners cleft, supporting setae of varying lengths. Pelopod 2 laterally fringed with several elongate setae; endopod distally thin, elongate.

Female: Slightly broader than male; operculum distally narrowing to rounded apex, bearing several slender setae along convex lateral margins. Ovigerous paratype with 9 eggs in brood pouch.

*Material.*—Holotype male, TL 0.86 mm, USNM 184946. Allotype female, TL 0.98 mm, USNM 184947. Paratypes, DISL Museum 6183-1509.

*Etymology.*—The specific name is in honor of George Wilson, University of

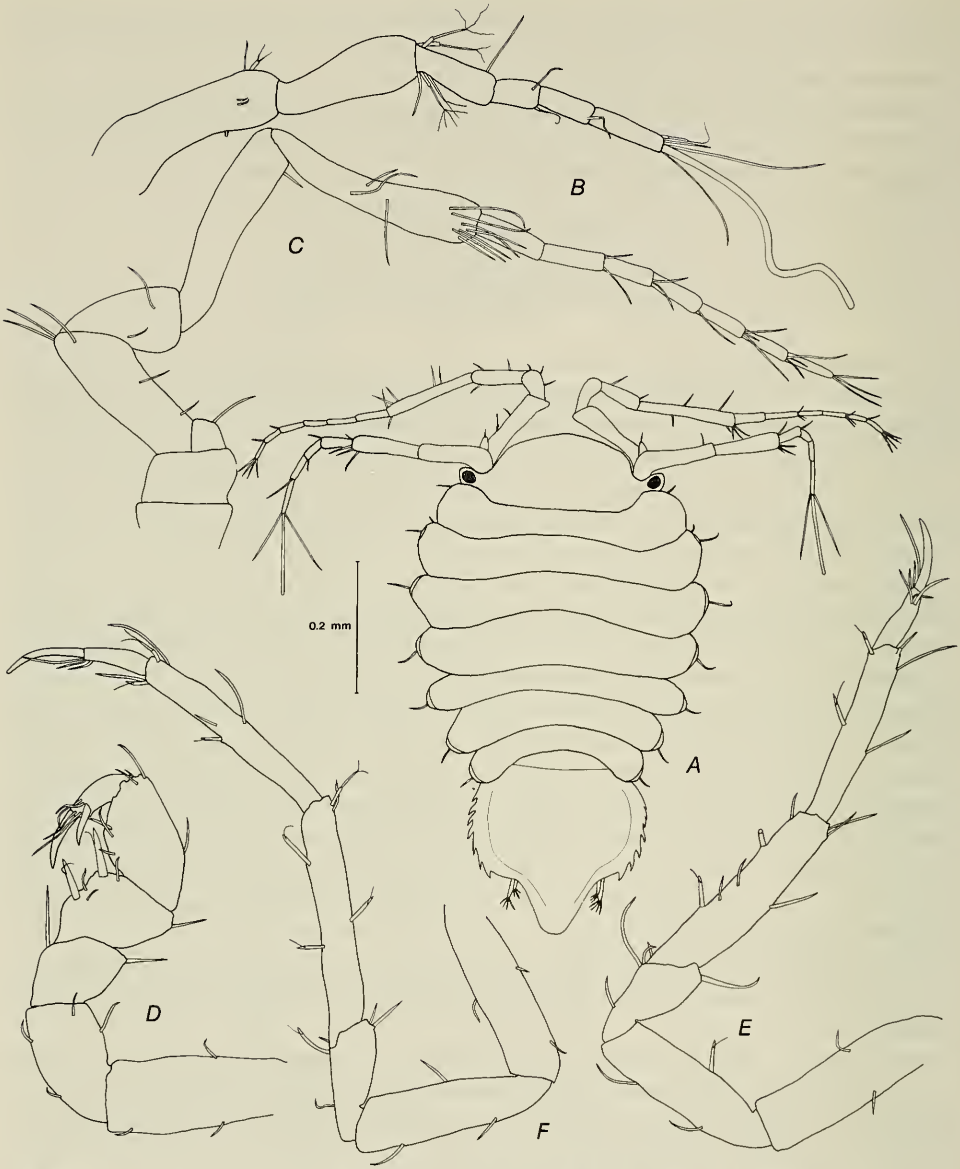

Fig. 7. *Munnogonium wilsoni*: A, Holotype ♂, dorsal view; B, Antenna 1; C, Antenna 2; D, Pereopod 1; E, Pereopod 2; F, Pereopod 7.

California at San Diego, who has recently helped to rectify paramunnid-munnid inconsistencies, and has helped me immeasurably.

*Remarks.*—A new genus and species, *Munnogonium waldronense,* was instituted by George and Stromberg (1968) after collecting what was thought to be a previously undescribed asellote from the San Juan Archipelago, Washington. Although justified in their erection of a new genus, the asellote was not, in fact, a new species. Menzies and Barnard (1959) had described the same species, placing

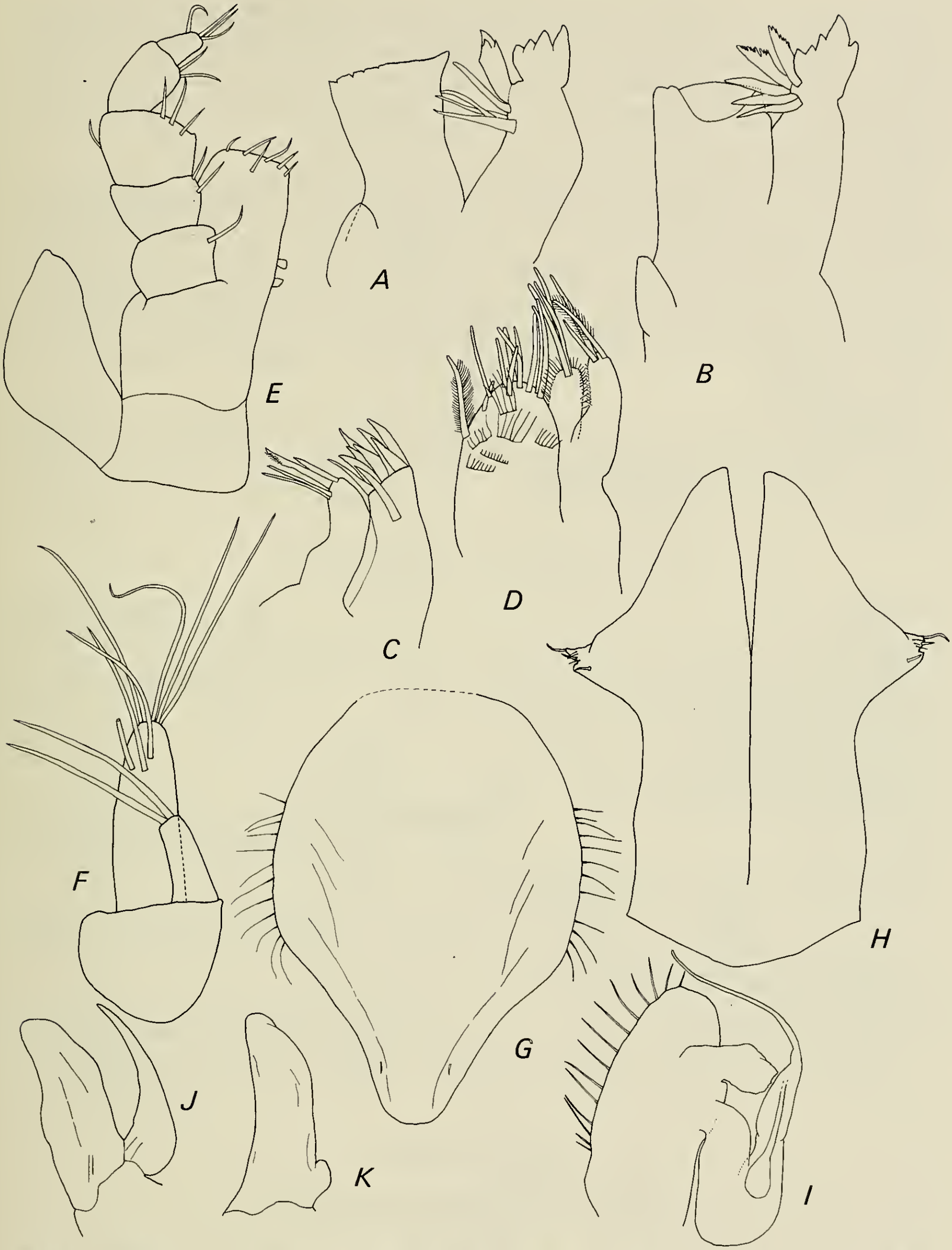

Fig. 8. *Munnogonium wilsoni*: A, Left mandible; B, Right mandible; C, Maxilla 1; D, Maxilla 2; E, Maxilliped; F, Uropod; G, Operculum ♀; H, Pleopod 1 ♂; I, Pleopod 2 ♂; J, Pleopod 3 ♂; K, Pleopod 4 ♂.

it in the genus *Austrosignum* Hodgson, 1910, naming it *A. tillerae.* Discovering the conspecificity of *M. waldronense* and *A. tillerae,* Bowman and Schultz (1974) reviewed *Munnogonium,* comparing it to *Munna* Krøyer, 1838, *Pleurogonium* Sars, 1864, and *Austrosignum.* They found *Munnogonium* most closely related to *Austrosignum,* but differing from its generic allies in the absence of a mandibular palp, "... character of generic value ..." (Bowman and Schultz 1974). By transferring *A. tillerae* (and all other previously described *Austrosignum* species lacking mandibular palps) to *Munnogonium* and applying the law of priority, the type-species became *M. tillerae* (Menzies and Barnard, 1959).

Based on the position of the anus, shape of the male first pleopod, and proportions of the third antennal segment, Wilson (1980) transferred *Munnogonium* and several other genera from the family Munnidae to the resurrected family Pleurogonidae Wilson, 1980. Holthuis (pers. comm.), however, correctly indicates that the law of priority dictates the family name Paramunnidae Vanhoffen, 1914, takes precedence over Pleurogoniidae Nordenstam, 1933, if the genera *Pleurogonium* Sars, 1899, and *Paramunna* Sars, 1866, are considered to belong to the same family.

*Munnogonium wilsoni* can be distinguished from all its congeners by the presence of coxal plates on pereonites 2–7, and the unique combination of antennal peduncular scales and short eyestalks.

### Key to the Species of *Munnogonium*

1. Eyes not visible dorsally, lacking ocular peduncles ........................................................ *M. erratum* Schultz, 1964
– Eyes visible dorsally, borne on short or long peduncles ............... 2
2. Pereonites 3 and 4 laterally notched ............ *M. subtilis* Kensley, 1976*
– Pereonites 3 and 4 not laterally notched ............................ 3
3. Lateral pleonal margin non-serrate ................................ 4
– Lateral pleonal margin serrate ...................................... 5
4. Eyes borne on elongate peduncles; antennule of 6 articles .................................................... *M. grande* Hodgson, 1910
– Eyes borne on short stalks; antennule of 7 articles ....................................................... *M. globifrons* Menzies, 1962
5. Antenna without peduncular scale *M. tillerae* (Menzies and Barnard, 1959)
– Antenna with peduncular scale ..................................... 6
6. Eyes borne on elongate peduncles; male antenna with peduncular segment 3 suboval, swollen .................. *M. maltinii* Schiecke and Fresi, 1972
– Eyes borne on short stalks; coxal plates dorsally visible on pereonites 2–7 .............................................. *M. wilsoni,* n. sp.

## Family Janiridae

### *Janira biunguicula,* new species
Figs. 9, 10

*Description.*—Body about 3 times longer than wide, widest at pereonite 4. Cephalon wider than long, projecting strongly at anterolateral corners; prominent frontal margin slightly concave distally. Eyes of 3 ommatidia, brown, dorsolateral. Pereonites 1–4 bearing bilobed coxal plates; pereonites 5–7 with single epimera; lateral margins of pereonites 1–3 directed anteriorly. Pleon 2-segmented, pleonite 1 inconspicuous; pleotelson shield-shaped, as wide as long.

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* Based on single ovigerous female.

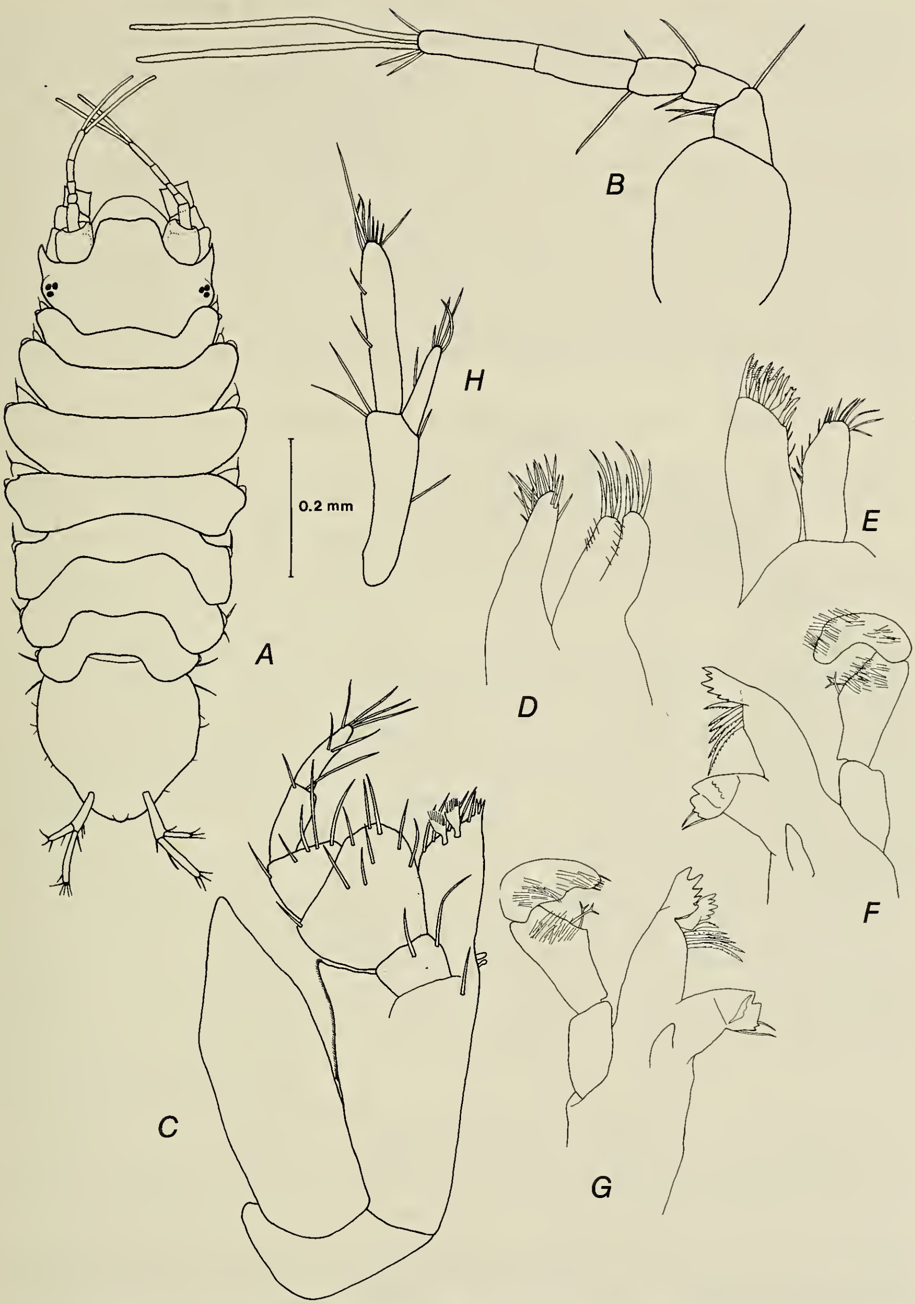

Fig. 9. *Janira biunguicula*: A, Holotype ♂, dorsal view; B, Antenna 1; C, Maxilliped; D, Maxilla 2; E, Maxilla 1; F, Right mandible; G, Left mandible.

Antennule with 2-segmented peduncle; flagellum of 4 articles, terminal article elongate, with 2 aesthetascs. Antenna broken at scale-bearing peduncular segment.

Mandibular palp 3-segmented, second segment bearing 2 prominent forked setae; strong molar process carrying 2 setae; scale present near base of molar

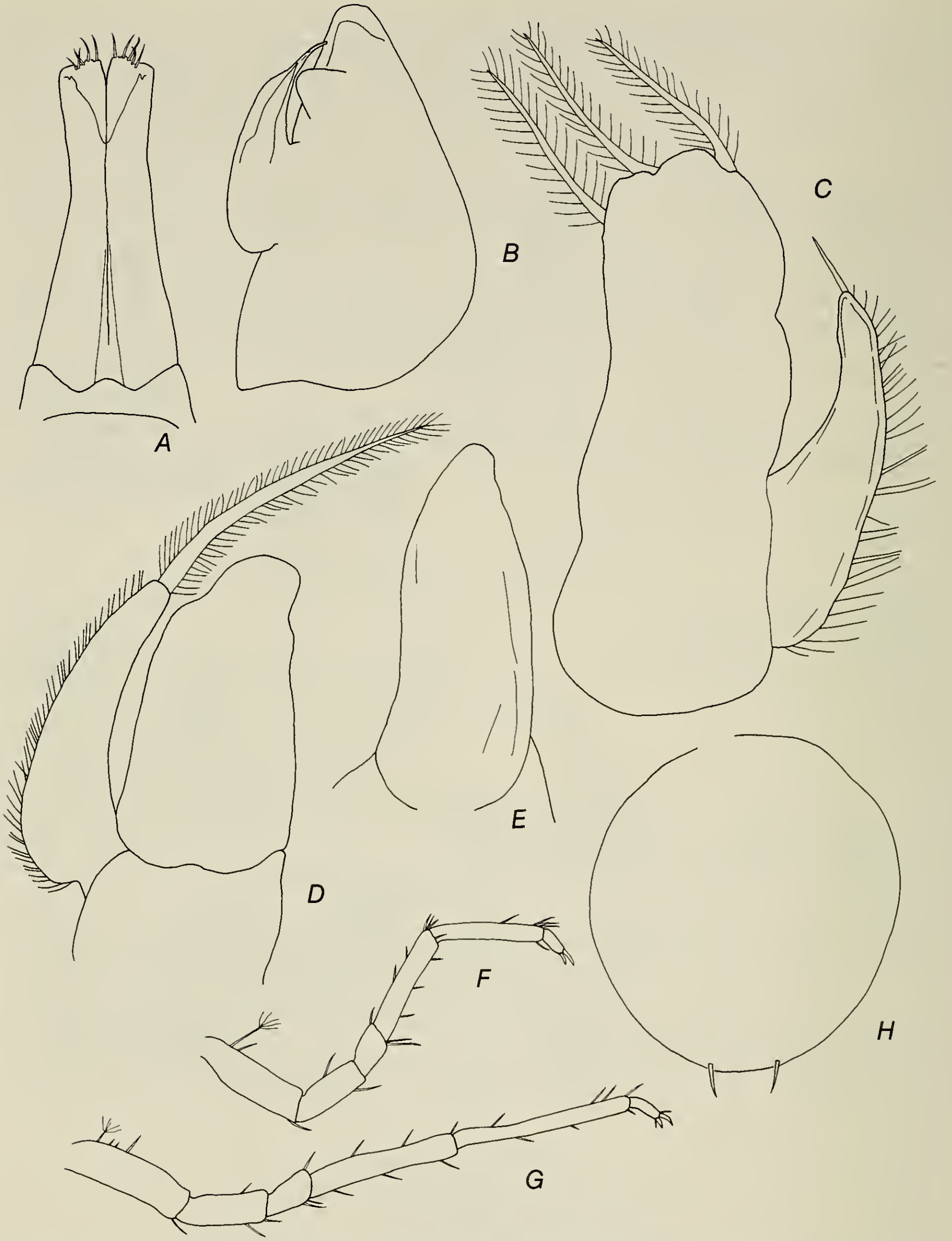

Fig. 10. *Janira biunguicula*: A, Pleopod 1 ♂; B, Pleopod 2 ♂; C, Pleopod 3 ♂; D, Pleopod 4 ♂; E, Pleopod 5 ♂; F, Pereopod 1; G, Pereopod 2; H, Operculum ♀.

process; 6 dentate spines in spine row; lacinia mobilis of left mandible with 5 teeth incisor 5-toothed; incisor of right mandible with 6 teeth.

Outer ramus of maxilla 1 with 6 plumose setae, 1 simple and 5 dentate spines on distal margin; inner ramus bearing several simple setae. Maxilla 2, inner ramus bearing numerous setae; inner lobe of outer ramus with elongate setae, outer lobe tipped with 4 elongate setae. Maxillipedal epipodite broad, distally subtriangular, apically narrowly rounded; palp 5-segmented, segments 1–3, and especially segment 2 wider than segments 4 and 5; endite bearing several fringed setae-spines distally; 2 retinaculae on inner margin.

Pereopod 1 ambulatory; dactyl shortest segment, biunguiculate; basis, propod, and carpus subequally long. Pereopod 2 with 2 claws on dactyl; carpus longest segment, slightly longer than propod; pereopod 7 shortest, dactyl biunguiculate.

Pleopod 1, rami elongate, tapering for proximal two-thirds of length, distal margin of rami slightly concave, with 4 or 5 stout setae; outer margin of pleopod 2 rounded, sympodal apex rounded, slightly longer than basally robust endopod. Endopod of pleopod 3 bearing 3 strong feather setae terminally; exopodal outer margin setose, spine present distally; exopod of pleopod 4 with prominent feather seta.

Uropod pedunculate, biramous; endopod twice length of exopod, nearly twice as wide.

Female: Broader than male; operculum nearly circular, with 2 setae distally.

*Material.*—Holotype male, TL 1.19 mm, USNM 184937. Allotype female, TL 1.08 mm, USNM 184938. Paratypes, DISL Museum 6183-1508.

*Etymology.*—The specific name *biunguicula* refers to the two dactylar claws present on all seven pereopods.

*Remarks.*—No other asellote family has demonstrated the heterogeneity of genera nor repeatedly presented taxonomic problems as has the Janiridae. Disregarding possible synonymies, Wolff (1962) listed 35 genera, and when combined with more recent generic designations, the number stands close to 40. Many of these genera are monotypic, casting doubt on their validity, in regard to characters traditionally considered generically diagnostic. Two major problems have contributed to the present taxonomic tangle. First, the family diagnosis is very broad, often serving as a catch-all for non-related genera. The disparate nature of janirid genera is exemplified by juxtaposing *Caecianiropsis* Menzies and Pettit, 1956, *Vermectias* Silvertsen and Holthuis, 1980, *Katianira* Hansen, 1916, *Carpias* Richardson, 1902, and *Neojaera* Nordenstam, 1933. Second, as Wilson (pers. comm.) suggests, no one really knows what a janirid is. Only three recurring morphological traits have been found among the janirids: uropods with a peduncle, a scale present on the antennal peduncle (not true for *Iais* Bovallius, 1887), and expanded maxillipedal palp segments 1–3.

The problems of systematics within the Janiridae are brought to light by *Janira biunguicula,* which falls into the same systematic category as many other newly described janirids, while all related genera (or perhaps, more appropriately, 'forms') can be precluded by their generic diagnoses. *Janira*'s most closely related genera, *Ianiropsis* Sars, 1899, and *Janiralata* Menzies, 1951, can both be discounted by their distally dilate first male pleopods, *Ianiropsis* by its elongate, prehensile first male pereopod, and *Janiralata* by its subchelate first pereopod in both sexes.

The dorsal display and arrangement of epimera, and the distally non-dilate male pleopod 1 of *J. biunguicula* agree with the *Janira* diagnosis; however, the type-genus, *Janira maculosa* Leach, 1814, differs from *J. biunguicula* in two important aspects: *J. maculosa* possesses triunguiculate dactyli, whereas *J. biunguicula* has biunguiculate dactyli, and pereopod 1 of *J. maculosa* is prehensile, while that of *J. biunguicula* is ambulatory.

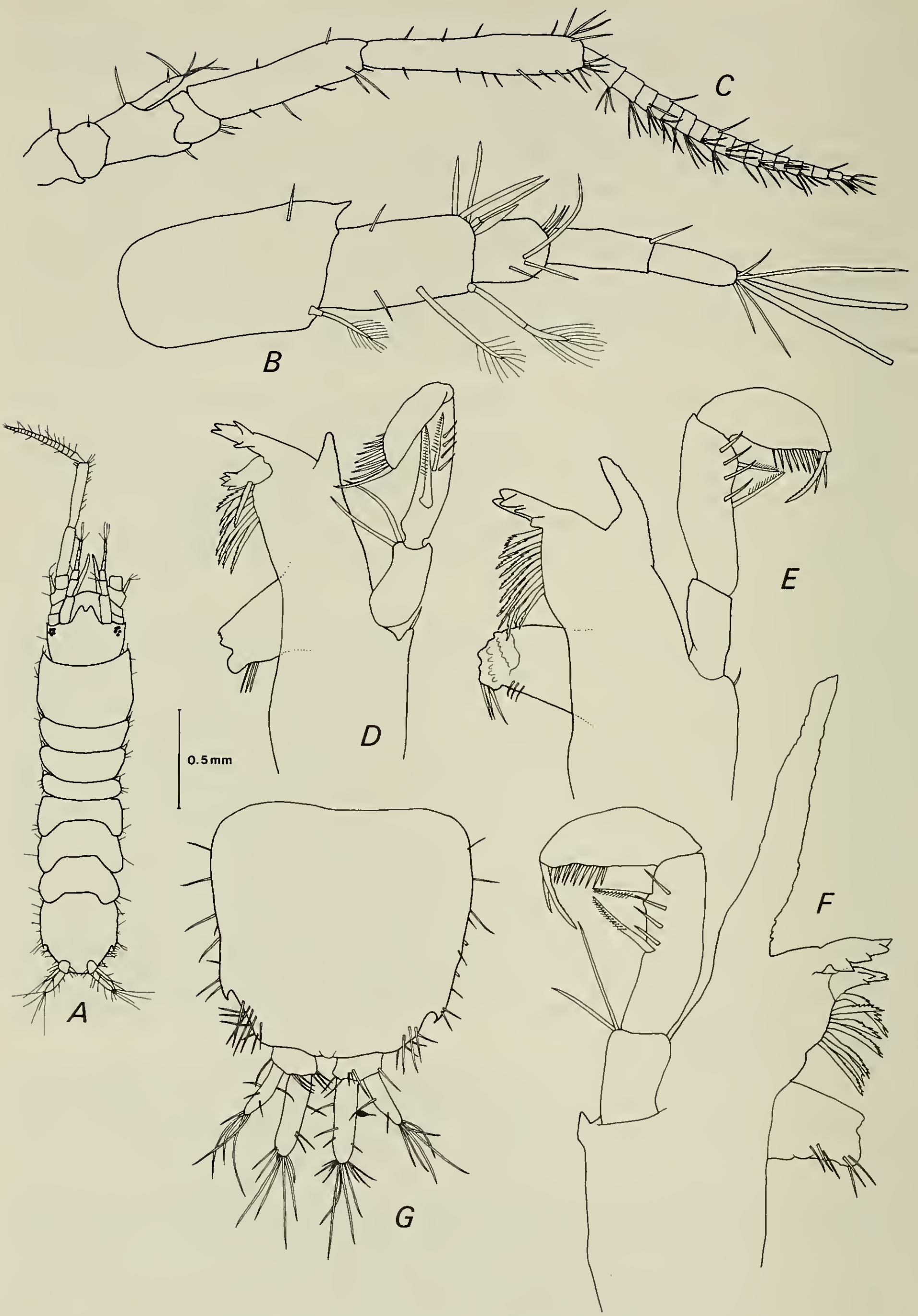

Fig. 11. *Gnathostenetrioides pugio*: A, Holotype ♂, dorsal view; B, Antenna 1; C, Antenna 2; D, Left mandible ♀; E, Right mandible, immature ♂; F, Left mandible, mature ♂; G, Pleotelson and uropods.

These differences may characterize a new genus, but *J. biunguicula* has been placed in *Janira* for two reasons. First for the aforementioned characters it shares with the generic diagnosis, and second, the Janiridae by sheer number of dissimilar genera, should not be burdened by yet another genus that may not be valid and which would only serve further to confuse the situation. Table 2 compares the distinguishing features of *J. maculosa* and *J. biunguicula.*

That the Janiridae require an intensive study to resolve the present complexity is obvious. Schultz (1976) suggests that the number of dactylar claws may be of generic or higher significance. Unfortunately, not all janirid descriptions contain claw number information. Wolff (1962) has found *J. alta* Stimpson, 1853, with three claws rather than two as mentioned by Stimpson, and suspects both *J. japonica* Richardson, 1908, and *J. tristani* Beddard, 1886, are also triunguiculate, contrary to their original descriptions.

## Superfamily Parastenetrioidea

### Family Parastenetriidae

### *Gnathostenetrioides pugio,* new species

Figs. 11–13

*Description.*—Male: Body elongate, parallel-sided. Cephalon length and width nearly equal; frontal margin projecting between antennulae, concave anteriorly; mandibular prolongation extending to midpoint of antennular flagellum; eyes dorsal, of 5 light-brown ommatidia. Pereonite 1 longest; pereonites 2–4 with seta-bearing coxae; pereonites 5–7 slightly produced posterolaterally. Pleotelson as wide as long, with lateral spines anterior to uropodal insertion, free pleonal segment lacking.

Peduncle of antennule 3-segmented, first segment broadest, as long as following 2 segments together; flagellum of 2 articles, 2 subequally long aesthetascs on terminal article, aesthetascs nearly as long as flagellum. Antennal peduncle of 6 segments, third segment bearing setiferous squama, segment 5 as long as segments 1–4 together, segment 6 longest; flagellum of 18 setose articles.

Mandibular palp 3-segmented, second segment with 2 fringed setae and 4 shorter simple setae, terminal segment with serrate seta distally; armed with elongate, slightly crenulate projection distolaterally, bearing truncate setiferous molar process; incisors with cusps; lacinia mobilis of left mandible bearing 4 teeth and single serrate seta. Outer ramus of maxilla 1 bearing 10 serrate spines distally; inner ramus slender, carrying several elongate simple setae terminally. Second maxilla, outer lobe of outer ramus with 4 elongate simple setae and 1 short simple seta. Maxillipedal endite narrow, with 3 coupling hooks, mediodistal margins setose; palp segment 2 widest, expanded distally; epipodite extending to third palp, apically subacute.

Merus of pereopod 1 with seta-bearing projecting corner; propod, merus, and carpus setiferous posteriorly; propod with seta-bearing tooth and several combed, curved spines along palmar edge; dactyl bearing several pectinate curved spines and short terminal claw. Pereopod 2 with subequally long merus and carpus; dactyl shortest joint, bearing 2 claws. Basis of pereopod 7 nearly oval, longest joint; dactyl shortest segment, biunguiculate.

Pleopod 1 large; sympods nearly 3 times broader than long; rami separate, non-

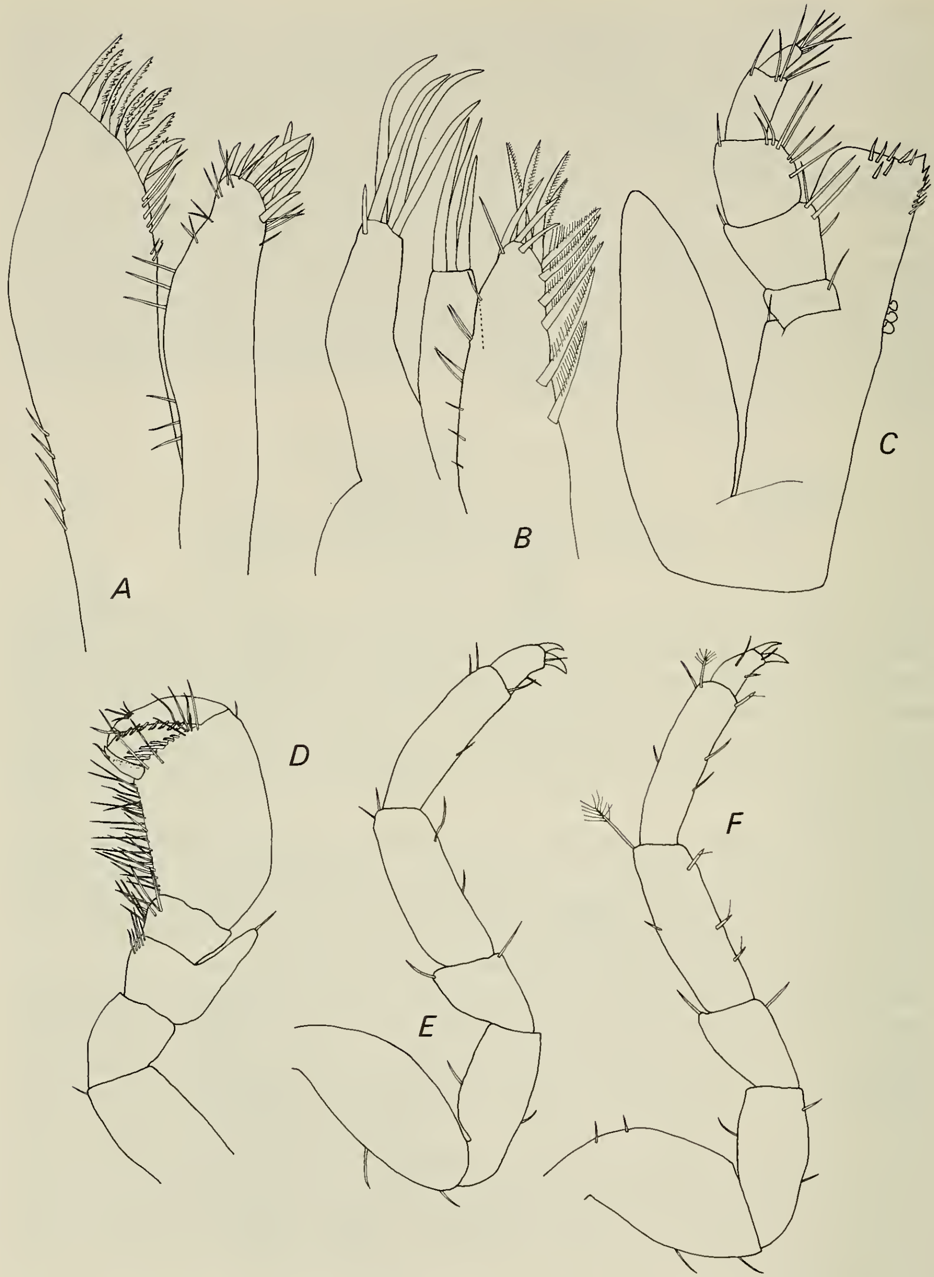

Fig. 12. *Gnathostenetrioides pugio*: A, Maxilla 1; B, Maxilla 2; C, Maxilliped; D, Pereopod 1 ♂; E, Pereopod 2; F, Pereopod 7.

overlapping, bearing numerous setae distally. Endopod of pleopod 2 2-segmented, second joint truncate distally, slightly expanded medially; 2-segmented, second joint truncate distally, slightly expanded medially; 2-segmented exopod, pleopod 3 exopod of 2 joints, endopod with 2 plumose setae terminally.

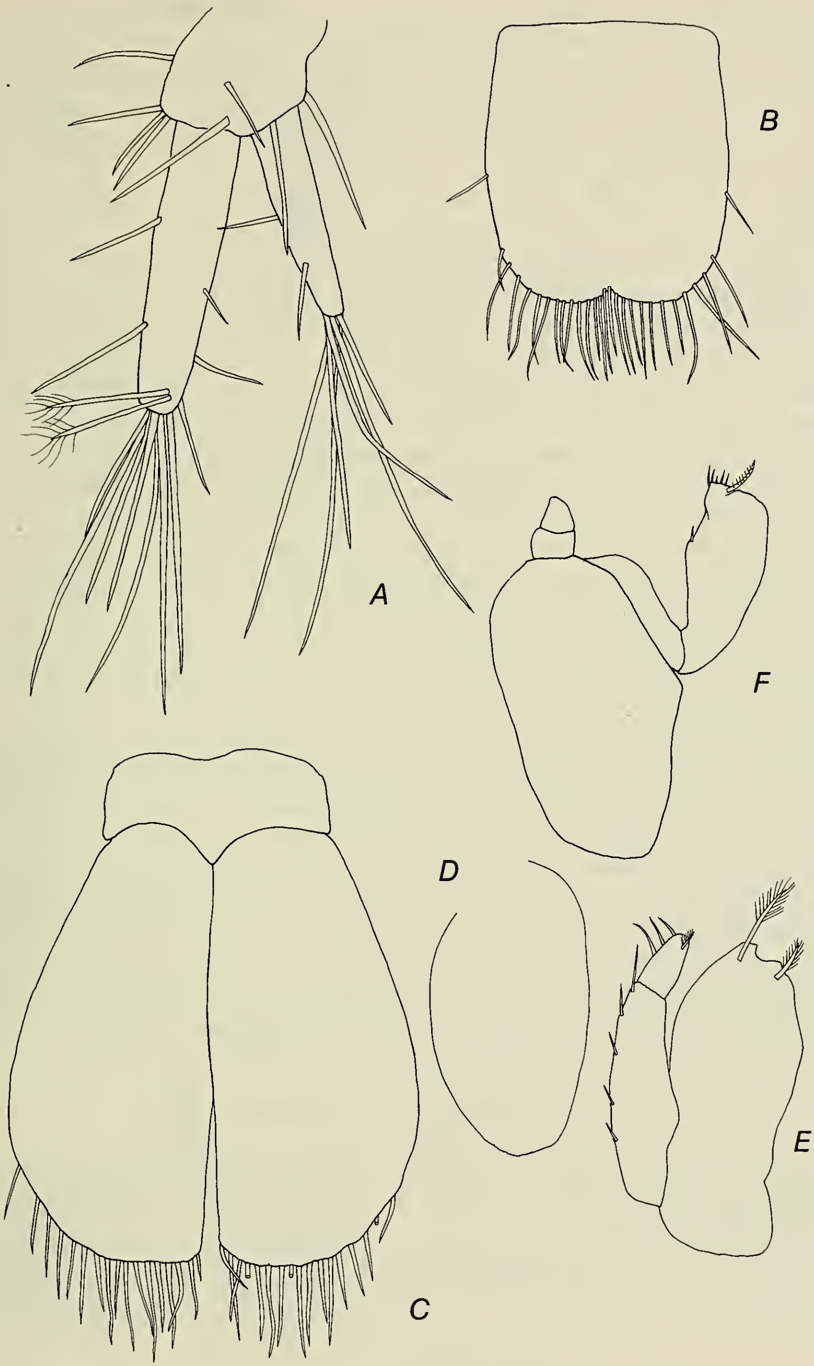

Fig. 13. *Gnathostenetrioides pugio*: A, Uropod; B, Operculum ♀; C, Pleopod 1 ♂; D, Pleopod 4 ♂; E, Pleopod 3 ♂; F, Pleopod 2 ♂.

Uropod pedunculate; inner ramus longer and broader than outer ramus, both carrying numerous elongate setae terminally.

Female: Similar to male, fewer setae on inner margin of pereopod 1 merus, carpus, and propodus; operculum with mesiodistal margin acutely cleft.

*Material.*—Holotype male TL 3.20 mm, USNM 184934. Allotype female TL 1.60 mm, USNM 184935.

*Etymology.*—The Latin *pugio* refers to the dagger-like process on the male mandible.

*Remarks.*—Describing a new asellote from the Mediterranean Sea, Amar (1957) found it necessary to designate a fourth subtribe, Parastenetrioidea, a new family, Parastenetriidae, and a new genus, *Gnathostenetrioides* to accommodate the unusual features of the new species *G. laodicense.* Amar felt the pleopodal structure, his basis for erecting a new subtribe, to be intermediate in form between the pleopodal morpohlogy of the subtribes Stenetrioidea Hansen, 1905, and Paraselloidea Hansen, 1905. Based upon features other than pleopods, *Gnathostenetrioides* is clearly more closely related to Stenetrioidea than to Paraselloidea. The parastenetrioideans and stenetrioideans have probably descended from a common ancestor with pleopodal differences evolving into the present dichotomy.

Besides diagnostic pleopods, *Gnathostenetrioides* also bears anomalous mandibular prolongations; an elongate, tusk-like protuberance in the male; a shorter, acute process in the female. The use of these remarkable processes is unknown, but they may be involved in mating behavior, which could account for their marked sexual dimorphism.

Unlike the stenetrioideans, the two parastenetrioidean species do not demonstrate marked sexual dimorphism in their subchelate first pereopod. Male parastenetrioidean gnathopods are, however, more hirsute on the inner margins of the merus, carpus, and propodus than in their female counterparts.

Only the second recorded species of the subtribe, *G. pugio* differs from its congener, *G. laodicense* by the absence of setae along the lateral margin of pleopod 1, an inner margin length of pleopod 1 less than twice the length of the palmar margin, and the female's acute opercular mesiodistal incision. The close similarity between the two species is not totally surprising; the related stenetrioidean genus, *Stenetrium* Haswell, 1881, also demonstrates conservatism with regard to interspecific differences among its approximately 40 members.

### Key to the species of *Gnathostenetrioides*

1. Pereopod 1 propodus bearing several setae on outer lateral margin, inner margin greater than twice the length of the palmar margin; female operculum incision rounded ........................ *G. laodicense* Amar, 1957
– Pereopod 1 propodus lacking outer lateral margin setae, inner margin less than twice the length of the palmar margin; female operculum distal incision acute ............................................ *pugio,* n. sp.

## Family Anthuridae

### *Mesanthura hopkinsi,* new species
Figs. 14, 15

*Description.*—Female: Body proportions: C = 1 < 2 > 3 < 4 = 5 > 6 > 7. Pigmentation pattern of cephalon dorsum triangular, originating anteriorly between

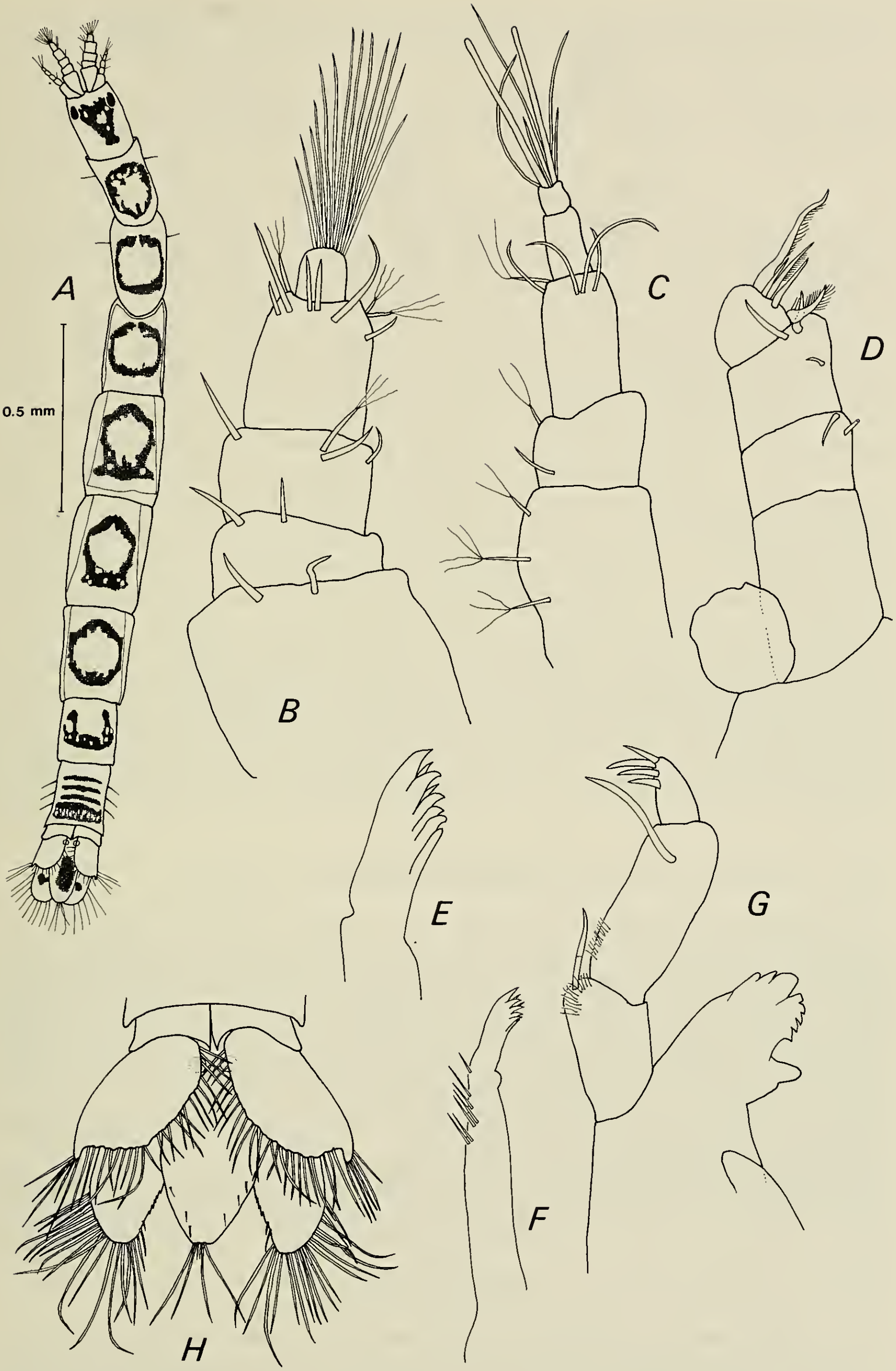

Fig. 14. *Mesanthura hopkinsi*: A, Holotype ♀, dorsal view; B, Antenna 2; C, Antenna 1; D, Maxilliped; E, Maxilla, apex enlarged; F, Maxilla; G, Mandible.

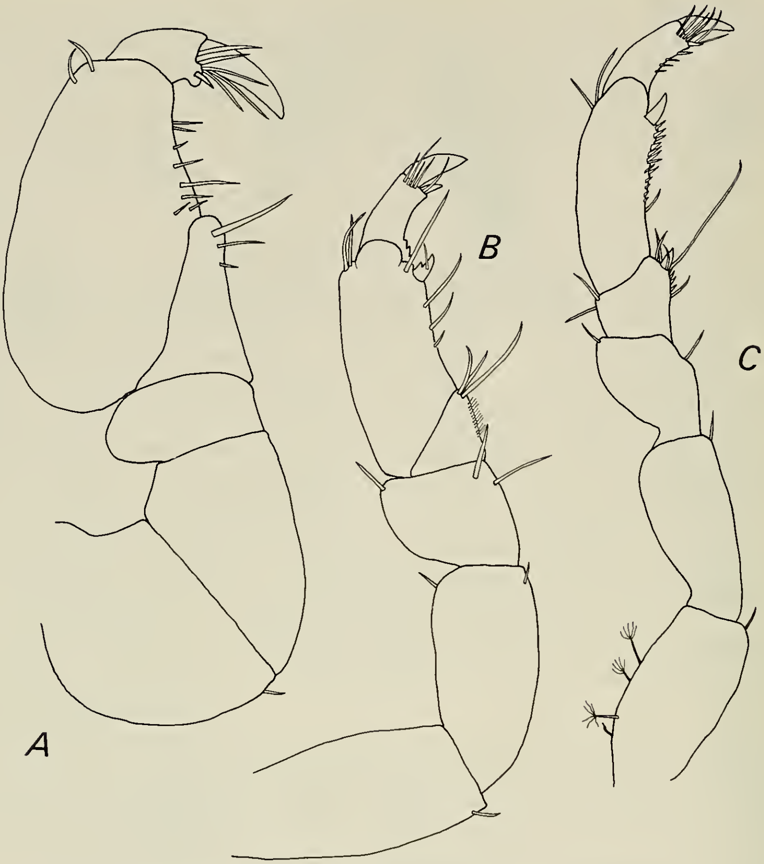

Fig. 15. *Mesanthura hopkinsi*: A, Pereopod 1; B, Pereopod 2; C, Pereopod 7.

black eyes. Pereonites 1–6 with non-pigmented central area surrounded by pigment in varying near-circular patterns; pereonite 7 with a U-shaped pigment. Telson with chromatophores, bearing 4 elongate setae distally. Pleonites 1–5 fused.

Antennular flagellum 2-jointed, terminal article with several setae and 2 aesthetascs; peduncle of 3 segments, second segment shortest.

Antennal peduncle 5-segmented, segments 1 and 2 wider than long, flagellum uniarticulate, bearing numerous apical setae.

Mandibular palp 3-segmented, setae-bearing distal segment shortest; second segment longest, carrying elongate setae distally; molar of 1 lobe; incisor of 3 cusps; lamina dentata with 5 serrations. Maxilla slender, with 8 spines distally. Maxilliped 5-segmented, terminal segment set obliquely on penultimate segment, with 2 simple setae, 2 fringed setae/spines and 1plumose seta/spine.

Unguis of pereopod 1 slightly longer than dactyl; dactyl with spine-bearing ventrolateral lobe, broadly rounded proximally; carpus rounded distally; merus with convex outer margin. Dactyl of pereopod 2 slightly longer than unguis, with strong ventrodistal spine; propodus with distal seta-bearing tooth; carpus triangular, with 3 simple setae and row of setules on inner margin. Carpus of pereopods

4–7 with anterior margin shorter than posterior margin. Propod of pereopod 7 with row of robust setae along posterior margin, longest article slightly longer than the basis.

Uropodal exopod heavily setose medially, notched apically, lacking pigment; endopod pigmented, rounded distal margin heavily setose, inner margin serrate.

Male: Unknown.

*Material.*—Holotype female TL 2.43 mm, USNM 184949.

*Etymology.*—In honor of Thomas S. Hopkins, Dauphin Island Sea Lab, who provided all the specimens of this study, and for his patience and understanding.

*Remarks.*—Species of the anthurid genus *Mesanthura* Barnard, 1914, are by definition, distinguished by the persistent chromatophoric pigmentation patterns displayed dorsally. The species-specific patterns vary widely in chromatophoric density, arrangement and location. One species, *M. protei* Kensley, 1980, (Kensley and Poore 1982) exhibits polychromatism, with three documented patterns and possibly more. Multiple intraspecific patterns would appear to be the exception since no other polychromatic members of this genus are known.

*Mesanthura paucidens* Menzies and Glynn, 1968, and *M. pulchra* Barnard, 1925, are also found in the waters off Florida. *Mesanthura hopkinsi* can be distinguished from these congeners by its pigmentation pattern, particularly that of the cephalon and pleon. *Mesanthura hopkinsi*'s cephalic pigment is triangular, whereas *M. paucidens*'s is a transverse band located just behind the eyes, and *M. pulchra* is a wide scattering nearly covering the entire head. *Mesanthura hopkinsi*'s pleonal pigmentation consists of three, laterally independent transverse bands on the first three pleonal segments, and a fourth, wide, transverse band on pleonal segments four and five, whereas *M. pauciden*'s is five, laterally connected, transverse bands and *M. pulchra*'s is a nondescript, broad scattering of chromatophores.

## Acknowledgments

I would like to express thanks to members of my graduate committee, Dr. Thomas Hopkins, University of Alabama; Dr. Brian Kensley, National Museum of Natural History; and Dr. Joseph Scheiring, University of Alabama, for all their guidance, assistance, and time. George Wilson, University of California at San Diego, provided expertise, insights, and encouragement. Richard Heard, Gulf Coast Research Laboratory, and David Camp, Florida Department of Natural Resources, also assisted in the taxonomic organization of the manuscript. Dawn Dardeau has my thanks and praise for her expert sorting. Finally, the entire faculty, staff, support personnel and graduate student body at Dauphin Island Sea Lab warrant thanks in appreciation for all their efforts. Funding was provided by BLM Contract AA550-CT7-34 to Dr. Thomas Hopkins.

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# *CRYPTOPENAEUS CROSNIERI,* A NEW SPECIES OF SHRIMP, AND A NEW RECORD OF *C. SINENSIS* (PENAEOIDEA: SOLENOCERIDAE) FROM AUSTRALIAN WATERS

Isabel Pérez Farfante and Brian Kensley

*Abstract.*—*Cryptopenaeus crosnieri,* a new species of solenocerid shrimp, is described from four specimens collected in Australian waters. It differs from *C. catherinae* in exhibiting neither a notch nor a depression on the postrostral carina, in having a longer scaphocerite, and in lacking an ischial spine on the third pereopod. Also, the thelycum exhibits a pair of small, flat to weakly convex plates, instead of strong bosses, on the anterior part of sternite XIII. *Cryptopenaeus crosnieri* differs from *C. sinensis* (originally described as the type and only species of the new genus *Crassipenaeus*), in lacking the three rounded thelycal prominences on sternite XIV typical of the latter, and in the presence of a meral spine on the third pereopod.

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The solenocerid genus *Cryptopenaeus* was proposed by De Freitas (1979) for *C. catherinae,* a new shrimp taken off southern Mozambique at depths between 310 and 500 m. Recently, three additional members of the genus have been discovered, one of them, *C. sinensis* (Liu and Zhenru, 1983) from the South China Sea, another from the waters of Indonesia, which is being described by A. Crosnier, and the third, described herein, from a locality off eastern Australia. Four specimens of the latter species were collected off the northeast coast of New South Wales by the R/V *Kapala* of the New South Wales Fisheries. The new record of *C. sinensis* is based on a male obtained off the northwest coast of Australia, southwest of Cape Leveque, by the U.S.S.R. R/V *Lira.* This latter species is the type-species of a new genus, *Crassipenaeus* Liu and Zhenru, 1983, which we consider to be a synonym of the earlier *Cryptopenaeus* De Freitas, 1979.

The terminology used in the descriptions has been discussed and illustrated by Pérez Farfante (1969, 1977).

## *Cryptopenaeus crosnieri,* new species
Figs. 1, 2

*Material.*—Holotype, ♀, Australian Museum, AM-P32481, carapace length 29.5 mm, rostral length 8.5 mm, total length about 102 mm. Type-locality: NE of North Solitary Island, New South Wales, Australia, 29°47–49′S, 153°41′E, 234 m, R/V *Kapala* sta 78-05-07, shrimp trawl.—Paratypes, 1 ♀, Australian Museum, 2 ♀, National Museum of Natural History, Smithsonian Institution, Washington, D.C., USNM 189097, collected with holotype.

*Description.*—Body relatively robust (Fig. 1); carapace microscopically setose-punctate, abdomen glabrous. Rostrum horizontal, with dorsal margin straight and ventral margin convex, short, its length 0.30 to 0.18 that of carapace, decreasing

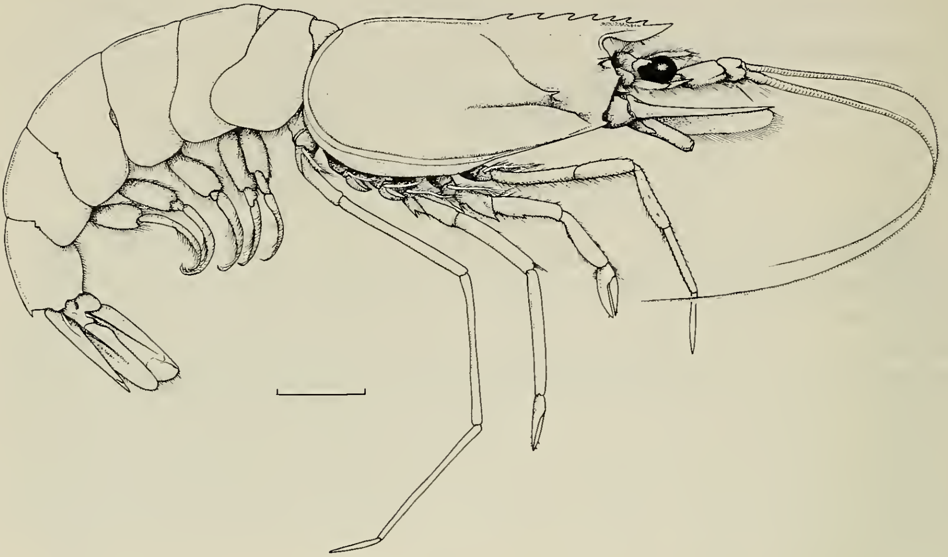

Fig. 1. *Cryptopenaeus crosnieri*, holotype ♀ 29.5 mm carapace length, NE of North Solitary Island, New South Wales, Australia. Lateral view. Scale = 10 mm.

proportionally with increasing size, and in adults reaching between distalmost part of first antennular article and midlength of second. Rostral plus epigastric teeth 7–9, fifth tooth situated at level of orbital margin, last tooth distinctly posterior to apex. Adrostral carina strong, separated from teeth by conspicuous groove, dorsal border of groove covered with narrow band of densely set short setae. Postrostral carina well marked, long, almost reaching posterior margin of carapace and lacking notch or depression. Orbital spine absent; postorbital spine slender, sharp, and long; antennal spine minute; pterygostomian spine strong, with broad base; hepatic spine slender, sharp, and as long as postorbital. Branchiostegal and suprahepatic spines lacking. Gastro-orbital sulcus lacking; cervical sulcus, accompanied by raised, sharp carina, gently sinuous, its dorsal extremity ending distinctly ventral to postrostral carina at about midlength of carapace; hepatic sulcus rather deep, subhorizontal posteriorly, anterior part of sulcus accompanied by sharp carina; branchiocardiac carina almost indistinguishable; submarginal carina well defined.

Antennular peduncle about 0.5 as long as carapace. Prosartema narrow, acute, long, attaining proximal 0.4 length of second antennular article, and bearing long, densely set marginal setae. Stylocerite ending in sharp spine and extending 0.6–0.7 distance between its proximal extremity and mesial base of distolateral spine; latter spine sharp, long, reaching as far as proximal 0.3 of second article. Antennular flagella subequal in length, long, 2.2 times carapace length in shrimp 29.5 mm cl and 1.4 in shrimp 50 mm cl; mesial flagellum slender and subcylindrical throughout its length, lateral flagellum moderately depressed in proximal half where about twice as broad as mesial, then becoming filiform. Scaphocerite exceeding antennular peduncle by as much as 0.25 of its own length; lateral rib

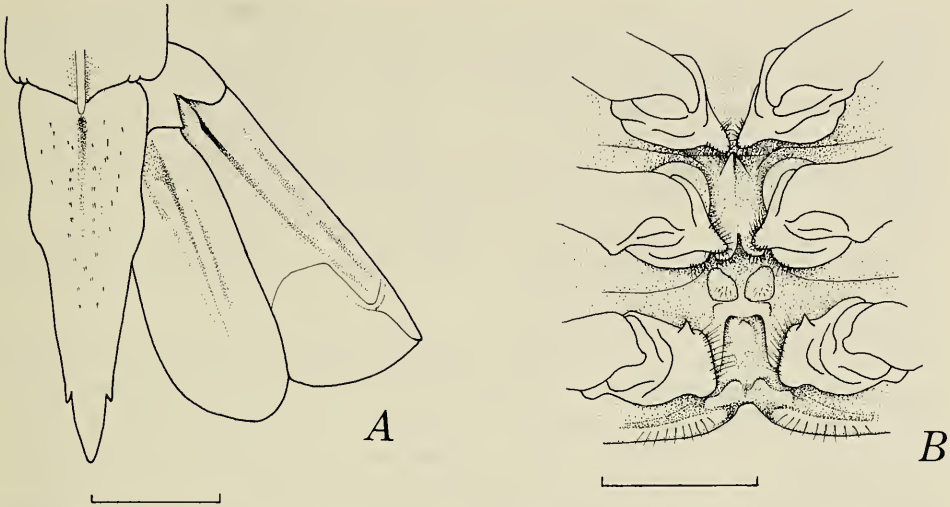

Fig. 2. *Cryptopenaeus crosnieri,* holotype: A, Telson and right uropod, dorsal view; B, Thelycum. Scales: 5 mm.

ending in long spine reaching distal margin of lamella. Antennal flagellum incomplete in all specimens examined.

Mandibular palp reaching between apex of ischiocerite and midlength of carpocerite. Third maxilliped exceeding antennular peduncle by at least length of dactyl and distal extremity, as much as 0.60 length, of propodus. First pereopod extending at least to apex of ischiocerite or as far as distal end of carpocerite. Second pereopod reaching distal end of antennular peduncle or exceeding it by 0.6 length of dactyl. Third pereopod extending to distal end of antennular peduncle or surpassing it by as much as propodus and 0.15 length of carpus. Fourth pereopod overreaching carpocerite by at least distal extremity, or by 0.7 length of dactyl. Fifth pereopod surpassing antennular peduncle by dactyl and at least 0.3 length of propodus or by as much as dactyl and 0.70 length of propodus. Order of pereopods in terms of their maximum anterior extensions: first (shortest), fourth, second, third, and fifth. Third maxilliped falling short of third pereopod. First pereopod armed with elongate acute spine on basis and ischium, and small spine on merus; second pereopod armed with small but sharp spine on basis. Coxa of fifth pereopod in female mesially produced into short plate bearing sharp spine anteromesially.

Abdomen either lacking or bearing weak dorsomedian carina along posterior half of second somite; third through sixth somites with well marked carina, sharp except on third; sixth somite armed with moderately strong tooth at posterior end of carina and small spines posteroventrally. Telson (Fig. 2A) bearing small pair of fixed, posterolateral spines; terminal part short, length about twice basal width; median sulcus moderately deep, extending to about midlength. Rami of uropod subequal in length, falling slightly short or barely surpassing apex of telson; lateral ramus with lateral ridge ending in short spine.

Thelycum (Fig. 2B) with subrectangular plate of sternite XIV bearing pair of deep, longitudinal furrows flanked laterally by strong ridges joined anteriorly by transverse one; area between furrows raised into low anteromedian protuberance, apical portion of which sometimes produced into minute spine. Pair of small setose anterior plates, abutting transverse ridge, flat or very slightly convex, and with mesial margins diverging anteriorly. Anterior part of sternite XIII with high median ridge produced anteriorly into strong, anteriorly directed blunt tooth. Posterior thoracic ridge produced anteriorly in paired, thick, biconvex processes separated by median depression, ridge strongly inflated posteriorly.

*Size.*—Females 25–30 mm carapace length, about 91–103 mm total length.

*Geographic and bathymetric ranges.*—This shrimp has been found off eastern Australia (Fig. 4), at a depth of 234 m.

*Discussion.*—*Cryptopenaeus crosnieri* can readily be separated from *C. catherinae* by the following characteristics: the lack of a notch or a depression on the postrostral carina posterior to the level of the cervical sulcus; the longer scaphocerite, which overreaches the antennular peduncle by as much as 0.25 of its own length instead of reaching or barely overreaching the peduncle; and the lack of an ischial spine on the third pereopod. Moreover, the thelycum of *C. crosnieri* bears a pair of flat or very slightly convex plates, with divergent mesial margins, on the anterior part of the sternite XIV, rather than a pair of strong, suboval bosses, as it does in *C. catherinae.* The thelycum of *C. crosnieri* also differs strikingly from that of *C. sinensis* by the armature of sternite XIV which in the latter species consists of one anteromedian and two lateral low, rounded prominences.

It seems worth mentioning that in *C. catherinae,* as in *C. crosnieri,* a very minute spine is present on the merus of the third pereopod, a character that is not mentioned by De Freitas in the original description. This meral spine is absent from the male of *C. sinensis* from Australia. Also, as in *C. crosnieri,* sternite XIII in females of *C. catherinae* is armed with a median carina produced anteriorly in a strong tooth, a feature not cited by De Freitas.

*Etymology.*—It is a pleasure to name this shrimp in honor of Alain Crosnier of O.R.S.T.O.M. and the Muséum National d'Histoire Naturelle, Paris, who has contributed greatly to our knowledge of decapod Crustacea.

### *Cryptopenaeus sinensis* (Liu and Zhenru, 1983)
Fig. 3

*Crassipenaeus sinensis* Liu and Zhenru, 1983:171, fig. 1.

*Material.*—1 ♂, Zoological Museum of the Moscow State University, off NW Australia, SW of Cape Leveque, 17°35′48″S, 119°33′00″E, 320–335 m, 28 May 1973, R/V *Lira* haul 63, coll. O. Petrov.

*Supplementary description of male genitalia.*—Petasma (Fig. 3C, D) cincinnulate along proximal half of dorsomedian lobe. Ventromedian lobule with membranous proximal part bordered by lateral rib, latter expanding and then merging distally with heavy sclerotized elongate plate; latter with subcircular terminal flap bearing marginal row of minute spinules and produced proximolaterally in concave, subcylindrical process; dorsal rim of concavity armed with five teeth (in only male available). Dorsolateral lobule supported by heavy rib extending its length and terminating in subacute projection at medial base of terminal part. Ventrolateral lobule heavily sclerotized, with ventral costa produced distally in

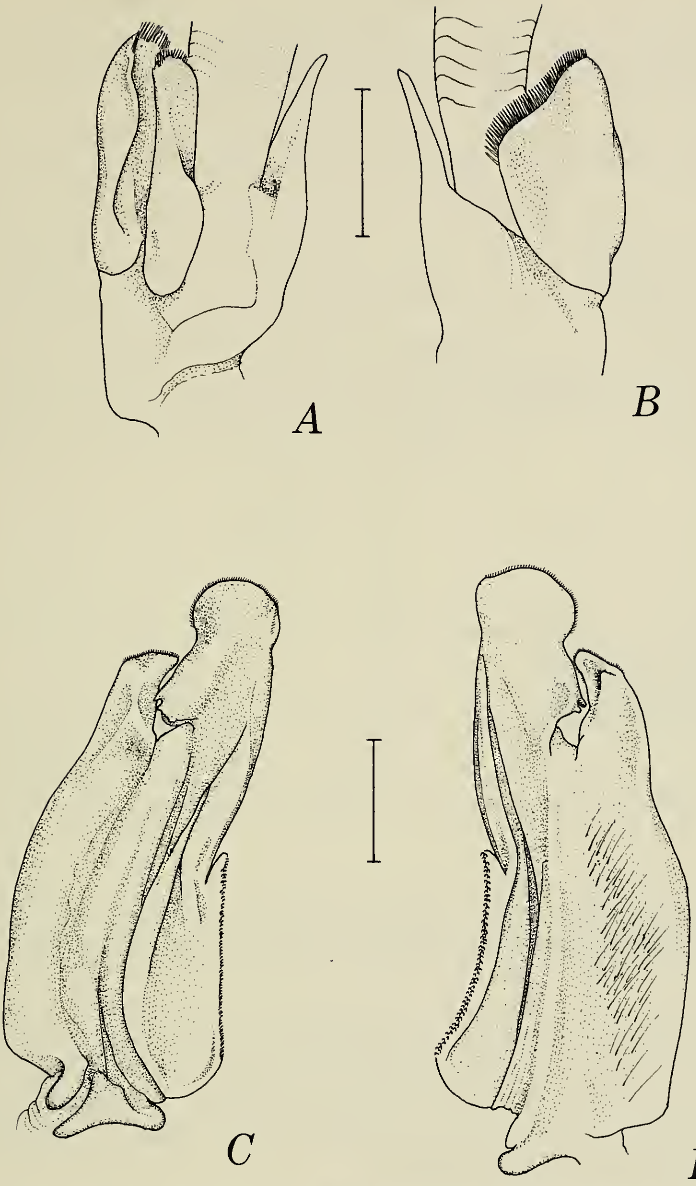

Fig. 3. *Cryptopenaeus sinensis,* ♂ 40 mm carapace length, off NW Australia: A, Ventral view of left appendices masculina and interna, and distolateral spur; B, Dorsolateral view of left appendix masculina and distolateral spur; C, Dorsal view of left half of petasma; D, Ventral view of same. Scales: A, B = 2 mm, C, D = 3 mm.

angular projection, its apex curving towards subcylindrical process and bearing marginal row of very minute spinules.

Appendix masculina (Fig. 3A, B) roughly trapezoidal, convex dorsally, excavate ventrally, with distal margin oblique and bearing short, stout setae; appendix interna subequal in length to appendix masculina, with lateral base expanded,

Fig. 4. Australian localities from which *Cryptopenaeus crosnieri* and *C. sinensis* were collected.

and rounded distal margin armed distally with brush of stout setae. Basal sclerite with lateral wall produced distolaterally in foliaceous projection terminating in blunt spur.

*Discussion.*—Liu and Zhenru (1983) proposed the new genus *Crassipenaeus* for their new species *C. sinensis,* recorded from 261 m in the South China Sea. Having compared the description of this genus with that of *Cryptopenaeus* De Freitas, 1979, it has become obvious that there are no significant differences between the two taxa to justify their separation. Consequently, we regard *Crassipenaeus* as a synonym of the earlier *Cryptopenaeus.*

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(IPF) National Marine Fisheries Service, Systematics Laboratory, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560; (BK) Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

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# THE FAUNA OF ATLANTIC MARINE CAVES: EVIDENCE OF DISPERSAL BY SEA FLOOR SPREADING WHILE MAINTAINING TIES TO DEEP WATERS

C. W. Hart, Jr., R. B. Manning, and T. M. Iliffe

*Abstract.*—Evidence is presented that significant ties exist between the faunas of marine caves and those of the deep seas, that marine cave faunas may contain very old elements, and that marine caves have served as faunal refuges over very long periods of time. In addition, the term "*crevicular*" is introduced to designate those aquatic habitats formed by crevasses in and among rocks, as well as to describe the organisms that live in those habitats.

We feel that data recently gathered in Bermuda, the Bahamas, the Turks and Caicos, Ascension, and the Canary Islands (Fig. 1) shed light on some of the puzzling distributional patterns noted for cavernicolous crustaceans found on oceanic islands of the Atlantic and the Pacific, and bear generally on sea floor spreading.

In our work we have been dealing exclusively with (and drawn our conclusions from) invertebrates—primarily shrimps—that inhabit anchialine waters and marine caves. That is, waters having no surface connection with the sea, but which nevertheless contain salt or brackish water the level of which fluctuates with the tides.

Sket and Iliffe (1980) summarized information then available on the fauna of the caves of Bermuda, and reported that pools in the caves were inhabited by a wide variety of marine invertebrates—ranging from ciliates to tunicates. In discussing the zoogeographical affinities of the cave fauna of the island, they noted striking zoogeographical connections between Bermuda and the east, and commented on four theories that had been proposed to explain the distribution of marine cave organisms:

1) Plate tectonics, as stated by Sterrer (1973) for interstitial fauna, was discussed and partially rejected because Bermuda had never been a part of the continental plates.
2) Stranding on the shoreline of receding fossil seas, as suggested by Stock (1977), was ruled out because Bermuda was too young to have experienced significant shoreline changes.
3) Connections with the abyssal depths, as suggested by Webb (in Sterrer 1973), was discounted because it was felt that changes in meiofauna with depth and substrate indicated that such interconnections were unlikely. Also, at that time no abyssal species had been identified from the caves.
4) Drifting on flotsam was deemed to be a possibility for short distances—such as from the Caribbean—but Bermuda was close enough to Africa for this to have been feasible only for a comparatively short time after the island was formed, about 110 million years ago.

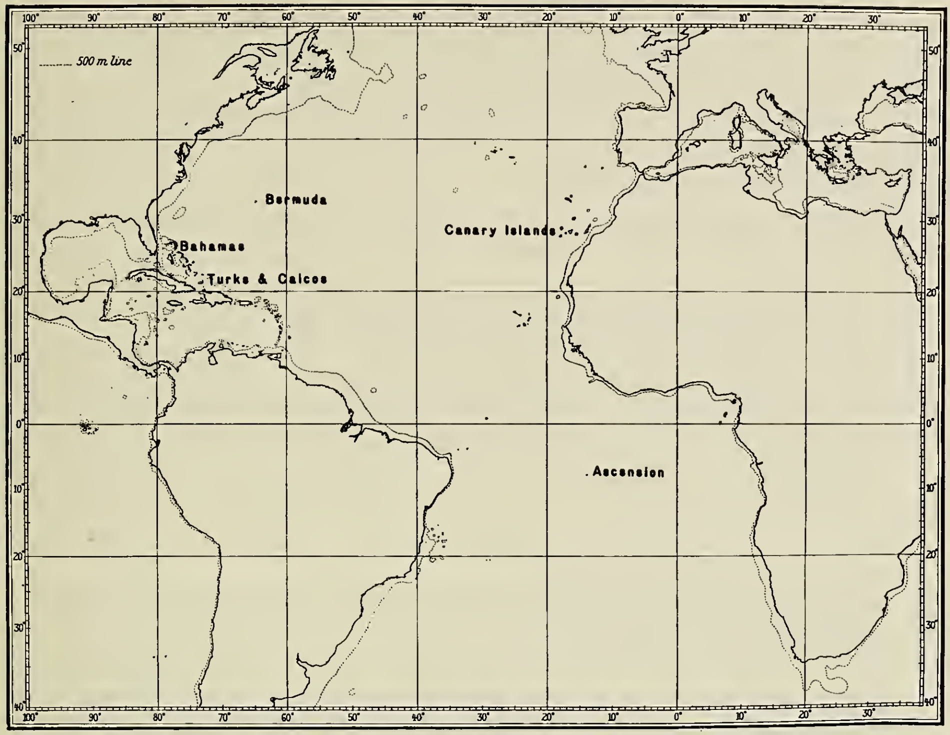

Fig. 1. Map showing Atlantic and Caribbean islands or island groups from which the organisms discussed in this paper were taken.

Since the Sket and Iliffe paper appeared, only four years ago, additional data have been gathered on the caves of Bermuda, the Turks and Caicos, the Bahamas, and the Canary Islands that allow us to expand on these observations—particularly as they relate to shrimp distributions and to abyssal connections.

With some of the cave organisms, it might be easy to believe that they could reach Bermuda through oceanic dispersal of pelagic larvae. The occurrence of species on Bermuda that are widespread in similar habitats in the Caribbean is such an example. However, the fact that we do not yet know if those shrimp produce pelagic larvae weakens such an hypothesis.

With other cave shrimps, however, it is even more difficult to create a scenario for their dispersal. *Typhlatya iliffei* Hart and Manning, 1981, endemic to Bermuda, has as its closest relative *Typhlatya rogersi* Chace and Manning, 1972—a species that is endemic on Ascension Island in the Southern Atlantic. The remaining representatives of the genus occur in subterranean fresh waters of Caribbean islands, Mexico, Central America, and the Galapagos.

The genus *Procaris* was described from Ascension Island by Chace and Manning (1972) and the following year Holthuis (1973) described another species belonging to the genus from Hawaii. Only recently a third species has been found on Bermuda (Hart, Manning, and Iliffe, in prep.).

The distributions of these species, as well as that of the *Ligur-Barbouria-Somersiella* complex spanning the Atlantic from the Mediterranean to Bermuda and the Caribbean (Manning and Hart 1984), lead us to give added credence to the deep-sea ties of these species, as well as emphasizing the hypothesis that some of the island species may represent relicts of ancient stocks.

Our investigations have revealed a number of examples leading to these conclusions, and a survey of the literature has yielded others. With regard to deep-sea ties, the following seem relevant:

1) Material recently collected in a Bermuda cave by Iliffe contained a representative of a new order of Peracarida (Bowman and Iliffe 1985). Almost simultaneously, a closely related species was collected in the open ocean at a depth of 1000 meters. (Sanders, Hessler, and Garner 1985).
2) A new halocyprid ostracod that has been found in a Bermuda cave is considered by Martin Angel (personal letter to Iliffe) to be intermediate between the undoubtedly ancient Thaumatocyprididae and the Halocyprididae. Angel suggests that this indicates the cave faunas to be important links in establishing the evolution of the present oceanic faunas.
3) An undescribed polychaete from a cave in the Turks and Caicos, representative of a group otherwise known from deep waters, is presently being described by Marian Pettibone.
4) A new ostracod from the Turks and Caicos, with deep sea relatives, is being described by L. S. Kornicker.
5) A new shrimp family from the Turks and Caicos, related to the bresiliid shrimp recently described from the thermal vents of the Galapagos Rift (Williams and Chace 1982), is being described by Hart, Manning, and Iliffe (in prep.).
6) A species of *Munidopsis* (*M. polymorpha* Koelbel), a speciose genus otherwise known from shelf, slope, and abyssal depths (Doflein and Balss 1913), is among the inhabitants of a lava tube formed 3000–5000 years ago in Lanzarote, Canary Islands. Wilkens and Parzefall (1974) suspect that this shrimp and other inhabitants of the lava tube might be widespread in the neighboring Atlantic. Miyake and Baba (1970), in their list of the known West African species, gave no records for this species outside of caves.
7) Another inhabitant of that lava tube is a species of the amphipod genus *Spelaeonicippe,* family Pardaliscidae, which, as pointed out by Stock and Vermuelen (1982:4), "are predominantly bathyal/abyssal/hadal, pelagic Amphipoda." These same authors described a second species of this genus from waters of a limestone cave on Providenciales, Turks and Caicos.
8) In addition, Pettibone (1976) discussed a polynoid polychaete, *Gesiella jameensis,* from the same lava tube. The polychaete belongs to a subfamily otherwise known only from deep water.
9) And three other genera—*Barbouria, Ligur,* and *Somersiella*—known primarily from anchialine or cave habitats point in the same direction. Four of the five species assigned to these genera occur only in these habitats, but the type-species of *Ligur* is a deep-sea species, known only from shelf-slope depths.

As for the possible antiquity of some crustacean species, J. Tuzo Wilson (in litt.) suggested that "it is just conceivable that forms of life might have survived on Ascension from the time when the Atlantic was very narrow and the forerunners of Ascension were in contact with Brazil and the Cameroons."

Following on this, Hobbs and Hart (1983), in a review of the genus *Atya,* found that two species—*A. gabonensis* and *A. scabra*—are identical on both sides of the Atlantic, and that *Atya intermedia* (inhabiting two islands in the Gulf of Guinea) is so similar to *Atya innocous* (inhabiting the Greater and Lesser Antilles and Central America) that they were reluctant to recognize them as separate species. They noted that these shrimps must be considered little, if at all, changed since the Africa-America continental masses were still approximate—suggesting that this group of shrimps is extremely old, dating from at least the Middle Jurassic, 175 million years ago.

And finally, Iliffe, Hart, and Manning (1983) hypothesized that part of the cavernicolous invertebrate marine fauna of Bermuda represent groups that survived on submerged or emergent sea mounts along the Mid-Atlantic Ridge since the early Mesozoic, and that geothermal activity may have maintained water temperatures in caves sufficiently high to protect certain species during periods of glaciation.

## Conclusions

We believe that the evidence presented here supports the conclusions 1) that there are significant ties between the marine cave fauna and the fauna of the deep sea, 2) that the cave faunas may contain very old elements, and 3) that caves have served as refuges over very long periods of time.

It seems likely that the subterranean habitats on ocean islands consist not only of caves, but of crevicular habitats in the rock—similar environments that are potentially available for colonization anywhere in the water column. Thus, while surface caves and pools in limestone may be relatively young, the actual habitat may be as old as the island on which it is found.

We use the term "crevicular" to designate those aquatic habitats formed by crevasses in and among rocks. We also use it to describe the organisms that live in those habitats. For the purposes of this definition, a cave sensu stricto is simply a large crevass, or it may be merely the gateway through which smaller crevasses are made accessible to the student of crevicular organisms. The crevicular habitat differs from the interstitial habitat primarily in size, and the animals that live in both habitats are likely to be thigmotactic.

Following on this, it seems probable that species, or species-groups, could form a continuum—reaching from the caves of one island into the deep waters via the natural crevasses among rocks and so on up the slopes of other islands or continental masses.

One does not have to wander far from that idea to see that if crustacean species are as conservative as some appear to be, then the actual spreading of the sea floor could be a means by which some species have achieved their present day distributions.

Indeed, Chace and Hobbs' (1969:21) tongue-in-cheek proposal of a "continuous spelean corridor" between islands may not be so far-fetched after all.

## Acknowledgments

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# INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE

℅ British Museum (Natural History)
Cromwell Road
London SW7 5BD

3 December 1984

The following Opinions have been published by the International Commission on Zoological Nomenclature in the *Bulletin of Zoological Nomenclature,* volume 41, part 4, on 30 November 1984:

| *Opinion No.* | |
|---|---|
| 1277 (p. 212) | *Ptilium* Gyllenhal, 1827 and *Ptenidium* Erichson, 1845 (Insecta, Coleoptera): conserved. |
| 1278 (p. 215) | The generic name *Rhincodon* A. Smith, 1829 (Pisces): conserved. |
| 1279 (p. 218) | *Chrysolina* Motschulsky, 1860 (Insecta, Coleoptera): conserved. |
| 1280 (p. 221) | Rafinesque, C.S., 1822 'On the Turtles of the United States': suppressed. |
| 1281 (p. 223) | *Acmaea limatula* Carpenter, 1864 (Mollusca, Gastropoda): conserved. |
| 1282 (p. 225) | *Panopeus* H. Milne Edwards, 1834 (Crustacea, Decapoda): designation of type species. |
| 1283 (p. 227) | LYMANTRIIDAE Hampson, [1893] given nomenclatural precedence over ORGYIIDAE Wallengren, 1861 and DASYCHIRIDAE Packard, 1864 (Insecta, Lepidoptera). |
| 1284 (p. 231) | *Peggichisme* Kirkaldy, 1904 (Hemiptera, Heteroptera): designation of type species. |
| 1285 (p. 233) | *Barbus altianalis* Boulenger, 1900 and *B. rueppelli* Boulenger, 1902 (Pisces, Cyprinidae): conserved. |
| 1286 (p. 235) | *Chermes fusca* Zetterstedt, 1828 (Insecta, Homoptera): conserved. |
| 1287 (p. 238) | *Sesia andrenaeformis* Laspeyres, 1801 (Insecta, Lepidoptera): conserved. |

The Commission regrets that it cannot supply separates of Opinions.

R. V. MELVILLE
Secretary

# INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE

% British Museum (Natural History)
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3 December 1984

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Correspondence should be addressed to the Secretary at the above address, if possible within six months of the date of publication of this notice.

| *Case No.* | |
|---|---|
| 2136 | THRESKIORNITHIDAE Richmond, 1917 (Aves): application to place on Official List of Family-Group names in zoology and to give precedence over PLATALEINAE Bonaparte, 1838, and other competing Family-Group names. |
| 1854 | *Cricetodon minus* [sic] Lartet, 1851 (Mammalia, Rodentia): revised request for a ruling on interpretation. |
| 2115 | Report on *Glyphipterix* Hübner, [1825] (Insecta, Lepidoptera). |
| 2469 | *Octolasion* Örley, 1885 (Annelida, Oligochaeta, Lumbricidae): ratification of the designation of the type species and the introduction of *Octolasion* (*Octodrilus*) by Omodeo, 1956 in accordance with usage, with the suppression of the designation of the type species and of the names *Octolasion* (*Incolore*) and *Octolasion* (*Purpureum*) by Omodeo, 1952. |
| 1766 | Revised submission regarding the nominal genus *Diplosoma* MacDonald, 1859 (Ascidiacea), and proposed alternative designation of *Leptoclinum fulgens* Milne Edwards, 1841, as type species of *Leptoclinum* Milne Edwards, 1841. |
| 2318 | *Aphodius rufus* Moll, 1782 and *Aegialia rufa* Fabricius, 1792 (Insecta, Coleoptera): proposed conservation under the plenary powers by suppression of *Aphodius scybalarius* Fabricius, 1792. |
| 2300 | Proposed use of plenary powers to conserve certain junior synonyms in the family PYGOPIDAE (Brachiopoda). |
| 2082 | *Delphinus truncatus* Montagu, 1821 (Mammalia, Cetacea): proposed conservation by suppression of *Delphinus nesarnack* Lacépède, 1804. |

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# A NEW SPECIES OF THE COLUBRID SNAKE GENUS *LIOPHIS* FROM BRAZIL

James R. Dixon

*Abstract.*—A new species of the colubrid snake genus *Liophis* (*L. maryellenae*) is described from the Brazilian state of Minas Gerais. Its closest congener is *L. jaegeri,* differing only in the number of body scale rows. The new species shows some affinities to *L. viridis* by its color and body scale rows.

A total of approximately 5600 specimens of 31 species of the colubrid snake genus *Liophis* were examined during the past eight years. Nearly all species were represented by 15 or more specimens. However, one taxon, represented by only ten individuals, was unique in having a combination of relatively small size at sexual maturity (474 mm total length), a scale row reduction of 19-19-17, no apical scale pits, and relatively high numbers of long, slender maxillary teeth (25–28). This taxon is similar to *Liophis jaegeri* in size, somewhat in color and color pattern, number of ventrals, subcaudals, head scales, maxillary teeth; tail length/total length ratio, and length of in situ hemipenes. However, it differs in the number of scales around the body. The species is also similar to *Liophis viridis* in color, number of scales around the body, but differs by fewer number of ventrals, higher tail length/total length ratio, and number of maxillary teeth. Other *Liophis* species that occur sympatricly or parapatricly with the new form are *L. miliaris, L. poecilogyrus, L. jaegeri, L. almadensis,* and *L. dilepis.*

## *Liophis maryellenae,* new species
Fig. 1

*Holotype.*—American Museum of Natural History (AMNH) 62202, adult male, taken (with AMNH 62206) from Annapolis (16°20'S–48°58'W), Goias, Brazil, 7 Mar 1936, by R. M. Gilmore (found unlabelled with Gilmore collection when material was cataloged).

*Paratypes* (All from Brazil).—AMNH 62206 female, Annapolis, Goias; Texas Cooperative Wildlife Collection (TCWC) 57701, female, 13°10'S, 46°00'W, ca. 150 km SW Barreiras, Bahia; Natural History Museum, Paris (MNHP) 3565, female, "Brazil"; Museum of Zoology, University of São Paulo (MZUSP) 6609 male, D. F., Brazilia (16°12'S, 44°26'W); MZUSP 8059 male, Minas Gerais, Itambe do Mato Dentro (19°24'S, 43°19'W); MZUSP 7989 female, Minas Gerais, Grao Mogol (16°34'S, 42°54'W); Instituto Butantan (IB) 1209 male, IB 5680 female, Minas Gerais, Araguari (18°39'S, 48°12'W); IB 12559 male, Minas Gerais, Ouro Branco.

*Description of holotype.*—Measurements in mm; total length 325; tail length 81; tail/total length ratio 0.249; head length 11.5; head width 6.8; eye diameter 2.4; eye/nostril distance 2.2; eye/snout distance 3.4; frontal width 2.1; frontal length 4.0; head width/head length ratio 0.59; eye diameter/eye–nostril distance 0.936; frontal width/frontal length ratio 0.525.

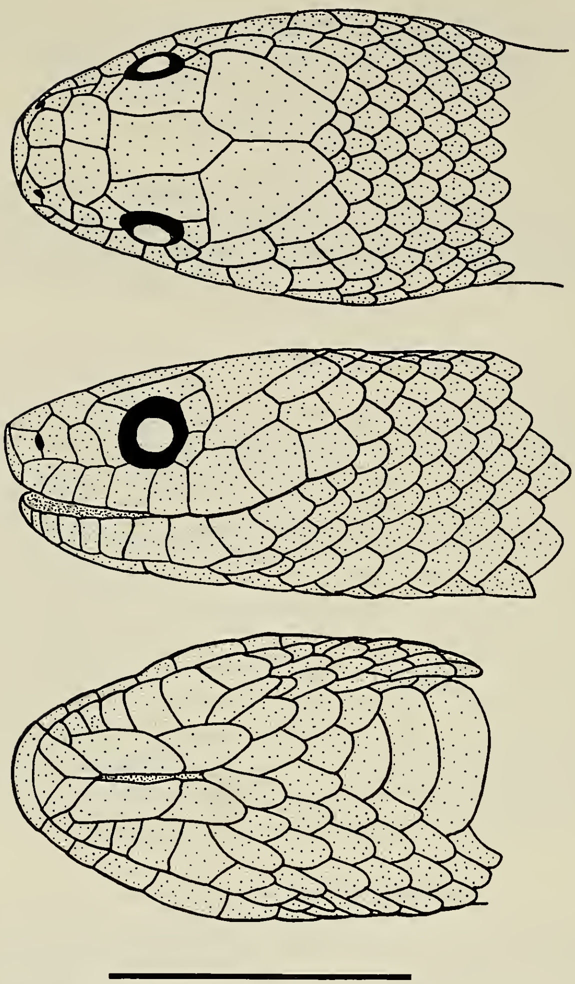

Fig. 1. Dorsal, lateral and ventral views of the head of *Liophis maryellenae* (TCWC 57710). Black bar equals one cm.

Scale rows number 19-19-17, smooth, no apical scale pits, reduction to 17 scale rows occurs through fusion of scale rows 3 + 4 over 79th ventral; tail scale row reduction 8-6-4-2 over 9th, 18th, and 41st subcaudals, respectively. Ventrals number 150, subcaudals 69; supralabials are 8-8, with 4th and 5th entering orbit; infralabials 10-10; preoculars 1-1, postoculars 2-2, temporals 1 + 2, loreal 1-1, 27 maxillary teeth, last two enlarged, ungrooved and separated from remainder by diastema equal to width of ectopterygoid process of maxillary; anal shield divided. Color (in alcohol): overall grayish brown; head uniform grayish brown; anterolateral portion of nasal scale and dorsal tip of rostral, whitish; supralabials 1–4 tipped with grayish brown, supralabials 7–8 dark grayish brown, remainder of supralabials, infralabials, chin, throat, and anterior 10–12 ventrals whitish. Hemipenes spinose, without calyces, but with apical, smooth disc; in situ hemipenis 12 subcaudals in length, slightly bilobed, lobe about two subcaudals in length; sulcus spermaticus forks at sixth subcaudal; basal naked pocket present; shank of hemipenis with moderate sized spines that slowly decrease in size towards tip of apical disc.

*Variation.*—The five female paratypes differ from the holotype as follows: number of ventrals vary from 146–153, $\bar{x} = 149.6$; number of subcaudals vary from 62–73, $\bar{x} = 66.2$; infralabials 10(4), 11(1); supralabials, preoculars, postoculars, temporals, supralabials entering orbit, loreal, and anal plate invariate, 8, 1, 2, 1 + 2, 4 + 5, 1, divided, respectively; tail/total length ratios vary from 0.221–0.254, $\bar{x} = 0.237$; total length varies from 295–530, $\bar{x} = 420.8$ mm; reduction site varies from 82nd to 85th, $\bar{x} = 84.2$ ventral; diameter of eye/snout distance ratio varies from 0.605–0.697, $\bar{x} = 0.666$; tail scale row reduction of 8-6-4-2 occurs over subcaudals 9, 23, 48, or 8, 23, 50, respectively (not recorded for MNHP specimen).

The AMNH female paratype has a paravertebral dark stripe beginning at the 96 ventral on the seventh scale row, passing posteriorly onto the upper edge of the fourth scale row of the tail. Gilmore's field notes for the latter specimen are "neck greenish, below and behind yellowish brown." Color in life of the Bahia (TCWC) specimen "dark gray-green dorsum, yellow-orange venter." Neither color descriptions mention the presence of lateral and/or paravertebral dark lines of the body, but they are present in preservative (Fig. 2a, b).

Besides the faint "lined" patterns that appear in preservation, definite areas of darkened pigment appear as well as defined patterns in other specimens (Fig. 2c, d). The patterns may appear as paravertebral lines on the eighth scale row and a series of dashes or dots on scale row four and frequently parts of scale rows three and five. Occasionally, a series of black flecks (spots?) occur in scale rows one, two, three, four, seven and/or eight, or any combination of these. The venter is immaculate cream or yellowish in preservation, with some darkening along the outer edge of scale row one and the adjoining ventral. The dark color may extend completely across the ventral along its anterior edge.

Five males vary as follows: number of ventrals vary from 144–159, $\bar{x} = 152.2$; number of subcaudals vary from 64–82, $\bar{x} = 69.6$; supralabials, infralabials, preoculars, postoculars, temporals, supralabials entering orbit, loreal, and anal plate invariate, 8, 10, 1, 2, 1 + 2, 4 + 5, 1, divided, respectively. The tail/total length ratio varies from 0.234–0.262, $\bar{x} = 0.243$; total length varies from 325–435, $\bar{x} = 394.4$ mm; hemipenial length in situ varies from 9.5 to 12, $\bar{x} = 10.5$ subcaudals; reduction site varies from the 78th to 95th, $\bar{x} = 83.4$ ventral; diameter of eye/snout distance ratio varies from 0.632–0.844, $\bar{x} = 0.706$; tail scale row reduction of 10-8-6-4-2 for two males and 8-6-4-2 for one male occur over subcaudals 7, 17, 38, 63; 5, 7, 26, 58; 10, 20, 43, respectively. Maxillary teeth for both sexes vary from 25–28; $\bar{x} = 26.1$.

*Distribution.*—This taxon is known only from the tablelands of southeast Brazil (Fig. 3).

*Comments.*—Two "green" *Liophis* species (*jaegeri, viridis*) are sympatric and/or parapatric with *L. maryellenae. Liophis viridis* appears to be sympatric with it (at least the ranges appear to overlap) in eastern Brazil (Fig. 3), and *Liophis jaegeri,* its closest congener, overlaps the southeastern distribution of *L. maryellenae* (Fig. 3).

*Liophis maryellenae* and *L. jaegeri* may hybridize where the range of the two species coalesce in the vicinity of Belo Horizonte, Minas Gerais. There are seven specimens (Instituto Butantan) from the latter vicinity that show aberrancies in

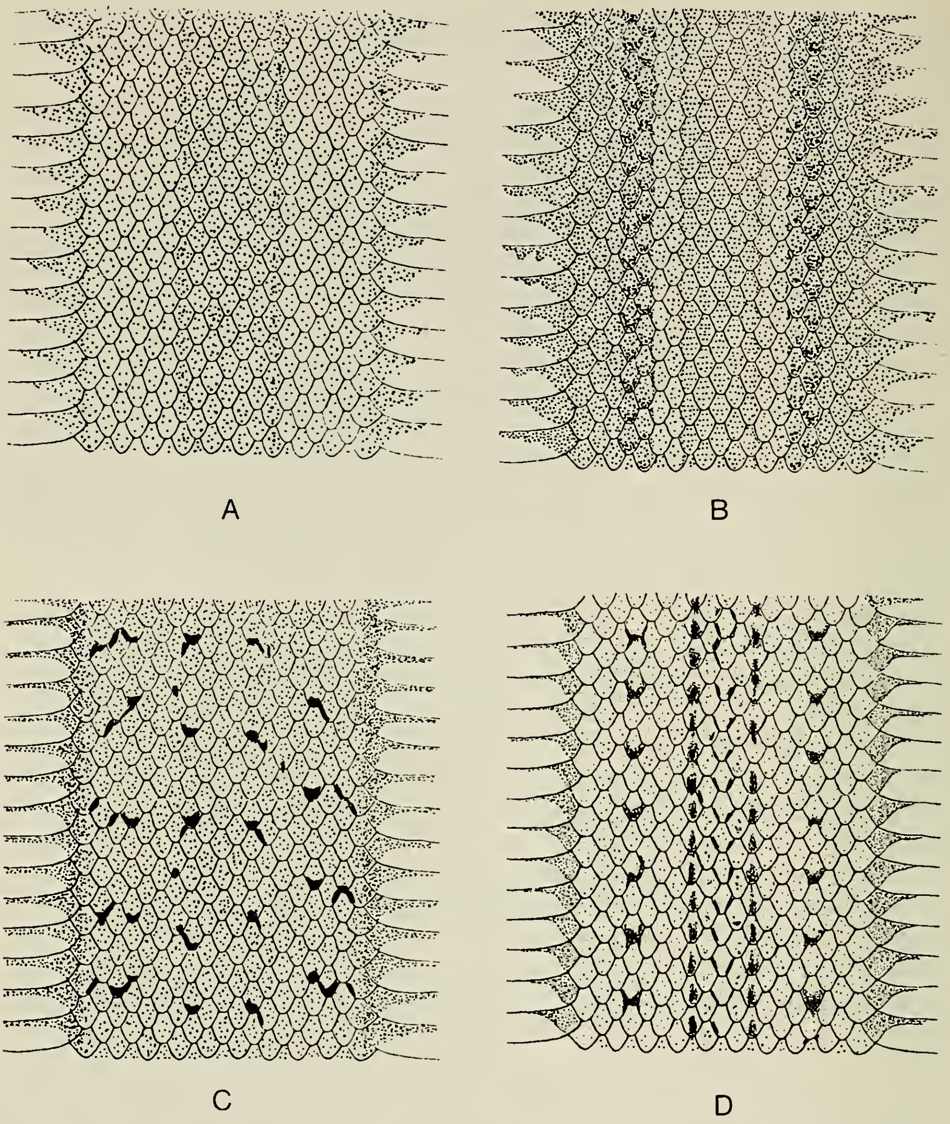

Fig. 2. Dorsal color patterns of four individuals of *Liophis maryellenae*. A, MZUSP 8059; B, TCWC 57701; C, MZUSP 7989; D, AMNH 62202.

their scale row reductions. Three individuals have a simple reduction pattern (Dowling 1951, method), i.e.,

$$18(10)\frac{\phantom{3+4\ (44)}}{3+4\ (44)}17(156);\quad 19(10)\frac{4+5\ (49)}{4+5\ (53)}17(149);\quad 18(10)\frac{\phantom{3+4\ (49)}}{3+4\ (49)}17(150).$$

The remaining four specimens have very complicated reduction patterns of division and fusion of scale rows three and four and/or four and five on the same, opposite and/or alternating sides of the body. The explanation of the reduction

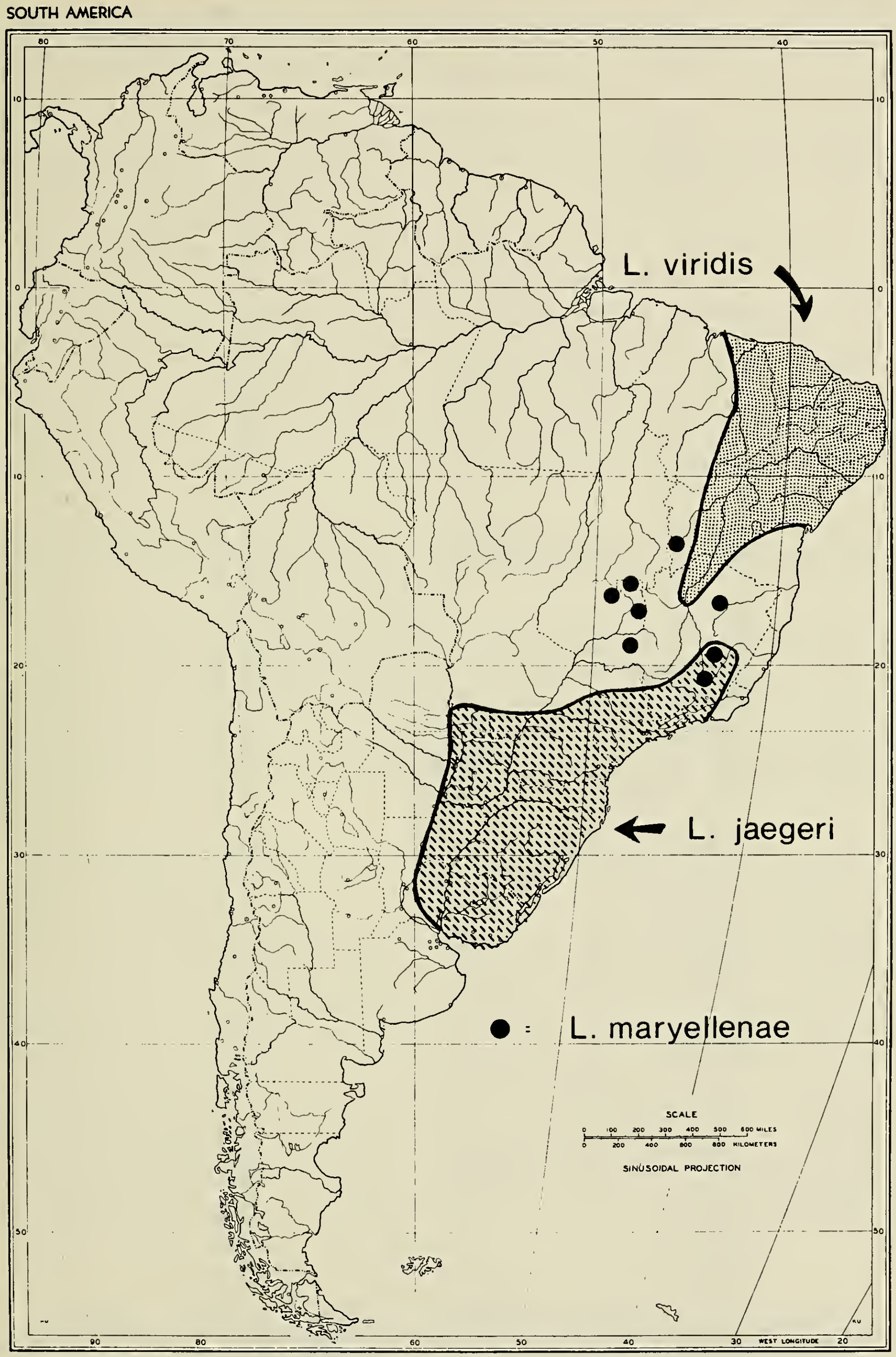

Fig. 3. Distribution of *Liophis maryellenae* in Brazil. Black dots are known localities for *L. maryellenae*; shaded dot area represents the known distribution of *L. viridis*; diagonal dashed area represents the known distribution of *L. jaegeri.*

Table 1.—Scutellation characters of two populations of *Liophis viridis,* one of *L. jaegeri* and one of *L. maryellenae.* The total range of variation is given first, followed by the mean, standard deviation, and sample size in parenthesis.

| | Ventrals | | | Reduction site | | | Subcaudals | | | Maxillary teeth | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *L. viridis* (interior) | 181–202 | 189.8 | 4.30 (98) | 102–124 | 114.6 | 5.40 (40) | 68–84 | 75.1 | 3.10 (84) | 17–24 | 20.4 | 1.1 (92) |
| *L. viridis* (coastal) | 169–188 | 179.6 | 4.36 (57) | 98–116 | 106.6 | 4.80 (57) | 63–83 | 72.8 | 4.30 (54) | 17–22 | 19.8 | 1.4 (42) |
| *L. maryellenae* | 144–159 | 150.9 | 4.30 (10) | 74–95 | 82.9 | 5.50 (10) | 62–82 | 68.0 | 5.90 (10) | 25–28 | 26.1 | 0.9 (10) |
| *L. jaegeri* | 146–169 | 157.5 | 4.50 (151) | normally absent* | | | 52–75 | 61.2 | 4.20 (124) | 22–29 | 25.6 | 1.5 (128) |

Simplified scale row reductions

| | | |
|---|---|---|
| *L. viridis* (interior) | 19-19-17 | (98 specimens) |
| *L. viridis* (coastal) | 19-19-17 | (57 specimens) |
| *L. maryellenae* | 19-19-17 | (10 specimens) |
| *L. jaegeri* | 17-17-17 | (136 specimens) 19-17-17 (1), 17-17-16 (5), 17-17-15 (8) |

* When posterior reductions occur in *L. jaegeri,* they fall between ventrals 88–141, with a mean of 121.2.

mode for one specimen would fill one-half of a printed page (see Thomas and Dixon 1976). The standard counts of body scale rows for these four specimens (10 ventrals posterior to gular scales, midbody, and 10 ventrals anterior to vent) are 18-19-17 (two spec.), 19-17-17, and 19-17-15. One specimen with abnormal body scale rows is from the city of São Paulo. It is an aberrant *L. jaegeri* with a standard body scale row count of 17-17-17. However, an examination of the scale rows by the Dowling method would suggest that the scale rows are (summarized) 17-18-19-18-17-17-19-17-17 (159).

Of the seven specimens from the southeastern edge of the distribution of *L. maryellenae,* two with 19 scale rows at midbody have ventral counts of 148 and 149, well within the median range of *L. maryellenae.* The remaining five specimens with 17 scale rows at midbody have ventral counts of 149, 150, 150, 156, and 157. Three of these have median ventral counts for *L. maryellenae,* and two have the median ventral counts for *L. jaegeri.* In addition, one individual has 36 maxillary teeth (one side), considerably higher than the known range for either *L. jaegeri* or *L. maryellenae* (see Table 1), suggesting considerable abnormality of the sample.

*Liophis viridis* has a reduction pattern similar to *L. maryellenae,* but has significantly lower numbers of maxillary teeth, higher numbers of ventrals, and higher numbers of ventrals at the first dorsal scale row reduction site ($P = 0.001$) (Table 1).

The data suggest that *L. maryellenae* and *L. jaegeri* are closely related but there are significant differences between them in the scale row reduction mode, numbers of ventrals, subcaudals ($P = 0.001$) and the numbers of maxillary teeth ($P = 0.005$). However, the seven specimens mentioned above suggest a zone of hybridization. The hybrid zone may be extremely narrow because typical specimens of each species have been taken 17 airline km apart without evidence of hybridization.

A description discrepancy occurred in Günther's (1858) description of *Coronella jaegeri.* Günther maintained that *L. jaegeri* had "seventeen or nineteen rows." Neither of Günther's cotypes have 19 scale rows, but he may have examined one with 19 rows but failed to include it with the specimens examined. Boulenger (1894) and Peters and Orejas-Miranda (1970) perpetuated Günther's statement of *L. jaegeri* having 17 or 19 scale rows. Jensen (1900) stated that his new taxon, *Rhadinaea lineata* (ZMUC 601253), from Taboleiro Grande, Minas Gerais, had 19 scale rows. An examination of its essential features indicates that the scale rows are 17 and other scutellation features are similar to *L. jaegeri.* Hence, we have two descriptions that suggest that one or more individuals of *L. maryellenae* may have been examined by Günther and Jensen and left out of their type series, or both men made errors in their original counts. A recent report concerning the salient features of *L. jaegeri* suggests that it has only 17 scale rows (Miranda et al. 1982). I have examined 151 individuals of *L. jaegeri* and all have 17-17-17 or 17-17-15 scale rows (not including aberrancies mentioned in text).

*Etymology.*—Because of my wife's dedication to my interest in obtaining knowledge of neotropical herpetology, and especially her indulgence in aiding me to accumulate data on over 5000 specimens of *Liophis,* I take pleasure in naming the species for her.

## Acknowledgment

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# THE GENUS *PARANAIS* (OLIGOCHAETA: NAIDIDAE) IN NORTH AMERICA

Ralph O. Brinkhurst and Kathryn A. Coates

*Abstract.*—Nephridia have been found in some specimens of three *Paranais* species. These vary in degree of development from rudimentary structures to fully formed but closed nephridia, all within each species. Because the genus *Wapsa* is identical to *Paranais* apart from the supposed absence of nephridia in the latter, we now regard *Wapsa* as a synonym of *Paranais. Paranais birsteini* Sokolskaya is reported from the Pacific Northwest, bringing the total number of *Paranais* species in North America to four. *Wapsa grandis* Harman is transferred to *Paranais*; *Paranais frici* Hrabe is confirmed as a North American species with *Wapsa mobilis* Liang as a probable synonym. The type-species, *Paranais litoralis* (Muller) is widely distributed in North America.

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While *Paranais litoralis* (Muller) has been recognised as part of the North American fauna since 1905 (Moore 1915), it was not until much later that the second species, *Paranais frici* Hrabe was identified in the San Francisco Bay area (Brinkhurst and Simmons 1968). The latter is now recognised as a North American species by its original describer (Hrabe 1981).

The genus *Wapsa* was erected by Marcus (1965) for a single Brazilian species, *W. evelinae,* the new genus being separable from *Paranais* by the presence of nephridia. Brinkhurst (1971) transferred the Chinese species *Paranais mobilis* Liang to *Wapsa* because it shared the nephridial character with the type-species, and both species have papillate body walls. Harman (1977) described *Wapsa grandis* based on differences between this species (from Louisiana) and the two existing *Wapsa* species, but relied on the papillate nature of the body wall for the separation from *Paranais* species. Hiltunen and Klemm (1980) preferred to recognise other papillate North American material (with setae that differ from those of *W. grandis*) as *W. mobilis* rather than *P. frici,* a position not supported by Brinkhurst and Kathman (1983). The separation of the genus *Wapsa* from *Paranais* can no longer be maintained because it is shown here that nephridia may be present in all of these species, and that there may be at least some accumulation of foreign material, with or without papillae, on the body wall in all of them. This, coupled with the discovery of a fourth North American taxon in a large collection of fully mature specimens from many parts of the world, has prompted this revision of the genus *Paranais* with special reference to the North American forms.

## Methods

This study was based on examination of stained whole mounted specimens of all four North American species in Canada Balsam, sectioned material of *P. litoralis* and *P. frici,* and some unstained whole mounted material, all from a variety of sources noted under each specific account. Mature specimens were used throughout. A much larger collection of immature specimens from Western Europe and North America was not used even though all four species can now be recognised on the basis of somatic characters alone, and two species have a limited distribution.

The type-specimens of *P. botniensis* from the Swedish Museum of Natural History were examined for us by C. Erséus.

Not all of those characteristics that were measured (setal lengths, widths and lengths of atria and spermathecae, thickness of the walls of those organs) could be discerned on every specimen, so that the number of measurements reported in Table 1 and Fig. 4 is less than the number of mature specimens available. Hotelling's $T^2$ statistic (generalised t statistic) was used to test for a significant difference between the mean lengths and widths of the atria in *P. litoralis* and *P. birsteini.*

Since complete synonymies were reported by Brinkhurst (1971), only those citations published subsequent to that account are documented here.

### *Paranais* Cerniavsky, 1880

No eyes. Setae all of one shape, starting in V dorsally, II ventrally. Ventral setae of II often slightly longer than rest, and somewhat more lateral in position. Glandular pharyngeal pouch in III, pharyngeal glands in IV. Nephridia closed, or absent, variable within a species. Coelomocytes present. Spermathecae and testes in IV, ovaries and atria in V, no prostates on either atria or vasa deferentia. Penial setae slightly or fully modified. Body wall often with covering of foreign matter, sometimes with papillae. Cosmopolitan.

*Type-species.—Nais litoralis* Muller.

*Remarks.*—The discovery of nephridial tissue in all four North American species of *Paranais* (Fig. 1 illustrates this for two of the species) makes the retention of the genus *Wapsa* Marcus, 1965 unnecessary. As a result, some species of *Wapsa* prove to be synonymous with *Paranais* species as detailed below.

### *Paranais litoralis* (Muller, 1784)

Figs. 1–4, Table 1

*Paranais litoralis* (Muller), subspecies *orientalis* Sokolskaya, 1964:57, fig. 1.

*Diagnosis.*—l = 9–14 mm (living), s = 13–46. Ventral setae of II mostly 5, from 4–7 per bundle, slightly longer than rest (Table 1) with upper teeth distinctly longer than lower. Ventral setae of III–IV mostly 3, sometimes 4 per bundle, with upper teeth nearly equal in length to lower, in median and posterior bundles usually 3, ranging from 2–4, with upper teeth varying from slightly longer to slightly shorter than lower. Penial setae from 3–6 or even 7 per bundle with long, straight, proximal ends and short, strongly curved, distal ends terminating in small bifid tips. Dorsal setae from V, 2–4, mostly 3 per bundle, all with teeth approximately equal in length. Spermathecal ampullae and atria long, 2–5 times longer than broad (average 3.04, n = 42, s = 0.71) atria with muscle layers from 2–18 $\mu$m thick. Spermathecal and atrial ducts distinct but varying in length. Spermathecal pores lie well ahead of and below setal line in IV. Body wall exhibits deep transverse folds (preserved material) with thin layer of attached foreign

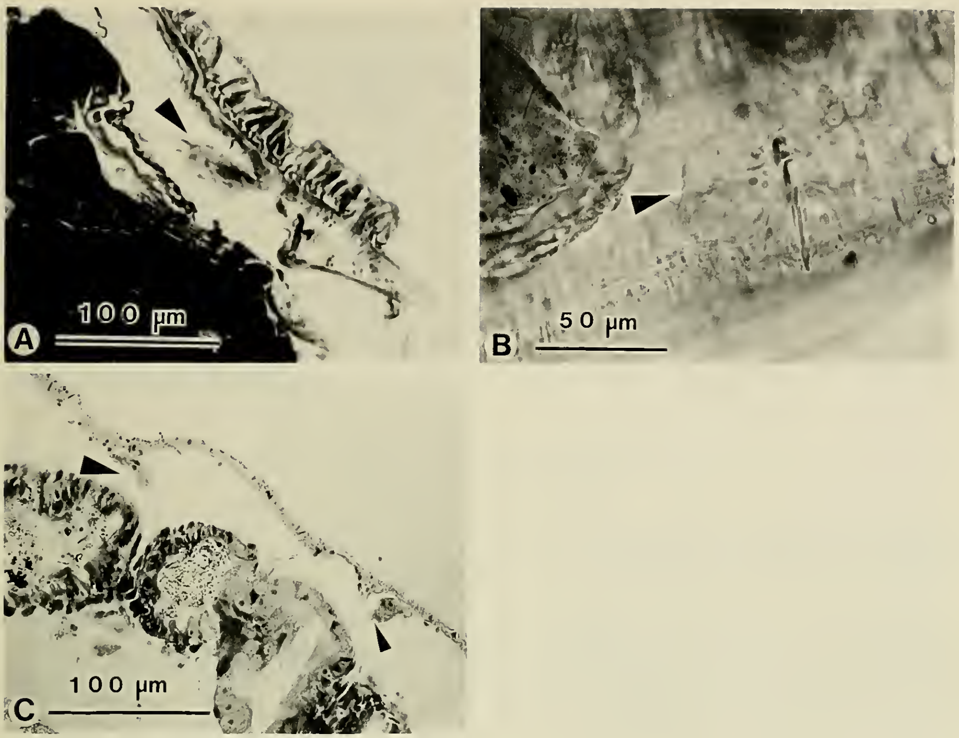

Fig. 1. Nephridial tissue: A, B, *Paranais litoralis*; C, *P. frici.*

material in some specimens. Cosmopolitan. Salt or brackish water, inland as well as coastal.

*Remarks.*—This description is based on examination of 50 mature specimens from North America, Europe, Australia, and Hong Kong. The lengths and breadths of the atria, a feature of importance in the separation of this species from another North American species, *P. birsteini,* are plotted in Fig. 4 for material from five geographic areas. Considerable overlap in the ratios is demonstrated between these five sets of *P. litoralis* material, but when considered as a single set, *P. litoralis* is significantly different to *P. birsteini* ($P$ value less than 0.005). This can largely be attributed to differences in length. Care should be exercised in the application of these measurements, because partially mature or even mature but unmated individuals of *P. litoralis* can yield small values that fall within the range observed for *P. birsteini.* While the length/breadth ratios for spermathecae and atria vary (Europe 2.7, Atlantic North America 2.7, Pacific Canada 2.6, Australia 3.4), we feel that the large degree of overlap observed precludes the recognition of subspecies, such as that erected by Sokolskaya (1964).

This species is common and abundant in so many saline habitats that a listing of those sites from which specimens were obtained in western Europe and North America is unnecessary. Two collections should be mentioned, which are material from Hong Kong (Deep Bay and Tolo Harbour, New Territories, coll. C. Erséus) and Australia (Fraser Island, Gippsland Lakes and Port Phillip Bay, Victoria, G. C. B. Poore, deposited National Museum of Victoria, Melbourne, Australia).

Table 1.—Setal lengths of *Paranais* species, expressed as mean μm($s/\sqrt{n}$). n is a maximum figure, in some instances fewer measures were available.

| Setae from: | II | III/IV | Penial | After VI | n |
|---|---|---|---|---|---|
| *P. litoralis* | | | | | |
| Pacific Canada | 87 (5) | 72 (2) | 87 (5) | 75 (3) | 16 |
| Australia | 69 (4) | 66 (4) | 54 (4) | 60 (4) | 11 |
| Europe | 96 (3) | 78 (3) | 90 (4) | 78 (3) | 14 |
| All specimens | 77 (3) | 72 (2) | 78 (4) | 72 (2) | 41 |
| *P. birsteini* | 69 (2) | 66 (2) | 66 (2) | 66 (2) | 30 |
| *P. frici* | 99 (6) | 87 (4) | 90 (4) | 93 (4) | 15 |
| *P. grandis* | 136 (4) | 96 (5) | 105 (15) | 119 (9) | 8 |

### *Paranais frici* Hrabe, 1941
Figs. 1–3, Table 1

*Paranais frici* Hrabe, Finogenova, 1972:114, figs. 51–53.
*Wapsa mobilis* Liang, Hiltunen and Klemm, 1980.

*Diagnosis.*—l = 9 mm (living), s = 13–42. Ventral setae of II 2–4 per bundle, upper tooth at least twice as long as lower. In all other bundles apart from ventrals of V, 1–2, rarely 3, setae per bundle, all with upper teeth distinctly longer than lower. Penial setae in V thicker than rest, with short distal ends, clearly bifid, 2–3 per bundle. Mean lengths of setae are presented in Table 1. Spermathecal and atrial ampullae small, globular, and having very thin muscle layers. Spermathecal and atrial ducts distinct but variable in length, up to twice as long as broad. Spermathecal pores varying in position from well in front of the ventral setae to beside them in IV. Body wall with transverse furrows and thin layer of foreign matter. Fresh and brackish water, Europe, North America, Africa, possibly South America (see below).

*Material examined.*—Upper Newport Bay, California, Jun 1978, M. Quammen; San Francisco Bay area, 1961/62, see Brinkhurst and Simmons 1968; Fraser River, British Columbia, see Brinkhurst 1978; Lake St. Claire, Michigan, May 1979, coll. et det. J. Hiltunen.

*Remarks.*—The setae of this species are distinctive, especially the shape of the upper tooth relative to the lower and its length in postclitellar bundles. This setal form is shared by *P. grandis* (see below), but in that species the setae are both more abundant and much larger (Table 1) and the penial setae are more strongly modified than in the former. Sperber (1948) stated that the setae of *P. frici* reached 105 μm in II, the others being a little shorter. Sokolskaya says they reach a maximum of 106 μm but are all similar in length, but Laakso (1969) quotes a maximum of 139 μm in II reducing to at least 105 μm posteriorly.

In the original accounts of both *P. frici* and *P. simplex,* Hrabe (1936, 1941) referred to the penial setae as being shaped like ordinary ventrals (according to translations from Russian and Czech). We take this to mean that they are sigmoid, as in other ventral setae, which indeed they are. They are modified, however, as they are thicker than usual, and they have shortened distal ends (Fig. 2). The

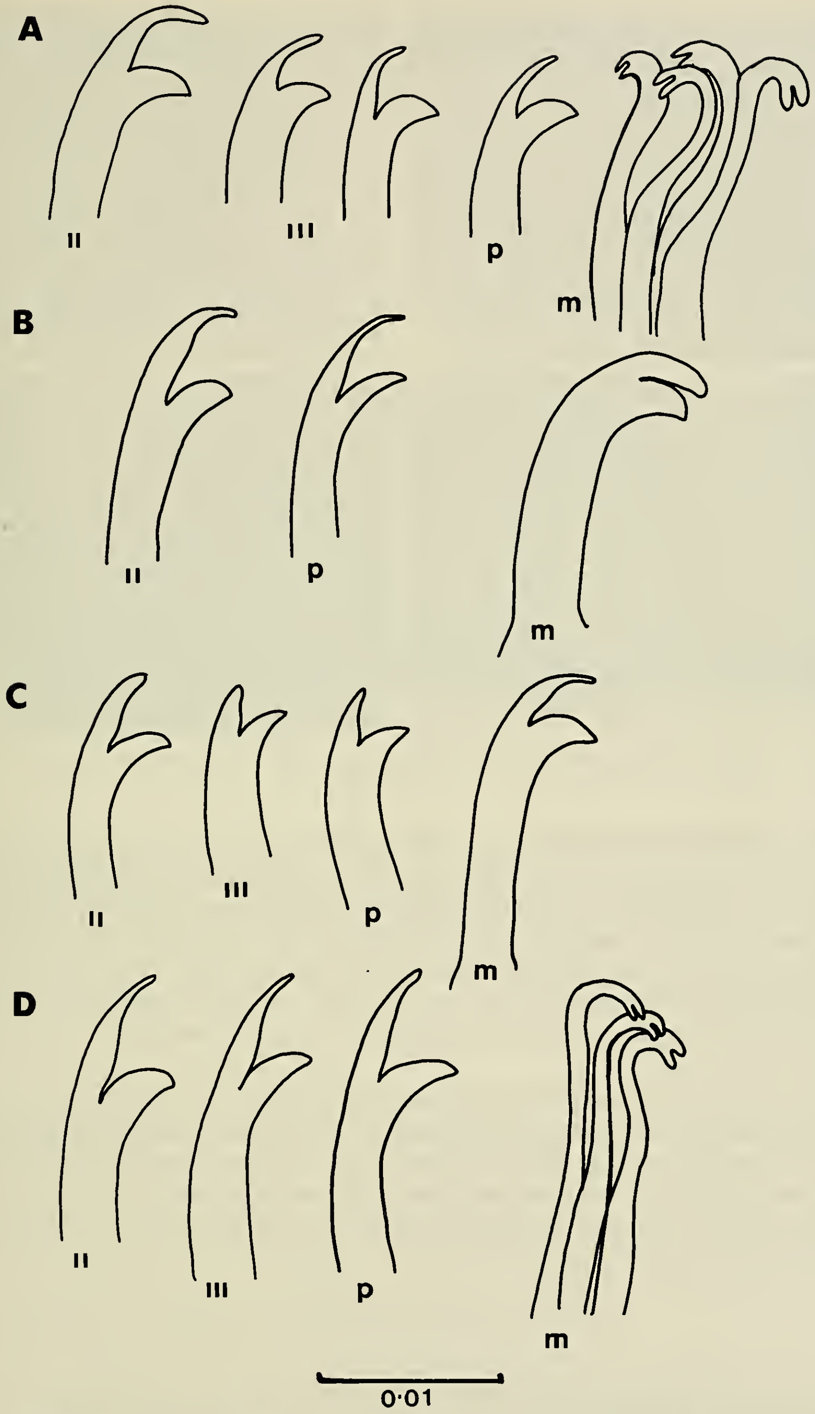

Fig. 2. Setae of *Paranais* species: A, *P. litoralis*; B, *P. frici*; C, *P. birsteini*; D, *P. grandis*. II, III, ventral setae of segments II, III; p, posterior setae; m, penial setae.

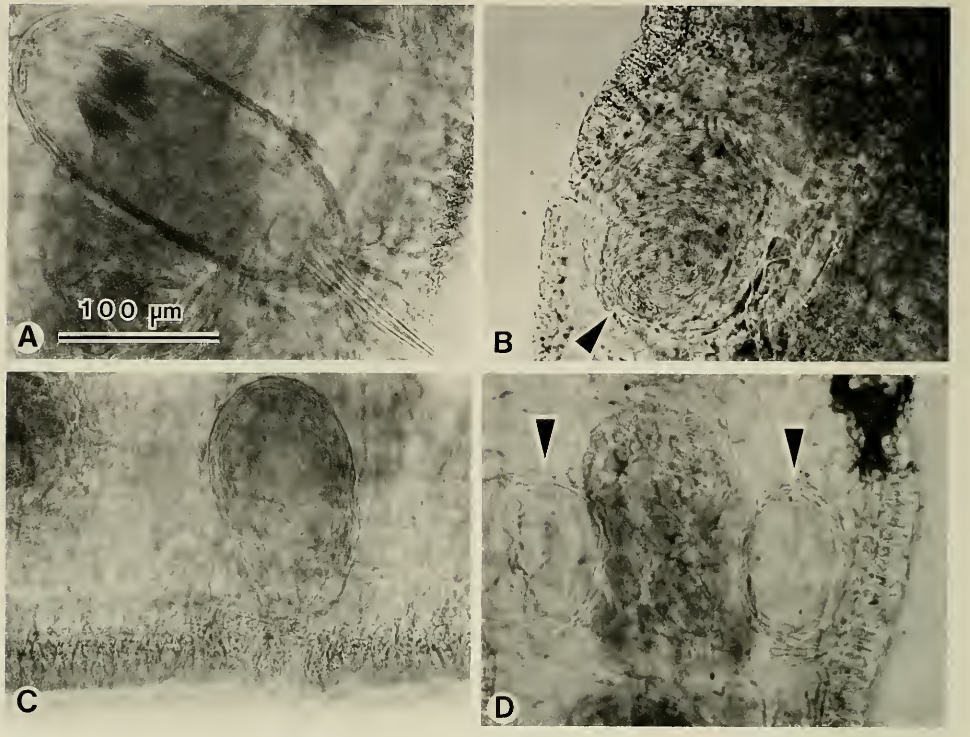

Fig. 3. Atria of *Paranais* species: A, *P. litoralis*; B, *P. frici*; C, *P. birsteini*; D, *P. grandis*.

distal ends are bifid, but the teeth are short and equally long in contrast to other ventrals. In this respect the description of the penial setae by Liang (1958, translated from Chinese) at least acknowledges these differences by identifying them as genital setae. It is primarily because definite penial setae can be observed in North American material that Hiltunen and Klemm (1980) changed the original identification of this species from *P. frici* to *W. mobilis.* The genital setae illustrated by Brinkhurst (1978) are attributable to a specimen of *P. litoralis* found among some *P. frici.*

Because several of our specimens have nephridia, there do not seem to be any substantial differences between *P. frici* and *W. mobilis,* as discussed by Sokolskaya (1971). According to that account, both species have similar atria with walls 8 µm thick, the other dimensions being 84 × 67 µm versus 82 × 70 µm. The body wall of *P. frici* is now acknowledged to be covered in foreign matter according to all recent accounts (see Hrabe 1981, for example).

### *Paranais birsteini* Sokolskaya, 1971
Figs. 2–4, Table 1

*Paranais birsteini* Sokolskaya, 1971:930, figs. 1–6.

*Diagnosis.*—1 = 3.5–5.0 mm, s = 21–42. Ventral setae of II 5–7, with upper teeth twice length of lower. Ventral setae of III–IV 4–5 per bundle with upper teeth longer than lower, reduced to 2–4 behind the clitellum, where teeth are

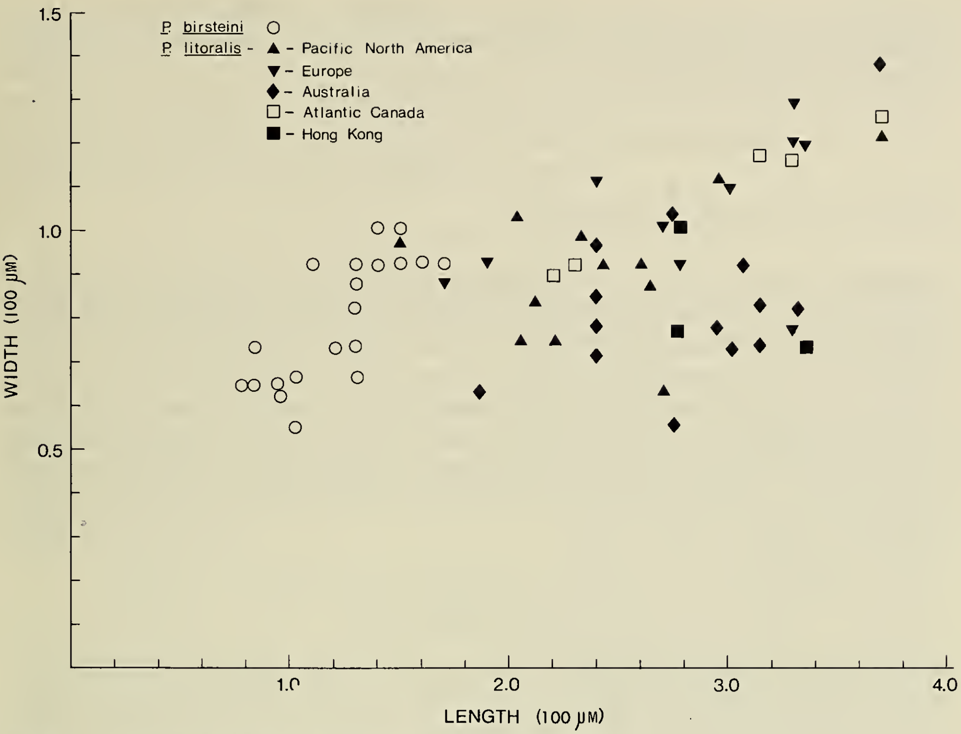

Fig. 4. Dimensions of atria of *Paranais litoralis* and *P. birsteini.*

nearly equal in length. Penial setae in V paired in each bundle, with short distal ends and short teeth of equal length. Dorsal setae 3–4, rarely 5 in V, 2–4 in rest of dorsal bundles. Spermathecal and atrial ampullae ovoid, atrial length to breadth ratio 1.2–1.9 ($\bar{x}$ = 1.5, n = 19, s = 0.19), atrial ampullae with thick muscular walls. Spermathecal and atrial ducts distinct, spermathecal pores vary in position from in front of and below or adjacent to ventral setae. Body wall distinctly papillate, with transverse ridges with foreign material in grooves. Kamchatka, USSR, and Pacific coast of Canada.

*Material examined.*—19 mature specimens, from: Wainwright Basin, Tsimpsean Peninsula below Prince Rupert; Tomahawk Island, Nowlan Passage; Hokarson Point and Ram Bluff, Dean Channel, Rattenbury Point, Fisher Channel, near Ocean Falls; Mowitch Point and Ecstall River confluence with Skeena River, Skeena River estuary; Alberni Inlet, Tahsish Inlet, Moyeha Bay, Sydney Inlet, Vancouver Island, all British Columbia, coll. H. R. Baker and K. A. Coates, 1979–1981. Skagit River Flats, mouth of the north fork, Skagit River, Washington coll. E. Gallagher, Dec 1979.

*Remarks.*—The new material from British Columbia and Washington is remarkably similar to that described from Kamchatka, and it would be reasonable to assume that this is a Pacific Rim species. The atrial walls in the original material are said to be 17 μm thick; here they vary from 9 to 24 μm with a mean of 17 μm. The length/breadth ratio of the atria of the original is 1.7, that of the new material is 1.5 (see Fig. 4). The species combines the somatic setae and muscular atrial walls of the form seen in *P. litoralis* with penial setae like those of *P. frici.* The length and breadth of the atria and spermathecae are intermediate between those of *P. litoralis* and *P. frici.*

### *Paranais grandis* (Harman, 1977), new combination

Figs. 2–3, Table 1

*Wapsa grandis* Harman, 1977:83, fig. 1.

*Diagnosis.*—3.0–4.0 mm, s = 28 plus (all fragments). Ventral setae of II 6–7, longer than other setae (105–150 μm versus 80–122 μm) with upper teeth much longer than lower. Ventral setae of III–IV 3 per bundle, with similar teeth, ventral setae of V 4, strongly modified penial setae with short, thin, recurved distal ends (88–140 μm long). Most other ventral bundles with 3 setae, all with long upper teeth. Dorsal setae 2–3 per bundle, similar to rest in form. Spermathecal and atrial ampullae ovoid, length to breadth ratios of 1.3 and 1.4 respectively, with walls thin when fully distended (5 μm). Body wall papillate with foreign matter attached. Louisiana, Texas, U.S.A.

*Material examined.*—13 whole-mounted specimens, Sea Rim State Park, Texas, 29 Jan, 1979, coll. J. Wern, det. M. Loden.

*Remarks.*—Harman (1977) cited the setal lengths in this species as 128–148 μm in II, 98–106 μm in III, 109–121 μm in other ventrals, and a total range of 74–123 μm for dorsals, the anterior setae being longer than the more posterior setae. He compared these with setal lengths for other *Wapsa* species (*W. mobilis, W. evelinae*) and showed that those of *W. grandis* were distinctly longer than those of the other two species. He did not compare the setae with those of *Paranais* species. The setal measurements based on mature specimens of the four species available to us confirm the fact that there is a much greater difference between the setae of II and the other bundles in *P. grandis* than in the other species (Table 1), and that the setae are generally longer overall. Otherwise this species differs from *P. frici* primarily by the possession of fully developed penial setae of the form observed in *P. litoralis,* and by the larger number of somatic and penial setae (Fig. 2).

## Other Species

Only one of the following species has been examined, the type-specimens of *P. botniensis* having been studied for us by C. Erséus. Type-material is not available for eastern European species, and the South American species were described from immature specimens.

### *Paranais simplex* Hrabe, 1936

*Paranais simplex* Hrabe, Kasprzak, 1977:93, figs. 1–4, plates 1–5.

This Ponto-Caspian species has 5–6 ventral setae in II with the teeth equally long, and 3–4 in other bundles with the upper teeth shorter than the lower. The penial setae are paired, sigmoid and bifid. The reproductive system, described by Kasprzak (1977), includes ovoid spermathecae and atria, the latter with thick muscular walls. No dimensions were given in this description, but the illustration shows the atrial muscles to be about 15 μm thick. This species is very similar to *P. birsteini* apart from the form of the setal teeth. Because of the limited distribution and freshwater habitat, recognition of this as a separate species causes no practical problems, and so unless the setal form can be shown to be the result of the ambient salinity by experimentation, the question of synonymy of *P. birsteini* with this species will not be pursued.

### *Paranais botniensis* Sperber, 1948

This species shares the small setal number and thin muscle layer of the atrial ampulla (2–7 μm) with *P. frici,* but the length/breadth ratio of the atria approaches that of *P. birsteini* (64 by 48 μm, or 76 by 37 in another specimen) as does the form of the setae. The penial setae are paired and bifid, sigmoid as in both of the above. This species has not, to our knowledge, been found outside the brackish water type-locality in Sweden. The setal numbers together with other differences noted by Sperber, strongly suggest that this be regarded as a distinct species. In any case, it does not appear to be a geographic race of *P. litoralis,* one possibility suggested by Sperber.

### *Paranais macrochaeta* Cernosvitov, 1939 and *Paranais salina* Cernosvitov, 1939

These two species were recorded from saline water in the Lake Titicaca basin, Peru, described from very few immature specimens. The principal difference between these and existing taxa was claimed to be the lateral position of the ventral setae of II relative to those of other bundles, a suggestion maintained by Sokolskaya (1971) in her key to the species in the genus. In all of the species examined by us the setae of II seem to be in this position. The number of setae in *P. macrochaeta* (8–9 in II, 4–5 in all others bar III–IV) is much higher than in *P. frici,* which shares the pattern of setal teeth, with the upper teeth always much longer than the lower. *Paranais salina* resembles *P. litoralis,* but mention of the anus opening into a rectangular fossa raises doubts. Until mature specimens are collected, these species must remain dubious taxa.

### *Paranais mobilis* Liang, 1958

As nephridia and foreign matter on the body wall have now been discovered in *P. frici,* and the question of the form of the penial setae has been resolved (see above), this species is here regarded as synonymous with *P. frici* (q.v.).

### *Wapsa evelinae* Marcus, 1965

The primary reason for the erection of this species as the type of a new genus was the presence of nephridia. Marcus (1965) did compare the species briefly with the existing *Paranais* species other than *P. mobilis.* The species clearly differs from *P. litoralis* in that the penial setae are sigmoid and bifid, and the atria and spermathecae are globular to ovoid in shape. The muscular layer of the atrial wall is said to be thick, but no measurements are presented and the illustration suggests that they are thinner than those of *P. birsteini* (for example). It is clear that there was considerable variation in setal number and form in the material described by Marcus (ventrals of II 3–4 or 5–6, in III–IV 2 or 3–4, the upper teeth twice as long as the lower, or less than twice as long). The specimens with the smaller setal number distinctly resemble *P. frici* in both number and form of the setae.

Marcus interpreted literally the statement by Hrabe (1941) regarding the penial setae resembling the other ventral setae, and supposed the slightly modified penial setae of his specimens to be a distinguishing characteristic. He also quotes the presence of intracellular stomach canals in the new species, a character utilised by Sperber (1948). However, in view of our experience with nephridia, and in view of the level of distinction applied to the separation of species throughout the family, we do not feel that this is a sound character, and would not use a single residual character to maintain a distinct species in the absence of other differences.

Some part, at least, of the Marcus material would seem to be attributable to *P. frici* depending on the reliability of observations on the thickness of the muscle layer of the atrial walls. Otherwise some, or even all, of the material closely resembles *P. botniensis* although no mention of papillation of the body wall appears in the original description of that species. This species cannot be identified for certain.

### *Paranais multisetosa* Finogenova, 1972

*Paranais multisetosa* Finogenova, 1972:94, figs. 1–5.

In this species there are 8–10 setae in II, with the teeth of equal length. In other ventral bundles there are 3–6, and 3–4 in dorsal bundles. The penial setae number 3–4 and are said to resemble the ventrals (see discussion above). The setal lengths are 62–73 μm (anterior ventrals), 59–64 μm (posterior ventrals), and 61–68 μm (dorsals). The atrial ampullae are 112–117 μm long by 50–75 μm wide, the spermathecae are 70–129 μm long by 36 μm wide, with a long duct. The species is restricted to the Dnieper Bug Firth, in the Black Sea, salinity 0.14–5.6 parts per thousand.

The species is close to *P. simplex,* the Ponto-Caspian species, but has more setae of a shorter length.

### *Paranais palustris* Udaltsov, 1907

This species was tentatively attributed to *Homochaeta setosa* (Moszynski, 1933) by Marcus, 1965, but the available descriptions do not justify such an action, so that it is in the interest of stability to regard this species as a dubious taxon. Access to the type, even if one exists, is not feasible. Other *Homochaeta* species have been identified as *Paranais* species at various times (see Brinkhurst 1971).

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Note added in proof: Since this MSS. was prepared, two reports published by N. P. Finogenova have become available and have been translated. *Paranais tjupensis,* described from Issyk-kul Lake, is similar to *P. botniensis* (1977, Hydrobiological studies on the Tyup River and of Tyup Bay on Lake Issyk-kul. Collection of Scientific Papers; U.S.S.R. Academy of Sciences. Leningrad, Zoological Institute). In 1982 the subspecies *orientalis* was promoted to specific rank, though it is very similar to *P. litoralis* and within the range of variation of that species as defined here (Marine Invertebrates of coastal biocenoses of the Arctic Ocean and the Pacific Ocean. Explorations of the fauna of the seas; Academy of Sciences of the U.S.S.R., Zoological Institute).

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# *PANDION LOVENSIS,* A NEW SPECIES OF OSPREY FROM THE LATE MIOCENE OF FLORIDA

Jonathan J. Becker

*Abstract.*—*Pandion lovensis* n. sp. (Aves: Pandionidae) is described from the late Miocene (latest Clarendonian) of Florida. This species, based on pelvic limb elements, appears to be the most primitive member of the genus.

The modern osprey (*Pandion haliaetus*) is the sole living representative of an enigmatic family of diurnal raptors. A number of detailed studies have investigated the morphology of the osprey in order to clarify its taxonomic position (Compton 1938; Hudson 1948; Sibley and Ahlquist 1972; Jollie 1976–1977). These studies have placed the osprey in a separate family or suborder, usually allied with the hawks and eagles.

Warter (1976) discussed the fossil record of the Pandionidae and described the first paleospecies, *Pandion homalopteron,* from Sharkstooth Hill, but did not find any convincing evidence to ally the modern osprey closely with any other falconiform group. Sharkstooth Hill near Bakersfield, Kern County, California, is early middle Miocene (about 14.5–13 million years B.P.) and is "closely tied into the late 'Temblor' megainvertebrate stage and the Luisian microinvertebrate stage" (Repenning and Tedford 1977:79). *Pandion homalopteron,* based on associated humeri and ulnae, represents an osprey slightly larger than the average modern osprey, that shows evidence of weaker wing musculature (Warter 1976).

Brunet (1970) proposed the transfer of *Palaeocircus cuvieri* Milne-Edwards from the Accipitridae to the Pandionidae, but because of the incompleteness of the holotype, a fragmentary carpometacarpus, this has not been accepted by other workers (Warter 1976).

Reported here, from the late Miocene of Florida is the second known paleospecies of osprey.

*Abbreviations.*—Specimens cited below are housed in the following institutions: Florida State Museum (UF), collection of Pierce Brodkorb (PB), and Natural History Museum of Los Angeles County (LACM).

*Recent specimens examined.*—*Pandion haliaetus carolinensis* four male specimens, PB 20312, PB 39212, PB 27958, UF 19406; four female specimens, PB 17061, UF 14546, UF 17082, UF 18215; four specimens of unknown sex, PB 34670, PB 39613, PB 37976, PB 34669.

*Fossil specimens examined.*—Referred proximal end of left tibiotarsus of *Pandion homalopteron* (LACM 42815). Subsequent to Warter's (1976) description of this species, this tibiotarsus was collected by Mr. William Hawes from the same location at Sharkstooth Hill (LACM locality 3205) that he collected the type-material of *P. homalopteron* (L. G. Barnes, in litt. 1982). It should be noted, that although this specimen bears the same catalog number as the holotype, it cannot be considered type-material (except as a referred hypotype), as it was not included in the original description.

Descriptive statistics are based on all above recent specimens. Morphological comparisons are based on the seven specimens in the Brodkorb collection. Measurements (Table 1) were made with Kanon dial calipers, accurate to 0.05 mm and rounded to the nearest 0.1 mm. BMDP Statistical Software program BMDPlD was used to calculate simple descriptive statistics (Dixon 1981). Computations were made at the Northeast Regional Data Center (NERDC) at the University of Florida, Gainesville. All fossil specimens are deposited in the Vertebrate Paleontology collections of the Florida State Museum, University of Florida (UF). Anatomical terminology follows Baumel et al. (1979) and Howard (1929).

## Order Accipitriformes (Falconiformes auct.)

## Family Pandionidae (Sclater and Salvin, 1893)

Skeletal elements of pelvic limb distinguished from other accipitriform families by the following combination of characters: (1) femur with very deep popliteal fossa; (2) tibiotarsus with extensor canal very deep under tendinal bridge with single distal opening; (3) fibula fused far distad; (4) tarsometatarsus relatively short, with ossified retinaculi extensoris for M. extensor digitorum longus; (5) hypotarsus extremely large with a single circular opening for tendons of Mm. flexor digitorum longus and flexor hallucis longus; (6) calcaneal ridge grooved; (7) trochleae strongly arched; (8) claws rounded beneath.

## Genus *Pandion* Savigny, 1809

## *Pandion lovensis,* new species

Figs. 1, 2

*Holotype.*—Nearly complete left tarsometatarsus. Vertebrate Paleontology collections of the Florida State Museum, UF 25950 (Fig. 1b, c); collected in 1979 by personnel of the Florida State Museum.

*Type-Locality.*—Love Bone Bed local fauna. Florida, Alachua County, along State Road 241, NW ¼, SW ¼, NW ¼, Sec. 9, T. 11 S., R. 18 E., Archer Quadrangle, U.S. Geological Survey 7.5 minute series topographical map, 1969. Webb et al. (1981) give an overview of this local fauna.

*Horizon.*—Late Miocene, latest Clarendonian land mammal age (approximately 9 million years B.P.). The Love Bone Bed local fauna originates from fluvial sediments of the Alachua Formation (Williams et al. 1977).

*Etymology.*—For the type locality, the Love Bone Bed.

*Paratypes.*—Distal half of right femur, UF 25766; distal end of right tibiotarsus, UF 25884; complete left tibiotarsus, UF 25928; right tarsometatarsus lacking proximal end, UF 25863; ungual phalanges, UF 26055, UF 26056, UF 29660.

*Measurements.*—Table 1.

*Diagnosis.*—Distinguished from *P. haliaetus* by: longer and more slender tarsometatarsus, lateral proximal vascular foramen opening within hypotarsal canal; femur with patellar sulcus broader and caudal intermuscular line more mediad; tibiotarsus with anterior and posterior intercondylar sulci wider and less deep, cranial opening of extensor canal larger and more transversely oriented, and distal end wider. Distinguished from *P. homalopteron* by a tibiotarsus with smaller transverse width of proximal end and deeper fossa retrocristalis.

Table 1.—Measurements of *Pandion* spp. Data are number of specimens (n), mean ± standard deviation ($\bar{x}$ ± SD) and range. Tibiotarsus—A, Total length; B, Length fibular crest; C, Least depth shaft; D, Depth proximal end; E, Transverse width proximal end; F, Transverse width distal end, across anterior portion of condyles; G, Transverse width distal end, across posterior portion of condyles; H, Depth medial condyle; I, Depth lateral condyle; J, Least depth intercondylar area. Tarsometatarsus—K, Total length, from eminentia intercondylaris through trochlea III; L, Length metatarsal I facet; M, Transverse width trochlea III; N, Transverse width distal end; O, Depth trochlea III; P, Transverse width proximal end; Q, Depth proximal end, excluding hypotarsus. Femur—R, Transverse width of lateral condyle; S, Transverse width of medial and lateral condyles; T, Transverse width lateral condyle and trochlea fibularis; U, Transverse width distal end; V, Depth distal end; W, Depth femoral shaft cranial to condyles.

| Measurement | *P. h. carolinensis* | | | *P. homalopteron* | *P. lovensis* |
|---|---|---|---|---|---|
| | $\bar{x}$ ± SD | (n) | Range | $X_i$ | $X_i$ |
| Tibiotarsus: | | | | | |
| A | 123.59 ± 4.62 | (12) | 119.2–130.8 | — | 124.8 |
| B | 34.82 ± 2.09 | (13) | 31.2–38.2 | — | 32.7 |
| C | 5.59 ± 0.29 | (12) | 5.2–6.1 | — | 5.5; 5.7 |
| D | 17.00 ± 0.92 | (13) | 15.9–18.5 | 17.4 | 17.0 |
| E | 13.17 ± 0.60 | (13) | 12.3–14.0 | 14.3 | 13.1 |
| F | 14.08 ± 0.69 | (12) | 13.1–15.1 | — | 14.9; 15.0 |
| G | 10.36 ± 0.50 | (12) | 9.6–11.1 | — | 12.0; 12.1 |
| H | 13.18 ± 0.68 | (12) | 12.4–14.2 | — | 13.2; 13.3 |
| I | 12.77 ± 0.57 | (12) | 12.0–13.6 | — | 12.0; 12.5 |
| J | 5.83 ± 0.29 | (12) | 5.4–6.5 | — | 6.6; 6.6 |
| Tarsometatarsus: | | | | | |
| K | 51.86 ± 1.64 | (12) | 49.7–54.9 | — | 59.5 |
| L | 9.38 ± 0.80 | (12) | 8.0–10.6 | — | 8.0; 8.4 |
| M | 6.80 ± 0.56 | (12) | 5.8–7.6 | — | 7.8; 7.8 |
| N | 15.00 ± 0.54 | (12) | 14.4–15.9 | — | 16.4 |
| O | 4.98 ± 0.26 | (12) | 4.6–5.5 | — | 5.7; 5.7 |
| P | 14.46 ± 0.76 | (12) | 13.4–15.7 | — | 14.7 |
| Q | 5.49 ± 0.28 | (12) | 5.1–6.0 | — | 6.7 |
| Femur: | | | | | |
| R | 3.12 ± 0.27 | (13) | 2.8–3.6 | — | 3.1 |
| S | 12.14 ± 0.69 | (13) | 11.2–12.9 | — | 12.4 |
| T | 6.81 ± 0.56 | (13) | 6.0–7.9 | — | 6.6 |
| U | 15.29 ± 0.89 | (13) | 14.0–16.6 | — | 15.2 |
| V | 13.51 ± 0.47 | (13) | 12.7–14.2 | — | 12.8 |
| W | 7.70 ± 0.35 | (13) | 7.2–8.3 | — | 7.2 |

*Comparisons and description.*—Unless otherwise stated, all comparisons are made in relation to 7 specimens (Pierce Brodkorb collection) of *Pandion haliaetus carolinensis* Gmelin, 1788.

Femur.—*Pandion lovensis* n. sp. has caudal intermuscular line more mediad, merging smoothly with the crista supracondylaris medialis, forming a sharp caudomedial border immediately above the medial epicondyle. Caudal aspect of the medial condyle broader. Popliteal fossa slightly broader. Caudal aspect of lateral condyle (i.e., tibial articular surface) extending less craniad and is not inclined laterad. Crista tibiofibularis and lateral epicondyle less pronounced. Patellar sulcus slightly broader.

*Tibiotarsus.*—Fibular crest shorter. Both anterior and posterior intercondylar

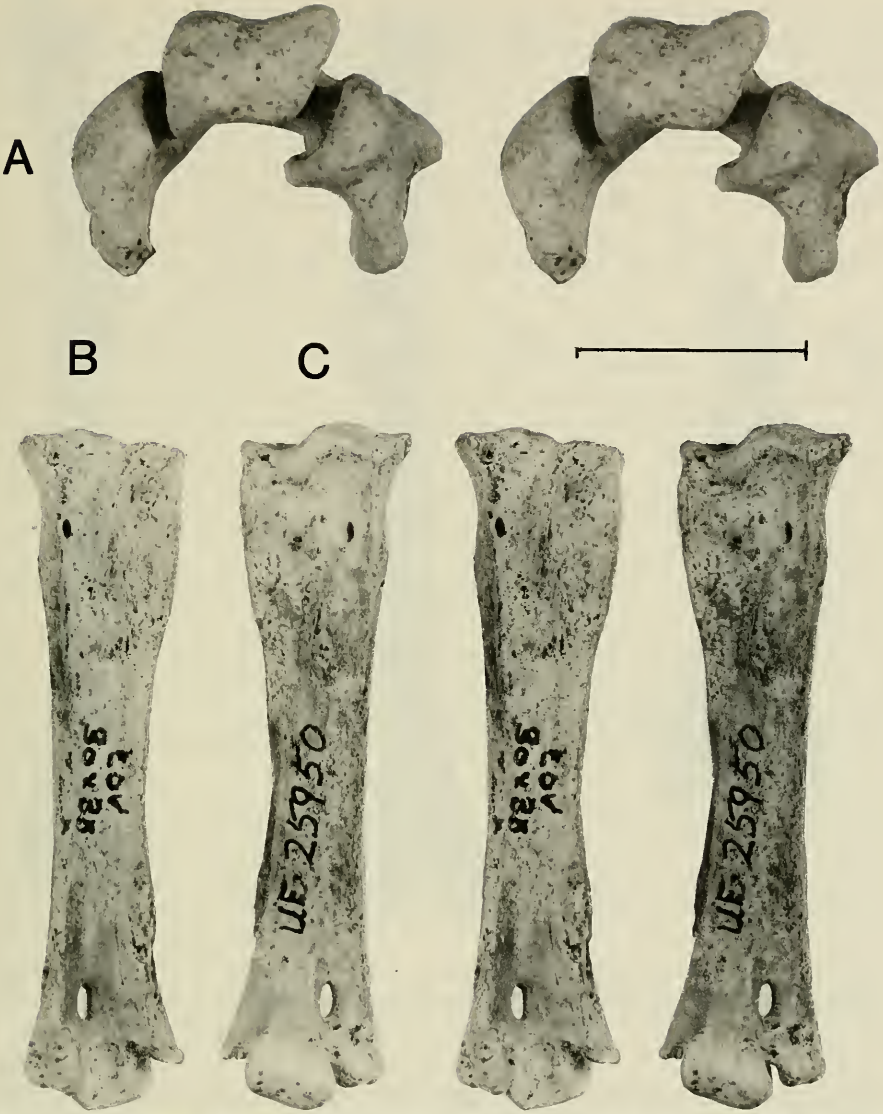

Fig. 1. Stereophotographs of tarsometatarsi of *Pandion lovensis* n. sp. A, Paratype UF 25863, distal view. B, C. Holotype, UF 25950. B, Caudal view; C, Cranial view. Scale equals 10 mm. (A); 20 mm. (B, C).

sulci wider and less deep. Both lateral and medial epicondylar depressions deeper and more distinct. Cranial opening of extensor canal larger and more transversely oriented. Internal ligamental prominence more distinct. Distal end wider, especially caudal portion.

The referred proximal end of tibiotarsus of *Pandion homalopteron* (LACM 42815), when compared with *P. haliaetus,* is robust, with a greater transverse width of proximal end. Crista cnemalis lateralis slightly elongated, producing a more pronounced incisura tibialis and a broader sulcus intercristalis. Facies gas-

Fig. 2. Paratypes of *Pandion lovensis.* A, Caudal view femur UF 25766; B, Cranial view tibiotarsus UF 25928; C, Caudal view tibiotarsus UF 25928. Scales = 10 mm.

trocnemalis flatter. Distinct notch present on caudo-lateral margin of proximal articulating surface. Slight ridge extends proximad from tuberositas poplitea.

In comparison with *Pandion homalopteron, P. lovensis* has a smaller transverse width, a less distinct notch on the caudo-lateral margin of the proximal end, and a distinctly deeper fossa retrocristalis.

*Tarsometatarus.*—Shaft longer, more slender, and less flattened dorso-plantarly. Fossa parahypotarsalis medialis slightly more excavated. Crista medialis hypotarsi extends a proportionally shorter distance down shaft. Lateral foramen vascularia proximalia opens within hypotarsal canal (outside in all specimens of *Pandion haliaetus* examined). Fovea ligamentum collateralis on trochlea IV larger and deeper. Trochlea IV less recurved, anterior surface flattened. Trochlea III larger. Medial foramen vascularia proximalia proximal to origin of inner strut of arcus extensoris. Fossa infracotylaris dorsalis deeper. Medial border of trochlea III projects laterad (dorsad in *P. haliaetus*). Distal end larger. In medial view, caudal process on trochlea II proportionally longer.

*Discussion.*—The power-arm ratio of the tarsometatarsus has been the focus of many investigations (Miller 1911, 1912; Howard 1932; Jollie 1976–1977; among others). The major flexor of the tarsometatarsus on the shank is the M. tibialis anterior (=M. tibialis cranialis of Baumel et al. 1979) and, to a lesser degree, the M. extensor digitorum longus. In *Pandion haliaetus,* the tibialis anterior arises by two heads, a tibial head on the anterior side of the tibial crest, extending in a narrow line down the medial side of the tibial shaft; and a femoral head extending from the distal apex of the external condyle of the femur. This muscle inserts by a single tendon on the tibialis anterior tuberosity on the proximal end of the tarsometatarsus (Hudson 1937, 1948).

The power-arm ratio (Miller 1912, 1925) is calculated by dividing the length from the proximal end to the midpoint of the tibialis anterior tubercle (=power-arm) multiplied by 100, by the total length of the tarsometatarsus (=resistance or weight-arm). Miller (cited in Jollie 1976–1977) noted that species with long tarsi have a short power-arm ratio while those species with a short broad tarsus have a relatively large ratio. Miller (1911), Howard (1932), and Jollie (1976–1977) provide tables of power-arm ratios for comparison. It is interesting to note that the modern osprey has the greatest power-arm ratio (32.2%) of any accipitriform species. *Pandion lovensis* has a much smaller power-arm ratio (17.0 mm/59.5 mm × 100 = 28.6%). This is approximately 11% less than the modern osprey. An increase in length of the tarsometatarsus, without a concomitant shift in the position of the tibialis anterior tubercle is responsible for the decrease in the power-arm ratio in *P. lovensis.* The increase in length would also allow the distal end of the tarsometatarsus to be moved at a faster rate, all other things being equal.

The interpretation of these differences is difficult. Fisher (1945:742) states "The development of this great flexor of the tarsus may be correlated with ability to walk or run, ability to grasp with the foot as in perching or in predation, and with weight of the foot or of the entire body. In fact it is impossible to define and distinguish individual adaptations."

Because *P. homalopteron, P. lovensis,* and *P. haliaetus* have only one known skeletal element in common, any proposed phylogeny is tenuous. *Pandion homalopteron* is not very distinct in wing morphology from the modern osprey, even though a large interval of time separates them (Warter 1976). The only known hindlimb element of this species, a proximal end of a tibiotarsus, also appears close to that of the modern osprey. *Pandion lovensis* is less derived than either of these species and shares a number of characters with the Accipitridae, the proposed sister taxa of the Pandionidae (Jollie 1976–1977). These characters include a femur with a broader and less deep patellar sulcus, and the caudal intermuscular line medial; a tibiotarsus with broader intercondylar sulci; and a tarsometatarsus which is longer and less broad, with a reduced power-arm ratio. *Pandion lovensis* appears to be the least derived member of the genus and represents a lineage distinct from that of *P. homalopteran* and *P. haliaetus.*

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# NEOTROPICAL MONOGENEA. 7. PARASITES OF THE PIRARUCU, *ARAPAIMA GIGAS* (CUVIER), WITH DESCRIPTIONS OF TWO NEW SPECIES AND REDESCRIPTION OF *DAWESTREMA CYCLOANCISTRIUM* PRICE AND NOWLIN, 1967 (DACTYLOGYRIDAE: ANCYROCEPHALINAE)

Delane C. Kritsky, Walter A. Boeger, and Vernon E. Thatcher

*Abstract.*—*Dawestrema cycloancistrium* Price and Nowlin, 1967, *D. cycloancistrioides* n. sp., and *D. punctatum* n. sp. are reported and described from the pirarucu, *Arapaima gigas* (Cuvier), collected from the Solimões River near Manaus, Amazonas, Brazil. An emended generic diagnosis of *Dawestrema* Price and Nowlin, 1967, is presented incorporating new information on internal anatomy and structure of the copulatory complex and haptor. A summary of the parasitic helminths reported from *A. gigas* is provided.

The pirarucu, *Arapaima gigas* (Cuvier), Osteoglossidae, inhabits the Amazon River drainage, the western Orinoco and the Rupununi and Essequibo river systems of the Guianas, and is thus limited in its distribution to parts of northern South America. This fish is of considerable economic importance and is regarded as a food fish of the highest quality.

Studies on the parasites of the pirarucu were begun during the early nineteenth century with the description of larval *Gnathostoma gracilis* by Diesing (1838). Including that record, a total of 14 helminth species have been reported from this fish. Baylis (1927) listed the following (names appearing below are as given by Vicente and Pinto 1981, Rego et al. 1974, and Noronha 1981): Nematoda—*Goezia spinulosa* (Diesing, 1839), *Terranova serrata* (Drasche, 1884),* *Camallanus tridentatus* (Drasche, 1884), and *Gnathostoma gracilis* (Diesing, 1838); Acanthocephala—*Polyacanthorhynchus macrorhynchus* (Diesing, 1856); and Cestodaria—*Schizochoerus liguloideus* (Diesing, 1850), and *Nesolecithus janickii* Poche, 1922. Baylis (1927) also described the nematode, *Philometra senticosa* (*Nilonema senticosa* in Vicente and Pinto 1981), from the swim-bladder of the fish. Machado Filho (1947) reported *Polyacanthorhynchus rhopalorhynchus* (Diesing, 1851) and *P. macrorhynchus* (Diesing, 1856) from *A. gigas*; and Travassos (1960) reported the nematode, *Rumai rumai,* as a new species from the host's body cavity. Prudhoe (1960) described *Caballerotrema brasiliense* (Trematoda)

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* According to Baylis (1927), *Porrocaecum draschei* (Stossich, 1896) is a synonym of this species since *Ascaris serrata* "was very briefly described by v. Drasche (1884), who had before him only a single male specimen. Stossich (1896), who changed the name of the species to *A*[*scaris*]. *draschei* (apparently on the ground of the previous existence of *Ancyracanthus serratus* Wright, 1879, which he believed to be an *Ascaris,* but which is probably to be referred to *Cystidicola*), added nothing to the description."

from the intestine of the host. This species was redescribed, and *C. arapaimense* proposed as a new species from pirarucu by Thatcher (1980). *Himasthla piscicola,* described by Stunkard (1960) from the intestine of the host, is likely a synonym of one of the *Caballerotrema* species. The only monogene previously reported from *A. gigas* is *Dawestrema cycloancistrium* Price and Nowlin, 1967. The present study adds two new species to the parasite fauna of this host and includes a redescription of *D. cycloancistrium.*

## Materials and Methods

The host was collected from the Solimões River near Manaus, Amazonas, Brazil, on 15 April 1983. Fish gills were placed in finger bowls and covered with a 1:4000 formalin solution. After one-half hour, the gills were agitated in this liquid and then removed from the bowl. The helminths were allowed to settle to the bottom and were subsequently removed with the aid of a small probe and dissecting microscope. They were immediately fixed and stored in AFA. Some were mounted unstained in Gray and Wess' medium for study of sclerotized structures. Other specimens stained with Semichon's carmalum or Gomori's trichrome were used to determine internal features. Measurements were taken only on specimens collected during the present study; all, in micrometers, were made according to the procedures of Mizelle and Klucka (1953) except that the cirrus measurement is the diameter of the largest ring of the coil. Numbering of hook pairs follows that proposed by Mizelle (1936). Illustrations were prepared with the aid of a camera lucida or microprojecter. Type-specimens are deposited in the collections of the Instituto Nacional de Pesquisas da Amazônia (INPA), the U.S. National Museum Helminthological Collection (USNM), and the University of Nebraska State Museum (UNSM) as indicated below.

Species of many genera of Monogenea from the Neotropical Region are characterized by a cirrus comprising a variably developed base from which a coiled shaft arises. The coil of the shaft may consist of less than one complete ring to many rings. While the direction of the coil has not been specifically addressed in previous studies on Neotropical forms, a counterclockwise or clockwise coil may be shown to have diagnostic value at the specific and/or generic level as understanding of the Monogenea from this region develops. Thus, the coil direction is determined by viewing the cirrus in ventral view. If the cirrus shaft is directed in a clockwise direction from the base to the ventral tip of the shaft, the rings are defined to have a clockwise direction, and conversely so, counterclockwise. In the present study, all species of *Dawestrema* were found to have counterclockwise rings, and this character is incorporated into the emended diagnosis of the genus.

## *Dawestrema* Price and Nowlin, 1967

*Emended diagnosis.*—Dactylogyridae, Ancyrocephalinae. Body elongate, divisible into cephalic region, trunk, peduncle, and haptor. Tegument thin, smooth. Head organs, cephalic glands present. Four eyes. Mouth subterminal; pharynx muscular, glandular; esophagus elongate; intestinal crura 2, confluent in posterior trunk, lacking diverticulae. Gonads intercecal, slightly overlapping or tandem; testis postovarian. Vagina sinistroventral; seminal receptacle overlapping or lying immediately anterior to ovary along body midline; uterus delicate; genital pore midventral. Vitellaria well developed as 2 bilateral bands coextensive with gut; eggs with terminal filament(s). Vas deferens looping left intestinal crus; 2 seminal vesicles, simple dilations of sperm duct; prostatic reservior present; cirrus comprising a coil of one to many counterclockwise rings; accessory piece articulated to cirral base, proximal part lying within cirrus coil, terminal portion serving as cirrus guide. Haptor with 2 pairs of anchors (dorsal and ventral), dorsal and ventral bars (nonarticulated), 7 pairs of hooks. Hook pairs 1, 2, 3, 4, 6, 7 arranged concentrically around haptor usually anterior to anchors. Ventral bar with medial anterior projection arising from posterior or dorsal margin of bar. Parasitic on gills of freshwater fishes of the Osteoglossidae.

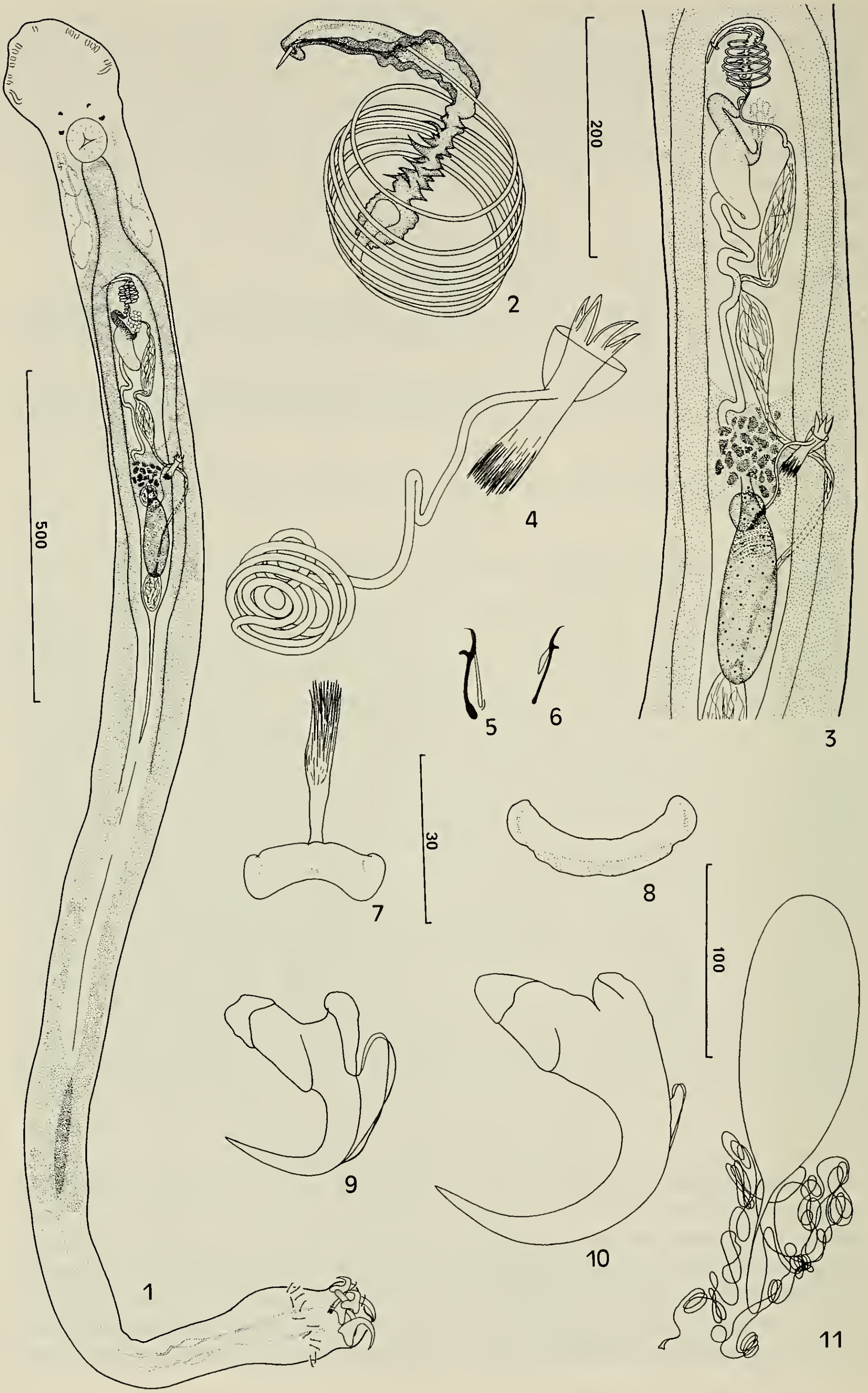
*Type-species, host, and locality.*—*Dawestrema cycloancistrium* Price and Nowlin, 1967, from the gills of *Arapaima gigas* (Cuvier), from Amazon River and tributaries, Brazil.

*Other species.*—*Dawestrema cycloancistrioides* n. sp., *D. punctatum* n. sp., both from the gills of *Arapaima gigas,* Solimões River near Manaus, Amazonas, Brazil.

### *Dawestrema cycloancistrium* Price and Nowlin, 1967
Figs. 1–11

*Specimens studied.*—Holotype, USNM 62985; voucher specimens, INPA 00000, USNM 78224, UNSM 22092.

*Description* (based on 22 specimens and holotype).—Body graciliform; length 2180 (1618–2552), greatest width 112 (83–138) near level of vagina or cephalic region. Cephalic margin rounded, lobes poorly developed; head organs comprising loosely associated cephalic gland ducts; postpharyngeal bilateral groups of unicellular cephalic glands well developed. Each eye with lens; members of posterior pair of eyes larger, farther apart than those of anterior pair; eye granules small, variable in shape; accessory granules absent. Pharynx spherical, 62 (45–72) in diameter; gut confluent apparently at several locations posterior to testis. Peduncle elongate, with pair of conspicuous glands; haptor bulbous, with anchors situated on posterior lobe; haptor 156 wide, 129 (86–159) long. Anchors similar; ventral anchor robust, with elongate straight point, heavy base, ornate deep root, superficial root with conspicuous saddle-like fold; ventral anchor 35 (33–37) long, base 25 (23–28) wide. Dorsal anchor with curved point and shaft, fold of superficial root weakly developed; dorsal anchor 51 (47–54) long, base 35 (29–43) wide. Anchor filament simple, double, conspicuous. Ventral bar plate-like, with anterior medial projection arising near posterior margin; bar 25 (21–29) long. Dorsal bar with globose ends, heavy ridge along posterior margin; bar 38 (28–43) long. Hook distribution typical with ring of hooks well anterior to anchors; hook 16 (13–18) long; pairs 1, 2, 3, 4, 6, 7 similar; each with depressed thumb, shank with small terminal enlargement, point recurved, FH loop ⅘ shank length; pair 5 delicate, with small enlargement of proximal end of shank, FH loop ½ shank length. Testis ovate, postovarian, 29 (21–37) wide, 57 (46–74) long; seminal vesicles fusiform; prostatic reservoir elongate, thin walled, frequently twisted. Cirrus with 5–7 rings, slightly enlarged base, largest ring diameter 42 (37–48); accessory piece terminally enclosing cirrus shaft. Ovary elongate ovate, 28 (24–33) wide, 108 (94–121) long; oviduct short; ootype not observed; uterus (when empty) a delicate duct with terminal expansion, extending to right of midline; genital pore at level of cirrus;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vagina tubular, proximally coiled, with distal petal-shaped sclerotization protruding from aperture; seminal receptacle pyriform, lying anterior to vagina coil. Vitellaria appearing as hollow tubular longitudinal structures. Egg elongate ovate, with proximal filament; filament exceptionally long; egg 136 (126–147) by 34 (29–37).

*Remarks.*—Examination of the holotype of *Dawestrema cycloancistrium* and comparison of it with our specimens showed them to be conspecific. The holotype, mounted unstained in glycerine jelly, is apparently contracted as a result of fixation procedures, which explains the significant differences of body shape and size between our specimens and measurements and drawings provided by Price and Nowlin (1967). Further, we determined several erroneous interpretations in the original description concerning the internal anatomy and structure of the sclerotized haptoral armament and copulatory complex. These are evaluated in the discussion below.

### *Dawestrema cycloancistrioides,* new species
Figs. 12–20

*Type-specimens.*—Holotype, INPA 00000; paratypes, INPA 00000, USNM 78222, UNSM 22093.

*Description* (based on 24 specimens).—Body cylindrical, tapered at extremes; length 1281 (1015–1766), greatest width 92 (73–118) at or posterior to gonads. Two terminal, 2 subterminal cephalic lobes well developed; head organs distinct in each lobe; cephalic glands well developed, comprising prepharyngeal, pharyngeal, and postpharyngeal bilateral paired groups of unicellular glands; bilateral pair also lying immediately anterior to level of vagina. Members of posterior pair of eyes with lenses, larger and farther apart than those of anterior pair; eyespot granules small, variable in size and shape; accessory granules usually restricted to immediate region of eyes. Pharynx spherical, 53 (40–60) in diameter. Peduncle moderately elongate; haptor bulbous, tapered posteriorly with ventral anchors situated on posterior lobe; haptor 83 (60–107) wide, 82 (65–122) long. Anchors dissimilar; ventral anchor robust, with evenly curved point and shaft, exaggerated and truncate superficial root, small deep root; anchor 49 (46–51) long, base width 28 (24–30). Dorsal anchor with delicate, evenly curved point and shaft, vestigial deep root, tapered superficial root; anchor 32 (29–34) long, base width 22 (17–28). Anchor filament simple, double, conspicuous. Ventral bar plate-like, with anterior projection originating from posterior margin of bar; bar 21 (20–23) long. Dorsal bar broadly U-shaped with slightly enlarged ends; bar 28 (26–30) long. Hook pairs 1, 2, 3, 4, 6, 7 distributed around the widest part of the haptoral bulb at level of dorsal anchor bases; hooks 1, 2, 3, 4, 6, 7 similar, each with two-part shank, slightly depressed thumb, tapered shaft and point; hook pair 5 with slender

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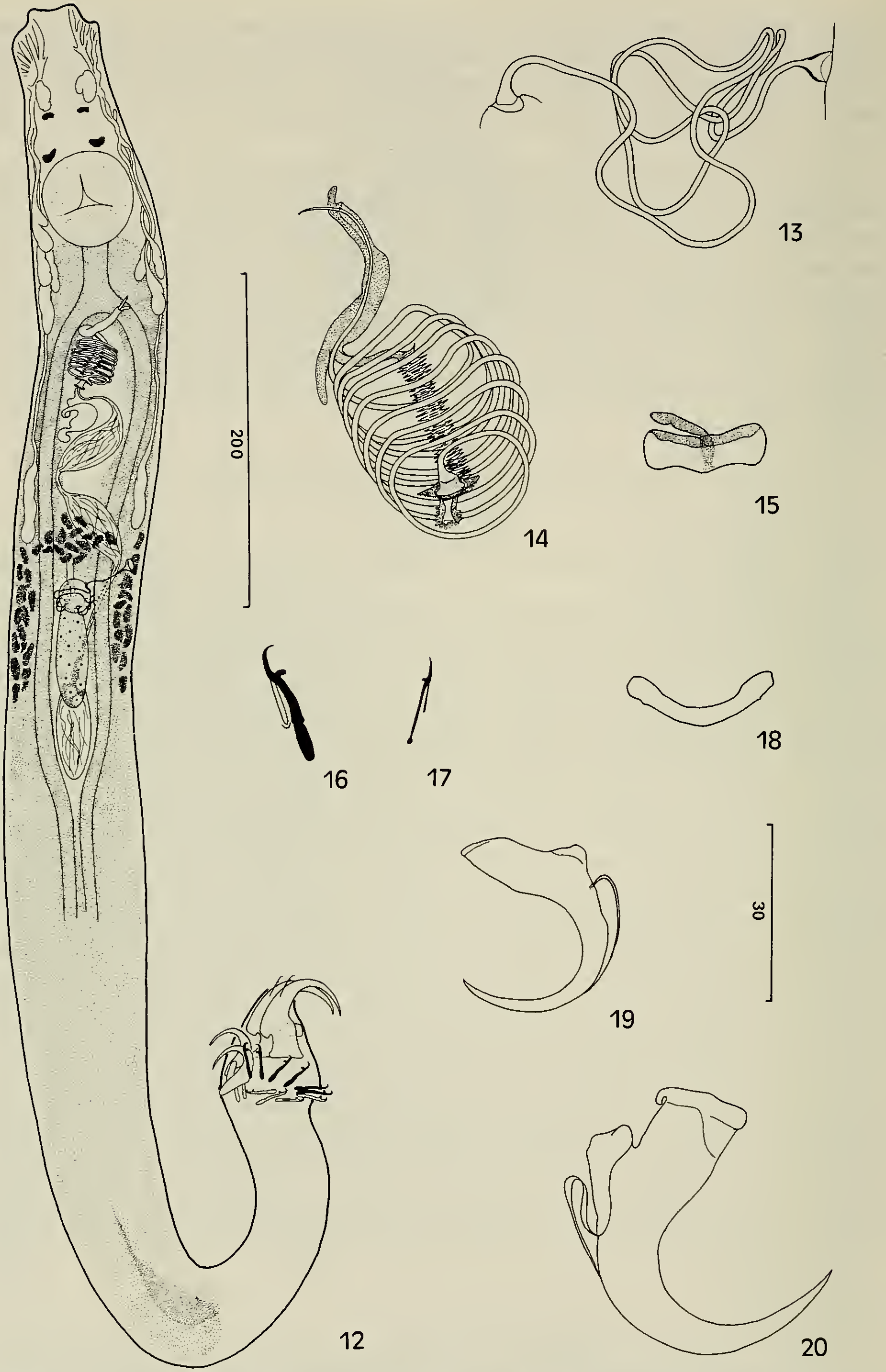
Figs. 1–11. *Dawestrema cycloancistrium*: 1, Composite drawing of whole mount (ventral); 2, Copulatory complex; 3, Enlargement of worm at level of reproductive systems (ventral); 4, Vagina; 5, Hook (pair 1); 6, Hook (pair 5); 7, Ventral bar; 8, Dorsal bar; 9, Ventral anchor; 10, Dorsal anchor; 11, Egg. All figures are reproduced to the same scale (30 micrometers) except Figs. 1, 11 (500 micrometers, 100 micrometers, respectively).



Figs. 12–20. *Dawestrema cycloancistrioides*: 12, Ventral view of holotype; 13, Vagina; 14, Copulatory complex; 15, Ventral bar; 16, Hook (pair 1); 17, Hook (pair 5); 18, Dorsal bar; 19, Dorsal anchor; 20, Ventral anchor. All figures are drawn to the same scale (30 micrometers) except Fig. 12 (200 micrometers).

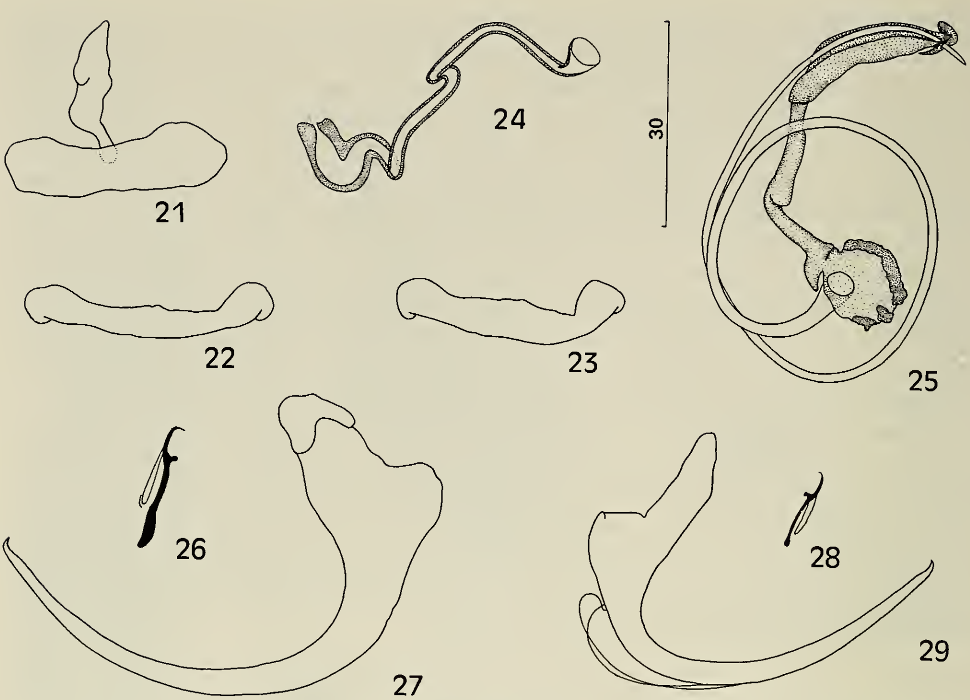
shank and small proximal enlargement; hook length 19 (17–23). FH loop extending to union of 2 parts of shank. Cirrus a coil of 7–8 rings, with flared base, largest ring diameter 33 (28–37); accessory piece terminally enclosing cirral shaft. Gonads overlapping. Testis dorsoposterior to ovary, elongate ovate, 16 (14–19) wide, 64 (43–85) long; seminal vesicles stout, fusiform, anterior vesicle larger; prostatic reservoir a delicate pyriform sac lying near level of anterior seminal vesicle; prostrate not observed. Ovary spindle-shaped, elongate, 34 (20–47) wide, 77 (74–79) long; oviduct short; ootype not observed; uterus delicate, extending along ventral midline opening into midventral genital atrium by darkstaining structure apparently functioning as sphincter; vagina comprising a distal funnel with elongate twisted tube, opening into inconspicuous seminal receptacle; vitellaria confluent posteriorly, vitelline commissure lying at level immediately anterior to vaginal coils; egg ovate with proximal short filament, 80 (61–98) by (45–46).

*Remarks.*—*Dawestrema cycloancistrioides* most closely resembles *D. cycloancistrium,* as shown by the comparative morphology of the copulatory complex. The new species differs from *D. cycloancistrium* by having 1) a smaller body size, 2) a vaginal tube without a tight proximal coil, 3) a short anteromedial process of the ventral bar, 4) robust hooks (except pair 5), 5) anchors of a different morphology, and 6) a short proximal egg filament. The specific name, from Greek, indicates the relationship of these two species.

### *Dawestrema punctatum,* new species
Figs. 21–29

*Type-specimens.*—Holotype, INPA 00000; paratypes, USNM 78223, UNSM 22094.

*Description* (based on 5 specimens).—Body spindle shaped; length 852 (796–923), greatest width 86 (65–114) near midlength or in anterior half. 2 terminal, 2 bilateral cephalic lobes well developed; some specimens with an incipient lobe between major pairs. Head organs well developed, one in each cephalic lobe; cephalic glands not observed. Members of posterior pair of eyes larger, closer together than those of anterior pair, lens usually visible in posterior pair; eye granules subspherical, small, variable in size; accessory granules generally absent (eye granules frequently disassociated in flattened specimens). Pharynx spherical, 40 (37–43) in diameter; esophagus moderate in length; gut apparently normal. Peduncle elongate to moderately long; haptor bulbous, tapered posteriorly, with ventral anchors situated on posterior lobe; haptor 108 (98–119) wide, 89 (75–106) long. Anchors similar, each with well-developed base, roots moderately developed, elongate point with terminal recurved tip, ventral anchor 54 (53–55) long, base width 30 (28–32); dorsal anchor 41 (35–45) long, base width 25 (21–30). Anchor filament simple, double, inconspicuous. Ventral bar subrectangular, with anterior projection arising from dorsal surface, bar 30 (26–33) long; dorsal bar rod-shaped with slightly enlarged ends, bar 36 (32–39) long. Hook pairs 1, 2, 3, 4, 6, 7 lying in ring at level of dorsal anchor bases, similar in shape, 21 (18–24) long, each with slender distal shank, proximal shank enlarged, thumb erect, point recurved; hook pair 5 with slender shank and small proximal enlargement, 13 (12–14) long. FH loop extending to union of 2 parts of shank. Cirrus a coil of about 1½ rings, base of cirrus lying ventral in body, with first ring of shaft directed dorsally, termination of shaft curved ventrally, ring diameter 39 (37–41); accessory



Figs. 21–29. Sclerotized parts of *Dawestrema punctatum*: 21, Ventral bar; 22, 23, Dorsal bars; 24, Vagina; 25, Copulatory complex; 26, Hook (pair 1); 27, Ventral anchor; 28, Hook (pair 5); 29, Dorsal anchor. All figures are at the 30 micrometer scale.

piece variable, terminally enclosing cirrus shaft. Gonads overlapping. Testis elongate, dorsoposterior to ovary; loop of vas deferens immediately posterior to vagina; seminal vesicles c-shaped; prostatic reservoir with outer circular muscles and enlarged duct. Limits of ovary not observed; oviduct short; ootype not observed; uterus delicate, frequently containing single egg; genital pore midventral at level of cirrus; vagina a short sclerotized tube flaring proximally and opening simply at left margin; vitellaria generally distributed throughout trunk, commissure anterior to seminal receptacle; egg elongate ovate, with terminal short filament at each pole; egg 132 long, 32–33 wide.

*Remarks.*—This species differs significantly from both *Dawestrema cycloancistrium* and *D. cycloancistrioides* in the comparative morphology of the haptoral armament, copulatory complex, vagina, and egg. However, it is apparently closest to *D. cycloancistrioides* based on the similar nature of the superficial roots of the anchor bases. The specific name is from Latin (*punctata* = thorn) and refers to the recurved tips of the anchor points.

## Discussion

Price and Nowlin (1967) proposed *Dawestrema* for monogenes characterized by having a circle of hooks located well anterior to the remainder of the haptoral armament, two prostatic reservoirs, an intercecal vas deferens, and apparently non-confluent intestinal crura. However, our examination of the holotype confirmed that one of our forms was the type-species, *D. cycloancistrium,* and that errors in the original study had been made concerning the structure of the copulatory complex, ventral bar, and internal anatomy which necessitated a redefinition of the genus.

While the hook arrangement in *Dawestrema cycloancistrium* is as originally described, our discovery of how two new species show that the anterior position of the ring of hooks is only a specific trait. In *D. cycloancistrioides* and *D. punctatum,* the hook ring is at the level of the bases of the dorsal pair of anchors. Hook pairs 1 (submedial), 2, 3, and 4 are ventral, each pair situated more laterally, respectively. Pairs 6 and 7 continue the ring on the dorsal surface of the haptor with pair 7 being nearest the midline. In those species in which the hook ring is at the level of the dorsal anchor bases, pair 7 lies lateral to the anchors. Pair 5 (ventral) lies between the shafts and points of the more posterior ventral anchors.

All known species of *Dawestrema* possess a medial, anteriorly directed projection on the ventral bar. Price and Nowlin (1967) indicate in their fig. 8 that the origin of the process is the anterior bar margin, while in all of our specimens, the process originates from the posterodorsal or posterior bar surfaces.

Availability of three species of *Dawestrema,* some specimens of which were stained for study of internal structure, provided an opportunity to clarify morphologic features of the reproductive and digestive systems. Our findings differed from the original description as follows: (1) the presence of two tandemly arranged seminal vesicles (one described by Price and Nowlin 1967, which probably represents the anterior expanded part of the uterus); (2) a vas deferens looping the left intestinal crus (intercecal in the original description); (3) one prostatic reservoir (two in Price and Nowlin 1967); (4) confluent intestinal crura (Price and Nowlin apparently mistook the hollow nature of the bilateral vitelline bands in *D. cycloancistrium* as intestine); and (5) a testis smaller than ovary.

Lastly, our specimens clearly show that the proximal portion of the accessory piece (connecting piece of Price and Nowlin 1967) is located within the rings of the cirrus coil and not external to them as originally described. This configuration of the copulatory complex, along with observations on specimens in which the terminal portion of the cirral shaft was partially protruded from the genital pore, provides some insight to the functional morphology of this structure during copulation. In specimens with partly protruded cirri, the cirrus base may have the bottom surface facing ventrally, while in others this surface faces dorsally. In addition, the diameter of the cirral rings does not change appreciably in specimens with extruded cirri. Since the terminal part of the accessory piece, serving as a cirrus guide, is apparently fixed in location at the genital pore or within the genital atrium, these observations suggest that protrusion of the cirrus during copulation is not a result of a tightening of the cirrus coil, but rather an unwinding of the cirral shaft with the cirrus base rotating as the shaft is extruded. The twisted nature of the proximal part of the accessory piece, its articulation with the base of the cirrus, and the supposed fixed location of the terminal part of the accessory piece in the genital atrium, suggest that the accessory piece serves as a means of retracting the cirrus shaft much the same as the spring of a carpenter's tape measure. This functional aspect, based on observed structure of fixed specimens, however, is assumed as the mechanism employed, and confirmation will depend on observation of living specimens and/or analysis of the composition of the proximal part of the accessory piece. This is the first time, nonetheless, that insight into mechanical function of these structures has been available.

Price and Nowlin (1967) suggested that the long cirrus shaft of *D. cycloancistrium* provides a survival advantage for copulation over some distance. However, comparison of the structure of the vaginae and the length of the cirral shafts of respective species in the genus would not suggest that this occurs. In *D. cycloancistrium* and *D. cycloancistrioides,* the elongate cirral shaft would be necessary to reach the seminal receptacle through the long, tortuous, and/or coiled vaginal tube, while in *D. punctatum,* the comparatively short cirral tube could effectively reach the seminal receptacle since the vaginal tube is correspondingly short. Similar relationships in cirral and vaginal tube lengths occur in other monogeneans (e.g., *Gonocleithrum aruanae* and *G. cursitans,* see Kritsky and Thatcher 1983).

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Note added in proof: Specimens for deposition in the helminthological collection at INPA were shipped on 31 May 1984 and to this date (11 March 1985) have not been received in Manaus. We assume that they have been lost, at least temporarily, and thus no INPA numbers have been assigned. Lost specimens include the holotypes of *D. cycloancistrioides* and *D. punctatum,* 6 paratypes of *D. cycloancistrioides,* and 6 vouchers of *D. cycloancistrium.*

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# FOUR NEW SPECIES OF SCALIBREGMATIDAE (POLYCHAETA) FROM THE GULF OF MEXICO, WITH COMMENTS ON THE FAMILIAL PLACEMENT OF *MUCIBREGMA* FAUCHALD AND HANCOCK, 1981

Jerry D. Kudenov

*Abstract.*—Four new species of Scalibregmatidae (Polychaeta) are described from the Gulf of Mexico: *Asclerocheilus mexicanus, Hyboscolex quadricincta, Neolipobranchius blakei,* and *Sclerocheilus unoculus. Mucibregma* Fauchald and Hancock, 1981, is probably referable to the Fauveliopsidae.

Recent systematic studies on scalibregmatid polychaetes have resulted in a generic review and classification (Kudenov and Blake 1978), and subsequent clarification and refinement of this scheme (Blake 1981). In all, 15 genera and 46 species of scalibregmatids have been described (Blake 1981; Fauchald and Hancock 1981), not including the undescribed genus represented by *Asclerocheilus californicus* Hartman (Blake 1981). Four new species are described here, including *Asclerocheilus mexicanus, Hyboscolex quadricincta, Neolipobranchius blakei,* and *Sclerocheilus unoculus.* The generic definition of *Neolipobranchius* is emended, and the recently described genus *Mucibregma* Fauchald and Hancock, 1981, is tentatively referred to the Fauveliopsidae Hartman and Fauchald 1971.

This study is based on two small collections from the Gulf of Mexico. One collection derives from the Hourglass Cruises (Kudenov 1985), and was kindly made available by Thomas H. Perkins, Florida Department of Natural Resources, St. Petersburg, Florida. The other was taken as part of the Bureau of Land Management's Outer Continental Shelf Baseline Environmental Survey along the coasts of Mississippi, Alabama, and Florida (MAFLA) and southwest Florida (SOWFLA). All MAFLA samples were collected by Dames and Moore, and SOWFLA samples by Woodward-Clyde Environmental Consultants. Details of the MAFLA survey are given by Dames and Moore (1979). These materials were generously made available by Paul G. Johnson and Joan Uebelacker, Barry Vittor and Associates, Mobile, Alabama (Kudenov 1984). All materials including most types are deposited in the National Museum of Natural History, Smithsonian Institution, Washington D.C. (USNM); two paratypes are also deposited in the Invertebrate Reference Collection of the Florida Department of Natural Resources Marine Research Laboratory, St. Petersburg, Florida (FSBC I).

## *Asclerocheilus mexicanus,* new species
Fig. 1

*Material examined.*—FLORIDA, GULF OF MEXICO: MAFLA sta 2211G, 27°56′29.5″N, 83°52′59.5″W, 43 m, Nov 1977; 1 paratype (USNM 97267). Sta 2211H, same, Jun 1976; 1 paratype (USNM 97268). Sta 2423J, 29°37′00.8″N, 84°29′58.4″W, 19 m, silty fine sand, Jul 1976; 1 paratype (USNM 97265). Sta

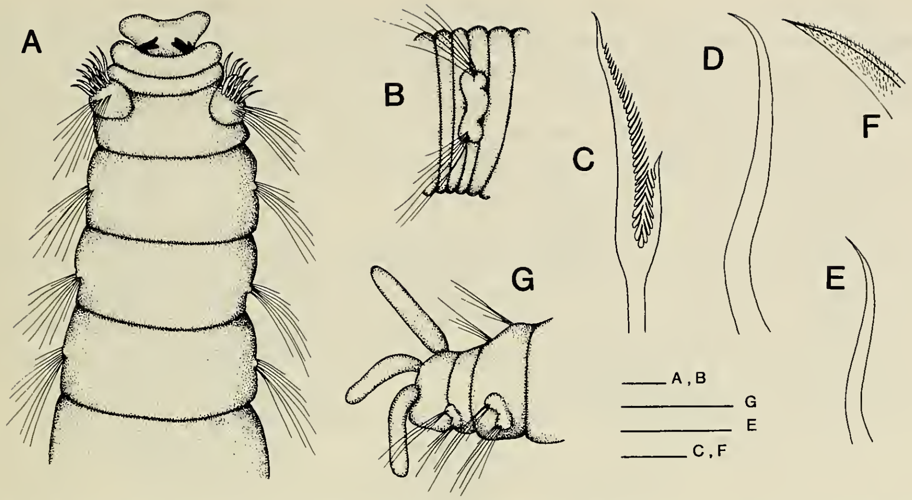

Fig. 1. *Asclerocheilus mexicanus* (holotype, USNM 97264): A, Anterior end, dorsal view; B, Parapodium, right setiger; C, Furcate seta; D, Notoaciculum from first row of setiger 1; E, Same from second row of setiger 1; F, Detail of tip of aciculum from setiger 1; G, Pygidium, lateral view. Scale: A, B = 2 mm; D, E = 40 μm; C, F = 10 μm; G = 100 μm.

2852E, 28°30′00.4″N, 83°29′58.4″W, 22 m, medium sand, Aug 1977; 1 paratype (USNM 97266). Sta 2528H, 29°54′58.6″N, 86°04′58.5″W, 37 m, coarse sand, no date; holotype (USNM 97264). Sta 2853C, 29°18′01.9″N, 84°19′59″W, 29 m, coarse sand, Aug 1977; 1 specimen (USNM 97269). Hourglass sta C, 27°37′N, 83°28′W, 38 m, sponge-algae-coral bottom, 5 Oct 1967; 1 paratype (FSBC I 31310).

*Description.*—Body arenicoliform, widest anteriorly, measuring up to 10 mm long, 0.9 mm wide, for 46 segments; opaque white in alcohol. Prostomium T-shaped, wider than long, with lateral process stout, distally blunt (Fig. 1A). Eyes numbering 2 pairs, partly fused along inner margins of a given pair (Fig. 1A). Buccal segment apodous, achaetous, uni- to biannulate dorsally and laterally, fused ventrally with setiger 1 (Fig. 1A). Parapodia biramous, poorly developed, resembling small conical papillae anteriorly (Fig. 1A), and flattened lobes posteriorly (Fig. 1B). Setae include smooth capillaries in all rami, furcate setae having tines of unequal lengths in all rami except first notopodium (Fig. 1C), and acicular spines having recurved, distally pointed shafts with minutely hirsute distal sheaths in the notopodia of setiger 1 only (Fig. 1A, F). Acicular spines arranged in 2 transverse rows, with 5–6 spines in the first (Fig. 1A, D), and 4–5 in the second (Fig. 1A, E). Pygidium damaged, with at least 3 anal cirri (Fig. 1G). Body segments indistinctly annulate, with anterior and posterior ones normally uniannulate (sometimes biannulate); medial ones tri- or quadriannulate (Fig. 1A, B, G).

*Remarks.*—*Asclerocheilus mexicanus* is most closely allied to *A. acirratus* (Hartman, 1966) and *A. tropicus* (Blake, 1981), in having acicular spines confined to the notopodia of setiger 1. There are two rows of these spines in both *A. mexicanus* and *A. tropicus,* and 1 in *A. acirratus. Asclerocheilus mexicanus* differs from *A. tropicus* in having stout, conical prostomial processes instead of flattened lateral wings; in having two pairs of eyes with dense ocelli, arranged obliquely and partially fused along their inner margins, rather than longitudinal lines of separate ocelli; in having acicular spines of two different sizes; in having furcate setae with parallel instead of divergent tines; in lacking body reticulae; and in having pygidial cirri. Tine ratios for the two species also differ, with 2.48 for *A. mexicanus,* and 2.66 for *A. tropicus* (Blake, 1981). Refer to Discussion for a further treatment of this character.

*Asclerocheilus mexicanus* is also related to *A. ashworthi* Blake, 1981, *A. beringianus* Uschakov, 1955, and *A. heterochaetous* Kudenov and Blake, 1978, in having only notoacicular spines. However, these spines are present in setigers 1–2 in both *A. ashworthi* and *A. beringianus,* and setigers 1–4 in *A. heterochaetus.*

*Etymology.*—The epithet derives from the Gulf of Mexico, and is an adjective formed from the noun Mexico.

*Distribution.*—Northeastern Gulf of Mexico, 18–31 m.

### *Hyboscolex quadricincta,* new species
Fig. 2

*Material examined.*—FLORIDA, GULF OF MEXICO: MAFLA sta 2852E, 28°30′00.4″N, 83°29′58.4″W, 22 m, medium sand, Aug 1977; 4 paratypes (USNM 97277). Hourglass sta B, 27°37′N, 83°07′W, 18 m, EJ-65-365, sponge-coral, 3 Dec 1965; 1 paratype (USNM 97271). Same, EJ-66-73, mud, coral, dead shell, 3 Mar 1966; 1 paratype (USNM 97272). Same, EJ-67-160, sand, rock, algae, 11 May 1967; 2 paratypes (USNM 97273). Same, EJ-67-179, sponge, coral and shell, 20 May 1967; holotype (USNM 97270), 1 paratype (USNM 97425). Same, EJ-67-213, sponge, coral, algae and shell debris, 2 Jun 1967; 1 paratype (USNM 97274). Same, EJ-67-328, sponge, algae, coral, 11 Sep 1967; 1 paratype (USNM 97275). Same, EJ-67-389, shell, algae, sponge and coral bottom, 20 Nov 1967; 1 specimen (USNM 97278). Sta J, 26°24′N, 82°28′W, 18 m, coral and sponge bottom, 6 Dec 1966; 1 paratype (USNM 97276). Same, 26°24′N, 82°25′W, EJ-66-194, 18 m, coral and algae, 11 May 1966; 3 specimens (USNM 97279). Same, EJ-66-460, coral and sponge bottom, 6 Dec 1966; 1 paratype (USNM 97425). Same, EJ-66-469, 1 paratype (FSBC I 31388). Sta K, 26°24′N, 82°58′W, 31 m, EJ-67-383, sand, sponge bottom, 14 Nov 1967; 1 specimen (USNM 97280). Sta 12 I-BC-C, EJ-81-104, Citrus County, Crystal River, approximately 18 km at 214 from mainland, mouth of discharge canal, 0.6 m, primarily exposed limestone overlain by muddy sand, 14 Apr 1981; 1 specimen (USNM 97281).

*Description.*—Body arenicoliform, widest anteriorly, measuring up to 13 mm long, 1.4 mm wide, for up to 69 setigers; opaque white in alcohol. Prostomium with stout lateral processes about as long as wide (Fig. 2A). Eyes numbering 2 pairs, arranged in 2 parallel to diverging rows of pigment (Fig. 2A, B). Buccal segment apodous, achaetous, uniannulate dorsally and laterally, fused ventrally with setiger 1 (Fig. 2A, B). Parapodia biramous, projecting slightly above body wall, resembling flat mounts anteriorly, becoming small conical lobes posteriorly (Fig. 2A). Spinulose capillary setae (Fig. 2C) and furcate setae with unequal tines (Fig. 2D) present in all rami. Pygidium variably developed, with 4–6 anal cirri (Fig. 2E–G). Body segments annulated with buccal segment and setigers 1, 44–59 uniannulate; setigers 2–4 and 27–43 biannulate; setigers 5–6 triannulate; setigers 7–32 quadriannulate (Fig. 2A, E–G).

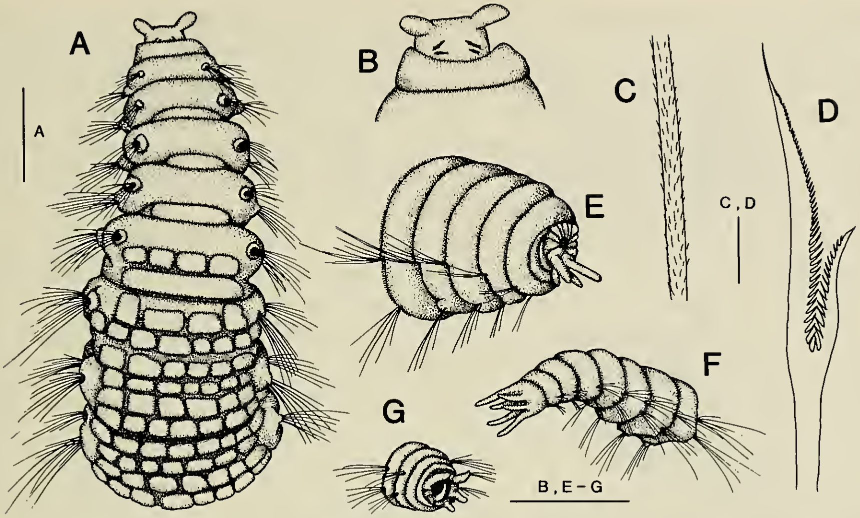

Fig. 2. *Hyboscolex quadricincta*: A–E, holotype (USNM 97270); F, paratype (MAFLA 2852E: USNM 97277); G, paratype (EJ-66-73:USNM 97272). A, Anterior end, dorsal view; B, head region, dorsal view; C, Spinulose capillary seta, detail of shaft; D, Furcate seta; E, Pygidium, left frontolateral view; F, Same, right frontolateral view; G, Same, left frontolateral view. Scale: A–B, E–G = 0.5 mm; C, D = 10 μm.

*Remarks.*—*Hyboscolex quadricincta* is most closely allied to *H. pacificus* (Moore, 1909) in the shape of the prostomium, configuration and placement of the eyes (Berkeley and Berkeley 1952:59), and in having a variable number of anal cirri (Imajima and Hartman 1964:304). *Hyboscolex quadricincta* differs in having anterior body segments quadriannulate, instead of triannulate or biannulate, in having spinulose capillaries, instead of smooth ones, and in having 4–6 anal cirri, rather than 0 or 6–7. It is noteworthy that furcate setae of *H. quadricincta* have a tine ratio of 2.4 compared to 1.7 determined from seven specimens of *H. pacificus* loaned by the Allan Hancock Foundation (AHF N2394).

*Etymology.*—The epithet derives from the presence of four transverse annuli on most body segments.

*Distribution.*—Northeastern Gulf of Mexico, 0.6–31 m.

### *Neolipobranchius* Hartman and Fauchald, 1971, emended

*Type-species.*—*Neolipobranchius glaber* (as *glabrus*) Hartman and Fauchald, 1971, by original designation.

*Description.*—Body maggot-like, widest anteriorly, tapering posteriorly. Prostomium entire, conical to bluntly conical, not incised; eyes and frontal processes absent. Buccal segment achaetous, apodous. Segments 2–3 reduced, apodous, with or without setae. Parapodia biramous from segment 4 to end of body. Parapodial lobes papillar to low-lying glandular mounds. Setae include limbate to smooth capillaries and furcate setae. Branchiae, parapodial cirri absent. Pygidium with or without anal cirri. Body segments either with transverse annuli or longitudinal striations; epidermis smooth.

*Remarks.*—The occurrence of a new species, described below, necessitates emending the generic definition of *Neolipobranchius*. The type-species, *N. glaber*, was recognized by Hartman and Fauchald (1971:124) as a highly modified scalibregmatid having an entire prostomium, and lacking segmental annuli, parapodial lobes, furcate setae, and pygidial cirri. The emended generic definition of *Neolipobranchius* recognizes that the latter four characters are present in the genus. However, it must be emphasized that *Neolipobranchius* is unique amongst scalibregmatids in having an entire prostomium.

As such, this genus is not as strongly isolated in the family as previously suspected (Hartman and Fauchald 1971:124; Kudenov and Blake 1978; Blake 1981). For example, *Neolipobranchius, Polyphysia* Quatrefages, 1865, and *Kebuita* Chamberlin, 1919, are all assigned to Division II sensu Kudenov and Blake (1978: 440–441; see also Blake 1981:1157) for scalibregmatids having maggot-like bodies and lacking tentacular prostomial processes. In all, these three genera are represented to date by eight described species. The latter two genera possess incised prostomia (Division IIA), while *Neolipobranchius* has an entire prostomium (Division IIB). *Mucibregma* Fauchald and Hancock, 1981, may be incorrectly assigned to the scalibregmatids and is here excluded from Division II. Refer to the Discussion where *Mucibregma* is treated separately.

Division II species exhibit typical scalibregmatid features such as an achaetous buccal segment, branchiae, segmental annuli, epidermal tesselations, parapodia, furcate setae and pygidial cirri. However, these characters are not evenly distributed amongst species of this group, are generally reduced, and may be absent in such highly modified species as *Neolipobranchius glaber*. Described species of Division II differ generally from those of Division I (arenicoliform scalibregmatids having prostomial tentacular processes) in lacking acicular setae, parapodial cirri, and normally also pygidial cirri.

### *Neolipobranchius blakei*, new species
Fig. 3

*Material examined.*—FLORIDA, GULF OF MEXICO: Citrus County, Crystal River, FSBC sta I-29172, EJ-81-104, approximately 18 km at 214 from mainland, 0.6 m, mouth of discharge channel, mixed algae primarily *Caulerpa* species, exposed limestone overlain by muddy sand and oyster shells, 14 Apr 1981, Applied Biology, Inc., colls; holotype (USNM 97283).

*Description.*—Body maggot-like, widest anteriorly, tapering posteriorly, measuring 3 mm long, 0.7 mm wide for 38 setigers (Fig. 3A); opaque white in alcohol. Prostomium bluntly conical, simple, lacking both eyes and lateral processes (Fig. 3A, B). Buccal segment and segments 2–3 (=setigers 1, 2) reduced, apodous, forming complete uniannulate rings (Fig. 3B); buccal segment achaetous; segments 2–3 with notopodial fascicles reduced or absent, lacking neurosetal fascicles (Fig. 3B). Segment 4 (=setiger 3) also reduced, about ½ the size of segment 5 (Fig. 3B). Parapodia biramous from segment 4 to end of body, as low-lying mound- to papilla-shaped lobes (Fig. 3A). Setae include smooth capillaries in all fascicles, and furcate setae with unequal tines from setiger 3, the latter having thin shafts anteriorly (Fig. 3C), becoming thicker posteriorly (Fig. 3D, E). Pygidium with 5 anal cirri (Fig. 3F). Body segments annulated with buccal segment and setigers 1–3, 31–38 uniannulate; setigers 4–18 quadriannulate; setigers 19–24 distended, annuli not recognizable; setigers 25–30 biannulate.

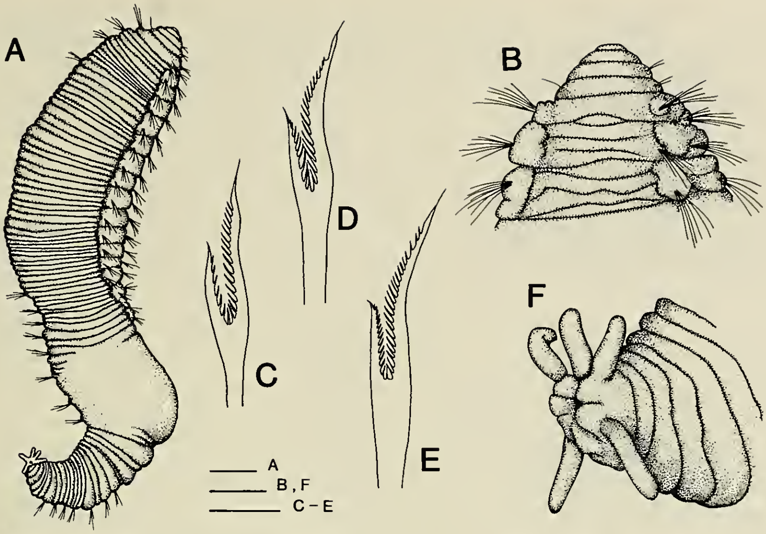

Fig. 3. *Neolipobranchius blakei* (holotype, USNM 97283): A, Entire worm, dorsal view; B, Anterior end, dorsal view; C, Furcate seta, setiger 5; D, Same, setiger 17; E, Same, setiger 29; F, Pygidium, right frontolateral view. Scale: A = 2 mm; B, F = 50 μm; C–E = 10 μm.

*Remarks.*—*Neolipobranchius blakei* differs from the only other described species, *N. glaber* (Hartman and Fauchald, 1971), in having capillary setae on segments 2–3, furcate setae, parapodia, pygidial cirri, and segmental annuli. This is the first record of the genus from a littoral habitat.

*Etymology.*—It is an honor to name this species for James A. Blake, teacher, friend, and fellow polychaetologist. The epithet is a noun in the genitive case.

*Distribution.*—Gulf of Mexico, 0.6 m.

### *Sclerocheilus unoculus*, new species
Fig. 4

*Material examined.*—FLORIDA, GULF OF MEXICO: Sta 2852E, 28°30′00.4″N, 83°29′58.4″W, 22 m, medium sand, Aug 1977; 1 paratype (USNM 97287). Hourglass sta B, 27°37′N, 83°07′W, 18 m, EJ-67-111, coral, shell, sponge and algae bottom, 3 Apr 1967; holotype (USNM 97285). Same, EJ-67-370, same, 2 Nov 1967; 1 paratype (USNM 97284). Sta C, 27°37′N, 83°28′W, 37 m, EJ-67-28, coral and sponge bottom, 20 Jan 1967; 1 paratype (USNM 97286).

*Description.*—Body arenicoliform, widest anteriorly, tesselate, measuring up to 6 mm long, 1 mm wide without setae, for up to 46 setigers; opaque white in alcohol. Prostomium T-shaped, wider than long, with lateral processes stout, distally blunt (Fig. 4A). Eyes fused, connected medially by amorphous red pigment, forming a yoke across prostomium (Fig. 4A). Buccal segment apodous, achaetous, uniannulate dorsally and laterally, fused ventrally with setiger 1. Parapodia biramous, well developed, resembling flat triangular lobes anteriorly (Fig. 4A), becoming inflated, conical posteriorly (Fig. 4B, C). Dorsal cirri absent. Ventral cirri present in setigers 24–36, short, digitiform, inconspicuous (Fig. 4C, D). Setae include smooth capillaries in all rami; furcate setae having tines of unequal

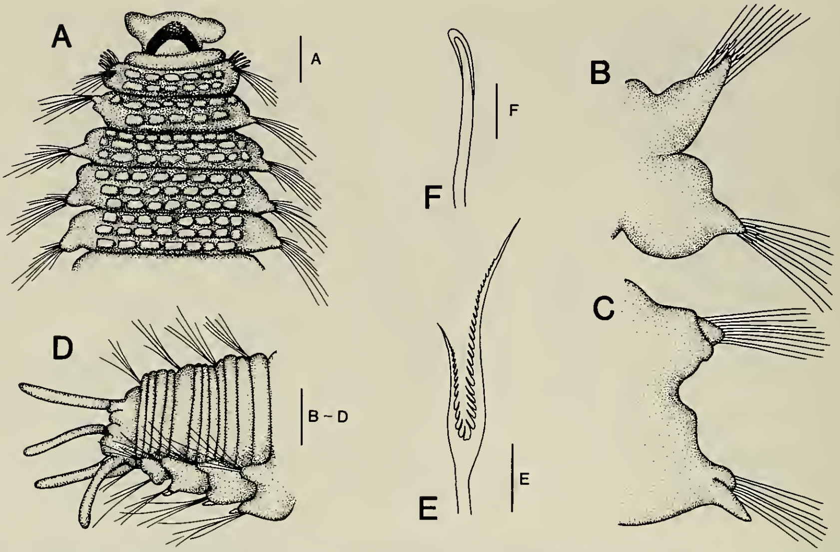

Fig. 4. *Sclerocheilus unoculus*: A–B, E–F, holotype (USNM 97285); C–D, paratype (EJ-67-28: USNM 97286). A, Anterior end, dorsal view; B, Right parapodium, setiger 16, posterior view; C, Right parapodium, setiger 29, posterior view; D, Furcate seta; E, Aciculum from setiger 1; F, Pygidium, right dorsolateral view. Scale: A = 2 mm; B–D = 50 μm; E = 10 μm; F = 20 μm.

lengths in all rami except the first notopodium (Fig. 4E); and short acicular spines having nearly straight shafts, blunt tips and clear, loose fitting hyaline sheaths in notopodia of setiger 1 (Fig. 4F). Acicula arranged in 1 transverse row of 4–5 spines (Fig. 4A). Pygidium with 4 long anal cirri (Fig. 4D). Body segments annulated with setigers 1–2 biannulate; setigers 3–5 triannulate; and setigers 6 to end of body quadriannulate.

*Remarks.*—*Sclerocheilus unoculus* is most closely allied to *Sclerocheilus minutus* Grube in having a single transverse row of acicular spines in the notopodia of setiger 1. *Sclerocheilus unoculus* differs from *S. minutus* in having eyes fused and connected medially across the prostomium by a yoke of pigment, triannulate anterior segments instead of biannulate ones, acicular spines having distal sheaths, and greatly reduced ventral cirri. There is also a difference in the relative tine lengths of furcate setae (tine ratio 2.1 in *S. unoculus*; 1.3 in *S. minutus*).

*Etymology.*—The epithet *unoculus* derives from Latin terms *unus* meaning one, and *oculus* meaning eye. It is a noun in apposition.

*Distribution.*—Gulf of Mexico, 18–38 m.

## Discussion

Preliminary data on tine ratios for the furcate setae of *Asclerocheilus, Hyboscolex,* and *Sclerocheilus* (this study) corroborate findings presented by Blake (1981:1132) for five species of *Asclerocheilus.* For example, tine ratios for *Asclerocheilus mexicanus* do not coincide with values listed by Blake (1981). However, some variability must be present, although it is probably small. For example, tine ratios for *A. beringianus* Uschakov, 1955, from the Gulf of Mexico are 1.8 (Kudenov 1985), compared to 1.7 reported by Blake (1981:1132). Although tine ratios are probably valid and useful taxonomic criteria, their ranges of variability must be determined before they can be used routinely.

The fact that scalibregmatids were becoming a polyphyletic assemblage of simply structured polychaetes (Fauchald 1977:43) was central to the review by Kudenov and Blake (1978) and the recent revision by Blake (1981). Fauchald and Hancock (1981:20) restated this concern in their description of a new scalibregmatid genus, *Mucibregma.* This genus is described as having a "T"-shaped prostomium, an extremely muscular peristomial segment, a dorsoventrally flattened body encased in a tough mucous sheath attached to a glandular peristomial ridge, biramous parapodia having acicular spines accompanied by long capillary setae, and in lacking furcate setae. However, examination of the type-species, *Mucibregma spinosum* Fauchald and Hancock, 1981, revealed significant anatomical features that are not associated with scalibregmatids. For example, the prostomium is not as conspicuously "T"-shaped in that the small prostomial processes project laterally and posteriorly (Fauchald and Hancock 1981, Pl. 3, fig. a). The extremely muscular and glandular peristomium is a character not encompassed by the family definition of scalibregmatids, and may include the presence of perhaps more than one achaetous segment in *Mucibregma.* Furthermore, the presence of heavy, spindle-shaped acicular spines accompanied by long, pliable capillary setae in all parapodia is simply not a scalibregmatid characteristic. Finally, scalibregmatids occupy burrows, and apparently do not construct tubes (Fauchald and Jumars 1979:245) such as that made by *Mucibregma.* However, in light of such unusual features, Fauchald and Hancock (1981) assigned *Mucibregma* to Division II scalibregmatids (sensu Kudenov and Blake 1978) for worms having maggot-like bodies and lacking distinct tentacular processes. However, Fauchald and Hancock do not define their new category "C," and it is surmised that their subcategory "1" refers to the absence of gills in *Mucibregma.* Overall, it appears that the inclusion of *Mucibregma* in the Scalibregmatidae results in an inappropriately polyphyletic taxon.

By contrast, *Mucibregma* appears to exhibit a greater affinity to the Fauveliopsidae Hartman and Fauchald 1971. For example, the primary criterion suggesting this relationship is the fascicles of thick spindle-shaped spines accompanied by long capillary setae present in all fascicles of both *Mucibregma* and *Fauveliopsis.* There is also a superficial similarity in the shape of the prostomia, which are bluntly rounded anteriorly; the posterolateral regions are not fused to the body in *Mucibregma* and are fused with the buccal segment in *Fauveliopsis* (Kudenov, unpublished data). Furthermore, both taxa lack furcate setae, which may simply be an example of convergence, and should probably not be weighted unduly. These two taxa differ from one another in that the anterior fragment on which *Mucibregma* is defined lacks the interramal papillae that are typically present in *Fauveliopsis*; it also has an extremely well developed peristomium. It is therefore suggested that *Mucibregma* be temporarily referred to the Fauveliopsidae. Although this association needs to be examined in greater detail, such a study may reveal that *Mucibregma* will need to be assigned to a separate family.

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# A NEW SPECIES OF *PAROTOCINCLUS* (PISCES: LORICARIIDAE) FROM GUYANA

Robert E. Schmidt and Carl J. Ferraris, Jr.

*Abstract.*—A new species of loricariid fish, *Parotocinclus collinsae,* is described from the Essequibo drainage, Guyana. This species is most similar to *P. maculicauda* from the Amazon River drainage and *P. britskii* from the Coppename River, Surinam. This is only the second species of the genus reported from north of the Amazon drainage.

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The most recent review of the loricariid genus *Parotocinclus* Eigenmann and Eigenmann (1889) listed thirteen species (Garavello 1977). In this paper we describe a new species of the genus *Parotocinclus* from the Essequibo River drainage, taken during recent collections of freshwater fishes made by RES in Guyana.

*Methods.*—Morphometric measurements were made with a Wild M-8 binocular microscope and an ocular micrometer. Morphometrics are those used by Garavello (1977) to differentiate species. Body depth was measured at origin of dorsal fin, head length was from tip of snout to rear margin of bony opercle, body width was measured at widest region of scapular bridge, and orbital diameter was measured horizontally. Morphometrics of holotype are given first followed by range of paratypes in parentheses. Spinous fin elements are designated with a small "I" since ostariophysans do not have true spines and unbranched rays are designated with "i." Meristics of the holotype are indicated by an asterisk (*). The following museum abbreviations are used: AMNH = American Museum of Natural History, USNM = National Museum of Natural History, Smithsonian Institution.

### *Parotocinclus collinsae,* new species
### Figs. 1–3

*Holotype.*—AMNH 55433, 25.0 mm SL; Guyana, Essequibo Province, tributary to Takutu River about 2 mi from Mazarahally Takutu lumber camp in Takutu Mountains, approximately 6°15′N, 59°5′W; R. E. Schmidt and A. Pappantoniou, 17 Aug 1983.

*Paratypes.*—Same data as holotype; AMNH 55434, 4 specimens, 18.5–25.5 mm SL; USNM 265091, 2 specimens, 18.5–22.0 mm SL.

*Diagnosis.*—A *Parotocinclus* with the following meristics and color pattern: 21–22 lateral line plates, more than 25 premaxillary and dentary teeth on each side, abdomen covered with regular series of plates; one light saddle at dorsal fin and two dark saddles: one between dorsal and adipose fins, and one between adipose and caudal fins.

*Description.*—Fin element counts typical for *Parotocinclus* (Garavello 1977): Dorsal—i, 7; Anal—i, 5; Pectoral—i, 6; Pelvic—i, 5; and Caudal—i, 14, i. Premaxillary teeth 29–33* on each side, mandibular teeth 23–32* on each side with the smallest specimens having the fewest teeth. Pored lateral line plates 21* or 22.

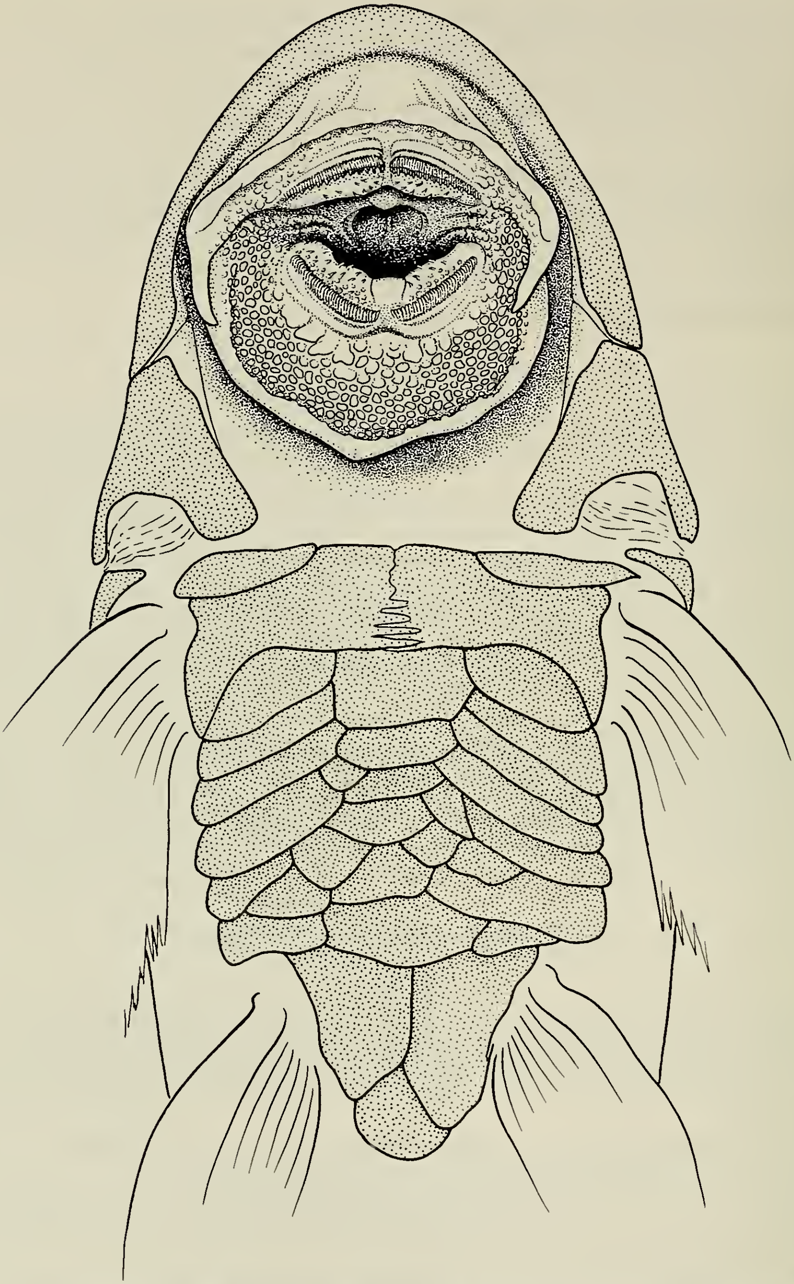

Fig. 1. Ventral view of head and abdomen of holotype of *Parotocinclus collinsae*, AMNH 55433 showing arrangement of abdominal plates.

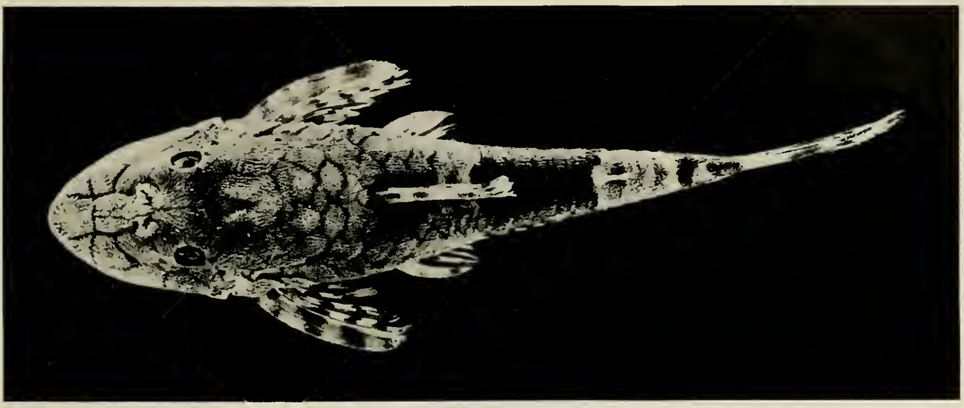

Fig. 2. Dorsal view of holotype of *Parotocinclus collinsae,* AMNH 55433 (25.0 mm SL) showing reticulated appearance of plate junctions.

Standard length/body depth 5.2 (4.8–6.6), SL/body width 3.9 (3.6–4.1), head length/orbital diameter 7.4 (6.1–8.1) and interorbital width/orbital diameter 2.8 (2.4–3.0). Lips covered with large papillae, lower lip extends approximately half way to exposed coracoids. Barbel extends posteriorly from the corner of mouth no further than posterior margin of lower lip.

Body covered with plates except for area between lower lip and exposed coracoids, triangular area around anal papilla, and opening of air bladder capsule ventral to posttemporal plate; plates uniformly covered with recurved denticles, those on snout somewhat enlarged. Plates without ridges except median carina on posterior two-thirds of snout to between nares, 2 shorter carinae extending from lateral to nares to above eye. One pair of plates posterior to occiput, followed by single median plate, second pair of plates, and second median plate, latter anterior to origin of dorsal fin in holotype; smaller specimens with fewer plates on nape. Six plates between dorsal and adipose fins, 4 between adipose and caudal fins. Abdomen with 3 rows of 6 plates each in holotype (Fig. 1), only lateral plates apparent in smaller specimens. Posttemporal plate imperforate.

Base color on dorsolateral surface light orange-brown in ethanol. Junctions between plates on head, back, and sides of body darker than plates, producing reticulated appearance, especially prominent on holotype (Fig. 2). Very faint, wide dark lateral band from anterior to eye to insertion of dorsal fin, with equally faint dorsal saddles at supraoccipital and base of dorsal fin. Nape comparatively light. Dark saddle between posterior of dorsal fin and anterior of adipose fin extends ventrally to mid-lateral line where it divides into anterior and posterior ventral projections (Fig. 3); latter almost completely encircling peduncle. Second, narrower dark saddle at base of caudal fin with similar pattern on ventral portion of sides, completely encircling peduncle. Ventral surface of head, abdomen, breast, and ventral and ventrolateral portions of peduncle white. Some discrete black spots on breast, abdomen, and ventral surface of head in holotype; spots fewer or absent on paratypes. Spines and rays of all fins with black dashes arranged to appear as bars; pectoral with 5 bars, pelvic-1 or 2*, anal-1 or 2*, dorsal-4, adipose-1, caudal-3.

Fig. 3. Lateral view of holotype of *Parotocinclus collinsae*, AMNH 55433 (25.0 mm SL) showing lateral plate arrangement and color pattern.

*Etymology.*—Named for Dr. Margaret Collins (Alfred Emerson Field Station, Kartabo, Guyana) who made it possible for the senior author to collect fishes in Guyana.

*Biology.*—The type-series was collected in a stream of moderate gradient in virgin rainforest in the Takutu Mountains, approximately 300 m elevation. The substratum was predominantly sand with many fallen trees. Collections were made with a 3 m seine in less than 1 m depth by kicking up and driving fishes downstream into the net.

*Discussion.*—*Parotocinclus collinsae* is most similar to *P. maculicauda* and *P. britskii* in having the abdomen covered with regular rows of plates and possessing more than 25 premaxillary and dentary teeth on each side. It differs from *P. maculicauda* in having 21–22 plates in the lateral line rather than 24–26. *Parotocinclus maculicauda* has four dark dorsal saddles situated differently. *Parotocinclus britskii* has five rows of plates on the abdomen (rather than three) and three dark dorsal saddles: one under the anterior part of the dorsal fin, one under the adipose fin, and one just anterior to the caudal fin.

Most *Parotocinclus* species are known from coastal Brazil (Garavello 1977). *Parotocinclus amazonensis* from Rio Solimões and *P. britskii* from the Coppename River, Surinam are exceptions. *Parotocinclus collinsae* is the first record of the genus from the Essequibo River drainage.

Inclusion of *P. collinsae* in the genus *Parotocinclus* is somewhat problematical. Boeseman (1974) distinguished *Parotocinclus* from other hypoptopomatine genera by the presence of an adipose fin, 3–5 series of plates on the abdomen and a slightly flattened head with eyes situated dorsolaterally, not visible from below. Garavello (1977) used a broader definition of the genus, to include species with naked abdomens or nearly lateral eyes. Further, he identified two species groups within *Parotocinclus* but did not designate them as genera because he was unable to place *P. spilurus* into either group. As with *P. spilurus, P. collinsae* shares characters with both groups and further blurs the distinction between them. If the genus were to be subdivided, *P. collinsae* would quite possibly remain in *Parotocinclus* due to its regular pattern of abdominal plates (also present on *P. maculicauda,* the type-species) which are, we believe, a derived feature within the group.

## Acknowledgments

We thank the government of Guyana for making it possible for RES to collect fishes in its country. The Mazarahally Timber Company arranged transportation to the collection site and Mr. Roy van Long, Takutu Camp, was especially helpful in providing facilities and transportation. Dr. Antonios Pappantoniou helped in the field, Mary Rauchenberger helped in the darkroom and Kathleen A. Schmidt drew the figures. This is Bard College Field Station-Hudsonia Contribution #30.

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# TWO NEW SPECIES OF *STRATIODRILUS*, *S. AEGLAPHILUS* AND *S. PUGNAXI* (ANNELIDA: HISTRIOBDELLIDAE) FROM CHILE

Irma Vila P. and Nibaldo Bahamonde N.

*Abstract.*—Two new species of Histriobdellidae (Annelida) from Chile of the genus *Stratiodrilus* are described: *Stratiodrilus aeglaphilus* from the gill chamber of *Aegla laevis* and *Stratiodrilus pugnaxi* from the gill chamber of *Parastacus pugnaxi.*

A key for the identification of all known species of *Stratiodrilus* is given and their known biogeographic distribution is described.

The family Histriobdellidae includes *Histriobdella* and *Stratiodrilus,* epizoic annelids living in the branchial chamber or on the eggs of marine and freshwater crustaceans, respectively. Histriobdellidae have the following characteristics: small, vermiform, head conspicuous, clearly separated from rest of body, coelom reduced, sexes separate, pharyngeal sac present, adhesive glands at the posterior end of the body, and male with copulatory organ. We agree with Borradaile and Potts (1958) that these characteristics, together with the absence of parapodia and chaetae, indicate an evolutionary specialization typical of parasites.

Haswell (1900) proposed the genus *Stratiodrilus,* which now includes epizoic freshwater animals of circumantarctic distribution with species found in Australia, Tasmania, the southern region of South America, and Madagascar. They possess a conspicuous head, a trunk of five body segments and a caudal region. The head carries an unpaired median and two pairs of lateral tentacles, followed by paired conic retractile locomotive appendages. The trunk has three paired lateral cirri and in addition in the males, retractile gonopodia. The caudal region carries cirri, which in the genus *Stratiodrilus* are of great taxonomic significance.

The high degree of specialization of *Stratiodrilus,* together with its peculiar geographical distribution, supports the geological relationships supposed to have existed between Australia, Madagascar and South America.

The life cycle of *Stratiodrilus,* entirely confined to the branchial chamber of the host, differs substantially from that of most known polychaetes. However, the significance of this feature remains to be studied in detail. Further knowledge of the life cycle, taxonomy and ecology of *Stratiodrilus* will certainly help in tracing phylogenetic relationships between host freshwater crustaceans of the Southern Hemisphere.

To date, four species of *Stratiodrilus* have been described: *S. tasmanicus* Haswell, 1900; *S. novahollandiae* Haswell, 1913; *S. haswelli* Harrison, 1928, and *S. platensis* Cordero, 1927. We describe herein two new species of *Stratiodrilus*: *S. aeglaphilus* and *S. pugnaxi* and give a key for the identification of all known species of *Stratiodrilus.*

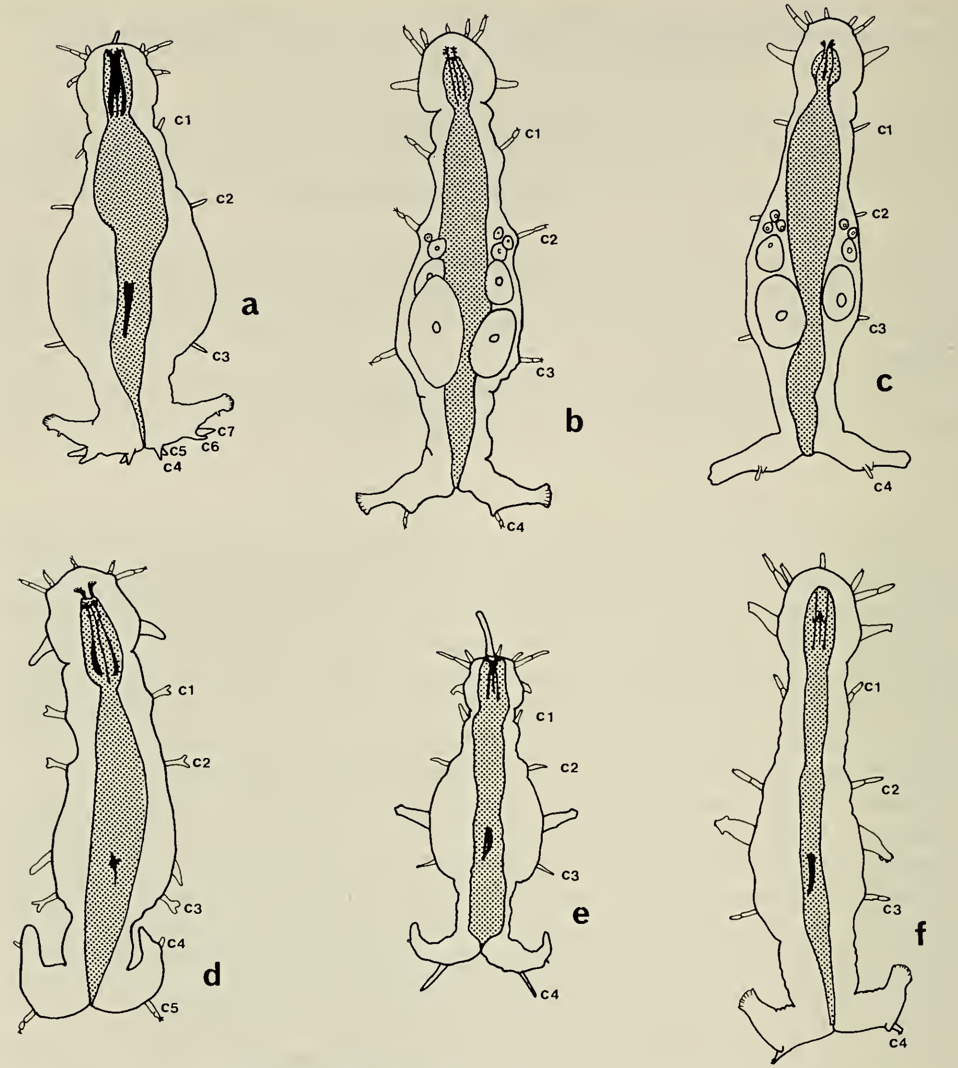

Fig. 1. The species of *Stratiodrilus,* habitus: a, *S. pugnaxi*; b, *S. novaehollandiae*; c, *S. platensis*; d, *S. haswelli*; e, *S. aeglaphilus*; f, *S. tasmanicus.* c1–c3, lateral cirri; c4–c7, caudal cirri.

### *Stratiodrilus aeglaphilus,* new species

*Diagnosis.*—Adult males reach an average total length of 750 μm (maximum 1200 μm); females average 500 μm (maximum 1000 μm). The mandibular apparatus of both sexes has an average length of 90 μm. As in other species, the trunk bears 3 pairs of lateral unsegmented simple cirri on the second, third, and fifth trunk segments. Each of the caudal appendages of the posterior region has a simple cirrus and a small tubercle, well separated, along the caudal border (Fig. 1e, Table 1).

*Differences from other species of the genus.*—*Stratiodrilus aeglaphilus* is the smallest of the species so far known. It has a maximum total length of 1200 μm

Table 1.—Geographical distribution of *Stratiodrilus.*

| Species | Host | Geographic distribution |
|---|---|---|
| *S. tasmanicus* Haswell, 1900 | *Astacopsis franklinii* (Gray) *Astacopsis franklinii tasmanicus* Erickson | Tasmania, Hobart. |
| *S. novaehollandiae* Haswell, 1913 | *Astacopsis serratus* Shaw | New South Wales. Streams 2000 to 3000 feet in blue mountains. Hawkesbury River System. Cataract River and London River. Post Hacking Waterfall Creek. Middle Harbour, Port Jackson, Pitt water off Broken Bay. Murrum Bridgee River of Murray River System. |
| *S. platensis* Cordero, 1927 | *Aegla laevis** (Latreille) | Uruguay. Stream Solís Chico, Departamento de Canelones, Arroyo Miguelete. |
| *S. haswelli* Harrison, 1928 | *Astacoides madagascariensis,* Milne Edwards | Madagascar. |
| *S. aeglaphilus,* n. sp. | *Aegla laevis* (Latreille) | Central Chile. Río Maipo. |
| *S. pugnaxi,* n. sp. | *Parastacus pugnax* (Poeppig) | Southern Chile, Reumén (Valdivia). |

* The available evidence (Schmitt 1942) indicates that two species of *Aegla* are present in Uruguay: *A. platensis* Schmitt and *A. uruguayana* Schmitt; whereas *A. laevis* has only been reported present in Central Chile (Bahamonde and López 1963).

in the male and 1000 μm in the female. Their simple unsegmented lateral cirri differ from the bifurcate ones of *S. haswelli* and the bisegmented ones of *S. tasmanicus* and *S. novaehollandiae. Stratiodrilus aeglaphilus* differs from *S. platensis* in having only one pair of caudal cirri.

*Material examined.*—Río Maipo, Chile, 33°45′S, 70°45′W, from branchial chamber of *Aegla laevis laevis* Latreille. Holotype: M.N.H.N. AN-2001 (Museo Nacional de Historia Natural) Santiago, Chile, Peñaflor tributary of Río Maipo, Chile. Paratypes: M.N.H.N. AN-2003, 2 males and 2 females.

### *Stratiodrilus pugnaxi,* new species

*Diagnosis.*—The average length of the adult male is 1200 μm (maximum 1360 μm) and that of the female is 1100 μm (maximum 1180 μm). It has the longest mandibular apparatus with an average length of 430 μm. The 3 pairs of lateral cirri are simple, unsegmented and clearly ciliated at their distal ends.

The caudal region has 4 paired retractile cirri: the first 2 pairs are highly retractile and located lateral and close to the anus. One pair is dorsal and the other is ventral. When the dorsal pair of caudal cirri is fully extended, it becomes bifurcate. The other 2 pairs of cirri are located distally on the caudal region (Fig. 1a, Table 1).

*Differences from other species of the genus.*—The most distinctive feature of *S. pugnaxi,* is the number of caudal cirri: 4 pairs in *S. pugnaxi* and 1–2 pairs in the other species.

*Material examined.*—Chile (Valdivia): Reumén, 39°45′S, 73°45′W. In the branchial chamber of *Parastacus pugnax.* Holotype: Male, M.N.H.N. AN-2002, Reumén 50 km, Valdivia, Chile. Paratypes: M.N.H.N. AN-2004, 5 males and 5 females.

## Key to the Species of *Stratiodrilus* Haswell, 1900

1( 2) One or two pairs of caudal cirri .................................... 3
2( 1) Four pairs of caudal cirri .................. *S. pugnaxi,* n. sp. (Fig. 1a)
3( 4) Two pairs of caudal cirri .................................... 5
4( 3) One pair of caudal cirri .................................... 7
5( 6) Caudal cirri bisegmented ... *S. novaehollandiae* Haswell, 1913 (Fig. 1b)
6( 5) Caudal cirri unsegmented .......... *S. platensis* Cordero, 1927 (Fig. 1c)
7( 8) Lateral cirri bifurcate ............ *S. haswelli* Harrison, 1928 (Fig. 1d)
8( 7) Lateral cirri non-bifurcate .................................... 9
9(10) Lateral cirri unsegmented ............... *S. aeglaphilus,* n. sp. (Fig. 1e)
10( 9) Lateral cirri bisegmented ........ *S. tasmanicus* Haswell, 1900 (Fig. 1f)

## Acknowledgments

We thank Dr. Juan Fernández for a critical review of the manuscript, Mr. Victor Bocic for providing some of the specimens of *S. pugnaxi,* and Mrs. Luz Uribe and Marta Cariceo for the illustrations and typing of the manuscript.

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# *SAXIPENDIUM CORONATUM,* NEW GENUS, NEW SPECIES (HEMICHORDATA: ENTEROPNEUSTA): THE UNUSUAL SPAGHETTI WORMS OF THE GALÁPAGOS RIFT HYDROTHERMAL VENTS

Keith H. Woodwick and Terry Sensenbaugh

*Abstract.—Saxipendium coronatum,* new genus, new species, is described from a rocky habitat at the edge of a geothermal vent of the Galápagos Rift. The spaghetti worms represent a new family, Saxipendiidae, in class Enteropneusta, phylum Hemichordata. Important differentiating characteristics at the familial level which are found in the spaghetti worms include weakly developed muscles of the proboscis, coronate proboscis skeleton, long recurved skeletal crura, simple digestive tract, and antra associated with testis. Structures lacking in spaghetti worms but present in other enteropneusts include vermiform process, cauliflower organ, synapticulae, pygochord, hepatic caeca, and large yolky eggs.

Most enteropneusts have been taken from the intertidal or shallow areas offshore (Hyman 1959); however a few forms from deeper waters have been described including *Spengelia sibogae* (Spengel, 1907) at 275 m, *Glandiceps talaboti* (Marion, 1886) at 30–350 m, and *G. abyssicola* (Spengel, 1893) at 4500 m. An additional deep-sea form was taken recently from near the hydrothermal vents of the Galápagos Rift area. These spaghetti worms were first seen at the original "Clambake" site in 1977 and were then collected in 1979 along with clams, mussels, crabs, and vestimentiferans (Jones 1981).

Dive 878 by the deep-diving submersible *Alvin* on January 19, 1979 carried it to a maximum depth of 2478 m at 00°47.9′N; 86°13.5′W where the spaghetti worms were found loosely attached to rocks located at the periphery of the vent area. These enteropneusts, as viewed in videotapes, were draped over the rocks with the posterior end on the rock and with the anterior part of the body alternately drifting freely in the water and then back over the surface of the rock. Many incomplete specimens were collected using a suction apparatus which pulled in the spaghetti worms and a certain amount of associated mucous debris and rock slivers.

The holotype (USNM 97395) and paratypes (USNM 97396–8) have been deposited in the collections of the Division of Worms, National Museum of Natural History (USNM).

## Methods and Materials

Some specimens were prepared for histological studies and others for investigation using an electron microscope. Specimens for histological studies were dehydrated through an ethanol-toluene series, embedded in Paraplast (56–57°C), sectioned at 10, 13 or 15 $\mu$ using an American Optical Rotary Microtome. Serial cross and sagittal sections were stained with Harris' Hematoxylin and Eosin Y.

Specimens were studied using an American Optical Stereozoom and Zeiss GFL compound with optivar and photographic attachments. Both Tri-X and Technical Pan black and white film were used.

Other specimens (glutaraldehyde fixed) were processed for scanning electron microscopy (SEM) using either histological sections or freeze fractured material. For sections the glutaraldehyde fixed material was dehydrated in a graded series of ethanol and paraffin embedded. Sections varying in thickness (10–25 $\mu$) were obtained using a Leitz Rotary Microtome. Sections were attached to round, 13 mm cover slips and deparaffinated with xylene; cover slips holding the sections were transferred to filtered Freon TF and critical point dried in liquid $CO_2$. The cover slips were then mounted using double-sided tape.

Following glutaraldehyde fixation the material for freeze fracturing was rinsed in cold (5°C) 0.1 M sodium cacodylate buffer solution and post-fixed for one hour in cold osmium tetroxide in the same buffer. The material was then rinsed in cold buffer and dehydrated through a graded series of ethanol up to 100%. Material was then, piece by piece, encapsulated in a thin parafilm tube (containing 100% ethanol), immersed in liquid $N_2$, and fractured with a scalpel. Fractured material was then returned to 100% ethanol, transferred to filtered Freon TF and critical point dried in liquid $CO_2$. The fractured material was mounted using graphite glue.

All SEM materials were metal coated with gold-palladium using a Jeol JFC-1100 ion sputter and examined at 15 or 25 kV using a Jeol JSM-35 scanning electron microscope.

## Saxipendiidae, new family

*Type-genus.*—*Saxipendium,* new genus

*Diagnosis.*—Enteropneusta with poorly developed proboscis muscles, coronate (in cross section) body of the proboscis skeleton, skeleton also with long recurved crura, simple post branchial gut (no regional specialization), testicular antra, small eggs; lack-synapticulae, vermiform process of buccal diverticulum, hepatic caeca, lateral septa (in trunk).

## *Saxipendium,* new genus

*Type-species.*—*Saxipendium coronatum,* new species.

*Gender.*—Feminine.

*Diagnosis.*—Characters of the family (above).

*Etymology.*—From Latin, *saxi* (rock, boulder) + *pend* (hanging) + ium, in reference to the habitat of the organism.

## *Saxipendium coronatum,* new species

Figs. 1–12

Unidentified organisms (draped like spaghetti).—Corliss and Ballard 1977:450 (with fig.).

"Spaghetti" (acorn worm, enteropneust) Sedgwick 1980:50 and 51 (figs.) 52, 53.

Acorn worms.—Hessler 1981:741, 744, 746.

*Diagnosis.*—Characters of the family (above).

*Etymology.*—From Latin, *corona* (crown) in reference to the appearance of the proboscis skeleton.

*Type-locality.*—Near "Rose Garden" geothermal vent, Galápagos Rift (00°47.9′N; 86°13.5′W), 2478 m depth.

*Material examined.*—Holotype (USNM 97395), and 8 male and 3 female specimens (paratypes) serially sectioned, cross or sagittal.

*General characteristics.*—The preserved specimens are in tortuous coils, wrapped upon themselves and welded together with mucous. Some detrital material as well as a few slivers of black rock are attached to their surface. The specimens fixed in glutaraldehyde are in better condition than those in alcohol.

None of the specimens was complete. The holotype (glutaraldehyde fixed) has the following measurements in mm: overall length—215, proboscis—11.0, collar—3.0, trunk—201. Maximum width which occurs at the base of the proboscis, at the collar, and at the anterior trunk region, was 8.0 mm. Two other long specimens (alcohol preserved) had the following measurements: overall—220 and 154, proboscis—10.0 and 8.0, collar—3.0 and 4.0, trunk—207 and 142, respectively.

The proboscis is softly pointed anteriorly and enlarges posteriorly to produce an arrow shape, overall (Fig. 1). It is indented dorsally in preserved specimens but this characteristic is not as strong on specimens viewed in the videotape. A narrow peduncle joins the proboscis to the collar. The cuff-like collar is as wide as the proboscis but is very short. It has a definite raised ring just anterior to the juncture with the trunk. Anteriorly the trunk is the same width as the collar but is reduced slightly in overall dimensions in succeeding regions. The branchial region is more rounded in cross section than the posterior regions which are slightly flattened and have a median longitudinal depression with raised lateral ridges. These ridges have undulations produced by the varied size of the individual gonads in the two longitudinal rows. The gill pores are not readily visible but the raised gonopores are.

Spaghetti worms are yellow-white in color. The proboscis is the lightest shade and the anterior part of the collar is the darkest. The posterior raised ring of the collar is, however, very light.

The iodine-like odor characteristic of many enteropneusts was not present in the preserved material or in the preservatives.

*Internal anatomy-proboscis.*—In cross section, external to internal, the bodywall of the proboscis includes a simple epidermis, nerve fiber layer, a basement membrane, and connective tissue and muscle (Fig. 2). The simple epidermis includes several cell types but is dominated by gland cells. In general the epidermis is thicker ventrally than dorsally. The muscles and connective tissues include fibers which are circular, longitudinal, or oblique in pattern but all are very weakly developed.

Dorsally the body wall of the proboscis is about 130 μm thick. The epidermis (100 μ) includes a basal grouping of nuclei, an open vacuolated area in the middle, an overlying grouping of nuclei and a few scattered distal goblet glands. Pseudostratification is evident. Laterally and ventrally the body wall is generally 130 μ, but in some areas is thicker. The epidermis basally is open with a few dispersed nuclei and distally is packed with goblet cells. Centrally it is dominated by a layer of dark staining nuclei.

The nerve layer is fibrous and is about 20 μ thick except near the base of the proboscis close to the peduncle where it may be as thick as 50 μ dorsomedially. Epidermis overlying this cord is made up of 50 μ of heavy basal nuclei and a 50 μ distal area of packed glands.

The muscle-connective tissue component of the body wall is poorly developed, only 10 μ, consisting mainly of short fibers of the circular muscle component and attachment fibers.

The internal muscular and connective tissue of the proboscis, in general, is weakly developed, also, and consists of circular, longitudinal, and oblique fibers traversing the entire interior area anteriorly and in the area surrounding the central proboscis coelom posteriorly. This sparsely muscular portion (Fig. 2) makes up the anterior two-thirds of the proboscis; the posterior one-third includes the beginning of the proboscis coelom and the contained proboscis complex.

The proboscis coelom makes up about 10% of the total proboscis area near the coelom's anterior end, 40% midway, and only a small percentage posteriorly. There it is reduced and divided into right and left lateral and dorsal and ventral cavities by the presence and increase in size of the proboscis complex. The right dorsal coelomic area is blind ending but the left dorsal area opens to the outside through the proboscis canal and pore.

The proboscis complex has a double attachment dorsally and a single ventral mesentery which slants posteriorly, first attaching to the coelomic lining and then penetrating to and attaching to the subepidermal basement membrane. The complex includes the glomerulus, central sinus, pericardial vesicle, and buccal diverticulum (Fig. 3). The glomerulus is a tortuous mass of tubules filled with vascular fluid. This vascular plexus covers the anterior end of the developing complex and then posteriorly covers the dorsal and lateral portions but not the ventral. The lateral glomerulus is reduced in size and the dorsal portion disappears as the double dorsal mesentery of the complex joins the dorsum of the pericardial vesicle. The vesicle overlies the central sinus and the buccal diverticulum is ventrally placed in the complex with the central sinus and pericardial vesicle dorsal to it. The buccal diverticulum continues posteriorly through the peduncle and opens into the buccal region (the anterior gut area) of the collar.

Anteriorly the proboscis coelom which more or less surrounds the proboscis complex is nearly round and measures 500 μ in diameter. It has a distinct lining and there is open space all around the contained complex which measures about 400 μ in diameter. At this level the glomerulus shows a few dorsal and lateral folds and the anterior tip of the buccal diverticulum appears along with the pericardial vesicle just dorsal to it.

A little posterior the coelom elongates dorsally and enlarges to measure 750 μ and 650 μ wide. The pericardial vesicle also elongates dorsally and the paired dorsal mesenteries which enclose it join the coelomic wall at the nerve fiber layer on each side; mesenteries are initially about 300 μ apart. The vesicle contains a few loose connective tissue and muscle fibers. The buccal diverticulum has enlarged to a diameter of about 475 μ and has a large central cavity, 170 μ high and 100 μ wide. The epithelium making up the buccal diverticulum is about 200 μ thick and is highly vacuolated with scattered elongate distal nuclei. The central cavity is lined with cilia. Just dorsal to the buccal diverticulum the blood-filled central sinus appears. A ventral mesentery is present but it is oriented anterodorsal to postero-ventral and is not attached ventrally at this level. The connective tissue and muscle of the proboscis external to the coelom continues to be weakly developed but shows a slight concentration midventrally.

To the posterior, the central sinus has a direct relationship with the open spaces of the glomerular plexus. Dorsally on the proboscis an external medial infolding occurs and the underlying internal structures also show changes. The epidermis is composed of a heavy nerve fiber layer (50 $\mu$), a layer (50 $\mu$) of many nuclei round in shape basally and elongate distally, and a layer (50 $\mu$) of glands. To the posterior the nerve fiber layer expands to a width of 60 $\mu$ and the coelom broadens to 2000 $\mu$ (wide) × 800 $\mu$ (high). Farther posteriorly, the coelom is reduced to a breadth of 600 $\mu$ and a greatly reduced height of 70 $\mu$ as the dorsal mesenteries shorten. The buccal diverticulum is 600 $\mu$ across assuming the shape of a square with rounded corners; the central cavity is 100 $\mu$ in height and 80 $\mu$ across. The glomerulus is well-developed laterally next to the buccal diverticulum and on the lower external surface of the dorsal mesenteries. The ventral mesentery is complete. At this point in one specimen the central sinus had an X-shaped cross section. The two ventral arms represented the original sinus and the upper arms, anterior lateral extensions. To the posterior, they merged ventro-medially and flowed laterally into the glomerulus and up between the two layers of each dorso-lateral mesentery where each formed a subepidermal vessel.

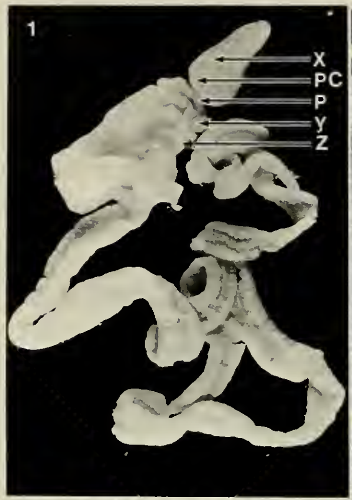
Posterior to this level as the proboscis decreases in overall width the glomerulus begins to disappear and the lateral horns of the buccal diverticulum fill the space which was originally part of the coelom and divide the remaining coelom into dorsal and ventral spaces. The internal cavities of the horns and the central area of the buccal diverticulum interconnect. The dorso-lateral vessels merge medially to form a major longitudinal vessel. There is no racemose organ.

The proboscis includes the preoral ciliary organ (Fig. 1) first described by Brambell and Cole (1939) which in this species is located on the posterior external face of the proboscis. The U-shaped organ has two parallel grooves with associated short epidermal cells and heavy ciliation. The medial groove of each arm has longer cells and shorter ciliation. The raised area between the grooves is not glandular but the medial groove area has granular acidophilic and reticular basophilic gland cells.

*Internal anatomy-peduncle.*—The peduncle (Fig. 1) connects the proboscis and collar and contains important nerve fibers, muscles, blood vessels, buccal diverticulum, skeleton and related materials, coelom remnants of both the proboscis and collar which, however, do not interconnect, and a surrounding epidermis which is different on the dorsal and ventral surfaces.

The dorsal epidermis which is underlain by a heavy nerve layer (60–70 $\mu$) is about 100 $\mu$. The basal 75 $\mu$ includes a layer of rounded and then centrally more elongate nuclei. The distal surface is vacuolated and contains only a few glands. Ventrally the nerve is only 20 $\mu$ and the epidermis about 70 $\mu$; the basal half is nuclei and the distal is mixed glands (goblet, reticular, granular). Near the posterior end of the peduncle the reticular glands dominate ventrally.

The buccal diverticulum has a large central cavity and through its expansion as lateral horns it crowds out the ventro-lateral portions of the proboscis coelom and reduces in size the dorso-lateral portions. On both sides the lining of the dorsal coelomic cavity shows a distinctly nucleated simple columnar epithelium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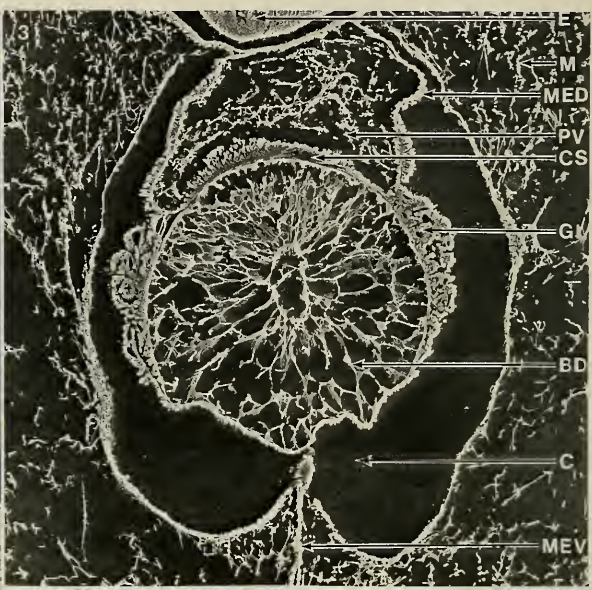
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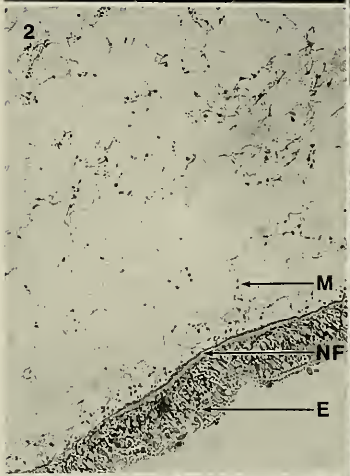
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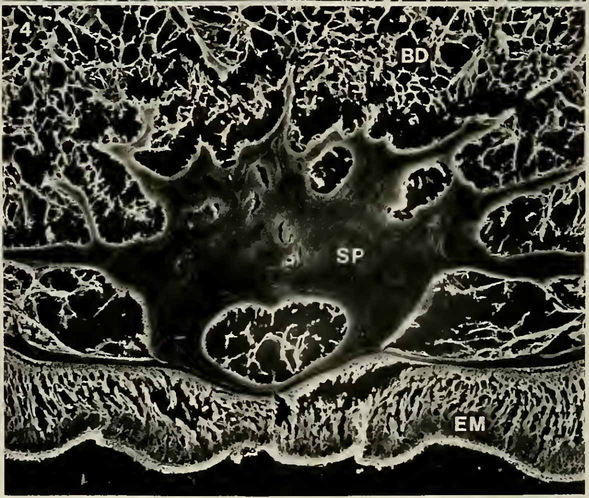
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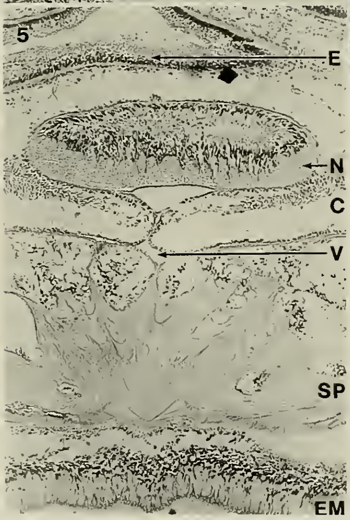
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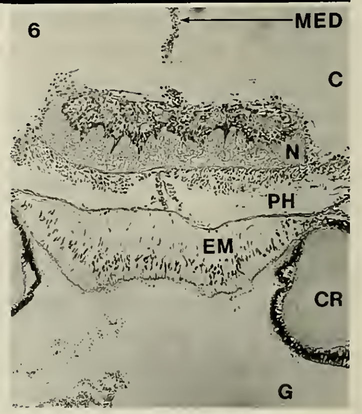
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which on the left side forms the proboscis canal and lines the proboscis pore which opens externally. The pore is not round but is an elongate slit running antero-posteriorly. Farther posterior in the peduncle the proboscis canal and pore disappear and the proboscis skeleton begins to replace the buccal diverticulum positionally. The main part of the skeleton, which is in the peduncle, is beautifully crown-shaped in cross section (Fig. 4), and the spikes of the crown divide into subsections the central part of the buccal diverticulum; the large lateral horns and a small median-ventral caecum remain intact, each with an open central area. Closer to the collar the skeleton crowds out the ventral caecum and divides the lateral horns into subsections (Fig. 5). Then the spikes of the skeleton are reduced in length and the central body develops medio-lateral concentrations evidenced by a two-whorl pattern. Those two areas become the separate lateral skeletal crurae of the collar. The dorsal median subepidermal vessel is present throughout the peduncle and posteriorly it joins medio-ventrally with a vessel which lies between the two perihaemal cavities (Fig. 6).

The free anterior cuff of the collar overlaps the posterior part of the peduncle but as the dorsal half of the cuff turns ventrally and posteriorly it joins the peduncle, first laterally and then dorso-medially. An anterior pocket is produced just above the heavy nerve fiber layer of the peduncle (Fig. 5). The pocket partly closes off and as a collar epidermis shifts dorsally the nerve fiber layer comes to have a more internal position. Throughout the collar this neurocord (Fig. 6) is the dominant part of the nervous system. In the posterior peduncle this nerve fiber layer which is at first flat, develops lateral dorsal curlings, and then a strong dorsal and medial recurving of the two lateral areas so that the fibers fold over the central cellular area.

As the dorsal half of the collar cuff joins the peduncle the coelom of the collar directly interconnects with small lateral coelomic and muscular areas which first appeared lateral to the proboscis skeleton in the posterior region of the peduncle. The two lateral muscle groups attach anteriorly to the proboscis skeleton and posteriorly in the collar.

*Internal anatomy-collar.*—The cuff-shaped collar (Fig. 1) has a complex of epidermal zones, the neurocord, the anterior portion of the digestive tract, and a coelom with connective tissue poorly developed peripherally but with well-developed muscles associated with the crura of the proboscis skeleton (Fig. 6).

The epidermis is characterized by five main zones arranged generally as successive rings from anterior to posterior. A five-zone pattern is not uncommon (e.g., *Protoglossus koehleri,* Burdon-Jones 1956) but a few species have been

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Figs. 1–6. *Saxipendium coronatum*: 1, Overall view of holotype, ×1.2; 2, Proboscis, transverse section, ×64; 3, Proboscis complex, transverse section (SEM), ×90; 4, Peduncle, transverse section of skeleton (SEM), ×162; 5, Peduncle-collar interphase, transverse section, ×58 (paratype, USNM 97396); 6, Collar, transverse section, ×81 (USNM 97396). BD: buccal diverticulum, C: coelom, CR: skeletal crura, CS: central sinus, E: epidermis, EM: epithelium, G: gut cavity, GL: glomerulus, M: muscle (and connective tissue), MED: dorsal mesentery, MEV: ventral mesentery, N: neurocord, NF: nerve fibers, P: peduncle, PC: preoral ciliary organ, PH: perihaemal cavity, PV: pericardial vesicle, SP: proboscis skeleton, V: blood vessel, X: proboscis, Y: collar, Z: trunk.

described as having three or four zones. The number of zones may be a matter of varied specificity in histological interpretation. In *Saxipedium coronatum* two of the zones show variations designated as subzones.

The epidermis of Zone I which comprises the inner portion and turned edge of the anterior part of the cuff is 100 $\mu$ in thickness and has a heavy basal band of nuclei and the distal portion consists of packed acidophilic goblet cells. There are two subzones with the more posterior having the nuclei in a wider and more unevenly dispersed band, a slightly greater concentration of goblet cells and an occasional basophilic reticulated gland cell.

Zone II has an epidermis of 125 $\mu$. The nuclei are still basal but form a less distinct band followed distally by an open vacuolated region and then a superficial region lightly stained with goblet cells and a few granular gland cells.

Zone III is the widest region and has the thickest epidermis. It includes the area preceding the raised posterior ring as a subzone and the ring itself as another. Overall, the epidermis is 175 $\mu$ thick and has a basal and a distal grouping of nuclei. In the anterior subzone the basal nuclei dominate and a few goblet cells are present distally; in the posterior subzone the distal elongate nuclei form a distinct band. This extremely thick zone of the epidermis is highly vacuolated throughout.

Zone IV comprises the posterior edge and infolding of the ring. The epidermis is 100 $\mu$ and includes a dispersed basal grouping of nuclei, a vacuolated central region, and a distal region which includes a heavy concentration of acidophilic cells and sparse granular gland cells.

Zone V comprises the juncture of the collar and trunk. The epidermis is 100 $\mu$ and includes a concentrated basal layer of nuclei similar to Zone I but with only sparse goblet cells distally.

Underlying the epidermis and included in all measurements is a nerve fiber layer 12–15 $\mu$ thick.

The fibrous portion of the neurocord is continuous anteriorly with the epidermal nerve fiber layer of the peduncle and posterior face of the proboscis as well as the dorso-median concentration and other nerve fibers in the proboscis. Posteriorly the neurocord is continuous with the solid dorso-median nerve cord of the trunk and the collar-trunk lateral connectives which join to form the solid ventral nerve cord of the trunk.

The neurocord is 650 $\mu$ wide and 150 $\mu$ thick and the lateral and ventral fibrous portion makes up about 65% of the cross sectional surface. There are anterior and posterior openings into the cellular portion of the neurocord which is also irregularly open throughout (Figs. 5 and 6).

Just ventral to the neurocord are located the dorsal vessel and the perihaemal cavities which are thin paired anterior extensions of the trunk coelom (Fig. 6). These cavities which contain longitudinal muscles reach into the peduncle. In some specimens at their anterior extremity they become an undivided cavity. Posteriorly they open into the general trunk coelom and the muscles become part of the weak dorsal musculature of the trunk. The anterior part of the perihaemal cavities is at the level where the proboscis skeleton separates into left and right crura. The crura (Fig. 6) bend down and around the gut as they extend posteriorly to near the end of the collar. The main anterior skeleton and the crura serve as the attachment points for the two muscle bundles noted above which connect posteriorly to the interface of the collar and trunk at a ventro-lateral position. The crura are unusual in having a thin recurved portion which bends back anteriorly for a short distance in the posterior collar. The position of the crura in relation to the gut epithelium causes the epithelium to push into the gut cavity on each side to produce an upper and lower chamber. Contraction of muscles and movement of the skeleton caused by fixation produced in some specimens dorso-lateral blind ending (posteriorly) gut pockets above the crura in the posterior part of the collar. The muslces and connective tissue of the collar coelom are poorly developed.

The anterior collar gut epithelium dorso-medially and lateral to each of the crura is similar to the tissue of the buccal diverticulum (Fig. 6). It is about 100 μ thick with a distal dispersed band of elongate nuclei and the majority of the thickness made up of vacuolated epithelium. The lateral components have a few distal basophilic reticular gland cells and the ciliation is heavier than it is medially. The dorsal central band has continuity with the central portion of the buccal diverticulum which is made possible by the reduction in size of the proboscis skeleton and the separation of the crura. The epithelium covering the crura is very thin and the nuclei dominate in a heavy basal band (Fig. 6). The ventrolateral and ventral gut epithelium is about half as thick as the dorsal. In the central collar thicker epithelium appears ventro-laterally and it extends into the ventromedial region in the posterior collar. The gut cavity decreases in overall size posteriorly, but the chamber above the crura increases in size relative to the lower chamber as the crura shift their position.

In the posterior collar as it interfaces with the trunk the neurocord begins to show a reduction in the dorso-medial recurving of the fiber portion and the central cellular area begins to open to the outside. The fibrous portion of the neurocord centrally forms the dorsal solid nerve cord of the trunk and bilaterally forms the connectives which shift ventrally and rejoin to form the ventral subepidermal solid nerve cord of the trunk. The perihaemal cavities widen laterally and increase in size as they approach a direct relationship with the dorsal trunk coelom.

The last important structures of the collar to appear are the collar pores which via short canals connect the collar coelom to the outside. In this species the canal connects the collar coelom to the outside through pores located in the dorsomedial area but the canals also connect to the most anterior gill pouch. The specialized epithelium lining the canals and pores is 200–250 μ in thickness. It has a distinct basal layer of heavy elongate nuclei, a narrow open distal zone, and heavy surface ciliation.

*Internal anatomy-trunk.*—The anterior trunk matches the collar in shape and width but the trunk is slightly flattened dorso-ventrally throughout most of its length. The dorso-median area is depressed and deeper sub-lateral grooves extend antero-posteriorly. The extreme dorso-lateral surface which is raised contains the gonads (Figs. 1 and 11). The trunk is not highly specialized in structure or variable in appearance but it does contain one of the more important enteropneust characters. A series of paired gill slits and pores and associated skeletal elements occurs in the anterior branchial region of the trunk. Following the unspecialized post branchial anterior esophagus, a series of paired canals and pores connect the gut with the surface dorsolaterally in the posterior esophagus. The intestine proper follows this esophageal pore region. The gonads occur with the gills anteriorly, and posteriorly to the gills the multiple paired gonads dominate the trunk. They are present in the esophageal region and continue throughout the entire trunk.

The ventral epidermis of the trunk is generally thicker, contains more glands, and is more heavily ciliated than the dorsal (Fig. 9). Just beneath the epidermis occur the nerve fibers which are concentrated medially to form dorsal and ventral solid longitudinal nerve cords. The dorsal cord anteriorly has short lateral dorsal wings which are a modified continuation of the posterior collar neurocord. Throughout the remainder of the trunk the dorsal cord (50 μ thick) has a triangular shape with the point dorsally placed pushing into the epidermis. The body does not bulge here because the epidermal cells are shorter where the nerve cord thickens. The ventral nerve cord (75 μ) is more strongly developed than the dorsal; it also has a triangular shape with the point dorsally placed but here it pushes into the basement membrane and towards the coelom (Fig. 9).

The gut of *Saxipendium coronatum* is not highly specialized. It contrasts greatly with that of many ptychoderids (e.g., *Balanoglossus stephensoni* Horst, 1940) and some spengeliids which have well developed hepatic caecea. It also contrasts with harrimaniids, especially those of *Saccoglossus* (e.g., *S. otagoensis* Thomas, 1972) which have many specialized regions of the gut with a variety of epithelial linings and strong ciliated grooves. The gut epithelium of the spaghetti worm is relatively unchanged from region to region and the gut cavity, although it changes in overall shape, is simple in pattern (Figs. 8, 9, 10, and 11).

The ventral longitudinal muscles of the trunk are slightly heavier than the dorsal series but both are weakly developed. Dorsal and ventral blood vessels (longitudinal) are present (Fig. 9).

In the branchial region the dorsal epidermis (60–70 μ) is only one half the thickness of the ventral. It has a strong band (15 μ) of slightly elongate basal nuclei. The remaining distal portion is open and vacuolated with a few superficial goblet glands. Laterally the ventral epidermis grades into the dorsal as it becomes thinner and the number of goblets decreases. The dorsal and ventral median nerve areas are 80 μ in thickness and the dorsal cord has small finger-like extensions into the epidermis. There are dorsal and ventral mesenteries and longitudinal bands of muscles. The weaker dorsal muscles reach laterally only to the gill pore region but the ventrals (50–70 μ) extend about 90° to each side gradually decreasing in thickness laterally. The lateral body regions have a thin epidermis and very little muscle. With slight variation the above characteristics apply to the entire trunk.

In the branchial gut the epithelium of the dorsal and ventral areas is similar. It is about 150 μ in thickness with an indistinct grouping of elongate distal nuclei. Central and basal regions are openly vacuolated. The lateral gill tongues and bars are covered mainly by a low epithelium with dark staining basal nuclei. The lateralmost wall of the gill pouch area resembles the dorsal gut epithelium but changes to the epidermal pattern at the gill pore (Fig. 7).

The branchial skeleton embraces only the upper half of the gut cavity and although the skeletal elements are not strongly curved their arrangement produces an upper and lower chamber in this part of the trunk.

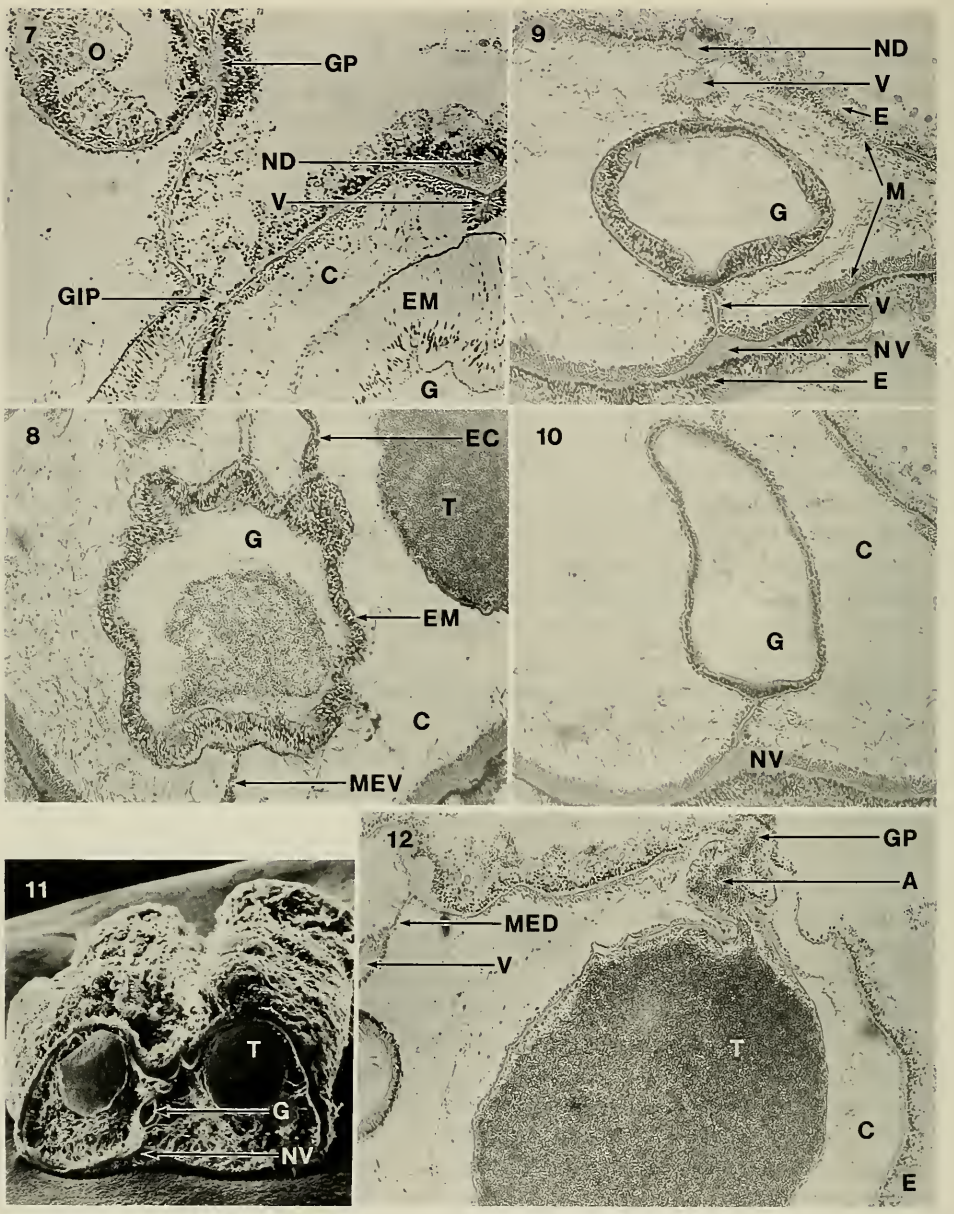
The number of gill slits in enteropneusts varies from species to species from only a few to one hundred or more. They also vary during the life of an individual; there are more in a mature adult than a young developing specimen. In one representative specimen of *Saxipendium coronatum* which was cleared and studied as a whole mount there was a total of 54 pairs of gill slits in a space of 27 mm. The gill slits are typically U-shaped and skeletal elements extend into the septa and tongues but are not strongly developed in either. There are no synapticulae. Anterior gill slits are larger. The branchial region includes about ⅕ of the length of the trunk. The next region, the anterior esophagus, has no opening from the gut to the outside. The posterior esophagus is as long as the anterior region. It has about 40 pairs of esophageal pores which have narrow canals connecting them to the dorsal lateral areas of the gut (Fig. 8). Small skeletal structures were associated with the openings of many of the pores. This is not unusual in enteropneusts and has led to the suggestion that esophageal and gill pores may be related in origin.

In the trunk posterior to the branchiae, the gonads fill most of the rounded lateral extensions of the body. Cross sectional views show three lobes to the body; two are lateral and include the gonads and one is central and includes the digestive tract (Figs. 1 and 2). The wall of the postbranchial gut is slightly folded and the cavity makes up about ¼ of the cross section. The epithelium averages about 50 μ in thickness; it has a basal and a distal grouping of nuclei and a central open vacuolated region. The epithelium mid-dorsally and mid-ventrally is a little thicker and each forms a medial groove containing heavier ciliation than the thinner lateral epithelium.

In the posterior part of the esophagus, paired pores open dorsally just lateral to the nerve cord and run ventrally 300 μ to the gut proper. The ventral half of the canal has a total diameter of 60 μ and a central cavity of 20 μ. The canal narrows dorsally as it approaches the pore. The epithelium of the lower canal is similar to but thinner than that of the gut proper (50 μ) which is open and vacuolated with a slight basal grouping of nuclei and a heavier distal grouping of elongate nuclei. The gut has a square to rectangular shape in cross section and the gut cavity makes up about ⅔ of the overall cross section (Fig. 8).

The intestine proper located posterior to the esophageal pores makes up about ¾ of the length of the trunk. Its gut and epithelium are even simpler than those of other trunk regions. The gut cavity is nearly round in cross section and comprises more than ⅔ of the gut area. The gut epithelium is not folded and is 25–75 μ in thickness. It has a heavy basal grouping of nuclei, very little central or distal vacuolation, a few granular acidophilic gland cells and scattered basophilic cells superficially. The gut has strong ciliation with heavier areas mid-dorsally and especially mid-ventrally (Fig. 9). Dorsal muscle bands are more concentrated near the gonopores.

The gonads occur as repeated individual lobes organized into lateral rows extending, as presently known, throughout the trunk. Sexes are separate. The testes, which are larger than the ovaries, average about 1000 μ in diameter. Lying one next to the other from anterior to posterior there would be about 200 testes on each side of one of the specimens described above which had a trunk of 205 mm. The main body of the testis is usually a little longer on the axis which leads to the gonopore (Figs. 11 and 12). The gonad is extra-peritoneal and as it extends into the coelom is covered by the peritoneum and underlain by a thin layer of muscle and heavy vascular concentrations. The testes have a thin superficial grouping of germinal cells and a concentrated central mass of spermatozoa. The



Figs. 7–12. *Saxipendium coronatum*: 7, Trunk (branchial region), transverse section, ×94 (USNM 97396); 8, Trunk (esophagus), transverse section, ×52 (USNM 97397); 9, Trunk (intestine), transverse section, ×39 (USNM 97397); 10, Trunk (intestine), transverse section, ×39 (USNM 97397); 11, Trunk (intestine), freeze fracture (SEM), ×13; 12, Trunk, transverse section, ×62. A: antrum, C: coelom, E: epidermis, EC: esophageal canal, EM: epithelium, G: gut cavity, GIP: gill pore, GP: gonopore, M: muscles, MED: dorsal mesentery, MEV: ventral mesentery, ND: dorsal nerve, NV: ventral nerve, O: ovary, T: testis, V: blood vessel.

sperm are about 29 μ in overall length including a head of about 4.0 μ. The head is not round; it has a full basal nuclear portion but the acrosomal region attenuates to a bluntly rounded tip. Between the main body of the testis and the gonopore there is a small specialized antrum (Fig. 12). The antrum has a heavy muscle covering which encloses a concentration of highly vacuolated cells surrounding the central canal leading to the gonopore. The epidermis near the gonopore includes concentrations of granular acidophilic gland cells.

The ovaries which are smaller than the testes measure about 750 μ in greatest width. The muscle covering is thin as in the testis but the vascular concentrations are greater. The gonopore canal does not have a distinct antrum but the cells surrounding the canal are vacuolated as in the testes. The internal tissues are organized as cords which attach peripherally and extend into the center of the ovary (Fig. 7). Each cord includes what appear to be covering follicle cells, dispersed internal vitelline material, and occasional internal oocytes. In some gonads the most mature oocytes occurred on the dorsal wall. The ovaries have internal open spaces and do not appear to be mature. The largest oocytes found were in the 40–50 μ range.

All specimens studied were incomplete; the terminal region of the trunk has not been found.

## Discussion

The spaghetti worms are readily assigned to phylum Hemichordata and class Enteropneusta but they are not readily assigned to any one of the three presently accepted families (Hyman 1959). The arrangement including Ptychoderidae, Spengeliidae, and Harrimaniidae was established by Spengel (1901). Caullery and Mesnil (1904) did establish a new family for *Protoglossus koehleri* but Burdon-Jones (1956) placed the genus in Harrimaniidae and returned to the three family pattern.

Members of Ptychoderidae are distinguished in part by the presence of lateral septa in the trunk, dorso-lateral ciliary grooves in the intestinal wall, hepatic caeca, synapticulae, pygochord, short skeletal crura, and a cauliflower organ (Horst 1939; Dawydoff 1948). Spaghetti worms lack all of the above. Ptychoderids lack esophageal pores which are present in spaghetti worms.

Members of Spengeliidae are distinguished in part by the presence of well-developed muscles and a vermiform process in the proboscis as well as by circular muscles internal to the longitudinal muscles of the trunk. These characters are not found in the spaghetti worms. Separation of the branchial gut into dorsal and ventral areas is characteristic of spaghetti worms but not generally in spengeliids. Both have long skeletal crura but they are recurved in the spaghetti worms.

Members of Harrimaniidae are distinguished in part by the presence of well-developed muscles in the proboscis (often arranged in concentric rings), and large yolky eggs and presumably direct development. The proboscis muscles of the spaghetti worms are very poorly developed, and the gonads of the females from the one collection contain small ova and have an internal organization which suggests a form with indirect development. Unlike the harrimaniids the spaghetti worms have widely spaced double dorsal mesenteries in the proboscis, a proboscis skeleton with a unique coronate pattern in cross section, a very simple epithelium and arrangement of the post branchial gut, and testicular antra.

When compared with each of the three families for overall similarity, *Saxipendium coronatum* is found to be closest to the family Harrimaniidae but recognition of its many special characteristics complemented by a suite of other characteristics emphasizes the need to place it in a new family.

Although many valuable contributions to our understanding of enteropneusts have been made during the past 40 years, it is important to note that nearly one-half of the species and three-fourths of the genera were described nearly a century ago between 1891 and 1910. In addition, since that time there has been limited consideration of the existing systematic pattern and evolutionary relationships of the species and genera of the class. It is hoped that the presence of the spaghetti worms in association with the interesting hydrothermal vent community along with the unusual characteristics of this form will lead to a general increase of interest in members of this group from all habitats and throughout the world.

## Acknowledgments

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# NOMENCLATURAL AND TAXONOMIC NOTES ON THE PTERIDOPHYTES OF COSTA RICA, PANAMA, AND COLOMBIA, II

David B. Lellinger

*Abstract.*—The purpose of this paper and the one which preceded it (Proc. Biol. Soc. Washington 89:703–732. 1977) is to publish lectotypes, new combinations, and new species of pteridophytes that will be included in my forthcoming "Ferns and Fern-allies of Costa Rica, Panama, and the Chocó."

Throughout this paper in the citation of type specimens, the word "photo" followed by a number refers to the numbered series of photographs taken by C. V. Morton and distributed from the U.S. National Museum. Photographs by others are identified by the name (and number, if any) of the person or institution who took them.

The principal entries are in alphabetical order for easy reference. In those cases where the principal entries are taxonomic or nomenclatural synonyms, the disposition of these names is given as I understand it at present.

### *Acrostichum aureum* L. Sp. Pl. 2:1069. 1753

*Lectotype.*—To fix the application of this name, I choose: plate 7 of Plumier's "Description des Plantes de l'Amérique," which is based on a specimen collected by Plumier at Ft. Royal, Martinique. The specimen bearing "Acrostich. 10 aureum" in the hand of Linnaeus (LINN 1245.5 not seen microfiche Smithsonian Institution Library), according to Jackson (Ind. Linn. Herb. 28. 1912), was not present in Linnaeus' herbarium until after 1755, and so cannot be a type.

### *Alsophila ichthyolepis* Christ, Bull. Herb. Boiss. II, 6:186. 1906

*Lectotype.*—To fix the application of this name, I choose: La Palma, Pcia. S. José, Costa Rica, 1459 m, *Tonduz 12527* (P not seen photo 3458; isolectotypes NY not seen, US). The other syntypes are: Costa Rica, *Wercklé 57* (P not seen); Navarro, Pcia. Cartago, Costa Rica, *Wercklé* (P not seen); and Tsaki, Talamanca, Pcia. Limón, Costa Rica, 200 m, *Pittier 9469* (P not seen). *Alsophila ichthyolepis* is a synonym of *Trichopteris stipularis* (Christ) Tryon.

### *Anemia hirsuta* var. *humboldtiana* Hieron.
### Bot. Jahrb. Engler 34:566. 1905

*Lectotype.*—To fix the application of this name, I choose: Between Caripe and Santa Cruz, Edo. Monagas—Sucre, Venezuela, *Humboldt 459* (B-Hb. Willd. 19495-2 not seen Tryon photo US). The other syntypes are: Panamanian Isthmus, Colombia, *Lehmann 1866* (B not seen); near Chaparral, Depto. Tolima, Colombia, 700 m, *Lindig 213* (B not seen); Edo. Cumaná, Venezuela, *Moritz 158* (B not seen); Venezuela, *van Lansberge* [probably *Landsberg*] (B not seen); and Peru, *Mathews 3299* (B not seen; isotype US). *Anemia hirsuta* var. *humboldtiana* is a synonym of *A. hirsuta* (L.) Swartz.

### *Anemia pastinacaria* Moritz in Prantl
### Untersuch. Morph. Gefaesskrypt. 2:110. 1881

*Lectotype.*—To fix the application of this name, I choose: "In convalli del Tigre," Venezuela, *Moritz 26* (B). The other syntypes are: Venezuela, *Landsberg* (B not seen); Caracas, Distr. Fed., Venezuela, *Galeotti 196* (B not seen): Chaparral, Depto. Tolima, Colombia, 700 m, *Lindig 213* [not *Karsten,* as Prantl has it; see Bot. Jahrb. Engler 34:566. 1905] (W not seen); Panama, *Duchassaing* (GOET not seen); Trapiche de la Concepción, Edo. Oaxaca, Mexico, *Liebmann* (C not seen); and Trinidad, *Fendler 62* (M not seen).

### *Asplenium cuspidatum* var. *triculum* Lellinger, sp. nov.
### Fig. 1

Plantae epipetricae vel epiphyticae, per radices repentes et gemmiferas multiplicatas. Rhizoma erectum parvum ad apicem paleaceum; paleis ovato-lanceolatis, ca. 2 mm longis 1 mm latis griseo-brunneis clathratis subbullatis persistentibus. Stipites 1–6 cm longi, 0.25–0.5 mm lati tereti exalati viridi vel adaxialiter brunnei, ad basin squamati, paleis eis rhizomatis similibus, supra basin paleis linearibus praediti. Rachides virides vel adaxialiter ad basin brunnei teretes vel ad apicem alatae sparse squamatae, paleis linearibus contortis fuscis. Laminae 2–20 cm longae 0.8–4.5 cm latae papyraceae lanceolatae vel anguste lanceolatae, ad basin obtusae, ad apicem acuminatae vel caudatae, (1)2-pinnato-pinnatifidae interdum tripinnatae; pinnis petiolatis alternis inaequilateralibus, ad basin inferiorem excavatis (parvissimis exceptis); pinnulis acutis vel acuminatis, basalibus acroscopicis saepe petiolulatis, acroscopicis dilatatis; segmentis angustis curvatis apiculatis; soris rectis usque ad 2 mm longis albidis integris.

*Type.*—Basin of El General, Pcia. S. José, Costa Rica, 675–900 m, *Skutch 4776* (US; isotypes F, GH).

*Paratypes.*—HONDURAS: Depto. Sta. Barbara: San Pedro Sula, 1200 ft, *Thieme* (US). COSTA RICA: Pcia. Cartago: Río Reventazón, Turrialba, *Godfrey 66328* (GH); Valley of the Río Reventazón 3 km SE of Turrialba, 500–600 m, *Holm & Iltis 37* (US), ca. 600 m, *Mickel 3355* (UC, US), ca. 1600 ft, *Rossbach 3557* (GH); Vicinity of Pejivalle, ca. 900 m, *Standley & Valerio 46892* (GH, US). Pcia. S. José: Cerro Turubales, 600 m, *Brade & Brade 427* (UC, US); Vicinity of El General, 880 m, *Skutch 2154, 2328* (both GH, US); Along the Río Sonador near the Panamerican Hwy., 600 m, *L. O. Williams et al. 28775* (US). Pcia. Puntarenas: Boruca, *Pittier 4823* (US), Las Cruces Tropical Botanical Garden 6 km S of S. Vito de Java, 4000 ft, *McAlpin* [*Las Cruces 74-445, 74-447*] (both US); Osa Peninsula ca. 20 km S of Rincon de Osa, ca. 150 m, ca. 150 m, *Mickel 23814* (US); Bahía Yglesias, Cocos Island, 10 m, *Gômez 6555* (US). PANAMA: Pcia. Panama: Río Piedras ca. 25 km NE of Cerro Azul, 550 m, *Mori & Kallunki 3468* (US). Pcia. Darién: Cana, *R. S. Williams 902* (US). VENEZUELA: Edo. Monagas: Montaña de Aguacate between Caripe and Caripito, 600–900 m, *Steyermark 62209* (US). Edo. Yaracuy: Fila La Enjalma S of Chivacoa, 500 m *Vareschi & Pannier 2629* (US). PERU: Depto. Huánuco: Near the confluence of the Río

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Fig. 1. Holotype of *Asplenium cuspidatum* var. *triculum* Lellinger, *Skutch 4776* (US). Fig. 2. Holotype of *Asplenium excelsum* Lellinger, *Maxon 5205* (US).

Cayumba with the Río Huallaga, 860 m, *Mexia 8290* (US). Depto. S. Martín: Near Tarapoto, *Spruce 4035* (US).

*Discussion.*—This is an entirely lowland variety that can be confused with small (pinnate-pinnatifid or 2-pinnate) forms of var. *tripinnatum* (Fourn.) Morton & Lellinger.

### *Asplenium excelsum* Lellinger, sp. nov.
Fig. 2

Plantae terrestres. Rhizoma erectum (0.5)1–1.5 cm diam. paleaceum; paleis lanceolatis ca. 10 mm longis 2 mm latis brunneis clathratis marginibus subrepandis. Stipites 12–30(40) cm longi ca. 3 mm lati profunde canaliculati exalati virides vel brunneoli, ad basin paleacei, paleis eis rhizomatis similibus. Rachides virides vel brunneolae canaliculatae uniformiter anguste alatae glabrae vel sparse squamatae, paleis linearibus ca. 1 mm longis 2 cellulis latis clathratis curvatis. Laminae ovatooblongae (32)35–65(70) cm longae (10)15–30(42) cm latae papyraceae, ad basin obtusae vel truncatae, ad apicem obtusae et abrupte acuminatae in modo *Struthiopteridis,* subtripinnatifidae vel tripinnato-pinnatifidae; pinnis manifeste petiolatis alternatis vel suboppositis subaequilateralibus, ad basin inferiorem leviter excavatis, ad apicem acuminatis, costulis alatis; pinnulis oblongo-ovatis; segmentis et venulis simplicibus vel ad apicem furcatis; soris brevibus rectis usque ad 3(4) mm longis albidis integris.

*Type.*—Slopes of Cerro de Lina, above El Boquete, Pcia. Chiriquí, Panama, 1300–1560 m, *Maxon 5205* (US; isotypes GH, NY, US).

*Paratypes.*—NICARAGUA: Depto. Jinotega: Region of Las Mercedes, sierra E of Jinotega, 1200–1500 m, *Standley 10725* (F, US). Depto. Managua: Sierra de Managua, 600–900 m, *Bro. Antonio Garnier A744* (US). COSTA RICA: Pcia. Alajuela: Zarcero, *A. Smith P.C.311* (F), 4500 ft, *A. Smith F71* (F), 1550 m, *A. Smith 48/140* (US), 1575 m, *A. Smith 48/128* (US), 2000 m, *A. Smith H.479* (US); San Antonio de Zarcero, 1475 m, *A. Smith 48/310* (US). Pcia. Heredia: Vara Blanca de Sarapiquí, 1310 m, *Skutch 3634* (NY, US). Pcia. S. José: La Palma, April 1910, *Wercklé* (US); Rancho Redondo, slopes of Volcán Irazú, ca. 6000 ft, *Scamman 7744* (GH, US); Cerro de Piedra Blanca above Escazú, *Standley 32519* (US); Tablazo, 1700 m, *Brade & Brade* [*Ros. Fil. Costar. Exs. 43*] (GH, NY); S. Pablo de Tarrazú, *O. Jiménez 1100* (US); El Copey, 1800 m, *Tonduz 11704* (US), 7500 ft, *Stork 1544* (US), ca. 2100 m, *Lellinger 1788* (US); 5 mi S of Sta. María de Dota, 6600 ft, *Stork 1779* (NY, US), 6800 ft, *Stork 1756* (US); Vicinity of Sta. María de Dota, 1500–1800 m, *Standley 41762* (US); Vicinity of El General, 1525 m, *Skutch 4185* (GH, MO, NY, US); 16.5 mi S of Villa Mills on Interamerican Highway, 4700 ft, *McAlpin 271* (DUKE); 25 km S of Villa Mills on Interamerican Highway, ca. 1450 m, *Mickel 3277* (NY, US); Pacific slopes of Chirripó Massif at Abra, 2500 m, *Davidse & Pohl 1531* (MO). Pcia. Cartago: Cerro Carpintera, 5000 ft, *Stork 2124* (US), 1500–1800 m, *Standley 34269* (US), 1500–1850 m, *Standley 35504* (GH, US), 1800 m, *Torres R. 111* (US); Mountains above Tres Rios, 5000 ft, *Scamman & Holdridge 80521* (GH, US); Navarro, 1500 m, *Torres R. 85* (US); Finca Navarro, 1350 m, *Maxon 663* (NY, US); El Muñeco, 1400–1500 m, *Standley & Torres 51035* (US); La Estrella, *Standley 39183* (US). PANAMA: Pcia. Chiriquí: Vicinity of El Boquete, 1000–1300 m, *Maxon 5079*

Fig. 3. Holotype of *Asplenium gomezianum* Lellinger, *Skutch 3203* (US). Fig. 4. Holotype of *Asplenium maxonii* Lellinger, *Maxon 5601* (US).

(US), 1000–1500 m, *Cornman 944* (US), *987* (F, US); Between Holcomb's Trail and Monniche Plantation above El Boquete, 1500–1725 m, *Killip 5082* (GH, NY, US); Vicinity of Casita Alta, Volcán de Chiriquí, ca. 1500–2000 m, *Woodson, Allen & Seibert 837* (US); Río Piedras Candela on logging road ca. 4 mi with junction of road to Las Mellisas, 1800–2000 m, *McAlpin 2208* (DUKE).

*Discussion.*—This species is fairly common in dense forests and along streams in ravines. Commonly it has been identified as *Asplenium solmsii* Baker, which is a much smaller plant from Guatemala. It is related to *A. commutatum* Mett. ex Kuhn and to *A. achilleifolium* (Liebm.) Mart. & Gal.

### *Asplenium gomezianum* Lellinger, sp. nov.
Fig. 3

Plantae epiphyticae. Rhizoma erectum vel ascendens ca. 3 mm diam. ad apicem paleaceum; paleis lanceatis ca. 5 mm longis 0.75 mm latis aeneis clathratis marginibus integris. Stipites approximati 6–22 cm longi 1–2 mm lati canaliculati anguste alati virides vel brunneoli glabri. Rachides virides vel brunneolae angustissime alatae glabrae ad apicem leviter flexuosae. Laminae oblongae (10)18–42 cm longae (4.5)8–12(20) cm latae papyraceae, ad basin obtusae vel truncatae, ad apicem subobtusae abrupte acuminatae vel caudatae, pinnatae; pinnis oblongo-lanceolatis petiolatis alternatis inaequilateralibus, ad basin inferiorem excavatis ad basin superiorem truncatis non auriculatis, ad apicem acuminatis interdum acutis marginibus crenulatis; venis furcatis leviter curvatis; indusiis usque ad 13 mm longibus viridibus integris.

*Type.*—Vara Blanca de Sarapiquí, Pcia. Herdia, Costa Rica, 1500–1750 m, *Skutch 3203* (US; isotypes GH, NY).

*Paratypes.*—COSTA RICA: Pcia. Puntarenas: Monteverde, 4500 ft, *Palmer 100* (NY). Pcia. Alajuela: La Palma de S. Ramón, 1310 m, *Brenes 3956* (NY); Río La Balsa ca. 23 km NE of S. Ramón, 850 m, *Taylor 17817* (NY); S of S. Ramón ca. 3 km above S. Rafael, ca. 1200 m, *Lellinger 1346, 1347* (both CR, F, MO, US). Pcia. Heredia: Zarcero, 1500 m, *A. Smith 48/198* (US). Pcia. S. José: La Palma, 1500 m, *Valerio A94, 198* (both US). Pcia. Cartago: Cartago, 4250 ft, *Cooper 6037* (US); 5 mi S of Cartago, ca. 1800 m, *Maxon 507* (NY, US); Estrella, 4400 ft, *Cooper 6038* (US), 5200 ft, *Stork 3281* (GH, US); Navarro, 1500 m, *Torres R. 76, 79* (both US); El Muñeco, ca. 1400 m, *Standley 33502, 33631* (both US); Vicinity of Orosi, *Standley 39840* (US); 2.2 km SSE of Purisíl above Finca La Concordia, ca. 1800 m, *Lellinger 1479* (US), *1499* (CR, F, US), *1518* (F, US); Ca. 6 km SE of Tapantí, *Wilbur & Stone 8901* (DUKE). PANAMA: Pcia. Chiriquí: Vicinity of El Boquete, 1000–1500 m, *Cornman 876, 1012* (both US); Slopes of la Sierra del Boquete, 4400 ft, *Bro. Maurice 828* (GH), *830* (US); Valley of the Río Piarnasta above El Boquete, 1525–1575 m, *Killip 5165* (US); Roballo Trail above El Boquete, 1600–1700 m, *Killip 5426* (US). Pcia. Veraguas: Near the Escuela Agricola Alto Piedra near Sta. Fé, 730 m, *Croat 34071* (MO).

*Discussion.*—This species resembles *A. auritum* Swartz, but has broader, thinner pinnae, and *A. auriculatum* Swartz, but has pinnae lacking a basal acroscopic lobe.

*Asplenium harpeodes* var. *major* Hieron. Hedwigia 60:237. 1919

*Lectotype.*—To fix the application of this name, I choose: Caracas, Distr. Fed., Venezuela, *Funck & Schlim* [probably actually *Moritz*] *246* (B not seen; isolectotypes FI-Hb. Webb not seen, GH not seen, W not seen). This is a synonym of *A. harpeodes* Kunze.

### *Asplenium maxonii* Lellinger, sp. nov.

Fig. 4

Plantae epiphyticae terrestres raro epipetricae. Rhizoma ascendens ca. (5)10 mm diam, usque ad 6(8) cm longum squamatum; paleis anguste lanceolatis usque ad 4 mm longis 0.5 mm latis subbicoloribus brunneis clathratis marginibus pallidioribus subclathratis integris. Stipites congesti 1–6 cm longi exalati. Stipites rachidesque canaliculati atropurpurei vel brunnei glabri. Rachides uniformiter anguste alati, alis viridibus, prolongati ad apicem bulbiliferi. Laminae rhombicae (9)25–45 cm longae (2.5)4–13 cm latae papyraceae, ad basin acuminatae raro obtusae, ad apicem obtusae vel subobtusae (rachidi prolongati excepto), tripinnatae; pinnis sessilibus lanceatis alternatis aequilateralibus; pinnulis oblongis inaequilateralibus segmentis obovatis vel elongatis saepe bilobatis ad apicem rotundatis non apiculatis; indusiis ca. 2 mm longis subviridibus integris.

*Type.*—Upper Caldera River, near "Camp I," Holcomb's trail above El Boquete, Pcia. Chiriquí, Panama, 1450–1650 m, *Maxon 5601* (US; isotypes GH, NY, US).

*Paratypes.*—COSTA RICA: Pcia. Puntarenas: Vicinity of the biological field station at Wilson finca, 1100–1400 m, *Mickel 2013* (NY), 1100–1200 m, *Mickel 3051a* (NY), *3051b* (NY, US); Finca las Cruces, 4000 ft, *Gillis 10154* (A); Las Cruces, ridge road, *Dressler 3589* (US); 3–5 km NW of the biological field station at Finca Wilson, 1300–1400 m, *Lellinger 813* (US); Ca. 5 km NE of Finca las Cruces, ca. 1400 m, *Burch 4514* (NY). Pcia. Alajuela: Upper drainage of the Río Peñas Blancas below the Monteverde Cloud Forest Nature Reserve, 1250–1350 m, *Burger, Visconti & Gentry 10728* (NY); 11 km N of S. Ramón, 1000 m, *Lellinger 747* (US), *Mickel 2942* (NY, US); Viento Fresco, 1600–1900 m, *Standley & Torres 47865* (US); San Antonio de Zarcero, 1500 m, *A. Smith 48/286* (US). Pcia. Limón: Suerre, Llanuras de Sta. Clara, 300 m, *Donnell-Smith 6890* (GH, NY, US); La Concepción, Llanuras de Sta. Clara, 250 m, *Donnell-Smith 6932* (NY). Pcia. Heredia: Vara Blanca, 1600–1700 m, *Maxon 8316, 8341* (both US), 1500–1750 m, *Skutch 3133* (GH, US); Yerba Buena NE of S. Isidro, ca. 2000 m, *Standley & Valerio 49668* (US); Cerro de las Caricias N of S. Isidro, 2000–2400 m, *Standley & Valerio 52056* (US). Pcia. S. José: La Palma, 1400 m, *Brade & Brade* [*Ros. Fil. Costar. Exs. 27*] (NY, US), ca. 1600 m, *Standley 33110, 33124* (both US); vicinity of La Palma, 1450–1550 m, *Maxon 368, 387* (both NY, US); Las Nubes, ca. 5000 ft, *Scamman & Holdridge 8046* (GH, US); Quebrada Bajo Máquina, 3 km NE of Cascajal, 1640 m, *Lent 2495* (GH); SW of Santiago de Puriscal, between Cerbatana and Mercedes Sur, ca. 1100 m, *Lellinger 1574* (US); Quebrada de los Yases, between La Guaria and Palmilera, 1700 m, *Jiménez M. 1459* (CR, F, NY, US); Vicinity of Sta. María de Dota, 1500–1800 m, *Standley & Valerio 43318* (GH); El Copey, *O. Jiménez 1103* (US); Lower SE slopes of Cerro Chirripó, 5500–7000 ft, *Evans & Lellinger 11* (US). Pcia. Cartago: Vicinity of Cartago, 1500 m, 19 April 1906, *Maxon* (NY); Finca Navarro, 1350 m, *Maxon 627* (NY); El Muñeco, 5000 ft, *Stork 2661* (US); Vicinity of Orosi, *Standley 39754* (US); Ca. 2.2 km SSE of Purisíl, above Finca La Çoncordia, ca. 1800–2300 m, *Lellinger 1550* (US); Ridge above Platanillo, 1200–1450 m, *Mickel 3411* (NY, US); Platanillo, 650–900 m, *de la Sota 5247* (US); New road from Tapantí ca. 7 km S of bridge, 1500 m, *Hauke 416* (NY); E slope above the Río Grande de Orosi ca. 10 km S of Tapantí, 1400–1600 m, *Burger & Stolze 5696* (F, GH, US), ca. 15 km S of Tapantí, 1500 m, *Burger & Liesner 6751* (F, GH); Road above the Río Grande de Orosi, 12–16 km S of Tapantí, 1500–1600 m, *Stolze 1482* (F, GH, NY, US); Flood plain of the Río Reventazón 3 km SE of Turrialba, 500–600 m, *Holm & Iltis 56* (US). PANAMA: Pcia. Chiriquí: Ca. 5 km NE of Boquete, 1700–1800 m, *Skog 4048* (US); Cerro Horqueta, 6500 ft, *von Hagen & von Hagen 2109* (NY); Valley of the Río Caldera from El Boquete to the Cordillera, 1400–1600 m, *Killip 5062* (GH), 1650 m, *5238* (GH, US); Vicinity of El Boquete, 1000–1500 m, *Cornman 1010, 1187* (both US). Pcia. Coclé: 5 mi N of El Valle, *Armond 375* (DUKE); El Valle de Antón, *Vergara 8* (PMA, US). COLOMBIA: Depto. Chocó: Rio Nuquí, ca. 300 m, *Haught 5497* (US); Río Mutatá ca. 3 km above its junction with the Río El Valle, NW of Alto del Buey, ca. 800 m, *Lellinger & de la Sota 145* (LP, US); NW side of Alto del Buey, ca. 1300 m, *Lellinger & de la Sota 329* (COL, HUA, LP, US). ECUADOR: Pcia. Napo: Talag, 15 km SSW of Tena, 2000 ft, *Grubb et al. 126* (US); Between Tena and Archidona, *Asplund 9274* (US). PERU: Depto. Huánuco, 1600 m, *Woytkowski 34518* (US). BOLIVIA: Depto. La Paz: Polo-Polo, 1100 m, *Buchtien 3479* (US).

*Discussion.*—This species is similar to *A. rutaceum* (Willd.) Mett., from which it differs in pinnule outline and in having round, rather than apiculate, segment apices (a character especially useful in distinguishing juvenile plants of the two species). This species was formerly called *A. conquisitum* Underw. & Maxon ex Christ, but that name has proved to be a synonym of *A. rutaceum.*

### *Blechnum occidentale* f. *pubirhachis* (Rosenst.) Lellinger, comb. nov.

*Blechnum occidentale* var. *pubirachis* Rosenst. Hedwigia 46:94. 1906. *Type.*—Passo Mansa, Munic. Blumenau, Est. S. Paulo, Brazil, *Haerchen 18* (S not seen; isotype NY not seen).

*Discussion.*—This form appears throughout the range of the species, although it tends to occur at higher elevations than does f. *occidentale,* and often has smaller, more congested fronds.

### *Ctenitis bidecorata* Lellinger, sp. nov.

Fig. 5

Plantae terrestres. Rhizoma erectum 5 mm diam. (basibus stipitum exclusis) paleaceum; paleis linearibus usque ad 10 mm longis 1 mm latis concoloribus aeneis pilosulis integris. Stipites approximati 7–20 cm longi squamati. Stipites rachides costaeque paleaceae dense aut sparse pilosae, paleis anguste lanceolatis 1.5–8 mm longis 0.1–0.5 mm latis concoloribus aeneis aut brunneis epilosulis integris, pilis usque ad 1 mm longis multicellularibus hyalinis. Laminae lanceolatae (12)15–37 cm longae (4)6–18(20) cm latae papyraceae, ad basin obtusae

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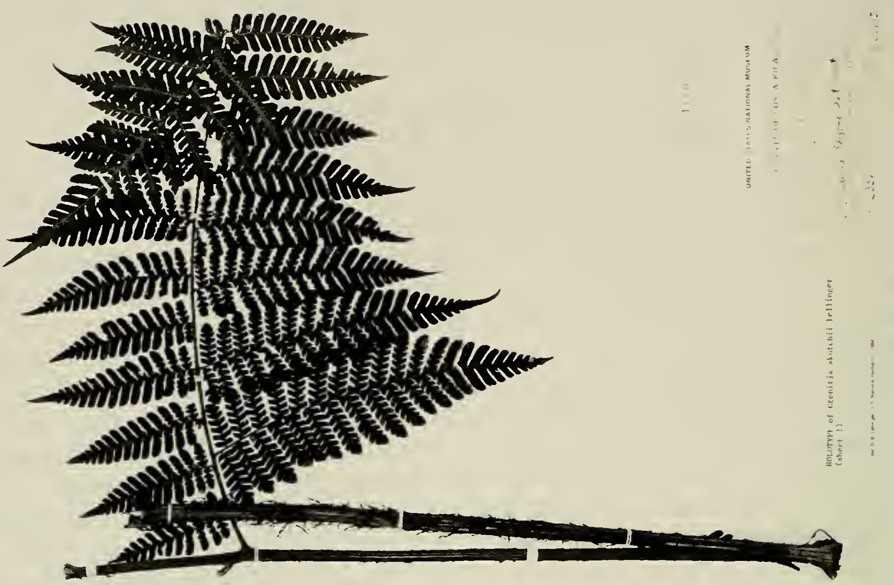

Fig. 5. Holotype of *Ctenitis bidecorata* Lellinger, *Stork 1518* (US). Fig. 6. Basal pinna of holotype of *Ctenitis skutchii* Lellinger, *Skutch 2337* (US).

bipinnato-pinnatifidae, ad apicem acuminatae pinnatifidae, pro parte maxima pinnato-pinnatifidae; pinnis sessilibus lanceatis inaequilateralibus (pinnis basalibus triangularibus basiscopice productis); segmentis oblongis obtusis, venis usque ad 6-jugis; soris rotundis ca. 1 mm diam. submedialibus exindusiatis.

*Type.*—Estrella–Sta. Maria road, Pcia. San José, Costa Rica, 7000 ft, *Stork 1518* (US).

*Paratypes.*—COSTA RICA: Pcia. Heredia: Aromal del Volcán Barba, 2800 m, *Valerio 28* (CR, US); Porrosatí, 1900 m, *Gômez 3553, 3564* (both CR). Pcia. S. José: Zurquí, 1900 m, *Gômez 3525* (CR); between Estrella and Sta. María, 7000 ft, *Stork 1523* (UC). Pcia. Cartago: Road above the Río Grande de Orosi, 12–16 km S of Tapantí, 1500–1600 m, *Stolze 1495* (F, US).

*Discussion.*—Christensen (in herb. US) considered this species to be a variety of what is now called *Ctenitis macrotheca* (Fée) Ching, a member of *Ctenitis* subg. *Subincisae.* However, the relationship does not seem close to me.

### *Ctenitis skutchii* Lellinger, sp. nov.
Fig. 6

Plantae terrestres. Rhizoma erectum ca. 1 cm diam. (basibus stipitum exclusis) paleaceum; paleis linearibus usque ad 15 mm longis 1 mm latis concoloribus aeneis denticulatis raro integris. Stipites approximati 15–55 cm longi paleacei et sparse pilosuli, paleis eis rhizomatis similibus, pilis appressis usque ad 0.5 mm longis hyalinis. Rachides costaeque paleaceae et dense pilosulae, paleis lanceolatis 1–3 mm longis 0.1–0.75 mm latis concoloribus subclathratis brunneis integris, pilis eis stipitum similibus. Laminae oblongae (30)50–100(150?) cm longae (25)30–60(80) cm latae papyraceae, ad basin obtusae manifeste tripinnato-pinnatifidae, ad apicem acuminatae pinnato-pinnatifidae, pro parte maxima tripinnatae vel obscure tripinnato-pinnatifidae; pinnis pinnulisque sessilibus oblongis aequilateralibus (pinnis basalibus triangularibus basiscopice productis); segmentis oblongis obtusis vel truncatis sparse pilosulis marginibus pilosulis, pilis curvatis; venis ca. 4-jugis; soris rotundis medialibus exindusiatis.

*Type.*—Vicinity of El General, Pcia. S. José, Costa Rica, 1190 m, *Skutch 2337* (US).

*Paratypes.*—COSTA RICA: Pcia. Puntarenas: Atlantic-facing ridge beyond the Monteverde Forest Reserve near road across the ridge, ca. 1600 m, *Lellinger 1748* (US); Cañas Gordas, 1100 m, *Pittier 10993* (US); Vicinity of the biological field station at Finca Wilson, 1100–1200 m, *Lellinger 814* (US). Pcia. Alajuela: Upper drainage of the Río Peñas Blancas below the Monteverde Cloud Forest Nature Reserve, 1250–1350 m, *Burger, Visconti & Gentry 10774* (CR, F). Pcia. S. José: 8–12 km SE of Desemparados on Calle Tablazo, 1800–1900 m, *Utley & Utley 3046* (F). PANAMA: Pcia. Chiriquí: Río Quebrada, 1650 m, *Killip 5502* (US, misnumbered *5136* at GH); Ca. 5 km NW of the town of Cerro Punta, 2000–2300 m, *Wilbur et al. 15230* (DUKE).

*Discussion.*—This species belongs to *Ctenitis* sect. *Subincisae* and has commonly been called *C. subincisa* (Willd.) Ching, but differs from that species in having pilosulous axes bearing usually flat, slightly toothed scales. It is closer to *C. adenopteris* (C. Chr.) Ching than to *C. subincisa.*

### *Cyathea pseudonanna* (Gômez) Lellinger, comb. nov.

*Trichopteris pseudonanna* Gómez, Phytologia 50:69. 1981. *Type.*—Cerro Tuti, Edo. Veraguas, Panama, *Folson & Edwards 3370* (MO).

*Discussion.*—A second gathering of this species from the type locality (*Knapp & Sytsma 2581,* MO, US) has minute, hemitelioid indusia. The specimen has alate rachises reminiscent of *C. parva* (Maxon) Tryon, but probably is most closely related to *C. decorata* (Maxon) Tryon, both members of the *C. speciosa* group as defined by R. M. Tryon (Contr. Gray Herb. 206:46–47. 1976).

### *Diplazium ferulaceum* (Moore ex Hook.) Lellinger, comb. nov.

*Asplenium ferulaceum* Moore ex Hook. Sp. Fil. 3:216. 1860. *Syntypes.*—Colombia, *Hartweg 1519* (K not seen); and Quito, Pcia. Pichincha, Ecuador, *Jameson* (K not seen).

*Gymnogramme sciatrophis* Donn.-Sm. Bot. Gaz. 19:266, t. 26. 1894, as "*sciatraphis.*" *Type.*—Río Jiménez, Llanuras de Sta. Clara, Pcia. Limón, Costa Rica, *J. D. Smith 5084* (US; isotype NY).

*Discussion.*—This species apparently is the endpoint in lamina reduction leading from *D. ordinatum* (Christ) Lellinger and *D. solutum* (Christ) Lellinger through *D. myriomerum* (Christ) Lellinger. See *D. solutum* for a further comment.

### *Diplazium multigemmatum* Lellinger, sp. nov.
Fig. 7

Plantae terrestres. Rhizoma erectum(?) paleaceum(?). Stipites ca. 70 cm longi sparse paleacei, paleis ca. 6–15 mm longis 1.25–3 mm latis concoloribus atrobrunneis sparse denticulatis, ad basin atrati, distaliter viriduli. Rachides glabriusculae viridulae. Laminae oblongae ca. 75 cm longae 25–40 cm latae papyraceae, ad basin obtusae vel truncatae bipinnatae, ad apicem anguste acutae pinnatopinnatifidae; pinnis petiolulatis (usque ad 1.5 cm) lanceatis (paribus infimis lanceolatis) usque ad 27 cm longis 7 cm latis aequilateralibus subfalcatis pinnatifidis raro ad basin pinnatis, ad apicem acutis aut acuminatis; segmentis oblongis subobtusis aut rotundis marginibus crenatis; venis 5–8(10)-jugis bifurcatis; indusiis 2–5 mm longis marginibus sparse aut dense ciliatis; gemmulis minutis nigris saepe in ramis acroscopicis venis basalibus acroscopicis.

*Type.*—North slopes of Cerro Chompipe ca. 10 km NNE of Heredia, Pcia. Heredia, Costa Rica, 2200 m, *Lellinger 1006* (US).

*Paratypes.*—COSTA RICA: Along Interamerican Highway, *Scamman 7143* (GH). Pcia. Alajuela: La Palma de S. Ramón, *Brenes 10560* (NY). Pcia. Heredia: Porrosatí, 1900 m, *Gômez 3561* (CR).

### *Diplazium myriomerum* (Christ) Lellinger, comb. nov.

*Athyrium myriomerum* Christ, Bull. Herb. Boiss. II, 6:169. 1906. *Syntypes.*—Navarro, Pcia. Cartago, Costa Rica, *Wercklé* in 1905 (P not seen; presumable isosyntype US); and Costa Rica, *Wercklê 100 p. p.* in 1903 (P not seen).

*Diplazium bradeorum* Rosenst. Repert. Sp. Nov. Fedde 9:69. 1910. *Type.*—Carrillo, Pcia. S. José, Costa Rica, 400 m, *Brade & Brade 383* (S not seen photo 6265; isotypes P not seen photo 4077, US).

*Discussion.*—See *D. solutum* (Christ) Lellinger.

### *Diplazium navarrense* Lellinger, sp. nov.
Fig. 8

Plantae terrestres. Rhizoma erectum dendroideum usque ad 25 cm longum 1 cm latum, ad apicem sparse paleaceum, paleis lanceatis ca. 4 mm longis 1 mm latis concoloribus brunneis integris. Stipites congesti 30–40 cm longi. Stipites rachidesque glabri viriduli sulcati exalati. Laminae oblongo-lanceatae 35–45 cm longae 20–30 cm latae papyraceae, ad basin truncatae, ad apicem acuminatae pinnatae, distaliter bipinnatae proximaliter pinnato-pinnatifidae; pinnis sessilibus alternatis oblongis usque ad 15 cm longis 3 cm latis aequilateralibus aut subaequilateralibus, ad basin basiscopicis interdum excavatis, pinnatis pinnatisectis vel pinnatifidis, ad apicem lobatis caudatis; pinnulis segmentisque ovatis vel oblongis, venis usque ad 6-jugis usque ad 3(4)-furcatis; soris usque ad 4 mm longis curvatis saepe singularibus; indusiis brunneis subscariosis integris.

*Type.*—Ravine of the Río Naranjo, Finca Navarro, Pcia. Cartago, Costa Rica, 1350 m, *Maxon 658* (US; isotype NY).

*Paratype.*—Same as the type, *Maxon 662* (NY, US).

### *Diplazium ordinatum* (Christ) Lellinger, comb. nov.

*Athyrium ordinatum* Christ, Bull. Herb. Boiss. II, 4:967. 1904. *Type.*—Costa Rica, *Wercklé* (P not seen).

*Athyrium reductum* Christ, Bull. Herb. Boiss. II, 4:966. 1904. *Lectotype.*—Alajelita, Pcia. S. José, Costa Rica, 1300 m, *Alfaro 16472* (US; isolectotypes NY, P not seen), chosen by Lellinger (Proc. Biol. Soc. Washington 89:708. 1977).

*Athyrium costaricense* Christ, Bull. Herb. Boiss. II, 5:252. 1905. *Type.*—Costa Rica, *Wercklé* (P not seen).

*Discussion.*—See *Diplazium solutum* (Christ) Lellinger.

### *Diplazium skutchii* Lellinger, sp. nov.
Fig. 9

Plantae terrestres. Rhizoma erectum dendroideum aetate usque ad 20 cm longum 1 cm latum (stipitibus excluso), ad apicem dense paleaceum, paleis usque ad 10 mm longis 1.5 mm latis concoloribus atrobrunneis integris. Stipites approximati 30–60 cm longi ad 5 mm lati straminei villosuli, villis contortis ca. 0.5 mm longis multicellularibus subcatenatis. Laminae oblongo-lanceolatae 50–75(100?) cm longae 25–40(50) cm latae papyraceae, ad basin obtusae bipinnato-pinnatifidae, ad apicem acuminatae pinnato-pinnatifidae aut pinnatifidae; pinnis sessilibus alternis suboppositis (infimis petiolulatis usuqe ad 1 cm) aequilateralibus oblongo-lanceolatis usque ad 25 cm longis 5 cm latis (infimis usque ad 30 cm longis 12 cm latis), ad basin truncatis, ad apicem anguste acutis; pinnulis vel segmentis oblongis, ad apicem rotundis, abaxialiter pilosulis, pilis hyalinis, venulis usque ad 12-jugis 2- vel 3-furcatis; soris 2–5 mm longis, plus minusve rectis saepe singularibus; indusiis brunneis ciliato-erosis.

*Type.*—Vicinity of El General, Pcia. S. José, Costa Rica, 1160 m, *Skutch 2959* (US; isotype NY).

*Paratypes.*—NICARAGUA: Depto. Matagalpa: Sta. María de Ostuma, ca. 1500

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Fig. 7. Basal portion of frond of holotype of *Diplazium multigemmatum* Lellinger, *Lellinger 1006* (US). Fig. 8. Holotype of *Diplazium navarrense* Lellinger, *Maxon 658* (US).

m, *Gomez, Cittar & Villa 6375* (CR). COSTA RICA: Pcia. S. José: Vicinity of El General, 1190 m, *Skutch 2329* (NY, US). Pcia. Cartago: Carpintera, 1700 m, *Brade 805* (UC). PANAMA: Pcia. Chiriquí: Vicinity of Camp Aguacatal, E slope of Volcán Chiriquí, *Maxon 5288* (US); Vicinity of El Boquete, 1000–1300 m, *Maxon 4939* (US), 1000–1500 m, *Cornman 1098, 1125* (both US), *1362* (UC, US).

### *Diplazium solutum* (Christ) Lellinger, comb. nov.

Fig. 10

*Athyrium solutum* Christ, Bull. Herb. Boiss. II, 4:967. 1904. *Type.*—Costa Rica, *Wercklé* in 1903 (P not seen photo 4038; isotype US).

*Discussion.*—This species, along with *D. ferulaceum* (Moore ex Hook.) Lellinger, *D. myriomerum* (Christ) Lellinger, and *D. ordinatum* (Christ) Lellinger, were formerly placed in *Athyrium*; Tryon and Tryon (Ferns Allied Pls. 544–545. 1982) pointed out their affinity with *Diplazium.* Although most have single, rather than the typical double sori found in *Diplazium,* double sori are found occasionally in *D. solutum,* and the segments of these species are not spinulose nor are the veins readily visible on the abaxial lamina surface, as is usual in most *Athyrium* species.

### *Dryopteris aspidioides* var. *subhastata* C. Chr.

K. Danske Vidensk. Selsk. Skr. VII, 4:287. 1907

*Lectotype.*—To fix the application of this name, I choose: Near Tarapoto, Depto. S. Martín, Peru, *Spruce 3964* (C not seen; isolectotypes B not seen, presumably K not seen, US). The other syntypes are: Loreto, Depto. Loreto, Peru, *Ule 6518* (P not seen); S. Gaván, Depto. Puno, Peru, *Lechler 2311* (B not seen); Colombia, *Lindig 53* (B not seen); and Caracas, Distr. Fed., Venezuela, *Otto 596* (B not seen). *Dryopteris aspidioides* var. *subhastata* is a synonym of *Thelypteris aspidioides* (Willd.) Tryon.

### *Dryopteris tablaziensis* Christ

Bull. Herb. Boiss. II, 7:262. 1907

*Lectotype.*—To fix the application of this name, I choose: La Palma, Pcia. S. José, Costa Rica, 1500 m, *Wercklé 17010* (P not seen), examined by A. R. Smith (in litt. 22 Mar 1977). The other syntype is: Tablazo, Pcia. S. José, Costa Rica, 1900 m, *Biolley 67* (P not seen); isosyntype US). *Drypteris tablaziensis* is a synonym of *Thelypteris pilosula* (Mett.) Tryon.

### *Grammitis barbensis* Lellinger, sp. nov.

Fig. 11

Plantae epiphyticae. Rhizoma ascendens minutum manifeste paleaceum; paleis lanceatis ca. 3 mm longis 0.5 mm latis cinereis clathratis marginibus pilosis, pilis simplicibus furcatis vel stellatis ca. 0.15 mm longis. Stipites 3–9 mm longi 0.4 mm lati. Stipites rachidesque teretes atropurpureae striatae glabrae. Laminae anguste oblongae (3.5)5–20 cm longae (0.7)1–2 cm latae membranaceae, ad basin acutae vel acuminatae, ad apicem acutae, pinnatisectae; segmentis oblongis vel aliquando triangularibus leviter ascendentibus 4–10 mm longis 1–3 mm latis, ad basin basiscopicis decurrentibus, ad basin acroscopicis truncatis raro subgibbosis,

Fig. 9. Basal portion of frond of holotype of *Diplazium skutchii* Lellinger, *Skutch 2959* (US). Fig. 10. Frond of *Diplazium solutum* (Christ) Lellinger, *Burger & Stolze 5695* (F).

ad apicem acutis vel raro rotundis, glabris marginibus integris vel leviter repandis; soris submedialibus rotundis leviter impressis.

*Type.*—Volcán Barba, Pcia. Heredia, Costa Rica, 3000 m, *Valerio 209* (US; isotype CR).

*Paratypes.*—Osa Peninsula, Pcia. Puntarenas, Costa Rica, 50–600 m, *Mickel 1942* (NY).

*Discussion.*—This species is a member of subg. *Cryptosorus* and seems to be related to *G. suprasculpta* (Christ) Seymour and to *G. micula* Lellinger.

### *Grammitis cornuta* Lellinger, sp. nov.

Fig. 12

Plantae epiphyticae. Rhizoma ascendens ca. 4 mm diam. paleaceum; paleis anguste lanceatis usque ad 10 mm longis 1 mm latis aeneis vel rufobrunneis nitidis repandis, ad apicem setaceis. Stipites approximati 7–30 cm longi usque ad 2 mm lati tereti brunnei setiferi et sparse paleacei, setis rectis usque ad 2 mm longis brunneis, paleis eis rhizomatis similibus. Stipites rachidesque glanduliferae, glandulis submoniliformibus saepe irregulariter furcatis, cellulis globosis leviter elongatis. Laminae oblongae vel lanceolatae (5)8–25 cm longae 4–9(12) cm latae subcoriaceae, ad basin truncatae vel obtusae, ad apicem acutae, profunde pinnatifidae; segmentis oblongis saepe subfalcatis 2–5(9) cm longis 5–8 mm latis, ad basin basiscopicis decurrentibus vel subtruncatis, ad basin acroscopicis truncatis vel leviter surcurrentibus, ad apicem acuminatis, paginis abaxialibus glanduliferis, costis adaxialibus leviter setiferis, marginibus involutis maturitate; venulis obscuris anastamosantibus; soris leviter submedialibus rotundis 2–3 mm diam. non impressis.

*Type.*—Las Nubes, Pcia. S. José, Costa Rica, ca. 1500–1900 m, *Standley 38843* (US; isotype GH not seen).

*Paratypes.*—COSTA RICA: Pcia. Heredia: Alto del Roble, ca. 11 km NNE of Heredia, 2100 m, *Lellinger 1062* (US). Pcia. Cartago: Sta. Clara de Cartago, 1950 m, *Maxon 8201* (US). PANAMA: Pcia. Chiriquí: Between Alto de las Palmas and the top of Cerro de la Horqueta, 2100–2268 m, *Maxon 5509* (US).

*Discussion.*—This species is a member of subg. *Cryptosorus* and is distinct in having areolate venation, a most unusual condition in *Grammitis* and one probably resulting from the wide segments.

### *Grammitis micula* Lellinger, sp. nov.

Fig. 13

Plantae epiphyticae. Rhizoma erectum vel ascendens paleaceum; paleis lanceatis usque ad 2 mm longis 0.25 mm latis cinereis clathratis marginibus sparse pilosis, pilis simplicibus ca. 0.2 mm longis hyalinis. Stipites 0.5–1 mm longi 0.15–0.2 mm lati exalati. Stipites rachidesque teretae atrae striatae sparse pilosuli juventute, pilis simplicibus aut furcatis hyalinis. Laminae oblongae (3)5–15(22) cm longae (0.8)1–1.5(3) cm latae membranaceae, ad basin et apicem acutae, pinnatae vel pinnato-pinnatifidae; pinnis oblongis leviter ascendentibus 4–17 mm longis 2–3.5 mm latis, ad basin basiscopicis decurrentibus, ad basin acroscopicis lobatis, ad apicem acutis vel acuminatis, crenatis aut lobatis glabris; soris submedialibus rotundis leviter impressis.


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Fig. 11. Holotype of *Grammitis barbensis* Lellinger, *Valerio 209* (US). Fig. 12. Holotype of *Grammitis cornuta* Lellinger, *Standley 38843* (US).

*Type.*—End of access road just above face of mine, Cerro Colorado, on the border of Pcias. Chiriquí and Bocas del Toro, Panama, 1600–1700 m, *Folsom, Small & Robbins 4744* (US; isotype MO not seen).

*Paratypes.*—COSTA RICA: Pcia. S. José: Vicinity of El General, 1190 m, *Skutch 2831* (US), 1000 m, *3015* (GH, NY, US).

*Discussion.*—This species is a member of subg. *Cryptosorus* and seems to be related to *G. suprasculpta* (Christ) Seymour and to *G. barbensis* Lellinger.

### *Grammitis pseudomitchellae* Lellinger, sp. nov.

Fig. 14

Plantae epiphyticae. Rhizoma erectum minutum epaleaceum. Stipites obsoleti aut usque ad 7 mm longi atri pilosi, pilis ca. 1 mm longis tenuibus laxis. Laminae oblongae, 1.5–6 cm longae 2–4 mm latae membranaceae, ad basin attenuatae, ad apicem leviter anguste rotundae, profunde crenato-lobatae, ad apicem fertilem crenatae; lobis ascendentibus rotundis sparse pilosis, pilis 1 mm longis rectis hyalinis vel brunneolis; venulis non furcatis; soris submedialibus rotundis vel leviter elongatis non impressis.

*Type.*—10 km N of S. Rafael de Heredia on Volcán Barba, Pcia. Heredia, Costa Rica, 1950 m, *Mickel 3033* (NY).

*Paratypes.*—PANAMA: Pcia. Chiriquí: Cordillera above "Camp I," Holcomb's Trail 10 mi above El Boquete, 1800–2000 m, *Killip 5289a* (US); Cordillera, E of the Río Caldera, 2150 m, *Killip 5331* (US).

*Discussion.*—This species is a member of subg. *Xiphopteris.* It closely resembles *G. mitchellae* (Baker) Stolze from Guatemala, from which it differs in having simple veins, non-setose sporangia, fewer and shorter marginal setae, and more and shorter setae on the abaxial surface of the laminae.

### *Grammitis rigescens* (Bory ex Willd.) Lellinger, comb. nov.

*Polypodium rigescens* Bory ex Willd. Sp. Pl. ed. 4, 5:183. 1810. *Type.*—Bourbon [Réunion], *Bory* (B-Hb. Willd. 19668 not seen microfiche Smithsonian Institution Library; isotypes FI not seen photo 16023, P-Hb. Juss. not seen photo 2951).

*Discussion.*—According to Pichi Sermolli (Webbia 37:118–125. 1983), Morton (Contr. U.S. Natl. Herb. 38:57–59. 1967) mislectotypified *Polypodium flabelliformis* Poir. in Lam., and so considered it to be an earlier name for *P. rigescens* Bory ex Willd. Pichi Sermolli has lectotypified the name on plate 87 (left) of Plumier's "Tractatus de Filicibus Americanis." His arguments for doing so are persuasive, and so *Grammitis flabelliformis* (Poir, in Lam.) Morton is the correct name for the small Antillean species which has been passing as *G. taenifolia* (Jenm.) Proctor.

### *Grammitis zeledoniana* Lellinger, nom. nov.

*Polypodium taxifolium* var. *fragillimum* Christ, Bull. Herb. Boiss. II, 4:1103. 1904, *non Grammitis fragillima* (Copel.) Morton. *Type.*—Costa Rica, *Wercklé* in 1903 (P).

*Selected specimens examined.*—COSTA RICA: Pcia. Alajuela: 11 km N of S. Ramón, 1000 m, *Lellinger 754* (US). Pcia. Heredia: Cerros de Zurquí, NE of S.

Fig. 13. Holotype of *Grammitis micula* Lellinger, *Folsom, Small & Robbins 4744* (US). Fig. 14. Holotype of *Grammitis pseudomitchellae* Lellinger, *Mickel 3033* (NY).

Isidro, 2000–2400 m, *Standley 52000* (US), *50453* (US). Pcia. S. José: La Palma area NE of S. Jerónimo above the La Hondura valley, 1500 m, *Burger & Stolze 5381* (F). Pcia. Cartago: SE of Orosi, ca. 2.2 km SSE of Purisíl, above Finca la Concordia, ca. 1800–2300 m, *Lellinger 1525* (US). PANAMA: Pcia. Chiriquí: Cerro Colorado, along mining road 31.6 km beyond the bridge over the Rio S. Felix, 1690 m, *Croat 37133* (MO); Between Alto de las Palmas and the top of Cerro de la Horqueta, 2100–2268 m, *Maxon 5449* (US), *5481* (US). Pcia. Darién: Serranía de Pirre, ca. 8 km W of Cana Gold Mine, 1430–1480 m, *Croat 37833* (MO).

*Discussion.*—This species has usually been confused with *G. taxifolia* (L.) Proctor, from which it differs in having glabrous, rather than sparsely setose, segment margins and in being densely setose at the base of the stipes and more sparsely setose distally, rather than in having evenly setose stipes.

### *Hymenophyllum mortonianum* Lellinger, sp. nov.

Fig. 15

Plantae epiphyticae. Rhizoma repens, ca. 0.4 mm diam. sparse pilosum, pilis ca. 1 mm longis hyalinis vel brunneolis manifeste pluricellularibus. Stipites 3–13 mm longi, basin versus alati. Stipites rachidesque teretes atrobrunneae striatae alatae pilosae, pilis stellatis sessilibus vel subsessilibus 4–6-brachiatis, brachiis ca. 0.4 mm longis hyalinis vel rufobrunneolis. Laminae anguste rhombicae indeterminatae(?) usque ad 23 cm longae 2.5 cm latae pinnato-pinnatifidae, ad basin et apicem acuminatae, apice plusminusve elongatae, pinnis oblongis vel triangularibus usque ad 10-lobatis, lobis 1 mm latis, marginibus minute stellato-pilosis; venulis simplicibus (venulis ad basin acroscopicis furcatis exceptis); involucris rotundis 0.75 mm diam., ad basin truncatis vel obtusis, marginibus dense stellato-pilosus.

*Type.*—Mojarras de Tadó, 8.5 km E of Istmina, Depto. Chocó, Colombia, 150–250 m, *Lellinger & de la Sota 425* (US; isotypes COL, CR, HUA, LP).

*Discussion.*—This species is a member of subg. *Leptocionium.* It is known only from the type.

### *Hypolepis grandis* Lellinger, sp. nov.

Fig. 16

Plantae terrestres. Rhizoma ascendens ca. 1 cm diam. pilosum, pilis rufobrunneis catenatis. Frondes usque and ca. 3 m longae repertis. Stipites ad basin atropurpurei, supra basin rufobrunnei, nitidi pilosi juventute non spinosi. Rachides laminaeque pilosae et pilosulae, pilis 1–3 mm longis, multicellularibus catenatis hyalinis vel brunneolis, pilosulis 0.25–1 mm longis, 1–3-cellularibus plus minusve acicularibus hyalinis. Laminae probabiliter deltatae usque ad 2 m longae 1 m latae, tripinnato-pinnatifidae papyraceae; pinnis basalibus usque ad 70 cm longis 35 cm latis basiscopice productis, pinnulis acroscopicis 20 cm longis 7 cm latis, pinnulis basiscopicis 15 cm longis, 4 cm latis; pinnis medianis oppositis lanceolatis vel oblongis usque ad 50 cm longis 30 cm latis, pinnulis ca. 20-jugis subsessilibus oblongis usque ad 15 cm longis 4 cm latis; segmentis oblongis vel lanceatis profunde pinnatifidis, lobulis 1.75–2.5 mm latis ad apicem rotundis; indusiis scariosis manifeste pilosis deciduis.

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Fig. 15. Holotype of *Hymenophyllum mortonianum* Lellinger, *Lellinger & de la Sota 425* (US). Fig. 16. Holotype (portion of probably a basal pinna) of *Hypolepis grandis* Lellinger, *Brade & Brade 348* [*Ros. Fil. Costar. Exs. 143*] (US).

*Type.*—La Palma, Pcia. S. José, Costa Rica, 1400 m, *Brade & Brade 348* [*Ros. Fil. Costar. Exs. 143*] (US; isotypes NY, UC).

*Paratypes.*—COSTA RICA: Pcia. S. José: 5 mi S of Sta. María de Dota, 6800 ft., *Stork 1754* (GH, UC, US). Pcia. Cartago: El Muñeco, 4800 ft, *Stork 2732* (NY, UC, US); La Estrella, *Standley 39214* (US). PANAMA: Pcia. Chiriquí: Valley of the Río Quebrada above El Boquete, 1650 m, *Killip 5137* (US).

*Discussion.*—This species resembles the South American *H. stuebelii* Hieron. in indument, but has larger laminae that are tomentose on the adaxial surface.

### *Osmunda hirsuta* L. Sp. Pl. 2:1064. 1753

*Lectotype.*—To fix the application of this name, I choose: plate 162 of Plumier's "Tractatus de Filicibus Americanis," which is based on a specimen collected by Plumier near the Leogane quarter, Sto. Domingo, Hispaniola. According to Jackson (Index Linn. Herb. 111. 1912), there was no specimen of this species in the Linnaean herbarium in the hand of Linnaeus prior to 1767. *Osmunda hirsuta* is a synonym of *Anemia hirsuta* (L.) Swartz.

### *Pecluma ptilodon* var. *caespitosa* (Jenm.) Lellinger, comb. nov.

*Polypodium pectinatum* var. *caespitosum* Jenm. Bull. Bot. Dept. Jamaica, n.s., 4:125. 1897. *Type.*—Old England, St. Andrew Parish, Jamaica, 4000 ft, *Jenman* (NY? not seen).

### *Pityrogramma ebenea* var. *aurata* (Moore) Lellinger, comb. nov.

*Gymnogramma tartarea* var. *aurata* Moore, Gard. Chron. 1870:493. 1870. *Type.*—Cultivated by Veitch, originally from Peru (not seen); according to Tryon (Contr. Gray Herb. 189:66. 1962), Peru, *Pearce 182* (K not seen photo GH not seen) is authentic or perhaps even the type.

### *Polypodium ambiguum* Mett. ex Kuhn
### Linnaea 36:134. 1869, non Desv., 1827, nom. illeg.

*Lectotype.*—To fix the application of this name, I choose: Near Colonia Tovar, Edo. Aragua, Venezuela, *Fendler 254* (US). The other syntype is: Colonia Tovar, Edo, Aragua, Venezuela, *Moritz* (not seen). No specimens, but only a drawing of part of one frond of the Fendler specimen, exist at B. *Polypodium ambiguum* is a synonym of *P. ursipes* Moritz ex C. Chr.

### *Polypodium beyerianum* Rosenst. Repert. Sp. Nov. Fedde 22:17. 1925

*Lectotype.*—To fix the application of this name, I choose: Turrialba, Pcia. Cartago, Costa Rica, 650 m, *A. C. Brade 21* (S; isoelectotype UC). The other syntype is: Puntarenas, Pcia. Puntarenas, Costa Rica, *Beyer 44* (S not seen). *Polypodium beyerianum* is a synonym of *P. loriceum* L.

### *Polypodium fraxinifolium* var. *articulatum* Christ
### Bull. Herb. Boiss. II, 6:49. 1906

*Lectotype.*—To fix the application of this name, I choose: Turrialba, Pcia. Cartago, Costa Rica, 550 m, *Pittier 9061* (US; presumable isolectotype P not seen).

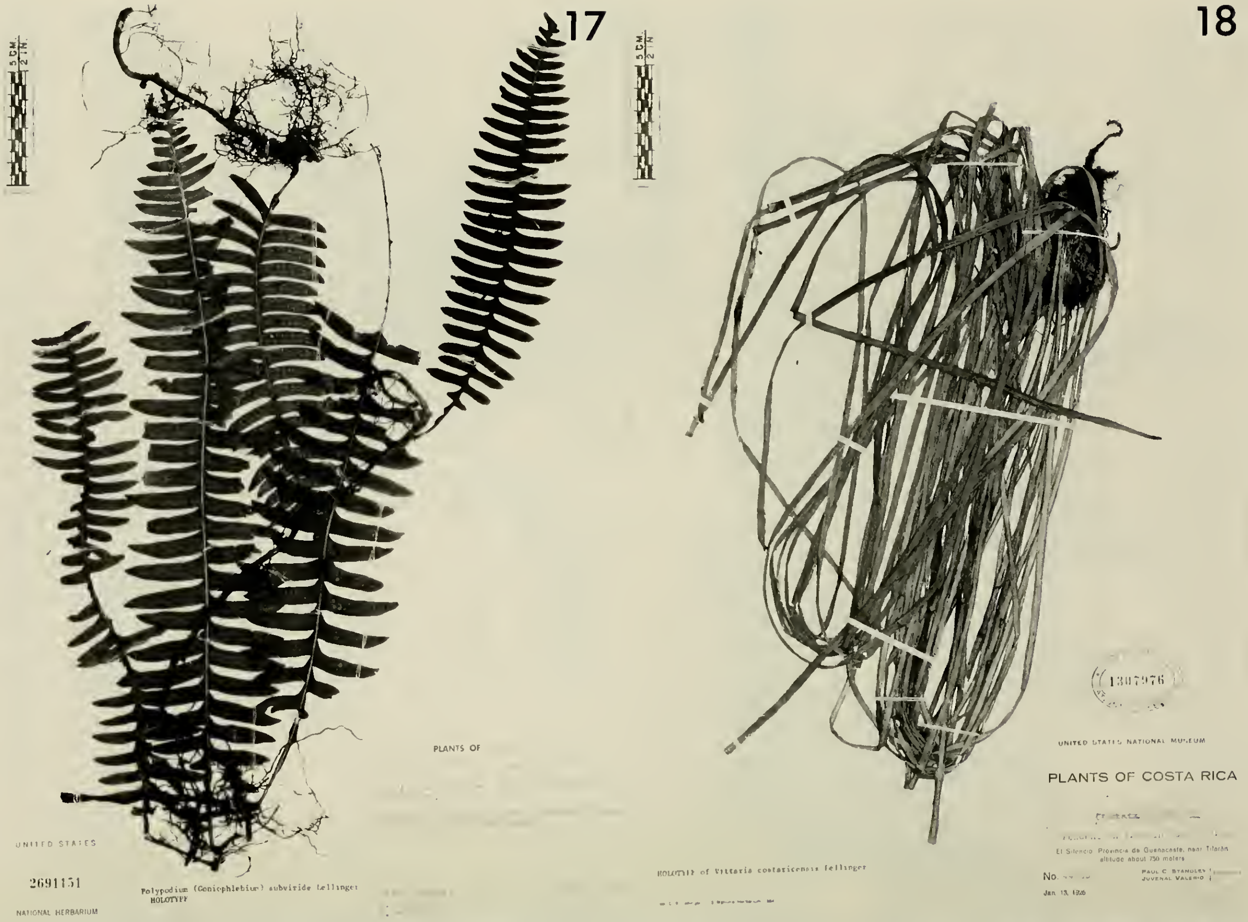

Fig. 17. Holotype of *Polypodium subviride* Lellinger, *Kennedy 1117* (US). Fig. 18. Holotype of *Vittaria costaricensis* Lellinger, *Standley & Valerio 44805* (US).

The other syntypes are: Carillo, Pcia. S. José, Costa Rica, *Pittier 1162* (P not seen); Tsaki, Talamanca, Pcia. Limón, Costa Rica, *Tonduz 9451* (P not seen; isosyntype US); and Costa Rica, *Wercklé* (P not seen). *Polypodium fraxinifolium* var. *articulatum* is a synonym of *P. giganteum* Desv.

### *Polypodium subviride* Lellinger, sp. nov.
Fig. 17

Plantae epiphyticae. Rhizoma late repens 2–3.5(4) mm diam., phyllopodiis 2–4 mm longis, irregulariter striatum atrum brunneum vel rufobrunneum paleaceum, paleis lanceolatis peltatis ca. 2 mm longis 0.5 mm latis, ad basin fuscatis clathratis, alibi hyalinis, deciduis (aliquot basibus circularibus exceptis) marginibus erosis. Stipites 2.5–8 cm distantes 2–14 cm longi 1–2 mm lati anguste alati brunneoli aut rufobrunneoli. Stipites rachides laminaeque pilosae, pilis 2 mm longis laxis multicellularibus hyalinis. Laminae oblongae vel raro anguste ellipticae (15)20–33(40) cm longae (3.5)4–5.5 cm latae papyraceae subviridae, ad basin obtusae vel truncatae, lobis abortivis infra basin, ad apicem acuminatae vel acutae, subpinnatisectae; segmentis oblongis saepe leviter falcatis, ad basin basiscopicis truncatis, ad basin acroscopicis surcurrentibus, ad apicem acutis vel rotundis, marginibus integris leviter revolutis; soris 0.75–1.25 mm diam. submedialibus 1-seriebus.

*Type.*—La Eneida region near Cerro Jefe, Pcia. Panama, *Kennedy 1117* (US; isotype DUKE).

*Paratypes.*—PANAMA: Pcia. Veraguas: 6–7 km W of Sta. Fé on road past agriculture school, 2900 ft, *Nee 9727* (US). Pcia. Coclé: 6 mi N of El Valle de Antón, 582 m, *Armond 343* (DUKE); La Mesa, 850–900 m, *Luteyn 4070* (DUKE), ca. 800 m, *Skog 4112* (US); Above Penonomé, *Williams 515* (NY, US). Pcia. Colón: Road from Portobello to María Chiquita, *Armond 490* (DUKE); Along Sta. Rita Ridge lumber road, *Correa & Dressler 751* (US); Near bridge over the Río Buenaventura, near Portobello, *Foster 1705* (DUKE). Pcia. Panama: Along road from Cerro Jefe to La Eneida, 1007 m, *Armond 325* (DUKE); Cerro Jefe, *Correa & Dressler 160* (US). COLOMBIA: Depto. El Valle: Río Cajambre, S. Isidro, 5–100 m, *Cuatrecasas 17346* (US). Depto. Nariño: Cordillera de Pasto, 1000-1300 m, *Lehmann 20* (US).

*Discussion.*—This rather common species (especially in central Panama) is a member of subg. *Goniophlebium.* Often it has been identified as *P. dasypleuron* Kunze, a species of South America that is less pilose on the lower surface and that lacks abortive segments on the stipe. It is related to *P. loriciforme* Rosenst. in the latter character, but that species has glabrous laminae.

### *Vittaria costaricensis* Lellinger, sp. nov.
Fig. 18

Plantae epiphyticae. Rhizoma repens ca. 1.5 cm diam. (paleis inclusis) dense paleaceum, paleis anguste lanceatis usque ad 10 mm longis 0.75 mm latis obscure rufobrunneis laxis tenuiter clathratis, ad apicem elongatum filiformibus, marginibus repandis vel distante et grosse dentatis. Stipites ca. 3 cm longi straminei canaliculati. Laminae lineares usque ad 60(75?) cm longae 4.5 mm latae subcoriaceae dilute virides, ad basin et apicem attenuatae, costis obscuris, sulcis fertilibus ca. 1 mm ex marginibus distantis, marginibus saepe subinvolutis stramineis; paraphysibus ca. 0.2 mm longis rufobrunneis multifurcatis, furcis subclavatis; sporis bilateralibus.

*Type.*—El Silencio near Tilarán, Pcia. Guanacaste, Costa Rica, ca. 750 m, *Standley & Valerio 44805* (US; isotype GH).

*Discussion.*—This species is known only from the type. It differs from *V. graminifolia* Kaulf. in having monolete spores and from *V. lineata* (L.) J. E. Smith, which has monolete spores, in having wider laminae and larger, less clathrate, and greatly toothed rhizome scales. The rhizome scales are very finely clathrate and have short cells only 2–3 times longer than wide, quite unlike most other New World *Vittaria* species.

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# A REVIEW OF *CUMMINGSIA* FERRIS (MALLOPHAGA: TRIMENOPONIDAE), WITH A DESCRIPTION OF TWO NEW SPECIES

Robert M. Timm and Roger D. Price

*Abstract.*—Descriptions and illustrations are given for the four previously recognized species of *Cummingsia*: *C. inopinata* Méndez, *C. intermedia* Werneck, *C. maculata* Ferris, and *C. peramydis* Ferris; and for two new species: *C. albujai* from *Caenolestes fuliginosus* (Tomes) and *C. perezi* from *Caenolestes convelatus* Anthony, both from Ecuador. A key is provided for the identification of these six species. *Acanthomenopon* Harrison is recognized as a subgenus to contain a single species, *C. peramydis*, parasitic on the marsupial genus *Monodelphis*. The subgenus *Cummingsia* contains the other five species which are parasitic on the marsupial genera *Caenolestes*, *Lestoros*, and *Marmosa*, and the rodent genus *Thomasomys*.

For nearly half a century, the mallophagan genus *Cummingsia* Ferris (Trimenoponidae) was known by only three sepcies distributed on South American marsupials: *C. intermedia* Werneck, 1937, from *Marmosa dryas* Thomas and *Marmosa incana* (Lund); *C. maculata* Ferris, 1922, from *Lestoros inca* (Thomas); and *C. peramydis* Ferris, 1922, from *Monodelphis brevicaudata* (Erxleben) and *Monodelphis domestica* (Wagner). In 1971 Méndez described a fourth species, *C. inopinata*, from a rodent, *Thomasomys cinereiventer* J. A. Allen.

We recently collected two new species of *Cummingsia* from two other South American marsupials, *Caenolestes convelatus* Anthony and *Caenolestes fuliginosus* (Tomes). The collections are of interest in that these two species of *Cummingsia* represent the first records of Mallophaga on hosts in the genus *Caenolestes*. Description of these two new species has prompted us to review the entire genus *Cummingsia* and to provide a key for the identification of all six species. The genus *Cummingsia* appears to be restricted to the New World marsupials and the rodent genus *Thomasomys*. We now recognize two subgenera, the nominate subgenus containing five species and *Acanthomenopon* Harrison containing a single species.

## Genus *Cummingsia* Ferris

*Cummingsia* Ferris, 25 Apr 1922:83.

*Type-species.*—*C. maculata* Ferris.

*Acanthomenopon* Harrison, 17 May 1922:156.

*Type-species.*—*A. horridum* Harrison.

*Remarks.*—Ferris (1922:83) characterized the genus *Cummingsia* as follows: "lateral margin of the head at the most but slightly notched; with two pairs of strong, flattened, backward-pointing spines on the ventral side of the head, these arising from just before the bases of the antennae; with the clypeal region not delimited dorsally by a transverse suture; with the antennal fossae not covered beneath by a flap; with the mesonotum quite distinct; without pulvilli on the first segment of the tarsi; with the genitalia of the males of a simple type."

To this characterization we would add the following: esophageal sclerites reduced; antenna 4-segmented, with pedunculate third segment and relatively small fourth segment bearing large sensillum and stout blunt seta and small setae (Fig. 2); each leg with 2 pairs of claws; with 5 pairs of abdominal spiracles, these distributed on III–VII; male genitalia of type in Fig. 3, parameres outwardly curved with short subapical seta (Fig. 4), medioposteriorly with broad bifurcate plate, and spinous sac with small sclerite of various shapes.

### Subgenus *Cummingsia* Ferris

*Remarks.*—The five species in this subgenus may be characterized by the following combination of features: head shaped much as in Fig. 1; temple with each side having 3 very long setae, placed submarginally (Figs. 1, 9, 12, 15, or 17); with shorter postmental setae (Fig. 1); gula with chaetotaxy of 1 very long + 4 much shorter setae on each side and without spinous sculpturing (Figs. 1 or 17); metanotal chaetotaxy as in Fig. 1, with 2 spiniform setae placed mediad to outer very long marginal seta; marginal tergal and sternal setae mostly subequal in length (Fig. 1); and female subgenital plate as in Figs. 8 or 14, with 4 short to minute medioposterior setae.

### *Cummingsia albujai*, new species

Figs. 1–8

*Type-host.*—*Caenolestes fuliginosus* (Tomes) [Marsupialia: Caenolestidae].

*Male.*—As in Fig. 1. Dorsal head chaetotaxy with seta mediad to large spiniform seta long, over twice length of spiniform; other setae with lengths as shown. Both ventral spinous processes on each side blunt, close together. With well-developed heavily pigmented carina across posterior head margin and lacking medioposterior protrusion such as in Fig. 17 or 21. Thoracic sternal plates as in Fig. 5; prosternal plate with 7 long, 7 short stout setae; mesosternal plate with 5 long, 5 (less often 4 or 6) short stout setae; metasternal plate with 15 (less often 16 or 17) short to long setae. Tergal setae: I, 6 (with outermost very short, innermost twice length of adjacent seta (Fig. 6)); II–VII, 6; VIII, 4 (less often 3); IX, 1 very long, 1 medium on each side. Sternal setae: I, 9–10; II, 20–22; III, 12–14; IV, 12–13; V, 10–12; VI, 7–9; VII, 6 (less often 5 or 7); those on I–II including shorter anterior setae. Subgenital plate (fused VIII–IX) with 10 setae, as in Fig. 7. Dimensions: preocular width (POW), 0.26–0.28; temple width (TW), 0.35–0.38; head length (HL), 0.23–0.25; prothorax width (PW), 0.32–0.35; metathorax width (MW), 0.37–0.40; abdomen width at segment V (AW), 0.54–0.59; total length (TL), 1.15–1.25. Genitalia as in Fig. 3, with genital plate broadly tapered, with sac sclerite thin, "U"-shaped, and with tip of paramere with subapical seta well removed from end (Fig. 4); genitalia width (GW), 0.08–0.10; genital plate width (GPW), 0.06–0.07; genital plate length (GPL), 0.05–0.06.

*Female.*—Much as for male, except as follows. Sternal setae: I, 9–11; II, 21–25; III, 13–15; IV, 12–14; V, 10–13; VI, 9–12; VII (fused with VIII), 8–12.

Subgenital plate (fused VIII–IX) with 12 (less often 11) setae, including 4 minute medioposterior setae associated with break in plate (Fig. 8). Anus circular, with 25–28 minute to medium setae (Fig. 8). Dimensions: HL, 0.23–0.26; PW, 0.35–0.36; MW, 0.43–0.45; AW, 0.68–0.73; TL, 1.21–1.40.

*Remarks.*—This is the only known species of *Cummingsia* for which both sexes have no abdominal tergites with more than six setae; this separation is further supported by differences in dimensions, dorsal head chaetotaxy, details of male genitalic structure, and sternal chaetotaxy.

*Etymology.*—This new species is named in honor of Dr. Luis Albuja V. of the Escuela Politécnica Nacional, Quito, in recognition for his studies on Ecuadorian mammals, and for generous assistance with this project.

*Holotype.*—Adult ♂, ex *Caenolestes fuliginosus,* Ecuador, Napo Province, 6.9 km W of Papallacta, 24 Jun 1978, collected by R. S. Voss (UMMZ 127107); in collection of University of Michigan.

*Paratypes.*—Ex *C. fuliginosus*: 5 ♂♂, same as holotype; 2 ♂♂, 2 ♀♀, Ecuador, Napo Province, vic. Papallacta, 4 May 1980, R. S. Voss #739 (UMMZ 155578); 3 ♂♂, 3 ♀♀, same except 6 May 1980, #749 (UMMZ 155693); 1 ♂, same except 23 Mar 1980, #630; 1 ♀, same except 7 May 1980, #763 (UMMZ 155580); 1 ♀, Pichincha Province, Volcan Pichincha, 10 Apr 1939, C. Ollalla (FMNH 53296). Paratypes will be distributed among the University of Michigan, University of Minnesota, Oklahoma State University, U.S. National Museum of Natural History, and Field Museum of Natural History.

## *Cummingsia maculata* Ferris
Figs. 9–11

*Cummingsia maculata* Ferris, 1922:83.

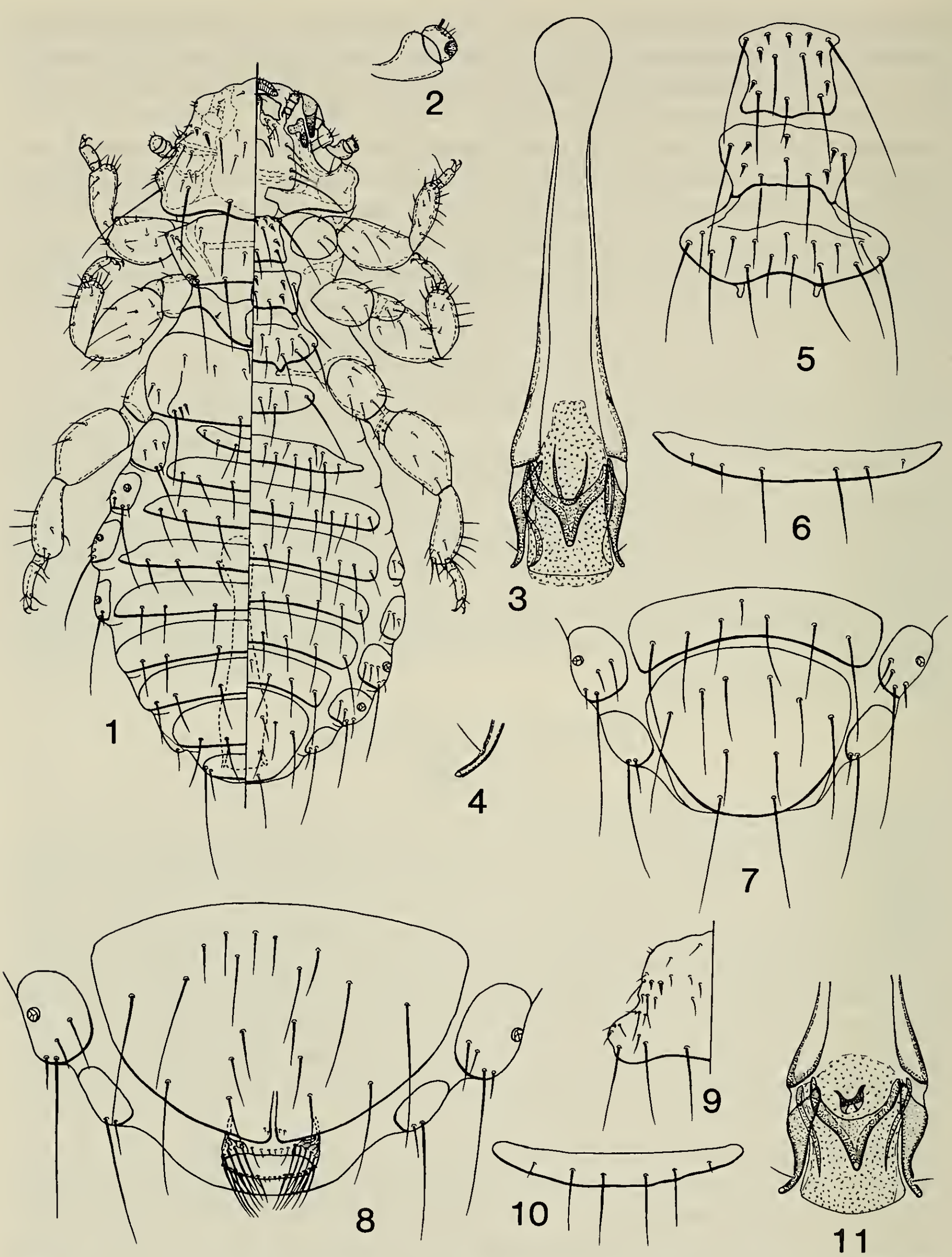
*Type-host.*—*Caenolestes* sp. = *Lestoros inca* (Thomas) [Marsupialia: Caenolestidae].

*Male.*—Close to *C. albujai,* differing as follows. Head with seta mediad to large spiniform seta short, of approximately same length; with 2 series of short + long + short setae posterior to spiniforms (Fig. 9). Tergite I with medial 4 setae subequal in length (Fig. 10). More tergal setae: III, 7–8; IV–VI, 8; VII, 7–8; VIII, 6. Sternal setae: II, 21–26; III, 14–16; IV, 12–14. Dimensions: HL, 0.22–0.24; PW, 0.29–0.30; AW, 0.50–0.56; TL, 1.05–1.16. Genitalia (Fig. 11) with small "butterfly"-shaped sclerite associated with genital sac.

*Female.*—Also close to *C. albujai,* differing in having chaetotaxy of head and tergite I same as for male. Metasternal plate with 18 setae. Tergal setae: III, 8; IV, 9; V, 10; VI, 9. Sternal setae: I, 12; II, 31; III, 20; IV, 17. Anus with 24 setae.

*Remarks.*—This species differs from the preceding species by consistently having tergites III–VII with more than six setae, by the lengths of certain setae on the dorsal head and tergite I, by the male with a differently-shaped genital sac sclerite, and by the female with more sternal setae on I–IV.

Ferris (1922:83) reported the type-host and type-locality for *Cummingsia maculata* as "*Caenolestes* sp., Cedrobamba Ruins, Peru," and mentioned that the specimens are from a skin in the United States National Museum. Emerson and Price (1981) subsequently listed *Lestoros inca* as the type-host for *C. maculata.*



Figs. 1–11. 1–8. *Cummingsia albujai*: 1, Dorsal-ventral male; 2, Male terminal antennal segments; 3, Male genitalia; 4, Tip of male genitalic paramere; 5, Male thoracic sternal plates; 6, Male abdominal tergite I; 7, Ventral male terminalia; 8, Ventral female terminalia. 9–11. *C. maculata*: 9, Dorsal male head; 10, Male abdominal tergite I; 11, Apical portion of male genitalia.

As *Caenolestes fuliginosus* recently has been reported in northern Peru (Barkley and Whitaker 1984), we thought it advisable to double-check the identity of the host. The mammal collection of the U.S. National Museum does contain a series of 17 specimens of *Lestoros inca* collected by Heller in May and June of 1915. The locality data for the series are listed on the skin tags as follows: Peru: Machu Picchu, Cedrobamba, Timber Line, 12,000 ft. On the back of the tag on two of these (USNM 194403 and 194427) it reads Cedrobamba Ruins rather than just Cedrobamba. Hence, it is likely that one of these two specimens represents the host animal from which Ferris obtained his series of one female and four males of *Cummingsia* that he described as *C. maculata. Lestoros inca* is the only caenolestid known from southern Peru and there is little doubt about the fact that it is the type-host for *C. maculata.*

*Material examined.*—Holotype ♀, allotype ♂, 3 ♂♂ paratypes of *C. maculata,* ex *Lestoros inca,* Peru, Cedrobamba Ruins.

### *Cummingsia perezi,* new species
Figs. 12–14

*Type-host.—Caenolestes convelatus* Anthony [Marsupialia: Caenolestidae].

*Male.*—Close to *C. albujai,* but differing as follows. Dorsal head setae generally longer (Fig. 12). Metasternal plate with 16 setae. More tergal setae: II–IV, 8; V–VI, 9; VII, 8; VIII, 6. Lengths of setae on tergite I near to those of *C. maculata* (Fig. 10). More sternal setae: I, 15; II, 27; III, 22; IV, 20; V, 19; VI, 15; VII, 11. Subgenital plate with 11 setae. Much larger dimensions: POW, 0.31; TW, 0.40; PW, 0.39; MW, 0.44; AW, 0.69; TL, 1.29. Genitalia (Fig. 13) with broader terminal portion of genital plate and with different shape of sac sclerite; GW, 0.10.

*Female.*—Much as for male, except as follows. Metasternal plate with 17 setae. Tergal setae: I, 7; II, 11; IV, 9; VI–VII, 10. Sternal setae: I, 13; II, 31; III, 24; IV, 21; V, 18; VI, 16; VII, 13. Subgenital plate not medially divided, with longer medioposterior 4 setae and with 2 long lateroposterior setae on each side (Fig. 14). Anus with 30 setae, medial ones in both ventral and dorsal rows longer than for other species (Fig. 14). Also with large dimensions: POW, 0.32; TW, 0.42; PW, 0.42; MW, 0.50; AW, 0.84; TL, 1.50.

*Remarks.*—The combination of very large dimensions, large number of tergal and sternal setae, and details of dorsal head chaetotaxy for both sexes, the structure and chaetotaxy of the female ventral terminalia (it is the only *Cummingsia* with two long lateroposterior setae on each side of subgenital plate instead of only one), and the details of the male genitalia separate this species from all others of the genus.

It is interesting that the two adults representing the type-series of this new species occurred on the same individual host also yielding three adults of another *Cummingsia* species; of five fairly advanced nymphs found on the same host, two were consistent with this new species in size and chaetotaxy, three with the other species.

*Etymology.*—This new species is named in honor of Sr. Carlos Perez Q., owner of Hacienda La Vega, for graciously allowing us to work on his property where the new species of *Cummingsia* was obtained.

*Holotype.*—Adult ♀, ex *Caenolestes convelatus,* Ecuador, Imbabura Province, Hacienda La Vega, 5 km ESE of San Pablo del Lago, elevation ca. 2600 m, 11 Sep 1983, collected by R. M. Timm (FMNH 124620); in collection of Field Museum of Natural History.

*Paratype.*—1 ♂, same as for holotype.

### *Cummingsia inopinata* Méndez
Figs. 15–16

*Cummingsia inopinata* Méndez, 1971:23.

*Type-host.*—*Thomasomys cinereiventer* J. A. Allen [Rodentia: Cricetidae].

*Male.*—Close to *C. albujai* (Fig. 1), but differing as follows. Unique dorsal head chaetotaxy (Fig. 15), without any mediolateral heavy spiniform setae. Prosternal plate with 7 long, 5 (less often 6) short setae. Tergite I with lengths of setae intermediate between those in Figs. 6 and 10. Tergal setae: II, 4 (less often 5); IV, 8–10; V–VII, 10; VIII, 8; larger number of setae due to 1–2 shorter setae at end of each row (Fig. 16). Sternal setae: III–V, 14–16; VI, 10–13; VII, 6–8; larger number of setae as for tergites (Fig. 16). Dimensions (generally wider head and longer, slender body): POW, 0.30–0.31; TW, 0.39–0.40; PW, 0.34–0.36; MW, 0.39–0.42; AW, 0.46–0.51; TL, 1.27–1.38. Genitalia close to Fig. 3, but sac sclerite smaller and variably "U"- to "V"-shaped.

*Female.*—Essentially as for *C. albujai,* except for differences noted for male above and as follows. Sternal setae: III-IV, 14–17; V, 12–15. Dimensions: POW, 0.31–0.33; TW, 0.40–0.44; HL, 0.24–0.26; PW, 0.35–0.42; MW, 0.41–0.46; AW, 0.54–0.57; TL, 1.39–1.59.

*Remarks.*—This species can be separated from all others by the unique dorsal head chaetotaxy, the small number of short prosternal setae, and the large number of tergal and sternal setae due to additional shorter lateral setae in each row.

*Cummingsia inopinata,* the louse parasitizing *Thomasomys,* is a "marsupial" louse phylogenetically. The original description by Méndez (1971) of the new *Cummingsia* from a rodent host, *T. cinereiventer,* left some suspicion as to the possibility of contamination having occurred, and that the true host of *C. inopinata* might actually be a marsupial. Subsequently, we have obtained additional specimens of *Cummingsia* from two specimens of *Thomasomys erro* Anthony in Ecuador and two of *T. laniger* (Thomas) in Colombia. Thus, there is little doubt about the fact that rodents of the genus *Thomasomys* are parasitized by *Cummingsia.* As most Mallophaga found on small mammals are extremely host specific, we made a detailed examination of our specimens from *Thomasomys,* and were able to detect no significant variation in external morphology or in genitalia among the populations of *Cummingsia* found on the three distinct species of *Thomasomys* over a considerable geographic area. Our conclusion is that, at this time, there is no justification for recognizing more than the single species, *C. inopinata,* parasitizing *Thomasomys.*

How and when could a "marsupial" louse have transferred to a rodent host? Méndez (1971) had a series of five males and 18 females from a single *T. cinereiventer* at the type-locality, and a single female from a second *T. cinereiventer* from another locality in Colombia. He suggested that "*T. cinereiventer* may have acquired the original stock from which the new species of *Cummingsia* . . . was derived, many years ago from opossum nests" (Méndez 1971:27). *Thomasomys* is part of the "complex penis" group of South American cricetines (subfamily: Sigmodontinae) that originated from North American stock, migrating to South America prior to the connection of the two continents by the Panamanian land bridge in the early Pleistocene. The ancestoral cricetine may have arrived in South America by the early Pliocene. *Thomasomys* has undergone a tremendous radiation in South America, with some 25 extant species now recognized. With three different species of *Thomasomys,* each being parasitized by the same species of *Cummingsia,* we suggest that an ancestral population of *Thomasomys* acquired *Cummingsia* from a marsupial host prior to the later major radiation in *Thomasomys.* This may have occurred in the Pliocene. *Cummingsia* has undergone little differentiation, even though considerable time has elapsed and speciation within *Thomasomys* has occurred. It will be most interesting to see if additional species of *Thomasomys* are found to harbor *Cummingsia,* and, if so, whether any differentiation has occurred.

*Material examined.*—1 ♂, 1 ♀ paratypes of *C. inopinata,* ex *Thomasomys cinereiventer,* Colombia, Depto. de Nariño, Laguna de la Cocha, elevation 2700 m. 3 ♂♂, 3 ♀♀, ex *Thomasomys laniger,* Colombia, Antioquia, Paramo. 2 ♂♂, 3 ♀♀, ex *Thomasomys erro,* Ecuador, Napo Province, Papallacta.

### *Cummingsia intermedia* Werneck
Figs. 17–20

*Cummingsia intermedia* Werneck, 1937:70.

*Type-host.*—*Marmosa incana paulensis* Tate [Marsupialia: Didelphidae].

*Male.*—Differing from *C. albujai* as follows. Dorsal head chaetotaxy with only minute setae or alveoli medially; mediolateral setae close to *C. maculata* (Fig. 17). Slender pointed inner head spinous process well separated from outer (Fig. 17). With reduced carina across posterior head margin and with medioposterior protrusion (Fig. 17). Prosternal plate with 11 short stout setae; mesosternal plate with 9 such setae; metasternal plate with total of 22 setae. Tergal setae: II, 7; III–IV, 8; V–VI, 9; VII, 8. Sternal setae: I, 18; II, 34; III, 26; IV, 25; V, 21; VI, 20; VII, 11; included in these 12, 9, 7, 6, and 1 short anterior setae on III–VII, respectively. Dimensions: POW, 0.29; HL, 0.26; MW, 0.43; AW, 0.61; TL, 1.35. Genital plate shaped as in Fig. 19, much like that of foregoing species; genital sac sclerite semicircular (Fig. 18); tip of paramere (Fig. 20) with seta near end in close proximity to dark button-like projection; GW, 0.11.

*Female.*—Much as for male, except as follows. Prosternal plate with 10 short stout setae; metasternal plate with 21 setae. Tergal setae: II, 6; IV, 9; V, 8; VII, 9; VIII, 5. Sternal setae: I, 15; II, 36; III, 23; IV, 22; V, 20; VI, 16; VII, 10; included in these 8, 8, 6, 4, and 2 short anterior setae on III–VII, respectively. Anus with 30 setae; ventral terminalia essentially as in Fig. 8. Dimensions: POW, 0.31; TW, 0.39; HL, 0.26; PW, 0.36; MW, 0.44; AW, 0.69; TL, 1.50.

*Remarks.*—This species differs from all of the preceding species by its medial dorsal head chaetotaxy, the shape and proximity of the ventral spinous head processes, the large number of short stout spiniform setae on the prosternal and mesosternal plates, the shape of the male genital sac sclerite and the details of the tip of the paramere, and the large number of abdominal setae.

In the absence of specimens from the type-host, *M. incana,* we tentatively assign our material from *M. dryas* Thomas to *C. intermedia* in accordance with Emerson and Price (1975). There are slight discrepancies between the illustrations provided by Werneck (1937) and the material from *M. dryas* that we have before us. As Werneck's illustrations and descriptions are of insufficient quality to evaluate these discrepancies, we chose not to treat them at this time, hoping additional material will be available in the future.

Illustrations of the adult male and female and details of the genitalia of *C. intermedia* from *M. dryas* may be found in Emerson and Price (1975:figs. 19–22).

*Material examined.*—1 ♂, 1 ♀, ex *Marmosa dryas,* Venezuela, Merida, Tabay.

### Subgenus *Acanthomenopon* Harrison

*Acanthomenopon* Harrison, 1922:156.

*Type-species.—A. horridum* Harrison.

*Remarks.*—In his description of the genus *Cummingsia,* Ferris (1922:83) stated "It is with some hesitation that I refer the two species above named to the same genus, for in the structure of the head there is a rather notable difference. I would especially call attention to the apparent absence of the maxillary lobes in *C. peramydis.* However, they are not so different that their association in the same genus is entirely incongruous and in some respects they are very similar."

We concur with the belief of Ferris that *C. peramydis* presents an array of differences from the other species of *Cummingsia,* but, rather than place it in a genus of its own, we prefer to place it in a subgenus of *Cummingsia.* The following features characterize the subgenus *Acanthomenopon*: head shaped much as in Fig. 21; temple with each side having 3 very long, 1 long, and 1 minute setae placed at margin (Fig. 21); postmentum with 1 long seta (Fig. 21); gula with chaetotaxy of 2 very long + 3 much shorter setae on each side and with spinous sculpturing on posterior portion (Fig. 21); metanotal chaetotaxy as in Fig. 22, with 3 very long marginal setae on each side and shorter setae placed as shown; marginal tergal and sternal setae with short among long (Fig. 23); and female subgenital plate as in Fig. 23, with 4 prominent medioposterior setae.

### *Cummingsia peramydis* Ferris
Figs. 21–24

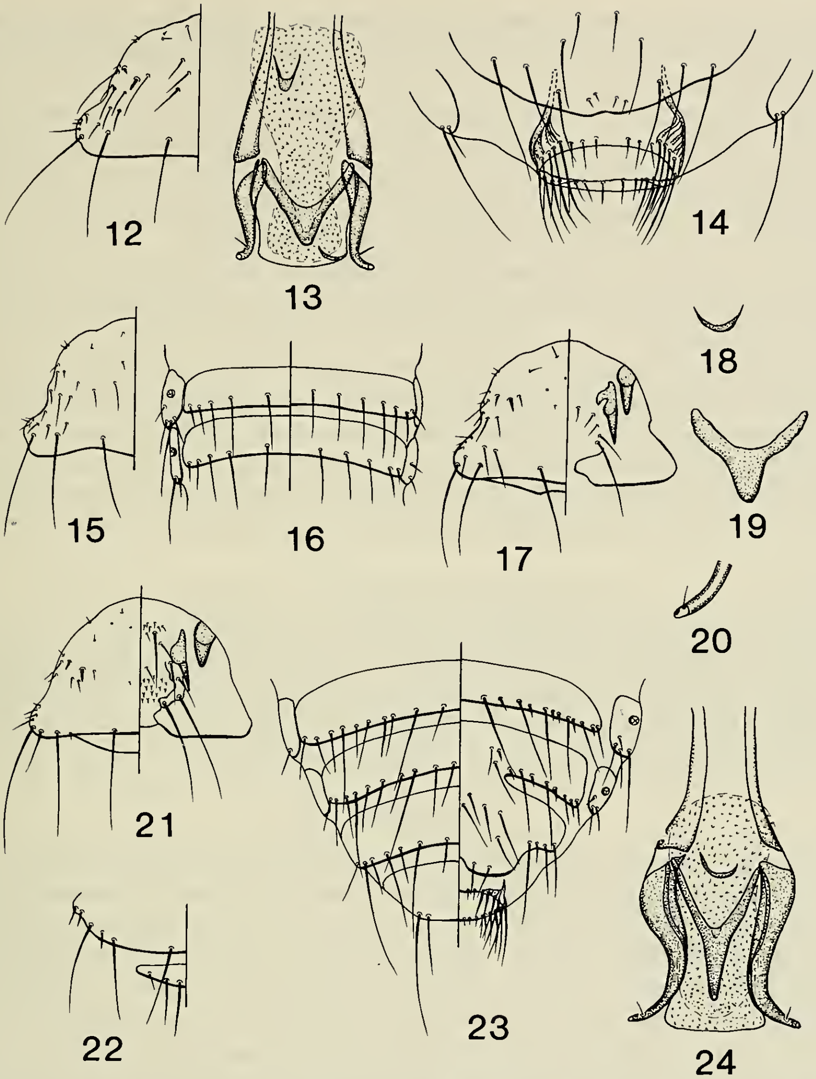
*Cummingsia peramydis* Ferris, 1922:85.

*Type-host.—Peramys domesticus = Monodelphis domestica* (Wagner) [Marsupialia: Didelphidae].

*Acanthomenopon horridum* Harrison, 1922:156.

*Type-host.—Peramys domesticus = Monodelphis domestica* (Wagner).

*Male.*—Grossly as in Fig. 1. Dorsal head chaetotaxy as in Fig. 21, with at most only minute seta medioanteriorly. Ventral spinous head processes (Fig. 21) much as for *C. intermedia.* With reduced carina across posterior head margin and with



Figs. 12–24. 12–14. *Cummingsia perezi*: 12, Dorsal male head; 13, Apical portion of male genitalia; 14, Ventral female terminalia. 15–16. *C. inopinata*: 15, Dorsal male head; 16, Dorsal-ventral male abdominal segments V–VI. 17–20. *C. intermedia*: 17, Dorsal-ventral male head; 18, Male genital sac sclerite; 19, Male genital plate; 20, Tip of male genitalic paramere. 21–24. *C. peramydis*: 21, Dorsal-ventral male head; 22, Dorsal male metathorax margin and abdominal tergite I; 23, Dorsal-ventral female terminalia; 24, Apical portion of male genitalia.

medioposterior protrusion (Fig. 21). Prosternal plate with 5–6 long, 11–13 short stout setae; mesosternal plate with 4 long, 12–15 short stout setae; metasternal plate with 18–21 setae. Tergal setae: I, 5–6; II, 10–12; III, 13–16; IV, 15–18; V, 16–19; VI, 15–19; VII, 14–18; VIII, 12–17; IX, 8. Sternal setae: I, 11–12; II, 24–29; III, 21–22; IV–V, 22–25; VI, 21–22; VII, 15–19. Subgenital plate with 13–14 setae. Dimensions: POW, 0.29–0.32; TW, 0.35–0.40; HL, 0.23–0.26; PW, 0.31–0.38; MW, 0.34–0.43; AW, 0.51–0.56; TL, 1.18–1.39. Genitalia as in Fig. 24, with semicircular sac sclerite much as for *C. intermedia,* greatly elongated genital plate, and pronouncedly outwardly curved paramere tips; GW, 0.09–0.10; GPW, 0.06–0.07; GPL, 0.10.

*Female.*—Much as for male, differing as follows. Prosternal plate with 12–15 short stout setae. Tergal setae: I, 6–7; II, 12–13; IV–VII, 17–20; IX, 4. Sternal setae: II, 27–32; III, 22–23; IV–VI, 22–26; VII, 17–21. Subgenital plate with 20–22 setae (Fig. 23). Anus with 30–33 setae. Dimensions: POW, 0.31–0.33; TW, 0.38–0.43; PW, 0.35–0.40; AW, 0.64–0.66 TL, 1.46–1.60.

*Remarks.*—As the sole member of the subgenus *Acanthomenopon, C. peramydis* is easily separated from the other five species of *Cummingsia* on the basis of the subgeneric characters.

Ferris (1922:85) listed the type-host and type-locality of *C. peramydis* as "*Peramys domesticus,* Quixada, Brazil, from skins in the Field Columbian Museum." The mammal collections of the Field Museum of Natural History contain a series of nine *Monodelphis domestica* from: Brazil, Ceará Province, Quixada, collected between 18 and 29 June 1913 by R. H. Becker (FMNH 20245–20251, 20254–20255). We were able to obtain five additional specimens of *C. peramydis* from these skins.

Illustrations of the adult male and female of *C. peramydis* and details of the genitalia were provided by Emerson and Price (1975:figs. 15–18).

*Material examined.*—5 ♂♂, ex *Monodelphis domestica,* Brazil, Ceará, Quixada. 3 ♂♂, 2 ♀♀, ex *M. brevicaudata* (Erxleben), Venezuela, Trujillo, Valera (Isnotu), and Falcón, 5 km N, 13 km E of Mirimire near La Pastora. 1 ♂, 2 ♀♀, ex *M. brevicaudata touan* (Shaw) Brazil, Amapá, Serro do Navio.

## Discussion

The genus *Caenolestes* as now defined contains five parapatric species: *C. caniventer* Anthony known from southwestern Ecuador, *C. convelatus* Anthony known from north-central Ecuador, *C. fuliginosus* known from north-central Ecuador and extreme northern Peru, *C. obscurus* Thomas, known from northern and western Colombia and extreme western Venezuela, and *C. tatei* Anthony known from south-central Ecuador. All five species are distributed throughout the Andean mountains from northern and western Colombia and extreme western Venezuela south through Ecuador. The populations of *Caenolestes* now recognized as species probably represent only two or three valid species (Kirsch 1977). Three of the currently named taxa are known only from or very near the type-localities. *Lestoros* and *Rhyncholestes* are both monotypic. Simpson (1970) also suggested that the three genera of the family Caenolestidae, *Caenolestes, Lestoros,* and *Rhyncholestes,* would perhaps best be regarded as three species of a single genus. Marshall (1980), in a review of both the fossil and Recent forms of the family, considered the genera *Caenolestes* and *Lestoros* as marginally separable. This close relationship between *Caenolestes* and *Lestoros* is strongly supported by Hayman et al. (1971) who reported that the karyotypes of *Caenolestes obscurus* and *Lestoros inca* are nearly identical. The genus *Marmosa* contains some 44 species distributed throughout much of Central and South America. Mallophaga have been collected on only two of those species, *M. dryas* which is found in western Venezuela and *M. incana* which is found in eastern Brazil. The genus *Monodelphis* contains some 17 species distributed throughout much of South America. Again, Mallophaga have been collected on only two species, *M. brevicaudata* which is found in Venezuela, the Guianas, Brazil, Paraguay, and northern Argentina, and *M. domestica* which is found in eastern and central Brazil, Bolivia, and Paraguay. In a cladistic analysis of the carnivorous marsupials, Kirsch and Archer (1982:616) suggested that *Marmosa* and *Monodelphis* (along with *Lestodelphys*) formed a monophyletic unit and that the specialized caenolestids were derived from "forms like *Monodelphis brevicaudata*."

Herein, we recognize six species of *Cummingsia* from seven species of South American caenolestid and didelphoid marsupials and from three species of the rodent genus *Thomasomys*. Except for the caenolestids, all of the mammalian genera involved as hosts for *Cummingsia* are widespread in South America and all are in need of revision. However, combined they provisionally contain over 80 species and we have lice from only nine of these. Thus, we suspect that numerous new species of *Cummingsia* have yet to be collected, and much remains to be learned about the systematics and host relationships in this genus.

### Key to the Species of *Cummingisa*

1\. Marginal setae of abdominal tergites and sternites III–VII with obviously shorter among longer setae (Fig. 23); gula with 2 very long setae on each side (Fig. 21) ....... Subgenus *Acanthomenopon* ....... *peramydis* Ferris

– Marginal setae of abdominal tergites and sternites III–VII essentially of subequal lengths, except for occasional 1–2 setae at end of row (Fig. 1 or 16); gula with only 1 very long seta on each side (Fig. 1 or 17) ........ ...................... Subgenus *Cummingsia* ...................... 2

2\. Abdominal tergites II–VII each with only 6 setae (Fig. 1) ..... *albujai* n. sp.

— At least several of abdominal tergites II–VII with more than 6 setae ... 3

3\. Median dorsal head with only minute setae or alveoli (Fig. 17); prosternal plate with at least 10 short stout setae; male genitalia with paramere tip as in Fig. 20 and sac sclerite as in Fig. 18 ............ *intermedia* Werneck

– Median dorsal head with short to medium setae (Figs. 9, 12, or 15); prosternal plate with only up to 7 short stout setae; male genitalia with paramere tip near to Fig. 4 and sac sclerite nearer to Fig. 11 or 13 ..... 4

4\. Laterodorsal head without stout spiniform setae (Fig. 15); prosternal plate with only 4–6 short stout setae ...................... *inopinata* Méndez

– Laterodorsal head with stout spiniform setae (Fig. 9 or 12); prosternal plate with 7 short stout setae ...................................... 5

5\. Head with long seta immediately mediad to inner dorsal spiniform seta (Fig. 12); posterior portion of female subgenital plate as in Fig. 14, with pair of very long lateroposterior setae on each side and lacking medioposterior division; male genital sac sclerite as in Fig. 13 ....... *perezi* n. sp.

– Head with short seta immediately mediad to inner dorsal spiniform seta (Fig. 9); posterior portion of female subgenital plate as in Fig. 8, with only single very long lateroposterior seta on each side and with medioposterior division; male genital sac sclerite as in Fig. 11 ........... *maculata* Ferris

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# *CRYSTALLODYTES PAUCIRADIATUS* (PERCIFORMES), A NEW CREEDIID FISH SPECIES FROM EASTER ISLAND

Joseph S. Nelson and John E. Randall

*Abstract.*—A new species of creediid fish, *Crystallodytes pauciradiatus,* is described from Easter Island. It is distinguished from *C. cookei,* the other member of the family with scales only along the lateral line, in having only 30–32 dorsal-fin rays and 48–52 lateral-line scales. The new species represents an eastern extension in the range of the family. *Crystallodytes cookei,* previously reported from Hawaii and Enderbury and Tau islands, is reported here also from the Pitcairn Group (Pitcairn, Henderson, and Ducie islands), Swains Island in northern American Samoa, and perhaps Tahiti. The creediid *Chalixodytes tauensis* is recorded from Pitcairn and Mangareva. A key to the species of the family is presented.

Some 14 species are recognized in the Indo-West Pacific family Creediidae (Nelson 1983). One of the seven genera, *Crystallodytes,* is currently considered to be monotypic, although the nominal species is recognized with two subspecies, *C. cookei cookei* Fowler from Hawaii, and *C. cookei enderburyensis* Schultz from Enderbury Island (Phoenix Islands) and Tau Island (American Samoa) in the South Pacific. *Crystallodytes cookei* is distinguished from all other creediids in having scales only along the lateral line. Relatively little is known of the biology of *Crystallodytes*; Leis (1982) described its spawning time, eggs, larvae, and occurrence in the plankton. We describe here a second species of *Crystallodytes,* from Easter Island, distinguished from the other species primarily in having fewer meristic parts.

Measurements were made to the nearest 0.1 mm with needle-point dial calipers and are expressed as thousandths (0/00) of standard length (SL). The pectoral ray count excludes the short dorsal splint. Vertebral counts were made from radiographs. Material of the new species is deposited in the following museums: AMNH, American Museum of Natural History, New York; AMS, Australian Museum, Sydney; BPBM, Bernice P. Bishop Museum, Honolulu; CAS, California Academy of Sciences, San Francisco; USNM, National Museum of Natural History, Smithsonian Institution, Washington, D.C. Material utilized of *C. cookei* is from BPBM. Collections of *Crystallodytes pauciradiatus* and *C. cookei enderburyensis* consist primarily, if not exclusively, of females.

## *Crystallodytes pauciradiatus,* new species
Figs. 1–2

*Holotype.*—BPBM 6734, female, 31.3 mm SL, Easter Island, off Ahu Akapu, depth 10.7 m, sand, 7 Feb 1969.

*Paratypes* (all females unless otherwise noted).—AMNH 49554, 2 specimens, 34.1 and 30.4 mm SL, taken with BPBM 6733. AMS I.24606-001, 2 specimens,

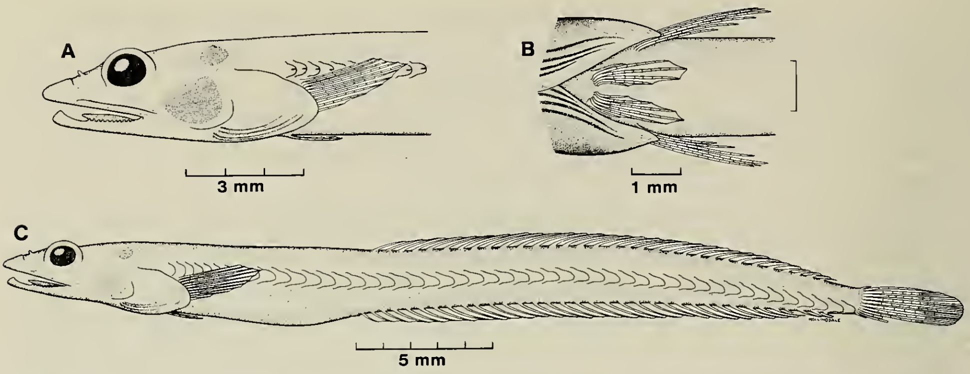

Fig. 1. *Crystallodytes pauciradiatus,* holotype BPBM 6734, 31.3 mm SL. A, Lateral view of head region; B, Ventral view of pelvic fin region; C, Lateral view.

30.4 and 30.2 mm SL, taken with BPBM 6733. BPBM 6733, 3 specimens, 32.5, 32.3, and 31.7 mm SL (disarticulated while clearing and staining following taking of measurements and counts), Easter Island, west coast off south end of Hanga Roa, depth 12.2 m, sand near rocks, 10 Feb 1969. BPBM 29656, 28.7 mm SL, taken with the holotype. CAS 54946, 2 specimens, 27.5 and 27.3 mm SL, taken with BPBM 6733. USNM 266462, 5 specimens (3 of uncertain sex), Easter Island, Mataveri 0 Tai, depth 6.1 m, black and white sand, 2 Feb 1969.

*Non-type material.*—The following material was too small to obtain comparable measurements and counts. BPBM 6735, 2 specimens, taken with USNM 266462. BPBM 29657, 6 specimens, taken with BPBM 6733. BPBM 29658, 2 specimens, disarticulated while clearing and staining, taken with BPBM 6733.

All specimens were collected with rotenone by one of us (JER), accompanied by G. R. Allen or G. R. Allen and B. A. Baker.

*Diagnosis.*—A creediid with scales only along the lateral line and having 30–32 dorsal-fin rays, 48–52 lateral-line scales, and 50–53 vertebrae. The only other species with scales confined to the lateral line is the congeneric *Crystallodytes cookei,* which has a larger number of meristic parts (see key). The only other creediids with a comparable number of dorsal-fin rays are *Limnichthys polyactis* and *L. rendahli* of New Zealand, and the only species with a comparable number of lateral-line scales and vertebrae is *Tewara cranwellae,* also of New Zealand.

*Description.*—Morphometric and meristic data are given in Tables 1–4. Snout relatively elongate, sloping gradually in dorsal profile. Upper jaw with fleshy extension, projecting beyond lower jaw; maxilla extending posteriorly to behind eye; posterior tip of maxilla rounded. Bony dorsal projection on symphysis of lower jaw. Lower jaw bordered by 1 row of short cirri, about 10–18 per side in specimens 27–34 mm in length. Eyes dorsolateral; total interorbital width about 16–22% SL, bony width much less. Ventral opercular flap overlapping branchiostegal membrane and extending far forward; posterior portion of gill cover overlapping base of pectoral fin. Branchiostegal rays 7. Subopercle heavily splintered, interopercle moderately splintered. Scales present only along lateral line. Lateral line arising at upper edge of gill cover, running above pectoral fin, descending gradually and reaching ventral profile only posteriorly; scales behind pectoral fin

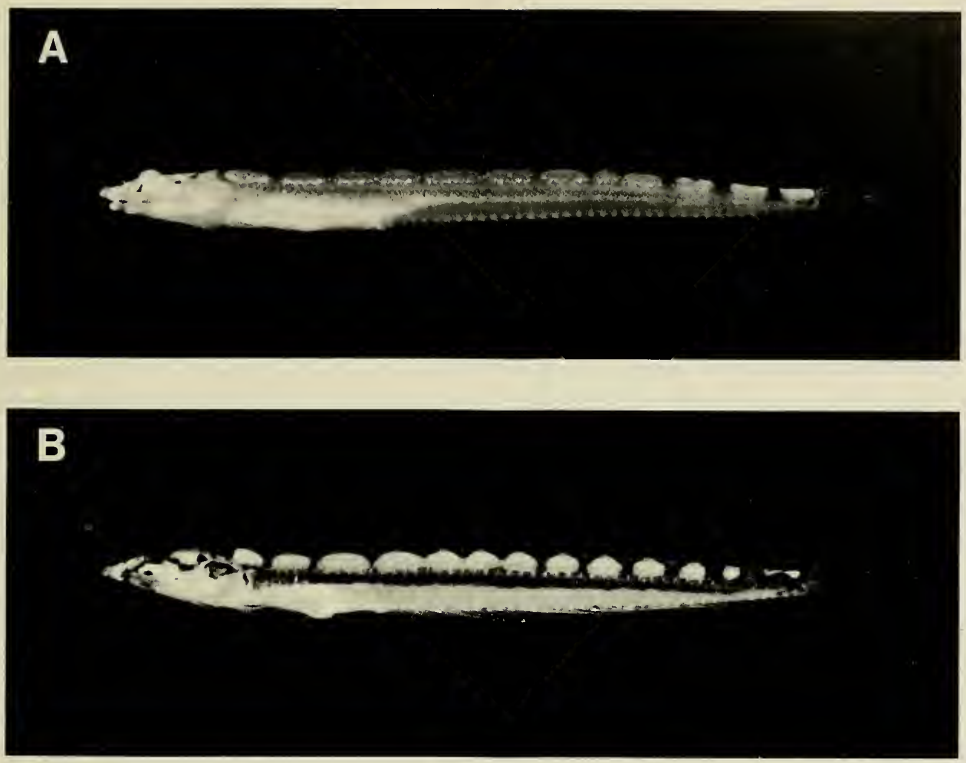

Fig. 2. *Crystallodytes pauciradiatus,* showing pigmentation pattern in fresh specimens. A, Holotype, BPBM 6734; B, Paratype (30 mm SL when fresh), USNM 266462.

elongate, with rounded posterior margin, not trilobate. Base of pelvic fins slightly anterior to base of pectoral fins; inter-pelvic distance small, less than length of base of pelvic fin; pelvic fins each with 1 spine and 5 soft rays. Dorsal, anal, pectoral, and pelvic rays unbranched. Branched caudal rays 8, countable in only one specimen. Teeth along upper and lower jaws ending well before anterior tip; small isolated patch of vomerine teeth on each side. Iliac spurs (Nelson 1979) elongate and curved and with short posteriorly-directed processes at midline. Last haemal and neural spines relatively narrow.

The color pattern is not apparent in the preserved material. However, in a color transparency and a black and white photograph of the holotype taken at capture by one of us (JER) the body is whitish with 12 short dorsal saddles (described in field notes as consisting of yellow spots edged in dark red-orange) with a faint trace of a lateral band. In a black and white photograph of a 30 mm specimen of USNM 266462, originally part of BPBM 6735, there are 13 dorsal saddles (each with a central light area) with some extending ventrally to join the conspicuous lateral band. Color notes of fresh material of BPBM 6733 describe the yellowish spots in the dorsal saddles as being edged with dull orange to dark brown.

*Etymology.*—The specific name *pauciradiatus* (Latin) is for the low number of dorsal, anal, and pectoral rays relative to *Crystallodytes cookei.*

*Discussion.*—The new Easter Island form is more similar to *Crystallodytes*

Table 1.—Proportional measurements of the species and subspecies of *Crystallodytes* in thousandths of standard length.

| | *C. pauciradiatus* | | | *C. cookei cookei* | | *C. c. enderburyensis* | |
|---|---|---|---|---|---|---|---|
| Character | Holotype | Paratypes n = 15 range | All $\bar{x} \pm SD$ | n = 4 range | $\bar{x} \pm SD$ | n = 17 range | $\bar{x} \pm SD$ |
| Standard length (mm) | 31.3 | 26.3–34.1 | 30.1 ± 2.2 | 34.3–41.8 | 38.3 ± 3.3 | 34.2–43.2 | 39.1 ± 3.9 |
| Body depth | 73 | 65–84 | 72.8 ± 4.7 | 65–78 | 73.5 ± 5.9 | 65–88 | 77.2 ± 5.8 |
| Predorsal length | 430 | 427–455 | 443 ± 12.6 | 350–377 | 368 ± 12.4 | 325–379 | 357 ± 14.7 |
| Preanal length | 422 | 401–434 | 416 ± 10.2 | 368–371 | 370 ± 1.3 | 354–413 | 379 ± 15.2 |
| Pectoral fin length | 75 | 75–99 | 86.6 ± 7.5 | 92–99 | 95.0 ± 3.2 | 93–111 | 102 ± 4.1 |
| Head length | 217 | 205–233 | 217 ± 7.9 | 190–197 | 193 ± 3.0 | 192–222 | 202 ± 7.7 |
| Head width | 73 | 61–77 | 69.0 ± 4.2 | 66–71 | 68.3 ± 2.6 | 61–82 | 72.3 ± 5.8 |
| Snout length | 50 | 43–52 | 48.4 ± 2.6 | 36–45 | 40.5 ± 3.9 | 43–53 | 47.9 ± 3.1 |
| Length of orbit | 42 | 36–48 | 40.0 ± 2.8 | 32–36 | 34.7 ± 1.9 | 36–43 | 38.6 ± 2.2 |

Table 2.—Frequency distribution of number of pectoral-fin rays in the species and subspecies of *Crystallodytes.*

| Species | 9 | 10 | 11 | 12 | 13 | $\bar{x}$ | n |
|---|---|---|---|---|---|---|---|
| *C. pauciradiatus* | 7 | 7 | 2 | | | 9.7 | 16 |
| *C. cookei cookei* | | 2 | 2 | | | 10.5 | 4 |
| *C. c. enderburyensis* | | | | 11 | 6 | 12.4 | 17 |

*cookei cookei* from the Hawaiian Islands than it is to its geographically nearest neighbor *C. c. enderburyensis* in the meristic characters examined. The difference between *C. c. cookei* and the new form is greater than that between the two recognized subspecies of *C. cookei* in three of the five variable meristic characters.

The occurrence on Easter Island of a new creediid represents an eastern extension for the family (to approximately 109½°W longitude) and the first recorded occurrence of a member of the family on the Nasca Plate. The nearest record of other creediids to Easter Island is that of *C. c. enderburyensis,* here recorded and well represented from Ducie, Henderson, and Pitcairn islands (based on BPBM collections, as are the following except as noted). Poorly fixed material from Tahiti may belong to this subspecies; it occurs on Swains Island, American Samoa (Scripps Institution of Oceanography 67-215). *Chalixodytes tauensis* occurs on Pitcairn and also on Mangareva of the Tuamotu Archipelago (one specimen of three from BPBM 13543 is virtually fully scaled). Oeno Island, of the Pitcairn Group, has a species of *Limnichthys,* perhaps *L. donaldsoni* (BPBM 16536).

## Key to the Species of Creediidae

1. Pelvic-fin rays I,4 or I,3 or fins absent; lateral-line scales behind pectoral fin not trilobate or only weakly so (but with posterior lobe) .......... 2

– Pelvic-fin rays I,5; lateral-line scales behind pectoral fin distinctly trilobate except in *Crystallodytes* spp. where the posterior margin is rounded and without indentations .......................................... 7

2. Pelvic fins absent; anal-fin rays 32–36 ............................ .................................. *Apodocreedia vanderhorsti* de Beaufort

– Pelvic fins present; anal-fin rays fewer than 29 or more than 35 ...... 3

Table 3.—Frequency distribution of numbers of dorsal and anal-fin rays in the species and subspecies of *Crystallodytes.*

| Species | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | $\bar{x}$ | n |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dorsal-fin rays | | | | | | | | | | | | | | | | |
| *C. pauciradiatus* | 1 | 6 | 9 | | | | | | | | | | | | 31.5 | 16 |
| *C. cookei cookei* | | | | | | | 1 | 1 | — | 2 | | | | | 37.7 | 4 |
| *C. c. enderburyensis* | | | | | | | | | | | 6 | 5 | 4 | 2 | 41.1 | 17 |
| Anal-fin rays | | | | | | | | | | | | | | | | |
| *C. pauciradiatus* | | | | | 1 | 11 | 4 | | | | | | | | 35.2 | 16 |
| *C. cookei cookei* | | | | | | | 1 | 1 | 1 | 1 | | | | | 37.5 | 4 |
| *C. c. enderburyensis* | | | | | | | | | 4 | 10 | 2 | 1 | | | 39.0 | 17 |

Table 4.—Frequency distribution of numbers of lateral-line scales and vertebrae in the species and subspecies of *Crystallodytes* (the non-type material of *C. pauciradiatus* is included in the vertebral counts).

| Species | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | $\bar{x}$ | n |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lateral-line scales | | | | | | | | | | | | | | | |
| *C. pauciradiatus* | 2 | 1 | 4 | 7 | 2 | | | | | | | | | 50.4 | 16 |
| *C. cookei cookei* | | | | | | | | 2 | 2 | | | | | 55.5 | 4 |
| *C. c. enderburyensis* | | | | | | | | | | 3 | 8 | 4 | 2 | 58.3 | 17 |
| Vertebrae | | | | | | | | | | | | | | | |
| *C. pauciradiatus* | | | 2 | 15 | 8 | 1 | | | | | | | | 51.3 | 26 |
| *C. cookei cookei* | | | | | | | 1 | 5 | 3 | 2 | | | | 55.5 | 11 |
| *C. c. enderburyensis* | | | | | | | | | | 2 | 13 | 4 | 2 | 58.3 | 21 |

3. Dorsal-fin rays 12–16; anal-fin rays 24–28; lateral-line scales 40–47; lateral line descending abruptly behind pectoral fin to near ventral profile; body fully scaled or not ........................................ 4
– Dorsal-fin rays 35–40; anal-fin rays 36–40; lateral-line scales 55–59; lateral line descending gradually; body scaleless except for lateral line, predorsal row, and caudal peduncle region [the two involved nominal species are poorly differentiated from one another and are only provisionally recognized here; one specimen of *Chalixodytes tauensis* from the Mangareva Islands is fully scaled] ........................... 6
4. Pelvic-fin rays I,3; dorsal-fin rays 12 or 13; lateral-line scales and vertebrae usually 40–42 ........................... *Creedia alleni* Nelson
– Pelvic-fin rays I,4; dorsal-fin rays 13–16; lateral-line scales and vertebrae usually 42–47 ............................................ 5
5. Body fully scaled; maxilla extending to about center of eye, tip forked; profile of snout sloping gradually, not strongly convex .............
........................................ *Creedia haswelli* (Ramsay)
– Body scaleless in anterior half except for lateral line and paired predorsal row; maxilla extending well behind eye and tip blunt, not forked; profile of snout convex ...................... *Creedia partimsquamigera* Nelson
6. Dorsal-fin rays about 35–37; anal-fin rays about 36–38 .............
...................................... *Chalixodytes tauensis* Schultz
– Dorsal-fin rays about 37–40; anal-fin rays about 37–40 ............
................................ *Chalixodytes chameleontoculis* Smith
7. Anal, pectoral, and most of pelvic-fin rays branched; usually 16 or 17 pectoral-fin rays, the lowermost thickened; 9 branched caudal rays; usually 18–20 dorsal-fin rays .................. *Schizochirus insolens* Waite
– Anal, pectoral, and pelvic-fin rays unbranched; usually 10–14 pectoral-fin rays, the lowermost not thickened; 8 branched caudal rays; usually 20–42 dorsal rays ............................................ 8
8. Lateral-line scales 48–60; anal-fin rays 35–41; usually 11–18 dorsal saddles ............................................................ 9
– Lateral-line scales 36–47; anal-fin rays 25–34; 5–12 dorsal saddles ... 11
9. Body fully scaled; body depth more than 9% of standard length ......
........................................ *Tewara cranwellae* Griffin

– Body scaleless except for lateral line; body depth less than 9% of standard length ........................................................ 10

10\. Dorsal-fin rays 30–32; lateral-line scales 48–52 ........................................ *Crystallodytes pauciradiatus* n.sp.

– Dorsal-fin rays 36–43; lateral-line scales 55–60 ........................................ *Crystallodytes cookei* Fowler

11\. Dorsal-fin rays 28 or more; anal-fin rays 30 or more ................ 12

– Dorsal-fin rays 27 or fewer; anal-fin rays 30 (rarely) or fewer ........ 13

12\. Origin of anal fin in front of vertical through origin of dorsal fin; snout length usually less than half maximum body depth; cirri along either side of lower jaw usually fewer than 20, of near uniform length ........................................ *Limnichthys polyactis* Nelson

– Origin of anal fin beneath or behind vertical through origin of dorsal fin; snout length usually greater than half maximum body depth; cirri along either side of lower jaw usually more than 20, of alternating size posteriorly ................................ *Limnichthys rendahli* Parrott

13\. Combined number of dorsal and anal-fin rays 50–55 (usually 52 or more); at least some of the 5–9 dorsal saddles reaching lateral band ........................................ *Limnichthys fasciatus* Waite

– Combined number of dorsal and anal-fin rays 45–53 (usually 51 or fewer); dorsal saddles, usually 9–11, not reaching lateral band (band may be absent) ........................................................ 14

14\. Lateral-line scales 39–41; combined number of dorsal and anal-fin rays 48–53; lateral band usually present ............ *Limnichthys nitidus* Smith

– Lateral-line scales 36–38; combined number of dorsal and anal-fin rays 46–50; lateral band usually absent ....... *Limnichthys donaldsoni* Schultz

The above key excludes the following two forms: a new species of *Creedia* from Japan being described by Mr. Kazuhiko Shimada; a form similar to *Limnichthys fasciatus* but with fewer meristic parts. Material of the latter collected in Fiji was sent to one of us (JSN) by R. Winterbottom of the Royal Ontario Museum (ROM). It may be deserving of subspecific status or may represent a separate but undescribed species. It has the following diagnostic characters: dorsal-fin rays 22–24; anal-fin rays 25–27; vertebrae 37–40 (most with 39); two epurals; 5–8 dorsal saddles (including a faint one on nape) and a lateral band (most or all saddles join the band in specimens over 19 mm SL, but four small specimens have short saddles not reaching the band); in addition, there is a dark interorbital bar. Specimens similar to this form have been collected from New Britain and Solomon Islands, based on BPBM and ROM material, respectively, and from Lizard Island, Great Barrier Reef (taken with *L. donaldsoni*), based on AMS material. Further study and more specimens are required to determine if this material is the same form as represented by the above-mentioned Fiji specimens.

## Acknowledgments

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# THE VOICES AND RELATIONSHIPS OF THE CHILEAN FROGS *EUPSOPHUS MIGUELI* AND *E. CALCARATUS* (AMPHIBIA: ANURA: LEPTODACTYLIDAE)

J. R. Formas

*Abstract.*—The voices of *Eupsophus migueli* and *E. calcaratus* are described. The calls of both species are short in duration and consist of a single note. The call data together with genetic information indicates that *E. migueli, E. calcaratus,* and *E. roseus* comprise a related species group that is quite different from *E. vittatus.*

Frogs of the genus *Eupsophus* (*E. vittatus, E. roseus, E. migueli, E. calcaratus,* and *E. insularis*) are endemic to the *Nothofagus* temperate forest of southern Chile and Argentina. *Eupsophus migueli* is restricted to the Coastal Range in Valdivia Province (Formas 1978), whereas *E. calcaratus* occurs widely in southern Chile (Formas and M. I. Vera 1982). *Eupsophus migueli* is sympatric but not syntopic with *E. roseus* (Iturra and Veloso, 1981) and this latter species is allopatric with *E. calcaratus* (Formas and M. I. Vera, 1982).

Calls of frogs can be useful in revealing systematic and evolutionary relationships at the species level. In general, closely related species have some acoustic characteristics in common (Blair 1958; Kuramoto 1974, 1977; Mecham 1971; Schiøtz 1973). In order to establish the evolutionary trends of the species of the genus *Eupsophus* we analyzed the voices of *E. migueli* and *E. calcaratus.* These data are compared with the calls of *E. roseus* and *E. vittatus* which were previously described (Formas and M. A. Vera 1980). The voice of *E. insularis* remains unknown. The call data presented in this paper demonstrate that *E. migueli* and *E. calcaratus* show strong similarities with *E. roseus* but that this species group is different from *E. vittatus.*

## Methods and Materials

Field recordings were made at 19 cm/sec on an Uher 4000 Report-IC portable tape-recorder and an Uher m 517 microphone. Audio-Spectrograms were made with a Kay Electric audio spectrograph model 675 employing 85-8000 Hz frequency scale and narrow (45 Hz) and wide (300 Hz) band filters. Temperature, location and behavior of all individuals used in the analysis were taken at the time of recording. Call repetition rates were measured in the field by counting consecutive calls over one minute. Specimens and tapes were deposited in the collection of Amphibians of the Institute of Zoology at the Universidad Austral de Chile (IZUA), Valdivia.

## *Eupsophus migueli* Formas

The call characteristics here described are based on the call of 25 individuals recorded at 9–12°C at the locality of Mehuín (Valdivia Province) during September

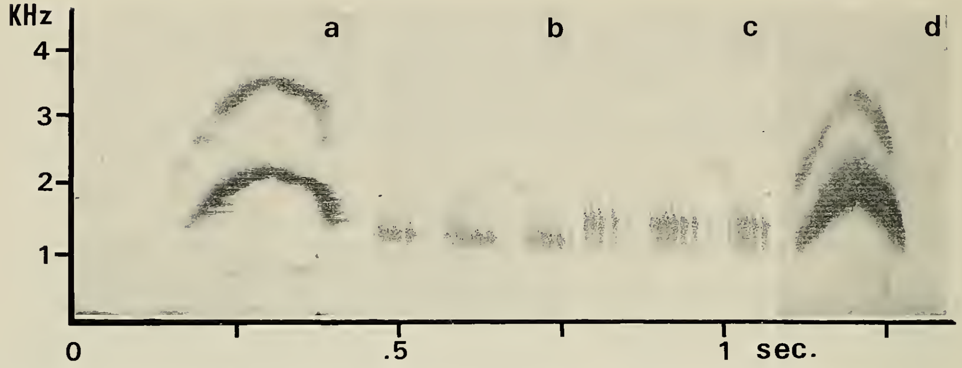

Fig. 1. Sound spectrograms of calls of *Eupsophus migueli* (a, b, c) and *E. calcaratus* (d). a, Type A call (45 Hz); b, Type B call (45 Hz); c, Type B call (300 Hz); d, Call of *E. calcaratus* (300 Hz).

1981. Eight calls, from five specimens were analyzed in detail. Males of this species were observed and collected while they were calling from cavities in the ground near a cool stream. No aggregation of individuals was observed when they were calling but calls of two or more males were organized into duets or trios. Two types of calls were observed. The call type A consists of a single note (Fig. 1a, Table 1) lasting 0.20–0.35 seconds. The repetition rate is 3–8 calls/minute. The call shows poor modulation and a well defined harmonic is present between 3200–3900 Hz. Maximum sound energy is spread over the frequency range 1500–2500 Hz. Type B calls (Fig. 1b, Table 1) of *E. migueli* are trills consisting of 19–33 notes per call. The call duration is 2.7–4.4 seconds and each note last about 0.08–0.09 seconds with poorly defined silent intervals between notes within a call. Each note is composed of 4–7 pulses per note. Maximum sound energy of the poorly modulated notes is spread over the frequency range 900–1500 Hz. The repetition rate is 5–8 calls/minute. Harmonics are absent; the fundamental frequency equals the dominant. This type of call was only observed in two animals.

### *Eupsophus calcaratus* (Günther)

The description of the call is based on 15 calls from three individuals. The calls were recorded at 11°C at the locality of Puntra (Chiloé Province) during December 1982. Males were collected while they were calling at the bank of a stream. In this area males are isolated; however, in the locality of Pucatrihue (Osorno Province, October 1983) a moderate aggregation was observed.

The call of this species (Fig. 1c, Table 1) consists of a single note lasting 0.15–0.21 seconds. A well defined harmonic (2200–3800 Hz) is present and the call is poor in modulation. Maximum sound energy is distributed between 1100–2700 Hz. The repetition rate is 16–25 calls/minute.

### *Eupsophus roseus* (Duméril and Bibron) and *E. vittatus* (Philippi)

The calls of both species were previously described by Formas and M. A. Vera (1980). The calls characteristic of *E. roseus* and *E. vittatus* are included in the Table 1.

Table 1.—Call characteristic (mean and ranges) of *Eupsophus* species.

| Species | Call type | Notes per call | Call length (sec) | Repetition rate | Dominant frequency (Hz) |
|---|---|---|---|---|---|
| *E. migueli* | A | 1 | 0.24 (0.20–0.35) | 6 (3–8) | (1500–2500) |
| *E. migueli* | B | 24 (19–33) | 3.4 (3.3–4.4) | 6 (5–8) | (900–1500) |
| *E. calcaratus* | | 1 | 0.19 (0.15–0.21) | 19 (16–25) | (1100–2700) |
| *E. roseus*† | | 1 | 0.20 (0.19–0.21) | 64 (60–72) | (1600–2900) |
| *E. vittatus*† | | 5 (4–6) | 0.6 (0.4–0.8) | 4 (2–10) | (1100–2500) |

† From Formas and M. A. Vera (1980).

## Discussion

When two types of calls are produced as in *E. migueli* and some other species (Heyer 1971; Straughan and Heyer 1976; Narins and Capranica 1976; Pyburn 1978), the signals may have a different meaning for the two sexes. Type A call observed in *E. migueli* shows a frequency range between 1500–2500 Hz, a repetition rate of 5–8 calls/minute and the single note lasts 0.20–0.35 seconds. The characteristics here described suggest that the type A call could code information in order to attract gravid females because the frequency is relatively narrow and not difficult to locate, and especially because the call is repeated at predictable intervals. The unusual call type B is a trill with a dominant narrow energy band (900–1500 Hz). This voice was observed at regular intervals (5–8 call/minute) when two males were at the same burrow. Mostly on the basis of this observation we suggest that this signal codes information in order to maintain the territory of a calling male in a particular burrow.

When we compare the voices of *Eupsophus migueli* (call type A), *E. calcaratus,* and *E. roseus* (Fig. 1, Table 1) it is noteworthy that all three species show strong similarities. As suggested above this type of call could be useful in attracting females and, since the calls are similar, they could attract females of any species of this species group. However, this appears unlikely because these species do not occur in the same place. *Eupsophus roseus* and *E. calcaratus* are allopatric in distribution (Formas and M. I. Vera 1982), and *E. migueli* and *E. roseus* are sympatric but not syntopic at the locality of Mehuín (39°26'S, 73°10'W) (Iturra and Veloso 1981).

If we compare the voice of *E. vittatus* with other *Eupsophus* species, two distinctive groups can be established. The first group which includes *E. roseus, E. migueli,* and *E. calcaratus* is characterized by producing a short single note (Table 1). The calls have a distinct harmonic in the frequency range 2200–3900 Hz and a maximum sound energy range between 1500–2500 Hz. All species calls have poor modulation and pulsation. The second group, contains only one species, *E. vittatus.* In this frog the call duration is 0.4–0.8 second and is composed of four to six well pulsed notes. The dominant frequency range is between 1900 and 2500 Hz (Table 1).

Some authors (Blair 1958; Kuramoto 1974, 1977; Mecham 1971; Schiøtz 1973) have suggested that related species have acoustic characteristics in common. If this hypothesis is true, the strong similarities of the calls of *E. roseus, E. migueli,* and *E. calcaratus* suggest that these species are closely related to each other.

Formas (1980) established two species groups in the genus *Eupsophus* based on chromosomal information. The first contains only *E. vittatus,* which has 28 biarmed chromosomes and a fundamental number (FN) of 56. The second group contains the following species: *E. roseus* and *E. calcaratus* (2n = 30, 8 biarmed pairs and 7 monoarmed, and FN 46), and *E. migueli* (2n = 30, 7 biarmed pairs and 8 monoarmed pairs, and FN 44). In addition, Formas *et al.* (1983) analyzed the allozymic differentiation in these species and found that Nei's genetic distance of *E. vittatus* with respect to the other species indicates a higher level of genetic differentiation, whereas the remaining species (*E. roseus, E. migueli,* and *E. calcaratus*) have a lower differentiation when compared with *E. vittatus.* If acoustical and genetic data are compared it is interesting to observe the agreement between both sets of information. This could be useful in establishing systematic and evolutionary trends in the genus *Eupsophus.* On the basis of the evidence previously cited we conclude that the *E. roseus, E. migueli,* and *E. calcaratus* group is comprised of very closely related species while *E. vittatus* remains clearly separated.

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# A NEW SPECIES OF THE AQUATIC BEETLE GENUS *DRYOPOMORPHUS* FROM BORNEO (COLEOPTERA: ELMIDAE: LARINAE)

Paul J. Spangler

*Abstract.*—A new species of an asiatic elmid genus, *Dryopomorphus satoi,* from Sabah, Borneo, is described, illustrated with line drawings and scanning electron micrographs, and distinguished in a key from the other three described species.

The genus *Dryopomorphus* was described by Hinton (1936) with *D. extraneus* from Japan as the only included species. Since that time, one additional species, *D. nakanei* Nomura (1958), was described from Japan, and a third species, *D. bishopi* Hinton (1971), was described from Malaysia. The new species described below is the second known species of *Dryopomorphus* from Malaysia.

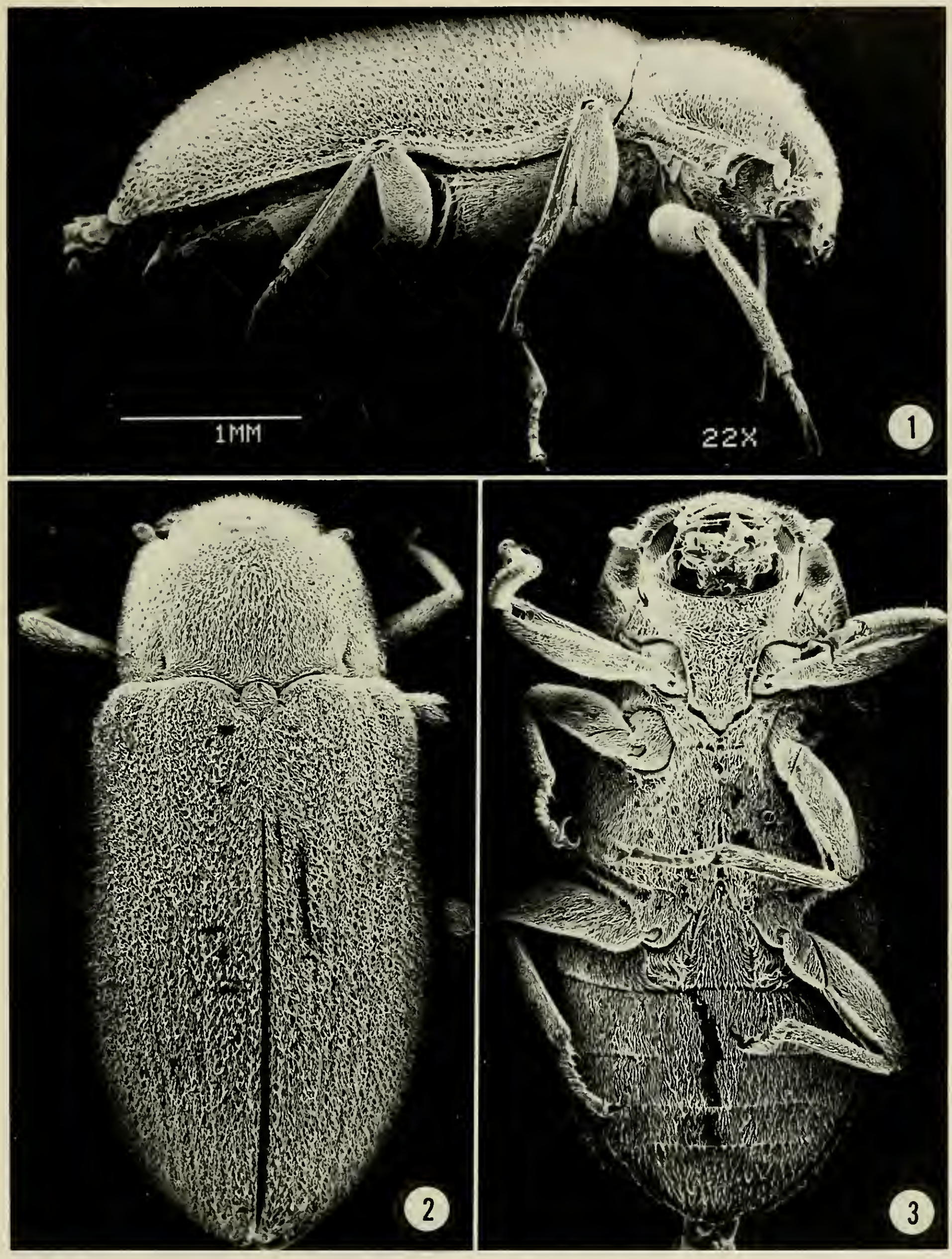
### *Dryopomorphus satoi,* new species
Figs. 1–9

*Holotype male.*—Body form and size. Oblong; moderately convex dorsally. Length, 4.0 mm; width, 1.7 mm (Figs. 1–3).

*Color.*—Black dorsally except antennae yellowish-brown basally and slightly darker brown apically. Dorsum covered with long, sparse, black setae and short, dense, light yellowish-brown hydrofuge setae. Venter dark reddish-brown except genae, sides of prosternum, anterior half of hypomeron, all palpi, labium, coxae, trochanters, and tarsi lighter reddish brown.

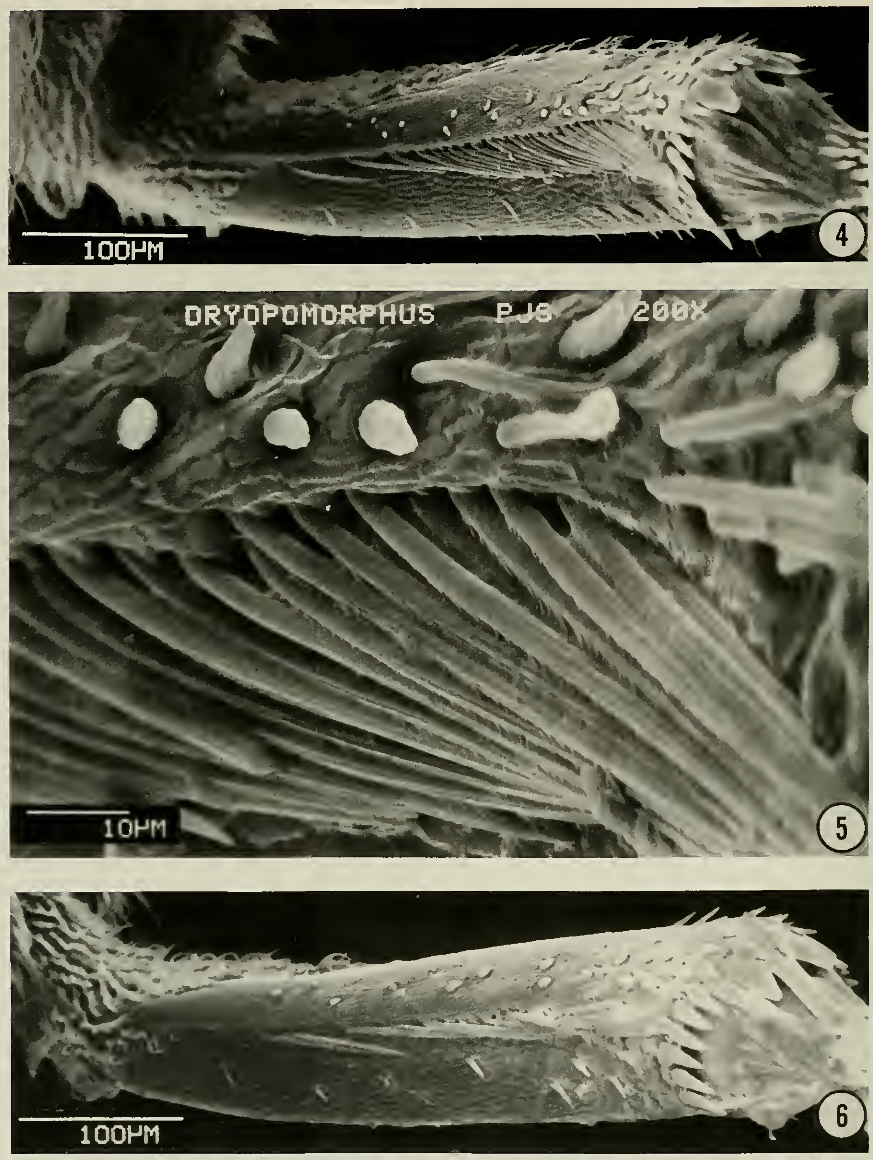
*Head.*—Surface with dual punctation; coarse punctures sparse, widely separated; fine punctures dense, separated by distance equal to their diameters. Patch of dense pubescence posteromediad of each eye. Eyes moderately strongly convex. Clypeus with anterior margin nearly truncate; surface punctate similarly to head; without conspicuous transverse row of long setae bent over labrum. Labrum with anterior margin bordered with dense golden setae; lateral angles with moderately dense tuft of long golden setae curved toward midline; surface punctate similarly to head. Labium with prementum bearing 2 transverse tufts of long, stout, black, bristle-like setae; submentum with numerous, long, yellowish setae on middle.

*Thorax.*—Pronotum 0.8 mm long, 0.9 mm wide; widest across base; sides moderately arcuate; disc without median longitudinal impression, evenly convex; surface of disc punctate similarly to head; sublateral basal sulcus deep, straight, and subequal to length of scutellum; sides not steeply sloping; anterolateral angles obtuse, rounded; posterolateral angles obtuse, not rounded; lateral margins each distinctly rimmed. Hypomeron with anterior cavity for reception of antenna moderately deep and separated from posterior portion by distinct, transverse ridge; surface behind cavity coarsely, moderately densely punctate. Prosternum in front of coxae about one and one-half times longer than length of procoxae. Prosternal process broad, margined laterally, and tapering broadly to protuberant apex. Mesosternum deeply foveate for reception of protuberance of prosternal process.



Figs. 1–3. *Dryopomorphus satoi,* new species, habitus: 1, Lateral view; 2, Dorsal view; 3, Ventral view.

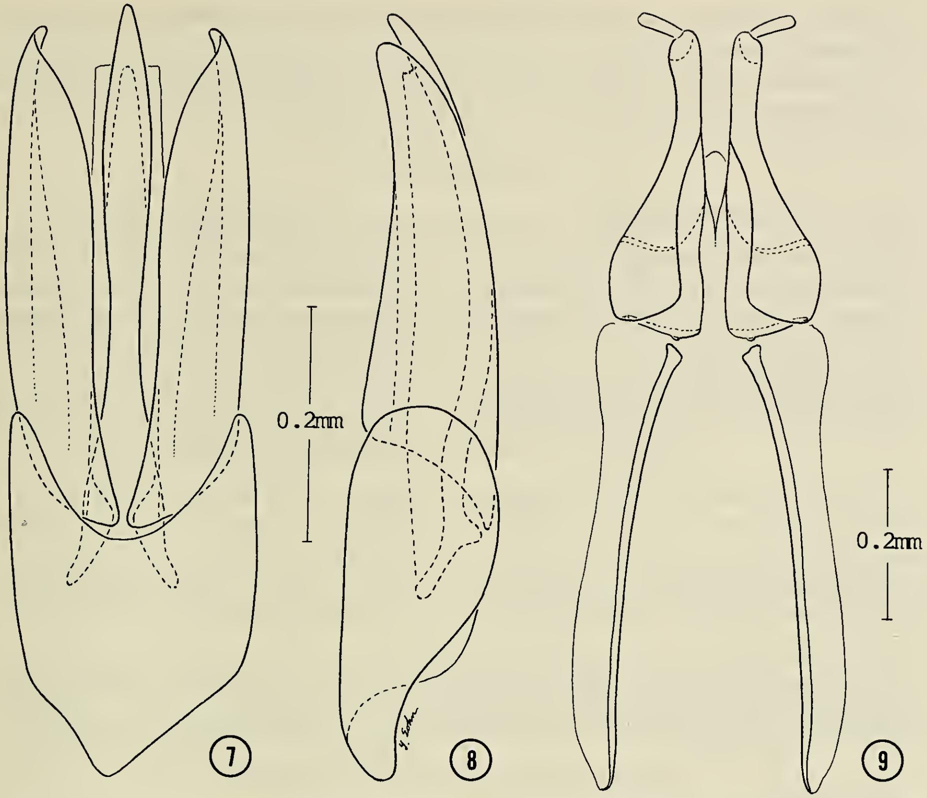
Metasternum with shallow median longitudinal impression; sides with punctures about 4 times as coarse as facets of eyes and separated by 1 to 3 times their diameters; disc densely, moderately coarsely punctate and with 4 or 5 very coarse punctures laterally adjacent to declivous sides. Foreleg uniformly pubescent. Middle and hind legs pubescent except posteromedial surfaces of tibiae glabrous;



Figs. 4–6. *Dryopomorphus satoi,* new species: 4, Mesotibial fringe, 200×; 5, Mesotibial fringe, 1200×; 6, Metatibial fringe, 200×.

mesotibia with rather slender cleaning fringe of longer setae on inner, apical three-fourths (Fig. 6); metatibia with moderately dense cleaning fringe on inner apical three-fourths (Figs. 4, 5). Scutellum flat, ovate; base and apex about equally rounded; surface finely, densely punctate. Elytron with 10 rows of coarse punctures; surface finely densely punctate; with fine erect setae as long as intervals are wide; with fine, much denser, shorter, suberect setae between erect setae; base adjacent to scutellum with short, indistinct, transverse plica in distinct impression.

*Abdomen.*—First sternum with sublateral carinae prominent and complete; sur-



Figs. 7–9. *Dryopomorphus satoi,* new species, genitalia: 7, Male, dorsal view; 8, Male, lateral view; 9, Female, dorsal view.

face between carinae densely, moderately coarsely punctate; with large, deep, ovoid cavity laterally on each side of each carina; cavities surrounded with long setae that extend across openings. Surface with coarse, sparse punctures and fine, dense punctures.

*Male genitalia.*—As illustrated (Figs. 7, 8).

*Female.*—Similar to male externally. Genitalia as illustrated (Fig. 9).

*Type data.*—Holotype male: BORNEO: SABAH: Poring, 18 Sep 1983, Warren E. Steiner, Jr., and Gary F. Hevel; USNM Type-No. 100122; deposited in the National Museum of Natural History, Smithsonian Institution. Allotype and paratypes (29), same data as holotype.

Paratypes: Specimens will be deposited in the British Museum (Natural History) London; California Academy of Sciences, San Francisco; Canadian National Collection, Ottawa; Muséum National d'Histoire Naturelle, Paris; Institut royal de Sciences Naturelles de Belgique; Stovall Museum of Science and History, Norman, Oklahoma; Zoologische Sammlung Bayerischen Staates, München; and Dr. Satô's personal collection.

*Etymology.*—This species is named for my friend Dr. Masataka Satô in honor of his numerous contributions to our knowledge of Asiatic water beetles.

*Habitat.*—The type-series was collected from leaf packs among rocks in a partially shaded stream.

*Comparative notes.—Dryopomorphus satoi,* n. sp., resembles *D. bishopi* and keys to that species in Hinton's (1971) key to the species. However, *D. satoi* may be distinguished from *D. bishopi* as tabulated below.

| *Dryopomorphus satoi* | *Dryopomorphus bishopi* |
|---|---|
| 1. Pronotum with fine and coarse punctures. | Pronotum uniformly finely, densely punctate. |
| 2. Hypomeron with anterior cavity for reception of antenna very deep; plane of floor of cavity at an angle of about 80° to plane of posterior surface of hypomeron. | Hypomeron with anterior cavity for reception of antenna moderately deep; plane of floor of cavity at an angle of about 20° to plane of posterior surface of hypomeron. |
| 3. Intervals between rows of coarse elytral punctures distinctly, finely, and densely punctate. | Intervals between rows of moderately coarse elytral punctures microalutaceous and with very few, indistinct, fine punctures. |
| 4. Surface of first abdominal sternum between carinae densely, moderately coarsely punctate. | Surface of first abdominal sternum between carinae very sparsely, moderately coarsely punctate. |
| 5. Scutellum about equally rounded basally and apically; surface finely, densely punctate. | Scutellum wider basally, angulate apically; surface not punctate. |

The following key, modified from Hinton (1971), will serve to distinguish the four species presently known in the genus *Dryopomorphus.*

## Key to the Species of *Dryopomorphus*

1. Eyes flattened, scarcely convex. Hypomeron with anterior cavity for reception of antenna only moderately concave and without transverse carina separating cavity from posterior part of hypomeron. Sublateral pronotal sulci distinctly longer than scutellum. Length, 4.9 mm. Japan .................................................................. *extraneus* Hinton
– Eyes strongly convex. Hypomeron with anterior cavity for reception of antenna deep and separated from posterior part of hypomeron by distinct transverse ridge ................................................ 2
2. Clypeus, near anterior margin, with row of long, conspicuous setae that are bent over labrum. Sublateral pronotal sulci present on basal two-fifths, nearly twice as long as scutellum. Length 2.6 mm. Japan .................................................................. *nakanei* Nomura
– Clypeus, near anterior margin, without conspicuous transverse row of long setae. Sublateral pronotal sulci present on basal fourth, about as long as scutellum ................................................ 3
3. Pronotum with fine and coarse punctures. Hypomeron with anterior cavity for reception of antenna very deep; plane of floor of cavity at angle of about 80° to plane of posterior surface of hypomeron. Intervals between rows of coarse elytral punctures distinctly finely, densely punctate. Length, 4.0 mm. Malaysia ........................................ *satoi,* new species
– Pronotum uniformly finely, densely punctate. Hypomeron with anterior cavity for reception of antenna moderately deep; plane of floor of cavity

at angle of about 20° to plane of posterior surface of hypomeron. Intervals between rows of moderately coarse punctures microalutaceous and with very few, indistinct, fine punctures. Length, 3.4 mm. Malaysia ........ .................................................. *bishopi* Hinton

## Acknowledgments

I thank the following people who contributed to this article: Warren E. Steiner and Gary F. Hevel, for collecting this new species and other interesting aquatic beetles for me in Borneo; Christine von Hayek of the British Museum (Natural History), for making the type-series of *Dryopomorphus bishopi* Hinton available, which allowed me to recognize *D. satoi* as new and distinct; Young T. Sohn, entomological illustrator, for the line drawings; Robin A. Faitoute, museum technician, and Susann Braden, scanning electron microscopist, for the micrographs; and my wife, Phyllis M. Spangler, for typing the manuscript.

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# MIOCENE AND PLIOCENE MOLIDAE (*RANZANIA, MOLA*) FROM MARYLAND, VIRGINIA, AND NORTH CAROLINA (PISCES: TETRAODONTIFORMES)

Robert E. Weems

*Abstract.*—Three species of fossil molid fish (Tetraodontiformes) are represented in the Miocene and Pliocene deposits of the central Atlantic Coastal Plain. Two species belong to the genus *Ranzania* (*R. grahami* and *R. tenneyorum*) and one belongs to the genus *Mola*. Premaxillary beaks were found to be best suited for osteologically defining species and genera in this family. Osteological definitions for the living and fossil genera and species in this family are proposed based principally on the character states present in the premaxillary elements.

Fossil molid remains were first recognized in 1883, when Van Beneden described the upper and lower "beaks" of "*Orthogoriscus chelonopsis*" from Belgium. Later, Leriche (1907) pointed out that Van Beneden already had described two dermal bones of molids in 1881, but that he had incorrectly assigned them to the genus *Pagrus,* as *P. pileatus* and *P. torus.* Because Leriche considered all of these materials to belong to a single species, he therefore called all of these specimens *Orthogoriscus pileatus* on the basis of page priority. In 1926, Leriche figured more material recovered from the Brussels basin and compared it to the living species *Mola mola* (then usually called *Orthogoriscis mola*). Leriche decided that all of his fossil material constituted a single species which was collectively distinct from the modern species. More recently, Van Deinse (1953) described some dermal bones of a molid from the upper Miocene strata of the Netherlands which he also chose to refer to *Mola pileata.* These Miocene dermal bones are quite comparable to the material Van Beneden and Leriche described, especially since dermal bones are highly variable in shape in the living *Mola mola* (Harting 1864, cited in Van Deinse 1953). Romer (1966:361) listed the genus *Mola* as occurring in the Tertiary of South America, but no other reference to such an occurrence was located. Apart from this one reference, all fossil specimens of molids reported in the literature have been from Miocene strata of France, Netherlands, and Belgium, and all of this material has been referred to a single fossil species of the extant genus *Mola.*

Berry (1941) unknowingly described a molid premaxillary beak from the upper part of the Calvert Formation of Virginia; he considered it to be the fused dentaries of the sea turtle *Syllomus.* D. H. Dunkle brought this error to my attention and it was footnoted in my paper on Calvert sea turtles (Weems 1974). Because only a footnote was published, the true nature of this premaxillary beak is still not widely recognized by ichthyologists. Since Berry's paper, much more molid material has been collected from the Calvert and from the overlying Choptank Formation. Much of this material has good stratigraphic control. A large selection of premaxillary beaks are known from the upper Calvert which can be used to determine the degree of variability in the premaxillary beaks of what was probably a single genetic population. Three other specimens, one from Calvert-age beds in central Virginia, one from the Choptank Formation of Maryland, and the third from the Yorktown Formation of North Carolina, clearly fall outside of the range of variability seen in the upper Calvert population of specimens. This indicates that a major revision of the taxonomy of the fossil members of this family is warranted and that two new species of molids can be recognized.

## Material

The following specimens were used for comparisons made in this paper. "Zones" are from Shattuck (1904):

1) AMNH 1679. Premaxillary beak. Calvert Formation, upper "zone" 11, "zone" 12, or lower "zone" 13, Horsehead Cliffs, Westmoreland State Park, Westmoreland County, Virginia. Charles T. Berry, 9 Jun 1940 (see Berry 1941).
2) USNM 16363. Premaxillary beak. Calvert Formation, Chesapeake Beach, Calvert County, Maryland. William Palmer.
3) USNM 16364. No data.
4) USNM 16615. Premaxillary beak. Calvert Formation, Scientists Cliffs, Calvert County, Maryland. W. E. Salter, 1941.
5) USNM 16668. Premaxillary beak. Calvert Formation, Scientists Cliffs, Calvert County, Maryland. Mr. Foshag and Remington Kellogg, 1941.
6) USNM 16743. Premaxillary beak. Calvert Formation, "zone" 11, Scientists Cliffs, Calvert County, Maryland. L. P. Schultz, 1943.
7) USNM 186982. Dentary beak. Calvert Formation, "zone" 11, about 2 feet above shell layer, 1.7 miles south of Plum Point, Calvert County, Maryland. R. Lee Collins, 6 Jul 1936.
8) USNM 186983. Premaxillary beak. Choptank Formation, "zone" 19, just north of Bay Haven Camp, Calvert County, Maryland. R. Lee Collins, 8 Sep 1933.
9) USNM 186984. Dentary beak. Found on beach at Randle Beach. Lauck W. Ward, Aug 1969.
10) USNM 186986. Premaxillary beak, dentary beak, dorsal armor shield, nasal plate, jugular plate, and branchial arch or vertebral spine fragments. Calvert Formation, upper "zone" 11, Horsehead Cliffs, Westmoreland State Park, Westmoreland County, Virginia. R. E. Weems, Mar 1967.
11) USNM 265391. Fragmentary premaxillary beak. Calvert Formation, upper "zone" 11, Stratford Cliffs, Westmoreland County, Virginia. James Kaltenbach.
12) USNM 265392. Premaxillary beak. Calvert Formation, in the local basal phosphate horizon of Calvert Formation, Gravett's Mill Pond, King William County, Virginia. R. E. Weems, Dec 1969.
13) USNM 265393. Fused dentary beak. Calvert Formation, upper "zone" 11, 4 feet above beach, Stratford Cliffs, Westmoreland County, Virginia. Robert E. Weems, around 1970.
14) USNM 265394. Premaxillary beak. Calvert Formation, upper "zone" 11, 4 feet above beach, Stratford Cliffs, Westmoreland County, Virginia. R. E. Weems, Mar 1970.
15) USNM 265395. Fragmentary premaxillary beak. Calvert Formation, "zone"

12, 6 feet above beach, south corner of second bluff north of Parker Creek, Maryland. James Kaltenbach.

16) USNM 265650. Fragmentary premaxillary beak. Yorktown Formation, Lee Creek Mines, Aurora, North Carolina.
17) USNM 265651. Isolated dermal plates. Calvert Formation, "zone" 12, Parkers Creek, Calvert County, Maryland. Collector unknown, 20 Apr 1935.
18) USNM 265653. Molid jugal plate. Probably Calvert Formation, Scientists Cliffs, Calvert County, Maryland. Collector Walter Simonson.
19) USNM 291211. Fragmentary premaxillary beak. Yorktown Formation, Lee Creek Mines, Aurora, North Carolina.
20) USNM 336431. Small premaxillary beak. Calvert Formation, "zone" 10, Plum Point, Calvert County, Maryland. David O. Bohaska, 15 Oct 1983.

## Description

Of the above-cited specimens, five include much or all of the premaxillary beak and also come from either upper "zone" 11 of the Calvert or possibly from "zone" 12 or lower "zone" 13. Three others almost certainly come from this same interval. These specimens occur within a narrow stratigraphic range, so it is reasonable to compare them to see if they represent more than a single population. The angle of these beaks are all within the rather narrow range of 77° to 88°, with a mean value of 84.5° and a standard deviation of ±2°. The beaks vary considerably in total size, but this is to be expected due to wide differences in the age of individuals at death. The most variable character is the ratio between the beak length and the length of the bony palate that lies behind the beak. Even here, however, the changes are readily correlated with size and can be ascribed to age variation within a single species (Fig. 1).

Except for USNM 336431, each specimen is toothless in the region of the anterior biting edge of the beak, but farther back on the roof of the mouth the bony palate region contains three poorly defined rows and clusters of teeth sharply demarcated from the toothless area (Figs. 1, 3D, 6D, 7B). The teeth are poorly developed and show no clear sign of enamel covering. The bony palate above and behind the tooth-bearing region consists of a large mass of bone which acts as a brace for the teeth. This is variably developed, but generally is more massive in larger specimens.

One specimen within this population (USNM 186986) is a partial skeleton of a single large individual. This specimen includes the premaxillary beak, the dentary beak, the nasal plate, the jugular plate, a large sheet of dermal armor, and poorly ossified bones possibly representing branchial arch supports or vertebral spines (Figs. 3–5). This material constitutes most of what could reasonably be expected to be fossilized in a molid. This specimen and the previously discussed isolated premaxillary beaks from the upper Calvert Formation can be referred to a single species that is variable within well-defined limits. Collectively, these beaks all differ from the described European specimens in the massive development of the tooth-bearing bony palate behind the beak (Fig. 7). Such a palate is absent in all but one of the specimens described by Leriche and in the living *Mola mola*. Therefore, the upper Calvert population represents a single species that is distinct from the one described European molid species.

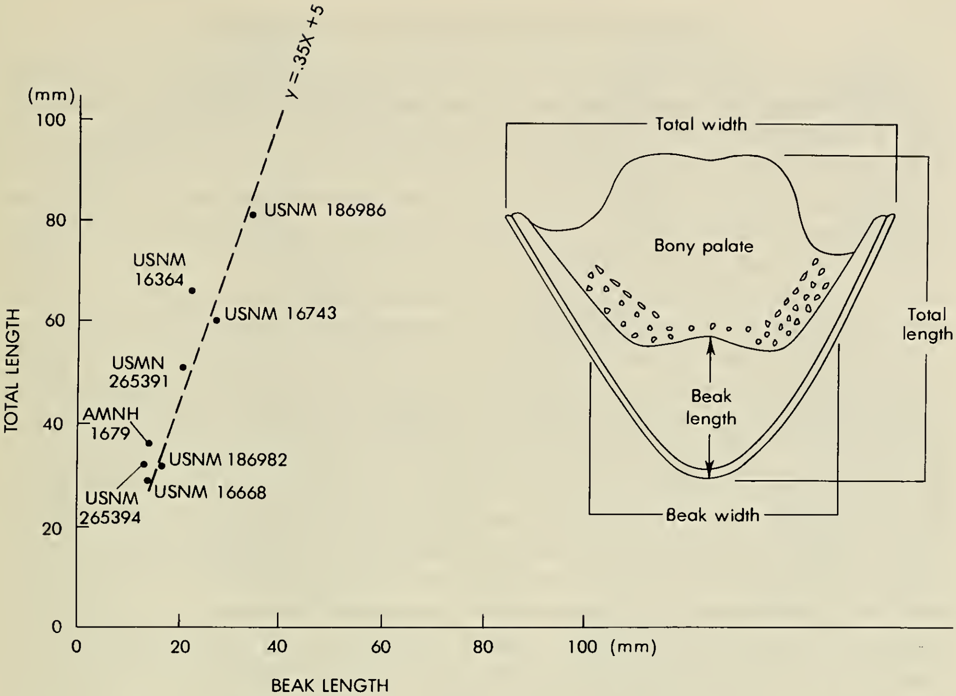

Fig. 1. Graph showing the distribution in size of specimens of *Ranzania grahami* n. sp. from the upper Calvert Formation. Although total length and beak length vary greatly (see inset), the ratio of these two values are related by the simple algebraic relationship $y = 0.35X + 5$ (dashed line). Thus, these specimens probably represent different growth stages within a single population.

Three other premaxillary beaks from Maryland, Virginia, and North Carolina fall well outside the range of variation seen in the upper Calvert specimens. One specimen comes from beds in central Virginia that appear to be equivalent to the upper Plum Point Marl Member of the Calvert Formation (L. W. Ward, written communication, 1983). This beak differs from the previously described specimens in the development of three pairs of well-defined tooth rows on the oral surface of the palate (Fig. 7D). These are quite distinct, unlike the poorly developed tooth rows of the specimens already considered. The other two beaks, a premaxillary beak from "zone" 19 of the Choptank Formation of Maryland (Fig. 7C), and a premaxillary beak from the Yorktown Formation of North Carolina (Figs. 6A, B), have lost all trace of the tooth rows and most of the mass of bone above the tooth rows. Their conformation is most like that of the European molids that have been described in the literature. In these two kinds of beaks we can see (1) an earlier morphological stage where teeth are better developed than in the previously considered upper Calvert population and (2) a later morphological stage in which the teeth are essentially gone, closely approaching the condition seen in the all but toothless living *Mola mola.* Since the toothless beaks are still better ossified than those of the living *M. mola,* they are best referred to *M. chelonopsis* and not to either of the living species. The beak with well developed tooth rows appears to represent a second new species of molid.

## Osteology of the Living Genera of Molids

Although all fossil molid materials previously have been referred to the genus *Mola,* there are three extant genera in the family (Tyler 1980). Fraser-Brunner (1951) considered *Mola* to include two species (*M. mola* and *M. ramsayi*), but Tyler (1980) seems unconvinced that the two species are distinct. Both Tyler and Fraser-Brunner consider *Ranzania* and *Masturus* to be monotypic. Several papers have appeared on the anatomy of these fishes (for *Mola*: Gregory and Raven 1934; for *Ranzania*: Raven 1939a; for *Masturus*: Gudger 1937a, b; Raven 1939b), but the only paper that has dealt with the dental apparatus of any of these fishes is Tyler (1980). Although Tyler notes a crowded tooth battery in young *Mola,* study by the present author of adult skeletal remains has shown no instance in which distinct teeth are rooted in the bony portion of either the upper or lower beaks. Apparently the teeth are entirely embedded in cartilage in the living adult fish. Study of whole specimens of *Ranzania* by the author has shown that this genus possesses well developed rows of teeth which move past each other as the fish chews, apparently producing a shredding and chopping action (e.g., USNM 75155; ANSP 106723) (Fig. 2). *Ranzania* has been reported to eat only littoral seaweed (Barnard 1927), so the utility of this dental apparatus seems obvious. Only two specimens of *Masturus* could be located; neither was available for dissection (USNM 5704; AMNH 15962). Observation of the mouth, however, revealed a battery of rounded pavement teeth (Fig. 2) reminiscent of those developed in pycnodont fishes and the living drumfish (*Pogonias*). The conformation of the teeth in the premaxillary beak differs somewhat from that shown in Tyler (1980:387), possibly due to age or size variation, but the dentary tooth battery in the specimens I observed agree well with the one figured by Tyler (p. 389). Although I could not observe if a bony mouth roof is present in *Masturus,* the figure of the skull of *Masturus* in Tyler (1980) suggests that one is possibly present. No such mass is present in the very cartilaginous *Mola.* Of the three living genera, only *Ranzania* has an extensive dermal skin external covering of regularly polygonal, bony armor plates; in both *Masturus* and *Mola* there are only scattered dermal patches bound in a cartilaginous sheet (Fraser-Brunner 1951, Tyler 1980).

## Taxonomy of the Miocene and Pliocene Molids

From the foregoing descriptions, it is clear that only the Choptank and Yorktown premaxillary beaks can be referred properly to the genus *Mola.* The presence of regular rows of shredding teeth and a large mass of bone reinforcing the dental battery readily place the central Virginia beak in the genus *Ranzania.* The upper Calvert specimens afford a somewhat intermediate state between *Ranzania* and *Mola,* but since the bone reinforcing the dental battery is retained and an extensive bony dermal armor (albeit composed of irregular rather than polygonal plates) is retained, this form as well is best considered still to belong within the genus *Ranzania.* It is obvious, however, that this species had evolved far in a direction toward the character states present in the living genus *Mola.*

Since the jugular and nasal bones are quite variable in shape and show no major change in form and shape from the upper Calvert population of *Ranzania* through the modern *Mola mola,* they are of little more than familial taxonomic value.

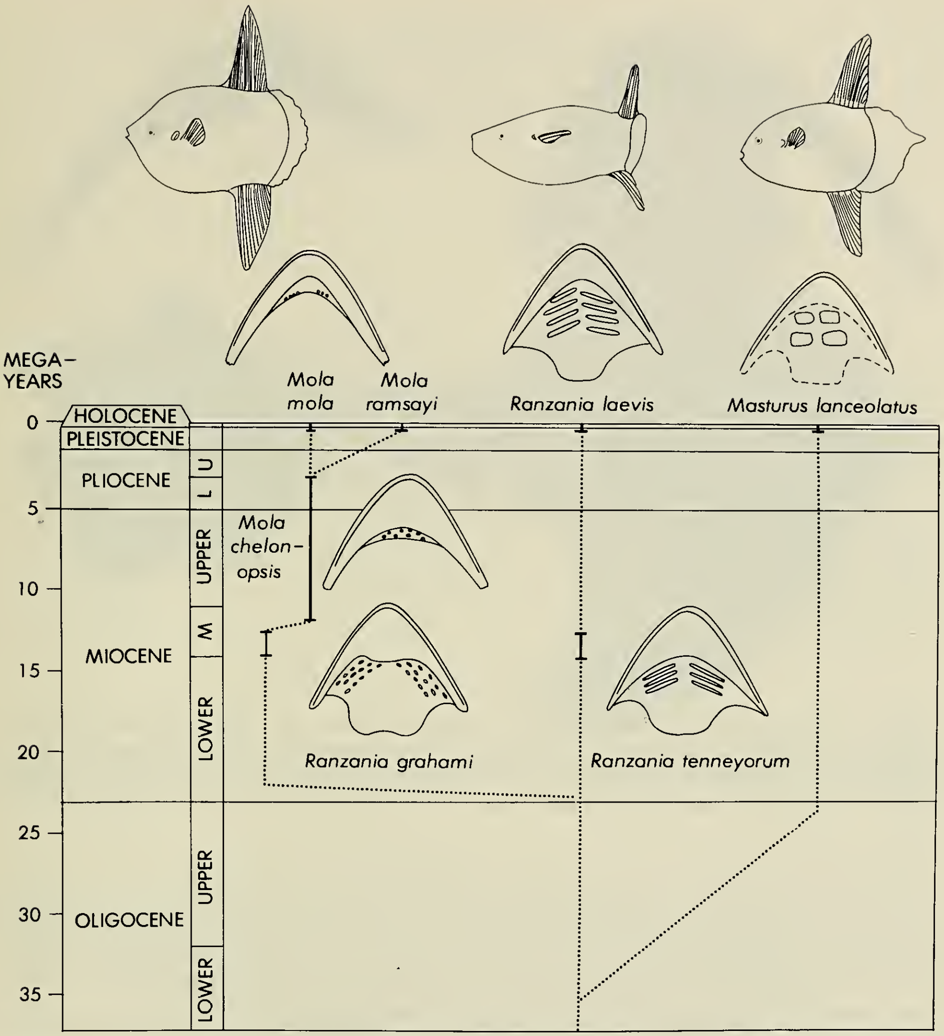

Fig. 2. Morphology and oral characteristics represented in the various fossil and living species of the family Molidae. Age ranges (solid lines) and probable phyletic pathways (dotted lines) are indicated.

Therefore, the species described by Van Beneden as *Pagrus pileatus* and *Pagrus torus* are considered to be each a nomen dubium; they could belong to any of at least three species of fish. Only "*Orthagoriscus chelonopsis*" shows enough characters to merit designation as a type, and the proper name for this species should be *Mola chelonopsis.* This specimen is quite comparable to the nearly toothless species present in the Choptank and Yorktown (cf. Leriche 1926). The upper Calvert species is undescribed, so the name *Ranzania grahami* is proposed after Robert A. Graham, who has accompanied the author on numerous fossil molid collecting trips. The central Virginia species also is undescribed, and the name *Ranzania tenneyorum* is proposed after Eleanor and Wilton Tenney, who also

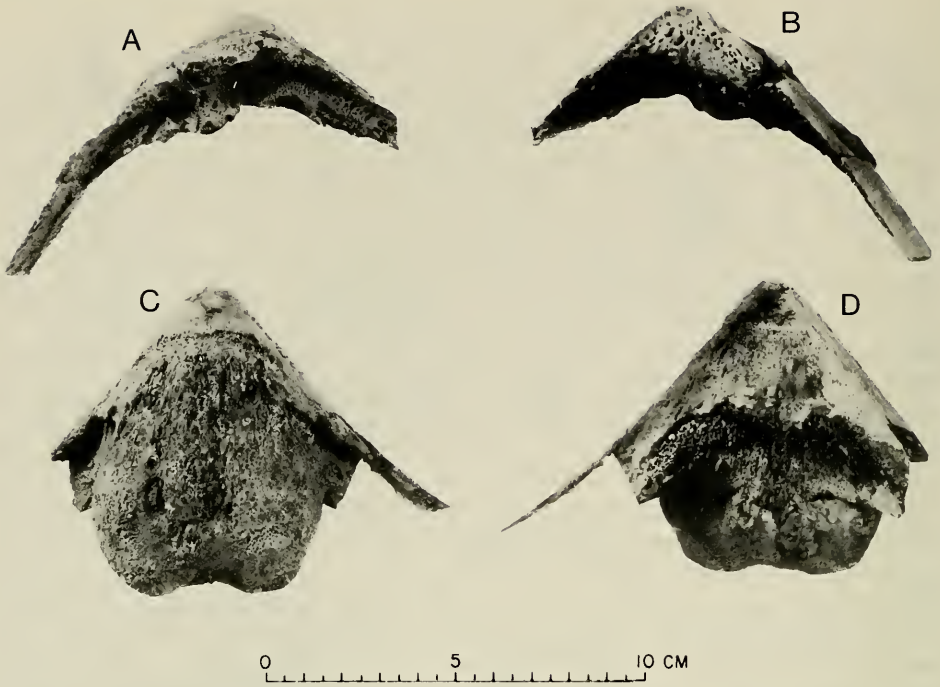

Fig. 3. Dentary and premaxillary beaks of *Ranzania grahami* n.sp. (type), USNM 186986. A, Dentary beak, ventral (aboral) view; B, Dentary beak, dorsal (oral) view. Note the notch cut in the right dentary by a predator's tooth (dark shadow) and the piece of bone displaced outward by this injury; C, Premaxillary beak, dorsal (aboral) view; D, Premaxillary beak, ventral (oral) view.

spent considerable time collecting with the author on the trips when molid remains were found. Because *Masturus* is so poorly known, it cannot be adequately defined yet in osteological terms. However, the presence of rounded crushing teeth is obviously a key distinguishing character. Osteologically the three recognizable living and fossil species of *Ranzania* can be defined as follows:

### *Ranzania* Nardo, 1840

*Ranzania* Nardo, 1840:10, 105 (type-species: *Ranzania typus* Nardo (=*Ostracion laevis* Pennant) by Whitley 1933).

*Generic diagnosis.*—External dermal coating of polygonal plates, internal skeleton largely cartilaginous except for premaxillaries and dentaries fused respectively into upper and lower beak. Upper beak posteriorly containing rows or patches of teeth fused against thick mass of bracing bone overlying roof of mouth.

*Range.*—Middle Miocene to Holocene.

### *Ranzania laevis* (Pennant, 1776)

*Species diagnosis.*—In addition to generic characters, this species shows a regularly polygonal array of dermal plates. Teeth occur in four discrete intermeshing

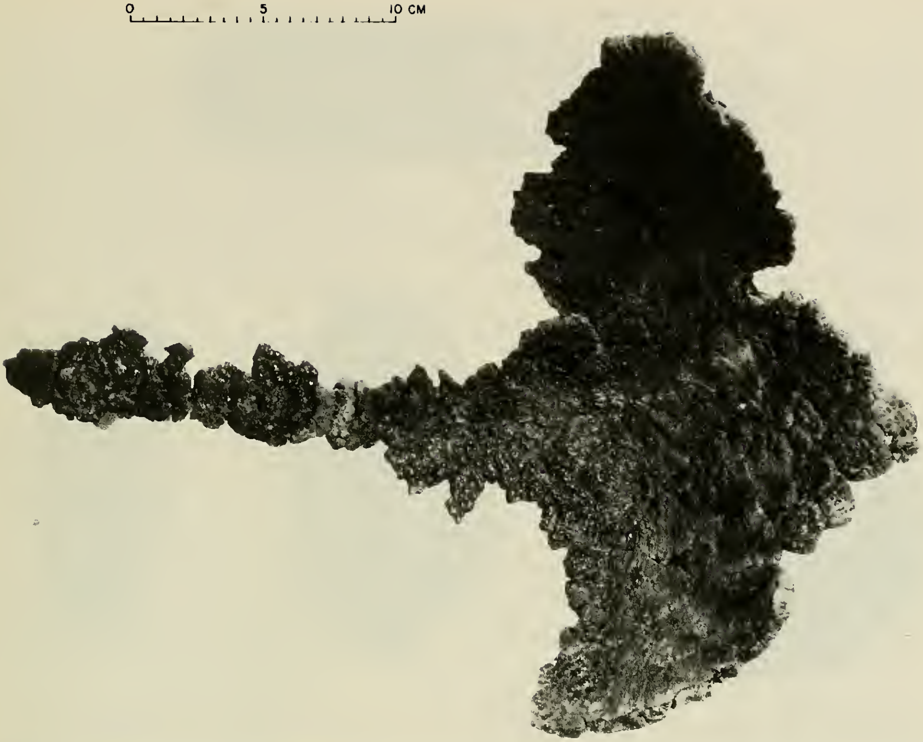

Fig. 4. Ventral view of the dorsally located dermal armor shield of *Ranzania grahami* n.sp. (type), USNM 186986.

rows on both the dorsal and ventral surfaces of the mouth, ventral row not attached to a bony shelf.

*Range.*—Holocene.

*Ranzania grahami,* new species
Figs. 3–5, 6C–D, 7A–B, 8

*Holotype.*—USNM 186986, Premaxillary beak, dentary beak, dorsal armor shield, nasal plate, jugular plate, and branchial arch or vertebral spine fragments; Calvert Formation, upper "zone" 11, Horsehead Cliffs, Westmoreland State Park, Westmoreland County, Virginia; R. E. Weems, Mar 1967.

*Species diagnosis.*—In addition to generic characters, dermal coating made of very irregularly-shaped polygonal plates. Teeth present but in poorly defined rows and patches that are rooted directly to the palatal bracing bone. In the one known very young premaxillary beak specimen (less than 20 mm length), the anterior beak region may contain up to six pairs of tooth ridges crowded against the front of the beak, followed posteriorly by the irregular tooth rows on the bony palate typical of this species. Apparently the anterior six rows wear out with age, leaving this region toothless in larger individuals. Nasal plate and jugular plate similar to those of living *Mola mola.*

*Range.*—Lower middle Miocene.

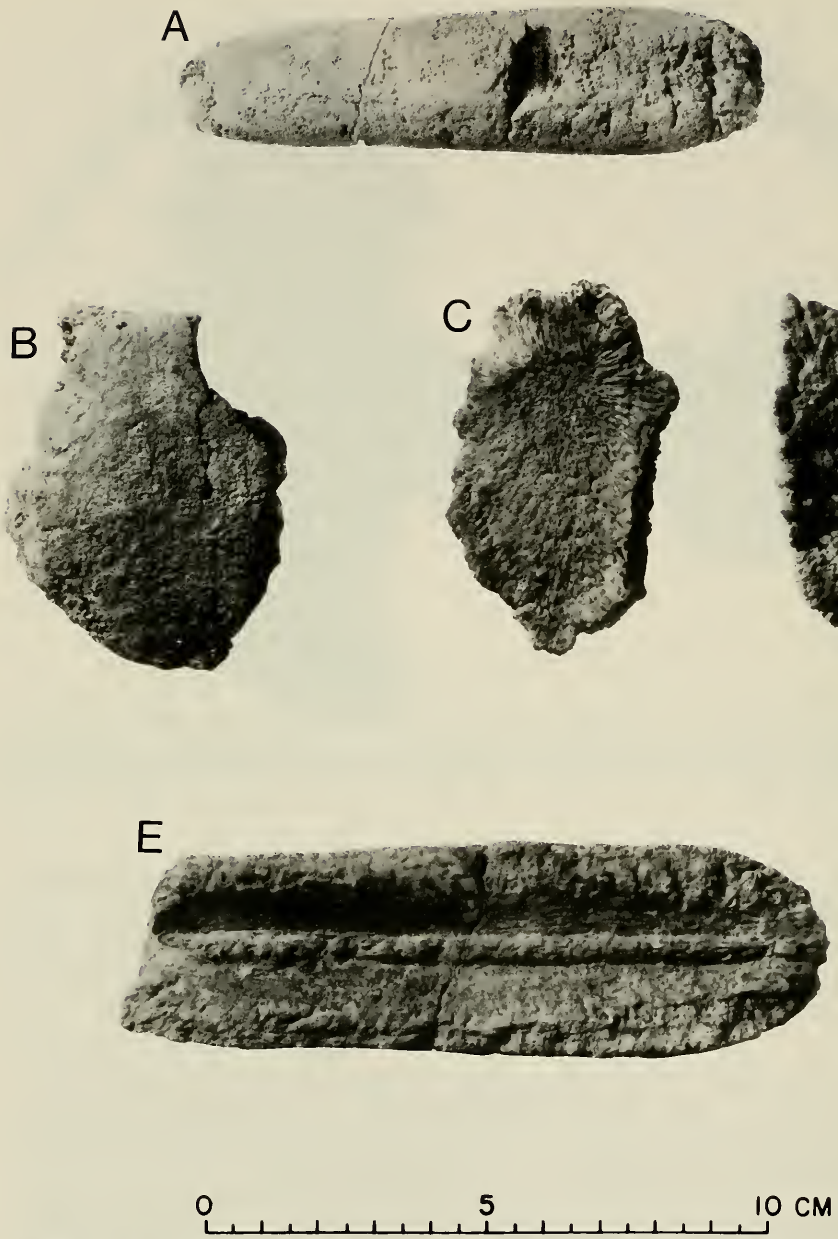

Fig. 5. Isolated dermal bones of *Ranzania grahami.* A, Jugular plate (USNM 265651); B, Nasal plate (USNM 186986, type); C, Dermal element (USNM 186986, type); D, Fragmentary jugular plate (USNM 186986, type); E, Jugular plate (USNM 265653).

### *Ranzania tenneyorum,* new species
Fig. 7D

*Holotype.*—USNM 265392, premaxillary beak; Calvert Formation, in the local basal phosphate horizon of Calvert Formation, Gravett's Mill Pond, King William County, Virginia; R. E. Weems, Dec 1969.

*Species diagnosis.*—Based solely on the fused premaxillaries. Beak small, with three well developed pairs of tooth rows present behind it which are located on a bony shelf well below the level of the palatal bracing bone, so that there is a well developed notch behind the tooth rows. Other premaxillary beak characters as in genus.

*Range.*—Lower middle Miocene.

### *Mola* Koelreuter, 1770

*Mola* Koelreuter, 1770:337 (type-species: *Mola aculeata* Koelreuter (=*Tetraodon mola* Linnaeus, juvenile) by Jordan, 1885).

*Generic diagnosis.*—Dermal armor reduced to a nasal plate, a jugular plate, scattered small dermal plates along the body and along the clavus. Premaxillary and dentary beaks reduced nearly to totally toothless condition with only a few, isolated, scattered teeth present along the internal beak margin. Palatal bony brace for the teeth totally reduced to cartilage.

*Range.*—Upper Middle Miocene to Holocene.

Osteologically, the three living and fossil species of *Mola* can be defined as follows:

### *Mola mola* (Linnaeus, 1758)

*Species diagnosis.*—In addition to the generic characters, 8 to 9 ossicles along the clavus, paraxial pair of ossicles fused. Premaxillary beak strongly reduced.

*Range.*—Holocene.

### *Mola ramsayi* (Giglioli, 1883)

*Species diagnosis.*—In addition to the generic characters, 12 ossicles along the clavus, paraxial pair not fused. Dentary and premaxillary beaks not described, presumably as for *M. mola.*

*Range.*—Holocene.

### *Mola chelonopsis* (Van Beneden, 1883)

*Species diagnosis.*—Premaxillary beak toothless, and lacking palatal tooth brace, toothless shelf anterior to location of the former tooth position much longer than in *M. mola,* such that the antero-posterior beak length is greater than the lateral beak width at the level of the back of the shelf. Dentary beak comparable to *M. mola.*

*Range.*—Upper middle Miocene to lower Pliocene.

*Remarks.*—All but one of the premaxillary beaks which Leriche (1926) described totally lack both the bony mass above the mouth roof and the rows of

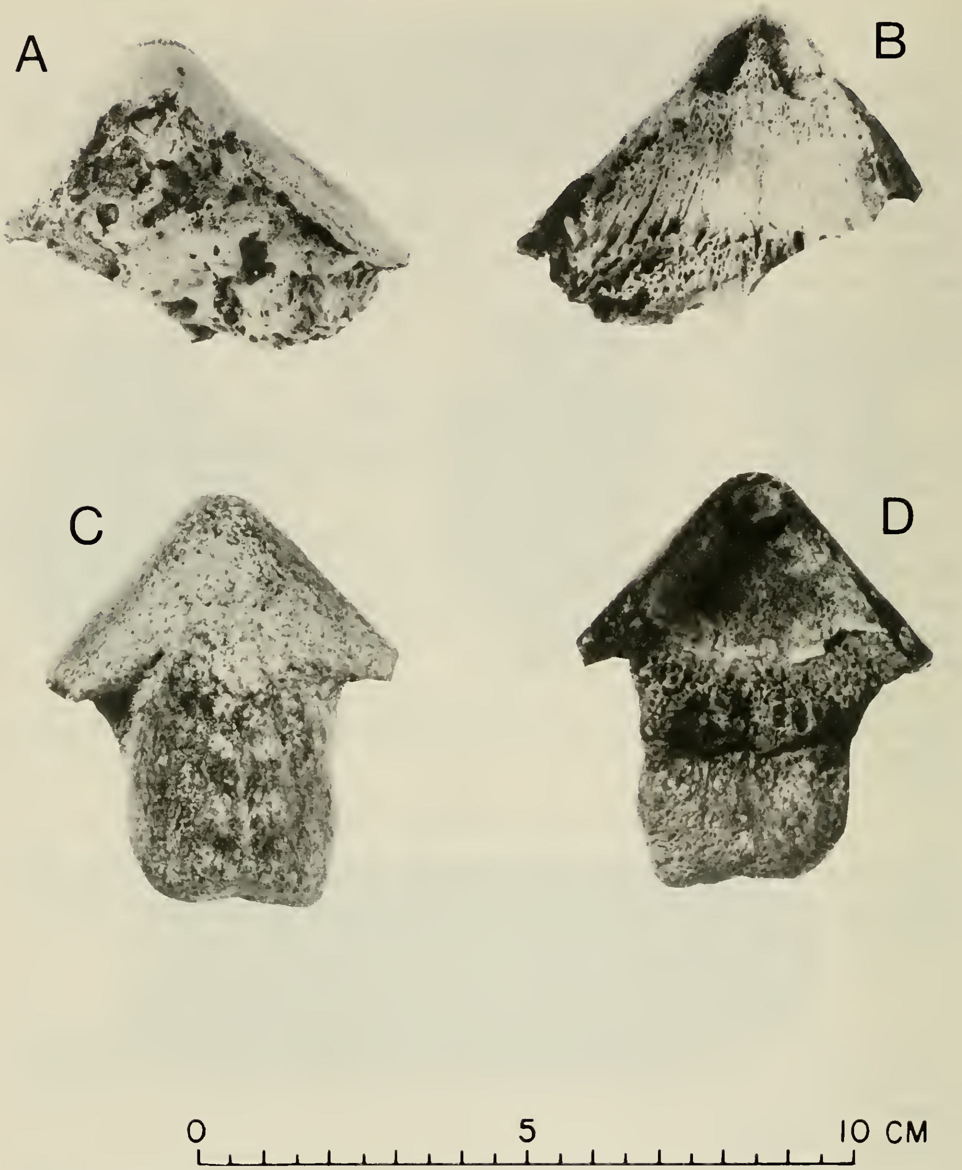

Fig. 6. Dorsal and ventral views of the premaxillary jaw of *Ranzania grahami* and *Mola chelonopsis*. A, *Mola chelonopsis* (USNM 265650), dorsal view; B, *Mola chelonopsis* (USNM 265650), ventral view; C, *Ranzania grahami* (USNM 265395), dorsal view; D, *Ranzania grahami* (USNM 265395), ventral view.

teeth. These specimens therefore should be referred to the above species. All of these specimens presumably came from the upper middle Miocene. One small beak that Leriche described has two (but not three) tooth rows imbedded in a bony palate. In the number of tooth rows present it is somewhat different from

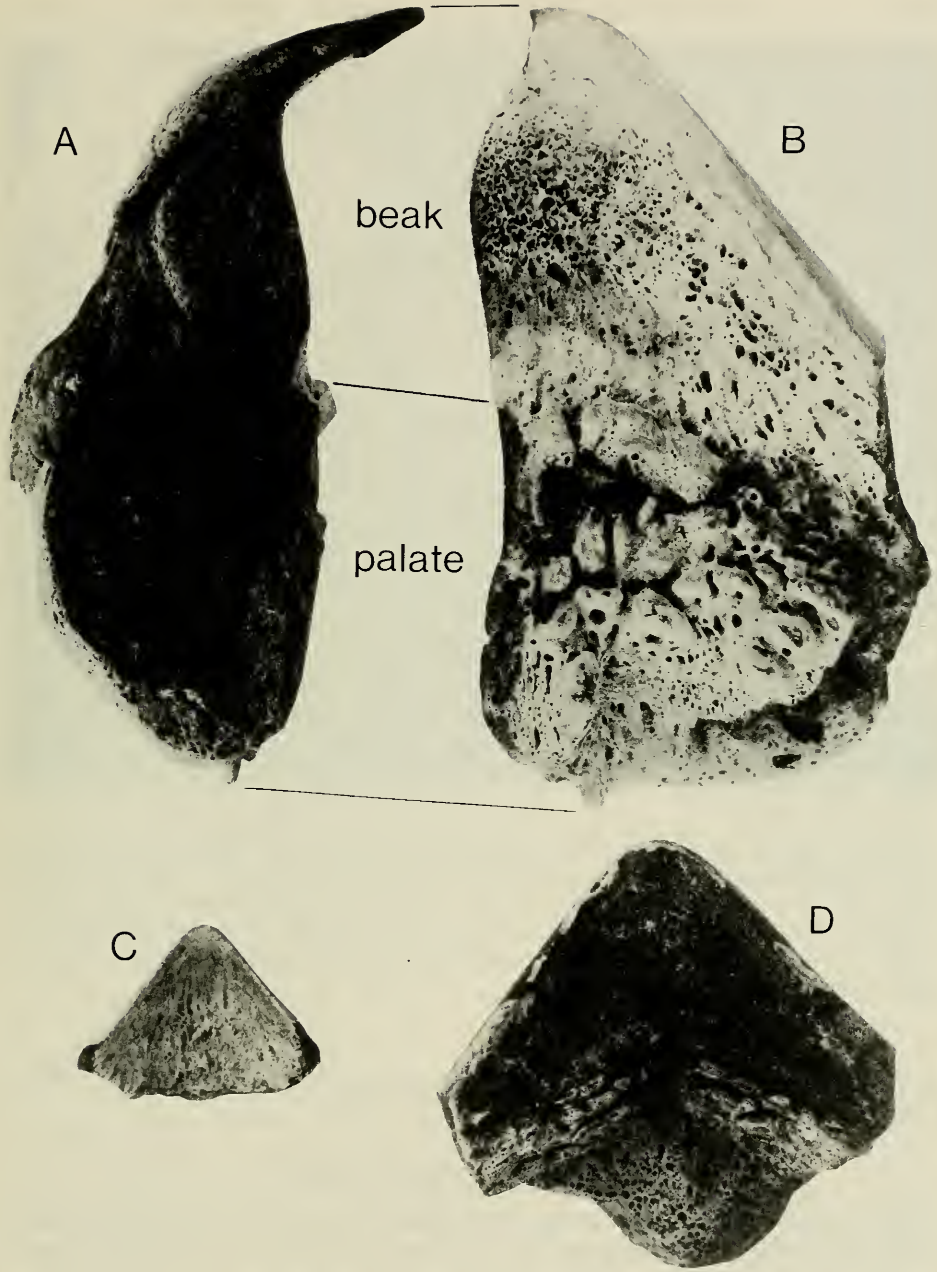

Fig. 7. The premaxillary jaws of *Ranzania tenneyorum, Ranzania grahami* and *Mola chelonopsis.* A, Midline section through a beak of *Ranzania grahami* (USNM 265391); B, Ventral view of same beak of *Ranzania grahami* showing poorly developed and irregularly placed teeth on the bony palate; C, Ventral view of beak of *Mola chelonopsis* (USNM 186983) lacking development of a bony palate. Total length 23 mm; D, *Ranzania tenneyorum* (USNM 265392) showing three well developed pairs of tooth rows on the bony palate. Total length 25 mm.

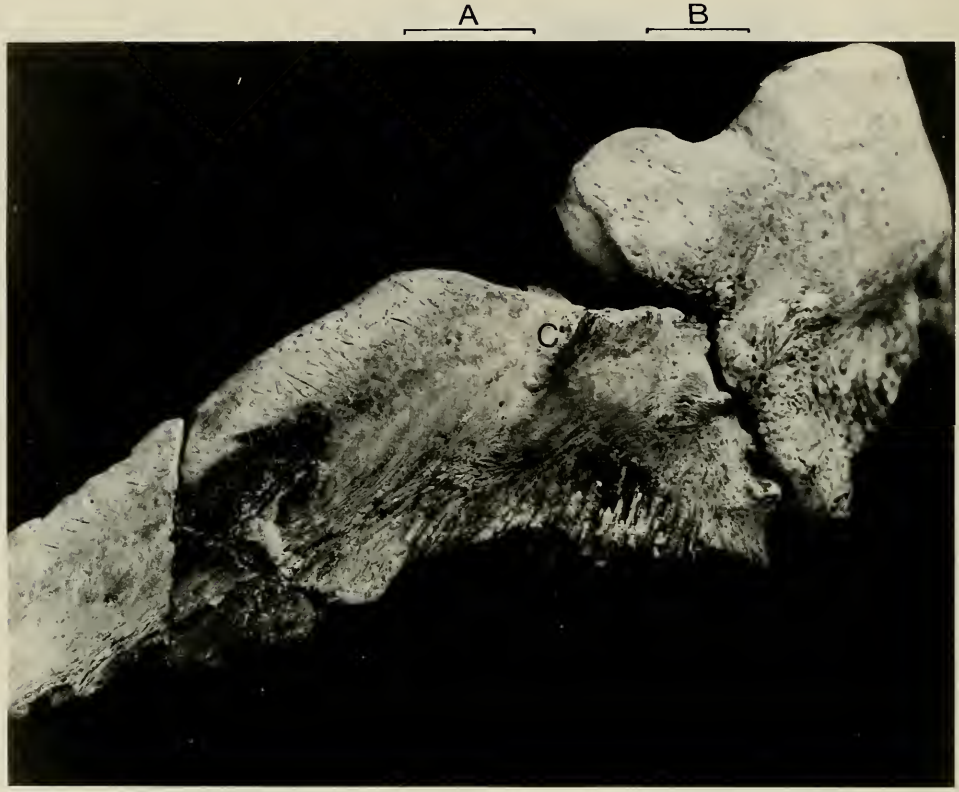

Fig. 8. Lateral view of the right dentary of *Ranzania grahami,* showing a partially healed fracture running down from a wedge shaped groove (A) produced by the tooth of an attacking predator. Although the wound partially healed, jaw occlusion was permanently altered. As a result, the premaxillary beak margin cut a broad U-shaped notch into the dentary element (B). The dark, linear shadow to the right and below "C" is a second fracture line which healed. Both the healed and unhealed fracture lines are visible in Plate 1B, because the triangular bone fragment lying between them was displaced outward at the time of injury.

*R. tenneyorum,* but otherwise it is similar to that species and thus probably should be assigned to it.

## Phylogeny of the Family Molidae

The Calvert and Choptank specimens suggest that the genus *Mola* was derived from a form like *Ranzania tenneyorum* by way of *R. grahami* and *Mola chelonopsis* (Fig. 2). *Ranzania tenneyorum* is both morphologically and temporally a suitable ancestral form for the living *Ranzania laevis,* even though no specimens of intermediate age are known. Thus, the genera *Mola* and *Ranzania* can be closely linked by intermediate fossil forms. The crushing dental apparatus of *Masturus,* on the other hand, is quite different and suggests that *Masturus* has a more remote affinity with both *Ranzania* and *Mola.* The family Molidae is considered to be derived from a distant common stock with the mollusc-eating family Diodontidae and to be most closely related to the family Triodontidae (Tyler

1980). While different in detail, the dental apparatus of *Masturus* more closely approaches the dental apparati of these related families than the dental apparati of either *Ranzania* or *Mola* within its own family. Moreover, only *Masturus* retains the primitive characteristic of a vestige of the true tail, which has been eliminated totally in the other two genera and been replaced functionally by the dorsal and anal fins, and the clavus (Fraser-Brunner 1951). Therefore, it seems most likely that *Masturus* separated from the *Ranzania-Mola* stock before the appearance of the Miocene species *R. tenneyorum* and *R. grahami,* perhaps as early as Oligocene time. This indicates relationships within the family as shown in Fig. 2. Working only with modern material, Raven (1939b), Fraser-Brunner (1951), and Tyler (1980) suggested that *Mola* and *Masturus* were the more closely related living genera. Fraser-Brunner considered *Ranzania* to be the most generalized genus, while Raven and Tyler considered it to be the most derived. While I agree with Fraser-Brunner and Tyler that *Ranzania* is the most derived member of this family, the fossil sequence used for this study suggests that the gene pools of *Ranzania* and *Mola* became isolated from each other at a time later than when both became isolated from *Masturus.* This leads me to argue: 1) that the highly cartilaginous state of *Mola* and *Masturus* is the result of parallel evolution; 2) the tail remnant and dental apparatus of *Masturus* represent uniquely retained primitive features within the family; and 3) the numerous similarities between *Mola* and *Masturus* are commonly retained primitive familial characters that cannot be used to prove an especially close relationship between these two genera. This implies that the elongate and dorso-ventrally flattened body form of *Ranzania* (Fig. 2) is a derived character within this family (as Fraser-Brunner 1951, also pointed out), in contrast to the body form of *Mola* and *Masturus* which represent the primitive family character. The fact that the mouth of *Ranzania* closes along a vertical line, rather than along a horizontal line as in most vertebrates (Fraser-Brunner 1951), clearly shows that it has undergone unique specializations relative to the other genera in its family and is not simply a primitive and conservative member of this group. Therefore, it is reasonable to argue that the body shape of *Ranzania* also is a specialized rather than a primitive trait. On the basis of morphology alone, *Mola* and *Masturus* are similar, but this is believed to have resulted from persistent conservatism in these two genera rather than from an especially intimate phylogeny.

If the above phylogeny is accepted, then a graded series of evolutionary steps can be postulated to derive the living pelagic *Mola mola* (and *M. ramsayi*?) from a bottom-dwelling, mollsucivorous ancestor. While the dental apparatus of *Masturus* is similar to that of the mollusc-eating Diodontidae, its body is not so rounded as that of most persistent bottom dwellers and catch records also suggest a world-wide pelagic distribution. Its known diet includes seaweed (Palmer 1936) as well as sponges, mollusks, and annelid worms (Yabe 1950). Yabe considered this diet to indicate that these fish normally feed on the sea beds. This implies that the first step in the derivation of this family was a change of feeding habit from gathering sea bed bivalves to foraging for food along the sea floor. This resulted in a major modification of the body from relatively wide and flattened to relatively narrow and high. In the line leading to modern *Ranzania,* the fish became specialized and adopted a diet that no longer included meat and consisted entirely of seaweed (Barnard 1927). This resulted in a change in the dental apparatus from a crushing dentition to a shredding dentition like that found in *R. tenneyorum*. In the other, less specialized branch of *Ranzania* (*R. grahami*) leading toward the modern *Mola*, the fish became adept at eating both plants and animals. The modern *Mola* has been reported to eat algae (Bigelow and Welsh 1925; Breder 1932; Fries *et al.* 1895), seaweed (Breder 1932; Reuvens 1897; Townsend 1918), eelgrass (*Zostera*) (Bigelow and Welsh 1925; Fries *et al.* 1895; Reuvens 1897), sponges (Breder 1932), hydroids (Bigelow and Welsh 1925), jellyfish (Bellomy 1961; Bigelow and Welsh 1925; Binney 1842; Breder 1932; Dieuzeide *et al.* 1955; Fries *et al.* 1895; Hargitt 1905; Hubbs and Schultz 1929; Linton 1901; MacGinitie and MacGinitie 1949; Nichols and Breder 1927; Zimbelman 1967), ctenophores (Bigelow and Welsh 1925; Hargitt 1905; Linton 1901), mollusks (Bigelow and Welsh 1925; Dieuzeide *et al.* 1955; Fries *et al.* 1895), crustaceans (Bigelow and Welsh 1925; Dieuzeide *et al.* 1955; Fries *et al.* 1895; Linton 1901; Nichols and Breder 1927), echinoderms (Bigelow and Welsh 1925), salps (Bigelow and Welsh 1925; Dieuzeide *et al.* 1955; Fries *et al.* 1895; Linton 1901; Nichols and Breder 1927), and fish (Boulenger 1936; Dieuzeide *et al.* 1955; Fraser-Brunner 1951; Fries *et al.* 1895; Grassi 1897; Norman 1931; Norman and Fraser 1949; Reuvens 1897; Schmidt 1921). This kind of a diet only requires a dental apparatus for plucking and swallowing. This set the stage for the nearly total loss of palatal teeth and their supporting bony shelf that has occurred in *Mola*. Thus the morphological changes that can be seen in the premaxillary beak, from *Ranzania tenneyorum* through *R. grahami* and *Mola chelonopsis* to *M. mola* and *M. ramsayi*, are interpreted here to reflect a progressive change in the habitat and diet of these forms.

## Pathology

The type-specimen of *Ranzania grahami* (USNM 186986) has a broad notch in the dentary beak. Below this notch two radiating fractures are present. One fracture is completely knit but the other is not, even though a great deal of bone growth has occurred in the vicinity of the fracture (Figs. 3A, B, 8). This is obviously a pathological condition perhaps resulting from an attack by a large predator. The partial healing of the fracture indicates that the victim survived for an extended period of time, as does the strongly asymmetrical wear on the dentary beak tip and the presence of a deep wear-notch cut into it by the premaxillary beak (Fig. 8). The notch facet and wear pattern clearly show that jaw occlusion was severely distorted by the attack, and the fact that the animal survived at all suggests that it could swallow food whole without complex mastication. This suggests that *R. grahami* was far along in its feeding habits towards handling a *Mola*-like rather than a *Ranzania*-like diet. It is interesting to note that the osteological response to this wound was similar to that seen in untreated human fractures; i.e. formation of bony masses around the persistently unknit fracture.

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# *SPEONEBALIA CANNONI,* N. GEN., N. SP., FROM THE CAICOS ISLANDS, THE FIRST HYPOGEAN LEPTOSTRACAN (NEBALIACEA: NEBALIIDAE)

Thomas E. Bowman, Jill Yager, and Thomas M. Iliffe

*Abstract.*—*Speonebalia cannoni* is described from two marine caves on Providenciales Island. It is characterized by the small rostrum, eyestalks without visual elements, mandible without incisor, maxilla 2 with very small exopod and unidivided endopod, and broad caudal ramus with densely setose margins.

A rich marine fauna has recently been found to inhabit marine caves in the Bahamas and associated islands. Cohen and Robins (1970) described a cavernicolous brotulid fish from a limestone sink near Nassau on New Providence Island. Yager (1981) discovered Remipedia, a new class of Crustacea, from a marine cave on Grand Bahama Island. Carpenter (1981) identified a new genus of troglobitic cirolanid isopod from a seawater-filled cave on San Salvador Island. From the same cave, Lighthouse Cave, Carpenter and Magniez (1982) reported a new isopod genus in the Gnathostenetroidoidea; Van Soest and Sass (1981) found three new species of sponges, and Barr (1984) described a new demersal calanoid copepod. From a cave in the Turks and Caicos Islands, Stock and Vermuelen (1982) identified a new genus of amphipod in the primarily abyssal family Pardaliscidae which also has a second species in the same genus inhabiting a lava tube cave on the Canary Islands. Buden and Felder (1977) have reported on the presence of cavernicolous shrimps in the Turks and Caicos. We describe herein a new genus and species of Nebaliacea (Phyllocarida: Leptostraca) collected during an expedition to marine caves in the Turks and Caicos Islands. This is the first known troglobite to be reported within the Leptostraca.

## Nebaliidae Baird 1850, emend. Hessler 1984

## *Speonebalia,* new genus

*Diagnosis.*—Blind, unpigmented. Carapace strongly compressed laterally, covering thoracopods and pleopods 1–5. Rostrum small, shorter than eyestalks, without carina. Eyestalks rather narrow, tapering distally; margins smooth.

Antenna 1 slightly shorter than antenna 2, about ⅔ length of carapace; last segment of peduncle without spines or teeth; scale narrow. Antenna 2 with 4-segmented peduncle.

Mandible without incisor; palp long, distal segment tapering, with several longitudinal rows of setae. Maxilla 2, distal (4th) endite of protopod well developed; endopod 1-segmented, with series of oval marginal organelles; exopod very small.

Thoracopods all similar, like those of *Nebalia,* with broad exopods and epipods having plumose marginal setae.

Pleopod 1 exopod without the usual dense row of short complex spines on lateral margin.

Caudal rami short and broad, margins densely setose, setae on medial margin very long.

*Type-species.—Speonebalia cannoni,* new species.

*Etymology.—*From the Greek "speos," cave, plus *Nebalia.*

### *Speonebalia cannoni,* new species
Figs. 1–2

*Material.—*Turks and Caicos Islands, Caicos Islands, Providenciales Island: The Hole, 30 Oct 1982, leg. Thomas M. Iliffe, 11 paratypes, USNM 213480, from 5–7 m depths with suction bottle, using scuba. Airport Cave, 31 Oct 1982, leg. Thomas M. Iliffe, holotype, USNM 213478, and 14 paratypes, USNM 213479, from 10 m depths with suction bottle, free-diving.

*Description.—*Length from anterior end of rostrum to posterior end of caudal ramus 8–11 mm (holotype 10.4 mm). Carapace oval, about 1.7× as long as high, reaching posteriorly to pleonite 6, with angular posterodorsal corner below which posterior margin is armed with a series of close-set obtuse spines. Rostrum short, barely reaching beyond anterior margin of carapace, without keel, about ¾ as long as wide, narrowly rounded apically. Eyestalks narrowly pyriform, reaching beyond rostrum by about ⅖ of their lengths, completely lacking visual elements.

Antenna 1 much shorter than carapace, flagellum 13–19-segmented; scale about 6× longer than broad, with cluster of apical setae, longest 1.5× as long as scale, and row of setae on distal half of ventral surface. Antenna 2 slightly longer than antenna 1, segments 3 and 4 of peduncle not fused, armed with rows of long setae; flagellum 16–18-segmented, each segment with distomedial cluster containing long and short naked setae, seta with serrate section near midlength, and 1 or 2 esthetes (Fig. 1i, Table 1).

Mandible with incisor absent or possibly represented by low triangular process distal to molar; molar well developed, with granular oval chewing surface; 1st segment of palp short, unarmed; 2nd segment long, with long seta on anterior margin distal to midlength; 3rd segment slender, slightly shorter than 2nd, with row of long setae rising on medial surface and extending anteromedially and 2 rows of short setae on posterior margin, medial row perpendicular to axis of segment, lateral row directed obliquely distad. Maxilla 1 proximal endite with 12 setae having shape resembling hypodermic syringe, 1 slender distal seta and 1 seta on surface; distal endite with 9 stout spines, some bifid apically, and 2 longer setae distally; palp with cluster of 10 setae at level of endites and about 13 well separated setae along rest of shaft. Maxilla 2 with 4 well-developed densely setose endites, proximal endite about 2× as broad as subequal endites 2–4; endopod 1-segmented, about 3× as long as wide, with 6–7 setae on medial margin, 2 at apex, and 1 on lateral margin distal to midlength; anterior margin with 8–9 papillae having central canal leading to pyriform glands within endopod; exopod very small, about 0.2× as long as endopod, with 5–8 setae on anterior margin and apex.

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Fig. 1. *Speonebalia cannoni*: a, Habitus, lateral; b, Anterior body and carapace, dorsal; c, Rostrum and left eyestalk, lateral; d, Eyestalks, dorsal; e, Right antenna 1, dorsal; f, Antenna 1, segment 9 of

flagellum; g, Antenna 1 scale, ventral; h, Antenna 2 proximal segments, dorsal; i, Antenna 2 flagellum, setal cluster on segment 8; j, Labrum; k, Mandible; l, Maxilla 1; m, Maxilla 1, distal endite; n, Maxilla 2; o, Maxilla 2 endopod, lateral, showing glands; p, Pleonite 4, left lateral.

Table 1.—Composition of setal clusters on flagellum of antenna 2.

| Segment | Short, naked | Long, naked | Serrate at midlength | Esthete |
|---|---|---|---|---|
| 1 | 2 | 1 | — | 1 |
| 2 | 2 | 2 | — | 1 |
| 3 | 2 | 1 | 1 | 2 |
| 4 | 2 | 1 | 1 | 2 |
| 5 | 2 | 1 | 1 | 1 |
| 6 | 2 | 1 | 1 | 2 |
| 7 | 2 | 1 | 1 | 1 |
| 8 | 2 | 1 | 1 | 2 |
| 9 | 2 | 1 | 1 | 2 |
| 10 | 2 | 1 | 1 | 2 |
| 11 | 2 | 1 | 1 | 2 |
| 12 | 2 | 1 | 1 | 2 |
| 13 | 2 | 1 | 1 | 1 |
| 14 | 2 | 1 | 1 | 1 |
| 15 | 2 | 1 | 1 | 1 |
| 16—5 long terminal setae, 2 subterminal lateral setae | | | | |

Thoracopods all similar; endopod longer than exopod, curving laterad, with 4 segments distally, apical segment without marginal notches, medial margin densely setose; exopod lamellate, lateral and apical margins sparsely setose; epipod well developed, lamellate, with proximal and distal lobes, lateral and proximal margins sparsely setose.

Pleopods 1–4 with robust protopods having serrate posterior margins of lateral surface. Endopod longer and narrower than exopod, both margins setose, apex with long terminal spine lateral to which is shorter spiniform process; appendix interna with 2 retinacula. Exopod with setose medial margin; lateral margin armed with long spines and in pleopods 3 and 4 with plumose setae between each pair of spines except distal pair and sometimes proximal pair; apex with long spine. Pleopods 5 and 6 with setae on medial margin, apex, and distal part of lateral margin, those on medial margin shorter and more numerous in pleopod 5; apex with 2 long spines in pleopod 5, 3 in pleopod 6.

Pleonites 4–7 with serrate posterior margins; pleonite 4 with posteroventral corner produced into point; tergum of pleonite 8 (anal segment) incised posteriorly for about ⅓ length; sternum incised more broadly, with rounded shoulders laterally. Caudal ramus slightly longer than pleonites 7 and 8 combined, slightly more than 3× as long as wide; lateral margin armed with progressively longer spines; medial margin densely armed with very long plumose setae; apical spine about half as long as ramus.

We have been unable to determine the sex.

*Etymology.*—Named for H. Graham Cannon (1897–1963) in recognition of his outstanding contributions to our knowledge of the Nebaliacea (1927, 1931, 1960).

*Comparisons.*—Four genera of Nebaliidae are now recognized: *Nebalia* Leach, 1814; *Paranebalia* Claus, 1880; *Nebaliella* Thiele, 1904; *Dahlella* Hessler, 1984. The carapace of these genera is shorter than in *Speonebalia,* not reaching beyond pleonite 5. The rostrum is much larger than in *Speonebalia,* extending well beyond

Fig. 2. *Speonebalia cannoni*: a, Thoracopod 1; b, Thoracopod 8; c, Left pleopod 1, anterior; d, Same, posterior; e, Left pleopod 2, anterior; f, Right pleopod 4, anterior; g, Same, lateral; h, Pleopod 5; i, Pleopod 6; j, Anal segment and uropod, dorsal; k, Posterior part of anal segment, ventral.

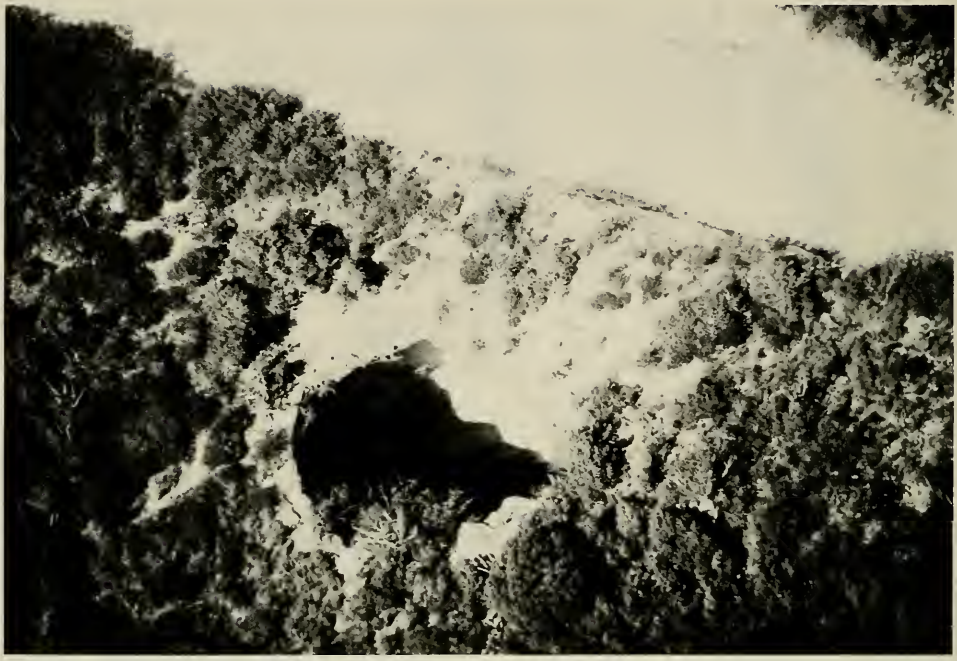

Fig. 3. Entrance to The Hole, Providenciales Island, aerial view. Photograph by Dennis Williams, November 1983.

the eyestalks in *Nebalia, Paranebalia,* and *Dahlella,* and the rostral carina present in *Paranebalia* and *Nebaliella,* is lacking in *Speonebalia.*

Antenna 2 is much longer than antenna 1 in *Nebalia, Paranebalia,* and *Nebaliella,* but only slightly longer in *Dahlella* and *Speonebalia.* The distal peduncular segment of antenna 1 has neither the armature of spines found in *Nebalia* nor the processes present in *Paranebalia* and *Nebaliella.*

The mandibular incisor, well developed in *Nebaliella,* is weakly developed in *Nebalia, Paranebalia,* and *Dahlella,* and absent in *Speonebalia.* The mandibular palp is unusually large in *Speonebalia,* reaching the distal segment of the peduncle of antenna 2; the 3rd segment is unusual in its slender tapering shape and its complex setal armament.

Maxilla 2 is the most distinctive appendage of *Speonebalia.* The 4th endite is well developed in *Nebalia* and *Paranebalia* as in *Speonebalia,* but reduced in *Nebaliella* and *Dahlella.* The 1-segmented endopod of *Speonebalia* is found in *Nebaliella* and *Nebaliopsis*; in *Nebalia, Paranebalia,* and *Dahlella* the endopod is 2-segmented. The glands in the endopod of *Speonebalia* have not been reported from any other Nebaliacean. Only in *Dahlella* is the exopod reduced as in *Speonebalia.*

In *Nebalia, Speonebalia,* and *Dahlella* the thoracopods have well developed endopods, exopods, and epipods. The epipods are absent in *Nebaliella* and much reduced in *Paranebalia.*

In all other genera of Nebaliidae the caudal rami are relatively slender. In *Speonebalia* the dense row of long setae along the medial margin presumably resists sinking and suggests a pelagic rather than a benthic life.

*Habitat.*—The Turks and Caicos Islands are a group of islands lying southeast of the Bahamas and north of Haiti. The basic geological and geomorphological setting is generally similar to that of the Bahama Islands (Gregor 1981). Providenciales Island is located on the northern edge of the Caicos Bank. The main topographical feature of the island is a line of hills 20 to 40 m above sea level running parallel to the coastline. These hills are formed from eolian carbonates, probably of Pleistocene age. Both The Hole and Airport Cave are situated within these hills.

The Hole is a shear-walled cenote-like pit about 15 m deep with a 15 m long by 10 m wide lake at the bottom, open to daylight (Fig. 3). This cave is located at the western end of Providenciales, 1.1 km from the nearest open water, the south coast. The 6 to 8 m deep lake is floored with breakdown and surface debris such that upon exploration of the lake with scuba, no human-sized cave passages were found extending off from it. *Speonebalia* specimens were collected from under a ledge in a dimly illuminated section of the lake. All specimens observed were swimming slowly about in the water column. Other species collected or observed in this lake include a new genus of ostracode in the family Thaumatocyprididae now being described by Louis Kornicker, a new genus of amphipod being studied by John Holsinger, a crab identified as *Sesarma* (*H.*) *miersii* Rathbun by C. W. Hart, Jr. and an uncollected copepod.

Airport Cave is located about 2.2 km inland from the north coast and 100 m north of the new airport terminal on the southern slope of Old Blue Hill. This cave was described by Buden and Felder (1977) as their collection site for the shrimp *Barbouria cubensis.* Airport Cave or one of several nearby caves may also be the nameless "waterhole" located northwest of the airfield which Stock and Vermeulen (1982) listed as the type-locality for the amphipod *Spelaeonicippe provo.* The cave consists of a nearly vertical collapse fissure in a large circular sink. A colony of bats, *Erophylla sezekorni sezekorni* (Gundlach), inhabits the cave, and their guano, dropping into the cave pool, has darkly stained the cave walls and sediments. The upper layer of the pool is anoxic as evidenced by a distinct hydrogen sulphide odor that was noted when the surface waters were disturbed. The visibility in the upper layers of the pool was somewhat reduced, but below about 2 to 3 m the water was very clear. *Speonebalia* specimens were observed to stay in loosely grouped clusters of up to 50 individuals. They were only found in the deeper waters of the pool in total darkness. Other animals observed in the pool include a new family of shrimps now being described by C. W. Hart, Jr. and Raymond Manning, and an amphipod of the same new genus as was found in The Hole. Several individuals of a new species of Remipedia were collected by Jill Yager from Airport Cave during a later visit in April 1983. Contrary to Buden and Felder's (1977) observations, no *Barbouria cubensis* were observed, nor did we find any *Spelaeonicippe provo* that Stock and Vermeulen (1982) had collected here.

During the April 1983 expedition, water salinity in Airport Cave was measured, with the following results: surface, 19.1‰; 3 m, 19.1‰; 5 m, 26.5‰; 7 m, 28.7‰. Temperature was 23.1°C at the surface and 25.6°C at 5 m.

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# ADDITIONAL BRANCHIATE SCALE-WORMS (POLYCHAETA: POLYNOIDAE) FROM GALAPAGOS HYDROTHERMAL VENT AND RIFT-AREA OFF WESTERN MEXICO AT 21°N

Marian H. Pettibone

*Abstract.*—A new subfamily of Polynoidae, Branchinotogluminae, is established for *Branchinotogluma,* new genus, for three new species: *B. hessleri, B. sandersi,* and *B. grasslei,* and *Opisthotrochopodus alvinus,* new genus, new species, all from hydrothermal vents in the eastern Pacific. They are characterized by the presence of well-developed arborescent brachiae and notopodial bracts on some or all of the elytrigerous segments. The posterior segments of *O. alvinus* are greatly modified, having most unusual wheel organs.

The present paper deals with the third subfamily of Polynoidae from the hydrothermal rift-area off Western Mexico at 21°N and the Galapagos hydrothermal vent that is characterized by the presence of the well-developed branchiae, an unusual feature in the family. The two previously described branchiate groups include *Branchipolynoe symmytilida* in Branchipolynoinae, commensal with the deep-sea vent mussels in the Galapagos Rift (Pettibone 1984a) and *Branchiplicatus cupreus* in Branchiplicatinae from the hydrothermal rift-area at 21°N (Pettibone, 1985). Two new genera and four new species, collected in the same two areas, are referred herein to a third new subfamily.

The available material was collected by the Galapagos Rift Biology Expedition in 1979, and by the OASIS group of Scripps Institution of Oceanography in 1982. The specimens were received from J. F. Grassle of the Woods Hole Oceanographic Institute (WHOI), with preliminary sorting by I. Williams. Numerous specimens, including many young, were collected in the Mussel Bed, Garden of Eden, and Rose Garden areas of the Galapagos Rift, in 2451 to 2493 meters, from washings, slurp samples, and residues of mussels and vestimentiferans (*Riftia pachyptila* Jones). From 21°N, specimens were collected in 2612 to 2633 meters, associated with washings and slurp samples of vestimentiferans (*Riftia pachytila* Jones), giant clams (*Calyptogena magnifica* Boss and Turner) and ampharetid polychaetes (*Alvinella pompejana* Desbruyères and Laubier).

The types and additional specimens are deposited in the National Museum of Natural History, Smithsonian Institution (USNM). This is OASIS Expedition Contribution number 26 and Galapagos Rift Biology Expedition number 54, supported by the National Science Foundation.

## Family Polynoidae
## Branchinotogluminae, new subfamily

### General Characteristics

The body is short, flattened, slightly tapering anteriorly and posteriorly, with 21 segments, the first achaetous. The parapodia are longer than the body width.

The posterior few segments may be unmodified (*B. hessleri, B. grasslei*; Figs. 1C, D, 5E, F), the posterior 3 segments may be somewhat modified (*B. sandersi*; Fig. 4B–H) or the posterior 4 segments may be greatly modified, including wheel organs (*O. alvinus*; Fig. 9A–N).

There are 10 pairs of elytra attached on prominent bulbous elytrophores on segments 2, 4, 5, 7, 9, 11, 13, 15, 17, and 19. The elytra are large, overlapping and cover the dorsum. They are oval, delicate, usually with branched "veins" arising from their place of attachment to the elytrophores; tubercles and papillae are lacking (Fig. 5G). Dorsal cirri are borne on segments 3, 6, 8, 10, 12, 14, 16, 18, 20, and 21. The cirrophores are short, cylindrical, attached posteriorly on the notopodia; the styles are long, filiform, smooth, extending to the tips of the neurosetae or far beyond (Fig. 2D). Dorsal tubercles on the cirrigerous segments, in line with the elytrophores, are inflated and indistinct (*B. grasslei, B. sandersi*) or elongate and tapered (*B. hessleri, O. alvinus*; Figs. 1B, C, 7C, E). The dorsum has transverse ciliated bands, 2 per segment, extending onto the elytrophores and dorsal tubercles Fig. 1A–C).

Compact arborescent branchiae, with short (*B. sandersi, B. grasslei*; Figs. 3E, 6C, D) or long (*B. hessleri, O. alvinus*; Figs. 2D; 7E) terminal filaments, are present as 2 main groups attached to the lateral sides of the elytrophores or dorsal tubercles and on the dorsal sides of the notopodia beginning on segment 3 (Fig. 2B–D). The branchiae continue to the posterior end (*B. hessleri*; *B. grasslei*; Figs. 1C, 5D), except for the species with modified posterior ends where the branchiae are absent on the posterior 3 (*B. sandersi*; Fig. 4B) or 4 (*O. alvinus*; Fig. 9A) modified segments.

The prostomium is oval, bilobed, with triangular or cylindrical anterior lobes with delicate frontal filaments (Figs. 1A, 3A). A median antenna with a bulbous ceratophore is inserted in the anterior notch. Paired palps are stout, smooth and tapered. Lateral antennae and eyes are absent. The first or tentacular segment is not visible dorsally. Tentaculophores, lateral to the prostomium, are achaetous, each with a pair of long dorsal and ventral tentacular cirri (Fig. 1A). Ventrally the tentacular segments contributes to the anterior and lateral lips of the mouth (Fig. 5C). The second or buccal segment bears the first pair of elytrophores, elytra, biramous parapodia, and paired ventral or buccal cirri with short cirrophores inserted basally on the neuropodia; their styles are longer than the following ventral cirri, similar to the tentacular cirri (Figs. 5B, C, 7A, B). The buccal segment contributes to the posterior lip of the ventral mouth. The muscular pharynx is eversible, with 5 papillae around the opening: 3 dorsal and 2 ventral (Figs. 1F, 8H). The two pairs of hooked jaws are minutely denticled along the border (Figs. 1F, 5H, 8H, I).

The parapodia are biramous, with the notopodia shorter than neuropodia, both rami having projecting acicular processes (Fig. 2B–D). Prominent notopodial bracts enclosing the acicular lobes and notosetae are present only on elytrigerous segment 2 (*B. sandersi*; *B. grasslei*; Figs. 3A, B, 5B, 6A) or on all the elytrigerous segments (*B. hessleri, O. alvinus*; Figs. 1A–C, 7A, B, D). The notosetae are stouter than the neurosetae, straight, acicular, smooth (Fig. 6E) or with scattered spines (Fig. 1E). The neuropodia have longer flattened conical presetal lobes with projecting acicular processes and shorter, rounded postsetal lobes. The neurosetae are slender, finely spinous, with slightly hooked tips (Fig. 3G, H). The ventral cirri are short, tapered, and attached on the middle of the neuropodia (Fig. 2B–D).

The pygidium is enclosed in the parapodia of the posterior few segments, with or without a pair of anal cirri (Fig. 1C, D, 4C). Ventral segmental papillae may be absent or variously developed, such as a pair of elongated papillae on segment 12, followed by 5 pairs of short rounded lamellae on segments 13–17 (*O. alvinus*; Fig. 9B); 4 pairs of long papillae on segments 12–15 and 3 pairs of rounded lamellae on segments 16–18 (*H. sandersi*; Fig. 4I); 6 pairs of small rounded lamellae on segments 11–16 (*B. hessleri*; Fig. 2H) or 5 pairs of small squarish papillae on segments 11–15 (*B. grasslei*; Fig. 6H).

### Key to the Genera and Species of Branchinotogluminae

1. Posterior 4 segments (18–21) compressed, with parapodia greatly modified, including wheel organs on segment 20 (Fig. 9N). *Opisthotrochopodus,* new genus. Notopodia with prominent rounded bracts on elytrigerous segments 2–17 (Figs. 7A, D, 8A, C). Arborescent branchiae on segments 3–17, with rather long terminal filaments (Figs. 7A, C–E, 8A–C). Dorsal tubercles elongate, tapered (Figs. 7C, 8A). Notosetae stout, acicular, smooth or with 1–2 rows of spines (Fig. 7F). With pair of elongated ventral papillae on segment 12 and 5 pairs of short rounded lamellae on segments 13–17 (Fig. 9B) .......................................... *O. alvinus,* new species

– Posterior 4 segments not compressed or only 3 posterior segments (19–21) slightly modified, without wheel organs on segment 20 .......... .................. *Branchinotogluma,* new genus ................. 2

2. Prominent notopodial bracts on all elytrigerous segments (Figs. 1A–C, 2A, C). Arborescent branchiae with rather long terminal filaments (Fig. 2D). Posterior segments not modified, with branchiae on all segments from segment 3 on (Fig. 1A, C). Dorsal tubercles projecting posteriorly, with branchiae on lateral side, ciliated on posterior side (Fig. 1B). Notosetae stout, acicular, smooth or with 2 rows of spines (Fig. 2E). Ventral segmental lamellae 6 pairs, on segments 11–16, small rounded (Fig. 2H) ......... ................................................ *B. hessleri,* new species

– Notopodial bracts on segment 2 only (Figs. 3A, B, 5A, B, 6A). Arborescent branchiae with short terminal filaments (Figs. 3E, 6D). Dorsal tubercles inflated, indistinct. Notosetae stout, acicular, smooth (Figs. 3F, 6E) .... 3

3. Posterior 3 segments slightly compressed and modified, with branchiae absent from segments 19–21 (Fig. 4B–H). With 4 pairs of elongated ventral segmental papillae on segments 12–15 (Fig. 4I) and 3 pairs of rounded lamellae on segments 16–18 ..................... *B. sandersi,* new species

– Posterior segments not compressed or modified, with branchiae on all segments from segment 3 on (Fig. 5B, E, F). Without elongated ventral segmental papillae; with or without 5 pairs of small, squarish segmental papillae on segments 11–15 (Fig. 6H) ............. *B. grasslei,* new species

### *Branchinotogluma,* new genus

*Type-species.—Branchinotogluma hessleri,* new species. Gender: feminine.

*Diagnosis.*—Body short, with 21 segments, first achaetous. Elytra and elytrophores 10 pairs, on segments, 2, 4, 5, 7, 9, 11, 13, 15, 17, and 19. Dorsal cirri with short cylindrical cirrophores and long distal styles, and dorsal tubercles, in line with elytrophores, on segments 3, 6, 8, 10, 12, 14, 16, 18, 20, and 21. Arborescent branchiae attached to lateral sides of elytrophores, dorsal tubercles, and dorsal sides of notopodia beginning on segment 3 and continuing to near or end of body. Prostomium bilobed, with triangular anterior lobes bearing minute frontal filaments, with median antenna in anterior notch and paired palps; without lateral antennae or eyes. First or tentacular segment not visible dorsally; tentaculophores lateral to prostomium, each with pair of dorsal and ventral tentacular cirri, without setae. Second or buccal segment with first pair of elytra, biramous parapodia and ventral or buccal cirri attached to basal parts of parapodia lateral to ventral mouth; styles longer than following ventral cirri. Parapodia biramous, with notopodia shorter than neuropodia. Notopodia of elytrigerous segments with prominent rounded bracts enclosing flattened conical acicular lobes and notosetae (*B. hessleri*) or present only on elytrigerous segment 2 (*B. sandersi, B. grasslei*). Neuropodia with longer flattened conical presetal and shorter rounded postsetal lobes. Notosetae stouter than neurosetae, straight, acicular, smooth or with few spines. Neurosetae long, slender, finely spinous, with slightly hooked tips. Ventral cirri short, tapered. Posterior 4 segments not greatly modified, without wheel organs or posterior 3 segments slightly modified (*B. sandersi*). Pharynx with 5 papillae around opening, 3 dorsal and 2 ventral; 2 pairs of dorsal and ventral hooked jaws each with row of numerous minute teeth along edge.

*Etymology.*—*Branchi* from the Greek *branchia* for gills, plus *noto* from *notos,* Greek for back, and *gluma* from the Latin *gluma,* a bract, referring to the presence of branchiae and notopodial bracts.

## *Branchinotogluma hessleri,* new species
Figs. 1, 2

*Material examined.*—Pacific Ocean off Western Mexico, 20°50′N, 109°06′W, OASIS *Alvin* dives in 1982: Dive 1214, 20 Apr, 2633 m, vestimentiferan wash, 19 paratypes including 6 young (USNM 97323). Dive 1218-15, 24 Apr, 2618 m, clam and crab trap wash, paratype (USNM 97324). Dive 1219-10A & B, 25 Apr, 2612 m, *Riftia* and clam wash, paratype (USNM 97325). Dive 1221-15, 4 May, 2618 m, *Riftia* and *Clayptogena* wash, coarse fraction, holotype (USNM 97321) and 7 paratypes (USNM 97322). Dive 1223-11, 7 May, 2616 m, *Riftia* and *Calyptogena* wash, coarse fraction, 4 paratype (USNM 97326).

East Central Pacific, from dive of the *Alvin* along the Galapagos Rift in 1979: ROSE GARDEN, 00°48′15″N, 86°13′28″W: Dive 984-32, 1 Dec, 2451 m, mussel washings, 3 paratypes (USNM 97327).

*Description.*—Length of holotype 14 mm, width 8 mm with setae, segments 21. Body flattened, tapering slightly anteriorly and posteriorly, with parapodia longer than body width. No color except for yellow amber-colored setae. Dorsum with transverse ciliated bands, 2 per segment, extending onto elytrophores and dorsal tubercles (Fig. 1A–C).

Elytra and prominent bulbous elytrophores 10 pairs (Figs. 1A–C; 2A, C). Elytra large, covering dorsum, round to oval, delicate, with branched "veins" (Fig. 1E). Dorsal cirri with short cylindrical cirrophores and long tapered smooth styles extending beyond tips of setae (Figs. 1A–D, 2B, D). Dorsal tubercles elongate.

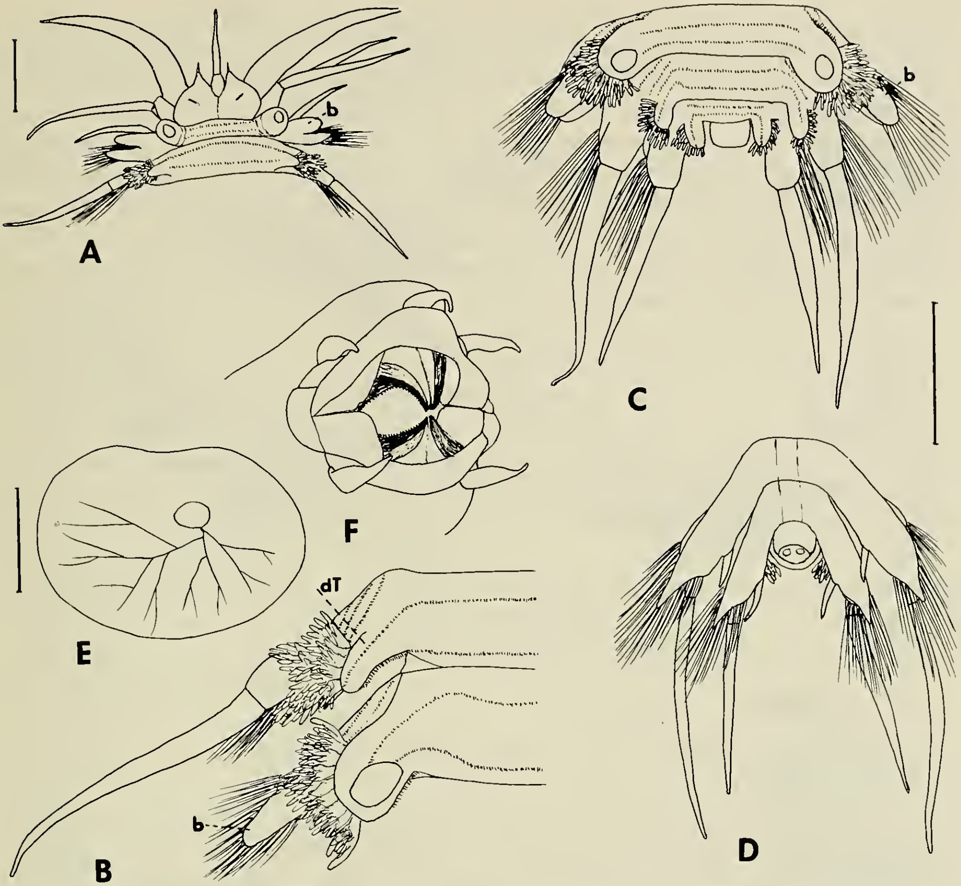

Fig. 1. *Branchinotogluma hessleri,* A–E, Holotype, USNM 97321; F, Paratype, USNM 97323: A, Dorsal view of anterior end, style of left dorsal tentacular cirrus missing; B, Dorsal view of left side of segments 8 (cirrigerous) and 9 (elytrigerous); C, Dorsal view of posterior end, including segments 19–21; D, Ventral view of posterior end, including segments 20 and 21; E, Right elytron from near posterior end; F, End view of opened pharynx, tipped slightly to left. b, notopodial bract; dT, dorsal tubercle. Scales = 1.0 mm for A; 1.0 mm for B–D, F; 1.0 mm for E.

Both elytrophores and dorsal tubercles directed posterolaterally, with group of delicate arborescent branchiae attached on their lateral sides and additional small group of branchiae attached on bases of notopodia; branchiae compact, with rather long terminal filaments (Figs. 1A–C, 2B–D). Branchiae beginning on segment 3 as 2 small groups (Fig. 2B), becoming larger on following segments (Fig. 2C, D) and continuing to posterior end (Fig. 1C, D).

Prostomium bilobed, oval, anterior lobes triangular with delicate frontal filaments; median antenna with bulbous ceratophore in anterior notch, with style about as long as prostomium; palps stout, tapered, smooth; without eyes (pair of shaded areas sometimes appearing as "eyes"; Fig. 1A). Tentaculophores of first segment lateral to prostomium, with 2 pairs of tentacular cirri similar in length and slightly shorter than palps; ventrally tentacular segment forming anterior and lateral lips of mouth. Second or buccal segment forming posterior lip of mouth

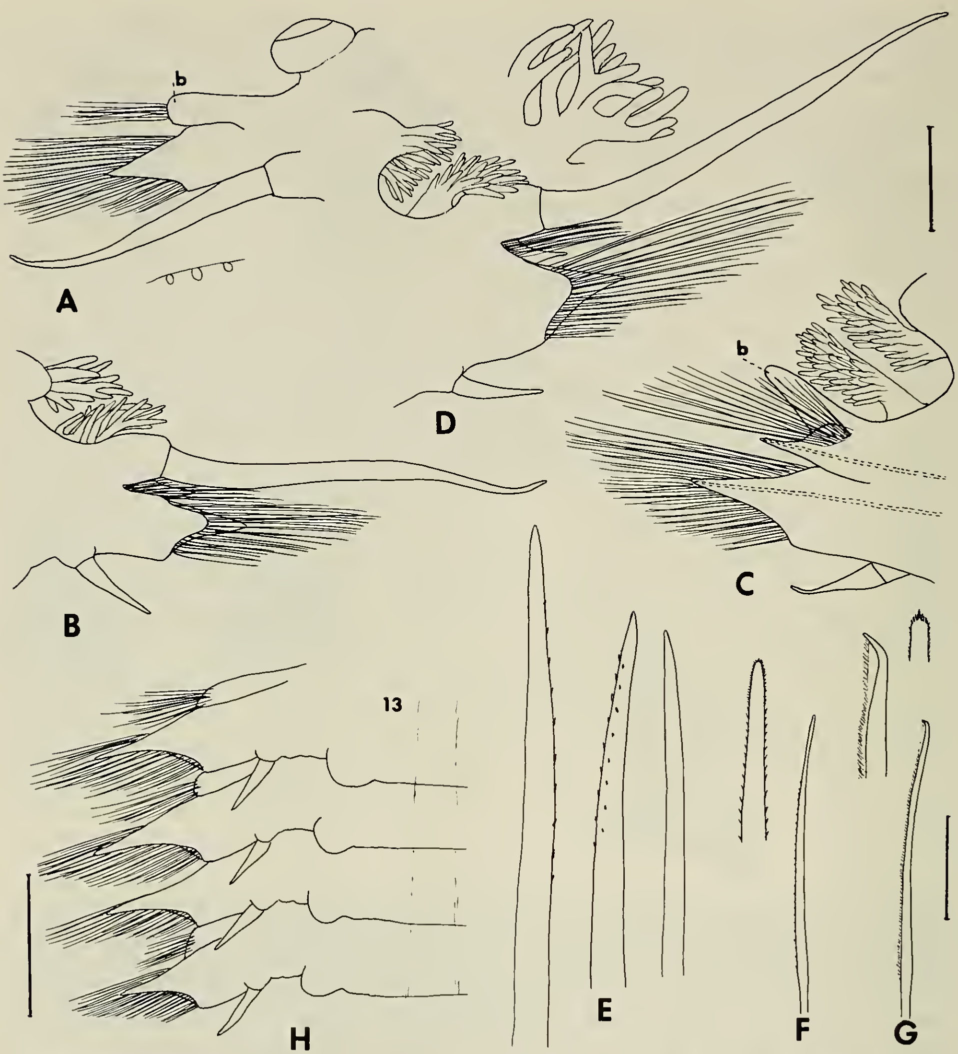

Fig. 2. *Branchinotogluma hessleri,* holotype, USNM 97321: A, Right elytrigerous parapodium of segment 2, anterior view, with detail of neuropodial border papillae; B, Right cirrigerous parapodium of segment 3, posterior view; C, Right elytrigerous parapodium of segment 9, anterior view, acicula dotted; D, Right cirrigerous parapodium of segment 10, posterior view with detail of branchial tips; E, Three notosetae; F, Upper neuroseta, with detail of tip; G, Middle neuroseta, with detail of tips; H, Ventral view of right side of segments 13–16, showing ventral segmental lamellae. b, notopodial bract. Scales = 0.5 mm for A–D; 0.1 mm for E–G; 1.0 mm for H.

and bearing biramous parapodia and first pair of elytrophores; notopodium with hood or bract encircling small bundle of notosetae; conical neuropodium with globular micropapillae on distal border; ventral buccal cirri similar to tentacular cirri, longer than following ventral cirri (Figs. 1A, 2A).

Everted muscular pharynx showing 5 papillae around opening: 3 dorsal and 2 ventral; 2 pairs of prominent jaws, minutely denticled on inner border (Fig. 1F).

Biramous parapodia with notopodia shorter than neuropodia, both rami with light yellow amber-colored setae (Fig. 2A–D). Notopodia with short conical acicular lobes and, on elytrigerous segments, with prominent bracts enclosing notosetae dorsally and posteriorly (Figs. 1A–C, 2A, C). Notosetae forming radiating bundles, short to long, some almost as long as neurosetae, acicular, much stouter than neurosetae, smooth or with 1–2 rows of short spines (Fig. 2E). Larger neuropodia with subconical presetal lobes tapering to sharp tips; postsetal lobes shorter, rounded; some globular micropapillae on distal borders. Neurosetae slender, very numerous, forming fan-shaped bundles. Few upper neurosetae with more prominent spines, with tips flattened and finely spinous (Fig. 2F). Remaining neurosetae with borders finely spinous; tips slightly hooked, with finely spinous hood (Fig. 2G). Lower neurosetae shorter and more slender. Ventral cirri short, tapered, attached on middle of neuropodia (Fig. 2C, D).

Pygidium consisting of small squarish to rounded lobe wedged between bases of posteriorly-directed parapodia of posterior 2 segments, with pair of anal cirri (mostly broken off; Fig. 1C, D). Six pairs of small rounded segmental lamellae near ventral bases of neuropodia of segments 11–16 (Fig. 2H); only 2–3 pairs on segments 11–13 of smaller specimens.

Young specimens with 17 or fewer segments may be confused with *Opisthotrochopodus alvinus.* See below under *Branchinotogluma* sp. A.

*Etymology.*—The species is named for Robert R. Hessler, one of the observers on the OASIS *Alvin* dives.

### *Branchinotogluma sandersi,* new species

Figs. 3, 4

*Material examined.*—East Central Pacific, from dives of the *Alvin* along the Galapagos Rift in 1979: MUSSEL BED, 00°47′53″N, 86°09′12″W: Dive 880, 21 Jan, 2493 m, mussel washings, paratype (USNM 97330). Dive 989, 6 Dec, 2482 m, bottle rack wash no. 1, paratype (USNM 97331). GARDEN OF EDEN, 00°47′41″N, 86°07′44″W: Dive 883, 25 Jan, 2493 m, slurp sample in mussel area, paratype (USNM 97332). Dive 884, 25 Jan, 2482 m, residue from vestimentiferan tubes, young paratype (USNM 97333). ROSE GARDEN, 00°48′15″N, 86°13′28″W: Dive 983-112, 30 Nov, 2457 m, washings, paratype (USNM 97329). Dive 990-41, 7 Dec, 2451 m, vestimentiferan wash, holotype (USNM 97328).

Pacific Ocean off Western Mexico, 20°50′N, 109°06′W, OASIS *Alvin* dives in 1982: Dive 1214, 20 Apr, 2633 m, vestimentiferan wash, 6 paratypes including 3 young (USNM 97334). Dive 1219-1B, 25 Apr, 2612 m, slurp sample in *Riftia* habitat, 3 paratypes (USNM 97335). Dive 1221-15, 4 May, 2618 m, *Riftia* and *Calyptogena* wash, coarse fraction, 6 paratypes (USNM 97336).

*Description.*—Length of holotype from Galapagos Rift (USNM 97328) 26 mm, width 13 mm with setae, segments 21. Length of largest paratype from 21°N (*Alvin* dive 1214; USNM 97334) 16 mm, width 6 mm, segments 21. Body rectangular, flattened, tapering slightly anteriorly and posteriorly, with parapodia longer than body width. Posterior 3 segments (19–21) compressed, with parapodia modified, differing from more anterior parapodia as well as from one another (Fig. 4B–H). No color except for golden-colored setae. Dorsum with transverse ciliated bands, 2 per segment, extending onto elytrophores and dorsal tubercles (Fig. 4A).

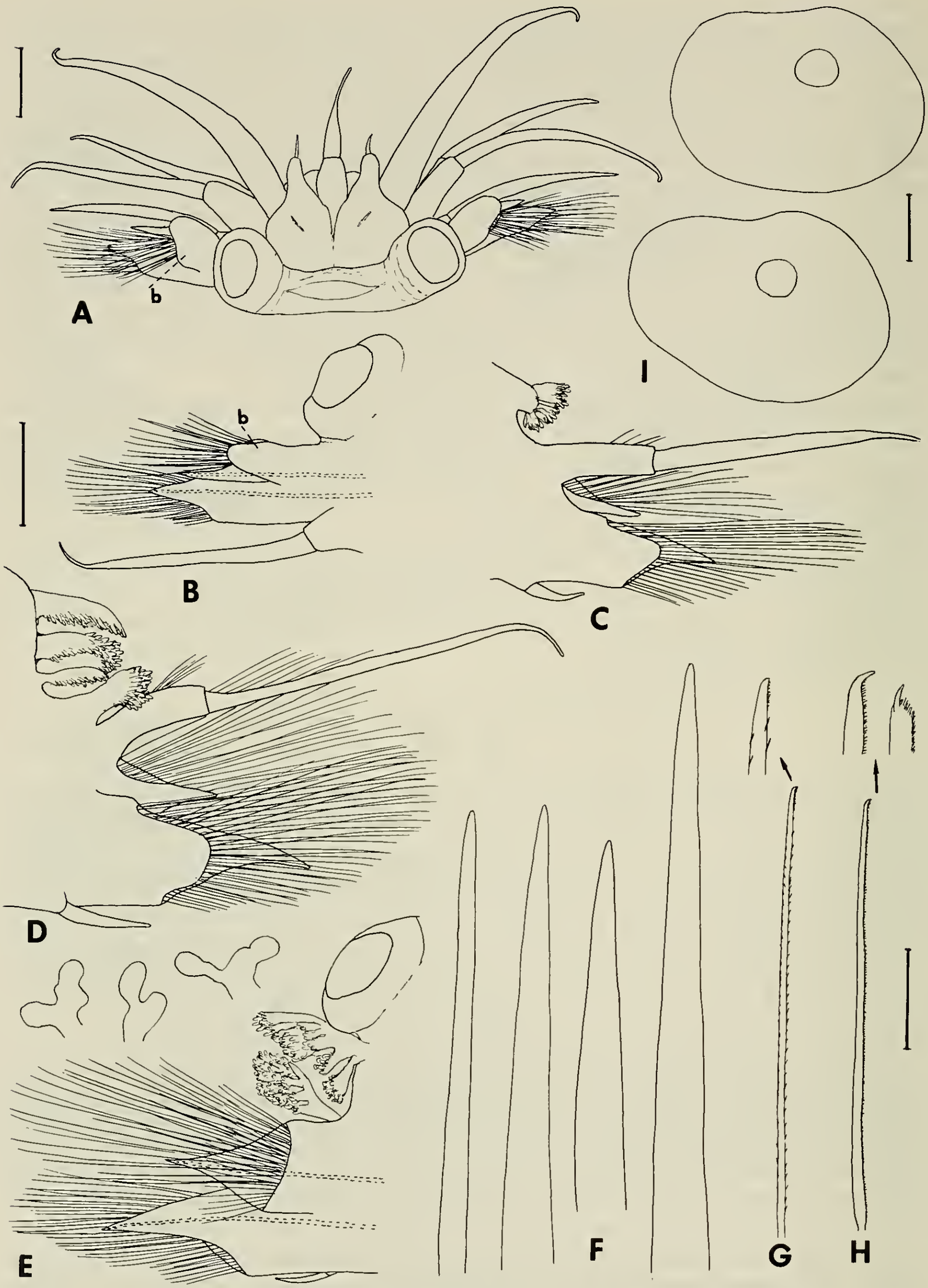

Fig. 3. *Branchinotogluma sandersi,* holotype, USNM 97328: A, Anterior end, dorsal view; B, Right elytrigerous parapodium of segment 2, anterior view, acicula dotted; C, Right cirrigerous parapodium of segment 3, posterior view; D, Right cirrigerous parapodium of segment 8, posterior view; E, Right elytrigerous parapodium of segment 9, anterior view, acicula dotted, with detail of branchial tips; F, Four notosetae; G, Supraacicular neuroseta, with detail of tip; H, Subacicular notoseta, with detail of tips; I, Two right elytra. b, notopodial bract. Scales = 1.0 mm for A; 1.0 mm for B–E; 0.1 mm for F–H; 2.0 mm for I.

Elytra and prominent bulbous elytrophores number 10 pairs (Figs. 3A, B, E, 4A, B, D). Elytra large, covering dorsum, round to oval, stiff, opaque (Fig. 3I). Dorsal cirri with rather long cylindrical cirrophores and long tapered smooth styles extending beyond tips of setae (Figs. 3C, D, 4A, B). Dorsal tubercles inflated, indistinct. Both elytrophores and dorsal tubercles with delicate arborescent branchiae attached on their lateral sides, with additional smaller groups of branchiae attached on dorsal bases of notopodia. Branchiae short, compact, with numerous short, curled branches and short terminal filaments (Figs. 3C–E, 4A, B). Branchiae beginning on segment 3 as single small group (Fig. 3C), becoming larger more posteriorly and continuing to segment 18 (Fig. 4B).

Prostomium bilobed, anterior lobes prominent, cylindrical, with terminal filaments; median antenna with cylindrical ceratophore in anterior notch, with style short, subulate, with long terminal filament; palps stout, tapered, smooth; without eyes (pair of shaded areas sometimes appearing as eyes; Fig. 3A). Tentaculophores with 2 pairs of tentacular cirri, dorsal ones about length of palps, ventral ones slightly shorter; ventrally tentacular segment forming anterior and lateral lips of mouth. Second or buccal segment forming posterior lip of mouth and bearing biramous parapodia and first pair of elytrophores; notopodia with rounded thickened bract on anterodorsal side of large bundle of notosetae; ventral buccal cirri similar to tentacular cirri, longer than following ventral cirri (Fig. 3A, B).

When everted, muscular pharynx showing 5 papillae around opening: 3 dorsal and 2 ventral; 2 pairs of prominent jaws minutely denticled on inner border.

Parapodia of segments 2 to 18 biramous, with notopodia shorter than neuropodia, both rami with golden-colored setae (Fig. 3A–E). Notopodia conical with projecting acicular process, without bracts except on segment 2. Notosetae numerous, short to long, forming radiating bundle, much stouter than neurosetae, tapered, straight, smooth, acicular (Fig. 3F). Neuropodia with long conical presetal acicular lobes; postsetal lobes shorter, rounded. Neurosetae very numerous, slender, forming fan-shaped bundles. Supraacicular neurosetae with 2 rows of more prominent spines; distal part finely spinous with tip slightly hooked (Fig. 3G). Subacicular neurosetae decreasing in length ventrally, finely spinous up to hooked tip, with flattened finely spinous hood (Fig. 3H). Ventral cirri short, tapered, attached on middle of neuropodia (Fig. 3D, E).

Parapodia of posterior 3 segments modified, directed posteriorly and enclosed in parapodia of cirrigerous segment 18, all with ventral cirri but with branchiae lacking (Fig. 4B, C). Parapodia of elytrigerous segment 19 biramous,with rami similar in length; notopodia with thickened dorsal bract (Fig. 4B, D).

Parapodia of segment 20 much smaller and enclosed in parapodia of segment 19 (Fig. 4B, C, E). Notopodial acicular lobe fused to cirrophore of dorsal cirrus, with short distal style; notosetae few (about 9), short, stout, curved, with 2 rows of spines on distal part (Fig. 4F). Neuropodia subconcial, rounded distally, with small bundle of neurosetae: upper ones stouter with scattered long spines and rounded tips; few lower ones slender, capillary, with single basal spine (Fig. 4G).

Parapodia of segment 21 (Fig. 4B, C, H) with notopodia similar to that of 20, formed of fused acicular lobe and dorsal cirrophore, with very short distal style and with notosetae lacking. Neuropodia formed of short conical acicular lobe with small group of delicate neurosetae.

Pygidium squarish, wedged between parapodia of segments 19 to 21, with pair

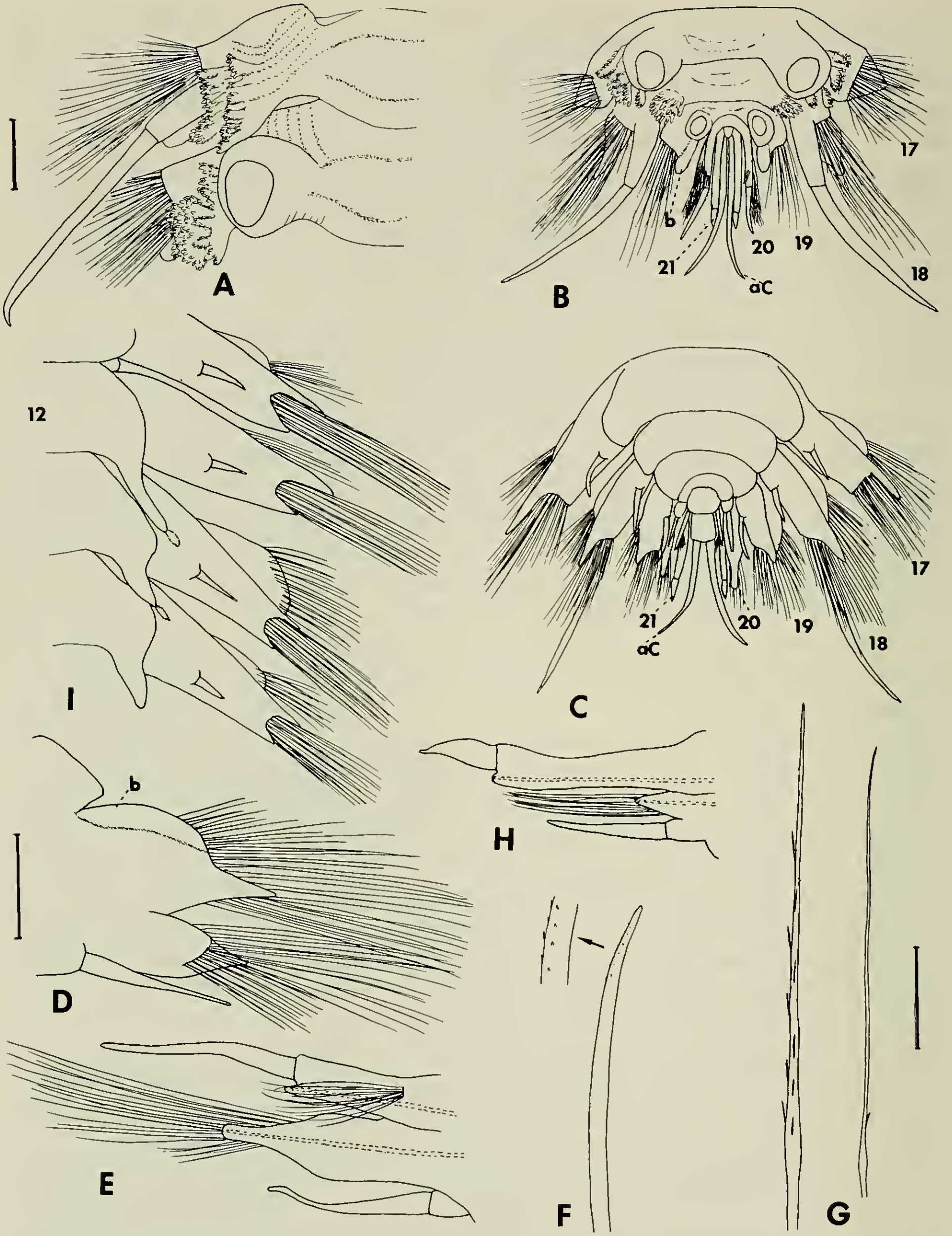

Fig. 4. *Branchinotogluma sandersi,* holotype, USNM 97328: A, Dorsal view of left parapodia of segments 8 (cirrigerous) and 9 (elytrigerous); B, Dorsal view of posterior end including segments 17–21; C, Same, ventral view; D, Right elytrigerous parapodium of segment 19, posterior view; E, Right cirrigerous parapodium of segment 20, anterior view, acicula dotted; F, Notoseta from same, with detail of part; G, Upper and lower neurosetae from same; H, Right cirrigerous parapodium of segment 21, anterior view, acicula dotted; I, Ventral view of left side of segments 11–14, showing long segmental papillae; aC, anal cirrus; b, notopodial bract. Scales = 1.0 mm for A–C, I; 0.5 mm for D, E, H; 0.1 mm for F, G.

of long anal cirri (Fig. 4C). Four pairs of long segmental ventral papillae on segments 12 to 15, becoming shorter posteriorly, some showing "secretion" emanating from papillar opening (Fig. 4I). Three pairs of rounded ventral lamellae on following segments 16 to 18. On juveniles, small developing papillae on segment 12 to 13 or 14.

Young specimens with 17 or fewer segments may be confused with *Branchinotogluma grasslei.* See below under *Branchinotogluma* sp. B.

*Etymology.*—The species is named for Howard L. Sanders, one of the observers on the OASIS *Alvin* dives.

### *Branchinotogluma grasslei,* new species
Figs. 5, 6

*Material examined.*—Pacific Ocean off Western Mexico, 20°50′N, 109°06′W, OASIS *Alvin* dives in 1982: Dive 1214, 20 Apr, 2633 m, vestimentiferan wash, 7 paratypes (USNM 97317). Dive 1215-6A, 21 Apr, 2616 m, slurp sample, paratype (USNM 97318). Dive 1219-1A, 10A & B, 25 Apr, 2612 m, slurp sample in *Riftia* habitat, *Riftia* and clam wash, 4 paratypes (USNM 97319). Dive 1221, 4 May, 2618 m *Riftia* and *Calyptogena* wash, coarse fraction, holotype (USNM 97314) and 11 paratypes (USNM 97315, 97316).

East Central Pacific, from dive of the *Alvin* along the Galapagos Rift in 1979: MUSSEL BED, 00°47′53″N, 86°09′12″W: Dive 989, 6 Dec, 2482 m, bottle rack wash no. 1, paratype (USNM 97320).

*Description.*—Length of holotype from 21°N (USNM 97314) 19 mm, width 11 mm with setae, segments 21. Length of large paratype from Galapagos Rift (USNM 97320) 31 mm, width 20 mm, segments 21. Body flattened, tapering slightly anteriorly and posteriorly, with parapodia longer than body width. No color except for golden- or bronze-colored setae. Dorsum with transverse ciliated bands, 2 per segment, extending onto elytrophores and dorsal tubercles (Fig. 5B, D).

Elytra and prominent bulbous elytrophores number 10 pairs (Figs. 5A, B, D, E, 6C). Elytra large, covering dorsum, round to oval, delicate, with branched "veins" (Fig. 5G). Dorsal cirri with cylindrical cirrophores and long tapering smooth styles extending to about tips of setae or beyond (Figs. 5B, D, E, 6B). Dorsal tubercles inflated, indistinct. Both elytrophores and dorsal tubercles with group of delicate arborescent branchiae attached on their lateral sides and additional smaller group of branchiae on bases of notopodia; branchiae short, compact, with numerous short, curled branches (Figs. 5D, E, 6B–D). Branchiae beginning on segment 3 as 2 small groups (Fig. 5B), becoming larger on following segments (Fig. 6B–D) and continuing to posterior end (Fig. 5E).

Bilobed prostomium with prominent cylindrical anterior lobes with terminal filaments; median antenna with bulbous ceratophore in anterior notch, with short tapered style; palps stout, tapered, smooth; without eyes (shaded areas may appear as pair of eyes; Fig. 5A, B). Tentaculophores with 2 pairs of tentacular cirri, dorsal pairs longer than palps, ventral pairs slightly shorter; ventrally tentacular segment forming anterior and lateral lips of mouth (Fig. 5A–C). Second or buccal segment forming posterior lip of mouth and bearing biramous parapodia and first pair of elytrophores; notopodia with hood or bract encircling bundle of notosetae; ventral buccal cirri similar to tentacular cirri, longer than following ventral cirri (Figs. 5A–C, 6A).

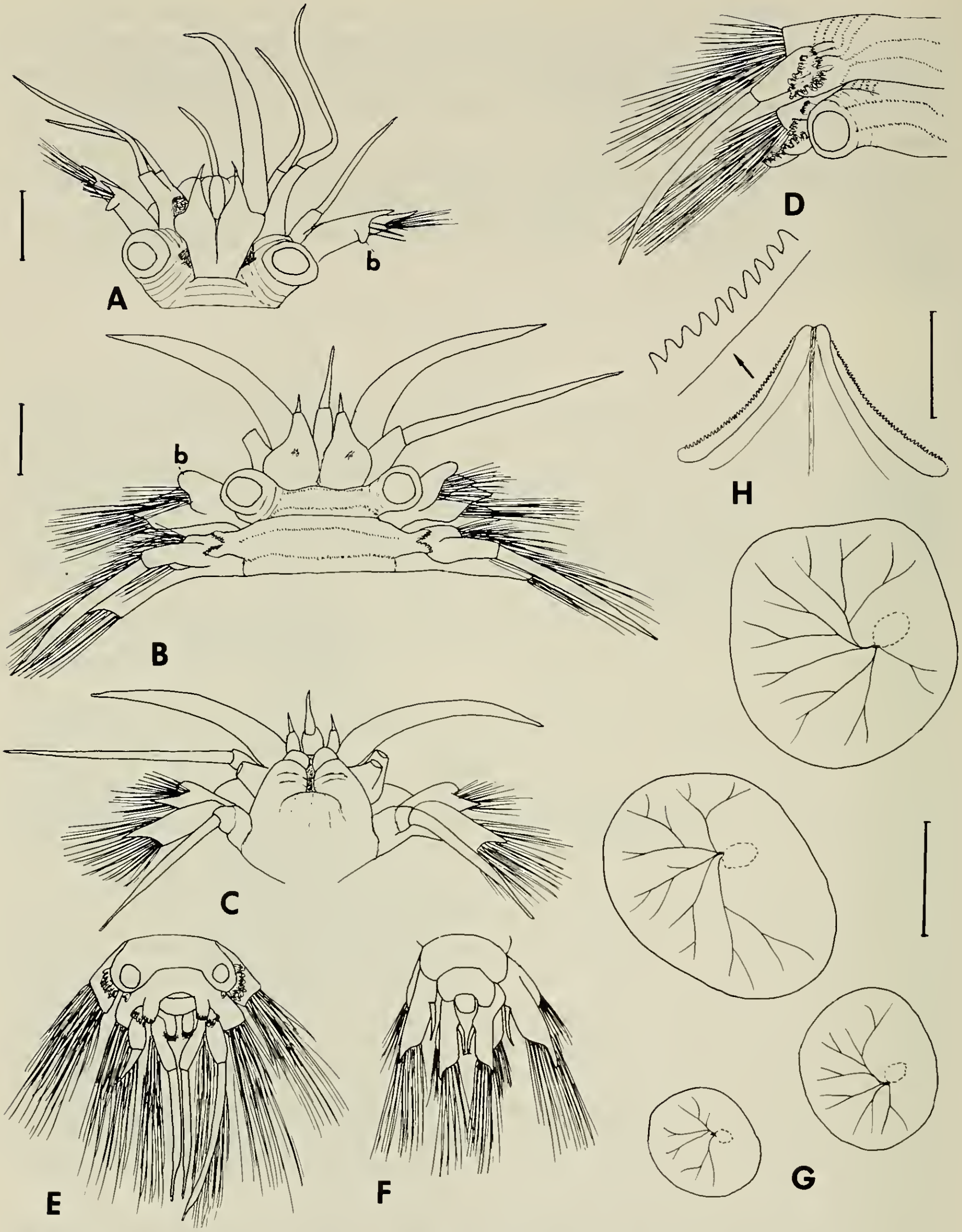

Fig. 5. *Branchinotogluma grasslei,* A, paratype, USNM 97320; B–G, holotype, USNM 97314; H, paratype, USNM 97315: A, Anterior end, dorsal view, pharynx partially extended; left palp missing; B, Anterior end, dorsal view, right ventral, left dorsal and ventral tentacular cirri missing; C, Same, ventral view; D, Dorsal view left parapodium of segments 10 (cirrigerous) and 11 (elytrigerous); E, Dorsal view posterior end, including segments 19–21, left dorsal cirrus of segment 20 short, regenerating; F, Ventral view posterior end, including segments 20 and 21; G, Four elytra; H, Dorsal jaws spread apart, with detail of part. b, notopodial bract. Scales = 2.0 mm for A; 1.0 mm for B–F; 2.0 mm for G; 0.5 mm for H.

Everted muscular pharynx showing 5 papillae around opening: 3 dorsal and 2 ventral; 2 pairs of prominent jaws, minutely denticled on inner border (Fig. 5H).

Biramous parapodia with notopodia shorter than neuropodia, both rami with golden- or bronze-colored setae (Fig. 6A–C). Notopodia conical, with prominent projecting acicular process; notopodia with notopodial bract on segment 2 only (Fig. 5A). Notosetae numerous, short to long, not as long as neurosetae, tapered, straight, acicular, smooth, much stouter than neurosetae (Fig. 6E). Larger neuropodia with conical presetal lobes tapering to sharp tips, diagonally truncate dorsally, rounded on ventral half; postsetal lobes shorter, rounded. Neurosetae slender, very numerous, forming fan-shaped bundle. Supraacicular neurosetae with 2 rows of prominent spines, with tips flattened and finely spinous (Fig. 6F). Subacicular neurosetae finely spinous along border, with tips slightly hooked and with finely spinous hood (Fig. 6G). Few lower neurosetae with capillary tips. Ventral cirri short, tapering, attached on middle of neuropodia (Fig. 6B, C).

Pygidium consisting of small squarish lobe wedged between posteriorly-directed parapodia of posterior 2 segments (20, 21), with pair of anal cirri (all missing; Fig. 5E, F). With or without 5 pairs of small squarish segmental ventral papillae near ventral bases of neuropodia on segments 11–15 (Fig. 6H).

Young specimens with 17 or fewer segments may be confused with *Branchinotogluma sandersi.* See below under *Branchinotogluma* sp. B.

*Etymology.*—The species is named for J. Frederick Grassle, one of the observers on the OASIS *Alvin* dives.

## *Opisthotrochopodus,* new genus

*Type-species.*—*Opisthotrochopodus alvinus,* new species. Gender: masculine.

*Diagnosis.*—As in *Branchinotogluma* with following additions: Notopodia of elytrigerous segments 2–17 with prominent rounded bracts enclosing subconical acicular lobes and notosetae. Posterior 4 segments (18–21) without branchiae, compressed, with parapodia directed posteriorly and greatly modified, including expanded delicate lamellae, elongated cylindrical notopodia fused with dorsal cirrophores and distal styles on segments 20 and 21; achaetous notopodia on segments 19–21; achaetous neuropodia on segments 18 and 19; unique neuropodial wheel organs on segment 20, including stout acicular and hooked neurosetae.

*Etymology.*—The name is derived from Greek: *opistho,* behind, plus *trocho* from *trochos,* a wheel, and *podus* from *podos,* foot, referring to the modified posterior parapodium forming a wheel organ.

## *Opisthotrochopodus alvinus,* new species

Figs. 7–9

*Material examined.*—East Central Pacific, from dives of the *Alvin* on 3 vent areas along the Galapagos Rift in 1979: MUSSEL BED, 00°47′53″N, 86°09′12″W: Dive 880, 21 Jan, 2493 m, mussel washings, paratype (USNM 97253). GARDEN OF EDEN, 00°47′41″N, 86°07′44″W: Dive 884, 25 Jan, 2482 m, clam bucket with mussels, paratype (USNM 97254). ROSE GARDEN, 00°48′15″N, 86°13′28″W: Dive 983-112, 30 Nov, 2457 m, mussel washings, holotype (USNM

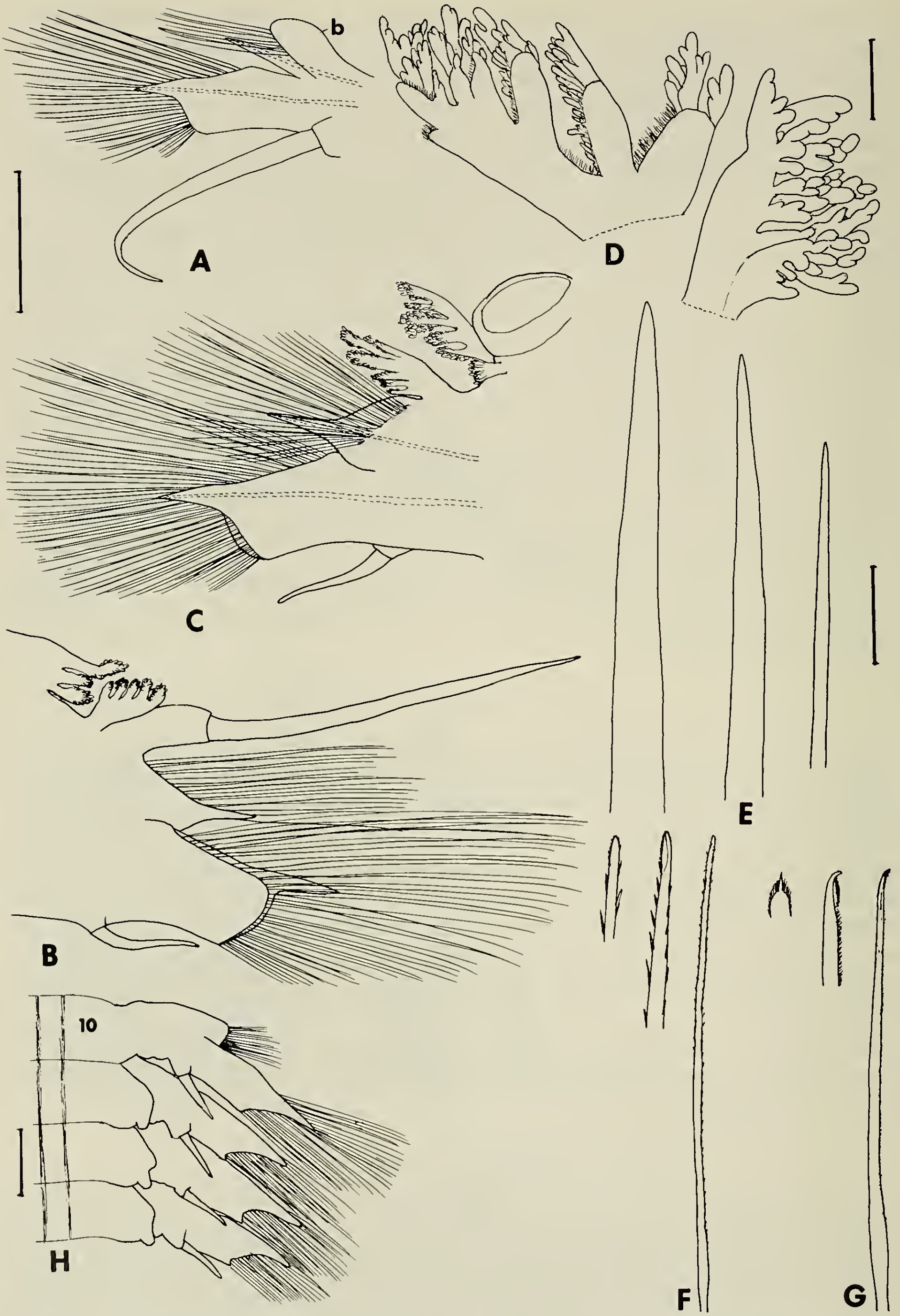

Fig. 6. *Branchinotogluma grasslei,* holotype, USNM 97314: A, Right elytrigerous parapodium of segment 2, anterior view, acicula dotted; elytrophore not shown; B, Right cirrigerous parapodium of segment 6, posterior view; C, Right elytrigerous parapodium of segment 7, anterior view, acicula dotted; D, Upper and lower branchiae from same; E, Three notosetae; F, Supraacicular neuroseta,

80639) and paratype (USNM 97251). Dive 984-32, 1 Dec, 2451 m, mussel washings, 2 young paratypes (USNM 97252).

Pacific Ocean off Western Mexico, 20°50'N, 109°06'W, OASIS *Alvin* dives in 1982: Dive 1214, 20 Apr, 2633 m, vestimentiferan wash, 21 paratypes including 8 young (USNM 97255). Dive 1219-2A, 25 Apr, 2612 m, slurp sample from *Alvinella* habitat, paratype (USNM 97256). Dive 1221-15, 4 May, 2618 m, *Riftia* and *Calyptogena* wash, 8 paratypes (USNM 97257). Dive 1223-11, 7 May, 2616 m, *Riftia* and *Calyptogena* wash, coarse fraction, 10 paratypes including 6 young (USNM 97258; 97259). Dive 1225-7, 9 May, 2618 m, *Riftia* and *Calyptogena* wash, fine fraction, paratype (USNM 97260). Dive 1226-7, 10 May, 2616 m, *Riftia, Calyptogena* and *Alvinella* wash, coarse and fine fractions, 2 paratypes (USNM 97261).

*Description.*—Length of holotype from Galapagos Rift (USNM 80639) 10 mm, width 5 mm with setae, segments 21. Length of largest paratype from 21°N (USNM 97258) 14 mm, width 6 mm, segments 21. Body subrectangular, flattened, tapering posteriorly, with parapodia longer than body width. Posterior 4 segments (18–21) compressed, with parapodia greatly modified, differing from more anterior parapodia as well as from one another (Fig. 9A, B). No color except for yellow amber-colored setae. Dorsum with transverse ciliated bands, 2 per segment, extending onto elytrophores and dorsal tubercles (Figs. 7A, 8A).

Elytra and prominent bulbous elytrophores number 10 pairs (Figs. 7A, D, 8A, C, 9A). Elytra large, covering dorsum, round to oval, last pair elongate-oval, nearly covering posterior modified parapodia (Figs. 8D–G, 9A, B, E). Elytra delicate, with branched "veins." Dorsal cirri with short cylindrical cirrophores and long tapered smooth styles extending beyond tips of setae (Figs. 7A, C, E, 8B). Dorsal tubercles elongate and tapered (Figs. 7C, E, 8A). Both elytrophores and dorsal tubercles with delicate arborescent branchiae attached on their lateral sides, with additional smaller group of branchiae on bases of notopodia; branchiae compact with rather long terminal filaments (Figs. 7A, C–E). Branchiae beginning on segment 3 as 2 small groups (Fig. 7A), becoming larger more posteriorly, with long terminal filaments, and continuing to segment 17 as single small group (Fig. 9A).

Prostomium bilobed, anterior lobes triangular with delicate frontal filaments; median antenna with bulbous ceratophore in anterior notch, with tapered style and long slender tip; palps stout, tapered, smooth; without eyes (Fig. 7A, B). Tentaculophores with 2 pairs of tentacular cirri, dorsal pair about length of palps, ventral pair slightly shorter; ventrally tentacular segment forming anterior and lateral lips of mouth (Fig. 7A, B). Second or buccal segment forming posterior lip of mouth and bearing biramous parapodia and first pair of elytrophores; notopodia with hood or bract encircling small bundle of notosetae; ventral buccal cirri similar to tentacular cirri, longer than following ventral cirri (Fig. 7A, B).

When everted, muscular pharynx showing 5 papillae around opening: 3 dorsal

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with detail of tips; G, Subacicular neuroseta, with detail of tips; H, Ventral view left side of segments 10–13, showing segmental papillae. b, notopodial bract. Scales = 1.0 mm for A–C; 0.2 mm for D; 0.1 mm for E–G; 1.0 mm for H.

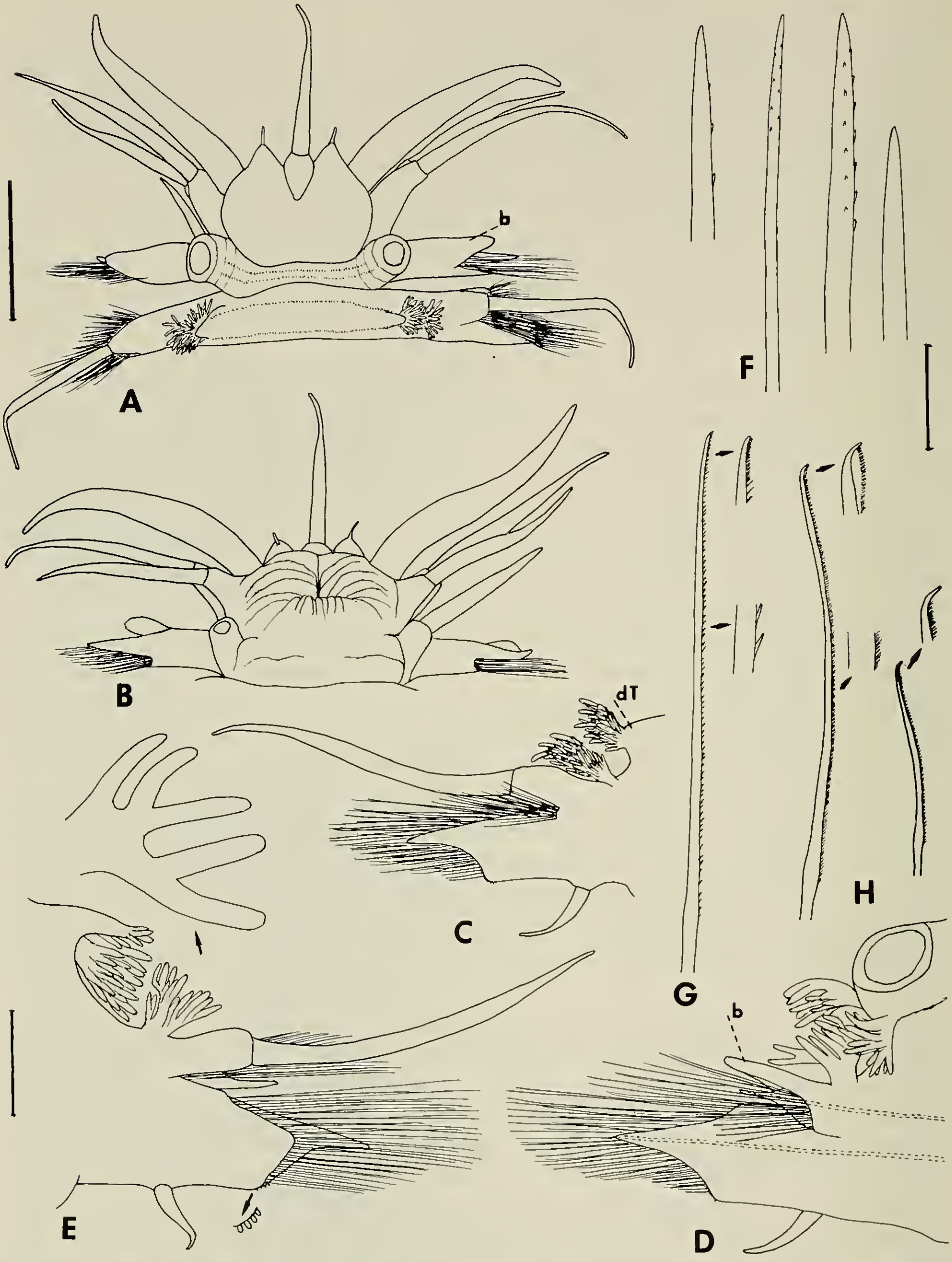


Fig. 7. *Opisthotrochopodus alvinus,* holotype, USNM 80639: A, Anterior end, dorsal view; B, Same, ventral view, style of right buccal cirrus missing; C, Right cirrigerous parapodium of segment 3, anterior view; D, Right elytrigerous parapodium of segment 7, anterior view, acicula dotted; E, Right cirrigerous parapodium of segment 8, posterior view, with detail of branchial tips and neuropodial papillae; F, Four notosetae; G, Supraacicular neuroseta, with detail of part; H, Middle and lower subacicular neurosetae, with detail of part. b, notopodial bract; dT, dorsal tubercle. Scales = 1.0 mm for A, B; 0.5 mm for C–E; 0.1 mm for F–H.

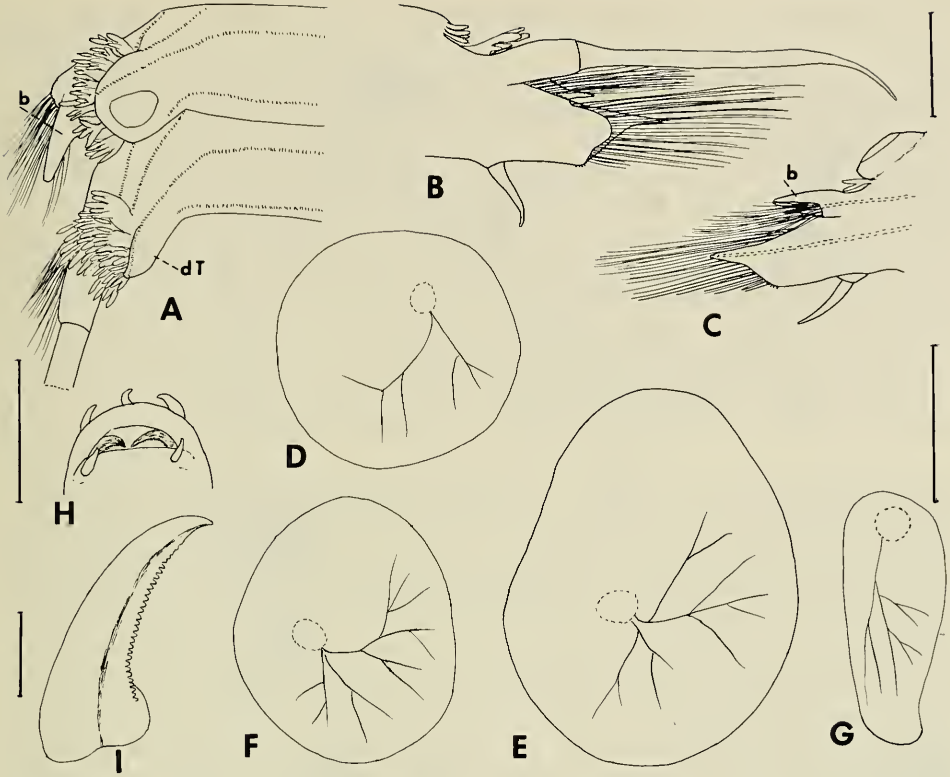
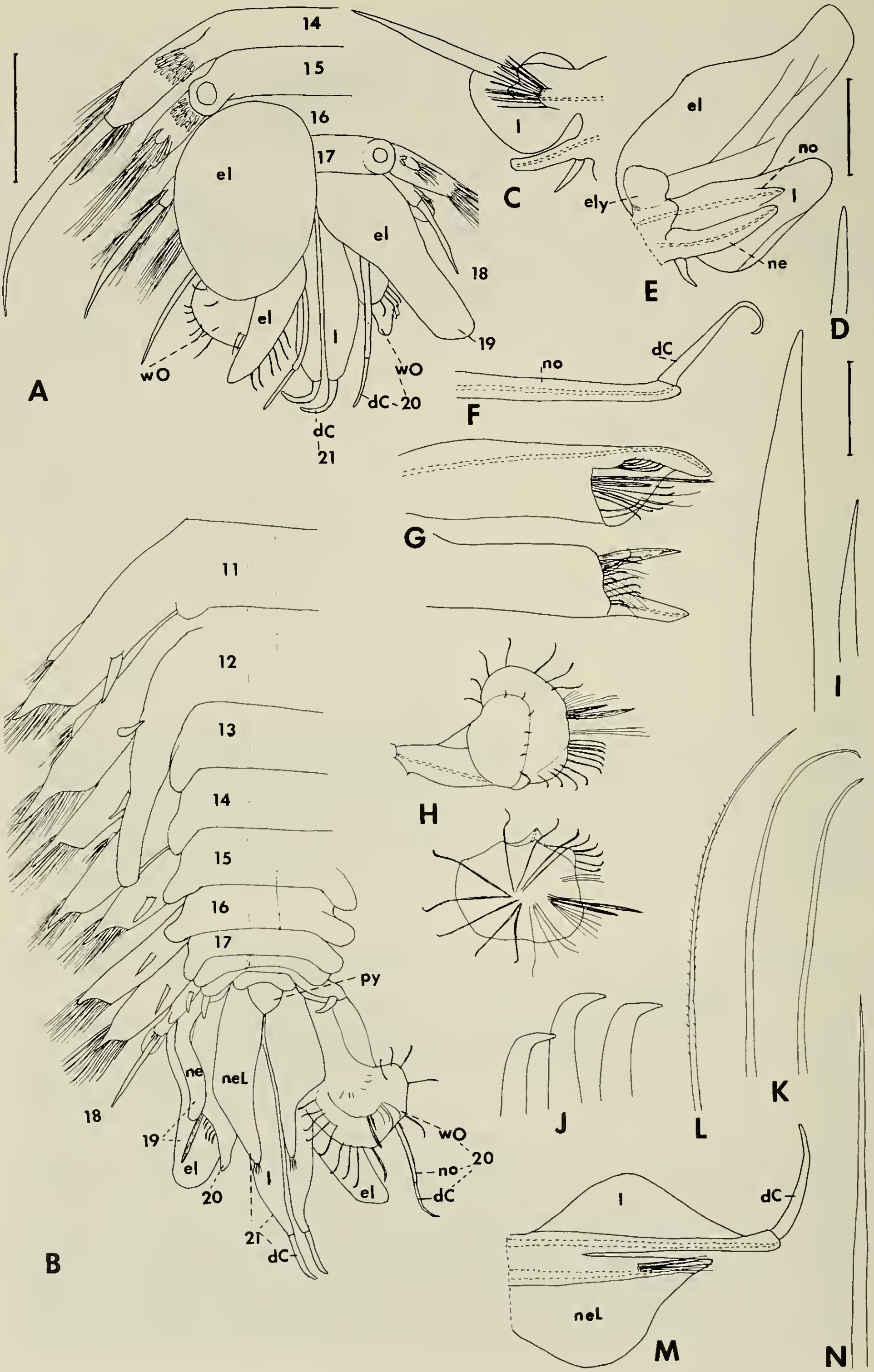


Fig. 8. *Opisthotrochopodus alvinus.* A, paratype, USNM 97255; B–G, I, holotype, USNM 80639; H, paratype, USNM 97254: A, Dorsal view left side of segments 9 (elytrigerous) and 10 (cirrigerous), base of style of dorsal cirrus only shown; B, Right cirrigerous parapodium of segment 16, posterior view; C, Right elytrigerous parapodium of segment 17, anterior view, acicula dotted, D, Right elytron 4 of segment 7; E, Left elytron 8 of segment 15; F, Left elytron 9 of segment 17; G, Right elytron 10 of segment 19; H, Distal end of extended pharynx, ventral view; I, Isolated jaw. b, notopodial bract; dT, dorsal tubercle. Scales = 1.0 mm for A, H; 0.5 mm for B, C; 1.0 mm for D–G; 0.2 mm for I.

and 2 ventral; 2 pairs of prominent jaws minutely denticled on inner border (Fig. 8H, I).

Parapodia of segments 2 to 17 biramous, with notopodia shorter than neuropodia, both rami with light yellow amber-colored setae (Figs. 7A–E, 8B, C). Notopodia with short tapered acicular lobes and, on elytrigerous segments, prominent rounded bracts enclosing notosetae dorsally and posteriorly (Figs. 7D, 8C). Notosetae moderate in number, stouter than neurosetae, straight, acicular, tapered, smooth or with 1–2 rows of spines (Fig. 7F). Larger neuropodia with long flattened conical presetal lobes with projecting acicular processes; postsetal lobes shorter, rounded; with some micropapillae on distal borders (Fig. 7C–E). Neurosetae very numerous, forming fan-shaped bundles. Supraacicular neurosetae longer, with more widely-spaced spines extending to near distal tip, more finely spinous distally (Fig. 7G). Subacicular neurosetae decreasing in length ventrally, finely spinous up to hooked tips, sometimes showing delicate flattened distal part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(Fig. 7H). Ventral cirri short, tapered, attached on middle of neuropodia (Fig. 7C–E).

Parapodia of posterior 4 segments (18–21) modified and directed posteriorly, differing from one another (Fig. 9A, B). Parapodia of cirrigerous segment 18 (Fig. 9A–C) smaller than preceding (Fig. 8C) and following parapodia (Fig. 9E). Notopodium represented by small acicular lobe, dorsal cirrus with cirrophore fused to acicular lobe, with distal style, bundle of short smooth acicular notosetae (Fig. 9D), and delicate, rounded, flattened lamella (1); neuropodium forming small tapered acicular lobe with small ventral cirrus; without neurosetae (Fig. 9C).

Modified parapodia of elytrigerous segment 19 lacking both notosetae and neurosetae (Fig. 9A, B, E). Notopodium with short acicular lobe (no), enclosed in large delicate lamella (1), with small elytrophore (ely) and elongate-oval elytron (el) extending posteriorly and covering more posterior parapodia; neuropodium forming tapering acicular lobe (ne) with small ventral cirrus, similar to neuropodium of segment 18.

Parapodia of segment 20 greatly modified and nearly covered dorsally by elongated elytra of segment 19 (Fig. 9A, B, F–H). Notopodium represented by achaetous elongated cylindrical acicular lobe with distal style of dorsal cirrus (Fig. 9F). Neuropodium forming large cylindrical lobe with projecting conical acicular process and enclosing circle of neurosetae of several types (Fig. 9G): stout reddish amber-colored neurosetae, 2 stout, tapered pointed setae–one long, one short (Fig. 9I) and about 14 stout strongly hooked setae (Fig. 9J), few slender smooth neurosetae with curved tips (near stout acicular setae; Fig. 9K), and delicate curved spinous setae (Fig. 9L). Ventral cirri lacking. Neuropodia capable of being flared and flattened distally, with neurosetae radiating like spokes of wheel (Fig. 9H). On holotype, neuropodium on left side expanded (Fig. 9A, B, H) and on right side not expanded (Fig. 9A, B, G). On other paratypes, both wheel organs found extended and flared, neither one flared, both only partially exposed or completely withdrawn into body and not visible.

Segment 21 with right and left parapodia closely approximated medially and directed posteriorly (Fig. 9A, B, M, N). Notopodium consisting of expanded thin lamella (1) and thickened acicular lobe fused with cirrophore of dorsal cirrus, with distal style (dC); without notosetae. Neuropodium also with expanded thin lamella

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Fig. 9. *Opisthotrochopodus alvinus,* holotype, USNM 80639: A, Posterior end, dorsal view, showing left side of segments 14–21 and right side of segments 17–21; parapodial wheel organ of segment 20 expanded on left side, unexpanded on right side; B, Same, ventral view, showing right side of segments 11–21 and left side of segments 20 and 21; C, Right cirrigerous parapodium of segment 18, anterior view, acicula dotted; D, Notoseta from same; E, Right elytrigerous parapodium of segment 19, posterior view, acicula dotted; F, Right notopodium with dorsal cirrus of segment 20, aciculum dotted; G, Two views of right unexpanded neuropodial wheel organ from same, aciculum dotted; H, Left neuropodium of segment 20 showing ventral and posterior views of expanded wheel organ, aciculum dotted; I, Two stout acicular neurosetae from same; J, Three hooked neurosetae from same; K, Two curved smooth neurosetae from same; L, Curved spinous neuroseta from same; M, Right cirrigerous parapodium of segment 21, posterior view, acicula dotted; N, Neuroseta from same. dC, style of dorsal cirrus; el, elytron; ely, elytrophore; l, notopodial lamella; ne, neuropodial acicular lobe; neL, neuropodial lamella; no, notopodial acicular lobe; py, pygidium; wO, neuropodial wheel organ. Scales = 1.0 mm for A, B; 0.5 mm for C, E–H, M; 0.1 mm for D, I–L, N.

(neL) and thickened acicular lobe on upper side and joined basally to notopodium; small group of needle-like neurosetae extending slightly beyond tips of neuropodium, their tips mostly broken (Fig. 9M, N). Ventral cirri lacking.

Pygidium (py) consisting of small oval lobe wedged between bases of parapodia of last segment (21), without anal cirri (Fig. 9B). Ventral segmental nephridial areas on bases of neuropodia of segments 4 to 11 low, rounded, with greatly elongated papillae on segment 12, extending posteriorly to segment 15, and with short rounded lamellae on segments 13 to 17 (Fig. 9B).

Young specimens with 17 or fewer segments may be confused with *Branchinotogluma hessleri.* See below under *Branchinotogluma* sp. A.

*Etymology.*—The species is named for the submersible *Alvin,* which has been the means of collecting so many unusual animals.

## Young of Branchinotogluminae

Young specimens of 17 or fewer segments belonging to this subfamily are difficult to separate to species, since the diagnostic posterior segments and ventral segmental papillae or lamellae are not yet developed. Based on their anterior ends, they may be separated into two groups, herein designated as *Branchinotogluma* sp. A or B, based on the following characters:

| | *Branchinotogluma* sp. A = Young of *B. hessleri* or *Opisthotrochopodus alvinus* | *Branchinotogluma* sp. B = Young of *B. grassslei* or *B. sandersi* |
|---|---|---|
| Notopodial bracts | On all elytrigerous parapodia of segments 2 to 17 | On elytrigerous parapodia of segment 2 only |
| Notosetae | Both smooth and with 1–2 rows of spines | All smooth |
| Arborescent branchiae | With rather long terminal filaments | With short terminal filaments |
| Dorsal tubercles | Elongate, tapered | Inflated, indistinct |

## *Branchinotogluma* sp. A
### Young of *Branchinotogluma hessleri* or *Opisthotrochus alvinus*

*Material examined.*—East Central Pacific, from dive of the *Alvin* along the Galapagos Rift in 1979: ROSE GARDEN, 00°48′15″N, 86°13′28″W: Dive 990, 7 Dec, 2451 m, slurp gun, 1 young (USNM 97341).

Pacific Ocean off Western Mexico, 20°50′N, 109°06′W, OASIS, *Alvin* dives in 1982: Dive 1214, 20 Apr, 2633 m, vestimentiferan wash, 13 young (USNM 97342). Dive 1221-15, 4 May, *Riftia* and *Calyptogena* wash, coarse fraction, 4 young (USNM 97343).

## *Branchinotogluma* sp. B
### Young of *B. grasslei* or *B. sandersi*

*Material examined.*—East Central Pacific, from dives of the *Alvin* along the Galapagos Rift in 1979: MUSSEL BED, 00°47′53″N, 86°09′12″W: Dive 991-1, 8 Dec, 2490 m, clam bucket wash, 2 young (USNM 97339). GARDEN OF EDEN, 00°47′41″N, 86°07′44″W: Dive 884, 25 Jan, 2482 m, clam bucket with mussels, 1 young (USNM 97337). ROSE GARDEN, 00°48′15″N, 86°13′28″W: Dive 984-32, 1 Dec, 2451 m, mussel washings, 5 young (USNM 97338).

Pacific Ocean off Western Mexico, 20°50′N, 109°06′W, OASIS *Alvin* dive in 1982: Dive 1214, 20 Apr, 2633 m, vestimentiferan wash, 34 young (USNM 97340).

*Remarks.*—The subfamily Branchinotogluminae agrees with Branchipolynoinae Pettibone (1984a) and Branchiplicatinae Pettibone (1985) in having well-developed branchiae, an unusual feature in the Polynoidae. The above three subfamilies agree with Macellicephalinae Hartmann-Schröder (Pettibone 1976) and Lepidonotopodinae Pettibone (1983, 1984b) in the structure of the prostomium and tentacular segment in having a median antenna, paired palps, lacking lateral antennae and eyes, with two pairs of tentacular cirri on tentaculophores lateral to the prostomium.

Notopodial bracts are rare in the Polynoidae. The notopodial bracts of Branchinotogluminae, in the form of oval projections enclosing the notopodial acicular lobes and notosetae on the elytrigerous parapodia only, differ markedly from the notopodial bracts in the Lepidonotopodinae where they are truncate and are found on all the setigerous segments (Pettibone 1983, 1984b). The pharynx with serrated or denticulated jaws is also rare in the Polynoidae but is found in some members of the Macellicephalinae and Bathyedithinae (Levenstein 1971; Pettibone 1976, 1979) and in the Lepidonotopodinae (Pettibone 1983, 1984b).

The greatly modified posterior four segments in *Opisthotrochopodus alvinus* set it apart from all other members of the Polynoidae, especially with the development of extra lamellae and the wheel organs on segment 20, with large acicular and hooked neurosetae. Except for this unusual feature, it agrees with species of *Branchinotogluma* and is placed in the same subfamily.

The branchiate subfamilies of Polynoidae from the hydrothermal rift areas may be separated according to the following key:

### Key to three Branchiate Subfamilies of Polynoidae

1. Prostomium truncate anteriorly, not bilobed, without frontal filaments; median antenna with ceratophore in middle of prostomium. Segments up to 35, first achaetous. Elytra 12 pairs, on segments 2, 4, 5, 7, alternate segments to 23. Dorsal cirri on segments 3, 6, 8, alternate segments to 22 and on up to 12 posterior segments from 24 on. Branchiae beginning on segment 3, flattened elongate sacs, deeply folded and convoluted, attached to flattened elytrophores and dorsal tubercles, both with extra lobes. Elytra large, oval, covering dorsum. Parapodia biramous, both rami with projecting acicular processes. Notopodia without well-developed bracts. Paired palps, tentacular, buccal and dorsal cirri all long. Pharynx with 5 pairs of unequal papillae; 2 pairs of jaws, minutely denticled ................ ............................. BRANCHIPLICATINAE Pettibone, 1985
(see *Branchiplicatus cupreus* Pettibone, figs. 1–4, in Pettibone (1985))

– Prostomium bilobed, anterior lobes with minute or filiform frontal filaments. Segments 21, first achaetous. Elytra 10 pairs on segments 2, 4, 5, 7, alternate segments to 19. Dorsal cirri on segments 3, 6, 8, alternate segments to 20, 21. Elytrophores and dorsal tubercles not flattened, without extra lobes. Branchiae arborescent, in 2 main groups lateral to elytrophores and dorsal tubercles and on dorsal sides of notopodia ....... 2

2. Bilobed prostomium with minute frontal filaments; ceratophore of median antenna indistinct, with short style. Elytra small, leaving middorsum uncovered. Elytrophores and dorsal tubercles low, indistinct. Parapodia subbiramous. Notopodia small digitiform, without notopodial bracts. Notosetae few, stout, acicular. Neuropodia short, truncate, without projecting acicular processes. Arborescent branchiae beginning on segment 2, with long terminal filaments. Paired palps, tentacular, buccal and dorsal cirri all short. Pharynx with 5 pairs of jaws entire, not denticled. Associated with deep-sea mussels ....... BRANCHIPOLYNOINAE Pettibone, 1984a (see *Branchipolynoe symmytilida* Pettibone, figs. 1–8, in Pettibone (1984a))

– Bilobed prostomium with filiform frontal filaments; median antenna with distinct ceratophore in anterior notch. Elytra large, covering dorsum. Elytrophores prominent, bulbous; dorsal tubercles inflated, indistinct or elongate, tapered. Parapodia biramous, both rami with projecting acicular processes. Notopodia with prominent notopodial bracts on elytrigerous segment 2 or on all elytrigerous segments. Notosetae numerous, stout, acicular. Arborescent branchiae beginning on segment 3, compact, with short terminal filaments. Paired palps, tentacular, buccal and dorsal cirri all long. Pharynx with 5 papillae: 3 dorsal and 2 ventral; 2 pairs of jaws minutely denticled ........ BRANCHINOTOGLUMINAE, new subfamily (see *Branchinotogluma*, new genus; *Opisthotrochopodus*, new genus)

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# THE GENERIC AND SUBFAMILIAL CLASSIFICATION OF THE NAIDIDAE (ANNELIDA: OLIGOCHAETA)

R. O. Brinkhurst

*Abstract.*—Examination of the characters used to define genera within the family Naididae leads inevitably to the conclusion that the genus *Pristina* Ehr. requires subdividing into two genera, *Pristina* and *Pristinella* n. gen. Neither classical nor quantitative methods support the division of the family into subfamilies, but the latter support the erection of the genus *Pristinella* n. gen.

During the preliminary stages of an assessment of alternative quantitative approaches to classification of the Oligochaeta all generic characters currently applied in the family Naididae were examined, as was the subfamilial classification. Both of these have been accepted uncritically since they were revised by Sperber (1948), who reviewed the historical basis for that classification. Four subfamilies were recognized. Two are monotypic (Pristininae-*Pristina* Ehr., Paranaidinae-*Paranais* Czern.), the third contains two genera (Chaetogastrinae-*Chaetogaster* von Baer, *Amphichaeta* Tauber), and the fourth, the Naidinae, contains all other genera and is therefore disproportionately large. While this is not of itself evidence for the unsuitability of the existing classification, it does suggest careful re-examination. An intensive effort to examine quantitative means of doing this is underway; this provisional report is required in order to allow other publications to proceed based on the division of the genus *Pristina* in particular.

## Paranaidinae Sperber, 1948

Sperber (1948) established this subfamily based on the unique characteristic of absence of nephridia, even in budding segments. Additional characters cited were a reduction of the number of anterior segments formed on budding from 5 to 4, despite the fact that this is shared with *Stephensoniana* Cernosvitov, but the latter was held to be "otherwise so unlike *Paranais* that they can hardly be supposed to be especially related to each other." The male ducts are also said to be unusual, with narrow vasa deferentia, strongly muscular atria and no prostate glands, with other unusual characters in the ejaculatory ducts and clitellum. These are not, in fact, unique to the group (see the presence of the clitellum between the male pores in *Piguetiella* Sperber, for example) nor are the absence of both hair setae and eyes and the resemblance of dorsal and ventral needles. Since these studies, the genus *Wapsa* was defined, but a careful revision of North American species has shown that this is synonymous with *Paranais* (Brinkhurst and Coates 1984) and that both may possess nephridial tissue. Quantitative methods (see below) confirm the synonymy of these two genera and the lack of any clear separation of *Paranais* from all other genera, particularly *Chaetogaster, Amphichaeta,* and *Homochaeta* Bretscher.

The closed or even absent nephridia in many species of *Paranais, Amphichaeta,* and *Chaetogaster* may be associated with the estuarine habit of most species of the first two. This explanation will not suffice for the latter, though, as this is predominantly a freshwater genus. It may be that *Chaetogaster* is derived from a common ancestor of all three genera.

There is no clear basis for the separation of the Paranaidinae, either by cluster analysis based on overall similarity or by virtue of shared advanced characters (synapomorphy).

### Chaetogastrinae Sperber, 1948

This subfamily consists of two genera (*Chaetogaster* and *Amphichaeta*) that have a strongly lengthened pharynx, (which lacks the dorsal diverticulum of other genera but is connected to the body wall by strong muscle fibers), a short oesophagus, a stomach of unusual form, a strongly reduced vascular system and closed nephridia.

The nephridial characteristic is now known to be shared with *Paranais,* as described above. The possible functional reason for the reduction in the vascular system remains obscure, but the other characteristics, along with the reduced prostomium, are clearly associated with the adoption of a predatory mode of feeding. In most aquatic oligochaetes the roof of the pharynx is everted through the mouth in feeding, being returned by strong retractors. The glandular cells are greatly expanded by relocating the cell bodies on the septa of post-oral segments (the pharyngeal or septal glands). The pharyngeal diverticula of most naidid genera appear to be no more than large folds on either side and behind the pad-like pharyngeal roof which contacts the substrate once everted through the mouth (Sperber 1948, plate V fig. 5, plate VI fig. 1). The glandular cells of the pharynx are not often exported to form pharyngeal glands, and the retractor muscles may be poorly developed in the Naididae. The retractor muscles of the pharynx of the Chaetogastrinae are presumably developed from those present in other aquatic oligochaetes, but a comparative study of the pharyngeal structures would be in order to judge from the lack of recent descriptions of these structures.

There is no a priori reason to suppose that this pharyngeal modification was independently acquired by these two genera, but this is not in itself perhaps enough to provide the basis for a subfamilial classification. I would prefer to see independent characters that confirm a separation between these two genera and all other naidids. In fact, in most cluster analyses (see below), *Chaetogaster* is most closely aligned with *Homochaeta* Bretscher, which Sperber classified with the Naidinae, and only secondarily groups with *Amphichaeta* and *Paranais.* There is no clear evidence of a monophyletic group consisting solely of *Chaetogaster* and *Amphichaeta.*

### Naidinae Lastockin, 1924

According to Sperber (1948), this subfamily was originally established to incorporate all genera bar *Pristina* (Pristininae Lastockin, 1924), but was modified by her to exclude the foregoing. Even then, Sperber admits that this subfamily is "more heterogeneous" than the others. There are no distinct characters that identify this group as a monophyletic assemblage by virtue of shared apomorphies, and they do not cluster out in a single group without the interposition of some or all of the genera excluded from the subfamily.

## Pristininae Lastockin, 1924

The single genus in this subfamily is said to be "large and extremely varying, yet curiously homogeneous" by Sperber (1948). There follows a recitation of the subfamilial characters, which include a characteristic stomach with intracellular canals and male ducts which, while variable, have narrow atria without prostates with vasa deferentia entering at the top. The genital setae are of peculiar forms not seen elsewhere, according to Sperber.

The stomachal canals need to be re-investigated using electron microscopy.

The genus *Pristina* (as *Pristina* A and B) never appears separated from all other genera in any of the many analyses performed to date, though it is never consistently associated with any other genera. As none of the other subfamilies can be supported, there seems little point in returning to the position adopted by Lastockin, with this subfamily being contrasted to all others.

Even a superficial examination of the list of species currently included within *Pristina* suggests that it has been treated differently from all other genera. The presence or absence of a proboscis is used as a generic character throughout the rest of the family. Beginning with a breakdown based on that sole characteristic, it rapidly becomes clear that other, unrelated, characters are associated with this criterion, leading to the separation of two quite distinct genera as follows:

### *Pristina* Ehrenberg, 1828

*Type species.—P. longiseta* Ehr.

*Included species.—synclites* Steph., *peruviana* Cern., *aequiseta* Bourne, *longiseta* Ehr., *proboscidea* Bedd., *breviseta* Bourne, *plumaseta* Turner, *leidyi* Smith, *americana* Cern., *macrochaeta* Steph.

*Definition.*—Dorsal setae from II, hair setae present, ventral setae progressively differ from anterior to posterior bundles. Proboscis present. Septal glands present in some segments from III–VI. Stomach in VII or VIII with canals. Testes and spermathecae in VII, ovaries and atria in VIII, genital setae on VI, VI and VIII, or VII and VIII with glands. Prostates on the vasa deferentia. Spermathecae present. Cosmopolitan.

### *Pristinella,* new genus

*Type-species.—Naidium bilobatum* Bretscher, 1903.

*Included species.—rosea* (Piguet), *amphibiotica* (Last.), *notopora* (Cern.), *jenkinae* (Steph.), *sima* (Marcus), *longidentata* (Harman), *menoni* (Aiyer), *idrensis* (Sperber), *acuminata* (Liang), *bilobata* (Bret.), *osborni* (Walton), *longisoma* (Harman), ? *arcaliae* (Pop.).

The genus is quite similar to the older assemblage associated with the name *Naidium* Schmidt but because *N. luteum* Schmidt, the type-species, is a tubificid, the generic name is not available (Sperber 1948:211).

*Definition.*—Dorsal setae from II, hair setae present, ventral setae progressively differ from anterior to posterior bundles. Proboscis absent. Septal glands in some segments from III–VI. Stomach in VI, VII or VIII, with canals. Testes and spermethecae in VII, ovaries and atria in VIII. Genital setae absent, or present in VIII in one species. Prostate glands absent. Male pores median in one species. Spermathecae absent. Cosmopolitan.

Fig. 1. Dendrograms resulting from re-orientation of an evolutionary tree by Sperber 1948(A), and from cluster analyses of a 15 character by 24 taxa matrix by the methods of Ward (B) and Preston (C). There is no quantitative scale for A as the clusters were created qualitatively.

*Remarks.*—Full synonymies of these genera plus *Bratislavia* Kosel are discussed by Brinkhurst (1971) and subsequent changes by Harman (1973, 1974, 1982), Harman and McMahan (1975), Harman and Loden (1978), Loden and Harman (1980) and Brinkhurst and Kathman (1983). Other synonymies will undoubtedly be uncovered as recent observations using scanning electron microscopy continue to reveal intraspecific variation in the degree of serration of hair setae, the presence of pectinations in normally bifid setae, and the effects of environmental conditions on setal form. Care should be taken in separating species currently distinguished by such characters (e.g., *P. longidentata* and *P. idrensis*).

## Quantitative Analysis

A variety of quantitative methods are being evaluated using a data matrix derived from the characters used to define naidid genera. A 24 × 24 matrix of characters and taxa is used, with *Pristina* and *Slavina* divided into two taxa each, and the recent genera *Neonais* Sokolskaya and *Rhopalonais* Dzwillo and Grimm excluded by reason of lack of knowledge of the reproductive structures. A condensed data matrix of only 15 characters was created by eliminating those characters thought to be less reliable by virtue of the difficulty experienced in scoring them, or their dependence on other characters. Serrations on the hair setae, for example, may vary in degree of development and their existence depends on the presence of hair setae in the first instance. For the purposes of this discussion only three cluster diagrams will be used (Fig. 1). The first was derived from the evolutionary tree proposed by Sperber (1948). The dendrogram was created by measuring the distances between dichotomies on the evolutionary tree, and so there is no scale of similarity involved (Fig. 1A). The four subfamilies form monophyletic groups, identified as groups 1, 2, 8, and 3-7 respectively. The analysis according to the Ward method (Ward 1963) is illustrated in Fig. 1B, that by the Preston method (small input pair-group cluster, unweighted pair-group mean clustering optimum rotation of dendrogram, Preston's resemblance equation Preston 1962) in Fig. 1C. Both of these were based on the shorter, more reliable data set. The features of these dendrograms referred to here are consistent in all of the analyses performed to date, though other details vary quite considerably.

The points to be emphasized here are that there is no evidence to support the separation of the subfamilies proposed by Sperber, and that, while the two sections of *Pristina* cluster together, they do so at a lower level of similarity than a great many other genera currently regarded as well established. Examples of the latter would be *Dero* Oken with *Branchiodrilus* Mich. (which always pair so closely that a single origin of gills in the family can be postulated) and *Ophidonais* Gervais with *Unicinais* Lev. The similarity of *Paranais* and *Wapsa* Marcus was rendered total when the latter was shown to be a synonym of the former by Brinkhurst and Coates (1984).

These results are obtained with both the Ward and Preston analyses (and others) despite the fact that the first method recognizes all similaarities (0-0, 1-1) whereas the latter only recognizes positive matches (1-1) in a Hennigian manner. The data were polarized with respect to a supposed ancestor in the Preston analysis as required by the method.

In a later presentation, the data matrix will be discussed in detail, and the possible new subfamilial groupings derived from a variety of phenetic and cladistic methodologies will be explored.

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# DEEVEYINAE, A NEW SUBFAMILY OF OSTRACODA (HALOCYPRIDIDAE) FROM A MARINE CAVE ON THE TURKS AND CAICOS ISLANDS

Louis S. Kornicker and Thomas M. Iliffe

*Abstract.*—Deeveyinae, a new subfamily of the Halocyprididae (Ostracoda, suborder Halocypridina) is proposed for *Deeveya spiralis,* a new genus and species of troglobitic ostracode from an anchialine cave in the Turks and Caicos Islands, West Indies. The new genus and species is described and illustrated.

Danielopol (1972) described the first troglobitic halocyprid ostracode from a marine cave in Cuba. Therefore, the discovery of a second halocyprid in an anachialine cave on the Turks and Caicos Islands, which are a southeast continuation of the outer line of the Bahama Islands, is of interest. Although the two caves are relatively close geographically, differences between the specimens from the two caves led to the proposing a new subfamily for the specimens from the Turks and Caicos Islands. Danielopol (1972) referred his species to the Thaumatocyprididae, whereas the present new species is referred to the Halocyprididae.

## Family Halocyprididae

The Halocyprididae comprises five subfamilies, Conchoecinae, Halopyridinae, Archiconchoecinae, Euconchoecinae, and Deeveyinae, the new subfamily described herein.

## Deeveyinae, new subfamily

*Diagnosis.*—First antenna with 8 segments. Sixth limb with distal dorsal process on 1st exopodial segment. Seventh limb with 3 bristles. Organ of Bellonci bifurcate.

*Discussion.*—The new subfamily is referred to the Halocyprididae rather than to the Thaumatocyprididae because the furca of *Deeveya spiralis* is of the halocyprid rather than the thaumatocyprid type. None of the other subfamilies of Halocyprididae have members having the combined characters listed in the diagnosis above.

## *Deeveya,* new genus

*Etymology.*—The genus is named for Georgiana B. Deevey. Gender: Feminine.

*Type-species.*—*Deeveya spiralis,* new species.

*Distribution.*—The type-species from a marine cave in the Turks and Caicos Islands, depth 7 m.

*Diagnosis.*—Carapace without rostrum. First antenna with 8 segments: first segment without bristles; eighth segment bearing 4 bristles. Endopodite of second antenna with 3 segments: first segment without processus mammillaris but with 2 dorsal bristles; second segment with 3 long bristles; small third segment with 2 long bristles. Sixth limb with dorsal process bearing 4 bristles on first exopodial segment of type-species. Seventh limb with 3 bristles. Furca with 7 claws on each lamella, and 1 unpaired dorsal bristle; claws 5–7 bristle-like; all claws separated from lamella by suture. Organ of Bellonci short, bifurcate.

*Comparisons.*—The new genus differs from previously described members of the Halocyprididae in having no rostrum, eight segments on the first antenna, a dorsal bristle-bearing process on the first exopodial segment of the sixth limb, and three bristles on the seventh limb. *Deeveya* differs from known members of the Thaumatocyprididae in having all furcal claws separated from the lamellae by a suture, three bristles on the seventh limb, a bifurcate organ of Bellonci, and no bristles on the first segment of the first antenna. Some species of the halocyprid genera *Halocypris* and *Halocypria* have a minute rostrum.

### *Deeveya spiralis*, new species

Figs. 1–12

*Etymology.*—From the Latin *spiralis* (=coil, twisted), in reference to the two twisted bristles of the mandibular basis.

*Material.*—Turks and Caicos Islands, Caicos Islands, Providenciales Island, The Hole, 30 Oct 1982, coll. Thomas M. Iliffe, specimens collected with suction bottle from 5 to 7 m depths using scuba. Holotype, USNM 193117, adult female; paratype, USNM 193118, adult female.

*Distribution.*—Known only from the anchialine habitats of The Hole, Providenciales Island, Turks and Caicos Islands.

*Habitat.*—The Turks and Caicos Islands are a southeast continuation of the outer line of the Bahama Islands. The basic geological and geomorphological setting is generally similar to that of the Bahamas. The Bahama Platform, including the Caicos Bank, is composed of a flat-lying shallow-water carbonate cap thicker than the surrounding ocean is deep (Dietz, Holden, and Sproll 1970). The thickness of this near homogeneous cap indicates that the depositional environment of the Platform—a shallow water situation—must have remained essentially the same since at least the early Cretaceous. A history of subsidence offset by upbuilding of coral-algal carbonates has maintained the plateau at sea level.

Providenciales Island is located on the northern edge of the Caicos Bank. The main topographical feature of the island is a line of rounded hills 20 to 40 m above sea level, running parallel to the coastline. These hills are formed from reef-derived eolian carbonates, probably of Pleistocene age.

The Hole is a sheer-walled cenote-like pit located near the crest of a line of hills at the western end of Providenciales, 1.1 km from the nearest open water, the south coast. It is about 15 m deep with a 15 m long by 10 m wide lake at the bottom, open to daylight. The bottom of the 6 to 8 m deep lake is completely choked with breakdown and surface debris such that no human-sized cave passages extending off from it were found. In addition to *Deeveya spiralis,* species observed or collected from the lake include a representative of a new genus of nebaliacean *Speonebalia cannoni* being described by Bowman, Yager, and Iliffe (1985), a new genus of amphipods being studied by John R. Holsinger, a crab identified as *Sesarma* (*H.*) *miersii* Rathbun by C. W. Hart, Jr., and an uncollected copepod. Other marine caves on Providenciales Island contain the shrimps *Barbouria cu-*

*bensis* and *Typhlatya garciai* (Buden and Felder 1977), the amphipod *Spelaeonicippe provo* (Stock and Vermeulen 1982), a new family of shrimps (Hart and Manning, in preparation), and a new species of stygiomysid (Bowman, Iliffe, and Yager 1984).

Although we did not measure salinity in the lake, we expect that, at least in the deeper waters from which the thaumatocyprids were collected, it is at or near open ocean levels (about 35 to 36‰). Salinities presumably measured from the surface waters of other caves on Providenciales were 18 and 19‰ (Buden and Felder 1977; Stock and Vermeulen 1982). Under similar conditions in Bermuda caves, a several meters-thick surface layer of 3 to 30‰ overlies full salinity waters (Sket and Iliffe 1980; Iliffe, Hart, and Manning 1983).

*Discussion.*—A number of taxa from primarily deep water groups have been recently discovered in shallow water marine caves. Several species inhabiting a sea water flooded lava tube cave in the Canary Islands show affinities to deep sea species (Iliffe *et al.* 1984). These include *Munidopsis polymorpha* from the primarily bathyal group of the Galatheidae, the amphipod *Spelaeonicippe buchi* belonging to the mainly abyssal family Pardaliscidae, and the polychaete *Gesiella jameensis* from the mostly deep water group Macellicephalinae. Similarly, from marine caves in the Caicos Islands, the amphipod *Spelaeonicippe provo,* a close relative of *S. buchi,* and a new polychaete being described by Pettibone and coworkers, also from the subfamily Macellicephalinae, may have a deep sea origin.

Among the ostracodes, a thaumatocyprid *Thaumatocypris orghidani* from caves in Cuba (Danielopol 1972, 1976), *Deeveya spiralis,* and new species having appendages similar to those of *D. spiralis* from Bermuda caves (Angel and Iliffe, in preparation) are most probably derived from stocks now inhabiting the deep sea.

The stability and constancy of the shallow water environment on the Bahama Platform over prolonged geological periods has probably been a significant factor in sustaining relict populations of marine cavernicoles long after their open sea ancestors had become extinct. A large number of marine caves are now known from the Bahama Platform including the famous "Blue Holes," submerged circular sink holes of often spectacular dimensions (Warner and Moore 1984). These tidal, seawater-flooded caves have most probably existed on the Platform since the earliest stages of limestone deposition. A number of these Blue Holes have been explored to depths of 100 m or more and probably extend much deeper than that. A characteristic of the Bahama Platform is its steep-walled sides which rapidly drop off into oceanic depths. Strong tidal currents flowing into and out of those caves located near the edge of the Platform could draw deep water organisms or their larvae directly into caves. Subsurface water temperatures in those Bermuda marine caves remote from the sea have been found to remain seasonally constant at near the average year-round temperatures, thus indicating by extension that marine caves in general could have served as refugia for temperature-sensitive species during periods of Pleistocene glaciation (Iliffe, Hart, and Manning 1983). As a result of their age, geological and environmental stability, and proximity and tidal exchange with deep waters, marine caves of the Bahama Platform, including those caves in the Caicos Islands, are indeed highly suitable sites to serve as preserving centers for deep-water species.

*Description of adult female* (Figs. 1–12).—Carapace oval in lateral view except for linear dorsal margin and slightly concave anterior margin (Figs. 1, 4a). Car-

Fig. 1. *Deeveya spiralis,* lateral view of holotype, length 2.87 mm.

apace having greatest height just anterior to adductor muscles, greatest length just dorsal to adductor muscles, and greatest width near middle (Figs. 1, 4a–c). Right valve with small tubercle on dorsal margin near posterior end (Fig. 1).

Ornamentation (Figs. 1–6): Carapaces appearing reticulate in transmitted or reflected light (Figs. 4, 5), but reticulations mostly within translucent shell wall (Figs. 2, 3). Shell surface smooth except for minute bosses occurring mostly at intersections of walls forming reticulations (Figs. 5e, f, 6a–c, e), and for minute, round, shallow fossae occurring mostly in center of low domes within reticulations. Internal reticulations smaller and more numerous where muscles attach to shell (Fig. 2). Internal reticulations mostly with 4 sides but a few with 3 to 6 sides. (SEM micrographs show reticulations to be ubiquitous except in areas of muscle attachments where the shell appears smooth, except for shallow fossae and minute bosses (Figs. 6a–c). Reticulations appearing on surface in SEM micrographs probably occur during freeze-drying prior to taking micrographs when "skin" of shell contracts more at center of reticulations than at wall-forming reticulations. This interpretation is warranted because under the light microscope, reticulations are present in all areas of shell, not only in areas away from muscle attachments (Figs. 2, 3).)

Bristles (Figs. 1, 7a, b): 2–4 very long bristles present along posterior shell margin (Figs. 1, 7a); short bifurcate bristles along anterior and ventral shell margins (Fig. 7b); lateral surface of shell with very few slender short and medium length single bristles. Small bristle bearing long spines present at tip of dorsal tubercle of right valve.

Infold (Figs. 7a, b): Broad infold along anterior, ventral and posterior shell margins, narrowest opposite anterior concavity of margin, widest at anteroventral corner. Narrow list present near inner margin of infold, bearing narrow lameller

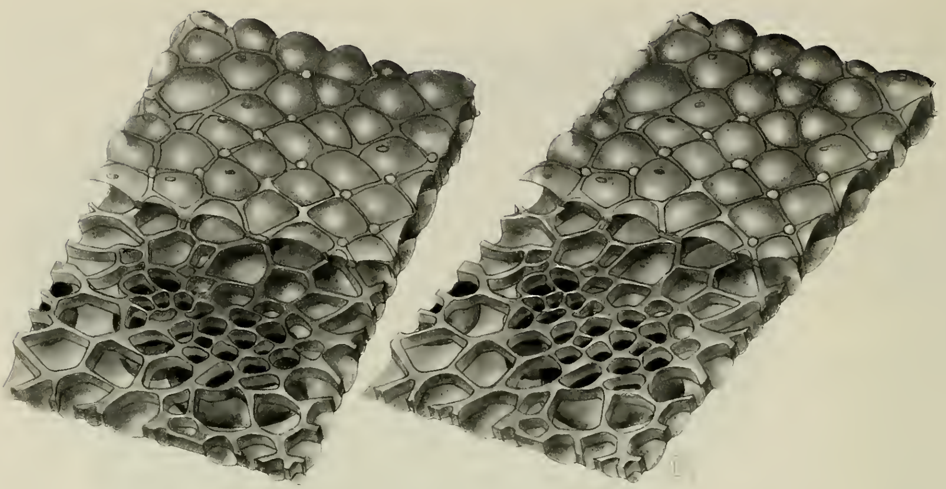

Fig. 2. *Deeveya spiralis,* stereoscopic pair of part of shell of holotype showing internal reticulations in vicinity of adductor muscles (ends black) and pillow structure of outer surface (upper half of illustration).

prolongation with smooth outer edge. Selvage along outer margin of infold with narrow lamellar prolongation with smooth outer edge.

Glands: No glandular openings observed on infold. Glandular opening on tip of dorsal tubercle of right valve anterior to minute seta.

Muscle attachments (Figs. 1–4a, d): Adductor muscles consisting of about 20 ovoid muscles attaching in elliptical area oriented obliquely just anterior to valve midlength; 3 muscle attachments forming row just anterior and ventral to central adductor muscle attachments (3 muscles may also be adductor muscles); few additional muscles attaching to valves closer to dorsal margin. Internal shell reticulations smaller and more numerous at points of muscle attachments than elsewhere (possible means of strengthening shell at points of muscle attachments).

Shell microstructure (Fig. 6f): When calcium carbonate of shell is dissolved by lactic acid, abundant fibers are visible in areas within walls of polygons. Some fibers are visible within broken edge of shell shown in Fig. 6f.

Shell size: Holotype, length 2.87 mm, height including tubercle 2.08 mm; paratype, length 2.67 mm, height including tubercle 2.05 mm.

First antenna (Fig. 8a): Elongate with 8 segments. First segment with distal lateral spines becoming longer near ventral margin; distal end of lateral side of first segment overlapping proximal part of second segment, especially in vicinity of ventral margin. Second segment with dorsal midbristle bearing short marginal spines; distal end of second segment overlapping proximal end of third segment, especially near ventral margin; distal half of second segment bearing abundant short spines (spines not shown on illustrated limbs). Third segment elongate, with spinous ventral bristle distal to middle, short proximal spines along dorsal margin, and longer spines on medial surface more or less restricted to distal ventral quarter. Fourth segment short, with slender dorsal bristle bearing short, faint, marginal spines. Fifth segment shorter than fourth, with long, ventral, terminal, filament-

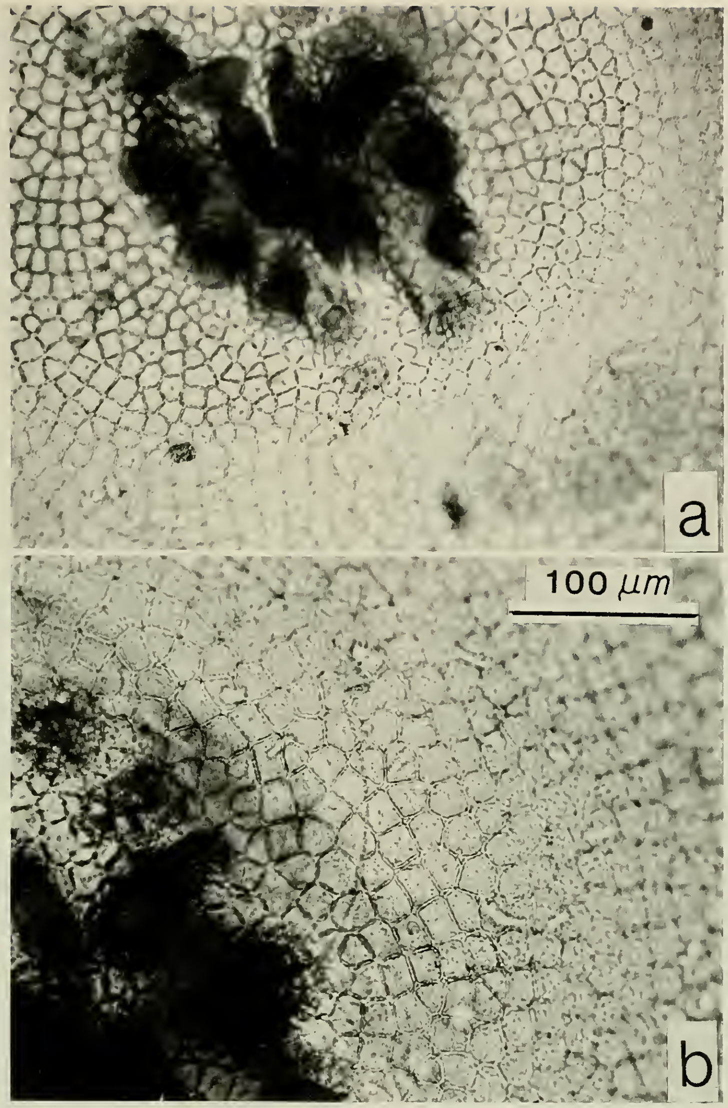

Fig. 3. *Deeveya spiralis,* a, Photograph using transmitted light and phase contrast of right valve of holotype showing internal reticulations in vicinity of adductor muscles (dark areas); b, Detail from a. Photographs by Dr. Robert P. Higgins.

like bristle bearing widely spaced short marginal spines and minute terminal spine. Sixth segment shorter than fifth, bare. Seventh segment about same length as fourth segment, with 1 short, distal, lateral, spinous bristle near dorsal margin, and 2 long, spinous (spines widely spaced) bristles on terminal ventral pedestal (both bristles longer than bristle of fifth segment; medial bristle about ¾ length of lateral bristle and filament-like). Eighth segment with long principal bristle (about 2 times length of stem) and 3 filament-like bristles about ½ length of principal bristle, all bristles with widely spaced marginal spines.

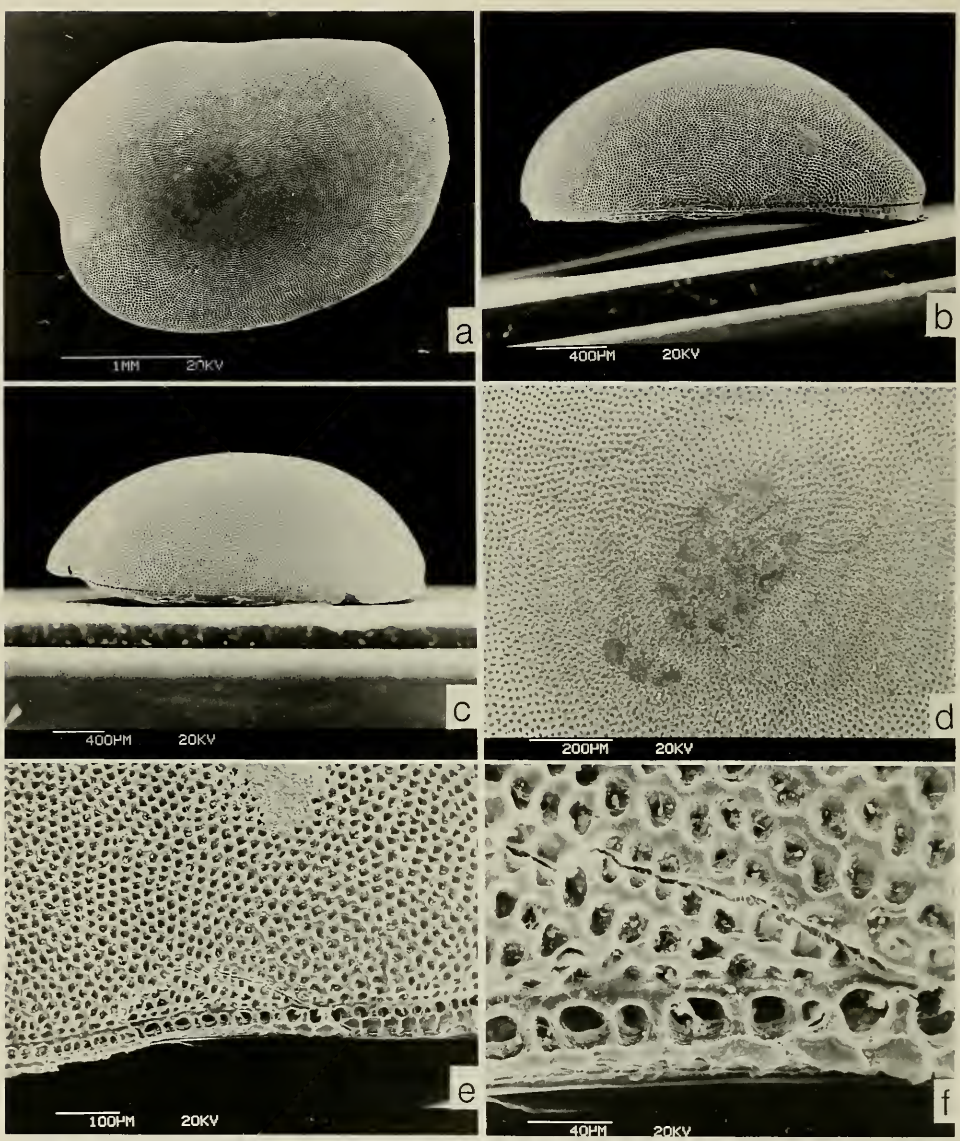

Fig. 4. *Deeveya spiralis,* SEM micrographs of left valve of holotype: a, Lateral view; b, Anterior view; c, Ventral view; d, Central area showing places where adductor muscles attach; e, Anterior view in vicinity of anteroventral concavity, from b; f, Detail from e.

Second antenna (Fig. 9a): Protopodite with long lateral spines forming 2 groups (1 proximal, 1 distal), and minute medial spines along dorsal margin. Endopodite 3-segmented: First segment with 2 spinous bristles on distal dorsal protuberance; second segment with 4 bristles (1 short, dorsal, spinous bristle and 3 long filament-like bristles with short widely spaced marginal spines), and short spine-like lateral bristle near dorsal margin of terminal ventral pedestal. Third segment with 2 long terminal bristles bearing widely spaced marginal spines (1 of the bristles filament-

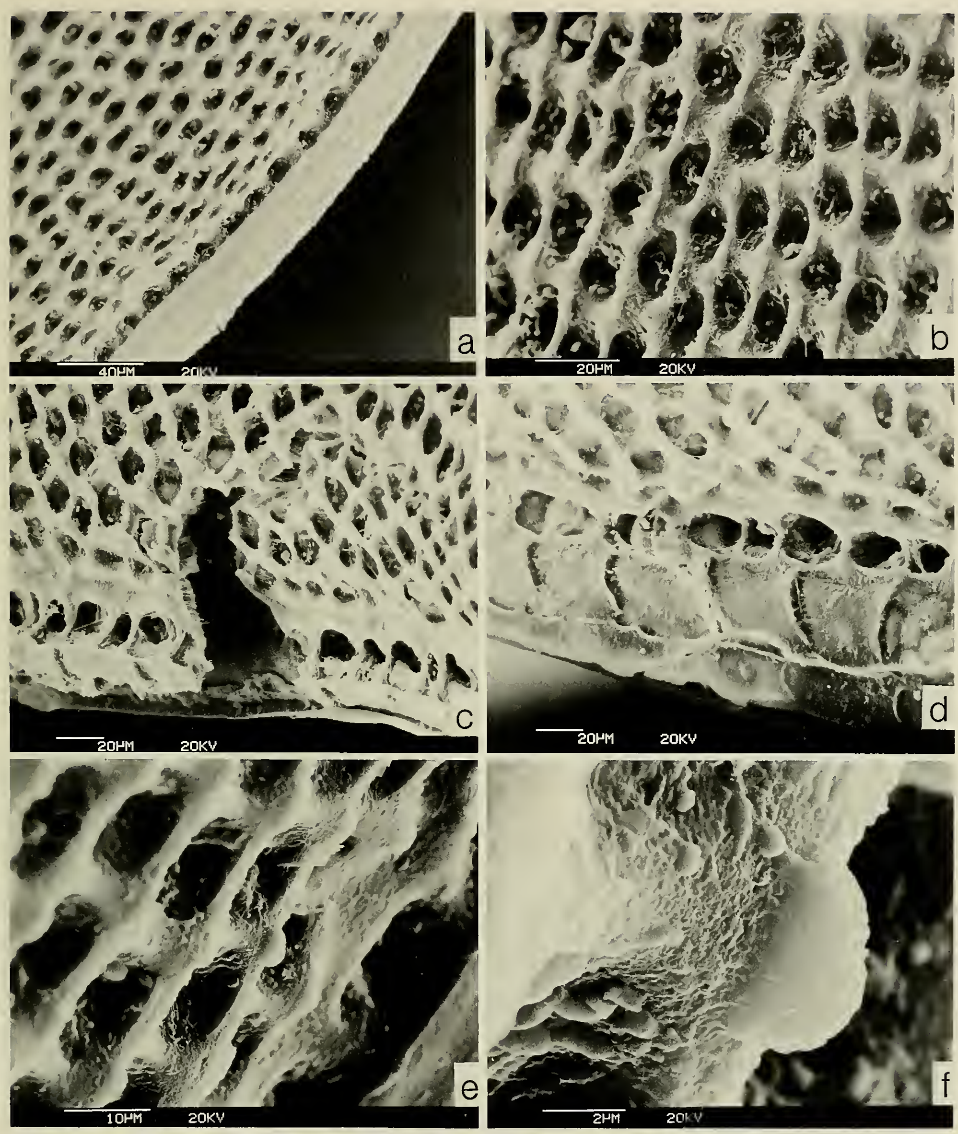

Fig. 5. *Deeveya spiralis,* SEM micrographs of left valve of holotype: a, Posteroventral corner, from Fig. 4a; b, Surface near anterior, from Fig. 4a; c, Surface near anterior showing fracture, from Fig. 4c; d, Surface at ventral margin, from Fig. 4c; e, Detail from a; f, Detail of protuberances shown in e.

like). Second and third segments forming right angle with first segment on holotype and paratype. Exopodite 9-segmented: First segment weakly divided into long proximal and short distal parts; proximal part with minute dorsal spines; distal part with slender, bare, medial bristle reaching past distal end of fifth segment. Segment 2 with long bristle bearing ventral spines and natatory hairs; joints 3–8 each with long bristle with natatory hairs; ninth joint with 4 bristles (2 short with marginal spines, 1 medium length with ventral marginal spines, 1 long with ventral

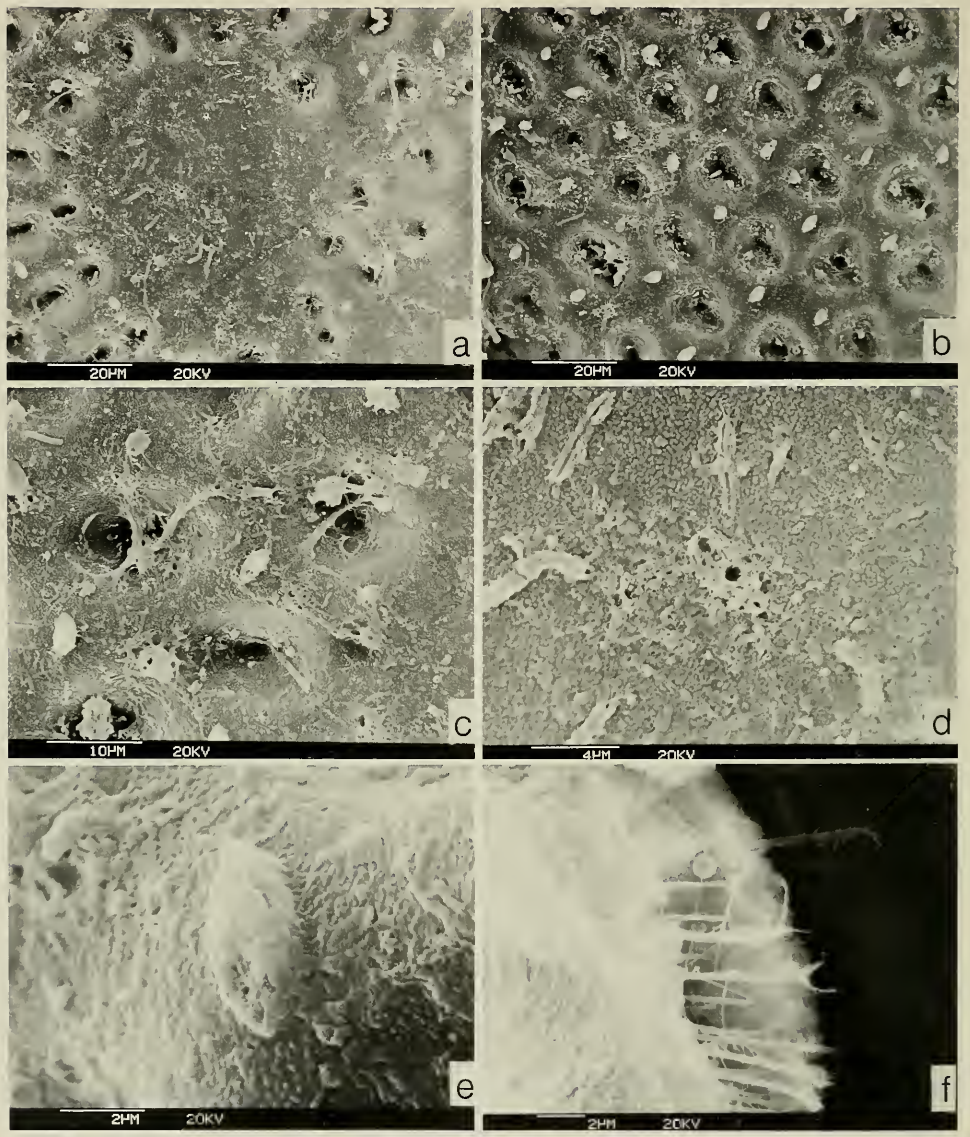

Fig. 6. *Deeveya spiralis,* SEM micrographs of left valve of holotype; a, Anterior muscle scar forming lower row in Fig. 4d; b, Fossae and minute protuberances near adductor muscles, from Fig. 4d; c, Detail from upper left of a; d, Detail of pore near middle of muscle scar shown in a; e, Detail of protuberance, from middle of Fig. 5b; f, Internal fibers perpendicular to shell surfaces, from fracture shown in Fig. 5c.

spines and distal natatory hairs); segments 2–8 decreasing in length distally along stem only slightly; ninth segment about ⅔ length of segment eight; segments 2–8 without basal spines or distal hairs or spines.

Mandible (Fig. 10): Coxal endite with proximal (also anterior) distal (also posterior) sets of teeth separated by small space (Fig. 10a, b): proximal (anterior) set

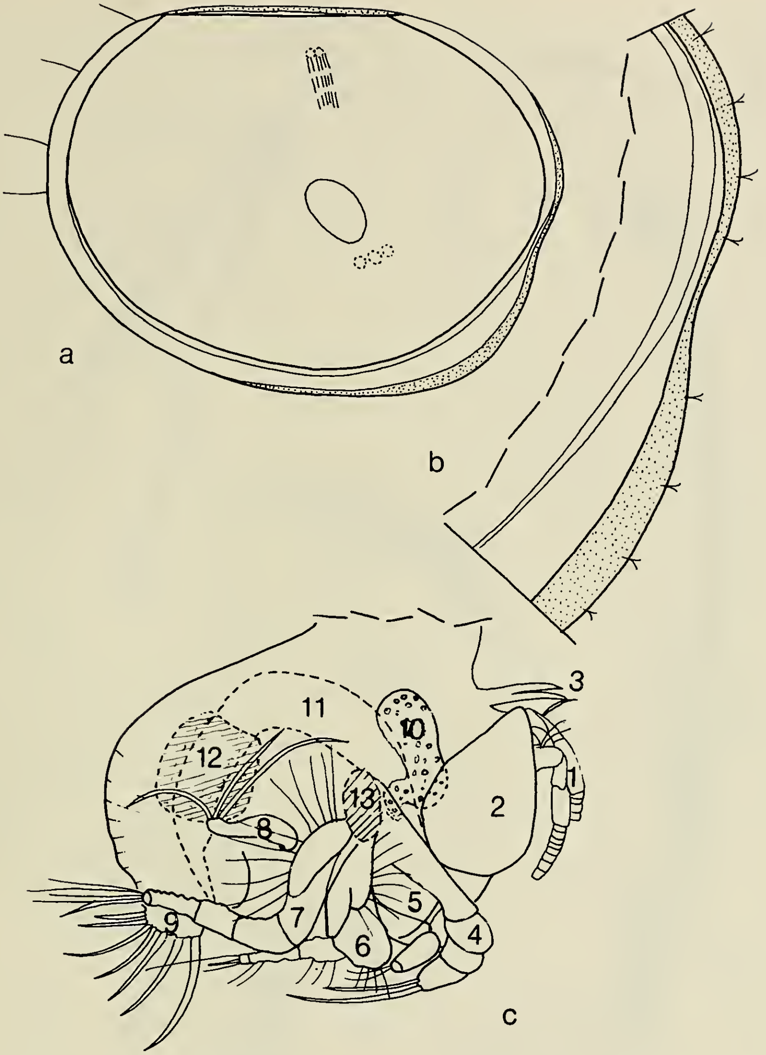

Fig. 7. *Deeveya spiralis,* a, Inside view of left valve of holotype showing infold, list on infold, and some muscles (main cluster of adductor muscles indicated by oval); b, Detail from a showing anterior concavity and bifurcate marginal bristles; c, Body of holotype from right side (1, 1st antenna; 2, 2nd antenna; 3, organ of Bellonci; 4, mandible; 5, maxilla; 6, 5th limb; 7, 6th limb; 8, 7th limb; 9, right lamella of furca; 10, hepatic appendage; 11, gut; 12, unknown receptacle; 13, central adductor muscle).

consisting of 4 broad teeth plus short, stout, spinous bristle near space; densely packed spines present between each tooth and anterior to anterior tooth and posterior to posterior tooth; slender spines also on medial surface proximal to teeth; distal (posterior) set of coxal teeth consisting of 2 terminal rows with 5 broad teeth in inner row and 6 in outer row (posterior tooth of inner row longer than others). Two lists present proximal and medial to inner row of distal coxal teeth; anterior of these consisting of anterior pectinate bristle-like tooth and posterior stout tooth; posterior list consisting of anterior pectinate bristle-like tooth

Fig. 8. *Deeveya spiralis,* holotype: a, Right 1st antenna; b, Anterior of body from left showing organ of Bellonci, part of left 1st antenna, and left hepatic appendage (with black spots); c, Anterior of body from right showing organ of Bellonci and first two segments of left 1st antenna; d, Upper and lower lips from right side; e, Unknown receptacle removed from right side of posterior part of gut.

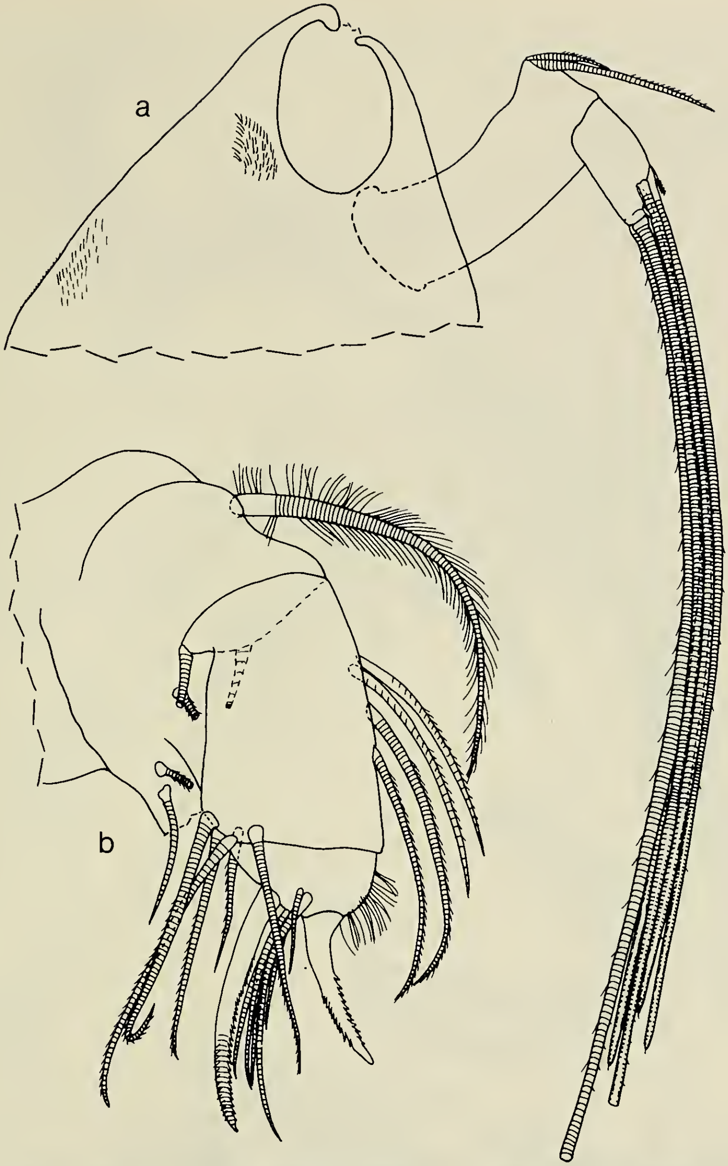

Fig. 9. *Deeveya spiralis,* holotype: a, Endopodite and part of protopodite of right 2nd antenna; b, Right maxilla (endites not shown).

and long curved tooth with rounded tip. Basal endite with 6 terminal non-serrate cusps (appearing worn); posterior cusp smaller than others and separated from them by space (Fig. 10b, c); posterior margin of endite not separated by suture from second segment but with single proximal bristle and distal, blunt, unringed bristle; anterior margin with single spinous bristle; medial surface with long hairs forming proximal cluster near posterior margin, and also forming distal rows;

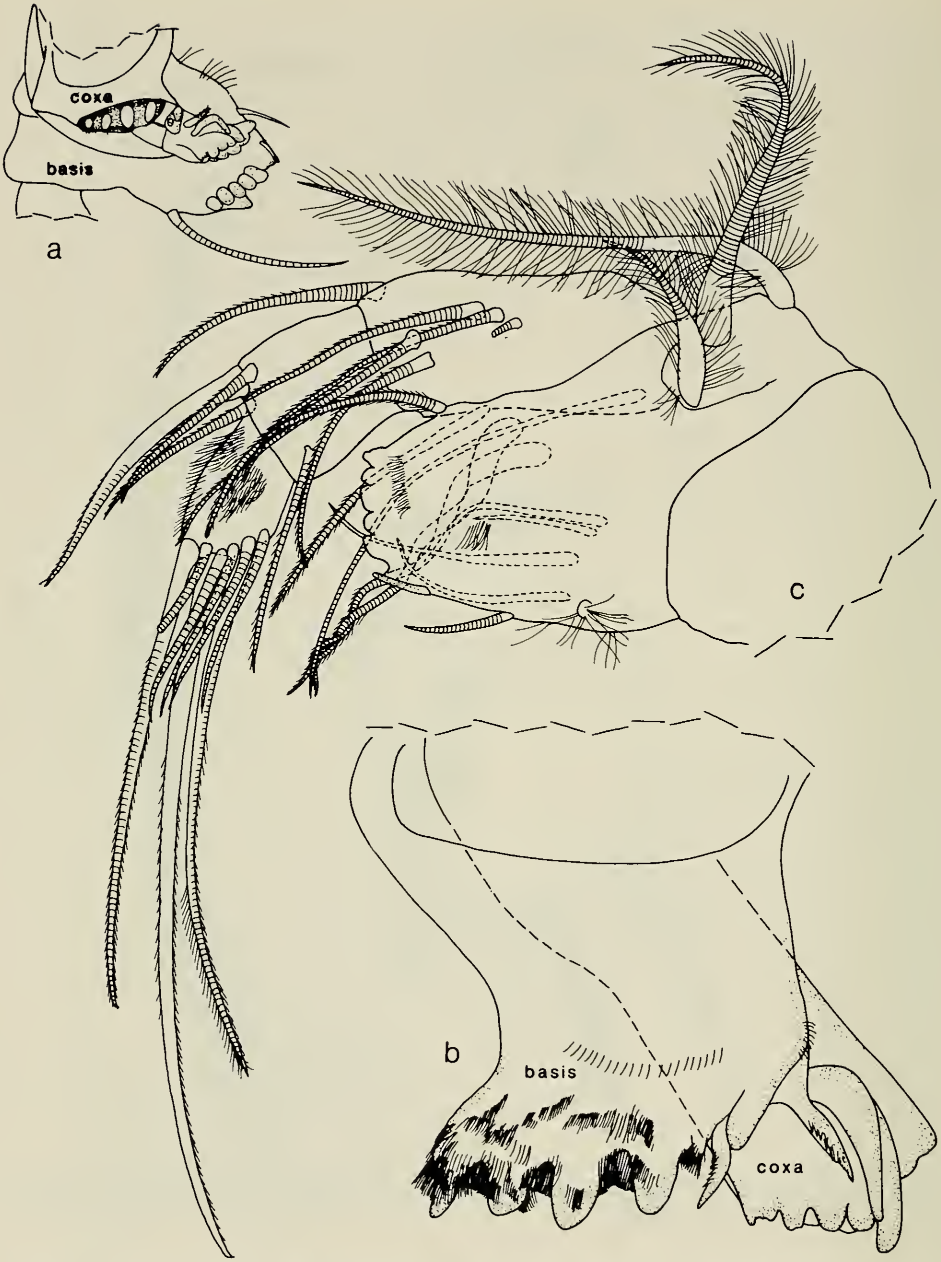

Fig. 10. *Deeveya spiralis,* right mandible of holotype; a, Medial view of distal ends of coxa and basis (not under cover slip); b, Basis and endopodite, medial view; c, Distal ends of coxa and basis (under cover slip).

lateral surface with 7 bristles (2 stouter than others and twisted together on both limbs of holotype and paratype); proximal lobe on medial surface with 2 hirsute bristles; dorsal margin of basis with long hirsute bristle. Endopodite 3-segmented with first segment about twice length of second and third segments; first segment

Fig. 11. *Deeveya spiralis,* holotype, limbs of right side: a, 5th limb; b, 6th limb; c, 7th limb; d, Right lamella of furca and single posterior bristle.

with 1 spinous anterior bristle, 1 spinous posterior bristle (behind basis on illustrated limb), and 5 medial bristles; second joint with medial bristle near distal posterior corner, and 3 terminal bristles at distal anterior corner (1 of bristles stout, claw-like); third joint hirsute medially and along anterior margin, with 5

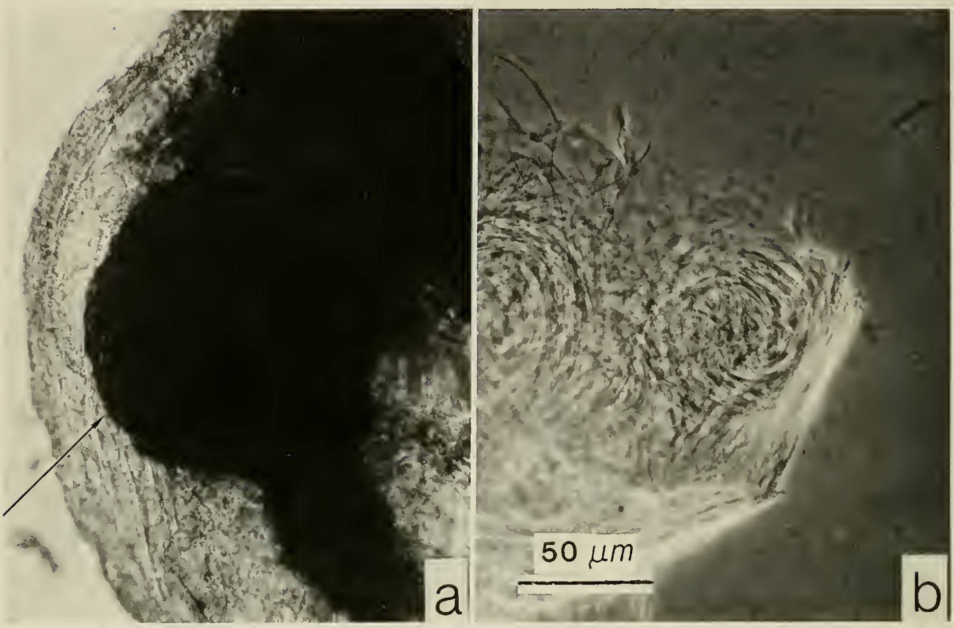

Fig. 12. *Deeveya spiralis,* holotype: a, Photograph of posterior of body showing unknown receptacle (arrow); b, Phase contrast photograph of part of unknown receptacle showing coils of thin filaments. Photographs by Dr. Robert P. Higgins.

distal medial bristles forming row, and 3 stout terminal bristles (middle and anterior of these with short marginal spines and with beak-like tip; posterior bristle with longer spines distally and with linear pointed tip).

Maxilla (Fig. 9b): Endites well developed and with numerous bristles (obscure on mounted appendage and not completely shown in illustration). Basis with 1 hirsute dorsal bristle and 2 ventral bristles (1 lateral, 1 medial). Endopodite: First segment with 4 spinous bristles on or near anterior margin, and 5 bristles at distal posterior corner; second segment with 2 stout claws, 6 slender bristles, and long hairs on anterior surface.

Fifth limb (Fig. 11a): Epipodial appendage with plumose bristles forming 3 groups, each with 5 bristles. Protopodite and endopodite with total of 28 bristles including 2 claw-like pectinate bristles at ventral margin of knee. Exopodite 3-segmented: First segment with 2 distal dorsal bristles (longest of these with minute widely spaced marginal spines, other with long marginal hairs), 2 lateral bristles (distal of these plumose), 1 medial bristle near middle, 4 proximal medial bristles with bases near ventral margin, and 4 distal bristles with bases on or near ventral margin; suture separating first and second segments more defined on medial side; elongate second segment with 4 bristles (1 dorsal, 3 ventral); small third joint with 2 stout pectinate claw-like bristles and 3 slender ringed bristles (bases of slender bristles medial to claw-like bristles).

Sixth limb (Fig. 11b): Epipodial appendage with plumose bristles forming 3 groups having 7 bristles in proximal group, 5 in distal group, and 6 in middle group. Protopodite divided distally by suture evident only on medial side; prox-

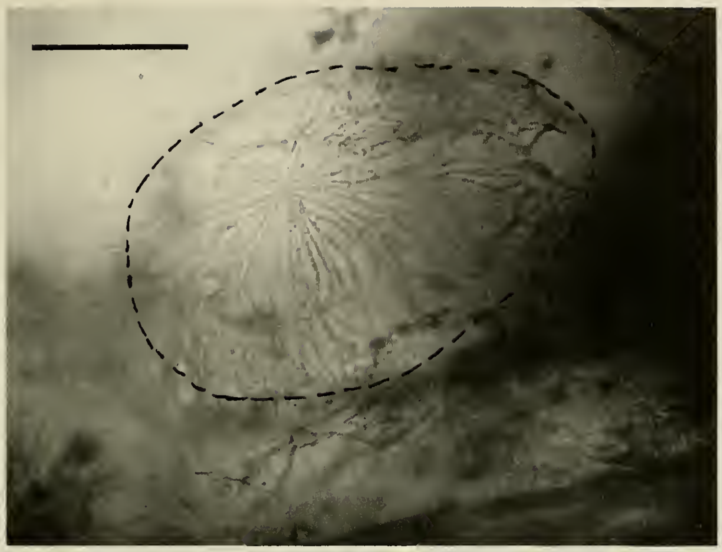

Fig. 13. *Deeveya spiralis,* holotype: photograph of elliptical organ (heart?) posterior to organ of Bellonci. Note network on surface. Photograph by Dr. Robert P. Higgins. Length of scale bar 0.10 mm.

imal segment with 4 bristles on or near ventral margin (all but 1 bristle plumose); distal segment with 2 ventral bristles with short marginal spines and 2 stouter medial plumose bristles. Exopodite 4-segmented: First segment with plumose lateral bristle near middle and 6 plumose bristles on or near ventral margin; process with 4 bristles (longest of these with short, faint, marginal spines, others plumose) present on distal dorsal corner of first segment; second segment with 4 bristles on or near ventral margin (all bristles with short marginal spines); third segment with 3 bristles (2 ventral, 1 dorsal); fourth segment with 2 long, stout, pectinate claw-like bristles, 2 slender bristles ventral to claw-like bristles, and 1 small bristle between and lateral to claw-like bristles.

Seventh limb (Fig. 11c): Limb with 1 segment or 2-segmented: First segment elongate, bare; second segment wtih 3 terminal bristles (1 long, 2 shorter, all with short, widely spaced, marginal spines).

Caudal furca (Fig. 11d): Each lamella with total of 7 pairs of claws followed by unpaired dorsal bristle; claws 1–4 with faint teeth along dorsal margins; claws 5–7 bristle-like with teeth along both margins (teeth stouter near midlength); teeth along margins of claw 7 smaller than those on claws 5 and 6; unpaired dorsal bristle about same length as claw 1, and with marginal spines; left lamella of furca of holotype slightly anterior to right lamella, but reverse relationship on paratype; ventral edge of lamellae between claw 7 and unpaired dorsal bristle with minute spines; minute spines also present on distal medial surface of lamellae.

Organ of Bellonci (Fig. 8b, c): Well-developed, cone-shaped, bifurcate distally, with tips of branches tapering to point.

Lips (Fig. 8b, d): Upper lip with about 6 glandular openings along ventral face and spines along posterior edge. Lower lip with triangular processes on each side and anterior spines.

Posterior of body (Fig. 7c): Evenly rounded, unsegmented.

Hepatic appendage (lumen) (Figs. 7c, 8b): Paired, elongate, tapering to narrow opening at esophagus near mouth, and containing many minute brown bodies.

Heart: Ellipsoid, just posterior to Bellonci organ of holotype, covered by unusual and unidentified network (Fig. 13) may be a heart.

Unknown receptacle (Figs. 7c, 8e, 12): Oval body to right of gut in posterior part of body; with pearly sheen in reflected light; receptacle packed with coils of long thin thread-like filaments.

Eggs: Both holotype and paratype with unextruded eggs that vary in size within same specimen.

*Remarks.*—Skogsberg (1920:560) referring to the seventh limb of halocyprids, which generally bears two bristles, noted "only in exceptional cases, in single specimens, are three bristles found." In the present species, three bristles were found on both limbs of the holotype and paratype, indicating that three bristles are normal. The basal endite of the mandible of this species bears two stout lateral bristles that are twisted around each other (Fig. 8c). This occurred on all four limbs of the two specimens on hand, suggesting that this unusual morphological character is normal for the species.

The "unknown receptacle" was initially thought to be a seminal receptacle and the coiled filaments spermatozoa. In order to verify that the filaments were spermatozoa the receptacle was sectioned with a microtome and the sections stained with hematoxylin and eosin. This treatment failed to stain the filaments, showing them not to be spermatozoa. The receptacle wall has nuclei and appears to be epithelium. No cells or nuclei were present inside the receptacle or within the filaments. The filaments were not identified. It is not known if the receptacle is part of the genitalia, gut, or unrelated to either. Because only two specimens are on hand it can not be ascertained if the organ is present on all specimens of the species, and not a foreign inclusion.

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# *QUADRYOPS*, NEW GENUS, AND THREE NEW SPECIES OF ARBOREAL DRYOPIDAE (INSECTA: COLEOPTERA) FROM PANAMA AND ECUADOR

Philip D. Perkins and Paul J. Spangler

*Abstract.*—A new genus, *Quadryops* (Coleoptera: Dryopidae), with three new species, *Q. chrysosetosus, Q. quasimodoi,* and *Q. obtusetosus* are described. Two of the species are from Panama: *Q. chrysosetosus* from the canopy of a lowland *Leuhea seemanni* forest (100 meters) and *Q. quasimodoi* from forest floor litter and wood chips from a montane logging area (1720 meters). The third species, *Q. obtusetosus,* was collected in Ecuador by sweeping forest vegetation at night (300 meters). The species are illustrated by scanning electron micrographs and line drawings. A key to the species and a tabular comparison of the states of selected taxonomic characters are given.

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Members of *Quadryops,* new genus, described below are unique among known Dryopidae in that the tarsi have four articles; all other described dryopid species have five articles. The most obvious diagnostic feature of members of *Quadryops,* however, is the shape of the pronotum which appears to be inflated due to the lobate discal area (Fig. 3). Development of a median longitudinal depression on the pronotum, and hence division of the pronotal prominence into two lobes, varies among the three species of *Quadryops* now known.

Members of *Quadryops* have two types of pubescence. Most of the body is clothed in indumentum consisting of aciculate hairlike setae whose density varies among the species. This indumentum abrades moderately easily, leaving distinctive punctures (termed micropunctures in the descriptions that follow; Fig. 39). In addition to indumentum, the body has longer, sparser, erect or suberect setae which differ in form among the three species. In *Q. chrysosetosus,* these setae are acute at the apex, enlarged subapically and have ridges (Fig. 19); erect setae of *Q. obtusetosus* are blunt and enlarged apically and have ridges (Figs. 6, 21); in the third species currently known, *Q. quasimodoi,* the holotype is badly abraded and the few remaining erect setae are blunt but not enlarged apically (Fig. 46). These erect setae emerge from punctures much larger than those of the indumentum; punctures (termed macropunctures in the descriptions that follow) are round and flat-bottomed on the elytra of *Q. obtusetosus,* and setal sockets fit closely around the setae (Figs. 20, 21). The elytral macropunctures of *Q. chrysosetosus,* contrastingly, are round-bottomed and have elongate sockets which would allow forward and backward movement of the setae but restrict side to side motion (Fig. 18).

Metathoracic wings are fully developed in the three species of *Quadryops.* The wings of *Q. chrysosetosus* and *Q. quasimodoi* are similar in that both have a well-developed vein $2A_1$, whereas wings of *Q. obtusetosus* lack that vein (Figs. 30, 31, 32). The antennae of all three species have 11 articles and well-developed sensilla in both sexes. The sensilla are of two types, simple and dendritic (Figs. 26, 28, 29). A comparison of the states of selected characters of the three species is given in Table 1.

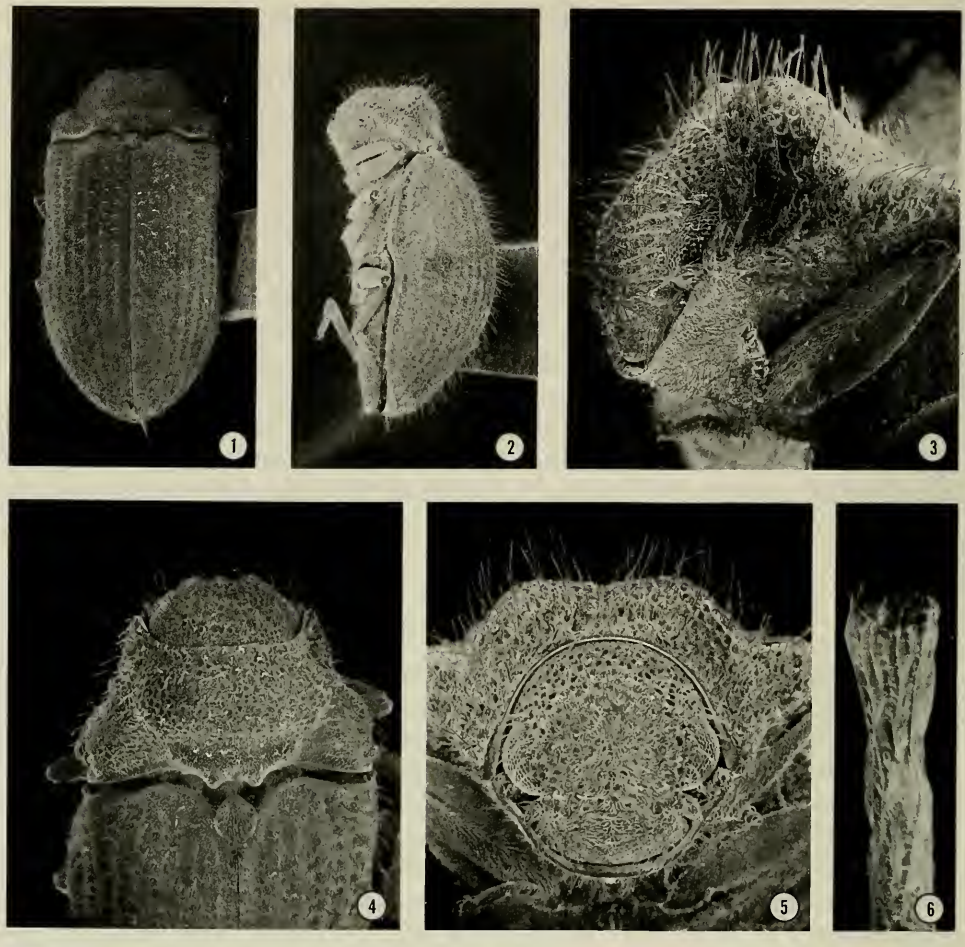
Members of this genus have been very rarely collected; presently only a single specimen of each species is represented in collections. Two species were collected in arboreal habitats: *Q. chrysosetosus* was collected in Panama during a pyrethrin fogging experiment in the canopy of a lowland forest of *Luehea seemanni* (100 meters); *Q. obtusetosus* was collected in Ecuador by sweeping forest vegetation at night. *Quadryops quasimodoi* may be a forest floor species, as the single known specimen was collected in Panama by berlese extraction of concentrated forest floor litter and wood chips from a logging area (1720 meters). However, a vast amount of debris from the canopy accumulates on the forest floor of logging areas and it is possible that *Q. quasimodoi* is an arboreal species like its congeners.

Although the habits of dryopid beetles are poorly known, most genera are known to inhabit semiaquatic habitats. However, several genera such as *Geoparnus* Besuchet, *Sostea* Pascoe, *Protoparnus* Sharp, *Oreoparnus* Deleve, and *Quadryops* n. gen. are terrestrial beetles. Because very little is known about dryopids, collectors are urged to record habitats and all biological data possible when the beetles are found.

## *Quadryops*, new genus

*Type-species.*—*Quadryops chrysosetosus,* new species.

*Description.*—Body form oblong, robust, markedly convex dorsally; integument with indumentum of moderately long setae that vary from dense to moderately sparse; dorsally and sometimes ventrally with distinctive suberect setae which may be acute at the apex and thickened subapically, blunt and thickened apically, or blunt and not thickened apically (Figs. 6, 19, 46). Head retractile; eyes well developed, widely separated, pubescent. Clypeus expanded laterally. Labrum partially or completely concealed beneath clypeus in dorsal view. Antennomeres 11, with setae and sensilla as illustrated (Figs. 26, 28, 29); head concave between raised and widely separated antennal acetabulae. Labial palpomeres 3 (Fig. 33). Maxillary palpomeres 4 (Figs. 34, 35). Pronotum with discal area very convex; apical ⅔–¾ lobate with distinctly or indistinctly developed median longitudinal depression which divides prominence into a lobe on each side (Figs. 5, 36); posterior part of pronotum broad lateral to elevated disc, subtriangular and slightly concave (Figs. 4, 36); lateral margin crenulate, sometimes angulate; prescutellar emargination well developed. Elytra width at base equals basal width of pronotum, parallel-sided, very convex; each elytron with nine more or less developed striae; margin sinuate in lateral view, basal half depressed to form vertical side of elytron (Fig. 2); epipleuron horizontal, except nearly vertical at subacute elytral apex. Scutellum large, produced anteriorly. Metathoracic wings present. Prosternum long in front of procoxae; process carinate, apex deflexed and inserted into deep mesosternal fovea; short longitudinal carina in front of procoxae on each side of prosternal process (Fig. 41). Trochantin exposed. Mesosternum moderately raised between mesocoxae. Distance separating mesocoxae greater than or less than that separating metacoxae. Metasternum with median longitudinal sulcus which may or may not be extended forward onto intercoxal process. Metacoxae moderately excavated to receive metatibiae. Legs short; tibiae slightly longer than femora;



Figs. 1–6. *Quadryops obtusetosus*: 1, Habitus, dorsal view; 2, Habitus, lateral view; 3, Head and prothorax, oblique view; 4, Head, pronotum and anterior region of elytra, dorsal view; 5, Head and prothorax, anterior view; 6, Apex of pronotal seta.

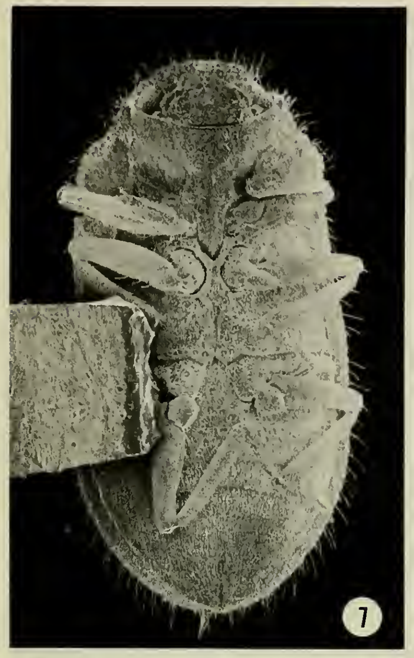
tarsus very short, about ⅓ length of tibia, with four articles, combined lengths of articles 1, 2 and 3 approximately equal to length of article 4 (Fig. 23).

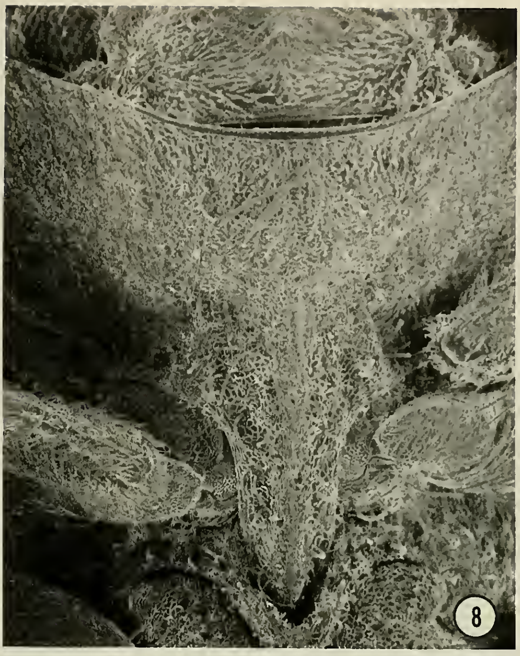
*Etymology.*—Greek *quad* (four), plus *dryops* (referring to family name). The tarsi of members of *Quadryops* have four articles.

### *Quadryops chrysosetosus,* new species
Figs. 10–19, 22, 26, 28, 32, 35

*Type-data.*—Holotype male: Panama, Canal Zone, 5.0 mi. NW Gamboa, 09°10′N, 079°45′W, 100 meters; canopy pyrethrin fogging experiment in *Luehea seemanni*; sample 1–2a, 12 Jul 1976, Montgomery and Lubin collectors. Deposited in the National Museum of Natural History, Smithsonian Institution; type no. 100893.

*Description.*—Holotype male: 2.60 mm long, 1.44 mm wide. Body form oblong,

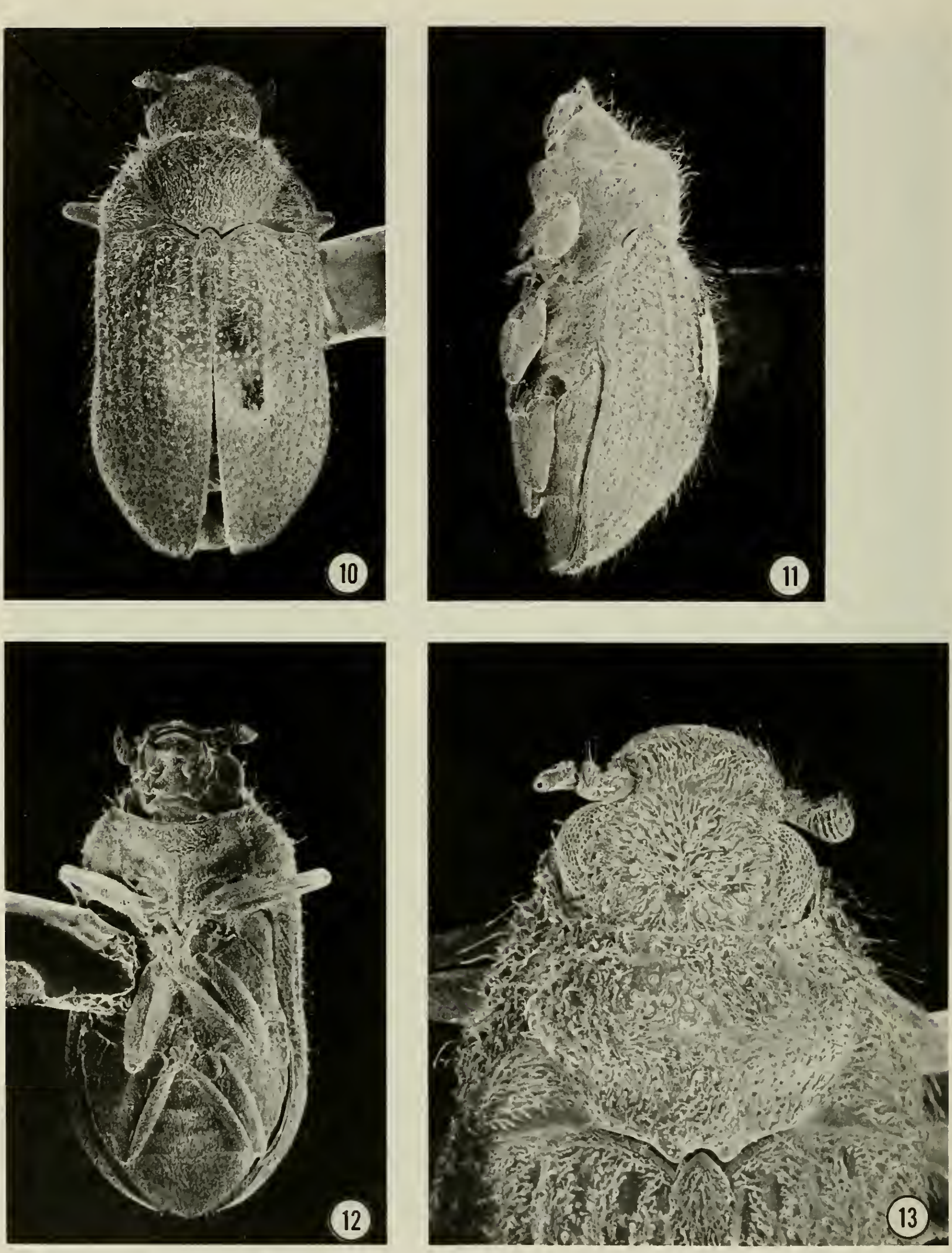




Figs. 7–9. *Quadryops obtusetosus*: 7, Habitus, ventral view; 8, Prosternum; 9, Antenna and associated head and prosternal structures.

markedly convex (Figs. 10, 11). Color brown; dorsum slightly darker than venter and legs. Integument with light brown indumentum; dorsal surface also with suberect setae about 0.16 mm long, each seta enlarged subapically and with pointed apex (Fig. 19).

Head: 0.60 mm long, 0.70 mm wide, 0.50 mm wide between eyes. Eyes large,



Figs. 10–13. *Quadryops chrysosetosus*: 10, Habitus, dorsal view; 11, Habitus, lateral view; 12, Habitus, ventral view; 13, Head, pronotum and anterior region of elytra, dorsal view.

hemispherical, pubescent. Frons and base of clypeus transversely confluently concave; frons markedly punctate. Clypeus in dorsal view with anterior margin straight in middle ⅓, arcuate laterally, middle ⅔ straight in anterior view; lateral angles deflexed. Labrum small, concealed beneath clypeus in dorsal view; anterior margin shallowly emarginate. Antennomeres 11 (Figs. 26, 27). Last labial palpomere flat, broad; width equal to ½ length. Maxillary palpomeres 2 and 3 each ⅓ length of palpomere 4 (Fig. 35).

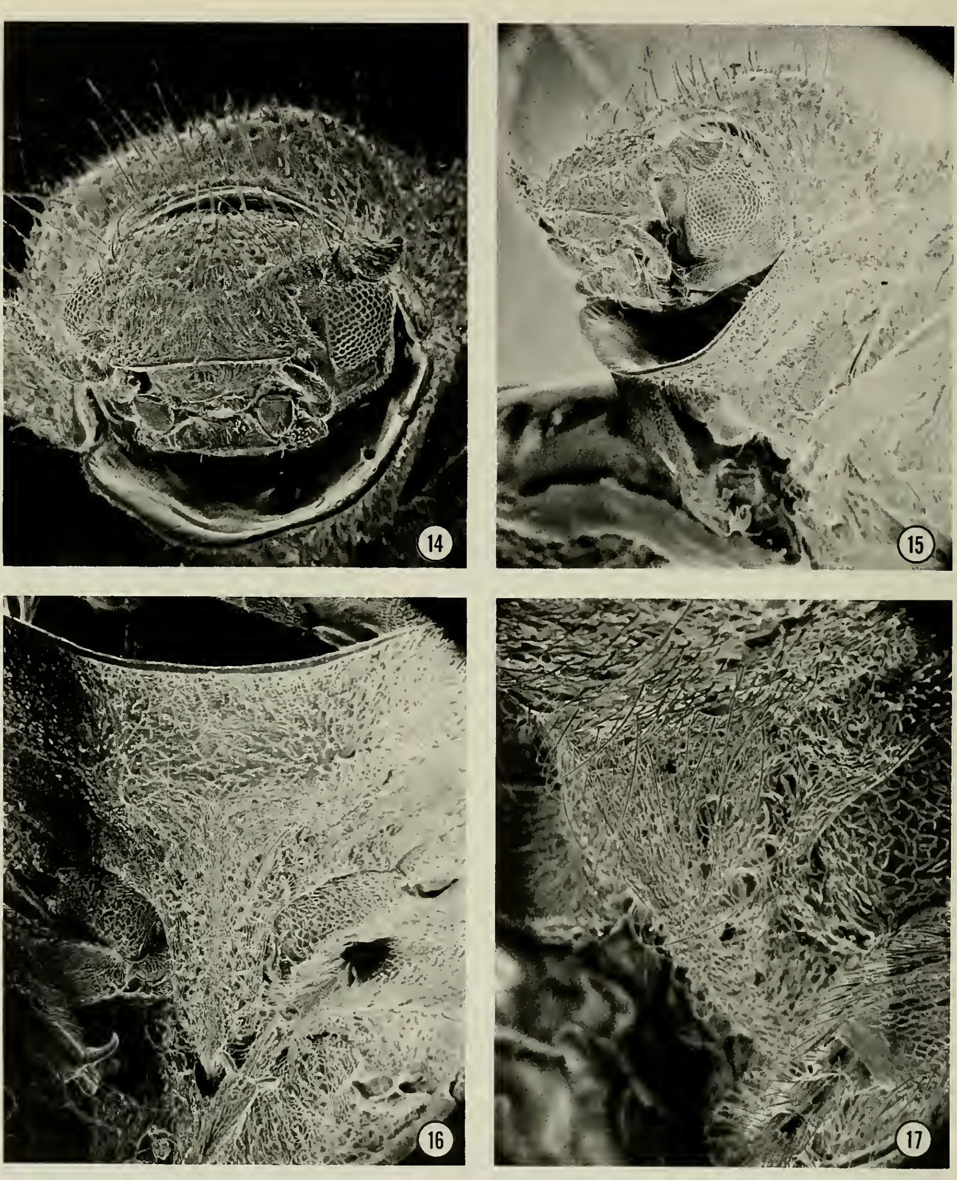
Pronotum: 0.60 mm long; width 1.32 mm basally, 0.80 mm apically. Apical ⅔ of pronotal disc markedly inflated, very slightly depressed longitudinally on midline to form lobe on each side. Posterior area lateral to elevated disc triangular, slightly concave; with shiny integument, except alutaceous lateral border. Anterior margin of pronotum with short shelf in front of discal lobes; lateral margin crenulate. Short pubescence more developed on reliefs than in area at margin of raised disc. Moderately markedly punctate, especially on inflated disc where punctures separated by 1–2 × their width. Integument shiny on disc, dull between disc and lateral margin. Posterior margin trisinuate, contiguous with elytral base, angularly emarginate to receive scutellum; small depression in front of prescutellar emargination. Scutellum more markedly angulate anteriorly than posteriorly.

Elytra: 1.92 mm long, 1.44 mm wide; parallel sided; markedly declivous laterally to form vertical sides; disc transversely and longitudinally convex. Each elytron with irregular, coarse, dense, setiferous punctures larger than those on pronotal disc; most punctures in 9 shallow, indistinct striae; punctures of striae 7–9 on vertical side of elytron very dense, some separated by narrow ridges. Basal tenth of interval 5 (humeral) irregularly cariniform. Lateral margin, in side view, markedly sinuate (Fig. 11). Stria 9 (marginal) well developed. Stria 1 more markedly developed in basal third than on remainder of elytron. Elytral apices subacute.

Prosternum: 0.66 mm long; with moderately dense indumentum and sparse, erect, longer hairs (these hairs not expanded subapically as those on dorsum). Prosternal process 0.26 mm long, 0.14 mm wide at base; carinate, carina extended anteriorly onto disc; slightly convex in lateral view; apex inserted into deep mesosternal fovea. Mesosternum with sides of median fovea raised slightly. Metasternum with median longitudinal depression; intercoxal process width less than length, raised slightly above plane of disc, median longitudinal depression well developed; metepisternum without basomedial carina; integument densely indumentose, also with large punctures, each puncture with a large suberect seta; large punctures in a marginal row at base of metasternum, absent from small sublateral area in front of marginal row; remainder of metasternum randomly punctate, punctures separated by about 2–3 × their diameter; basal margin lobate on each side of midline.

Abdomen: Midline length ratios of sterna: 2/1.2/1/1/3. Intercoxal process length equal to width at base, length about equal to length of remainder of sternum; narrowest separation of metacoxae slightly greater than that of mesocoxae. Sternum 5 with apical half raised on midline to form low ridge. Integument indumentose as metasternum. Macropunctures on intercoxal process as large as and as dense as those on metasternum; remainder of macropunctures on sterna denser and smaller. Each macropuncture with suberect seta.

Legs: Densely indumentose. Tarsi densely pubescent beneath; each slightly more than ⅓ length of respective tibia. Protibia with apical half slightly flattened lateromedially, widest near apical third. Metacoxae coarsely punctate similarly to metasternum; metatrochanter globose, size slightly smaller than median third of coxa; metafemur with upper surface of distal end angulate.

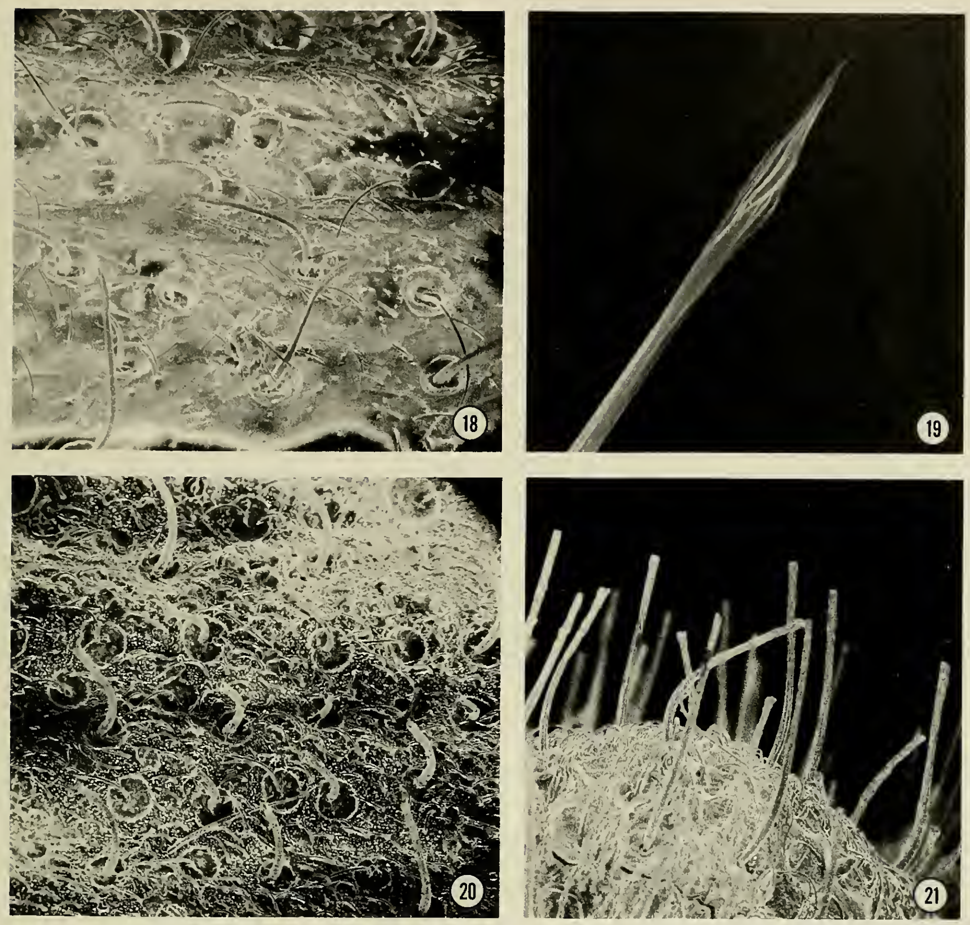


Figs. 14–17. *Quadryops chrysosetosus*: 14, Head and prothorax, anterior view; 15, Head and prothorax, oblique view; 16, Prosternum, ventral view; 17, Prosternum, oblique view.

Genitalia: Aedeagus as illustrated (Fig. 22). Female unknown.

*Distribution.*—Presently known only from the type-locality; Canal Zone, Panama.

*Etymology.*—*chrysosetosus,* from Chrysopidae and *setosus.* The prominent suberect setae of the body are expanded subapically, reminiscent of chrysopid eggs mounted on narrow stalks.



Figs. 18–21. 18, *Quadryops chrysosetosus,* disc of elytron; 19, *Q. chrysosetosus,* apex of pronotal seta (800×); 20, *Q. obtusetosus,* disc of elytron; 21, *Q. obtusetosus,* pronotal setae.

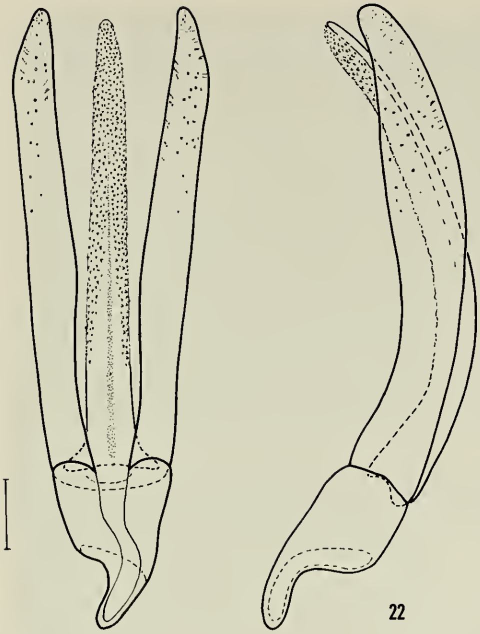
### *Quadryops obtusetosus,* new species

Figs. 1–9, 20, 21, 24, 27, 29, 31, 33, 34

*Type-data.*—Holotype female: Ecuador, Pastaza Province, Ashuara Rio Macuma, 10 km from Rio Morona, 300 meters, forest night sweep, 7–16 Jul 1971, coll. B. Malkin. Deposited in the Field Museum of Natural History, Chicago.

*Description.*—Holotype female: 3.20 mm long, 1.76 mm wide. Body form oblong, markedly convex (Figs. 1, 2). Color brown. Integument with indumentum and prominent, suberect, blunt setae.

Head: 0.74 mm long, 0.80 mm wide, 0.56 mm between eyes. Eyes large, hemispherical, pubescent. Frons slightly concave between eyes; apex of frons and base of clypeus confluently concave between antennal acetabulae; frontoclypeal suture distinct in middle of concavity; frons with punctures coarse, dense, deep; interstices with narrow walls, punctures absent from small median area. Clypeus in



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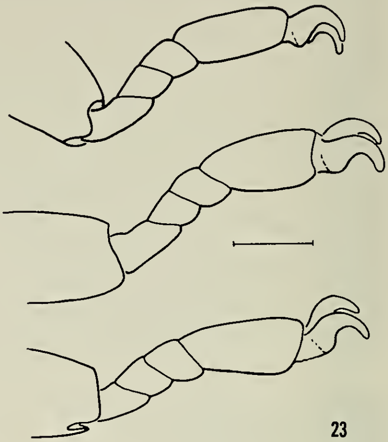

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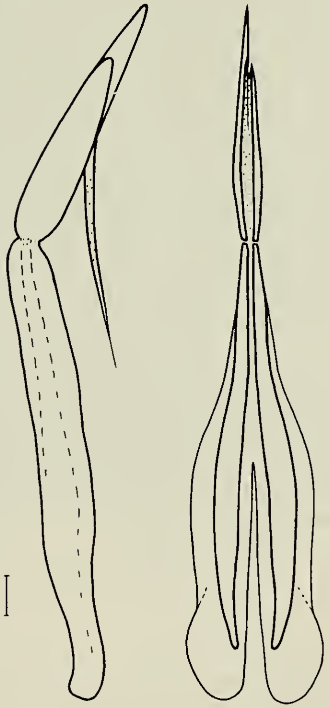

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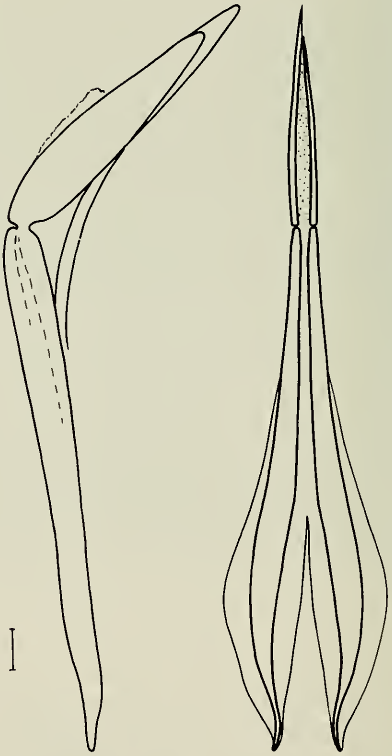

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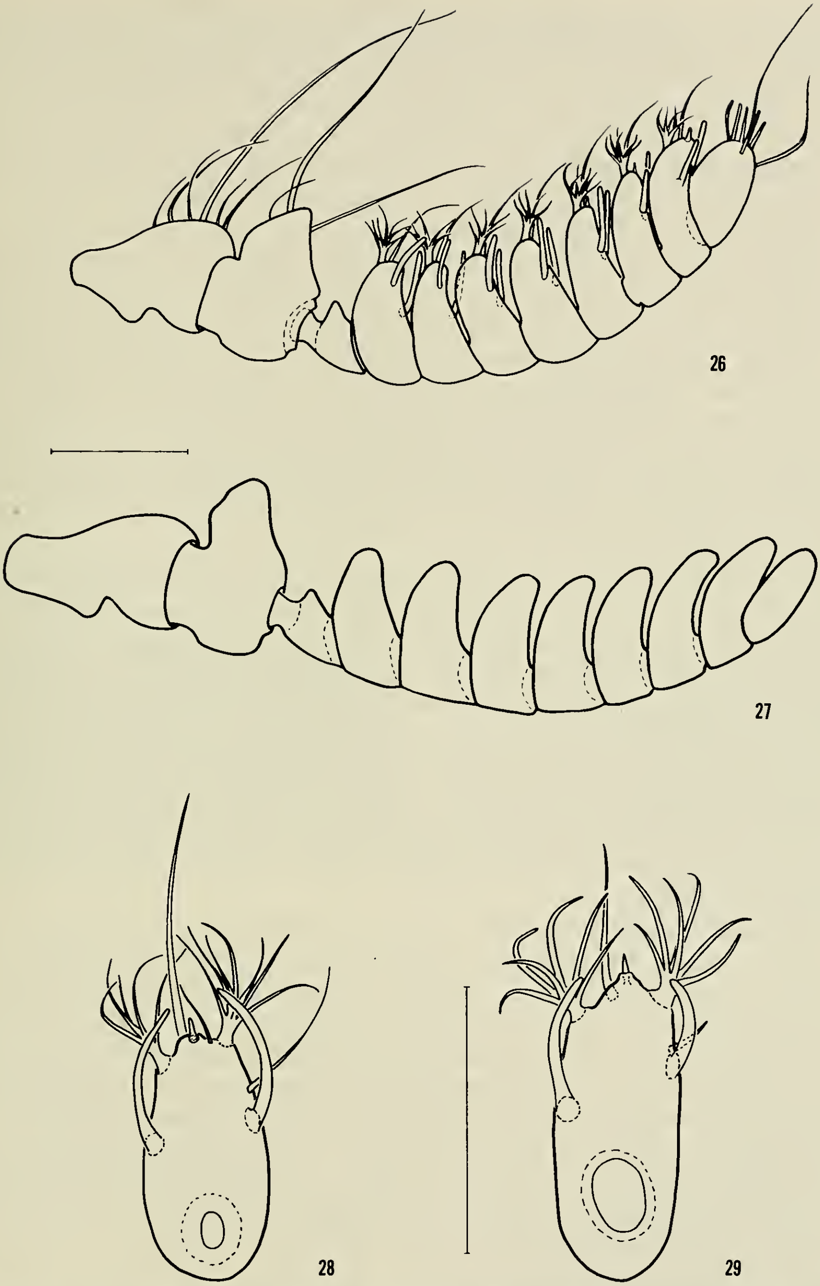
Figs. 22–25. 22, *Quadryops chrysosetosus,* aedeagus, dorsal and lateral views; 23, *Q. quasimodoi,* pro- (top), meso- and metatarsi (microslide preparation; pubescence omitted); 24, *Q. obtusetosus,* ovipositor, lateral and dorsal views; 25, *Q. quasimodoi,* ovipositor, lateral and dorsal views. (Scale lines equal 0.1 mm.)



Figs. 26–29. 26, *Quadryops chrysosetosus,* antenna (some simple setae omitted); 27, *Q. obtusetosus,* antenna (all setae omitted); 28, *Q. chrysosetosus,* antennomere 7; 29, *Q. obtusetosus,* antennomere 7. (Scale lines equal 0.1 mm.)

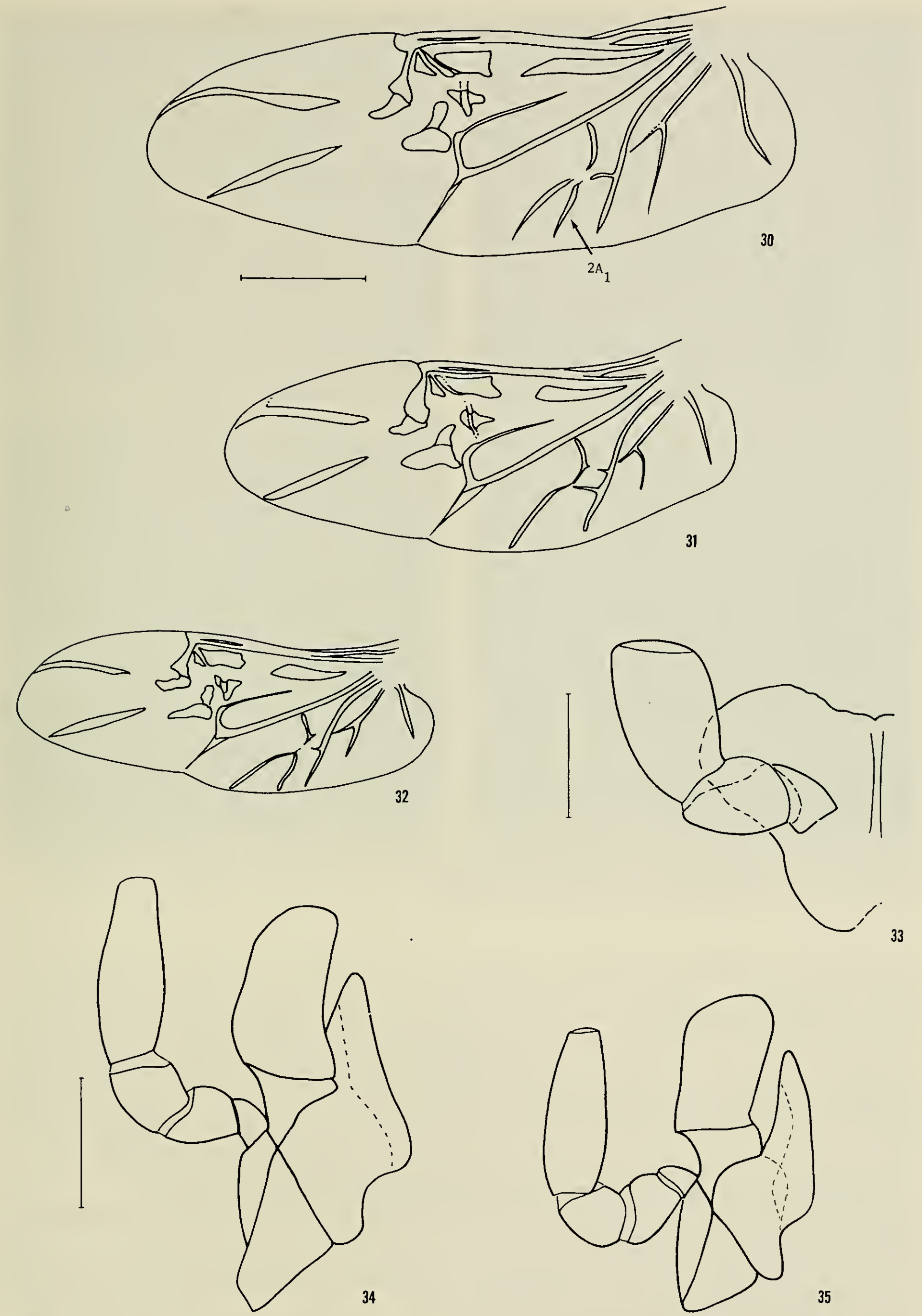
dorsal view with anterior margin nearly straight in middle third, more arcuate laterally; in anterior view, middle ⅔ slightly arcuate dorsally; lateral angles deflexed very slightly. Labrum small, concealed beneath clypeus in dorsal view; anterior margin shallowly and broadly emarginate. Antennomeres 11 (Fig. 27). Labial palpomeres 1–3, length ratios 2/5/7 respectively; palpomere 3 flat, broad, width slightly greater than ½ length (Fig. 33). Maxillary palpomeres 2 and 3 of equal length; palpomere 4 equals 2.5 × length of palpomere 3 (Fig. 34).

Pronotum: 0.80 mm long; width 0.96 mm apically, 1.52 basally. Apical ⅔ of disc markedly inflated, longitudinally depressed on midline to form a lobe on each side. Posterior area lateral to elevated disc triangular, concave; punctures less dense than those on disc. Lateral half alutaceous. Basal border very shiny; anterior border in form of narrow shelf in front of discal lobes, shelf widened laterally. Lateral margin sinuate, coarsely crenulate. Integument of inflated disc with dense, deep, coarse punctures; some punctures separated by narrow walls; interpunctal areas dull due to fine, dense indumentum; punctures less dense behind inflated lobes. Posterior margin markedly trisinuate, contiguous with elytral base; prescutellar emargination with small median process in front of which is a small depression. Scutellum ovoid.

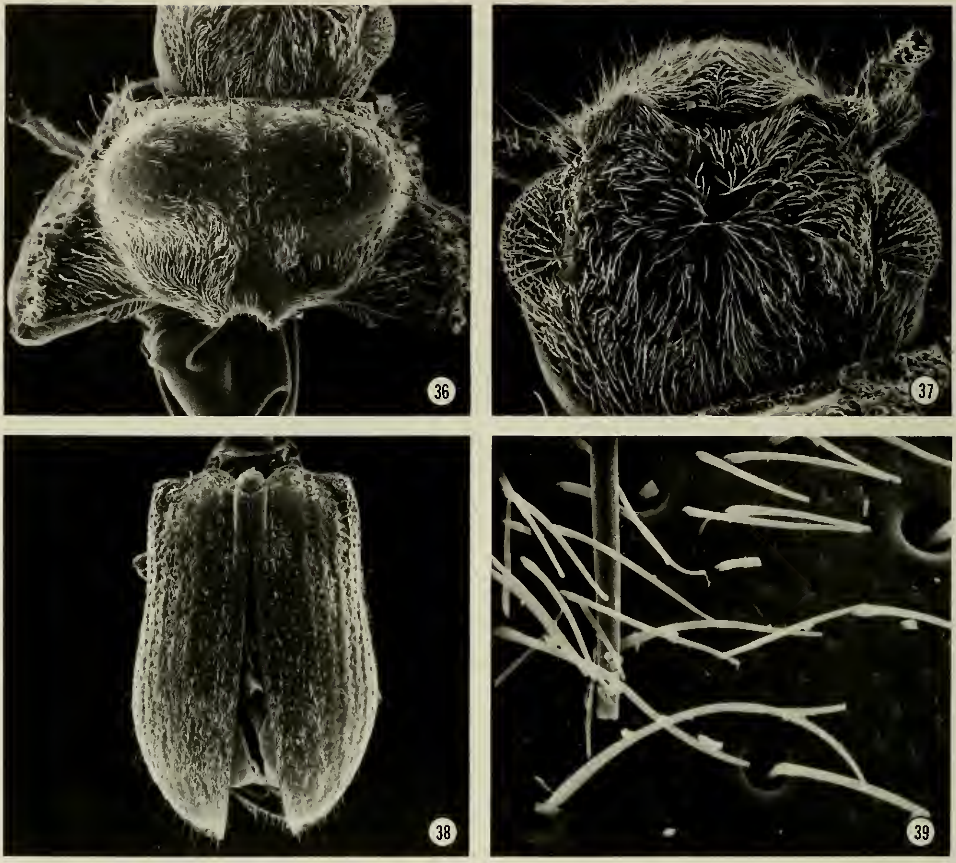
Elytra: 2.40 mm long, 1.76 mm wide. Lateral margins nearly parallel; markedly declivous laterally to form vertical sides. Disc transversely and longitudinally convex. Each elytron with 9 striae; stria 9 (marginal) well developed; stria 1 more markedly developed in basal fourth than on remainder of elytron; intervals subcostate; sutural interval raised in basal fourth; intervals 6 and 7 (humeral) confluent and raised in basal tenth; striae on disc with shallow, non-serial, flat-bottomed, setiferous punctures separated by about their diameter and about equal in size to punctures on pronotal disc; punctures of striae 5–9 denser, deeper and coarser than those on disc, some confluent. Integument dull between punctures due to extremely minute spicules (Fig. 20). Lateral margin sinuate in side view (Fig. 2). Elytral apices subacute.

Prosternum: 0.90 mm long. With short, dense indumentum and sparse, suberect, blunt setae; short basal carina in front of procoxae. Prosternal process 0.40 mm long, 0.16 mm wide at base; markedly carinate, carina extended anteriorly onto disc; markedly convex in apical half; apex inserted into deep mesosternal fovea. Mesosternum with sides of median fovea raised slightly. Metasternum with median longitudinal sulcus confluent anteriorly with irregular fovea at base of intercoxal process; intercoxal process narrow at apex, meso-metasternal suture not apparent; metepisternum with moderately developed basomedial carina. Integument indumentose and with large, shallow, setiferous punctures separated by about 1–2 × their diameter; punctures in marginal row at base of metasternum, otherwise random. Basal margin lobate on each side of midline.

Abdomen: Midline length ratios of sterna: 2.2/1.2/1/1/3.4. Intercoxal process length equal to basal width; length nearly ⅔ total length of sternum; narrowest separation of metacoxae slightly greater than that of mesocoxae. Sternum 5 with apical third raised on midline, with narrow apicomedial emargination. Integument moderately sparsely indumentose except in macropunctures which are prominent and shallow; those macropunctures on sterna 1 and 2 twice size of metasternal punctures, punctures becoming smaller posteriorly; punctures on sternum 5 equal



Figs. 30–35. 30, *Quadryops quasimodoi,* wing; 31, *Q. obtusetosus,* wing; 32, *Q. chrysosetosus,* wing; 33, *Q. obtusetosus,* labial palpus; 34, *Q. obtusetosus,* maxilla (setae omitted); 35, *Q. chrysosetosus,* maxilla (setae omitted). (Scale lines equal 0.1 mm for mouthparts and 1.0 mm for wings.)



Figs. 36–39. *Quadryops quasimodoi*: 36, Pronotum; 37, Head, dorsal view; 38, Elytra, dorsal view; 39, Micro- and macropunctures of pronotum (900 ×).

in size to metasternal punctures, punctures not uniformly arranged, separated by 0.5–2 × their diameter; most punctures with prominent, suberect, blunt seta.

Legs: Densely indumentose; all segments except tibiae and tarsi with sparse, suberect, blunt setae. Tarsi moderately densely pubescent beneath; each about ⅓ length of respective tibia. Protibia widest near apex. Metacoxa coarsely punctate similarly to metasternum; metatrochanter globose, size slightly smaller than median third of coxa; metafemur with upper surface of distal end angulate.

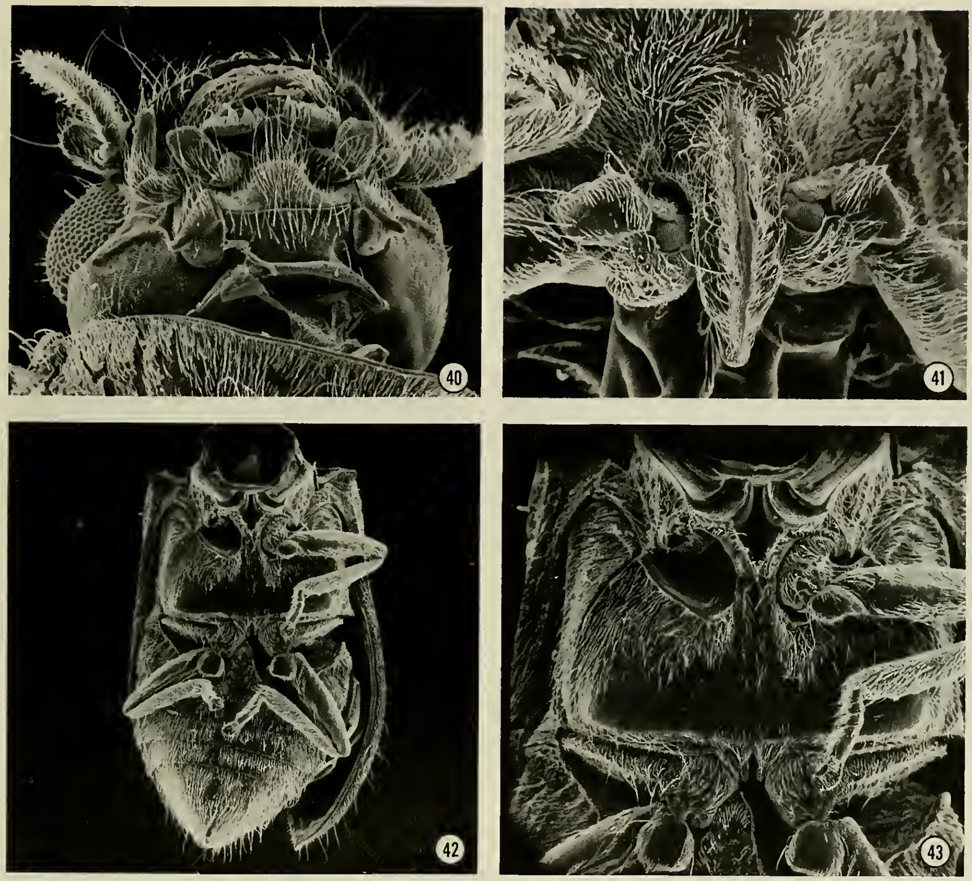
Genitalia: Ovipositor as illustrated (Fig. 24). Male unknown.

*Distribution.*—Currently known only from the type-locality on the eastern slope of the Andes in southern Ecuador.

*Etymology.*—Latin, *obtuse* (blunt) plus *setosus.* This epithet refers to the prominent, suberect, blunt setae on the body.

## *Quadryops quasimodoi,* new species
Figs. 23, 25, 30, 36–47

*Type-data.*—Holotype female: Panama, Chiriqui Province, "Barca" area, Finca Lerida nr. Boquete, 5650 feet; berlese (B-487), concentrated forest floor litter and

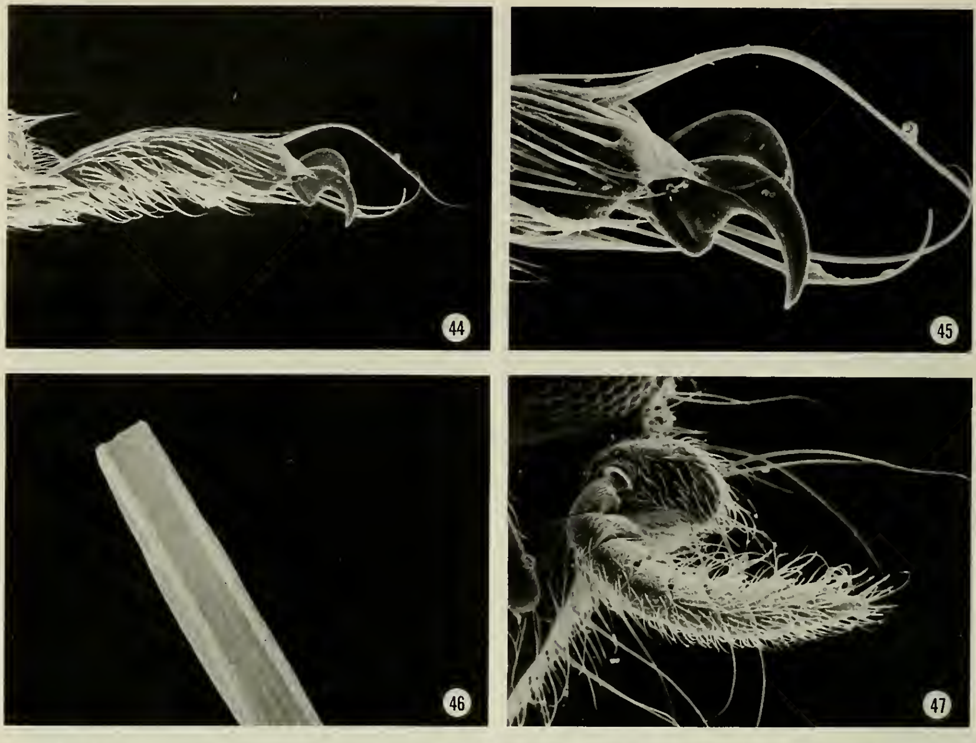


Figs. 40–43. *Quadryops quasimodoi*: 40, Head, ventral view; 41, Prosternum; 42, Mesothorax, metathorax and abdomen, ventral view; 43, Mesothorax and metathorax, ventral view.

wood chips in logging area, 14 Mar 1959, coll. H. S. Dybas. Deposited in the Field Museum of Natural History, Chicago.

*Description.*—Holotype female: 3.88 mm long, 1.92 mm wide. Body form oblong, markedly convex (Figs. 36, 38). Color brown. Integument with indumentum and prominent, suberect setae.

Head: 0.80 mm long, 0.98 mm wide, 0.70 mm between eyes. Eyes large, hemispherical, pubescent. Frons slightly concave between eyes; apex of frons concave between raised margins of antennal acetabulae. Indumentum sparser on small median area of frons than on remainder; macropunctures moderately coarse and dense, separated by 1–2× their diameter, absent from small median area. Labroclypeal suture subsulcate due to concavity of frontal apex and raised base of clypeus. Clypeus in dorsal view with anterior margin arcuate laterally, less so in middle ⅓; in anterior view, very shallowly emarginate in middle ⅓; lateral angles reflexed. Labrum directed ventrad, concealed beneath clypeus in dorsal view, broadly emarginate apically. Antennomeres 11 (Fig. 47). Labial palpomeres 1–3 with length ratios about 2/5/7 respectively; palpomere 3 flat, broad, width slightly



Figs. 44–47. *Quadryops quasimodoi*: 44, Protarsus; 45, Protarsal claws (450×); 46, Apex of pronotal seta (2300×); 47, Antenna (200×).

greater than length (Fig. 40). Maxillary palpomeres 2 and 3 of equal length; each ⅓ length of palpomere 4 (Fig. 40).

Pronotum: 0.80 mm long; width 1.08 mm apically, 1.64 mm basally. Apical ¾ of disc very markedly inflated, longitudinally depressed on midline to form lobe on each side. Posterior area lateral to elevated disc triangular, slightly concave, punctures less dense than those on disc; lateral border alutaceous, basal border very shiny. Anterior border in form of narrow shelf in front of inflated lobes, shelf widened laterally. Lateral margin extended slightly obliquely to midline from apical angle to midlength then markedly angulate to form wide base, margin coarsely crenulate (Fig. 36). Integument of inflated disc with sparse, round, small punctures separated by 2–5× their diameter; interpunctal areas with very fine, dense micropunctures of indumentum (abraded on holotype). Posterior margin markedly trisinuate, contiguous with elytral base; prescutellar emargination arcuate. Integument in front of emargination raised in form of inverted V. Elytral base diverging anterior of midlength of scutellum. Scutellum spindle shaped; disc raised slightly.

Elytra (Fig. 38): 3.00 mm long, 1.92 mm wide. Lateral margins almost parallel; markedly declivous laterally to form vertical sides. Disc transversely and longitudinally convex. Each elytron with 9 irregular striae. Stria 1 (sutural) deeply impressed in basal third; basal third of sutural interval markedly raised. Stria 2 nearly obsolete. Striae with irregular, non-serial punctures; punctures of striae 1 and 2 slightly larger than those on pronotal disc; punctures becoming larger and

Table 1.—Character comparison of *Quadryops* species.

| Character | *chrysosetosus* (male) | *quasimodoi* (female) | *obtusetosus* (female) |
|---|---|---|---|
| Base of clypeus | depressed | not depressed | depressed |
| Lateral angles of clypeus | deflexed | reflexed | deflexed slightly |
| Pronotal punctation | moderately coarse and dense | fine and sparse | very coarse and dense |
| Pronotal mid-longitudinal impression | faintly developed | well developed | well developed |
| Fraction of pronotum lobate | ⅔ | ¾ | ⅔ |
| Median process of pronotal prescutellar emargination | absent | absent | present |
| Lateral margin of pronotum | not angulate | markedly angulate | moderately angulate |
| Elytral striae | moderately developed | moderately developed | well developed, intervals subcostate |
| Elytral integument between punctures | smooth and shiny | smooth and shiny | asperate and dull |
| Suberect setae of dorsum | hastate | obtuse apically | obtuse and expanded apically |
| Median third of prosternal carina | straight | angulate | straight |
| Metasternal intercoxal process raised above plane of disc | distinctly | slightly | distinctly |
| Basomedial carina of metepisternum | absent | well developed | moderately developed |
| Ratios of lengths of abdominal sterna | 2/1.2/1/1/3 | 2.3/1.2/1/1/3.3 | 2.2/1.2/1/1/3.4 |
| Vein $2A_1$ of wing | present | present | absent |
| Size (mm) | 2.60 × 1.44 | 3.88 × 1.92 | 3.20 × 1.76 |

deeper laterally; those of striae 5–8 very deep and subconfluent. Intervals 5–8 irregularly subcostate; intervals 6–8 fused in basal fifth to form well-developed humeral ridge; medial margin of interval 6 in form of a low carina. Lateral margin sinuate in side view. Elytral apices subacute.

Prosternum (Fig. 41): 0.92 mm long; densely indumentose. Prosternal process 0.46 mm long, 0.20 mm wide at base; markedly carinate, width of carina at midlength subequal to width of shelf separating carina from procoxa; in lateral view, markedly angulate near midlength, this angle about equal to angle formed where prosternal carina joins prosternal disc; apex inserted into deep mesosternal fovea. Mesosternum with posterior margins of median fovea not raised. Metasternum with median longitudinal depression well developed on intercoxal process; intercoxal process width equal to its length; metepisternum with well-developed basomedial carina; disc almost devoid of macropunctures, especially laterally; basomarginal groove with macropunctures; basal margin lobate on each side of midline.

Abdomen: Midline length ratios of sterna: 2.3/1.2/1/1/3.3. Intercoxal process length slightly greater than basal width, length nearly ⅔ total length of sternum. Narrowest separation of metacoxae slightly less than that of mesocoxae. Sternum 5 with apical ¼ raised on midline; with narrow apicomedial emargination. Intercoxal process rugulose, contrasting with smoother discal areas of remaining sterna. Macropunctures of discal areas of sterna 2–4 sparse and small; macropunctures denser on sternum 5.

Legs: Densely indumentose. Tarsi moderately densely pubescent beneath (Fig. 44); each slightly more than ⅓ length of respective tibia. Metacoxae coarsely punctate; metatrochanter globose, size slightly smaller than median ⅓ of coxa; metafemur with upper surface of distal end angulate.

Genitalia: Ovipositor as illustrated (Fig. 25). Male unknown.

*Distribution.*—Currently known only from the type-locality in Chiriqui Province, Panama.

*Etymology.*—The hunchbacked appearance of this species calls to mind the character in Victor Hugo's novel.

*Notes.*—The holotype is badly abraded and several body parts are disarticulated. Disarticulated parts, including tarsi which were temporarily slide mounted for illustration, are in a microvial attached to the specimen's pin.

## Key to the Species of *Quadryops*

1. Pronotal disc coarsely and densely punctate (Figs. 3, 4); suberect setae of body expanded and blunt apically (Figs. 6, 21); ovipositor as illustrated (Fig. 24); Ecuador ............................ *obtusetosus,* new species

— Pronotal disc not coarsely and densely punctate (Figs. 13, 36); suberect setae of body otherwise ............................................ 2

2. Lateral margin of pronotum angulate near midlength (Fig. 36); median carina of prosternal process angulate near midlength (Fig. 41); suberect setae of body blunt at apex (Fig. 46); metasternal episternum with well-developed basomedial carina (Fig. 43); ovipositor as illustrated (Fig. 25); size 3.88 × 1.92 mm; Chiriqui Province, Panama ........................................................... *quasimodoi,* new species

— Lateral margin of pronotum not angulate (Fig. 13); median carina of prosternal process not angulate near midlength (Figs. 16, 17); suberect setae of body acute at apex, expanded subapically (Fig. 19); metasternal episternum without well-developed basomedial carina (Fig. 12); aedeagus as illustrated (Fig. 22); size 2.60 × 1.44 mm; Canal Zone, Panama .... ........................................ *chrysosetosus,* new species

## Acknowledgments

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# A NEW SPECIES OF *BIVIBRANCHIA* (PISCES: CHARACIFORMES) FROM SURINAM, WITH COMMENTS ON THE GENUS

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*Abstract.*—The genus *Atomaster,* described by Eigenmann and Myers (1927) for a single contained species, *A. velox,* is placed as a synonym of *Bivibranchia* Eigenmann. *Bivibranchia* is characterized by unique elaborations of the portions of the glossopharyngeal and vagus nerves innervating the branchial basket, and of the vagal lobe of the medulla oblongata. Derived modifications of the dorsal portions of the third and fourth pleural ribs, the associated parapophyses and articular fossae, and the intercostal ligaments of the first four ribs distinguish *Bivibranchia* within the Hemiodontidae. These characters and a variety of unique alterations of the jaws, suspensorium, and gill arches unite the three species of *Bivibranchia* (sensu lato) as a monophyletic lineage within the Hemiodontidae.

*Bivibranchia bimaculata,* an inhabitant of black acidic waters, is described as new from the Corantijn River drainage system of western Surinam. The species is distinguished from *B. protractila* and *B. velox,* the other species in the genus, by the two distinct dark, midlateral spots on the body, one above the pelvic fins and one on the caudal peduncle. Meristic and morphometric differences further distinguish *B. bimaculata* from its congenerics.

One of the most unusual taxa of New World characiforms is the genus *Bivibranchia* proposed by Eigenmann (1912:258) for the single contained species, *B. protractila,* described in the same publication (1912:259) based on specimens from the Essequibo River system of Guyana. That highly modified genus differed from all characiforms known at that time in its markedly protractile upper jaw, fleshy dendritic gill rakers, and a distinctive valvular apparatus on the roof of the mouth (see Eigenmann 1912:pl. 33, figs. 1–5). Subsequently Eigenmann and Myers (1927:565) proposed a new genus and species, *Atomaster velox,* for a second species of protractile-mouth characiform collected in the Rio Tocantins of Brazil. As noted by those authors, the two genera were very similar other than for the small ctenoid scales of *Atomaster* which contrasted with the larger cycloid scales of *Bivibranchia.* Roberts (1974:432), although lacking specimens of *Atomaster* for comparison with *Bivibranchia,* reemphasized the evident similarities of the genera and noted that Myers, in a personal communication, questioned the distinctiveness of the nominal genera.

Recent collecting activities in the Corantijn River system of western Surinam yielded a third species of characiform with a protractile mouth. The new species, *Bivibranchia bimaculata,* inhabits the main river channels, rocky pools, and creeks in the black water systems of that basin. Studies associated with the description of the species led to a reevaluation of the distinctiveness of *Bivibranchia* and *Atomaster.* These anatomical investigations revealed a series of additional synapomorphies for the species of *Bivibranchia* (sensu lato).

*Methods and materials.*—Counts of total vertebrae were taken from radiographs and cleared and stained specimens, and include the four vertebrae of the Weberian apparatus, with the fused $PU_1 + U_1$ of the caudal skeleton counted as a single element. Numbers in parentheses after a vertebral count are the number of specimens with that particular count. In counts of the pelvic and median rays, unbranched rays are indicated by Roman numerals and branched rays by Arabic numerals. The ranges for meristic counts are based on the holotype and paratypes, with the value for the holotype indicated in square brackets.

Specimens examined for this study are deposited in the following institutions: American Museum of Natural History, AMNH; Academy of Natural Sciences of Philadelphia, ANSP; British Museum (Natural History), BMNH; National Museum of Natural History, Smithsonian Institution, USNM. Specimens cleared and counterstained for cartilage and bone are indicated by CS.

In his discussion of the Bivibranchiinae, Roberts (1974:432) noted that *Atomaster* Eigenmann and Myers (1927) was originally distinguished from *Bivibranchia* Eigenmann (1912) by differences in scale form and number, but that the taxa were, at least externally, otherwise very similar, and that Myers (personal communication) now questioned the necessity for the recognition of separate genera. Roberts was, however, unable to pursue further the question of generic distinctiveness in the absence of comparative material of the single species of *Atomaster* (*A. velox*). Examination of a cleared and counterstained specimen of *Atomaster* shows that the genus shares the distinctive morphological modifications noted by Eigenmann (1912:258–259) and Roberts (1974:432–433) for *Bivibranchia.* These characters include the valvular processes on the roof of the mouth, the unusual fleshy ridges on the surfaces of the epibranchials and ceratobranchials, the pronounced restructurings of the upper jaw and suspensorium which permit pronounced protractility of the upper jaw, and the numerous distinctive adaptations of gill arch osteology described by Roberts for *Bivibranchia protractila.* Those shared derived characters along with the unique synapomorphies described below unite *Bivibranchia protractila, Atomaster velox,* and *Bivibranchia bimaculata,* described in this paper, as a phylogenetically monophyletic, and morphologically very distinctive subunit of the family Hemiodontidae. In light of those numerous derived similarities and given the few differences in scale form and number that are the primary distinguishing characters of the nominal genera, I follow Myers' suggestion and formally place *Atomaster* Eigenmann and Myers as a synonym of *Bivibranchia* Eigenmann. *Bivibranchia* in that more inclusive sense is used throughout the remainder of the paper.

Apomorphous modifications of two previously unanalyzed body systems serve further to characterize *Bivibranchia* and provide additional evidence that the three contained species (*protractila, velox, bimaculata*) constitute a monophyletic lineage within the Hemiodontidae. The first set of these synapomorphies involves the association of the anteriormost pleural ribs with the vertebral column, and the system of ligamentous connections of these ribs to each other. In all other hemiodontids and most characiform outgroups examined, the parapophyses associated with the anterior full pleural ribs are approximately round elements, each of which inserts into a circular or ovoid articular fossa limited to the lateral surface of its respective centrum (see Weitzman 1962:fig. 12). *Bivibranchia* alternatively has a marked vertical expansion of the articular fossae and parapophyses associated with the third and fourth full pleural ribs. This restructuring results in distinctly dorsoventrally elongate parapophyses and a parallel vertical lengthening of the associated articular fossae. Correlated with the restructuring of the parapophyses is the dorsal expansion of the portions of the third and fourth pleural ribs proximate to the vertebral column. A relatively slender bone rounded in cross section is the typical and hypothesized primitive condition of the proximate portion of the shaft of the pleural rib in characiforms. In *Bivibranchia* this section of the rib is apomorphously expanded dorsally into a transversely aligned, vertically triangular plate. This elaboration of the parapophyses, articular fossae, and ribs is similar to that described by Vari (1983:41–42, fig. 37) for the genera *Caenotropus* and *Chilodus* of the Chilodontidae. Differences in the identity of the ribs and vertebrae involved in this complex in *Bivibranchia* on the one hand, and chilodontids on the other raise questions as to the homology of the characters in the involved taxa. In chilodontids the first through third full pleural ribs all show the described modifications, with distinctly greater vertical development of the articular fossa, parapophysis, and proximal portion of the shaft of the rib on the second full pleural rib. In *Bivibranchia,* in contrast, the first two ribs, their articular fossae and associated parapophyses are unelaborated. Differences in the fourth pleural rib and the associated parapophyses and articular fossae also distinguish the two taxa. Chilodontids retain the conditions of those elements generalized for characiforms, whereas in *Bivibranchia* the proximal portions of the fourth pleural rib and the associated articular fossae and parapophyses are expanded dorsally to a degree equivalent to that on the third pleural rib.

The hypothesis of the homoplasy of these modifications in *Bivibranchia* and the Chilodontidae is, furthermore, congruent (parsimoniously consistent) with available phylogenetic information about the groups. Outgroup comparisons within the Hemiodontidae have not revealed any comparable pleural rib and vertebral alterations in *Argonectes,* the taxon most closely related to *Bivibranchia* (Roberts 1974), nor in any of the other examined genera in the family (*Anodus, Hemiodopsis, Hemiodus, Micromischodus*). The absence of pleural rib alterations in close relatives of *Bivibranchia* in conjunction with the closer phylogenetic association of the Chilodontidae with the Anostomidae, Curimatidae, and Prochilodontidae (Vari 1983:46–47) makes it most parsimonious to hypothesize that these similarities in *Bivibranchia* on the one hand, and the Chilodontidae on the other, represent convergencies at the level of the two involved taxa rather than synapomorphies for a lineage consisting of the Chilodontidae and *Bivibranchia.*

The second derived pleural rib associated modification shared by the three species of *Bivibranchia* is the presence of well developed intercostal ligaments interconnecting the four anteriormost full pleural ribs. A thick posterodorsally slanting ligamentous band arises from the posterior surface of the first full pleural rib, extends past, but does not contact the medial surface of the second rib, and attaches to the anterior margin of the dorsal portion of the third rib. A second thick intercostal ligament arises from the posterior surface of the first pleural rib ventral of the insertion of the first ligament, extends past the medial surfaces of the second and third ribs, again without direct contact, and attaches to the anterior surface of the fourth pleural rib. Somewhat similar versions of such intercostal connections are present in the other hemiodontid genera examined (*Argonectes, Hemiodopsis, Hemiodus, Micromischodus*), but in those taxa the intercostal connections are thin, flattened, strap-like bands rather than the thick cord-like structures characteristic of *Bivibranchia.* Thus the intercostal bands in those hemiodontid outgroups are more similar to the broad, thin connective tissue sheet that joins the pleural ribs along their medial surfaces in most characiforms. As such the connections in hemiodontids other than *Bivibranchia* may represent an intermediate step in a transition series that resulted in the evolution of the system of well developed intercostal ligaments in that genus. A complex of intercostal ligaments somewhat comparable to those in *Bivibranchia* was described by Vari (1983:41–42, fig. 36) in the Anostomidae and Chilodontidae, with a system of thick ligaments in the Chilodontidae most comparable to the pleural rib interconnections of *Bivibranchia.* The intercostal ligament complex in chilodontids differs, however, from that in *Bivibranchia* in having a dorsal ligamentous attachment of the first and second ribs not found in *Bivibranchia,* and in the absence of the ligament attaching the first and fourth ribs that is present in that genus. Furthermore the intercostal ligament in chilodontids that spans the first to third ribs is attached to the medial surface of the second rib, whereas in *Bivibranchia* the ligaments and the medial surfaces of the intervening ribs are distinctly separated by an intermediate tissue layer. These morphological differences raise questions as to the homology of the intercostal connections in the two groups, *Bivibranchia* and the Chilodontidae. Such a hypothesis of the non-homology of the modifications in the two taxa is congruent with the available data on phylogenetic relationships noted above which indicate that *Bivibranchia* and the Chilodontidae are not each other's closest relatives.

The functional basis for the expansion of the intercostal ligaments and the vertical elongation of the articular fossae, parapophyses, and ribs in *Bivibranchia* is obscure, but may be correlated with the head-down feeding orientation of members of the genus (personal observations on *B. bimaculata*). This feeding position parallels the more pronounced head-down swimming orientation typical of members of the Chilodontidae which homoplasiously demonstrate comparable morphological adaptations.

The second set of synapomorphies for the species of *Bivibranchia* is the series of hypertrophied modifications of the portion of the nervous system associated with the branchial basket. Most noteworthy is the hypertrophy of the nerve complex serving the gill arches, and the associated elaboration of the vagal lobes of the medulla oblongata. Among the numerous restructurings of the *Bivibranchia* branchial basket noted by Roberts (1974:420–421), one of the more conspicuous is the pronounced vertical expansion of the epibranchials and ceratobranchials via thin bony lamina. The surfaces of these expanded gill arch elements are covered by specialized layers of epithelial tissue with ". . . a uniform series of prominent finely papillose ridges." Each ridge is associated with a gill raker, and the ridges on opposing surfaces of the gill arches interdigitate when in contact. The vertical expansion of the epibranchials and ceratobranchials in addition to markedly increasing the surface area of the gill arches, also accommodates a change in the form of the central channel of the epibranchials and ceratobranchials of the first three gill arches. On these ossifications, the shallow median groove on the abpharyngeal surface of the bone that is typical of characiforms is expanded into a deep central trough. These troughs serve at least in part for the support of a greatly expanded nerve network innervating the anterior portion of the gill arches. Two

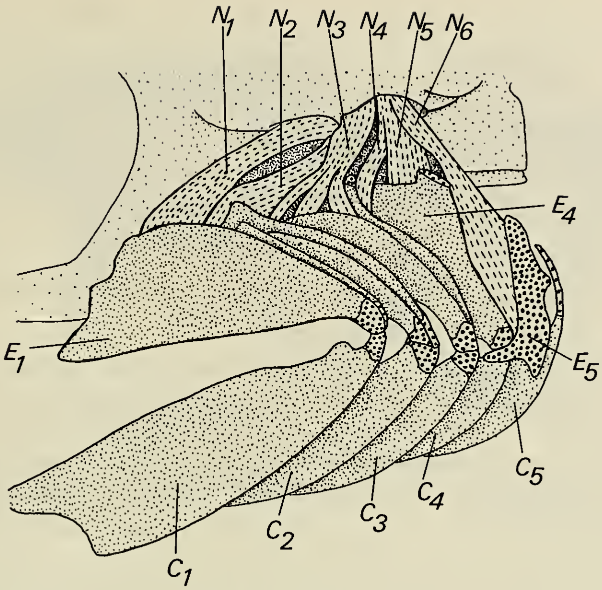

Fig. 1. *Bivibranchia bimaculata,* USNM 268203, paratype, gill arches, glossopharyngeal and vagus nerves, and posteroventral portion of neurocranium, left side, lateral view. Abbreviations: C—ceratobranchials (1 to 5); E—epibranchials (1 to 5, 2 and 3 not labelled); N—branches of hypertrophied nerve complex ($N_1$—glossopharyngeal nerve, $N_2$ to $N_6$—vagus nerve). Large stippling indicates cartilage, dashed lines indicate nerves.

primary trunks of cranial nerves form this hypertrophied nerve complex. In lateral view (Fig. 1) this complex is seen as a diverging series of large nerves that exit the neurocranium dorsal of the gill arches and pass ventrally into the branchial basket. The nerve complex passes through the wall of the neurocranium via two proximate enlarged foramina on the anteroventral surface of the exoccipital. These expanded apertures are visible as the enlarged openings in the exoccipitals as illustrated by Roberts (1974:fig. 24) in the ventral view of the skull of *Bivibranchia.* The enlargement of these foramina is particularly obvious when they are compared to the homologous openings in *Hemiodus* and *Argonectes* (Figs. 4 and 21 of Roberts).

The smaller anterior exoccipital foramen is the point of exit for the anteriormost nerve bundle (Fig. 1, $N_1$) which is part of the ninth cranial (glossopharyngeal) nerve. After exiting the skull, that nerve trunk extends ventrally into the medial margin of the central trough of the first epibranchial, diverges laterally in that element, with a smaller portion of the nerve continuing into the first ceratobranchial through the epibranchial-ceratobranchial joint. The remaining five major branches of the nerve complex innervating the gill arches all exit from the larger foramen located immediately posterior of the foramen for the glossopharyngeal nerve (Fig. 1, $N_2$ to $N_6$), and are all components of the tenth cranial (vagus) nerve. The anteriormost of these ($N_2$) has two subunits. The anterior branch of $N_2$ extends to the posterior surface and ventral margin of the first epibranchial, and the larger posterior section of $N_2$ enters the medial portions of the central trough of the second epibranchial within which it has a distribution comparable to the primary

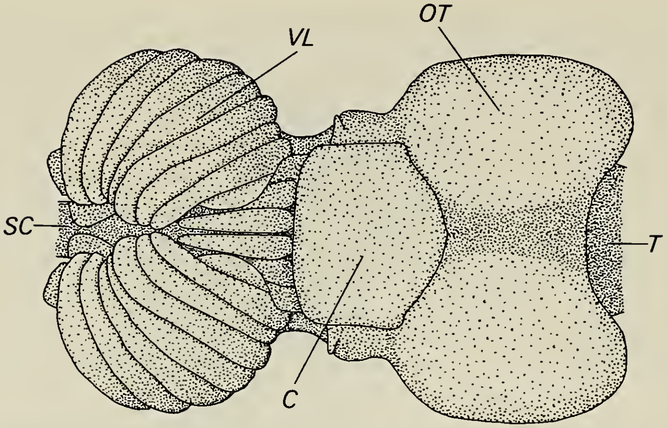

Fig. 2. *Bivibranchia protractila,* USNM 225491, brain, posterior portion, dorsal view, anterior to right. Abbreviations: C—cerebellum; OT—optic tectum; SC—spinal cord; T—telencephalon; VL—vagal lobe of medulla oblongata.

nerve branch in the first epibranchial, and with a section continuing into the second ceratobranchial. The next major nerve bundle ($N_3$) has three subsections. The anteriormost branch runs to the posterior surface and ventral margin of the second epibranchial, and the two remaining portions of $N_3$ enter the central trough of the third epibranchial, and are distributed in that element and the third ceratobranchial in a pattern comparable to that noted for the primary nerves of the first and second gill arches. The fourth nerve ramus ($N_4$) innervates the posterior surface of the third epibranchial, and the fifth major nerve branch ($N_5$) runs along the posterior portion of the fourth epibranchial with relatively few grossly obvious branches before continuing onto the dorsal surface of the fourth ceratobranchial. The sixth and final section of the complex ($N_6$) extends over the lateral surface of the fourth epibranchial before passing medial to the enlarged cartilaginous fifth epibranchial to innervate the anterior and dorsal surfaces of the fifth ceratobranchial.

The very large nerve bundles innervating the gill arches in *Bivibranchia* represent a hypertrophy of the glossopharyngeal (IX) and vagus (X) nerve complex relative to the much narrower nerves typical of other characiforms and most teleostean fishes (e.g., *Menidia,* Bernstein 1970:fig. 18). Information from other groups of fishes indicates that the ninth and tenth cranial nerves consist of both visceral sensory and visceral motor components. It is not possible to determine at present whether the dramatic increase in the size of these nerves in the species of *Bivibranchia* represents the hypertrophy of only one of these components, or whether both components of those nerves are involved. The question of the degree to which the increased size of the nerves is correlated with an increased degree of proprioperception of the gill arch elements, chemoreception for analysis of potential food items in the pharyngeal cavity, some combination of the above, or perhaps another function is similarly unresolved.

Not unexpectedly the dramatic enlargement of the glossopharyngeal (IX) and vagus (X) nerves is reflected in grossly obvious modifications of the central nervous

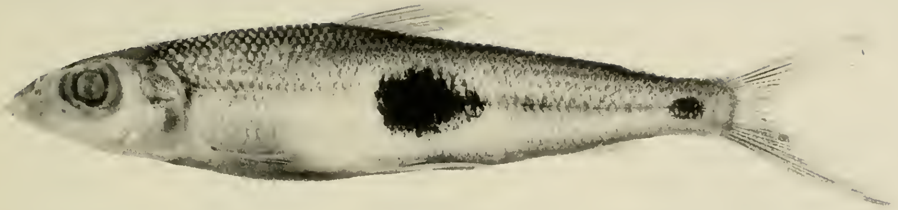

Fig. 3. *Bivibranchia bimaculata,* new species, holotype, USNM 225974, 80.5 mm SL.

system. Moderately developed vagal lobes of the medulla oblongata occur in various ostariophysans (Bernstein 1970:55, fig. 3) and within the Hemiodontidae have been found in both *Hemiodus* and *Hemiodopsis.* In *Bivibranchia* both of the enlarged cranial nerves (IX and X) communicate with the central nervous system at the base of the vagal lobe of the medulla oblongata, and the enlargement of the vagal lobes of the medulla oblongata is carried even further. The vagal lobes in *Bivibranchia* (Fig. 2) are dramatically enlarged into bulbous structures that are distinctly expanded laterally and extend to the level of the dorsal surface of the cerebellum. More striking is the elaboration of the surface of the markedly enlarged vagal lobes of the medulla oblongata into a series of posterodorsally oriented folds which cover the anterior, dorsal, and lateral surfaces of the lobes. These derived elaborations of this portion of the central nervous system are not apparent in other hemiodontids or other characiforms examined and are consequently considered synapomorphies for the three species of *Bivibranchia.* The functional significance of these vagal lobe elaborations is unknown, although they are presumably correlated with the hypertrophy of the associated glossopharyngeal and vagus nerves.

### *Bivibranchia bimaculata,* new species
Fig. 3, Table 1

*Holotype.*—USNM 225974, 80.5 mm standard length (SL), collected by R. P. Vari and L. R. Parenti, 17 Sep 1980, in a rocky pool in the center of the Corantijn River at "Camp Hydro," Nickerie District, Surinam (approx. 3°42′N, 57°58′W).

*Paratypes.*—All from Nickerie District, Surinam: 12 specimens taken with holotype: ANSP 153656, 1 specimen, 94.5 mm SL; BMNH 1984.10.23:1, 1 specimen, 97.8 mm SL; AMNH 55611, 1 specimen, 86.7 mm SL; USNM 268203, 9 specimens, 68.3–94.7 mm SL (1 specimen CS). 1 specimen, BMNH 1981.6.8: 816, 68.2 mm SL, collected by H. M. Madarie, 18 May 1980, in a small creek draining from the right bank of the Corantijn River near Mataway (approx. 4°58.5′N, 57°42′W). 7 specimens, AMNH 54807, Dalbana Creek, 150 m upstream of junction with the Kabalebo River (approx. 4°47′N, 57°26′W).

*Non-type specimens examined.*—All from Nickerie District, Surinam: 7 specimens, USNM 225491, same data as BMNH 1981.6.9:816 (1 specimen CS). 49 specimens, USNM 268204, taken with holotype, juveniles (3 specimens CS). 5 specimens, AMNH 54817, small stream entering Kabalebo River, 150 m upstream of mouth of Dalbana Creek. 1 specimen, AMNH 54835, stream draining

Table 1.—Morphometrics of *Bivibranchia bimaculata,* new species. Standard length is expressed in mm; measurements 1 to 10 are proportions of standard length; 11 to 15 proportions of head length.

| | | Paratypes (20) | |
|---|---|---|---|
| | Holotype | Range | Average |
| Standard length | 80.5 | 68.2–97.8 | 82.69 |
| 1. Greatest body depth | 0.24 | 0.22–0.26 | 0.243 |
| 2. Snout to dorsal-fin origin | 0.49 | 0.47–0.51 | 0.489 |
| 3. Snout to anal-fin origin | 0.81 | 0.80–0.84 | 0.820 |
| 4. Snout to pelvic-fin origin | 0.56 | 0.54–0.58 | 0.561 |
| 5. Snout to anus | 0.79 | 0.79–0.82 | 0.802 |
| 6. Origin of rayed dorsal fin to hypural joint | 0.53 | 0.51–0.56 | 0.544 |
| 7. Least depth of caudal peduncle | 0.09 | 0.09–0.10 | 0.093 |
| 8. Pectoral-fin length | 0.20 | 0.19–0.22 | 0.200 |
| 9. Pelvic-fin length | 0.19 | 0.18–0.20 | 0.189 |
| 10. Head length | 0.28 | 0.27–0.30 | 0.285 |
| 11. Snout length | 0.34 | 0.30–0.34 | 0.313 |
| 12. Orbital diameter | 0.38 | 0.34–0.38 | 0.358 |
| 13. Postorbital head length | 0.34 | 0.32–0.36 | 0.351 |
| 14. Interorbital width | 0.37 | 0.34–0.39 | 0.357 |
| 15. Gape width | 0.13 | 0.11–0.13 | 0.124 |

into Kabalebo River near Camp Avanavero, about 5 km downstream of DeVis Falls. 14 specimens, AMNH 54858, side channel of Kabalebo River, 1 km south of Avanavero Falls. 13 specimens, AMNH 54926, same locality as holotype. 13 specimens, AMNH 54959, rocky side pool of Corantijn River approximately 378 km from its mouth. 1 specimen, BMNH 1981.6.9:839, stream at km 212 of Amotopo-Camp Geology road, at "Machine Park." 1 specimen, USNM 225195, small stream entering Lucie River, 3 km upstream of junction of Lucie and Kabalebo rivers.

*Diagnosis.—Bivibranchia bimaculata* shares with the two other species of the genus a number of modifications of the jaws, branchial apparatus, anterior ribs, vertebral column, glossopharyngeal and vagus nerves, and vagal lobe of the medulla oblongata that distinguish the genus within the Hemiodontidae (see discussion above). The presence in *Bivibranchia bimaculata* of a large spot of dark pigmentation on the midlateral body surface centered slightly posterior of the vertical through the insertion of the posteriormost dorsal fin ray, and of a small darkly pigmented midlateral spot on the caudal peduncle separates the species from *B. protractila* and *B. velox* which have plain bodies. The 49 to 55 pored lateral line scales to the hypural joint, 8½ or 9½ scales in a transverse series above the lateral line to the origin of the dorsal fin, and the possession of cycloid scales distinguish *B. bimaculata* from *B. velox* which has 80 or more series of scales to the hypural joint, 12 to 16 scales in a transverse series to the origin of the dorsal fin, and ctenoid scales. The longer pelvic fins (0.18–0.20 of SL), 8 branched anal-fin rays, and typically 11, sometimes 10, branched pelvic-fin rays of *B. bimaculata* further separate that species from *B. protractila* in which the pelvic fins are 0.14–0.17 of SL, and which has 7 branched anal-fin rays, and 9, rarely 10, pelvic-fin rays.

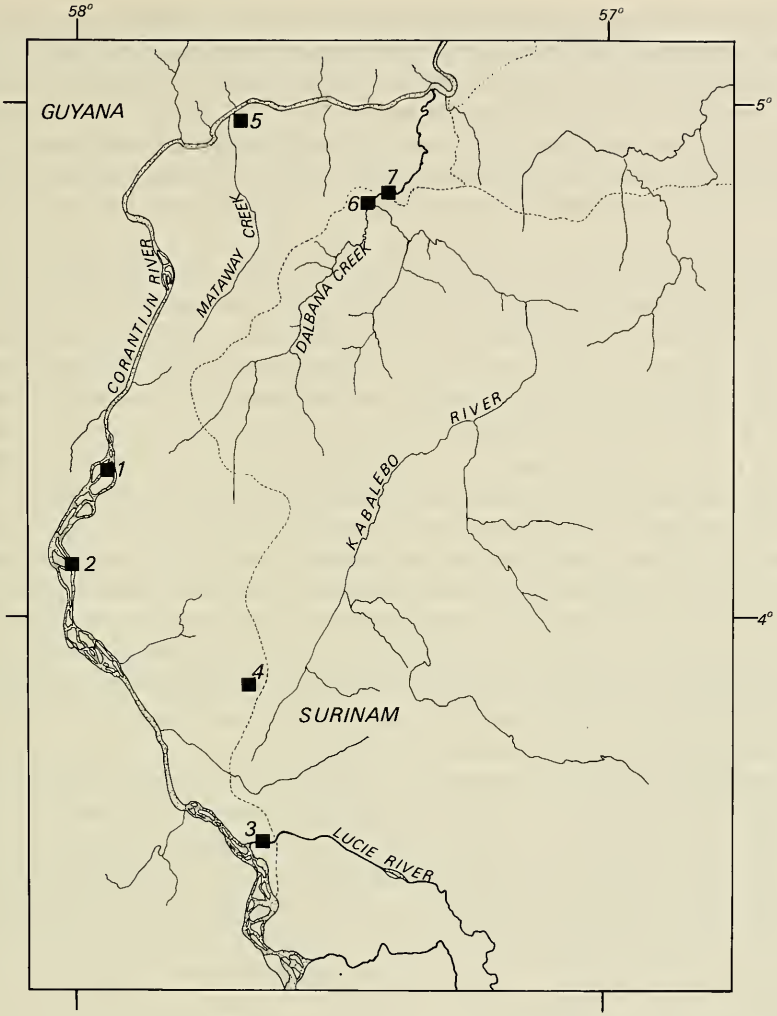

Fig. 4. Map of the middle portion of the Corantijn River basin region, Surinam and Guyana, showing collecting localities of specimens reported on in this paper (dotted lines depict road systems in area): 1, "Camp Hydro," type locality; 2, Km 378 of Corantijn River; 3, Lucie River; 4, "Machine Park"; 5, creek near Mataway; 6, Dalbana Creek; 7, Camp Avanavero and Avanavero Falls. Some squares indicate more than one locality or more than one lot of specimens. See listing of holotype, paratypes, and non-type specimens examined for detailed locality and collection information.

*Description.*—Morphometrics of the holotype and paratypes are given in Table 1. Body slender, slightly compressed laterally. Greatest body depth at origin of rayed dorsal fin. Dorsal profile of body gently curved from tip of snout to caudal peduncle. A slight median keel immediately anterior of origin of dorsal fin. Ventral profile of body smoothly convex from tip of lower jaw to caudal peduncle. Ventral surface of body transversely flattened anteriorly.

Head pointed in profile, interorbital region flattened. Fronto-parietal fontanel extensive, extending into rear of ethmoid and onto dorsal portion of supraoccipital. Parietals completely separated, frontals in contact only at epiphyseal bar. Upper jaw longer than lower jaw, highly protractile. Nostrils approximate, anterior opening round, posterior crescent shaped, partially closed by flap of skin separating nostrils. Eye relatively large. A large, horizontally ovoid "adipose eyelid" (a thick transparent connective tissue layer) extends from under nostrils posteriorly to opercle, thicker anteriorly; thicker and more developed longitudinally in larger specimens. Adipose eyelid with an ovoid, vertically elongate opening overlying pupil.

Lower jaw edentulous, rounded in ventral view, anterior margin fleshy. Upper jaw with a single series of functional teeth. All teeth tricuspidate, 7 on each side of jaw in all cleared and stained specimens examined (30–82 mm SL); teeth becoming progressively larger medially. A single row of partially formed replacement teeth internal to functional tooth row. Replacement tooth row embedded in flesh of inner surface of upper jaw. Dermopalatine and ectopterygoid edentulous. Fifth ceratobranchial bearing a relatively narrow band of posterodorsally directed teeth along medial and posteromedial borders; teeth along anterior portion of band elongate, tricuspidate; those along posterior margin elongate, conical. Fourth and fifth upper pharyngeal tooth-plates with a band of elongate tricuspidate teeth. Gill rakers elongate, with short side processes. Gill rakers extend along surfaces of vertically expanded ceratobranchials and epibranchials. Surfaces of expanded ceratobranchials and epibranchials with series of fleshy ridges aligned nearly perpendicular to their primary axes. Gill arches highly modified, innervated by hypertrophied glossopharyngeal and vagus nerves (see description above). Gill membranes narrowly attached medially to urohyal.

Scales cycloid, firm. Pored lateral line scales between supracleithrum and hypural joint 49 to 55 [55]. Five to 8 pored lateral line scales extending beyond hypural joint onto base of caudal fin. Scales above lateral line in a transverse series to origin of rayed dorsal fin 8½ or 9½ [9½]. Scales below lateral line in a transverse series to origin of anal fin 5 or 6 [6]. Body squamation extending onto base of caudal fin rays. Axillary process of pelvic fin formed by a single enlarged scale.

Vertebrae 38 (20), 39 (3).

Rayed dorsal fin obtusely pointed, second unbranched and first branched rays longest, subequal. Dorsal-fin rays ii,9 or iii,9 [iii,9]; when three unbranched rays present, first very short. Adipose dorsal fin of moderate size, unscaled. Anal fin obtusely pointed, anterior branched rays over twice length of posteriormost rays. Anal-fin rays ii,8 or iii,8 [ii,8]; when three unbranched anal-fin rays present, first very short. Pectoral fin pointed, reaching two-thirds of distance to vertical through origin of pelvic fin. Dorsalmost rays of pectoral fin correspond to a distinct groove along side of body formed by a connective tissue ridge extending posteriorly from posterior margin of cleithrum. Pelvic fin pointed, reaching slightly over one-half distance to anus. Pelvic-fin rays i,10 or i,11 (typically i,11) [i,11].

*Coloration in life.*—Overall coloration silvery with a greenish grey shading; silvery coloration more intense on ventral portions of body. Dark midlateral spot on body very obvious; spot on caudal peduncle somewhat masked.

*Coloration in preservative.*—Overall coloration in specimens fixed in formalin and preserved in ethanol light tan. Head darker on dorsal portions, particularly in interorbital region and across parietals. A broad band of scattered chromatophores extends over dorsal half of opercle. Overall coloration of body darker dorsally. A deep-lying dusky band along lateral line, pigmentation of band more intense posteriorly. A distinct dark, round or horizontally ovoid spot with irregular margins on midlateral surface of body. Spot extends 8 to 13 scales horizontally and 4 to 7 scales dorsally. Spot centered along or slightly posterior of vertical through insertion of last dorsal-fin ray, and somewhat dorsal of lateral line. A smaller darkly pigmented, round or horizontally ovoid spot on caudal peduncle immediately anterior of hypural joint. Caudal peduncle spot faint in larger individuals, absent in some large specimens. Caudal and rayed dorsal fins dusky, with fin-rays outlined by series of chromatophores. Adipose dorsal fin hyaline.

Juveniles with scale margins outlined by series of chromatophores. Midlateral body spot absent in specimens under 20 mm SL. Midlateral caudal peduncle spot not developed in smaller individuals.

*Etymology.*—The specific name, *bimaculata,* from the Latin bi, two, and macula, spot, refers to the two dark spots on the lateral surface of the body and caudal peduncle.

*Ecology.*—*Bivibranchia bimaculata* is widely distributed throughout the acid, black waters of the Corantijn River system of western Surinam above the region of tidal influence. It is most common in areas of sandy beaches and in rocky pools, with juveniles often also found in smaller side streams, sometimes a considerable distance from the main river channels. This species has been observed travelling in large schools over sandy beaches, evidently feeding on food items which individuals separate out of the substrate by manipulation of mouthfulls of sand.

*Comparative material examined.*—*Bivibranchia protractila* Eigenmann: GUYANA: BMNH 1972.10.17:1378–1397, 15 specimens, Rupununi River; USNM 197104, 13 specimens, Rupununi River; BMNH 1936.4.4:17–18, 2 specimens, Rockstone; BMNH 1911.10.31:484, 2 specimens, Rockstone, paratypes of *B. protractila*; USNM 66126, 1 specimen, Rockstone, paratype of *B. protractila*; BMNH 1934.9.12:291, 1 specimen, Mazaruni River; BMNH 1972.7.27:81–109, 27 specimens, Rupununi District, Jacaré; USNM 268205, 5 specimens, Essequibo River (2 specimens CS). BRAZIL, Mato Grosso: USNM 194302, 1 specimen, Rio Juruena; USNM 194287, 2 specimens, Rio Juruena.

*Bivibranchia velox* Eigenmann and Myers: USNM 268345, 1 specimen, Brazil, Pará, Rio Tocantins (CS).

*Argonectes longipinnis* Steindachner: USNM 243224, 2 specimens, Brazil, Roraima, Rio Jauaperi (1 specimen CS).

*Anodus elongatus* Spix: USNM 231550, 1 specimen, Peru, Loreto, Río Ucayali (CS).

*Hemiodopsis ocellata* Vari, USNM 225593, 1 specimen, Surinam, Nickerie District, Corantijn River (CS).

*Hemiodus* species, USNM 231551, 2 specimens, Brazil, Mato Grosso, Rio Arinos (CS).

*Micromischodus sugillatus* Roberts, USNM 205527, 1 specimen, Brazil, Pará (CS).

## Acknowledgments

Drs. Donn E. Rosen, Gareth Nelson, and Ms. M. Norma Feinberg (AMNH) made available many of the specimens associated within this study. Dr. P. Humphry Greenwood and Mr. Gordon J. Howes provided facilities for research at the BMNH and access to the series of comparative specimens of *Bivibranchia protractila* collected by Dr. Rosemary Lowe-McConnell in Guyana. Dr. Michael Goulding of the Museu Paraense "Emilio Goeldi," and Drs. Heraldo Britski, Naércio Menezes, and José Lima de Figueiredo of the Museu de Zoologia da Universidad de São Paulo made available comparative materials from the Rio Amazonas drainage basin. I thank all of the above for their generosity and assistance. The specimens that served as the basis for the description of the new species were collected during surveys carried out as part of preimpoundment studies associated with the Kabalebo Hydroelectric Project in western Surinam. The assistance of Drs. M. P. Panday-Verheuvel and S. Niekoop in organizing the survey, and Dr. Lynne R. Parenti, Mr. H. M. Madarie, Ms. S. Engel, and Mr. S. Silos in collecting activities is gratefully ackowledged. Mr. Kurt Bruwelheide and Mr. Andrew Gerberich provided technical assistance. Research associated with this project was partially supported by the Neotropical Lowland Research Program of the Smithsonian Institution. Figure 3 was photographed by Mr. T. Britt Griswald. This paper benefitted from the comments and suggestions of Drs. Stanley H. Weitzman and Wayne C. Starnes.

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98(2), 1985, pp. 523–525

# *PSYCHROPOTES HYALINUS,* NEW SPECIES, A SWIMMING ELASIPOD SEA CUCUMBER (ECHINODERMATA: HOLOTHUROIDEA) FROM THE NORTH CENTRAL PACIFIC OCEAN

David L. Pawson

*Abstract.*—*Psychropotes hyalinus,* new species, is described. The body is colorless and transparent, the dorsal appendage is situated approximately one-third of the body length from the posterior end of the body, the skin is more or less smooth, and contains two types of ossicles in the form of spinose crosses. The species is evidently capable of swimming, as the only known specimen was captured in a trap five meters above the seafloor.

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The deep-sea Order Elasipodida contains many holothurians that are capable of swimming for varying periods of time. Some species appear to be obligate swimmers, while others can swim for only short periods of time and short distances (Hansen 1975; Pawson 1976, 1982; Pawson and Foell, in press). Hansen (1975) and earlier authors have suggested that within the Family Psychropotidae some species are capable of swimming, and indeed *Psychropotes depressa* Theel was photographed in the act of swimming by Pawson (1976—reported as "*Euphronides* sp."). Through the kindness of Drs. Ken Smith and Nancy O. Brown of the Scripps Institution of Oceanography, La Jolla, California, I was sent a specimen of *Psychropotes* which had been captured in a near-bottom trap deployed in abyssal depths in the Pacific Ocean north of Hawaii. The specimen represents a new species, and is described below. I am grateful to Drs. Smith and Brown for allowing me to study this specimen, and to John E. Miller, Harbor Branch Foundation, for reading the manuscript of this paper. The specimen is deposited in the National Museum of Natural History (USNM), Smithsonian Institution, Washington, D.C., U.S.A.

Order Elasipodida Theel
Family Psychropotidae Theel, 1882
*Psychropotes* Theel, 1882
*Psychropotes hyalinus,* new species
Fig. 1

*Diagnosis.*—Body transparent, colorless. Dorsal appendage situated approximately one-third of the body length from the posterior end of the body. Dorsal body-wall ossicles of two types, larger crosses with spinose arms and single spinose apophyses, and smaller crosses with spinose arms.

*Material examined.*—HOLOTYPE USNM E31731, RAMA 2, 2 May 1980 central North Pacific north of Hawaii, 30°05.7′N, 158°44.5′W, tent trap deployed 5 m above seafloor in depth of 5891 meters.

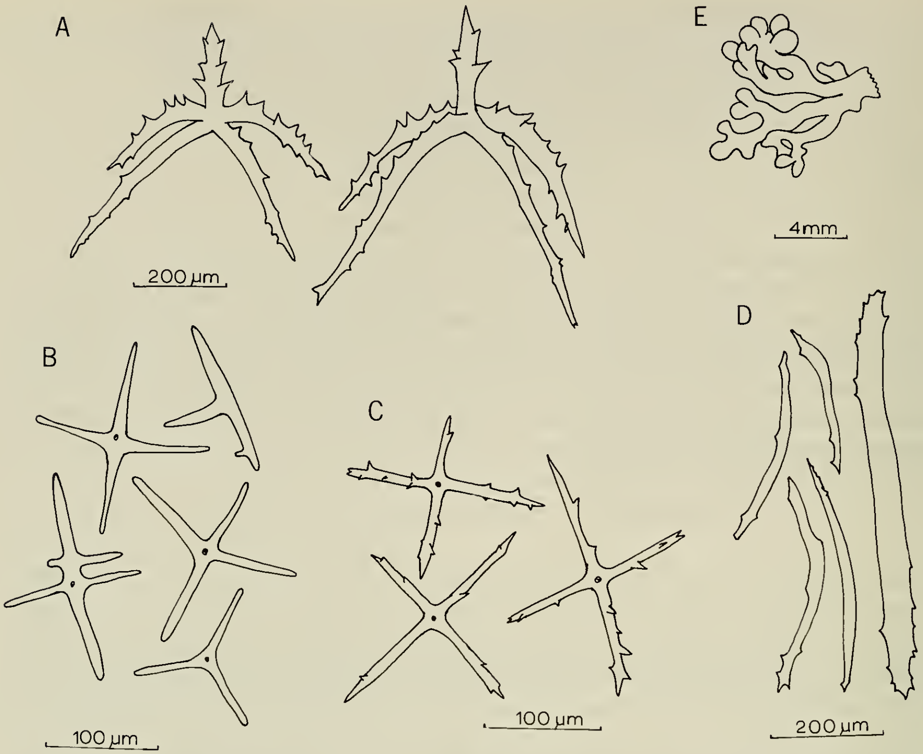

Fig. 1. *Psychropotes hyalina* new species. A, Large four-armed crosses from dorsal body wall; B, 3- and 4-armed crosses from wall of intestine; C, Small 4-armed crosses from dorsal body wall; D, Straight and curved rods from discs of tentacles; E, Portion of testis showing branching genital tubules.

*Description.*—Body of typical "*Psychropotes*-shape" (see Heezen and Hollister 1971, figs. 2.56, 2.57, 5.17), fragile, transparent, with light-reflective dermal layer of ossicles. Body approximately 160 mm long and 30 mm in diameter, more or less cylindrical, with flattened ventral surface. Conspicuous dorsal appendage approximately 70 mm long arising from middle of dorsum, 60 mm from posterior end of body. Flat subcircular brim overlying ventrally turned mouth and tentacles.

Tentacles 15, non-retractile, with elongate oval terminal discs approximately 8 × 6 mm; long axis of tentacle disc radial in relation to mouth. Edges of discs scalloped, with approximately 25 short, rounded digitiform projections. Mouth circular, 4 mm in diameter, at center of unadorned oral field.

Pinkish to violet internal organs clearly visible through body wall. Holotype, male; testis consisting of conspicuous bunch of branching tubules (Fig. 1E) located at extreme anterior end of body cavity. Internal musculature not well developed. Intestine empty.

Ossicles in body wall numerous 4-armed crosses of 2 types. Large crosses (Fig. 1A) reaching maximum diameter of 1.0 mm, having 4 curved spinous arms, with spines having no regular arrangement; long unbranched central apophysis carrying prominent spines. Large crosses oriented in body wall with apophyses pointing outwards, forming small contiguous pustules on body wall. Spaces between large crosses occupied by numerous small crosses (Fig. 1C) with slightly curved arms carrying weakly developed spines; central apophysis, when present, small; small crosses average 200 μm in diameter. Dorsal appendage with numerous smaller crosses; larger crosses also present but far less numerous.

Intestine wall with 3- and 4-armed crosses (Fig. 1B), latter type most common. Arms of crosses more or less straight, with 1 or 2 weakly developed blunt spines; occasionally, short blunt apophysis present. Average diameter of these ossicles 150 μm.

Tentacle discs contain straight or curved rods (Fig. 1D) with scattered spines or knobs. Rods greatly variable in length, maximum length approximately 650 μm.

*Behavior.*—As this species was captured some 5 meters above the seafloor, it is apparently capable of actively swimming, but nothing else is known about its living habits. The intestine is completely empty, but it is likely that this animal feeds on the seafloor, perhaps in the same manner as *Enypniastes* (Pawson, 1982).

*Remarks.*—The presence of a relatively smooth dorsal skin (rather than a skin with warts, each wart containing a giant cross-shaped ossicle), and the location and size of the dorsal appendage place this new species near *P. semperiana* Theel, 1882, and *P. minuta* Koehler and Vaney, 1905, in the key to *Psychropotes* provided by Hansen (1975). *Psychropotes hyalinus* differs from both species in color (they are dark violet) and in characters of the body wall ossicles. In *P. semperiana,* the smaller crosses have high central apophyses carrying downcurved hooks, while in *P. minuta,* the body wall crosses are of only one type, not two, as in *P. hyalinus.*

In having an essentially transparent to whitish body wall, *P. hyalinus* differs from almost all other species in the genus which usually tend to be violet or purple. According to Hansen (1975) only *P. loveni* Theel is whitish when it is small (20–25 mm long) but apparently this species becomes violet as it grows (Theel 1882). In addition, the dorsal appendage of *P. loveni* is very close to the posterior end of the body, in contrast to the situation in *P. hyalinus.*

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# A NEW SPECIES OF *SIPHONORHIS* FROM QUATERNARY CAVE DEPOSITS IN CUBA (AVES: CAPRIMULGIDAE)

Storrs L. Olson

*Abstract.*—A new species of nightjar, *Siphonorhis daiquiri,* is described from Quaternary cave deposits in eastern and central Cuba. It is intermediate in size between the other two species in the genus, *S. americana* of Jamaica, and *S. brewsteri* of Hispaniola. Because these elusive nocturnal birds are difficult to detect, it is possible that this species is still extant in the ornithologically poorly explored arid regions of eastern Cuba.

The distinctive nightjars of the genus *Siphonorhis* are among the lesser known elements of the Antillean avifauna. The Jamaican species, *S. americana,* is perhaps the rarest of caprimulgids, being known only from four recent specimens (Olson and Steadman 1977) and now presumed extinct. Nevertheless, *S. americana* has been recognized practically from the inception of scientific ornithology. It is the *Caprimulgus americanus* of Linnaeus (1758), the name being intended to compare with *C. europaeus,* the only other species of *Caprimulgus* then recognized. Linnaeus based his name on Sir Hans Sloane's description of the "small wood-owle," first published by Ray (1678) from Sloane's notes, and later by Sloane (1707) himself, along with an illustration.

Such a bird was unknown to Gosse (1847), the next chronicler of Jamaica's birdlife, and it was later questioned whether Sloane's bird had actually come from that island. Cassin (1851) reviewed the whole question in detail, concluding that a caprimulgid, which he referred to the genus *Nyctidromus,* indeed inhabited Jamaica. It was not until 1859, however, when the collector Osburn succeeded in obtaining two specimens, that the true nature of the species was revealed. With these specimens at hand, Sclater (1861) determined that *C. americanus* was quite distinct from other caprimulgids and he therefore proposed a new genus, *Siphonorhis,* for it. Sclater, followed by a number of other authors, used the spelling *Siphonorhis americanus,* but the generic name is feminine in gender, so the specific name must be rendered *americana.* Because of the long, bare tarsus, Sclater, too, considered *Siphonorhis* to be closely related to the mainland genus *Nyctidromus.*

In 1917, at Túbano, in the Dominican Republic, Rollo Beck obtained a single specimen of a new species of caprimulgid with obvious affinities to *Siphonorhis.* This was described in a new genus by Chapman (1917) as *Microsiphonorhis brewsteri.* The species is now known to be fairly widely distributed on Hispaniola (Bond 1928a; Wetmore and Swales 1931; Dod 1979). Bond (1928b) regarded Chapman's characters for *Microsiphonorhis* to be inconsistent and he placed *brewsteri* in *Siphonorhis.* Wetmore (Wetmore and Swales 1931) concurred in this and the genus *Microsiphonorhis* has since seldom been considered valid. Peters (1940) listed *brewsteri* as a subspecies of *S. americana,* but this unsupported view is not tenable (Olson and Steadman 1977).

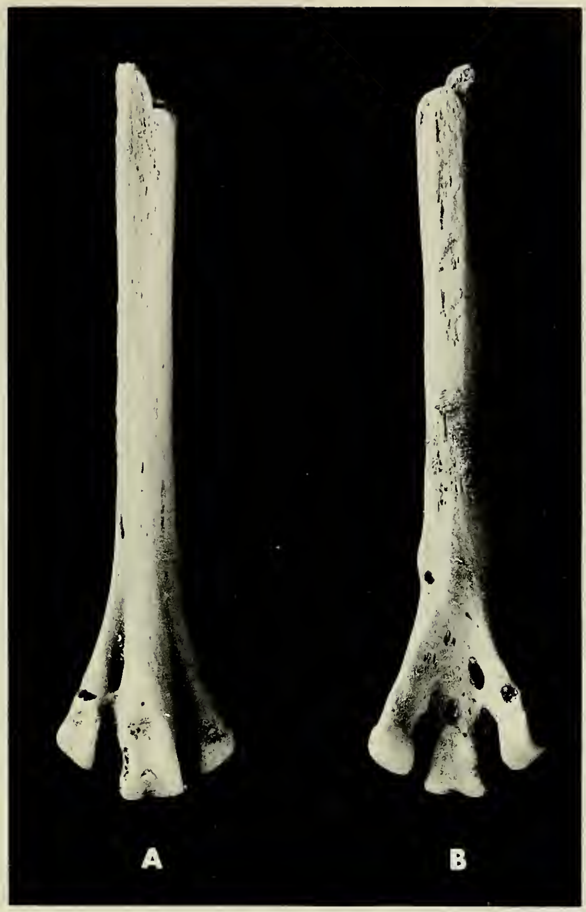

Fig. 1. Distal half of right tarsometatarsus, holotype of *Siphonorhis daiquiri,* new species (USNM 336506). A, Anterior view; B, Posterior view. 6× natural size.

The absence of the genus *Siphonorhis* in Cuba has not drawn comment from ornithologists, possibly because several other birds have a similar pattern of distribution, being found in Hispaniola and Jamaica but not in Cuba, viz: cuckoos of the genus *Hyetornis,* the potoo *Nyctibeus griseus,* and the swallow *Kalochelidon euchrysea.* Whatever the cause may be for the distributional patterns of those species, the pattern of *Siphonorhis* is the result of its having been overlooked in Cuba, for fossil remains from two cave deposits now prove the existence of a hitherto unrecognized species of *Siphonorhis* on that island.

*Comparative material examined.*—The fossil specimens were compared with Antillean genera of Caprimulgidae and most genera of the Neotropical mainland. No skeletons exist for *Caprimulgus cubanensis,* which is endemic to Cuba and Hispaniola, but this species is much larger than the fossil form under consideration here. Likewise, there are no entire skeletal specimens of either *Siphonorhis americana* or *S. brewsteri,* a lack I was able to make up for in part with bones removed from a skin of *S. brewsteri* (USNM 354527, Gonave Island, Haiti), including a nearly intact skull and mandible, tibiotarsus, tarsometatarsus, distal end of humerus, and proximal end of ulna. These were augmented by a humerus of *S. brewsteri* from a cave deposit in Haiti and humeri of *S. americana* from cave deposits in Jamaica (see Olson and Steadman 1977), as well as a previously unreported distal end of a tarsometatarsus of *S. americana* (UF 68055) from a cave deposit near Wallingford, St. Elizabeth Parish, Jamaica. Other taxa used in the comparisons were *Chordeiles minor, Caprimulgus noctitherus, C. carolinensis, Nyctidromus albicollis, Phalaenoptilus nuttallii,* and *Nyctiphrynus ocellatus.*

### Order Caprimulgiformes Ridgway
### Family Caprimulgidae Vigors
### Genus *Siphonorhis* Sclater, 1861

The following characters refer the Cuban fossils to the genus *Siphonorhis*: tarsometatarsus very long and slender, with trochleae splayed far apart and the intertrochlear spaces consequently very wide and deep; humerus with bicipital crest somewhat reduced, with distal margin very straight, presenting a squared appearance, with head more pointed and distinctly set off from ventral tubercle, and brachial depression deep.

Most authors have not departed from the opinions of Cassin and Sclater that *Siphonorhis* is closely related to *Nyctidromus.* However, because *Siphonorhis* is so distinctive in bill morphology, I previously suggested that the long tarsus shared by these two genera was probably an insufficient indication of close relationship, and that *Siphonorhis* may represent an ancient relict of an earlier caprimulgid stock that has been isolated in the West Indies (Olson 1978). The structure and proportions of the tarsometatarsus of *Siphonorhis* are now seen to be quite different from those in *Nyctidromus* (Fig. 2). Furthermore, the skull is also very distinctive in *Siphonorhis,* with the rostrum being much broader, reflecting its external appearance, and the anterior portions of the pterygoids lacking the distinctive expansion seen in *Nyctidromus.* I find no reason to consider *Siphonorhis* and *Nyctidromus* to be closely allied.

### *Siphonorhis daiquiri,* new species
Figs. 1–3

*Holotype.*—Distal half of right tarsometatarsus, collections of the Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, USNM 336506 (Figs. 1, 2b). Collected 31 Oct 1980 by Storrs L. Olson and others.

*Locality.*—"Cueva de Los Indios" (see Anthony 1919), on a hillside overlooking the roadstead of the former port of Daiquirí, on the southern coast of what is now the province of Santiago de Cuba (formerly part of Oriente Province), about 22 km ESE of the city of Santiago de Cuba (19°54.8′N, 75°38.6′W).

*Chronology.*—Quaternary, probably Holocene.

*Measurements of holotype.*—Length of specimen as preserved, 16.4 mm; shaft width above scar for hallux, 1.4 (1.2 in *S. brewsteri*; 1.9 in *S. americana*); distal width, 3.9 (3.4 in *S. brewsteri*).

*Paratypes.*—Topotypes collected by Olson and party in 1980 consist of a left coracoid (USNM 336507), proximal ends of right (USNM 336508) and left (USNM

Fig. 2. Right tarsometatarsi in posterior view. A, *Siphonorhis americana* (UF 68055); B, *S. daiquiri*, new species (holotype, USNM 336506); C, *S. brewsteri* (USNM 354527); D, *Nyctidromus albicollis* (USNM 344130). 3× natural size.

336509) humeri, and the proximal end of a left carpometacarpus (USNM 336510). Topotypes collected by H. E. Anthony in 1917 include two right humeri (AMNH 21905, 21906), a right humerus lacking the distal end (AMNH 21907), the proximal end of a right humerus (AMNH 21908), a left humerus lacking the proximal end (AMNH 21909), and a right carpometacarpus lacking the minor metacarpal (AMNH 21904).

*Measurements of paratypes.*—Humerus: length, 27.4 mm (24.8 in *S. brewsteri*; 31.5 in *S. americana*); shaft width at midpoint 2.0, 2.1, 2.1 (2.1 in *S. brewsteri*; 2.5 in *S. americana*); distal width 5.2, 5.6 (5.0 in *S. brewsteri*; 6.3–6.7 in *S. americana*). Carpometacarpus: length, 15.6; proximal depth, 4.4, 4.9. Length of coracoid, approximately 15.5.

*Additional locality and specimens.*—In April 1982, E. N. Kurochkin (Paleontological Institute, USSR Academy of Sciences, Moscow) showed me the distal end of a humerus and the proximal end of a tarsometatarsus of this species that he collected in "Cueva de Los Fósiles," 28.5 km NE of Camagüey, Camagüey Province, Cuba. These were not at hand when the present description was written. The site is approximately 280 km NW of the type-locality.

*Etymology.*—Named for the former port of Daiquirí, at the type-locality. This was the terminus of a railroad from an iron mine that was still operational at the time of H. E. Anthony's visit in 1917 (Anthony 1919), but has since been abandoned, there being scarcely a trace of the settlement left. Its name lives on,

Fig. 3. Humeri in anconal view. A, *Siphonorhis americana* (AMNH 11020); B, *S. daiquiri*, new species (AMNH 21905); C, *S. brewsteri* (USNM 336511). 2× natural size.

however, as a popular rum drink reputed to have been invented by a cyceonologist (Greek, *kykeon,* a mixed drink), who named it after his home town. In the present usage it is a noun in apposition.

*Diagnosis.*—Larger than *Siphonorhis brewsteri* and smaller than *S. americana.* Scar for hallux more elevated than in the other species of *Siphonorhis* and shaft of tarsometatarsus proportionately more slender than in *S. americana,* being more like that in *S. brewsteri.*

*Discussion.*—The cave deposits at the type-locality were first discovered and excavated in 1917 by H. E. Anthony, who reported on the mammalian remains (Anthony 1919). I visited the site briefly on 31 October 1980 as part of a joint expedition of the Smithsonian Institution and the Instituto de Zoologia, Academia de Ciencias de Cuba. At that time I excavated a small test pit near one wall of the cave, in sediments that proved to be richly fossiliferous.

The abundant bird material in the American Museum collections that Anthony obtained was long neglected and for years had been mislabelled as having come from Puerto Rico, a fact wholly incompatible with the species composition of the sample and unequivocally controverted by the discovery of slips of paper amongst the specimens bearing the notation "Daiquiri." The fossil avifauna as a whole from the Daiquirí cave will be treated elsewhere (Olson and W. Hilgartner, MS.).

As with most fossils from West Indian cave deposits, no firm dates were associated with the specimens of *S. daiquiri.* Both the mammalian (Anthony 1919) and avian (Olson and Hilgartner, MS.) faunas at Daiquirí consist mainly of extant species, with the more notable of the large extinct vertebrates of Cuba (e.g., ground sloths, giant owls, flightless cranes, condors) being absent. The species represented are all of a size compatible with their having been prey of the extant barn owl

*Tyto alba,* individuals of which still roost in the cave. The fossils are not heavily mineralized. Although some extinct rodents, the extinct insectivores of the genus *Nesophontes,* and even some extinct species of bats (Anthony 1919; Wołoszyn and Silva 1977) are present in the deposits, their disappearance could have taken place during the Holocene, as known for vertebrates in the Lesser Antilles (Steadman et al. 1984). At this point, the deposits can only be assigned to the Quaternary, but I consider it likely that they are post-Pleistocene in age.

Despite the fact that *Siphonorhis daiquiri* is known only from fossil remains, it would be premature to regard it as extinct. Being nocturnal and secretive, caprimulgids are often difficult to detect in life, and the species of *Siphonorhis* may be particularly recondite. As mentioned, Gosse (1847) never met with *S. americana* on Jamaica, although the species still existed in his time. On the ornithologically well-explored island of Hispaniola, *S. brewsteri* was not discovered until 1917. It eluded Wetmore and most subsequent collectors and was considered rare everywhere except Gonave Island, where Bond obtained a series in 1928 (Wetmore and Swales 1931). Since then, however, it has been shown to be fairly generally distributed in the Dominican Republic (Dod 1979). On Jamaica, *S. americana* is presumed to be extinct, and it is unlikely to have survived the plague of monogooses (*Herpestes*) on that island. Mongooses were also introduced to Hispaniola and Cuba but have not achieved the population densities apparent on Jamaica. *Siphonorhis brewsteri* has persisted on Hispaniola, so there is no good reason why *S. daiquiri* should be extinct on Cuba.

The very arid regions of Cuba east of Daiquirí have been relatively little explored ornithologically. Only in 1959 was a distinctive, isolated population of the sparrow *Torreornis inexpectata* discovered in the desert-like area near Baitiquirí (Spence and Smith 1961), and it is doubtful that collectors have spent much time in this region at night to hear any nightjars that might be calling. The rugged, arid landscape in this area is reminiscent of that in parts of the American southwest and in the unfrequented reaches away from the coast *Siphonorhis daiquiri* may still exist.

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# *CIRRIPECTES IMITATOR,* A NEW SPECIES OF WESTERN PACIFIC BLENNIID FISH

Jeffrey T. Williams

*Abstract.*—*Cirripectes imitator* is described from Taiwan, Japan, and the Ogasawara Islands. *Cirripectes imitator, C. castaneus* and *C. polyzona* frequently have been confused because all have similar color patterns. *Cirripectes imitator* is distinct among *Cirripectes* species in having the following combination of characters: a broad, expanded flap bearing cirri on each side of the nape; numerous pores at most cephalic sensory pore positions; dorsal-fin rays XII, 14; anal-fin rays II, 15; 7–14 lateral line tubes; lateral line tubes extending posteriorly to or almost to caudal-fin base; adult color pattern consisting of pale spots or bars on a dark background; nuchal cirri 43 or more; and total vertebrae 30.

While revising the Indo-Pacific blenniid genus *Cirripectes* Swainson, I discovered an undescribed species from Taiwan, Japan, and the Ogasawara Islands. The similarity of the color pattern of this species to that of two other *Cirripectes* species has caused workers to make numerous misidentifications. To solve this problem, I have decided to publish the new species description prior to completion of the revision.

Counts follow Smith-Vaniz and Springer (1971) as modified by Williams and Maugé (1983) except as follows: number of distinct nuchal cirri bases were counted instead of the free tips; nasal and supraorbital cirri counts include free tips on both left and right sides; gill rakers refer to the total number of rakers on the first arch; nuchal flap is a broadly expanded flap bearing the ventralmost group of cirri on each side of nape; mid-snout pores (Fig. 1, MSP) refer to two pore positions (one each in left and right supraorbital series) in the middle of the snout between the left and right posterior nostrils; extra interorbital pore position (EIP) refers to a pore position (Fig. 1) in both left and right supraorbital series that lies immediately behind and to each side of the supraorbital commissural pore position; pore positions behind nuchal flap (PBN) are those behind the lower part of the nuchal flap (Fig. 1).

The following institutional abbreviations are used: BPBM, Bernice P. Bishop Museum, Hawaii; FAKU, Department of Fisheries, Faculty of Agriculture, Kyoto University, Japan; NTUM, National Taiwan University Museum; UF, Florida State Museum, University of Florida; USNM, National Museum of Natural History, Smithsonian Institution, Washington, D.C. Other abbreviations used are: SL, standard length and LL, lateral line.

## *Cirripectes imitator,* new species
Fig. 2

*Holotype.*—FAKU 48203 (male: 65.6 mm SL), Ogasawara Islands, Chichi Jima Island (approximately 27°30′N, 142°30′E), Sakiaura; 0.5–5 m; 8 Apr 1974.

*Paratypes.*—TAIWAN: BPBM 23228 (12 specimens: 34.0–81.6 mm SL), east

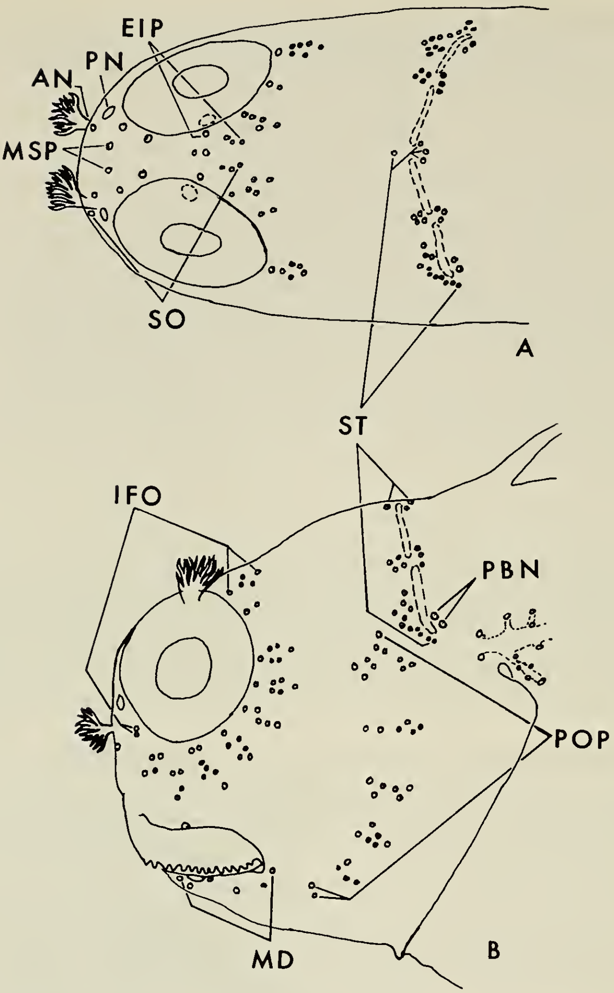

Fig. 1. Diagrammatic illustration of cephalic sensory pore system of *Cirripectes imitator* based on a 50 mm SL male (USNM 258316). A, Dorsal view of head; B, Left-lateral view of head. Abbreviations: AN, anterior nostril; EIP, extra interorbital pore position (position on right side indicated); IFO, infraorbital series; MD, mandibular series; MSP, mid-snout pores; PBN, pore positions behind nuchal flap; PN, posterior nostril; POP, preopercular series; SO, supraorbital series; ST, supratemporal series. First and last pore positions indicated for each series. Dashed lines above eyes and across nape indicate bases of cirri not illustrated.

coast off San Shien Tai, 0–2 m; NTUM 5777-1 and 2 (2: 78.1–79.1), Su-ao Harbor; NTUM 5780 (1: 42.1), Yeh-jen-chuen (Lan-yu); UF 41606 (1: 41.4), 22°40′N, 121°29′E, Green Island, tidepool; USNM 227979 (2: 80.6–92.9), rocky headland NW of Sha Tao, 1–6 m; USNM 227980 (6: 73.0–90.8), Ch'uan-fan-shih, 4–6 m; USNM 258315 (8: 46.1–57.2) and USNM 258316 (2: 47.7–50.3), 22°40′N, 121°29′E, Green Island, tidepool. RYUKYU ISLANDS: FAKU 48109 (1: 52.0), Okinawa Island, Hedomisaki; FAKU 50400 (1: 71.6) and FAKU 50402 (1: 34.7), Okinawa Island; FAKU 47989 (1: 56.8), Okinawa, Sesoko Jima, 0.5–5 m; FAKU

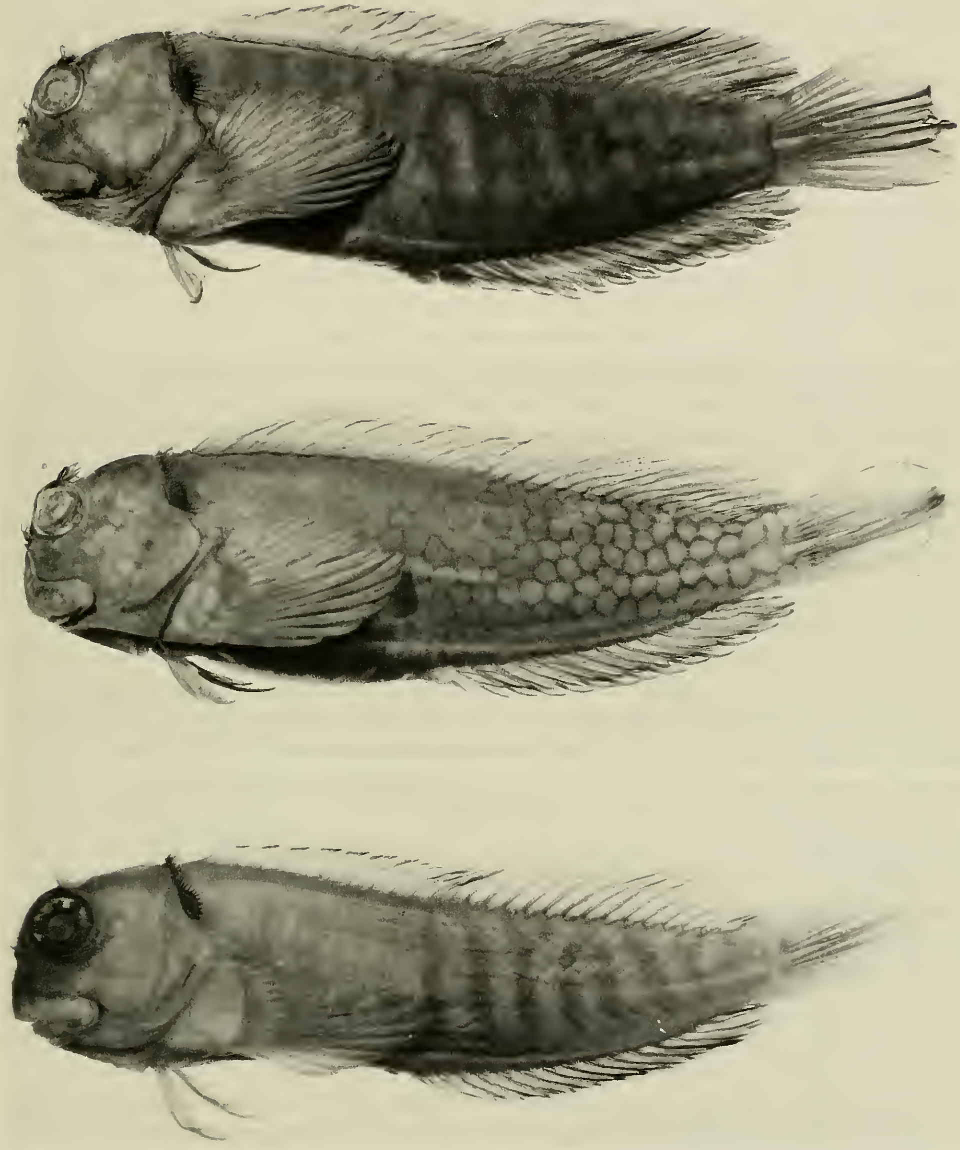

Fig. 2. Typical color patterns of *Cirripectes imitator* new species. Top, male holotype, FAKU 48203 (65.6 mm SL); middle, female, FAKU 48187 (61.9 mm SL); bottom, young male, FAKU 48478 (31.2 mm SL).

[111459] (1: 74.9) and FAKU [111460] (1: 76.2), Yoron Jima, Kanebo; FAKU [111461] (1: 101.4), Okino Erabu Shima. HONSHU, JAPAN: FAKU [111458] (1: 56.8), FAKU 48268 (1: 45.9), FAKU 48269 (1: 51.7), FAKU 48272 (1: 46.0), FAKU 48398 (1: 42.7), FAKU 48399 (1: 38.5), FAKU 48400 (3: 39.5–53.6),

FAKU 48478 (1: 31.2), FAKU 48963 (1: 28.3), and FAKU 48968 (1: 34.1), Shirahama, 0.5–4 m. JAPAN: USNM 76288 (1: 45.1), no other data. MIYAKE JIMA: BPBM 18983 (1: 75.2), Chodara-ika, 0–2 m. OGASAWARA ISLANDS: FAKU 48184 (1: 52.4), FAKU 48185 (1: 58.6), FAKU 48186 (1: 54.7), and FAKU [111455] (6: 50.6–62.4), Chichi Jima Island, 0.5–5 m; FAKU 48187 (1: 61.9), Nishi Jima Island, 0.5–5 m.

*Description.*—Dorsal fin XI-XIII (XII in 95.2% of specimens), 13–15 (14 in 95.2%); total dorsal-fin elements 26; anal fin II, 14–16 (15 in 95.2%); total procurrent caudal-fin rays 11–14; pelvic fin I, 3–4 (bilaterally I, 4 in 88%, bilaterally I, 3 in 6%, one side I, 3 and other I, 4 in 6%); vertebrae 10 + 20 = 30; last pleural ribs on vertebral centrum 11; last epipleural rib on vertebral centrum 18–21 (19–20 in 85.5%); anal pterygiophores 1-1-1, 1-1-2, 1-2-1 (1-1-2 in 92.1%); nuchal cirri 40–59 (45–53 in 82.4%); supraorbital cirri 13–46 (15–35 in 82.7%); nasal cirri 9–93 (9–33 in 84.6%); LL tubes 5–14 (8–13 in 94.6%); last LL tube beneath dorsal-fin ray 9 to caudal-fin base (to caudal-fin base in 84.5%); no scale-like flaps along LL; lower lip smooth mesially (plicate laterally); gill rakers 24–27 (based on 22 specimens); pseudobranchial filaments on one side 7–9 (based on 22 specimens); premaxillary teeth 192–230 (based on 11 specimens); dentary teeth 84–120 (based on 11 specimens); upper lip crenulae approximately 34–50; nuchal cirri in four groups (two on each side) separated at dorsalmost point on nape and about halfway down length of row on each side (gaps less than about 0.5 mm), two groups on one side rarely connected by a low basal membrane, ventralmost group of cirri on each side borne on a broad nuchal flap; adults of both sexes with first dorsal-fin spine slightly longer than second (1–5 mm longer in males, 1–2 mm longer in females); dorsal-fin membrane deeply incised above last dorsal-fin spine; dorsal-fin membrane attached to caudal fin in adults; cephalic pore system complex (numerous pores at most positions; number of pores increases with increasing SL; Fig. 1); mid-snout pores present (Fig. 1); extra interorbital pore position present (Fig. 1); pore positions behind nuchal cirri flap 2 (Fig. 1); male genital papilla with urogenital orifice located basally between two widely separated slender filaments (less than 1.0 mm long) on a fleshy swelling behind anus; testes bulbous, width equals length; maximum size about 100 mm SL.

The smallest gravid female (ova about 0.5 mm diameter) examined was 55 mm SL, from the Ogasawara Islands. Some 40–50 mm SL females had large ovaries, but they were granular in appearance and had no large ova. Males mature by about 50 mm SL.

No geographic variation was noted for the meristic or morphometric characters examined. Fukao (1984) noted that his *Cirripectes polyzona* specimens from the Ogasawara Islands (=*C. imitator* at that locality) had bright yellow spots or blotches in life. I attribute this color variant to populational variation within the species.

*Color in alcohol.*—Color pattern is highly variable, ranging from alternating dark- and pale-brown bars to dark-brown reticulations around pale-brown pupil-sized spots on the body. Adult males tend to be darker overall, with spots coalescing to form pale bars on body. Females generally exhibit the reticulated pattern, but both sexes can exhibit either pattern. Pupil-sized spots on cheeks, snout, upper lip, and underside of head. These spots are pale brown on darker background or the reverse in either sex. In some specimens, spots on underside of head fuse to form 2 or 3 alternating dark and pale bars across the throat. Dorsal fin with translucent triangular area in anterodorsal part of spinous section, a narrow pale stripe runs through middle of fin to last dorsal spine, remainder of spinous and soft dorsal brown; upper part of caudal fin with translucent triangular area, remainder of fin brown; anal fin brown, tips of rays paler; pectoral and pelvic fins dusky. Rugosities on anal-fin spines of males pale-brown. Nuchal cirri black, other cirri brown.

*Color in life.*—Male (based on fig. 39–27a in Shen 1984, which he referred to as *Cirripectes sebae*) with alternating brown and bluish-white bars on head and body; those on head broken into irregular pupil-sized spots. Pale section in caudal and spinous-dorsal fins with orange rays; red stripe runs through middle of spinous dorsal. Each nuchal cirrus with pale-yellow band near base. Iris with yellow ring around pupil. Other colors same as in alcohol. Fukao (1984) states that the Ogasawara specimens have bright yellow spots or blotches on body in life.

Females (based on fig. 392–7b in Shen 1984; and plate 87-D in Masuda et al. 1975) similar to male except spots on body are not fused into bars; spots become smaller posteriorly. There is some doubt about the identification of the specimen in fig. 392–7b (Shen 1984). I tentatively identify it as *Cirripectes imitator,* but females of *C. castaneus* have a very similar color pattern and this could be a specimen of the latter species.

*Geographic distribution.—Cirripectes imitator* is known to occur from Taiwan northward to Shirahama, Japan, and in the Ogasawara Islands.

*Etymology.*—The specific epithet is derived from the Latin *imitor,* meaning to mimic, and refers to the similarity of the color pattern to that of *Cirripectes polyzona* and *C. castaneus.*

*Relationships and comparisons.—Cirripectes imitator* belongs to the *C. fuscoguttatus* complex of species, which is not yet resolved, but with which it shares two derived characters: a high number of nuchal cirri (usually 45 or more) and an enlarged nuchal flap on either side of the head. A large nuchal flap is also present in *C. auritus* and *C. kuwamurai* (Carlson 1981; Fukao 1984), but the nuchal flaps in these species appear quite different and are probably independently derived. *Cirripectes imitator* differs from the *C. fuscoguttatus* complex in having 7–14 (in 98.2% of specimens; 1 of 56 with 5) LL tubes, whereas the other members of the *C. fuscoguttatus* complex have 0–4 (in 98.5%; 2 of 69 with 5). The color pattern of *C. imitator,* with pale spots on a dark background, is the reverse of *C. fuscoguttatus,* which has dark spots on a pale background.

Over some part of its geographic range, *Cirripectes imitator* is sympatric with eight congeneric species: *C. fuscoguttatus* Strasburg and Schultz, *C. filamentosus* (Alleyne and Macleay), *C. castaneus* (Valenciennes), *C. perustus* Smith, *C. quagga* (Fowler and Ball), *C. polyzona* (Bleeker), *C. kuwamurai* Fukao, and *C. variolosus* (Valenciennes). The only species of *Cirripectes* known to occur in the Ogasawara Islands are *C. imitator* and *C. variolosus,* and this is the only locality where their geographic ranges overlap. The reticulated color pattern of *C. imitator* easily distinguishes it from *C. variolosus,* which has a brown body and small pale spots (red in life) covering head. In Japan and Taiwan, *C. imitator* is most frequently confused with *C. castaneus* and *C. polyzona. Cirripectes polyzona* (plate 87-C in Masuda et al. 1975; and fig. 392-6 in Shen 1984) differs from *C. imitator* in having 1 pore position (versus 2) behind lower part of ventralmost group of cirri on each side, 32–42 (in 94.7%; range 32–44) nuchal cirri (versus 43–59 in 96.1%; range

40–59), ventralmost nuchal cirri not borne on a large flap (versus large nuchal flap present), and I, 3 pelvic-fin rays (versus I, 3–I, 4 or I, 4–I, 4 in 94%). Both sexes of *C. polyzona* have the barred color pattern, only *C. castaneus* males are barred, and male *C. imitator* may have either bars or spots. *Cirripectes castaneus* differs from both of these species in having relatively few (1–2) pores (versus 3 or more) at most cephalic sensory pore positions. The similarity of these three species is evidenced by the recent treatment of the Japanese *Cirripectes* species by Fukao (1984). Mr. Fukao made available the specimens used in his analysis and a list of catalog numbers corresponding to his "*C. polyzona*" color pattern types A, B, and C. I found that his type A pattern included female *C. castaneus* and both sexes of *C. imitator*; his type B pattern consisted of male *C. imitator* and one female *C. castaneus*; and his type C pattern comprised male and female *C. polyzona,* male and female *C. castaneus,* and one male *C. imitator.* In addition to the spotted and barred color patterns, *C. castaneus* specimens sometimes have a uniform brown head and body (see Fukao 1984, fig. 3-C). This pattern usually is seen after a specimen has been preserved and may be an artifact of the preservation process.

*Cirripectes imitator* differs from the other sympatric species in having the following combination of characters: large expanded nuchal flap bearing ventralmost group of nuchal cirri, dorsal-fin segmented rays 14, anal-fin segmented rays 15, numerous pores at most cephalic sensory pore positions, LL tubes present to or almost to caudal-fin base, 43 or more nuchal cirri, and 30 total vertebrae.

## Acknowledgments

For the loan of specimens, I thank J. E. Randall, S. C. Shen, J.-J. Lin, R. Fukao, and H. K. Mok. Mr. R. Fukao kindly provided information on the specimens used in his revision of Japanese *Cirripectes.* V. G. Springer read and provided helpful comments on an earlier draft of the manuscript. This project was supported in part by National Science Foundation Grant DEB 8207313.

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# A NEW SPECIES OF DRAGONET, *SYNCHIROPUS RANDALLI,* FROM EASTER ISLAND (TELEOSTEI: CALLIONYMIDAE)

Guy T. Clark and Ronald Fricke

*Abstract.*—A new species of dragonet, *Synchiropus randalli,* is described from a male and two females collected at Easter Island. It is most closely related to *S. kiyoae* Fricke & Zaiser, 1983, from Japan. The new species is characterized by a first dorsal fin that is dusky except for two white blotches on the first membrane in the male, white blotches on the pelvic fin, a band of black and white blotches along the sides of the body, a third spine of the male's first dorsal fin which is much shorter than the first and second spines, a shorter caudal fin, and a broader interorbital space.

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Easter Island is of interest to biologists because of its isolated geographic position at the easternmost fringe of Polynesia (27°08′S, 109°23′W). Although relatively little is known of its fish fauna (Allen 1970), it appears to have a high rate of endemics, about 27.5% of the 109 recorded species (Randall 1970, 1973, 1976). The most recent collections are those of Ian Efford and associates during the Canadian Medical Expedition in 1964–1965, and Randall and Allen in 1969. Prior to these only 40 species had been recorded (Allen 1970).

Within the material collected by J. E. Randall and G. R. Allen in 1969, were included specimens of a previously undescribed species of the *postulus* species-group of the dragonet genus *Synchiropus* Gill, 1860 (Fricke 1981, 1983). Other species of this species-group are *S. kiyoae* Fricke & Zaiser, 1983, from Japan, *S. laddi* Schultz, 1960, from the western and central Pacific, *S. minutulus* Fricke, 1981, from the central Indian Ocean, *S. postulus* Smith, 1963, from the western Indian Ocean, and *S. springeri* Fricke, 1983, from Fiji.

Methods follow Fricke (1983). The type-material of the new species is deposited in the Bernice P. Bishop Museum, Honolulu (BPBM), and the National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM).

### *Synchiropus randalli,* new species

Fig. 1

*Holotype.*—BPBM 6754, male, 22.0 mm SL, Easter Island, west coast off southern end of Hanga Roa, sand near rocks 27°09.5′S, 109°27′W, 40 feet (12 m) depth, J. E. Randall and G. R. Allen, 10 Feb 1969.

*Paratypes.*—Same data as holotype. BPBM 26409, 1 female, 20.9 mm SL; USNM 221485, 1 female, 18.6 mm SL.

*Diagnosis.*—A *Synchiropus* of the *postulus* species-group with 4 spines in the first dorsal fin, 9 rays in the second dorsal fin, 8 rays in the anal fin, 19–20 pectoral fin rays, a preopercular spine formula—$\frac{4\text{–}5}{-}$ 1, the first dorsal fin of the male dusky (except for two white blotches on the first membrane), with the third spine much

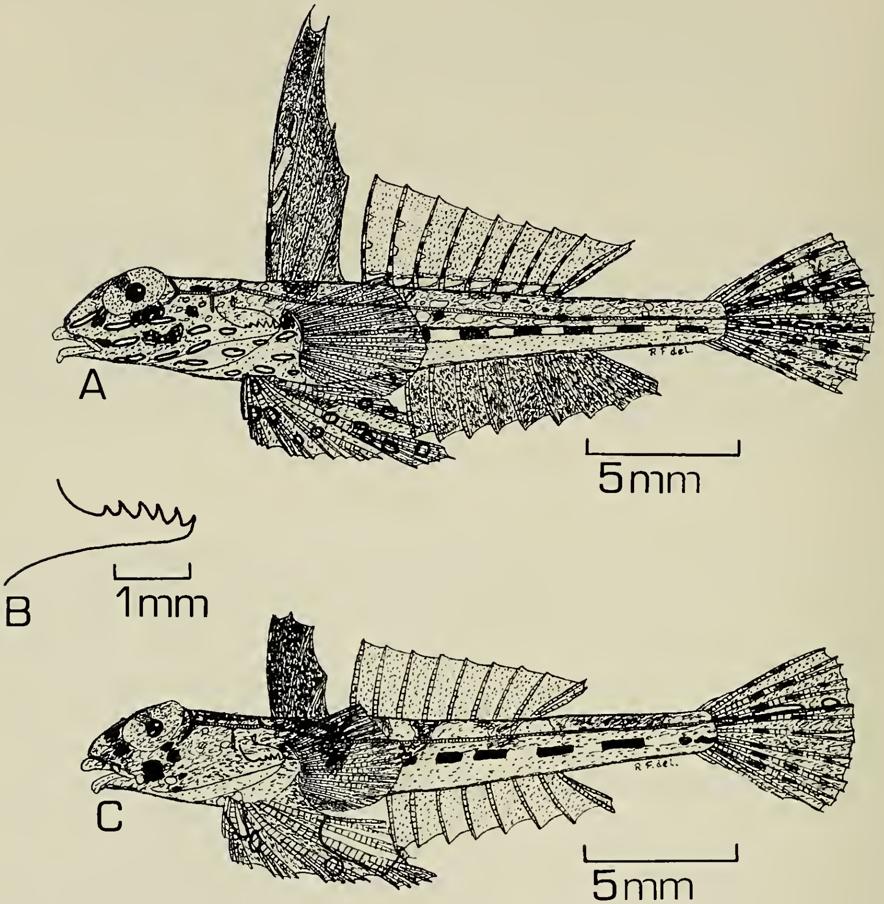

Fig. 1. *Synchiropus randalli,* new species, Easter Island. BPBM 6754, holotype, male, 22.0 mm SL: A, Lateral view; B, Left preopercular spine. BPBM 26409, paratype, female, 20.9 mm SL: C, Lateral view.

shorter than the first and second spines, the first dorsal fin of the female higher than the second dorsal fin, the male with light blue blotches on the sides of the head, both sexes with a black and white band along the sides of the body and with white blotches on the pelvic fin, and with the caudal fin 4.5–4.6 in SL.

*Description.*—$D_1$ IV; $D_2$ viii,1; A vii,1; $P_1$ i,16–17, ii (totally 19–20); $P_2$ I,5; C (i–ii), i,7, ii (i–ii). Proportions of the holotype and the larger female paratype see Table 1.

Body elongate and slightly compressed. Head slightly depressed (females) or slightly compressed (male), 3.5–3.9 in SL. Body depth 6.6–7.7 in SL. Eye diameter 2.5–2.9 in HL. Preorbital length 3.6–3.9 in HL. Interorbital distance 4.2–6.0 in eye. Occipital region with smooth bony plate. Branchial opening sublateral in position. Preopercular spine length 3.4–4.3 in HL; preopercular spine with upcurved main tip, smooth ventral margin, no antrorse spine at its base, and 4–5 curved points on its dorsal margin (formula—$\frac{4\text{–}5}{-}$ 1; see Fig. 1B). Urogenital

Table 1.—Proportions of the male holotype and one female paratype of *Synchiropus randalli,* new species (expressed as hundredths of SL).

| | Holotype | Paratype, BPBM 26409 |
|---|---|---|
| Predorsal (1) length | 31.04 | 29.86 |
| Predorsal (2) length | 45.02 | 41.81 |
| Preanal fin length | 52.12 | 48.16 |
| Prepelvic fin length | 27.08 | 21.79 |
| Head length | 25.58 | 28.57 |
| Body depth | 15.16 | 13.09 |
| Caudal peduncle length | 20.89 | 19.59 |
| Caudal peduncle depth | 6.24 | 5.06 |
| Caudal fin length | 21.89 | 22.02 |
| Eye diameter | 9.97 | 9.94 |
| Preorbital length | 7.10 | 7.36 |
| Urogenital papilla | 1.14 | — |
| First $D_1$ spine length | 42.60 | 15.86 |
| First $D_2$ ray length | 16.70 | 11.99 |
| Last $D_2$ ray length | 14.02 | 9.84 |
| First A ray length | 11.20 | 9.46 |
| Last A ray length | 11.92 | 10.08 |
| Pectoral fin length | 15.84 | 14.52 |
| Pelvic fin length | 34.36 | 35.45 |

papilla elongate in male, 22.5 in HL; not visible in female. Lateral line reaching from preorbital region to end of third branched caudal fin ray (counted from above), with short suborbital and short preopercular branch, as well as short ventral branch above pectoral fin base; lateral lines of opposite sides interconnected by commissure across occipital region. Caudal peduncle length 4.8–5.1 in SL. Caudal peduncle depth 16.0–19.8 in SL.

First dorsal fin very high in male, first to third spines elongate, with very short filaments, first spine 0.6 in HL, third spine shorter than first and second spines; in female relatively high, first to third spines elongate but not filamentous, longer than first ray of second dorsal fin, first spine 1.8 in HL. Predorsal (1) length 3.22–3.35 in SL. Second dorsal fin distally straight (female) or slightly convex (male), first ray in male 1.53 in HL, in female 2.38 in HL. Last ray in male 1.82, in female 2.90 in HL. Rays unbranched except for last which is divided at its base. Predorsal (2) length 2.22–2.39 in SL. Anal fin beginning on vertical through base of second membrane of second dorsal fin. Last anal fin ray in male 2.14 in HL, in female 2.83 in HL. Rays unbranched except for last which is divided at its base. Preanal fin length 1.92–2.08 in SL. Pectoral fin distally convex, reaching back to base of first anal fin membrane. Pelvic fin large, fourth ray elongate, reaching back to base of third anal fin membrane. Pelvic fin length 0.74–0.81 in HL. Pelvic fin connected with mid-base of pectoral fin by membrane. Prepelvic fin length 3.69–4.59 in SL. Caudal fin distally convex. Caudal fin length 4.5–4.6 in SL.

*Color in alcohol.*—Head and body brown, back with few dark brown saddles and dark brown and whitish spots. Ventral portions of body whitish in both sexes. Side of head with dark brown blotches; in male also with ocellate dark streaks which are light blue in fresh specimens. Side of body below lateral line with band

Table 2.—Comparison between *Synchiropus randalli,* new species and *S. kiyoae* Fricke & Zaiser, 1983.

| | *S. randalli* | *S. kiyoae* |
|---|---|---|
| Body depth in SL | 4.9–6.9 | 6.6–7.4 |
| Interorbital in eye | 4.3–5.9 | 6.3–24.1 |
| Predorsal (2) length in SL | 2.2–2.4 | 1.8–2.24 |
| Caudal fin length in SL | 4.5–4.6 | 3.0–3.8 |
| Third $D_1$ spine (male) | much shorter than 2nd spine | subequal to 2nd spine |
| First dorsal fin (male) | dusky, with light blotches on 1st membrane | light, with elongate vertical dark streaks and blotches |
| First dorsal fin (female) | 1st membrane dusky | 1st membrane whitish, distal one-third dusky |
| Caudal fin | with 2 rows of white blotches | without white blotches |
| Pelvic fin | with white blotches | without white blotches |
| Anal fin (female) | translucent, without blotches | with a dark brown blotch distally on each membrane |
| Sides of head (male) | with oval light blue blotches | with ocellate light blue streaks |

consisting of alternating black and white blotches. Eye brown, with dark brown spot in its upper rostral section. First dorsal fin dusky in both sexes, in male with two light blotches on first membrane. Second dorsal fin translucent, in male with about three dark brown spots on each ray, and with basal dusky (in fresh specimens blue) blotch on each membrane. Anal fin dusky in male, translucent in female. Caudal fin with 1–2 median horizontal rows of white blotches, and about three vertical rows of dark brown spots on rays. Pectoral fin translucent; pelvic fin with white blotches.

*Sexual dimorphism.*—Males have a higher first dorsal fin than females, the first and second spines being much longer than the third, a longer urogenital papilla, and a different color pattern of the second dorsal and anal fins and of the sides of the head.

*Distribution.*—This species is apparently endemic to Easter Island. No *Synchiropus* of the *postulus* species-group has been recorded from Pitcairn Island, Ducie Atoll Rapa, or any other islands near Easter Island. It has been collected at a depth of 12 meters, which is about the same depth at which *S. kiyoae* occurs in Japan (5–13.5 m).

*Etymology.*—This new species is named in honor of Dr. John E. Randall, whose contributions considerably increased our knowledge of the ichthyofauna of Easter Island, and who collected the type-material of the new species.

*Comparisons.*—*Synchiropus randalli* is compared with the most closely related species, *S. kiyoae* Fricke & Zaiser (1983:122–128, figs. 1–2; Fricke 1983:603–608, fig. 185), in Table 2. It differs from *Synchiropus laddi* Schultz (1960:406–409, fig. 131; Fricke 1981:124–126, fig. 39; Fricke 1983:608–611, fig. 187) in the proportions of the first dorsal fin spines in the male (in *S. laddi* second spine subequal to third, first spine shorter), in the first dorsal fin which is lower than the second dorsal fin, and in the general color pattern (*S. laddi*: completely pale, except for the eye and two ventral black spots on each side of the body). *Synchiropus randalli* can be distinguished from *S. minutulus* Fricke (1981:119–123, fig. 38; Fricke 1983:624–627, fig. 192) by the same characters as from *S. laddi. Synchiropus postulus* Smith (1963:560, fig. 7, pl. 86E; Fricke 1981:116–118, fig. 37; Fricke 1983:658–660, fig. 203) is distinguished by the proportions of the first dorsal fin spines of the male (second and third spines longest, first spine shorter), by the presence of long filaments in that fin, by the first dorsal fin of the female which is lower than the second dorsal fin, and by the general color pattern. *Synchiropus springeri* Fricke (1983:673–677, fig. 208) differs in the proportions of the first dorsal fin of the female (which is lower than the second dorsal fin), the bright rose pink occipital region, and the color pattern of the head, the body, and the pelvic fin. The two species of the *ocellatus* species-group of the genus *Synchiropus* occurring in the central Pacific, *S. ocellatus* (Pallas, 1770) (Fricke 1983:635–642, fig. 197, east to Marquesas Islands and Pitcairn) and *S. morrisoni* Schultz, 1960 (Fricke, 1983:630–635, figs. 195–196, east to Marshall and Fiji islands), differ from *S. randalli* in having eight rays in the second dorsal fin, seven rays in the anal fin, preopercular spine formulae of—$\frac{1-2}{-}\,1$, and completely different color patterns.

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# A NEW SPECIES OF BULLFINCH (AVES: EMBERIZINAE) FROM A LATE QUATERNARY CAVE DEPOSIT ON CAYMAN BRAC, WEST INDIES

David W. Steadman and Gary S. Morgan

*Abstract.*—A new species of bullfinch, *Melopyrrha latirostris,* is described from latest Pleistocene to early Holocene cave deposits on Cayman Brac, West Indies. This species is larger in its cranial dimensions than other species of West Indian finches. *Melopyrrha latirostris* represents one of many species of vertebrates that is known on Cayman Brac only from fossils. Specimens referred to *M. nigra taylori,* which occurs today only on Grand Cayman, were recovered from the same stratigraphic levels as *M. latirostris.*

The Cayman Islands are three small islands in the Caribbean Sea, about halfway between Cuba and Jamaica (Fig. 1). In 1965, Dr. Thomas H. Patton, then of the University of Florida, excavated several deposits of fossiliferous sediment from limestone caves on Cayman Brac, the easternmost island. From the richest of these sites, known herein as Patton's Fissure, thousands of vertebrate fossils were recovered from deposits of presumed Holocene age. These fossils, reported first by Patton (1966), are discussed in detail by Morgan (in press).

Patton's Fissure is located in the village of Spot Bay, 3 km west of the northeast point of Cayman Brac at 19°45'N and 79°45'W. It is in the side of a cliff about 15 m above sea level and 250 m inland from the northern coast. Patton's Fissure is about 50 m long, a maximum of 4 m wide at the base, and trends east to west, parallel to the cliff face. A layer of unconsolidated sediments 1–2 m deep covers the entire fissure. These sediments consist of buff to reddish-colored silts and clays, angular limestone fragments, land snail shells, and bones of small vertebrates. Three holes were excavated in Patton's Fissure, one of which (Hole 1) produced a significant amount of bone. Hole 1 was approximately 2 m square by 1.6 m deep. The stratigraphy of Patton's Fissure is as follows: Layer 1 (0–20 cm) contains abundant bone, including both extinct endemic mammals as well as introduced species such as *Rattus* that indicate a post-Columbian age. Layers 2–4 (20–80 cm) are sparsely fossiliferous, but contained no introduced species or evidence of human occupation, thus indicating a pre-Columbian age for these and all deeper layers. Layers 5–7 (80–140 cm) are extremely rich in both land snail shells and bones of small vertebrates. Most of the bird fossils described in this paper, and the great majority of all vertebrate fossils from Cayman Brac, are from these three layers. Layers 8–9 (140–160 cm) contain few bones and many are either covered with a calcareous precipitate or are contained in an indurated breccia. Solid limestone was encountered below Layer 9.

Unfortunately, neither Patton's original field notes nor the results from several radiocarbon ages determined in the late 1960's for Patton's Fissure are available, although Patton (pers. comm.) refers the age of the lower levels of this site to the early Holocene. This age is reasonable based upon preservation of the fossils and

Fig. 1. The West Indian Islands.

upon comparisons with fossil faunas from other West Indian caves. Recently we dated three samples of land snails from Patton's Fissure, using the single-species methodology of radiocarbon age determination on land snails developed for Jamaican species (Goodfriend and Hood 1983; Goodfriend and Stipp 1983). Our samples of Caymanian snails (*Hemitrochus caymanensis*) should provide a fairly accurate estimate of the age of Patton's Fissure, for *H. caymanensis* is an arboreal snail that does not feed on the ground (F. G. Thompson, pers. comm.). Therefore, this species should incorporate little if any "dead carbon" into its shell through ingestion of limestone. The age determinations are (in years BP, with lab number): 11,180 ± 105 (Layer 5, SI-6518); 13,230 ± 135 (Layer 7, SI-6519); and 13,850 ± 135 (Layer 9, SI-6520). These concordant results represent maximum ages, depending upon the level at which the dated snails had incorporated environmental carbonate into their shells during life. The radiocarbon data suggest an age of latest Pleistocene or earliest Holocene for the fauna from Layers 5–9 of Patton's Fissure.

The fauna from Patton's Fissure includes the extinct capromyid rodents *Capromys* and *Geocapromys* and the insectivore *Nesophontes,* as well as several living species of bats that no longer occur on Cayman Brac. Based upon Minimum Number of Individuals, lizards dominate the fauna of Patton's Fissure (67%), followed by mammals (25%, most of which are *Nesophontes*), and birds (8%, not including unidentified passerines).

The avian fossils from Patton's Fissure are mainly of small passerines that remain incompletely studied. Conspicuous among these passerine fossils are numerous cranial elements of a finch that is much larger than *Tiaris olivacea,* the only emberizine known historically from Cayman Brac. We describe these fossils as representing two sympatric forms of *Melopyrrha,* of which one is extinct and the other survives only on Grand Cayman, a larger island 130 km west of Cayman Brac.

## Systematic Paleontology

### Class Aves
### Order Passeriformes
### Family Fringillidae
### Subfamily Emberizinae
### Genus *Melopyrrha*

In possessing the following characters, the series of fossils from Patton's Fissure may be referred to *Melopyrrha* rather than to the closely related West Indian emberizine genera *Tiaris, Loxipasser, Loxigilla, Euneornis,* or *Melanospiza.* (Descriptive terminology follows Baumel et al. 1979; fossil specimens are deposited in the Vertebrate Paleontology Collections of the Florida State Museum [UF], while modern skeletal specimens are from the National Museum of Natural History, Smithsonian Institution [USNM].

*Maxilla.*—In lateral aspect, more arched (curved) along both the dorsal and ventral surfaces (most closely approached by *Loxipasser*); relatively broad medial bar of Os nasale; presence of a small but distinct foramen in medial portion of the lateral bar of Os nasale, near the dorsal margin of the nares; relatively much shorter and stouter than in *Euneornis campestris* or *Melanospiza richardsoni.*

*Mandible.*—In dorsal aspect, distal end of pars symphysialis less pointed; in lateral aspect, dorsal surface of dentary more curved than in all except *Tiaris bicolor* and *Loxipasser anoxanthus*; mandibular foramen relatively small; overall much stouter and more "finch-like" than in *Euneornis campestris.*

*Quadrate.*—Except for differences in size, it is difficult or impossible to distinguish individual quadrates among the six closely related genera of West Indies finches mentioned above. The fossil quadrates from Cayman Brac differ from those of the only other similarly-sized nine-primaried oscine in the fossil deposit (the tanager *Spindalis zena*; Thraupinae) in forming an obtuse angle in lateral aspect between the processus quadratojugalis and condylus squamosus, this angle being more nearly 90° in *Spindalis.*

In describing *Melopyrrha taylori* from Grand Cayman, Hartert (1896) doubted the distinctness of *Melopyrrha* from other (unspecified) genera of finches. Standard check-lists (i.e., Bond 1956, Paynter 1970, AOU 1983) recognize all six of the emberizine genera discussed above, although we believe that most or all of these genera can be accommodated in an expanded genus *Tiaris* Swainson, 1827, on the basis of plumage and osteology. These finches represent an unrecognized evolutionary radiation within the West Indies, in many ways comparable to that of emberizines in the Galapagos Islands. This West Indian emberizine radiation and its systematic ramifications have not yet been fully documented, so we will describe the new species from Cayman Brac in the genus *Melopyrrha* rather than in *Tiaris.*

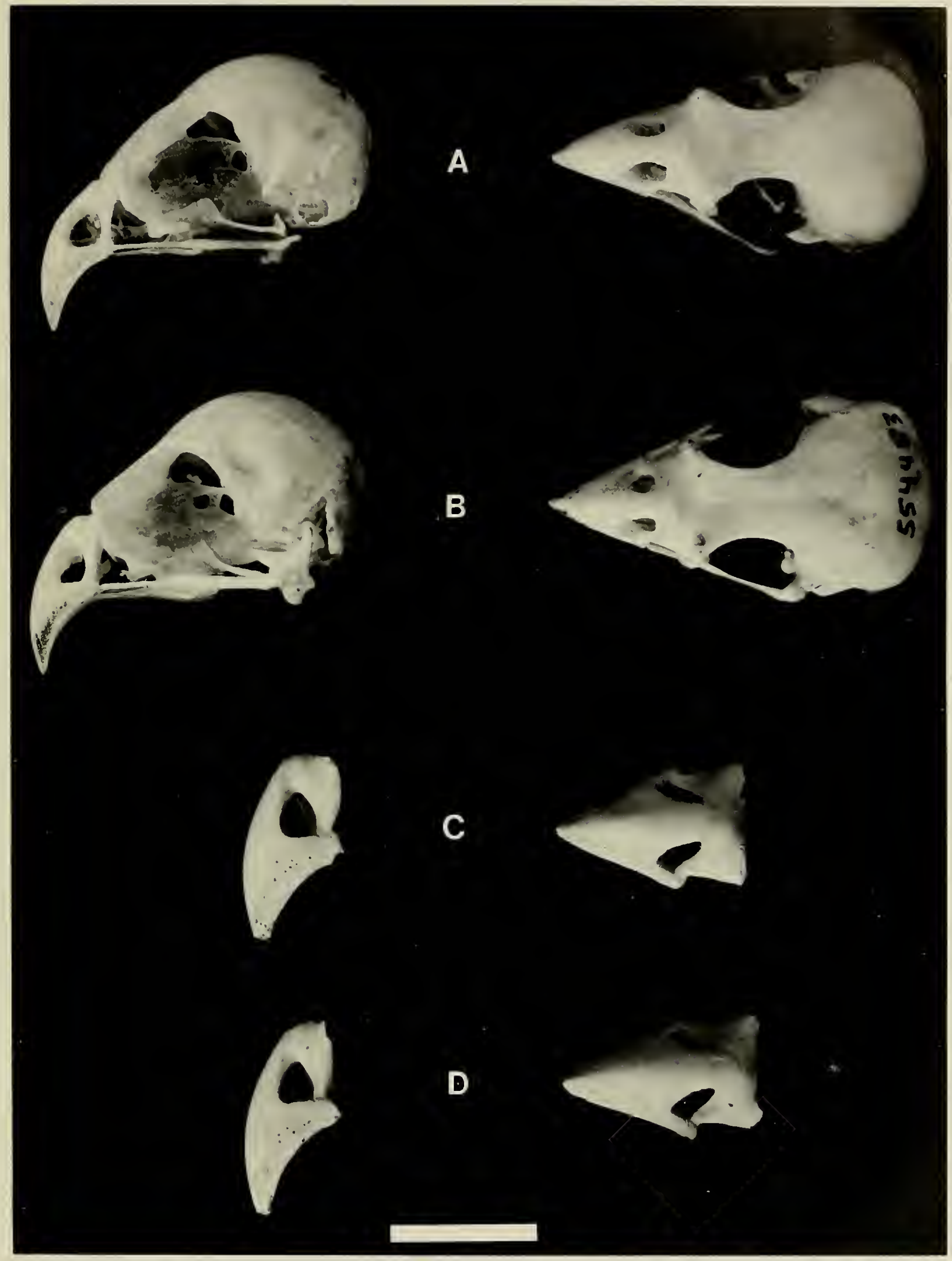

Fig. 2. Maxillae and skulls of fossil and modern *Melopyrrha*. Lateral aspect in left column, dorsal aspect in right column. A, *M. nigra nigra* male, USNM 321962, Cuba; B, *M. n. taylori* male, USNM 554483, Grand Cayman; C, *M. latirostris,* holotype, UF 23011, Cayman Brac; D, *M. latirostris,* paratype, UF 61022, Cayman Brac. Scale bar = 1 cm.

### *Melopyrrha latirostris,* new species
Figs. 2, 3

*Holotype.*—Complete maxilla, UF 23011, from Hole 1, Layer 7 of Patton's Fissure, Spot Bay, Cayman Brac, Cayman Islands. Collected by T. H. Patton during the summer of 1965 (exact date unknown).

*Paratypes.*—All from Hole 1, Layer 7 of Patton's Fissure. 12 complete or nearly complete quadrates, UF 61008–61019; 9 complete or partial maxillae, UF 61020–61028; 13 incomplete mandibles, UF 23012, 61029–61042.

*Referred material.*—All from Hole 1 of Patton's Fissure. Layer 2—partial maxilla, UF 23016. Layer 4—partial maxilla, UF 23015. Layer 5—complete or nearly complete quadrates, UF 61001, 61003, 61005. Layer 6—partial mandible, UF 23013.

*Diagnosis.*—Larger than *Melopyrrha nigra,* especially in width of maxilla and height of mandible (Table 1, measurements A, B, D, F, G). Nares relatively small compared to size of entire maxilla. In lateral aspect, ventral surface of mandible nearly straight (*M. nigra* with a distinctly obtuse angle at junction of Os surangulare and Os dentale). In lateral aspect, dorsal surface of Os dentale relatively straight. Os dentale proportionately long relative to length of entire mandible.

*Etymology.*—From the Latin *latus,* broad, and *rostrum,* bill or snout. The name *latirostris* is regarded as a noun in apposition.

## Discussion

*Evolution.—Melopyrrha nigra,* the only living species in the genus, occurs today on Cuba and the Isle of Pines (*M. n. nigra*) and Grand Cayman (*M. n. taylori*). *Melopyrrha latirostris* is much closer in size to *M. n. taylori* than to *M. n. nigra* (Table 1), and on this basis it is likely that *M. latirostris* evolved from a population of *M. n. taylori* or its immediate progenitor that became isolated on Cayman Brac. Nevertheless, several of the fossils from Hole 1 of Patton's Fissure are much too small to be referred to *M. latirostris* and are similar in size to modern specimens of *M. n. taylori* (Table 1). These smaller specimens, which we refer to *M. n. taylori,* include a mandible (UF 61045) from Layer 5, and a mandible (UF 61043) and a quadrate (UF 61006) from Layer 6. From these same layers are six other specimens that are intermediate in size between *M. latirostris* and *M. n. taylori* (a maxilla [UF 23014], a mandible [UF 61046], and two quadrates [UF 61002, 61004] from Layer 5, and a mandible [UF 61044] and quadrate [UF 61007] from Layer 6). We cannot say with certainty whether these last specimens represent very small female individuals of *M. latirostris,* or very large male individuals of *M. n. taylori,* or hybrids between the two species.

No specimens of *M. n. taylori* were recovered from Layer 7, the most fossiliferous layer collected. This fact suggests that *M. latirostris* was already established on Cayman Brac before *M. n. taylori* colonized (or re-colonized) the island. The intermediate specimens suggest that genetic interchange may have occurred between *M. latirostris* and *M. n. taylori* at that time, and the two specimens of *M. latirostris* from Layers 2 and 4 suggest that this species may have outlived its congener, only to disappear as well sometime in the Holocene. We regard *M. latirostris* as a full species rather than a subspecies of *M. nigra* because of its

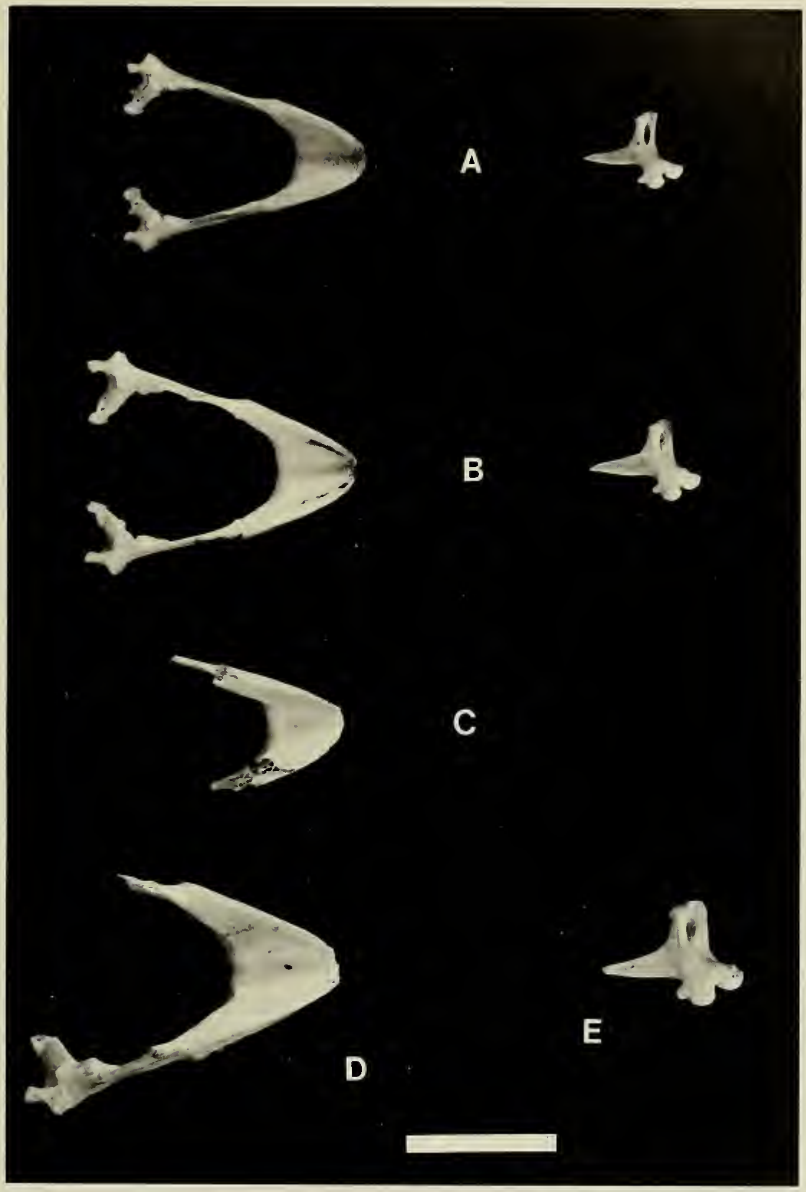

Fig. 3. Mandibles and quadrates of fossil and modern *Melopyrrha.* Dorsal aspect of mandibles in left column, lateral aspect of quadrate in right column. A, *M. nigra nigra* male, USNM 321962, Cuba; B, *M. n. taylori* male, USNM 554483, Grand Cayman; C, *M. n. taylori-M. latirostris* intermediate fossil, UF 61046, Cayman Brac; D, *M. latirostris* paratype, UF 23012, Cayman Brac; E, *M. latirostris* paratype, UF 61008, Cayman Brac. Scale bar = 1 cm.

sympatry with *M. n. taylori* and because of its very large size; it is larger relative to *M. n. taylori* than the latter is to *M. n. nigra* (see ratios in Table 1).

The maxilla, quadrate, and mandible of *M. latirostris* are broader and more massive than in other West Indian finches. All or nearly all of the diagnostic

Table 1.—Measurements (in mm) of fossil and modern *Melopyrrha,* giving mean, sample size (in parentheses), and range. UF catalogue numbers are given in parentheses for individual fossils referred either to *M. nigra taylori* or to *M. n. taylori-M. latirostris* intermediates.

| | A<br>Maxilla: minimum width of medial bar of Os nasale | B<br>Maxilla: minimum width of lateral bar of Os nasale | C<br>Maxilla: length from nares to tip of Os premaxillare |
|---|---|---|---|
| *M. nigra nigra*<br>Cuba, males | 1.3 (7)<br>1.1–1.7 | 0.5 (8)<br>0.4–0.7 | 6.1 (7)<br>5.8–6.5 |
| *M. n. taylori*<br>Grand Cayman, males | 1.7 (7)<br>1.5–1.9 | 0.6 (8)<br>0.5–0.8 | 7.0 (8)<br>6.7–7.4 |
| *M. n. nigra*<br>Cuba, females | 1.4 (2)<br>1.2–1.6 | 0.6 (2)<br>0.6 | 5.8 (2)<br>5.7–5.9 |
| *M. n. taylori*<br>Grand Cayman, females | 1.5 (5)<br>1.4–1.7 | 0.6 (5)<br>0.5–0.6 | 6.5 (5)<br>6.3–6.7 |
| *M. latirostris* | 2.5 (10)<br>2.2–2.8 | 1.2 (9)<br>1.1–1.5 | 8.2+ (3)<br>8.0+–8.4+ |
| *M. n. taylori*<br>fossils, Cayman Brac | — | — | — |
| Intermediate fossils,<br>Cayman Brac | 2.1 (UF 23014) | 0.9 (UF 23014) | 7.0+ (UF 23014) |
| Ratio of mean in *M. n. nigra* to that in *M. n. taylori* (males) | 0.76 | 0.83 | 0.87 |
| Ratio of mean in *M. n. taylori* males to mean in *M. latirostris* | 0.68 | 0.50 | 0.86 or less |

"+" after a value for certain fossil specimens means that the measurement of a slightly damaged specimen approaches to within 0.4 mm or less the actual value of the measurement if the specimen had been undamaged.

characters of *M. latirostris* are associated allometrically with its large size. The large, rounded maxilla of *M. latirostris* is reminiscent of that found in *Geospiza crassirostris,* a frugivorous emberizine finch from the Galapagos. The maxilla of *M. latirostris,* is more powerfully built than that of *G. crassirostris,* especially in the nasal region, so *M. latirostris* may have subsisted on a mixed diet of fruit and seeds. Alternatively, *M. latirostris* may have been mainly a seed-eater, for its larger bill would have permitted it to take a variety of seeds. Further speculation on the feeding habits of *M. latirostris* awaits better documentation of the feeding habits of living *M. nigra.* The only report we have found on this topic is Johnston's (1975:300) for *M. n. taylori* of Grand Cayman, where insects and unidentified seeds were found in the stomachs of four different birds.

*Zoogeography.*—The two species of *Melopyrrha* from Cayman Brac are most closely related to *M. n. nigra* from Cuba, reflecting the dominant zoogeographic pattern seen in the extinct and living vertebrate fauna from the island. In the combined vertebrate fauna from five cave deposits excavated on Cayman Brac, 17 (81%) of the 21 species of known zoogeographic affinities are conspecific with or are derived from Cuban species, whereas the remaining four species have Jamaican affinities (Morgan, in press). Several physical and biological factors favor Cuba over Jamaica as a source area for most of the vertebrate fauna of Cayman Brac. These include: the considerably larger area, and longer coastline of Cuba;

Table 1.—Extended.

| D Maxilla: maximum width | E Mandible: total length | F Mandible: maximum height of Os surangulare | G Mandible: height at junction of Os dentale and Os surangulare | H Mandible: maximum width of entire Os dentale | I Mandible: length of cotyla lateralis | J Quadrate: total height |
|---|---|---|---|---|---|---|
| 5.6 (8) | 18.2 (5) | 3.9 (7) | 2.7 (8) | 8.0 (7) | 2.2 (8) | 5.2 (7) |
| 5.0–6.1 | 17.4–18.6 | 3.5–4.4 | 2.3–3.1 | 7.8–8.5 | 2.1–2.4 | 5.0–5.3 |
| 6.3 (7) | 19.6 (5) | 5.0 (8) | 3.4 (8) | 9.5 (6) | 2.6 (8) | 5.6 (8) |
| 6.1–6.6 | 19.2–20.1 | 4.5–5.3 | 3.2–3.6 | 9.2–9.9 | 2.4–2.7 | 5.5–5.9 |
| 5.5 (2) | 17.2 (2) | 3.8 (2) | 2.4 (2) | 7.4 (2) | 2.0 (2) | 5.0 (2) |
| 5.4–5.6 | 17.1–17.3 | 3.8–3.9 | 2.4 | 7.3–7.5 | 2.0 | 4.9–5.2 |
| 5.8 (5) | 18.6 (2) | 4.4 (4) | 3.1 (4) | 8.5 (3) | 2.4 (5) | 5.4 (4) |
| 5.7–5.9 | 18.3–18.9 | 4.3–4.5 | 2.9–3.2 | 8.2–8.7 | 2.2–2.6 | 5.3–5.5 |
| 8.3+ (8) | 23.4 (1) | 6.5 (2) | 4.7 (8) | 11.4 (8) | 3.0 (4) | 7.1 (15) |
| 7.6+–8.8 | 23.4 | 6.4–6.6 | 4.1–5.0 | 10.3–12.3 | 2.8–3.2 | 6.6–7.5 |
| — | — | — | 3.1 (UF 61043)<br>3.2 (UF 61045) | 8.7 (UF 61045) | — | 6.1 (UF 61006) |
| 7.0+ (UF 23014) | — | — | 3.8 (UF 61044)<br>3.9 (UF 61046) | — | — | 6.4 (UF 61002, 61004, 61007) |
| 0.89 | 0.93 | 0.78 | 0.79 | 0.84 | 0.85 | 0.93 |
| 0.76 or less | 0.84 | 0.77 | 0.76 | 0.83 | 0.87 | 0.79 |

the closer proximity of Cuba to the Cayman Islands during Pleistocene glacial intervals; Cuba's greater species diversity; and, today's prevailing currents favor overwater dispersal from Cuba rather than Jamaica. Cayman Brac is almost equidistant (200 km) from Cuba to the east and northeast and from Jamaica to the southeast, and is separated from both islands by oceanic depths in excess of 1000 m, eliminating the possibility of land bridges during the late Tertiary. However, during periods of lower sea level in Pleistocene glacial intervals, Cuba would have extended to within 100 km of Cayman Brac as the extensive carbonate bank areas along its southern coast became exposed. The lack of evidence for a land connection leaves overwater dispersal as the only means by which Cayman Brac could have received its vertebrate fauna. Based on the low percentage of endemic species and the absence of generic level endemism on Cayman Brac, we believe that the majority of the fauna arrived during the Pleistocene.

*Extinction.*—Forty species of vertebrates have been identified from Holocene cave deposits on Cayman Brac (8 species of reptiles, 23 of birds, and 9 of mammals), the great majority of which are from Hole 1 of Patton's Fissure (Morgan, in press). Of these 40 species, 17 (11 species of birds and 6 of mammals) no longer occur on Cayman Brac. Of these 17 species, six are still found on Grand Cayman, seven no longer occur in the Cayman Islands but exist elsewhere in the West Indies, and four (including *Melopyrrha latirostris*) are extinct species known only from the Cayman Islands. The stratigraphy and chronology of the five caves excavated on Cayman Brac are not known well enough to determine precisely when the majority of these 17 species disappeared from the island. Fossils of all six species of mammals now extinct on Cayman Brac have been collected in caves from surface remains that are believed to be less than 500 years old based upon the presence of *Rattus*. On the other hand, only one of the 11 extirpated species of birds, *Puffinus lherminieri*, has been recovered from these same surface layers, while the remaining 10 species are known only from the pre-Columbian strata in Hole 1 of Patton's Fissure. From the data available, we cannot determine whether these 10 species, which include both species of *Melopyrrha*, disappeared from natural causes before AD 1500 or were extirpated as a result of extensive habitat disturbance by post-Columbian peoples.

There is no evidence of aboriginal occupation of any of the Cayman Islands (Hirst 1910; Richards 1955), so all Holocene habitat alteration can be attributed to post-Columbian settlers. Thus it is conceivable that the extinction of either or both forms of *Melopyrrha* on Cayman Brac was an historic event, but we need a refinement of the chronology of the upper sediments at Patton's Fissure or other fossil sites before the chronology of extinction of *Melopyrrha* on Cayman Brac can be resolved beyond "probably late Holocene." Nevertheless, the stratigraphic evidence suggests that *M. latirostris* may have swamped out *M. n. taylori* through interbreeding.

That two congeneric finches could co-inhabit an island as small as Cayman Brac is not extraordinary, for until recently a parallel situation existed on St. Kitts in the Lesser Antilles. Two species of bullfinches, *Loxigilla noctis* and *L. portoricensis grandis*, occurred on St. Kitts until several decades ago when *L. p. grandis* apparently became extinct (Olson 1984). St. Kitts is not much larger than Cayman Brac in area, but is much higher in elevation, supporting lush forest in the volcanic highlands. However, Olson points out that *L. p. grandis* may have evolved in the lowlands of St. Kitts, so habitat diversity may have played little if any role in permitting the two species of *Loxigilla* to co-exist on St. Kitts. Although the limestone forest of Cayman Brac has a low canopy height and a low species diversity today, birds elsewhere in the West Indies tend to be relatively abundant in both absolute numbers and numbers of species in arid habitats (Kepler and Kepler 1970; Pregill and Olson 1981). Thus we see no reason why the prehistoric forests of Cayman Brac could not have supported two or more species of congeneric finches.

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98(3), 1985, pp. 554–560

# *REMASELLUS*, A NEW GENUS FOR THE TROGLOBITIC SWIMMING FLORIDA ASELLID ISOPOD, *ASELLUS PARVUS* STEEVES

Thomas E. Bowman and Boris Sket

*Abstract.*—*Asellus parvus* Steeves, 1964, from Ten Inch Cave, Alachua Co., Florida, is assigned to a new genus, *Remasellus,* characterized by a simple pereopod 1, broad natatory pereopods 2–7 fringed with long setae, and male pleopod 1 without retinacula. New records are reported from the Split Spring Cave system, Wakulla Co., Florida, and the Peacock Spring cave system, Suwanee County, Florida. Its behavior is unusual for an asellid in that in addition to walking on the substrate like an ordinary asellid, it also swims weakly in the open water.

Preceding the Eighth International Congress of Speleology at Western Kentucky University, Bowling Green, Kentucky, 18–24 July 1981, an International Cave Diving Camp was held in Florida in which the second author participated. In two of the caves a swimming isopod was collected that proved to be *Asellus parvus* Steeves, 1964. The natatory pereopods 2–7, not described or illustrated by Steeves, together with other features have led us to place it in the new genus described below.

## *Remasellus,* new genus

*Diagnosis.*—Mandible with 3-segmented palp. Maxilla 1, inner lobe with 5 apical spines. ♀ maxilliped oostegite with apical plumose setae. Pereopod 1 simple, not subchelate; pereopods 2–7 natatory/ambulatory, with broad segments fringed with closely spaced setae. ♂ pleopod 1 without retinacula. ♂ pleopod 2 endopod with small inner and outer basal apophyses, tip with several processes. ♀ pleopods 2 not overlapping medially. Uropod exopod very short; endopod long (♂ only?).

*Type-species.*—*Asellus parvus* Steeves, 1964.

*Etymology.*—Remus = oar (Latin) + *Asellus,* referring to the shape and function of pereopods 2–7.

## *Remasellus parvus* (Steeves)
Figs. 1–4

*Asellus parvus* Steeves, 1964:450–451, figs. 10–14.—Fleming, 1973:295 (in list), 299 (in key).

*Material.*—FLORIDA: Alachua Co., Ten Inch Cave, 5 mi N of Newberry, leg. R. D. Warren: 9 Jun 1961, 1 ♂, 1 ♀, USNM 111142, holotype and allotype (not separated in vial); 4 Jun 1961, 1 ♀, USNM 111140; 20 Jan 1962, 1 ♂, 3.3 mm, USNM 111141.—Wakulla Co., Split Sink cave system, leg. Boris Sket and Wayne Marshall, Jul 1981, 1 ♂, 5.5 mm, USNM 213321; 4 ♀, 4.7, 6.0, 7.0, 8.7 mm, USNM 213332.—Suwannee Co., Peacock Spring cave system, leg. Boris Sket and Wayne Marshall, Jul 1981, 1 ♂, 2.7 mm, 2 ♀, 1.9, 2.35 mm, USNM 213323.

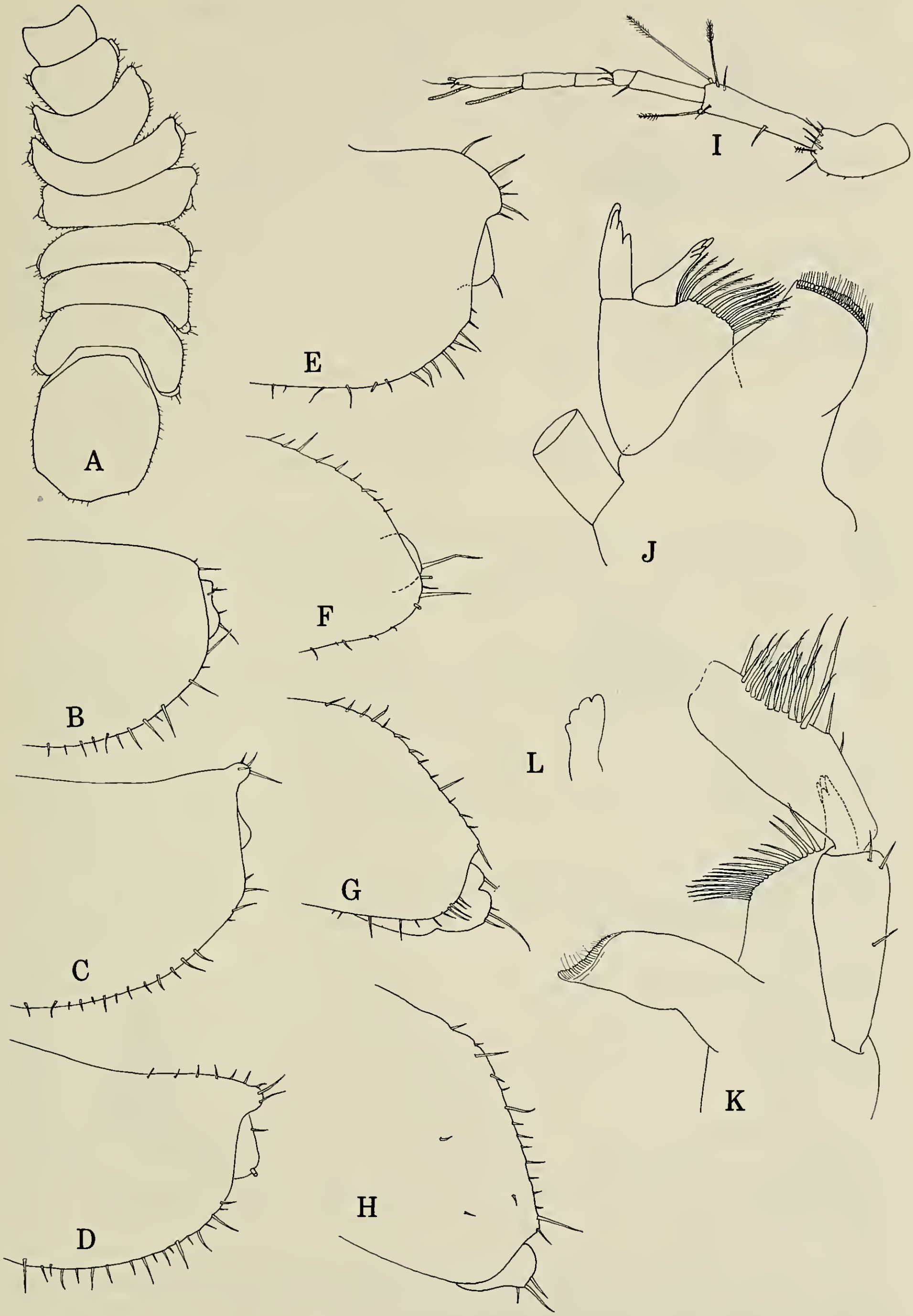

Fig. 1. *Remasellus parvus,* A–H, J–L, from Split Spring specimens; I, from Peacock Spring ♂: A, Habitus, 7.0 mm ♀; B–H, Pleura of pereonites 1–7, 7.0 mm ♀; I, Antenna 1, 2.7 mm ♂; J, Left mandible, palp omitted; K, Right mandible, distal segment of palp omitted; L, Incisor of right mandible.

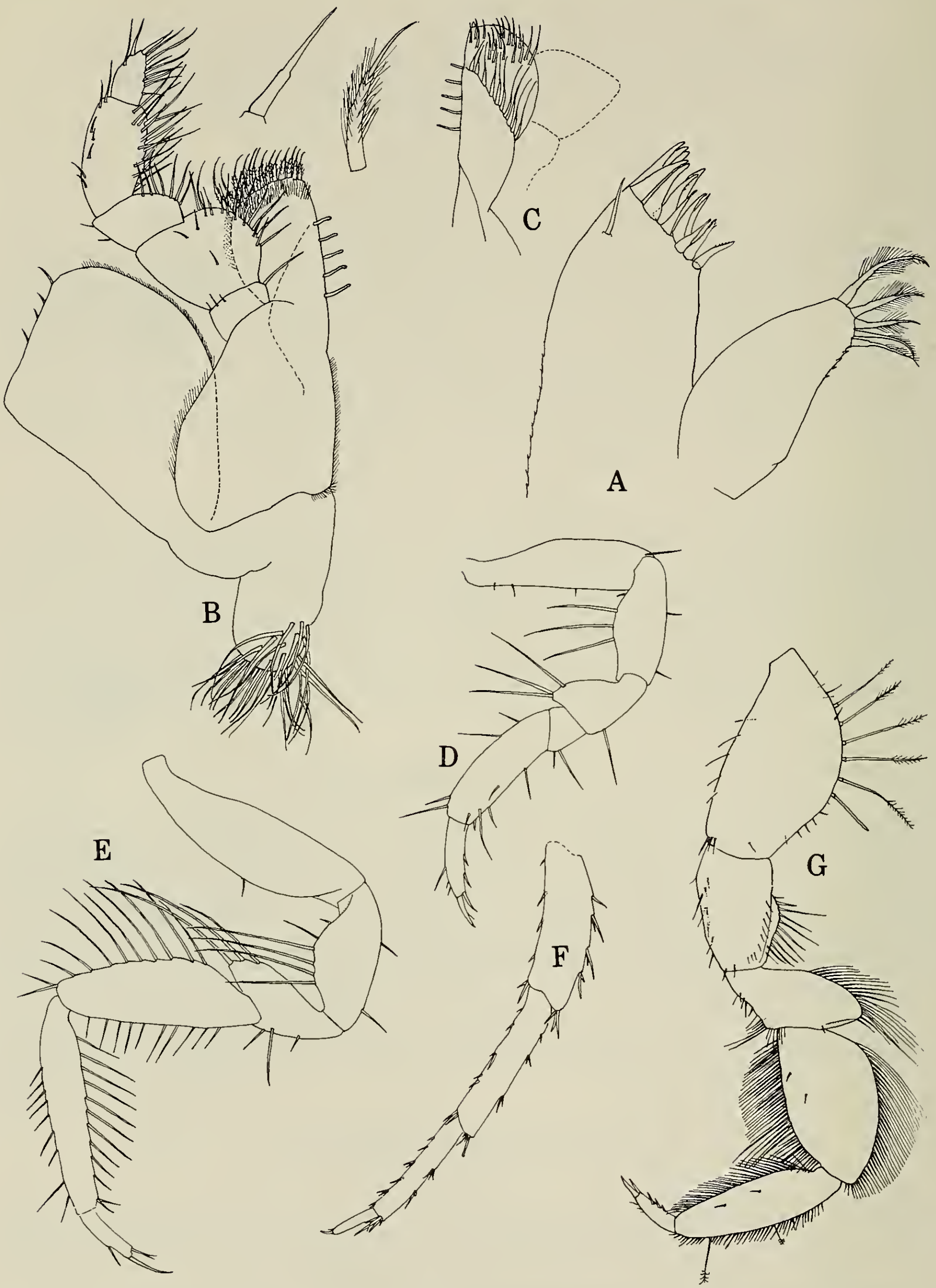

Fig. 2. *Remasellus parvus,* A–C, F–G, from Split Spring specimens; D–E, from Peacock Spring ♂: A, Maxilla 1; B, Maxilliped, ♀; C, Endite of same, anterior; D, Pereopod 1; E, Pereopod 2; F, Undetermined pereopod, distal segments; G, Pereopod 3 or 4.

Collections by Sket and Marshall were made with a "squeeze bottle" (Iliffe and Sket, in press).

Although the holotype and allotype were not separated, it can be safely assumed that Steeves intended the male to be the holotype since Steeves always selected males for holotypes. Curiously, Steeves stated that two allotypes were deposited, an impossibility since by definition there can be only a single allotype, and he failed to list the additional ♂ and ♀ although they were identified by him and are clearly topotypes.

*Description.*—Blind, unpigmented. Body about 3× as long as wide, widening from head to pereonite 3; pereonites 3–7 subequal in width. Head about 1.5× as wide as long; anterior margin shallowly concave; postmandibular lobes inconspicuous. Coxae visible dorsally on all pereonites. Telson about 0.8× as wide as long; lateral margins slightly convex; posterior margin slightly concave on either side of truncate caudomedial lobe.

Antenna 1, flagellum with short proximal segment and 3 distal segments progressively longer; esthete formula 1-1. Antenna 2 broken off at base in all specimens.

Mandibles with 4-cuspate incisors and lacinia; spine-row with 13 and 15 spines in left and right mandibles. Maxilla 1 with 5 and 13 apical spines on inner and outer lobes. Maxilliped with 5 retinacula; endite densely setose; epipod with few setae.

Pereopods of Split Spring specimen all detached and free in vial. Pereopods of Peacock Spring specimens absent except attached pereopods 1–2 in ♂. Detached pereopods identified by comparison with those of topotype ♂ (Fig. 4A–E).

Pereopod 1 slender, simple; ischium and merus with 3–4 long naked setae on anterior margin; carpus very short; propus slightly longer than ischium, with a few setae on both margins; dactyl slightly shorter than propus, biunguiculate, with 2–3 spines on posterior margin.

Pereopod 2 much longer than pereopod 1, with long setae on anterior margin of ischium, merus and carpus, and on posterior margin of carpus and propus; shorter setae on anterior margin of propus; propus slightly more than twice as long as dactyl.

Pereopods 3–6 successively longer, with flat expanded segments; basis usually with several broom setae on 1 margin; merus, carpus, and propus with rows of setae on both margins; dactyl with 3–5 spines on flexor margin.

Pereopod 7 much longer than pereopods 5–6, segments longer and narrower; carpus and propus with long setae on both margins.

♂ pleopod 1 endopod narrowly oval, about 1.6× as long as protopod; apex and distal third of lateral margin armed with short non-plumose setae. ♂ pleopod 2 protopod unarmed; exopod proximal segment with 1 lateral seta, distal segment obovate with 14 setae on apical margin and distal half of lateral margin; endopod with small basal apophyses, tip with short broad cannula, broadly rounded caudal process excavated centrally, and short recurved pointed lateral process.

♀ pleopod 2 with straight medial margin; lateral margin diverging gradually to widest point of appendage slightly beyond midlength where setae begin, then converging to narrow apex; 14 plumose setae on lateral and apical margins.

Other pleopods in poor condition, not examined.

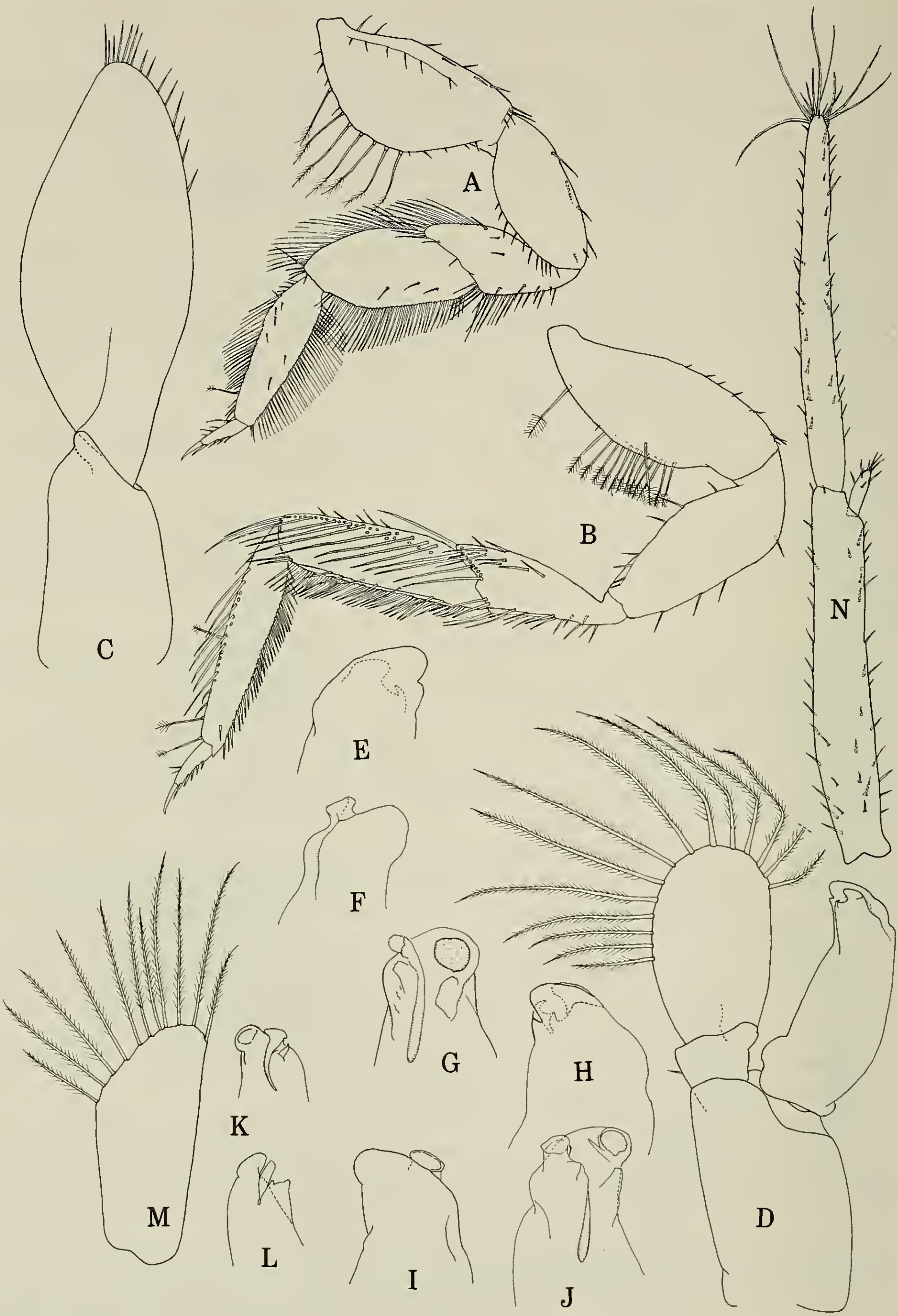

Fig. 3. *Remasellus parvus,* A–H, M, from Split Spring specimens; K–L, from Peacock Spring ♂: A, Pereopod 3 or 4; B, Pereopod 5 or 6; C, Pleopod 1, ♂; D, Pleopod 2, ♂; E–L, Pleopod 2, ♂, endopod tip in different aspects; M, Pleopod 2, ♀.

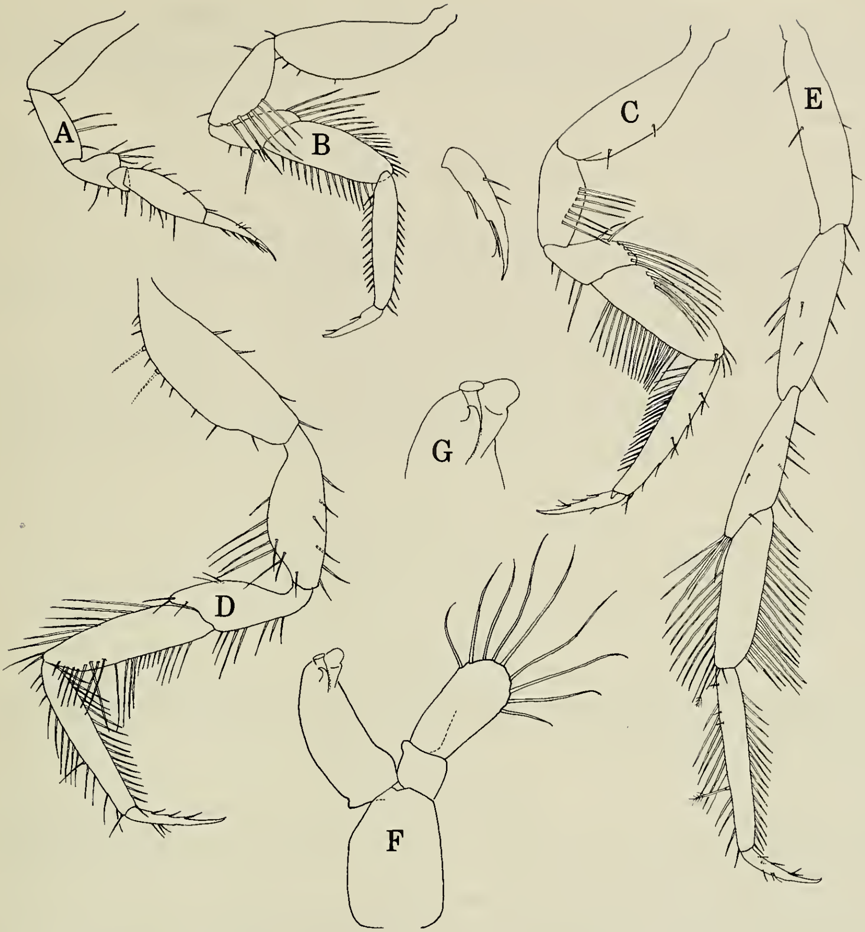

Fig. 4. *Remasellus parvus,* ♂ topotype: A, Pereopod 1; B, Pereopod 2; C, Pereopod 4; D, Pereopod 5; E, Pereopod 7; F, Pleopod 2; G, Pleopod 2, endopod tip.

Uropod with narrow protopod and endopod subequal in length, latter with cluster of long apical setae; exopod very short, less than one-seventh as long as protopod. The single uropod found appears to be from a ♂; in other asellids such unequal uropod rami are present only in the ♂; rami of the ♀ are nearly equal.

*Remarks.*—Some differences in detail can be seen between the type-locality specimens (Fig. 4) and those from the other localities (Figs. 1–2). Moreover, we are not absolutely certain that the much smaller specimens from Peacock Spring are identical with the larger Split Spring specimens. When adequate material becomes available the question of conspecificity should be carefully studied.

*Relationships.*—*Remasellus* is quite distinct from all other genera of Asellidae. Its apomorphic character states, simple pereopod 1 and natatory pereopods 2–7, and ♂ pleopod 1 without retinacula, are not found in combination in other genera of the family. The reduced basal apophyses of ♂ pleopod 1, also apomorphic, are found in some species of *Caecidotea,* the only other genus of Asellidae known from Florida. Three species of *Caecidotea* are known from Florida: *C. racovitzai australis* Williams, 1970, and *C. obtusus* Williams, 1970, both epigean, and the troglobitic *C. hobbsi* (Maloney, 1939). None of these is significantly similar to *Remasellus parvus.*

*Habitat.*—The Split Sink cave system, near Tallahassee, is a corridor occupied by a subterranean river, accessible through several collapse sinks. *Remasellus* was fairly common on the walls of one of the large drowned halls. The walls were covered by a compact black deposit that was tattered and fragile.

The Peacock Spring cave system is one of the largest drowned cave systems surveyed thus far (Exley and DeLoach 1981). *Remasellus* was found in one of the side branches where the bottom was partly covered with silt deposits.

*Behavior.*—The Split Sink specimens behaved like the usual asellid while on the rock walls. When removed form the walls to the water column, they swam slowly with what appeared to be metachronal movements of the pereopods and slight lateral sigmoid movements of the body. The body was in a vertical position with the head held upwards and the uropods downwards close to one another. The Peacock Spring specimens were seen in the water about 5 cm above the silt, also in a vertical position with the head up and the uropods down. A thin trail of silt was present between the uropods and the bottom.

## Acknowledgments

We are grateful to Wayne Marshall, who dove with the second author and called his attention to the presence of swimming asellids.

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# *EUPLEURODON PERUVIANUS* (RATHBUN, 1923); A SPECIES OF CRAB NEWLY RECORDED FROM CHILE (CRUSTACEA: DECAPODA: BRACHYURA)

Pedro Báez R.

*Abstract.*—Five specimens of the rarely collected crab *Eupleurodon peruvianus* were collected near Iquique, Chile (20°12′S, 70°10′W), during winter, 1977 and 1978. Two of them were found in the stomach contents of the labrid fish, *Pimelometopon maculatus*; the other three specimens were collected from the red alga, *Corallina officinalis chilensis,* in the rocky intertidal zone. These records represent an extension of the known latitudinal range of this crab which now reaches from Salinas, Ecuador, to Iquique, Chile, and adds a genus and species to the 15 species of Majidae recorded from Chilean waters.

Brachyuran decapods of the genus *Eupleurodon* Stimpson, 1871, are small crabs, which have been collected only from the intertidal zone of the Eastern Pacific. They have a carapace with depressed surface, its anterolateral angles being remarkably prominent, tooth-shaped, and projected forward subparallel to the body axis; the abdomen has only 5 free segments in both sexes and the ambulatory appendages are strongly prehensile, provided with crenate articles. The genus is closely related to *Epialtus.* There are three species of *Eupleurodon*: *E. trifurcatus* Stimpson, extending from Cape San Lucas, Baja California, Mexico (Garth 1958) to Chimbote, Perú (Chirichigno 1970); *E. rathbunae* Garth, 1958, collected only on Hood Island, Galapagos Archipelago and *E. peruvianus* (Rathbun) whose distribution ranges from Salinas, Ecuador to Iquique, Chile. The latter species was transferred from *Epialtus* (see Rathbun 1923, 1924) to *Eupleurodon* by Garth (1958) who stated that the differences used to distinguish the two forms as different species were sexual, with *Eupleurodon peruvianus* being the female and *Epialtus peruvianus* the male of the same species, *Eupleurodon peruvianus.*

*Material.*—A male and 4 females of *Eupleurodon peruvianus* were examined (Table 1): the male (MNHN D-10858) and an ovigerous female (MNHN D-10859) were captured by Prof. Raúl Soto M., in the rocky intertidal zone of Iquique in samples of *Corallina officinalis chilensis* during winter, 1977. The other 3 females were collected by Lic. Héctor R. Fuentes in Jun–Jul 1978 in the vicinity of Huaiquique beach: an ovigerous female (MNHN D-10860) obtained from intertidal seaweed samples; and two others, found in stomach contents of a labrid fish, *Pimelometopon maculatus* Pérez, captured between 3 and 20 m depth (Fuentes 1978).

*Diagnosis.*—(Modified from Garth 1958:243). Male: Hepatic width surpassing branchial width; rostrum elongate and bilobed; orbital arch making an obtuse angle with rostral border. First pleopod concave, with a thumb-shaped process, and opposed horny pointed tip.

Female: branchial width surpassing hepatic width; rostrum short, its point

Table 1.—Morphometric data of *Eupleurodon peruvianus* (Rathbun, 1923). Measurements in (mm).

| | Sex | | | | |
|---|---|---|---|---|---|
| | Males | | Females | | |
| Catalogue number | # | MNHN D-10858 | # | MNHN D-10859 | MNHN D-10860 |
| Carapace length | 9.50 | 12.49 | 7.30 | 8.84 | (rostrum fractured) |
| Carapace length to rostral base | — | 8.69 | — | 7.59 | 7.90 |
| Hepatic width | 6.45 | 7.74 | 5.25 | 7.19 | 7.10 |
| Branchial width | 6.45 | 8.64 | 5.45 | 7.49 | 7.26 |
| Rostral length | 2.70 | 3.78 | 1.80 | 1.62 | — |
| Rostral width | 1.50 | 1.82 | 1.00 | 1.43 | 1.63 |
| Chela length | 3.40 | — | 1.70 | (r) 2.52 | (r) 2.70 |
| Chela height | — | — | — | 1.13 | 1.08 |
| Chela dactylus length | 1.60 | — | 1.00 | 1.25 | 1.50 |
| Abdomen length (folded) | — | 4.08 | — | 5.90 | 6.30 |
| Abdomen width | — | 2.56 | — | 7.22 | 7.05 |
| Length second leg | 8.50 | — | — | 8.41 | 8.23 |
| third leg | — | 7.57 | — | 7.70 | 4.59 |
| fourth leg | — | 8.56 | — | 6.07 | 6.20 |
| fifth leg | 4.50 | — | — | 5.85 | 4.71 |

# = Taken from Garth (1958).
MNHN-D = Museo Nacional de Historia Natural, Chile; colección de Crustáceos Decápodos.
r = right.

divided; prominent pre-orbital lobe. Merus of external maxilliped with border entire or slightly V-shaped in both sexes.

*Discussion.*—The morphological characters of these specimens coincide in general terms with the description of *Eupleurodon peruvianus* (Rathbun). Nevertheless, they differ from it, particularly the male, in which the sulcus that separates the hepatic and branchial regions is tiny, and the interorbital sulcus is not very acute. The left hepatic lobe is fractured, so it is not possible to see if this sector is curved. The branchial lobe is slightly smaller than the hepatic lobe and its sides are lightly concave. The rostrum is remarkably bifurcate, thick, and provided with 2 lobes at the tip; it is longer than broad, with parallel sides in the proximal ⅔. The fingers of the chelae fit well although they will not close completely. The upper side of the merus of the first and the second ambulatory legs is not laminated as it appears in Garth's (1958) description; it is difficult to see the 2 or 3 teeth described. On the other hand, the female shows variations in the merus of the maxillipeds which when closed are slightly V-shaped at the anterior and internal angle; on the chelae the propodal finger is not strongly twisted, and the dactylus has a large basal tooth situated nearly at the midlength of its cutting border. The observed morphological variations are generally differences in growth stage rather than shape. The ovigerous females have about 700 eggs, those of MNHN D-10859 in an early stage of development, without ocular spots; MNHN D-10860 has eggs with ocular spots.

The specimens of *Eupleurodon peruvianus* from samples of *Corallina officinalis chilensis* were collected together with specimens of another majid, *Acanthonyx* *petiveri* H. Milne Edwards; the two specimens found by Fuentes (1978) in the stomach contents of *Pimelometopon maculatus* indicate that *E. peruvianus* is only an occasional prey item in the diet of this third level carnivorous fish within the food chain of the upper sublittoral.

The present finding of the rarely collected *Eupleurodon peruvianus* constitutes a new record of this genus and species for the carcinological fauna of Chile (Retamal 1981), and an extension of its known latitudinal distribution from Salinas, Ecuador, to Iquique, Chile. Sixteen species of Majidae are now known from Chile.

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# A NEW CRAYFISH OF THE GENUS *ORCONECTES* FROM THE LITTLE WABASH RIVER SYSTEM OF ILLINOIS (DECAPODA: CAMBARIDAE)

Lawrence M. Page

*Abstract.*—*Orconectes stannardi,* new species, is endemic to the Little Wabash River system of Illinois and appears to be most closely related to *O. propinquus. Orconectes iowaensis* Fitzpatrick is relegated to the synonymy of *O. propinquus.*

During a decade-long (1972–1982) survey of the decapods of Illinois (Page, in press), an undescribed species of *Orconectes* was discovered. It appears to be restricted to the Little Wabash River system of southeastern Illinois and brings to two (with *O. illinoiensis* Brown, 1956) the number of crayfishes known to be endemic to Illinois. Earlier investigators (Rietz 1912; Brown 1955) apparently collected the new *Orconectes,* but referred it to *O. propinquus* (Girard, 1852) or to *O. indianensis* (Hay, 1896). Based on data accumulated during the recent survey of Illinois, neither *O. propinquus* nor *O. indianensis* occurs in the Little Wabash River system.

### *Orconectes stannardi,* new species
Fig. 1

*Diagnosis.*—Body and eyes pigmented. Rostrum concave with margins moderately thickened, subparallel, slightly converging medially; terminating in spines; median carina extending onto long acumen. Areola 29.1–33.3 (mean = 30.2, n = 14) percent of total length of carapace, 3.6–6.7 (mean = 5.0) times as long as wide with 3 to 4 punctations across narrowest part. One large cervical spine on each side of carapace. Postorbital ridges well developed, grooved dorsolaterally and terminating in large spines. Suborbital angle weakly developed. Antennal scale broadest slightly distal to midlength, 2.3–3.0 (mean = 2.7) times as long as wide. Ischia of third pereiopods only of form I male with hooks overreaching basioischial articulation. Chela with 2 rows of tubercles along mesial margin of palm; small tufts of setae over dorsal surface; dorsal surfaces of fingers with well-defined longitudinal ridges. First pleopods of form I male symmetrical, extending to bases of second pereiopods when abdomen flexed. First pleopod of form I male with shoulder on cephalic surface at base of central projection; central projection corneous, strongly tapered to hooked tip; mesial process slightly shorter, non-corneous, tapered to rounded tip, with spur about midlength on caudal surface. Annulus ventralis immovable, subrhomboidal; cephalic half with medial trough and 2 caudally directed protuberances overhanging centrally located fossa; sinuate sinus extending from fossa to caudal edge.

Holotypic male, form I: Body somewhat depressed, abdomen narrower than thorax (12.4 and 14.3 mm). Greatest width of carapace greater than depth at caudodorsal margin of cervical groove (14.0 and 11.1 mm). Areola 5 times longer

(9.1 mm) than wide (1.8 mm) with 4 punctations across narrowest part; length of areola 31.6 percent of length of carapace. Rostrum excavated dorsally with submarginal and scattered punctations, median carina; thick margins terminating in corneous spines. Acumen terminating in upturned corneous spine reaching nearly to end of antennular peduncle. Postorbital ridge well developed, grooved dorsolaterally, terminating in prominent corneous spine. Suborbital angle poorly developed; branchiostegal spine small. Cervical spine large and corneous; hepatic area tuberculate; dorsal and branchiostegal areas of carapace punctate.

Abdomen longer than carapace (31.4 and 28.8 mm). Cephalic section of telson with one movable and one immovable spine in each caudolateral corner. Basal podomere of uropod with spine extending over mesial ramus. Lateral ramus of uropod with median and submedian ridges. Lateral ramus with moderately large movable spine submarginally at caudolateral corner. Mesial ramus of uropod with prominent median ridge terminating in premarginal spine. Dorsal margin of telson and uropods lightly setiferous.

Cephalic lobe of epistome spatulate with thickened cephalolateral margins; no cephalomedian projection. Antennal scale broadest subdistally; thickened part terminating in large corneous spine.

Mesial margin of palm of right (left is regenerated) chela with primary row of 9 tubercles and secondary row of 8 smaller tubercles on dorsal surface lateral to primary row; distoventral surface of palm with 2 large tubercles at base of dactyl; dorsal surface of palm covered with many small setal tufts. Propodus with lateral base of finger impressed dorsally, less so ventrally; dorsal and ventral surfaces with submedian ridges flanked by setiferous punctations; opposable margin with row of 6 tubercles, fourth from base largest, along proximal half of finger. Dorsal and ventral surfaces of dactyl with median longitudinal ridges flanked by setiferous punctations; opposable margin with row of 4 tubercles, first and fourth from base largest, on proximal half; mesial surface with 2 rows of tubercles on proximal half, one row on distal half. Fingers with distal tubercles small and inconspicuous, terminating in large corneous tips.

Carpus with deep oblique furrow dorsally; mesial surface with one tubercle proximally and large procurved spine near midlength. Dorsodistal surface of left merus with 3 spines (right with 2); ventral surface with 1 large spine laterally and mesial row of 7 tubercles, some corneous, decreasing in size proximally; row terminating on large corneous spine. Ischium with 1 small corneous-tipped tubercle on ventromesial margin.

Hook on ischium of third pereiopod only; hook simple, overreaching basioischial articulation and not opposed by tubercle on basis. First pleopods (see "Diagnosis" for description) barely reaching bases of second pair of pereiopods when abdomen flexed.

Allotypic female: Differing from holotype in following respects: areola constituting 30.9 percent of length of carapace (27.8 mm) and 4.3 times longer than broad. Left chela with mesial surface of palm bearing 8 tubercles in primary and 7 in secondary row (short tertiary row distally). Propodus with opposable margin bearing row of 6 tubercles, third from base largest. Dactyl with opposable margin bearing 8 tubercles, most proximal ones largest. Left merus with 2 spines dorsally; ventral surface with no spine laterally, mesial row of 8 tubercles.

Sternum between third and fourth pereiopods narrowly V-shaped. Postannular

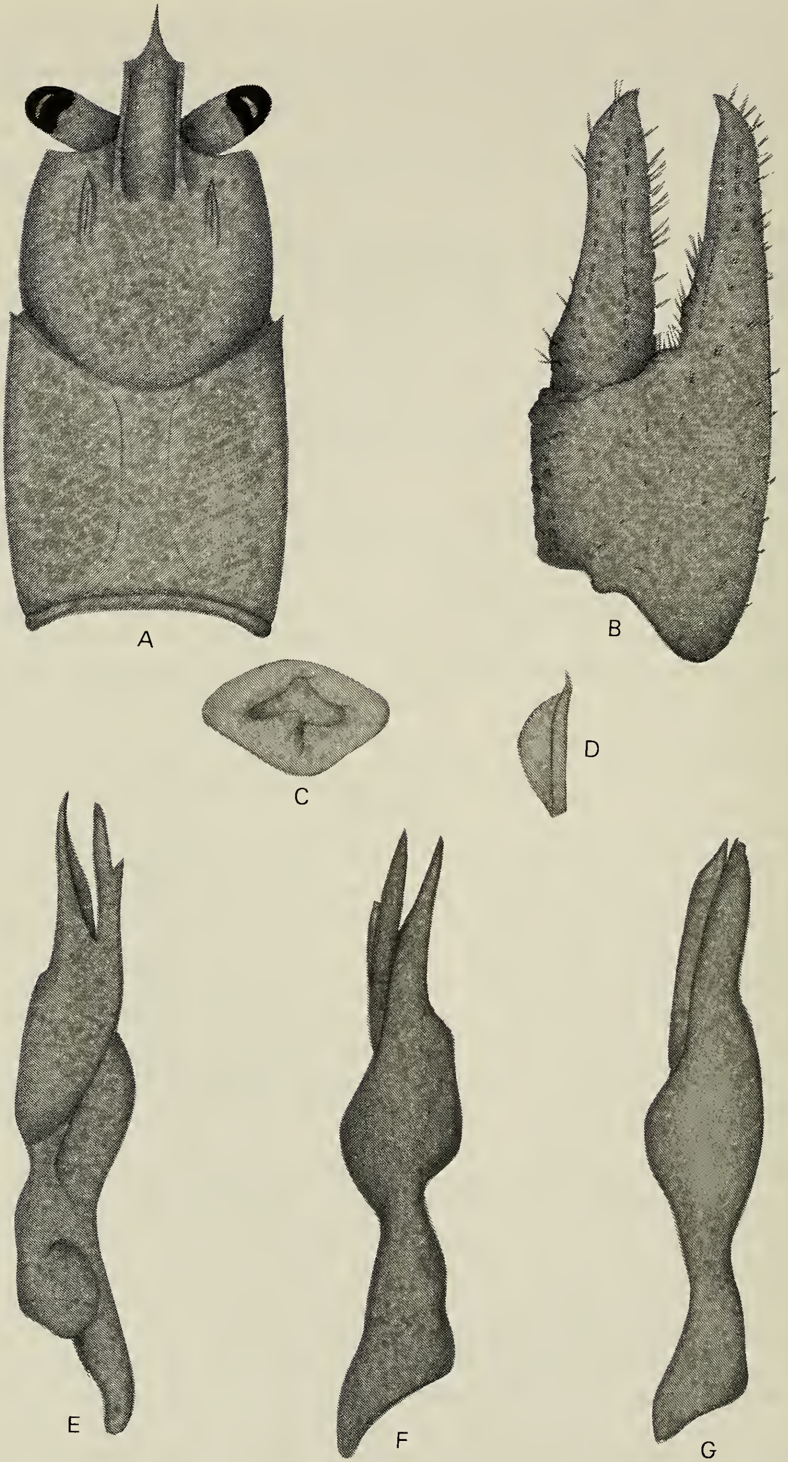

Fig. 1. *Orconectes stannardi*: a, Dorsal view of carapace; b, Dorsal view of chela; c, Annulus ventralis; d, Antennal scale; e, Mesial view of first pleopod of form I male; f, Lateral view of first pleopod of form I male; g, Lateral view of first pleopod of form II male. Drawings are composites based on type-specimens.

Table 1.—Measurements (mm) of *Orconectes stannardi.*

| | Holotype | Allotype | Morphotype |
|---|---|---|---|
| Carapace: | | | |
| Entire length | 28.8 | 27.8 | 32.4 |
| Postorbital length | 21.5 | 20.1 | 24.6 |
| Width | 14.0 | 13.1 | 15.1 |
| Height | 11.1 | 10.4 | 12.6 |
| Areola: | | | |
| Width | 1.8 | 2.0 | 2.1 |
| Length | 9.1 | 8.6 | 10.6 |
| Rostrum: | | | |
| Width | 3.9 | 3.4 | 4.4 |
| Length | 9.3 | 8.7 | 10.4 |
| Chela, left (except Holotype): | | | |
| Length, palm mesial margin | 7.8 | 5.5 | 5.8 |
| Palm width | 10.7 | 7.7 | 8.2 |
| Length, lateral margin | 26.9 | 18.2 | 24.5 |
| Dactyl length | 16.4 | 11.1 | 15.0 |
| Abdomen: | | | |
| Width | 12.4 | 13.5 | 12.8 |
| Length | 31.4 | 28.0 | 30.8 |

sclerite three-fourths as wide as annulus ventralis (described in Diagnosis). First pleopods of female uniramous, barely reaching annulus when abdomen flexed.

Morphotypic male, form II: Differing from holotype in following respects: areola constituting 32.7 percent of length of carapace (32.4 mm) and 5.0 times longer than broad. Mesial surface of palm of left chela with 6 tubercles in primary and 5 in secondary rows; propodus bearing 12 tubercles, second and fourth from base largest, on opposable margin. Dactyl with opposable margin bearing 12 tubercles, second and third from base largest. Merus with one spine dorsally, no spine ventrally, and mesial row of 5 tubercles.

Hook on ischium of third pereiopod much reduced, not overreaching basioischial articulation. First pleopod of uniform texture; both terminal elements straight, noncorneous. Spur of mesial process undeveloped, represented by small acute bulge.

*Size.*—The largest specimen examined is a 32.5 mm-CL form II male. The largest female is 31.9 mm. Form I males (n = 21) range from 15.8 to 28.9 mm CL.

*Color.*—Cephalothorax and abdomen olive-green to light brown and heavily speckled with dark brown dorsally, white ventrally. Side of carapace light green, subtended by darker green stripe. Caudal edge of carapace and first abdominal tergum crossed by dark brown band. Posterior edge of each abdominal tergum with thin red line. Chelae light brown with numerous dark brown specks; each finger with red tip and subdistal black band.

*Type-locality.*—Little Wabash River at Secondary Road 719, 6 km NNW Louisville (T5N, R6E, Sec. 33 SW), Clay County, Illinois. Immediately east of the river and secondary road junction is a large northward bend in the river coming within 10 m of the road; the type-specimens were collected from the east (downstream) side of the bend in a large slab riffle. At normal level the river bed at the riffle is about 5 m wide.

*Disposition of types.* —The holotype, allotype, and 10 paratypes (4 form I males and 6 females) collected with the holotype and allotype on 6 Nov 1983 are deposited at the Illinois Natural History Survey; 11 paratypes (USNM 209119; 5 form I males and 6 females) collected at the same time are deposited at the National Museum of Natural History, Smithsonian Institution. The morphotype and 18 paratypes (1 form I male, 12 form II males, and 5 females) collected at the type-locality with the morphotype on 17 May 1984 are deposited at the Illinois Natural History Survey; 10 paratypes (USNM 209120; all form II males) collected at the same time are deposited at the National Museum of Natural History, Smithsonian Institution.

*Etymology.* —Named in honor of Dr. Lewis J. Stannard, Entomologist Emeritus of the Illinois Natural History Survey, in recognition of his outstanding contributions to the study of Thysanoptera and to the conservation of natural habitats.

*Range and specimens examined.* —*Orconectes stannardi* has been found only in the Little Wabash River system of southeastern Illinois. Recent (since 1973) localities in addition to the type-locality (all Little Wabash River proper) are ½ mi N Louisville, Clay Co.; 1 mi E Clay City, Clay Co.; and 2 mi S Carmi, White Co.

Rietz (1912) and Brown (1955) recorded localities for *O. propinquus* and *O. indianensis* in the Little Wabash River system that almost certainly were based on misidentified *O. stannardi.* A recent survey of the crayfishes of Illinois (Page, in press) suggests that *O. propinquus, O. indianensis* and *O. stannardi* occur allopatrically, and that neither *O. propinquus* nor *O. indianensis* occurs in the Little Wabash River system. Unfortunately, the collections made by Rietz and Brown cannot be located and re-examined.

Although all collections of *O. stannardi* that have been made since 1973 are from the Little Wabash River proper, some of the collections of Rietz (1912) and Brown (1955) were from tributaries. Collections of Rietz (1912) were made in Big Muddy Creek between Richland and Clay counties, and in Skillet Fork at Wayne City, Wayne Co.; the former was identified by Rietz as *O. propinquus* and the latter as *O. indianensis.* Collections cited by Brown (all as *O. propinquus*) but which must have been of *O. stannardi* were made in Dismal Creek, 2¼ mi N Iola, Clay Co.; Salt Creek, 1 mi SE Effingham, Effingham Co.; Blue Point Creek, 2½ mi S Shumway, Effingham Co.; Lost Fork, 1½ mi E Omega, Marion Co.; branch of Little Wabash River, 1¼ mi SW Trowbridge, Shelby Co.; and Little Wabash River, 4 mi NE Shumway, Effingham Co.

*Habitat.* —Most individuals were found in shallow riffles composed of large flat stones. A few were found in deeper water but always in association with stones or accumulations of sticks and other debris. The preference of *O. stannardi* for rocky riffles is typical of the *propinquus* group of *Orconectes,* the members of which typically hide under stones and among debris.

*Life-history notes.* —All five collections of *O. stannardi* presently available (from Nov 1973, Nov 1983, and May 1984) contain form I males, and one (May 1984) contains two ovigerous females. All 20 males collected in November are form I; only one of 25 males collected in May is form I. The two ovigerous females collected in May 1984 were 20.7 mm and 28.9 mm CL, and carried 124 and 184 eggs, respectively. Eggs average 1.9 mm in diameter.

*Relationships.—Orconectes stannardi* appears to be most closely related to *O. propinquus* from which it differs in having, on the first pleopod of the form I male, a caudal spur on the mesial process and a shoulder on the cephalic surface at the base of the central projection; a longer rostrum with margins less converging anteriorly and a less prominent carina; and a narrower areola. *Orconectes stannardi* is endemic, and possibly autochthonous, to the Little Wabash River system. The region drained by the Little Wabash was glaciated during the Illinoian (ca. 100,000 y.b.p.) but not the Wisconsinan (ca. 10,000 y.b.p.) advances, suggesting that the species originated sometime within the past 100,000 years. Fitzpatrick (1967) postulated that some speciation within the *O. propinquus* group was associated with the Wisconsin glaciation.

Recognized members of the *O. propinquus* group, as defined by Fitzpatrick (1967, 1968) and Fitzpatrick and Pickett (1980) are *O. propinquus, O. erichsonianus* (Faxon, 1898), *O. illinoiensis, O. jeffersoni* Rhoades, 1944, *O. sanborni* (Faxon, 1884) (including *O. s. erismorphorous* Hobbs and Fitzpatrick, 1962, *O. obscurus* Hagen, 1870, *O. virginiensis* Hobbs, 1951, *O. iowaensis* Fitzpatrick, 1968, and *O. kinderhookensis* Fitzpatrick and Pickett, 1980. *O. stannardi* can be added to this group, but *O. iowaensis* should be removed.

Fitzpatrick (1967, 1968) described *O. iowaensis* as endemic to Iowa and a sister species to *O. propinquus.* Features distinguishing *O. iowaensis* from *O. propinquus* were stated to be the truncate or spatulate mesial process of the first pleopod of the form I male and the more prominently sculptured annulus ventralis. The mesial process and annulus ventralis of *O. propinquus* were described, respectively, as tapering to an acute tip and being wider than long. *Orconectes iowaensis* was recognized by Hobbs (1972, 1974) and by Phillips and Reis (1979), who extended its known range into southern Minnesota. In his report on the crayfishes of Iowa, Phillips (1980) again recognized *O. iowaensis* but commented on the difficulty of separating *O. iowaensis* from *O. propinquus.*

In studying Illinois crayfishes, I have been obliged to search, in the northwestern part of the state, for populations assignable to *O. iowaensis* and to look for evidence of intergradation between *O. iowaensis* and *O. propinquus.* No population of *O. iowaensis* was found in Illinois and comparisons of Illinois samples of *O. propinquus* and *O. iowaensis* from the Maquoketa and Volga rivers, Iowa (including paratypes USNM 117970 and 117971), reveal that *O. iowaensis* does not differ from Illinois populations of *O. propinquus*; i.e., the mesial process of the first pleopod of form I male is not more truncate or spatulate, and the annulus ventralis is not narrower and more prominently sculptured. Inasmuch as Fitzpatrick (1967) noted the absence of "morphologically distinct geographic races" within *O. propinquus,* Illinois samples can be considered typical of the species. *O. iowaensis* is relegated to the synonymy of *O. propinquus.*

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# NEW RECORDS OF CARIDEAN SHRIMPS IN THE GULF OF CALIFORNIA, MEXICO

Mary K. Wicksten and Michel E. Hendrickx

*Abstract.*—New records are provided for six species of caridean shrimps in the Gulf of California. *Alpheus splendidus* is reported for the first time from the eastern Pacific. *Veleronia laevifrons* and *Periclimenes soror* are noted for the first time from the Gulf of California. The pandalids *Pantomus affinis* and *Heterocarpus vicarius* are reported for the first time from off Sinaloa. *Alpheus websteri* has been taken off San Carlos, Sonora.

Recent collecting in the Gulf of California has resulted in the capture of caridean shrimps not reported there previously, or found outside of their recorded ranges. During a research cruise of the B/O *El Puma* of the Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, two series of specimens of Pandalidae were found off the coast of Sinaloa, on the eastern side of the Gulf of California. Alex Kerstitch, University of Arizona, collected shrimps by SCUBA diving along the coast of Sonora, to the north of Sinaloa. The specimens have been deposited at the Estacion Mazatlán and the Allan Hancock Foundation, University of Southern California.

## Family Palaemonidae

### *Periclimenes soror* Nobili

*Periclimenes soror* Nobili, 1904:232.—Bruce, 1976:299–306, figs. 1–4.—Castro 1982:11. (See Bruce 1976 for an extensive synonymy.)

*Previous records.*—Widespread in the Indo-West Pacific region: Red Sea, Indian Ocean, Australia, Malaysia, tropical Pacific east to Hawaii, Taboga Island, Panama (Bruce 1976); Gorgona Island, Colombia (Castro 1982).

*Material examined.*—SONORA: Bahía San Carlos, 20 m, on sea star *Mithrodia bradleyi* Verrill, 28 Dec 1982, A. Kerstitch, 2 specimens.—Punta Doble, 20 m, under sea stars *M. bradleyi, Oreaster occidentalis* Verrill, *Nidorellia armata* (Gray) and *Astrometis sertulifera* Xantus; 25 Jun 1983, A. Kerstitch, 24 specimens.

*Remarks.*—*Periclimenes soror* previously has been found in association with 16 species of sea stars, including *O. occidentalis, M. bradleyi,* and *N. armata* (Bruce 1976; Castro 1982). This is the first report of *Astrometis sertulifera* as a host of *P. soror.*

In his field notes, Alex Kerstitch reported that "about 75% of the larger sea stars may have 2–4 shrimps apiece" at Punta Doble.

### *Veleronia laevifrons* Holthuis

*Veleronia laevifrons* Holthuis, 1951:199–201, pl. 63, figs. f–m.

*Previous records.*—ECUADOR: off Cabo San Francisco, 4 m.—off La Playa, Bahía Santa Elena, 4–13 m. GALÁPAGOS: Gardner Bay, Isla Española (Hood Island), 7 m (Holthuis 1951).

*Material examined.*—SONORA: Bahía San Carlos, 20 m, among *Parazoanthus* sp., 28 Dec 1982, A. Kerstitch, 1 specimen.—Isla Peruano, 10 m, on gorgonians *Eugorgia aurantica* Verrill and *Muricea californica* Aurivillius, 28 Jun 1983, A. Kerstitch, 27 specimens.—Isla Candolero, near Guaymas, 20 m, on *Parazoanthus* sp., 2 Jan 1984, A. Kerstitch, 17 specimens.

*Remarks.*—Photographs of living animals by A. Kerstitch show the shrimp resting along the main axis of a branch of *E. aurantica,* which they match well in color.

### Family Alpheidae

### *Alpheus websteri* Kingsley

*Alpheus websteri* Kingsley, 1880:416.—Wicksten 1983:42–43. (See Wicksten 1983 for a more extensive synonymy.)

*Previous records.*—Eastern Atlantic, Caribbean, southern Gulf of California to Galápagos (Wicksten 1983).

*Material examined.*—SONORA: Morro Colorado, 10 m, among rocks and *Sargassum* sp., 1 Jan 1984, A. Kerstitch, 1 specimen.

### *Alpheus splendidus* Coutière

*Alpheus splendidus* Coutière, 1897:235.—Banner and Banner 1982:56–60, fig. 12.

*Previous records.*—Red Sea, Seychelles, Indonesia, Malaysia, Thailand, Philippines, and Hong Kong (Banner and Banner 1982).

*Material examined.*—SONORA: San Carlos, 5 m, under rock, 8 Jul 1983, A. Kerstitch, 1 specimen.

*Remarks.*—Alex Kerstitch took a color photograph of the living shrimp. The color pattern matches the description provided in French by Coutière (1897)—a slender bright yellow band from rostrum to the telson, bordered with two brown bands, the rest of the body reddish except for two straight white lines contiguous to the brown bands; pincers light orange.

### Family Pandalidae

### *Pantomus affinis* Chace

*Pantomus affinis* Chace, 1937:116–118, fig. 13.—Wicksten and Méndez 1983:82–85, pl. E, fig. 31.—Wicksten 1983:21.

*Previous records.*—Bahía Santa Inez, Baja California, western side of Gulf of California, Mexico.—Golfo de Dulce, Costa Rica.—southwest of Islas Lobos de Tierra, Perú (Wicksten and Méndez 1983).

*Material examined.*—Off coast of Sinaloa, 25°45′N, 109°34′W, trawled, 91 m, silty bottom, 12 May 1982, B/O *El Puma,* 56 specimens including 2 ovigerous females.

### *Heterocarpus vicarius* Faxon

*Heterocarpus vicarius* Faxon, 1893:203; 1895:148–151, pl. 40, figs. 1–1b.—Chace 1937:118.—Méndez 1981:100–101, pl. 41, figs. 296–299.

*Previous records.*—Isla de San Ildefonso and Punta Gorda, Baja California, Bay of Panama, Pacific coast of Colombia, Perú (Méndez 1981).

*Material examined.*—Off coast of Sinaloa, 24°57′N, 108°41′W, otter trawl, 75 m, sand, 3 May 1982, B/O *El Puma,* 58 specimens.

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# CALANOID COPEPODS (DIAPTOMIDAE) FROM COASTAL LAKES, STATE OF RIO DE JANEIRO, BRAZIL

Janet W. Reid

*Abstract.*—Three species of diaptomid copepods (Calanoida) were collected from the plankton of four coastal lakes, State of Rio de Janeiro, Brazil. *Notodiaptomus iheringi* (Wright) is redescribed based on topotype specimens in the collection of the National Museum of Natural History and on specimens from two of the Rio lakes. The female and male of "*Diaptomus*" *azureus,* new species, and the male of "*D.*" *fluminensis,* new species, are described.

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In the course of a survey of physical, chemical, and faunistic characteristics of lakes and lagoons along the coast of the State of Rio de Janeiro, Brazil (Esteves et al. 1983), samples of zooplankton from 14 lakes were taken by F. A. Esteves in January and September, 1983, and confided to me for determination of species present. Adult diaptomid copepods occurred in samples from 4 lakes. *Notodiaptomus iheringi* (Wright) occurred in Lagoa do Campelo and Lagoa da Saudade; "*Diaptomus*" *azureus,* new species, in Lagoa Comprida; and "*D.*" *fluminensis,* new species, in Lagoa Iodada (Coca-Cola). Wright (1935) supplied only a partial description of *N. iheringi.* The incompleteness of extant descriptions of many species of South American diaptomids is seriously impeding the understanding of interspecific and intergeneric relationships (Brehm 1958; Brandorff 1976). A redescription of this species from specimens collected by Wright from the type-locality and deposited in the collections of the National Museum of Natural History, as well as from the Rio specimens is presented. The female and male of "*D.*" *azureus* and the male of "*D.*" *fluminensis* are described also. Some physical and chemical characteristics of the Rio lakes appear in Table 1 (data supplied by F. A. Esteves).

### *Notodiaptomus iheringi* (Wright)
Figs. 1–28

*Diaptomus iheringi* Wright, 1935:223–226, pl. 1, fig. 4, pl. 2, figs. 3, 5–11.—Wright, 1936:80–81.—Wright, 1938:562.

*Notodiaptomus iheringi.*—Kiefer, 1936:197–198, figs. 3–4.—Cipólli and Carvalho, 1973:97, 98, 101, tab. 2.—Brandorff, 1976:616–617, fig. 2.—Sendacz and Kubo, 1982:69–71, 85–86, figs. 25–29.

*Material examined.*—1 ♀ (National Museum of Natural History—USNM 79542) topotype (after Wright's label, "from the type-locality, Açude Puxinamã, near Campino Grande, State of Parahyba, Brazil"), S. Wright coll.; 3 ♀ and 3 ♂ (USNM 216065), 3 ♀ (Museu de Zoologia da Universidade de São Paulo—MZUSP 6191), 4 ♂ (MZUSP 6192), 4 copepodites (MZUSP 6193), all alcohol-preserved, and 1 ♀, dissected (author's collection), from Lagoa da Saudade, State of Rio de Janeiro,

Table 1.—Physical and chemical characteristics of four lakes inhabited by diaptomid copepods, State of Rio de Janeiro, Brazil (data supplied by F. A. Esteves).

| | Lake | | | | | |
|---|---|---|---|---|---|---|
| | L. do Campelo | | L. da Saudade | L. Comprida | L. Todada (Coca-Cola) | |
| Sampling dates | 01/83 | 09/83 | 01/83 | 01/83 | 01/83 | 09/83 |
| Area (km$^2$) | 9.85 | | 0.79 | 0.11 | 0.12 | |
| Max. depth (m) | 1.5 | | 2.5 | 3.0 | 1.5 | |
| Water color | Clear | | Black | Black | Black | |
| Secchi depth (m) | 1.50 | — | 2.0 | 0.75 | 0.40 | 0.50 |
| pH | 7.45 | 9.0 | 6.6 | 4.4 | 5.3 | 5.6 |
| % sat. $O_2$ | 86 | 110 | 93 | 79 | 70 | 79 |
| Conductivity ($\mu$S cm$^{-1}$) | 440 | 645 | 410 | 530 | 4700 | 4520 |
| Chlorophyll ($\mu$g l$^{-1}$) | 10.42 | 4.10 | 1.20 | 0.67 | — | 8.47 |
| $Ca^{2+}$ (mg l$^{-1}$) | 11.07 | — | 4.68 | 6.30 | 19.43 | — |
| $Na^+$ (mg l$^{-1}$) | 53.8 | — | 57.0 | 85.9 | 561.9 | — |
| $Cl^-$ (mg l$^{-1}$) | 78.0 | — | 94.4 | 123.3 | 997.5 | — |
| $CO_3^{2-}$ (mg l$^{-1}$) | 0.012 | 0.101 | $7.0 \times 10^{-4}$ | — | $1.2 \times 10^{-5}$ | $6.1 \times 10^{-4}$ |
| $NO_3^-$ ($\mu$g l$^{-1}$) | 10.7 | 6.5 | 7.6 | 7.3 | 10.2 | 25.0 |
| $PO_4^-$ ($\mu$g l$^{-1}$) | 0.8 | 5.9 | 0.6 | 0.5 | 1.25 | — |

Brazil, 21°42′S, 41°20′W; 10 ♀ and 10 ♂ (USNM 216066), 10 ♀ (MZUSP 6194), 10 ♂ (MZUSP 6195) and 56 copepodites (MZUSP 6196), 22 ♀ and 14 ♂ (collection of F. A. Esteves), all alcohol-preserved, and 1 ♀ and 1 ♂, dissected (author's collection), from Lagoa do Campelo, State of Rio de Janeiro, 21°40′S, 41°11′W, all collected 28 Jan 1983.

*Description.*—Female: Length (including caudal rami) of Açude Puxinamã specimen 1.11 mm; mean length of 10 Lagoa da Saudade specimens 1.34 mm (range 1.24–1.40 mm); mean length of 10 Lagoa do Campelo specimens 1.23 mm (range 1.16–1.30 mm). Body widest at 1st pediger in dorsal view. Suture between 4th and 5th pedigers complete but faint dorsally. 3rd and 4th pedigers in Rio de Janeiro specimens each with 1 to 3 rows of spinules near posterior border, single row on 4th pediger continuing laterally (Figs. 1–4). 5th pediger produced on each side in small wing, ending in single spine; left wing directed laterally (Fig. 3), right wing dorsally (Fig. 4); inner corner of left wing slightly expanded (Fig. 2).

Urosome of 3 segments, most of 2nd segment covered by genital segment and hardly visible. Genital segment about 1.5× as long as rest of urosome (including caudal rami), slightly expanded anterolaterally, right expansion slightly larger than and anterior to left expansion, each expansion with laterally directed spine. Right posterolateral margin of genital segment slightly produced. Genital segment saddle-shaped in lateral view. Genital opening with conical process on either side (Fig. 5). Inner margins of caudal rami haired (Fig. 2).

Rostral points acute (Fig. 6). 1st antenna reaching well past caudal rami; segments 11 and 13–21 each with 1 seta; complete armature as in Fig. 7.

2nd antenna with normal setation; bases of terminal setae on exopod distinctly separated from segment 7 (Fig. 8). Mandible also with normal setation (Fig. 9); dentition of gnathal lobe in ventral to dorsal order as follows (nomenclature after

Fleminger 1967): apical and subapical teeth pointed. Medial teeth 4 in number, ventralmost a rounded lobe with tiny acute cusp, dorsal 3 medial teeth bicuspidate. Basal teeth 3 in number, ventralmost tooth tricuspidate, 2 dorsalmost teeth slender, bicuspidate (Figs. 13, 14).

Maxillula, maxilla and maxilliped as in Figs. 10–12 respectively; distal lobe at 1st basipod of maxilliped with only 3 setae.

Swimming legs with normal complement of spines and setae; setation of leg 4 identical to leg 3 (Figs. 15–17). Leg 2 with Schmeil's organ on posterior surface of 2nd endopod segment (Figs. 16, 18).

Leg 5 (Figs. 19–22) stout, 1st basal segment with prominent posteroventrally directed process tipped with stout spine. Posterodistal angle of 2nd basal segment produced in rounded process; lateral seta reaches to distal third of 1st exopod segment. 1st exopod segment unarmed, about 2× longer than broad. 2nd exopod segment with short spine lateral to base of 3rd exopod segment, about as long as 3rd segment (Fig. 21); claw stout, curved slightly inwards, middle part of each margin spinulose. 3rd exopod segment distinct from 2nd exopod segment, slightly longer than wide, bearing 2 terminal spines, inner spine about 2.3× longer than outer. Endopod of 1 segment, slightly constricted near base, reaching past midlength of 1st exopod segment, bearing 2 long spines on either side of group of hairs on oblique inner distal margin (Fig. 22).

Male: Mean length (including caudal rami) of 7 Lagoa da Saudade specimens 1.16 mm (range 1.14–1.18 mm); mean length of 10 Lagoa do Campelo specimens 1.06 mm (range 1.02–1.12 mm). Body widest at 2nd pediger in dorsal view. Suture between 4th and 5th pedigers complete but faint; posterior border of 4th pediger with row of spinules on each side. Each side of 5th pediger produced into posteriorly directed wings, each tipped with spine; left spine directed posteriorly, right spine directed obliquely outward. Urosome of 5 segments, curved slightly to right in most preserved specimens. Genital segment asymmetrical, right side expanded posteriorly over next urosomal segment. Inner margins of caudal rami haired (Fig. 23).

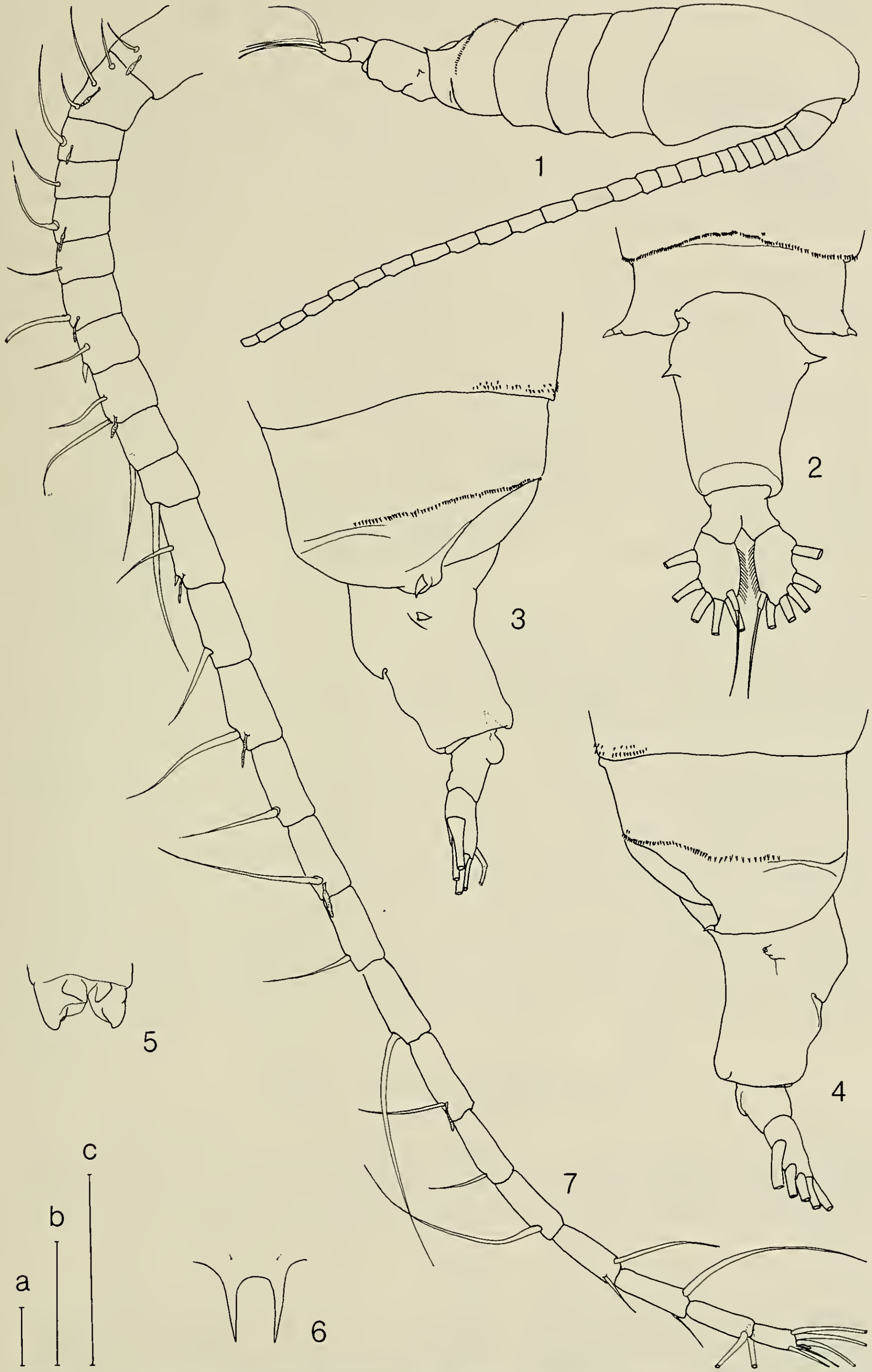
Right 1st antenna with socketed spines on segments 8 and 12; spines on segments 10, 11, 13, 15, and 16 without basal articulation (Fig. 24). Spines on segments 10 and 11 of equal length, parallel to axis of antenna; spine on segment 10 overlapping base of spine on segment 11. Spine on segment 13 large, with notched tip. Spine on segment 16 very small. Antepenultimate segment with narrow hyaline membrane (Fig. 25). Armature of left 1st antenna identical to that of female.

Structure and armature of 2nd antenna, maxillula, maxilla and maxilliped as in female. Dentition of gnathal lobe of mandible similar to female except dorsal 3 medial teeth and middle basal tooth each with additional tiny cusp on ventral surface (Fig. 26).

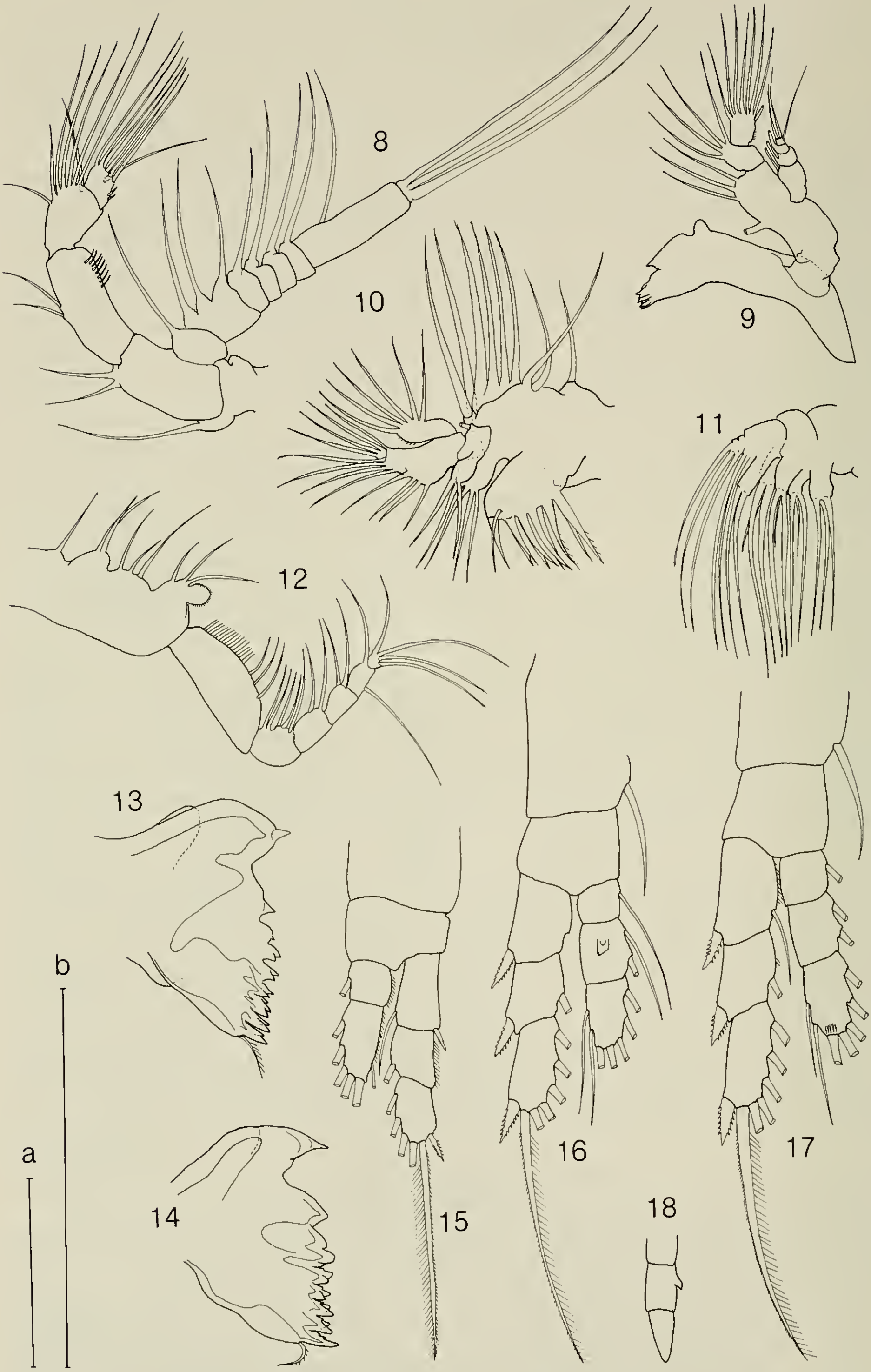
Structure and armature of swimming legs as in female.

5th legs agree in essential details with the descriptions of Wright (1935) and of Sendacz and Kubo (1982). Exopod of left leg 5 with widely separated proximal and distal hairy pads covered posteriorly by hyaline membrane extending to tip of wide, serrated distal process. Proximal pad in Lagoa do Campelo and Lagoa da Saudade specimens undivided. Spinous proximal process extending slightly beyond distal process (Figs. 27, 28).

*Remarks.*—Wright reported the mean length of 20 females to be 1.18 mm, with a range of 1.11–1.27 mm, and the mean length of 20 males to be 1.03 mm, with



Figs. 1–7. *Notodiaptomus iheringi,* female from Lagoa do Campelo: 1, Habitus, lateral; 2, Urosome, dorsal; 3, Urosome, left lateral; 4, Urosome, right lateral; 5, Genital area, ventral; 6, Rostrum, ventral; 7, 1st antenna. Scale a, Fig. 1; Scale b, Figs. 2–4, 7; Scale c, Figs. 5, 6; each scale = 100 μm.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a range of 0.97–1.11 mm; thus the Rio specimens are within these ranges or slightly larger.

Female specimens from Rio lakes differ from Wright's in several details: distal border of 4th pediger not dorsally elevated in some specimens; distal border of 3rd as well as 4th pediger with fine spinules; 1st antennae slightly longer (in Wright's specimens these reached to the end of the caudal rami); spinous process on basipod segment 1 of leg 5 stouter and exopod segment 1 somewhat broader; and urosome segment 2 never large, a feature which occurred "rarely" in Wright's specimens.

The spination of the right 1st antenna of the male agrees with Wright's verbal description. A few of Wright's specimens bore a short curved spur on the antepenultimate segment of the right 1st antenna; no Rio males bore such a spur. Sendacz and Kubo (1982) showed a divided proximal hairy pad of exopod of left 5th leg in specimens from São Paulo. Neither Wright (1935) nor Sendacz and Kubo (1982) noted the serration of the distal process of the exopod of left leg 5.

The dentition of the gnathal lobe in the dissected female from the type-locality (Fig. 14) differs in several respects from that of the Rio specimens, having the subapical tooth very broad and blunt, the cusps of the medial and basal teeth more rounded, and the notch between the apical and subapical teeth somewhat deeper.

*Ecology.*—*Notodiaptomus iheringi* was recorded by Wright (1935) from reservoirs, lakes and ponds in the States of Paraíba and Pernambuco; the type-locality is an açude (reservoir). Cipólli and Carvalho (1973) encountered the species in lakes near the Guamá and Capim Rivers and in the main stream and small side branches of the Tocantins River, State of Pará. Sendacz and Kubo (1982) recorded it from two reservoirs in the drainage basin of the Paraíba do Sul River, State of São Paulo. These reservoirs were warm (median temperature 23.3°C), with high concentrations of nutrients and chlorophyll (median 40.1 mg·$l^{-1}$), and water of high transparency. In Pará, this species occurred only in white and clear waters, but never in black (high in humic acids). Lagoas do Campelo and da Saudade resemble each other in being relatively transparent, of moderate conductivity, with pH close to neutral. *Notodiaptomus iheringi* appears to have a much broader ecological range than postulated by Wright (1935), who found it only in the arid interior of the Brazilian northeast, and in none of the coastal lakes in that area.

### "*Diaptomus*" *azureus*, new species
Figs. 29–59

*Material examined.*—1 ♀, holotype (MZUSP 6197) and 1 ♂ paratype (MZUSP 6198), dissected on slides; 4 ♀ (MZUSP 6199), 10 ♂ (MZUSP 6200) and 140 copepodites (MZUSP 6201), alcohol-preserved; 4 ♀ and 10 ♂ (USNM 216067),

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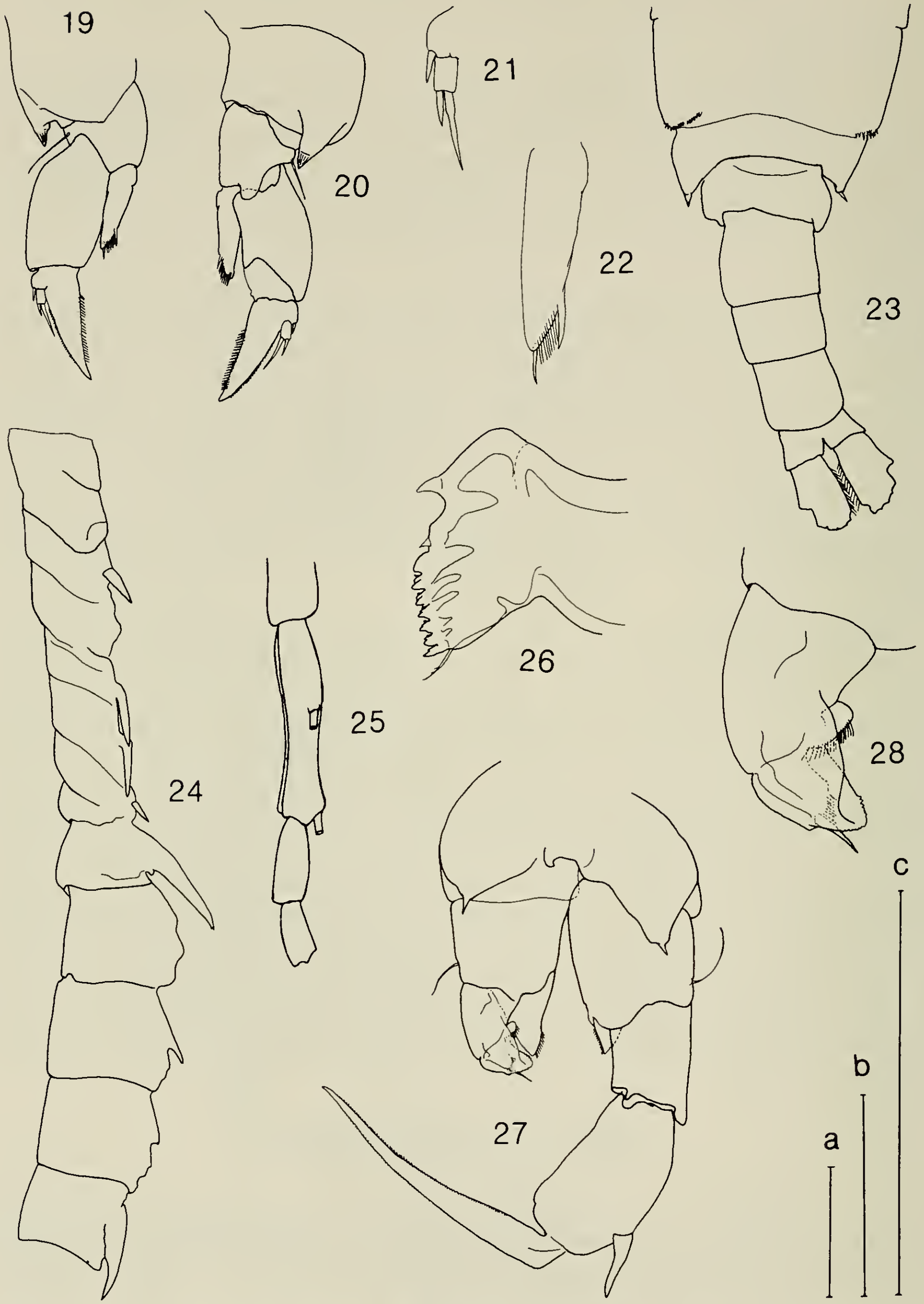
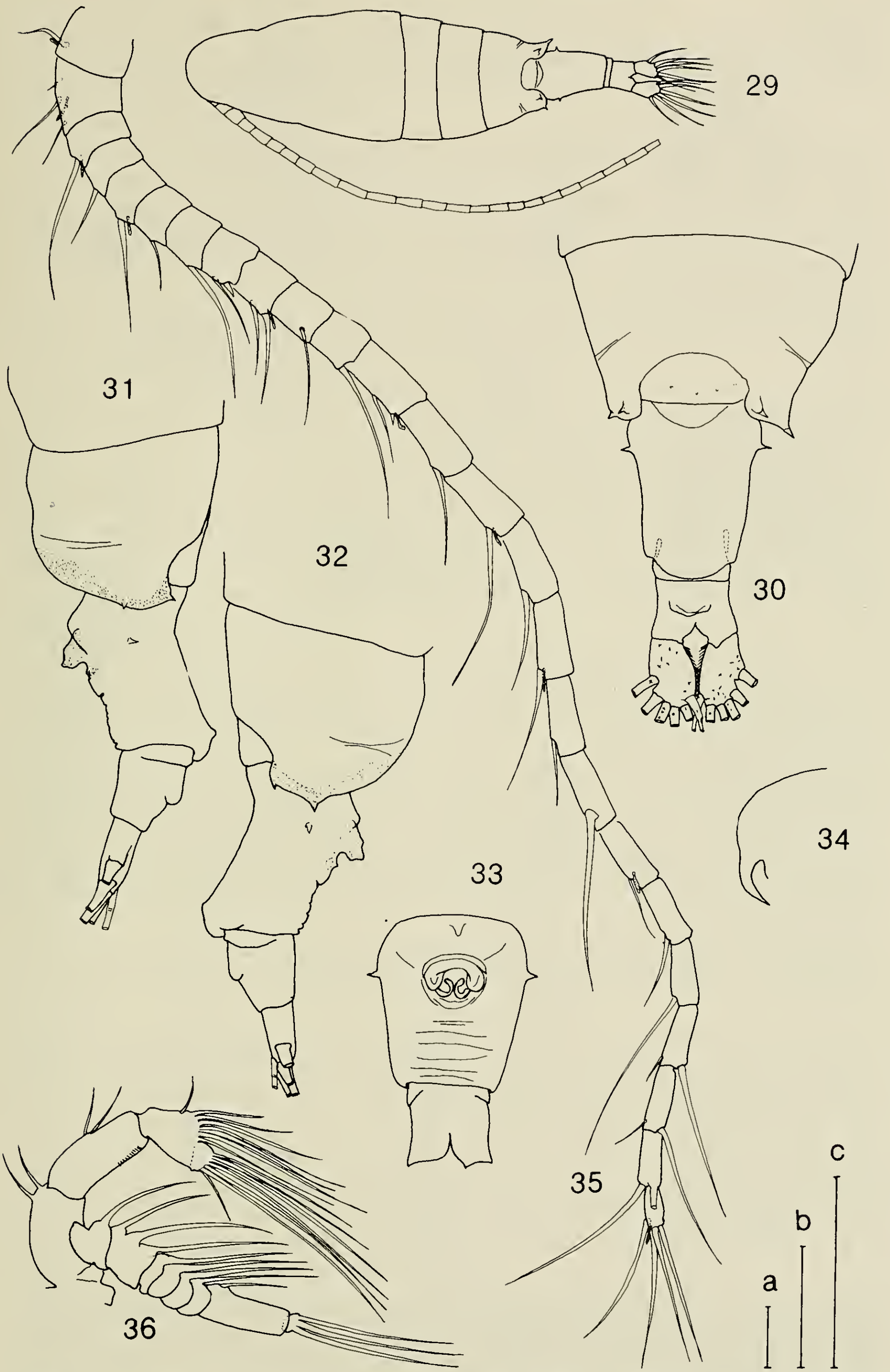
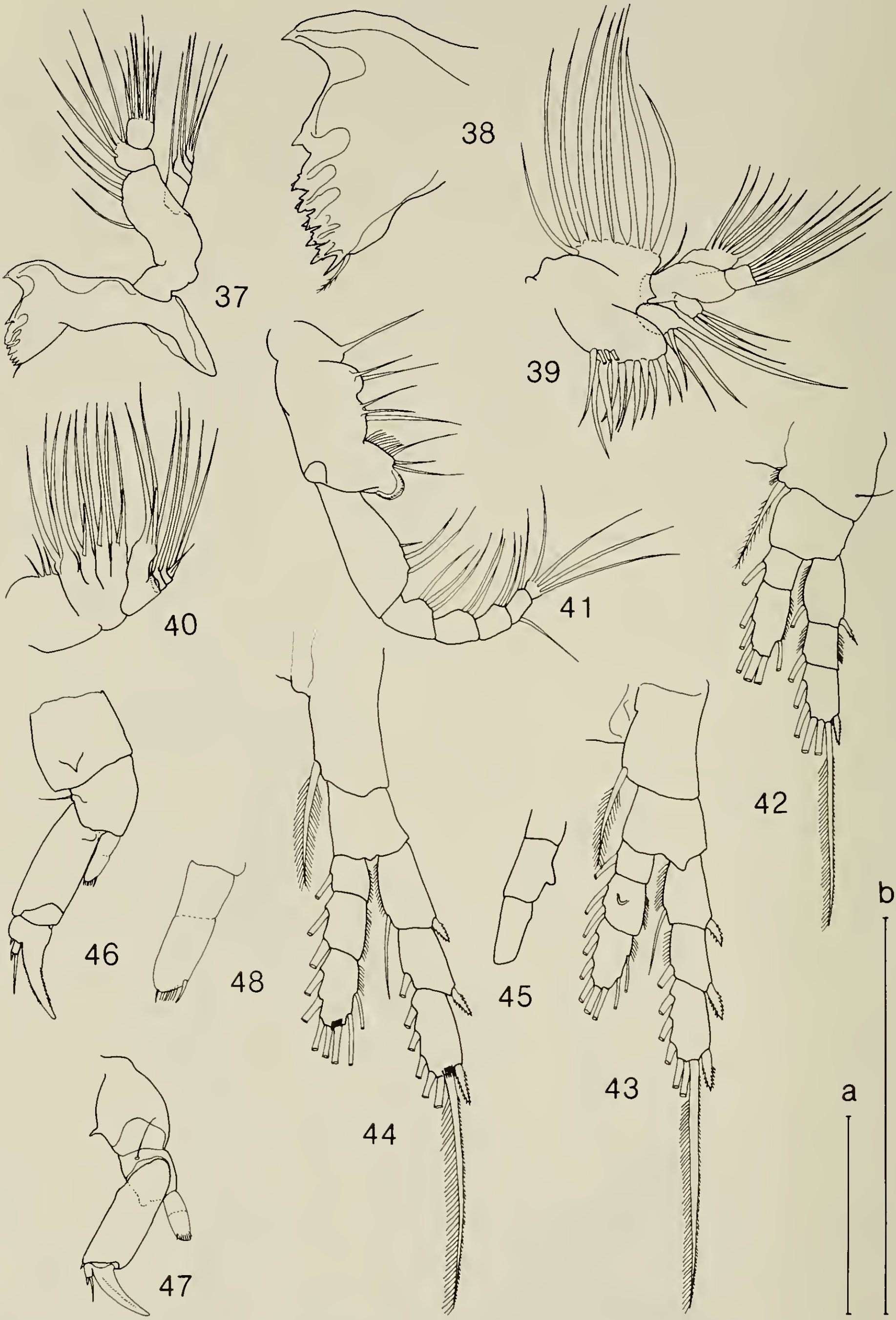
Figs. 8–18. *Notodiaptomus iheringi*: 8–13, 15–18, female from Lagoa do Campelo: 8, 2nd antenna; 9, Mandible; 10, Maxillula; 11, Maxilla; 12, Maxilliped; 13, Mandible, gnathal lobe; 14, Mandible, gnathal lobe, female from Açude Puxinamã; 15, Leg 1, anterior; 16, Leg 2, posterior; 17, Leg 4, posterior; 18, Leg 2 endopod, lateral. Scale a, Figs. 8–12, 15–18; Scale b, Figs. 13, 14; each scale = 100 μm.



Figs. 19–28. *Notodiaptomus iheringi*: 19–22, female from Lagoa do Campelo: 19, Right leg 5, anterior; 20, Right leg 5, posterior; 21, Leg 5, exopod segment 3; 22, Leg 5, endopod. 23–28, Male from Lagoa do Campelo: 23, Urosome, dorsal; 24, Right 1st antenna, segments 7–17; 25, Right 1st antenna, segments 23–25; 26, Mandible, gnathal lobe; 27, Legs 5, posterior; 28, Left leg 5 exopod, posterior. Scale a, Fig. 23; Scale b, Figs. 19, 20, 24, 25, 27; Scale c, Figs. 21, 22, 26, 28; each scale = 100 $\mu$m.



Figs. 29–36. "*Diaptomus*" *azureus*, female: 29, Habitus, dorsal; 30, Urosome, dorsal; 31, Urosome, left lateral; 32, Urosome, right lateral; 33, Urosome, ventral; 34, Rostrum, lateral; 35, 1st antenna; 36, 2nd antenna. Scale a, Fig. 29; Scale b, Figs. 30–33, 35; Scale c, Figs. 34, 36; each scale = 100 μm.



Figs. 37–48. "*Diaptomus*" *azureus,* female: 37, Mandible; 38, Mandible, gnathal lobe; 39, Maxillula; 40, Maxilla; 41, Maxilliped; 42, Leg 1, anterior; 43, Leg 2, posterior; 44, Leg 3, posterior; 45, Leg 2 endopod, lateral; 46, Left leg 5, posterior; 47, Right leg 5, lateral-oblique; 48, Leg 5, endopod. Scale a, Figs. 37, 39–47; Scale b, Figs. 38, 48; each scale = 100 μm.

alcohol-preserved; 3 ♀ and 11 ♂, collection of F. A. Esteves, alcohol-preserved; 10 ♂, alcohol-preserved, and 1 ♀ and 1 ♂, dissected on slides, author's collection; all paratypes; all from Lagoa Comprida, State of Rio de Janeiro, 21°17′S, 41°39′W, collected 26 Jan 1983.

*Description.*—Female: Mean length (including caudal rami) of 10 specimens 1.06 mm (range 1.0–1.15 mm). Body widest at 1st pediger in dorsal view. Suture between cephalic segment and 1st pediger indistinct dorsally; 4th and 5th pedigers fused dorsally, separated laterally by indistinct suture. 5th pediger produced posterolaterally into asymmetrical wings: left wing small, rounded, ending in small dorsally directed spine and bearing second smaller spine on posterolateral margin; right wing larger, directed latero-obliquely, ending in stout spine and bearing smaller spine on posterodorsal margin (Figs. 29–32).

Urosome 3-segmented, 2nd segment partly telescoped into and covered dorsally by genital segment, appearing fused with 3rd segment ventrally. Genital segment about 1.2× as long as rest of urosome, asymmetrically expanded anteriorly with left side slightly more expanded than right, each expansion bearing a laterally directed spine slightly posterior to broadest part of segment. Posterodorsal margin of genital segment produced. This segment slightly saddle-shaped dorsally, ventral surface rugose posterior to genital opening; area of genital opening produced ventrally, with rounded process on each side of opening (Figs. 30–33). Inner margins of caudal rami haired.

Rostral points acute (Fig. 34). 1st antenna reaching well past caudal rami; segments 11 and 13–21 each with 1 seta; complete armature as in Fig. 35.

2nd antenna with normal setation, terminal setae on exopod distinctly separated from segment 7 (Fig. 36). Mandible as in Fig. 37; dentition of gnathal lobe as follows: apical and subapical teeth pointed; medial teeth 3 in number, each with 2 principal cusps and 1 small ventral cusp; basal teeth 3 in number, ventralmost 2 each with 2 principal cusps and 1 ventral and 1 dorsal smaller cusp; dorsalmost basal tooth slender, with margin smooth (Fig. 38). Maxillula, maxilla and maxilliped as in Figs. 39–41 respectively; distal lobe of 1st basipod of maxilliped with 3 setae.

Segmentation and armature of swimming legs 1–4 normal for genus, leg 4 identical to leg 3; Schmeil's organ present on 2nd endopod segment of leg 2 (Figs. 42–45).

Leg 5, posterior surface of 1st basipod with small spinous process. 2nd basipod with short lateral seta; posterodistal margin slightly produced. 1st exopod segment about 2.5× longer than wide. 2nd exopod segment with spine on distolateral corner reaching to midlength of 3rd exopod segment; claw curved slightly inward, each margin finely toothed. 3rd exopod segment distinct from 2nd exopod segment, slightly longer than wide, inner terminal seta about 5× longer than outer terminal seta. Endopod indistinctly 2-segmented, reaching to midlength of inner margin of 1st exopod segment, bearing 2 short spines and group of fine hairs on rounded oblique distal margin (Figs. 46–48).

Male: Mean length (including caudal rami) of 10 specimens, 0.93 mm (range 0.90–0.96 mm). Body widest at 2nd pediger. Suture between 4th and 5th pediger complete. 5th pediger produced into small obliquely directed wings each ending in small spine; right wing slightly larger. Genital segment asymmetrical, right side slightly extended posteriorly. Inner margins of caudal rami haired (Figs. 49–51).

Rostral points acute (Fig. 52). Right 1st antenna with socketed spines on segments 8 and 12; spine on segment 10 about two-thirds length of spine on segment 11, these spines parallel to each other and directed obliquely outwards from axis of antenna. Spine on segment 13 large, acute, reaching midlength of segment 14. Spine on segment 15 slightly longer than spine on segment 16. Antepenultimate segment with smooth hyaline membrane (Figs. 53, 54).

2nd antenna and mouthparts similar to those of female. Medial and basal teeth of mandibular gnathal lobe slightly blunter than in female, with at most 1 secondary small cusp; dorsalmost basal tooth serrate (Fig. 55). Segmentation and armature of swimming legs as in female.

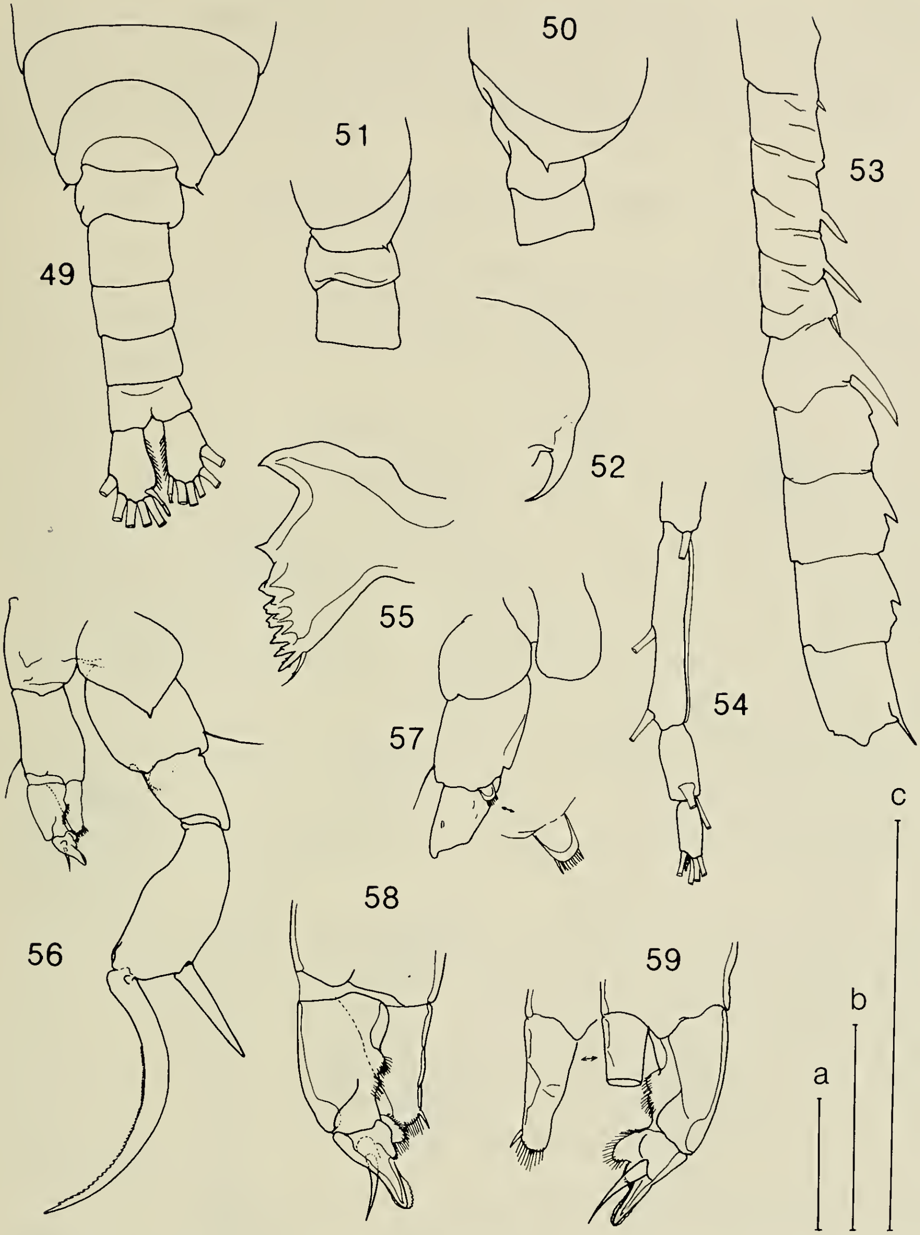
Right leg 5, 1st basal segment with posterior expansion ending in short spine. 2nd basal segment almost as broad as long; outer margin with seta at distal quarter; inner margin convex, smooth. Exopod, excluding claw, nearly twice as long as basipod; 1st segment about 1.3 × longer than broad, distolateral corner produced. 2nd exopod segment broadest at midlength, 2.5 × longer than 1st segment; strong, smooth lateral spine at distal quarter of outer margin, extending almost at right angle to axis of segment and about 1.3 × longer than greatest width of segment. Terminal claw slightly longer than exopod, evenly curved, teeth of inner margin increasing in size distally. Endopod short, located on inner posterodistal margin of and distinct from 2nd basal segment; slightly longer than broad and bearing fine hairs on distal margin (Figs. 56, 57).

Left leg 5 (Figs. 56, 58, 59) reaching proximal third of 2nd exopod of right leg. 1st basal segment slightly longer than wide, with small conical process on posterior surface. 2nd basal segment about 1.5 × longer than broad, broadest just beyond midpoint, with seta at distal quarter of outer margin. Proximal and distal hairy pads of exopod separate, proximal pad incompletely divided with proximal part slightly more expanded. Proximal expansion of distal pad with numerous fine hairs, separated by sinus from distal part which bears short spinules. Distal process about as long as 2nd exopod segment, with serrate hyaline flange on each side. Proximal process slender, acute, distinct from 2nd exopod segment, slightly longer than distal process. Endopod of 1 segment, conical, reaching midlength of 2nd exopod segment, with fine hairs and 1 spine on rounded distal margin.

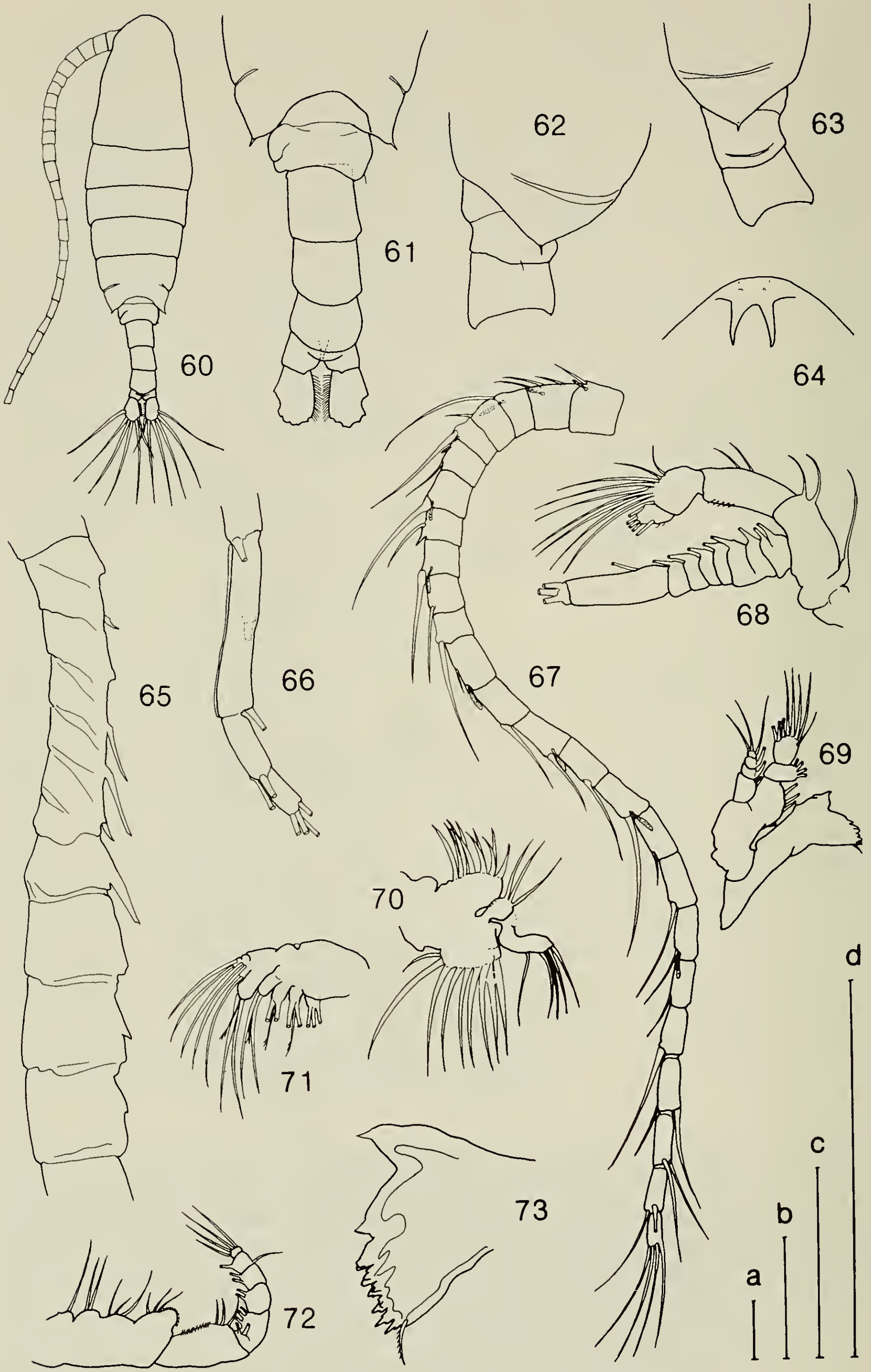
Color of formalin-preserved female and male specimens light tan with rostral area, margins of pedigers and thoracic wings, caudal rami and setae, 1st antennae, maxillipeds, swimming legs and area of genital opening colored dark blue (Figs. 31, 32). Some color persists in alcohol preservation with chromatophores in caudal rami and caudal setae remaining visible (Fig. 30).

*Etymology.*—The specific epithet *azureus* is derived from the Old French "azur," blue.

*Remarks.*—"*Diaptomus*" *azureus* resembles members of the genus *Notodiaptomus* in several respects, but differs in having the spines of segments 10 and 11 of the right antenna of the male angled outwards rather than parallel to the axis of the antenna; and in several details of the right leg 5 of the male, primarily the lack of a pointed process on the anterior surface of the 2st exopod segment; the blunt, not conical endopod; and the lack of a prominence on the inner border of the 2nd exopod segment. The left exopod of the left leg 5 of the male also differs from those of *Notodiaptomus* spp. in the structure of the distal pad and in having the proximal process extending past the distal process.



Figs. 49–59. "*Diaptomus*" *azureus,* male: 49, Urosome, dorsal; 50, Anterior urosome, right lateral; 51, Anterior urosome, left lateral; 52, Rostrum, lateral; 53, Right 1st antenna, segments 8–17; 54, Right 1st antenna, segments 23–25; 55, Mandible, gnathal lobe; 56, Legs 5, posterior; 57, Right leg 5, basipod and expanded view of endopod, anterior; 58, Left leg 5, exopod and endopod, posterior; 59, Left leg 5, exopod and endopod, anterior. Scale a, Figs. 49–51; Scale b, Figs. 52–54, 56, 57; Scale c, Figs. 55, 58, 59; each scale = 100 $\mu$m.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Since "*D.*" *azureus* closely resembles no other presently known South American diaptomid, it is provisionally assigned to "*Diaptomus*" sensu lato. It is distinguishable from all other species by details of the structure of the right 1st antenna and 5th legs of the male, and of the thoracic wings, urosome and 5th legs of the female.

### "*Diaptomus*" *fluminensis*, new species
Figs. 60–82

*Material examined.*—1 ♂, holotype (MZUSP 6202), dissected on slides; 1 ♂ (MZUSP 6203) and 2 Stage V copepodites (MZUSP 6204), alcohol-preserved; and 1 ♂, collection of F. A. Esteves, dissected on slides; all paratypes; all from Lagoa Iodada (Coca-Cola), State of Rio de Janeiro, 22°27′S, 41°51′W, collected 14 Sep 1983.

*Description.*—Male: Length (including caudal rami) of type-specimen 1.02 mm; length of adult paratypes 0.94 mm and 0.96 mm. Body widest at 1st pediger (Fig. 60). Suture between 4th and 5th pedigers incomplete dorsally. 5th pediger slightly elevated dorsally, produced laterally into short wings, each ending in elongate, obliquely directed spine, left wing slightly larger than right. Genital segment asymmetrical, right side produced over succeeding segment and bearing small posteriorly directed spine. Right margins of succeeding urosomal segments also slightly produced posteriorly. Inner margins of caudal rami haired (Figs. 60–63).

Rostral points acute (Fig. 64). Right 1st antenna with socketed spines on segments 8 and 12. Spines on segments 10 and 11 slender, subparallel to axis of antenna, each reaching past insertion of succeeding spine; spine on segment 11 with notched tip. Spine on segment 13 slightly stouter, subparallel to axis of antenna, reaching nearly to midlength of segment 14, with notched tip. Spine on segment 16 very small. Antepenultimate segment with narrow hyaline membrane (Figs. 65, 66).

Left 1st antenna with armature as in Fig. 67; segments 11 and 13–21 each with 1 seta. 2nd antenna, mandible, maxillula and maxilliped appear to have normal setation for genus (Figs. 68–72 respectively), though maxillula was broken during dissection. Terminal setae on exopod of 2nd antenna distinctly separated from segment 7. Gnathal lobe of mandible with following dentition: apical tooth pointed, subapical tooth blunt; ventralmost medial tooth bicuspidate, dorsal 2 medial teeth more acute, each with additional minor cusp; 3 basal teeth increasingly acute dorsally, each with 1 major and 2 minor cusps. Notch between apical and subapical teeth deep (Fig. 73).

Structure and armature of swimming legs normal for genus; leg 2 with Schmeil's organ on posterior surface of 2nd endopod segment. Setation of leg 4 identical to that of leg 3 (Figs. 74–77).

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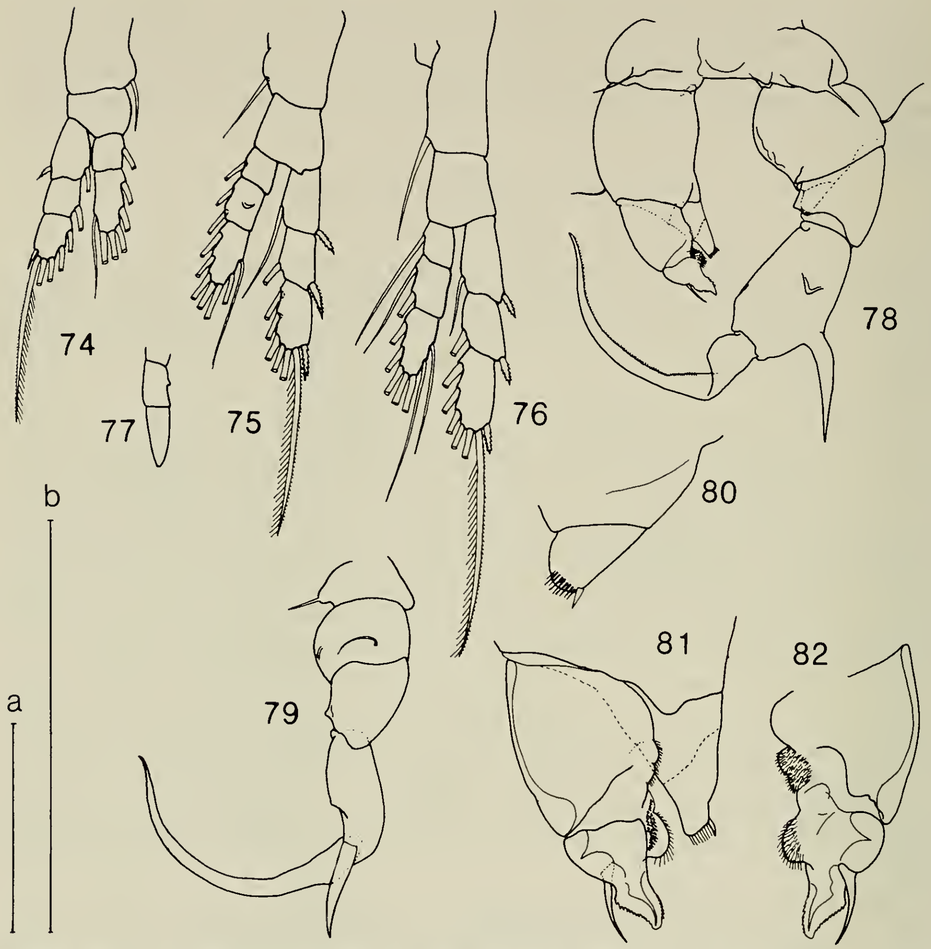
Figs. 60–73. "*Diaptomus*" *fluminensis*, male: 60, Habitus, dorsal; 61, Urosome, dorsal; 62, Anterior urosome, right lateral; 63, Anterior urosome, left lateral; 64, Rostrum, ventral; 65, Right 1st antenna, segments 7–16; 66, Right 1st antenna, segments 23–25; 67, Left 1st antenna; 68, 2nd antenna; 69, Mandible; 70, Maxillula (broken); 71, Maxilla; 72, Maxilliped; 73, Mandible, gnathal lobe. Scale a, Fig. 60; Scale b, Figs. 61–63, 67; Scale c, Figs. 64–66, 68–72; Scale d, Fig. 73; each scale = 100 μm.



Figs. 74–82. "*Diaptomus*" *fluminensis,* male: 74, Leg 1, anterior; 75, Leg 2, posterior; 76, Leg 3, anterior; 77, Leg 2 endopod, lateral; 78, Legs 5, posterior; 79, Right leg 5, lateral; 80, Right leg 5, endopod; 81, Left leg 5, exopod and endopod, posterior; 82, Left leg 5, exopod, anterior. Scale a, Figs. 74–79; Scale b, Figs. 80–82; each scale = 100 μm.

5th legs (Figs. 78–82) stout, 1st basipods broader than long, each with posterior conical projection ending in posterolaterally directed spine, right projection and spine larger than left. Right 2nd basipod also stout, broader than long, inner margin convex with several posteromedial cuticular thickenings, outer margin with short seta at distal third, anterodistal margin produced. Right exopod about 1.5× length of basipod, 1st exopod segment slightly longer than broad, outer margin about twice as long as inner margin, outer and inner distal corners produced. 2nd exopod segment broadest at distal quarter, slightly less than twice as long as broad, with cuticular thickenings on inner proximal corner, distal quarter of inner margin, and posterior surface. Smooth lateral spine at distal third of outer margin, bent slightly at proximal quarter. Terminal claw slightly longer than exopod, directed posterodorsally, recurved at tip, inner margin finely serrate. Endopod broadly triangular, of 1 segment, inserted on produced anterodistal margin of 2nd basal segment, reaching almost to mediodistal corner of 1st exopod segment, bearing subterminal row of fine hairs and 1 stout claw on outer margin.

Left 2nd basipod segment slightly longer than broad, both margins slightly convex, inner proximal corner produced into rounded knob, short seta proximal to outer distal corner. Left endopod broadly triangular, weakly 2-segmented with suture most apparent on anterior surface, reaching midlength of distal pad of left exopod; blunt tip with terminal group of fine hairs and 1 spine on mediodistal corner. Both segments of left exopod distinctly separated, pad on posterodistal corner of 1st exopod segment partly divided, haired on anterior surface. 2nd exopod segment, inner margin with crescentic pad set with spinules and anterodistal rounded pad with many long hairs on anterior surface. Distal process continuous with 2nd exopod segment, broadly triangular with tip recurved outwards, margins serrate. Slender proximal process about as long as and inserted slightly anterior to distal process.

Color of formalin-preserved specimens light tan.

*Etymology.*—The specific epithet is derived from the Brazilian term "fluminense," a native of the State of Rio de Janeiro.

*Remarks.*—Though many characters of "*D.*" *fluminensis* agree with those of the rather loosely defined genus *Notodiaptomus,* several details of the 5th legs such as the shape of the right 1st exopod, the 2-segmented left endopod and the placement of the proximal process of the left exopod preclude its inclusion in this genus. Principal differences from other species include the details of the spination of the right 1st antenna and the form of the distal process of the exopod of the left 5th leg. It is provisionally assigned to "*Diaptomus*" sensu lato.

## Discussion

As M. S. Wilson (1951) pointed out, knowledge of the structure and armature of mouthparts, particularly the maxilliped, the 1st and 2nd swimming legs, the armature of the 1st antennae of the female and of the left 1st antenna of the male is necessary for satisfactory comparison of species or genera of diaptomid copepods. Unfortunately these features have been described for only a few South American diaptomids. Lack of comprehensive knowledge of the morphology of most species has contributed to the present confusion in which about 20 species have not been assigned to genera (or subgenera), remaining in "*Diaptomus*" sensu lato (Brandorff 1976). Nor has it been possible to construct a complete key to the identification of all species (Brehm 1958).

Therefore I have included descriptions of mouthparts and other characters of uncertain taxonomic utility. For instance, the extent to which details of the dentition of the mandibular gnathal lobe may vary with sex, age or genetic differences has not been investigated. The dentition of the lobe in *N. iheringi* differs from *N. cearensis* as redescribed by Bowman (1973) in having the cusp of the ventralmost medial tooth produced in a separate acute tooth; the margin ventral to the subapical tooth produced into a distinct lobe; and most teeth tricuspidate rather than bicuspidate as in *N. cearensis.* The setation of the 1st basipod of the maxilliped is similar in both species.

Wilson (1951) noted that Schmeil's organ (Schmeil 1896) is lacking in both sexes of *Nordodiaptomus alaskaensis* and in females of *Nordodiaptomus siberiensis,* but is present in males of the latter species. This organ, of unknown function, occurs in both sexes of *Notodiaptomus venezolanus deeveyorum* Bowman (1973), *N. cearensis* as redescribed by Bowman (1973), and *Pectenodiaptomus caperatus* (Bowman, 1979), as well as in the three species described here.

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# NEW SUBSPECIES OF THICK-BILLED VIREO (AVES: VIREONIDAE) FROM THE CAICOS ISLANDS, WITH REMARKS ON TAXONOMIC STATUS OF OTHER POPULATIONS

Donald W. Buden

*Abstract.*—*Vireo crassirostris stalagmium* is described as a new subspecies from the Caicos Islands (southern Bahamas) and is compared with all other subspecies of *V. crassirostris.* The name *Vireo crassirostris alleni* Cory is resurrected for the Cayman Islands population.

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The Thick-billed Vireo (*Vireo crassirostris*) is a common resident in scrublands and xeric to mesic woodlands throughout most of the Bahamas, though apparently absent from the Turks Bank at the extreme southeastern end of the archipelago. This species is present elsewhere in similar habitats on Ile de la Tortue (off the northern coast of Haiti), on Grand Cayman, Little Cayman, and Cayman Brac (islands approximately equidistant from Cuba and Jamaica), and on Old Providence Island (=Providencia), including Santa Catalina Island (in the southwestern Caribbean)—the Little Cayman population may be recently extirpated (Diamond 1980). *Vireo crassirostris* has been recorded casually in Florida (American Ornithologists' Union 1983), presumably vagrant from the Bahamas.

Bond (1956) and Blake (1968) recognized three subspecies: *Vireo crassirostris crassirostris* (Bryant) in the Bahamas and the Cayman Islands, *V. c. tortugae* Richmond on Tortue, and *V. c. approximans* Ridgway on Old Providence. According to Bond (1965) *approximans* differs from the other subspecies mainly in voice; also, the mandible tends to be paler (more yellow) in the specimens from Old Providence. Chromatically, *V. c. tortugae* is the most distinctive subspecies. Specimens from Tortue are darker (more brown or buff) on the venter than are those from elsewhere in the range, though one or two (of nearly 200 examined) from the Bahamas approach this condition. Morphological variation among Bahaman and Cayman populations is more complex.

Cory (1886) described *Vireo alleni* as a new species based on material collected on Grand Cayman. In 1887, Ridgway proposed the name *Vireo crassirostris flavescens* for relatively bright yellow examples of Thick-billed Vireos in the Bahamas that he found exclusively on Rum Cay and Conception Island. He reported (Ridgway 1887, 1904) that *flavescens* and the nominate form both occurred together on Eleuthera, Cat Island, Green Cay, and Inagua. Cory (1892) treated *V. c. flavescens* as a synonym of *V. c. alleni* giving the range of the latter as Grand Cayman and Cayman Brac and the following Bahama Islands: Berry Islands, Bimini Islands, Eleuthera, Rum Cay, Conception Island, Mayaguana, Inagua.

Todd and Worthington (1911) reported that specimens of *V. crassirostris* in the southern Bahamas are more yellow ventrally than are those from the northern islands, and that geographically intermediate samples include "puzzling series of intergrades . . . as well as typical examples of each form occurring well within the area of predominance of the other." They treated *V. c. flavescens* as a synonym of *V. c. crassirostris,* but retained the name *V. alleni,* at least tentatively, for the Cayman population. Bangs (1916) followed Todd and Worthington (1911) in regarding *V. c. flavescens* as a synonym of *V. c. crassirostris* and included the Cayman Islands within the range of this subspecies stating that characters supposedly distinguishing *alleni* from *crassirostris* (browner back, shorter outer primary, broader wing bars) all prove illusive.

I have examined new material from the Bahamas together with other samples from throughout the range of this species; mensural data are given in Table 1. All measurements are in millimeters. Wings were measured flattened against a ruler and the comparisons involving wing and tail measurements (for all samples) are limited to specimens collected in the months January through April.

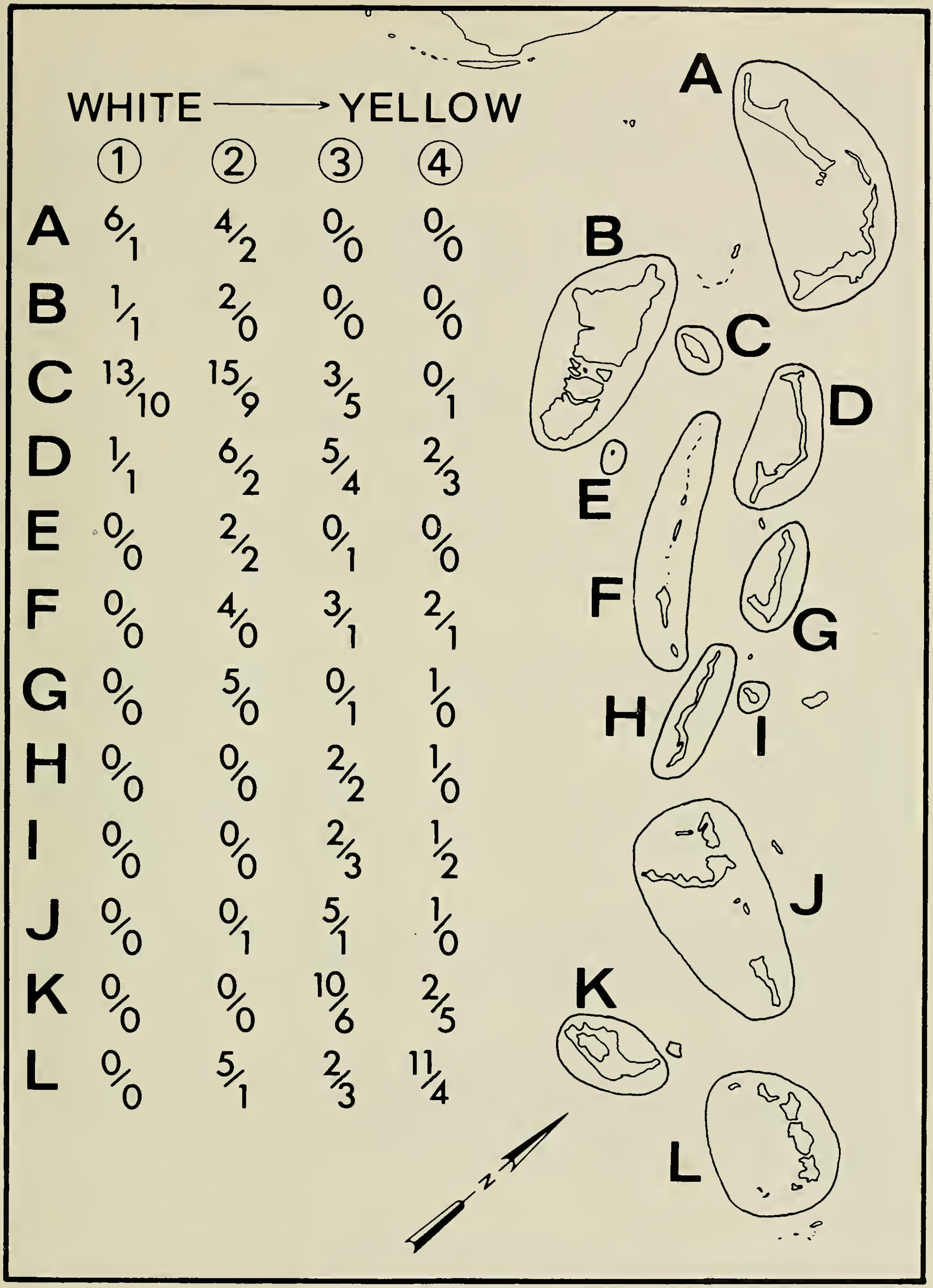
Specimens from the Cayman Islands tend to have darker bills than do those from elsewhere in the range of the species. The Cayman birds usually have a dark brown culmen that appears almost black in many individuals with dark pigment especially prominent on the proximal half of the bill; the tomial region is paler, more gray than brown or black. In Bahaman specimens, the culmen is medium brown with tan and/or reddish tones, especially toward the tip; the coloration of the tomial region is similar to that of the Cayman birds. The contrast in coloration between the mandibular tomial region and the darker parts of the gonys and rami is greater in Cayman birds than in Bahaman examples.

Among MCZ specimens of *Vireo crassirostris,* individuals with the darkest bills are from Little Cayman. Examples from Grand Cayman and Cayman Brac are, for the most part, intermediate in bill color between Little Cayman and Bahaman specimens. In my opinion, the difference in bill color justifies treating *V. crassirostris* in the Cayman Islands as members of a separate subspecies. The name *Vireo crassirostris alleni* Cory is available for this population. Except for the measurement tail length in females, the specimens from Grand Cayman average slightly smaller in bill, wing, and tail measurements than do those from Little Cayman and/or Cayman Brac (Table 1).

The pattern of distribution of color variants among 190 Bahaman specimens of *V. crassirostris* that I examined (Figure 1) essentially accords with the description given by Todd and Worthington (1911). The whitest birds are from the northwesternmost islands generally, whereas individuals with the greatest amount of yellow are from the central and southern Bahamas. Individuals that are relatively more yellow on the venter also are relatively more yellow-green (less olive, brownish-green, or grayish-green) on the dorsum.

Distribution of these "color-phases," however, is not consistent geographically; many samples, especially among those from the more central part of the archipelago, show much variation between (in some cases including) the two extremes in coloration. Also, "yellowish" individuals are well-represented in samples from the Bimini and Berry islands in the northwestern Bahamas where white-ventered individuals predominate. Todd and Worthington (1911) cite other examples of color extremes found outside of the areas they usually occur. I follow these authors in treating *V. c. flavescens* as a synonym of the nominate subspecies, as did Bangs (1916), Hellmayr (1935), and Bond (1956).

Todd and Worthington (1911) did not discuss mensural variation in *V. cras-*



| WHITE → YELLOW | ① | ② | ③ | ④ |
|---|---|---|---|---|
| A | 6/1 | 4/2 | 0/0 | 0/0 |
| B | 1/1 | 2/0 | 0/0 | 0/0 |
| C | 13/10 | 15/9 | 3/5 | 0/1 |
| D | 1/1 | 6/2 | 5/4 | 2/3 |
| E | 0/0 | 2/2 | 0/1 | 0/0 |
| F | 0/0 | 4/0 | 3/1 | 2/1 |
| G | 0/0 | 5/0 | 0/1 | 1/0 |
| H | 0/0 | 0/0 | 2/2 | 1/0 |
| I | 0/0 | 0/0 | 2/3 | 1/2 |
| J | 0/0 | 0/1 | 5/1 | 1/0 |
| K | 0/0 | 0/0 | 10/6 | 2/5 |
| L | 0/0 | 5/1 | 2/3 | 11/4 |

Fig. 1. Distribution of 190 specimens of *Vireo crassirostris* in four categories of ventral coloration ranging from predominately white (1) to predominately yellow (4) given as males/females for each sample; localities as follows: A = Little Bahama Bank, B = Andros, C = New Providence, D = Eleuthera, E = Green Cay, F = Exumas, G = Cat Island, H = Long Island, I = Rum Cay, J = Crooked-Acklins + Mayaguana, K = Great Inagua, L = Caicos Islands.

Table 1.—Mean, and sample size (row 1) and range (row 2) for four measurements in 16 samples of *Vireo crassirostris* from throughout the range of the species; the first 11 localities (Little Bank through Caicos Bank) are Bahama Islands. Wing and tail measurements are of specimens collected only during the months of January through April; all measurements in millimeters.

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| Locality | Wing length | Tail length | Bill length | Bill depth | Wing length | Tail length | Bill length | Bill depth |
| Little Bank | 63.8 (10) | 49.4 (11) | 11.8 (19) | 4.6 (16) | 62.0 (1) | 48.2 (10) | 11.7 (13) | 4.6 (10) |
| | 62.0–66.0 | 47.0–52.0 | 10.4–12.8 | 4.3–4.9 | — | 46.2–51.4 | 11.1–12.9 | 4.3–5.0 |
| Andros | 63.0 (2) | 50.6 (2) | 11.3 (6) | 4.4 (3) | — | 46.4 (1) | 11.3 (2) | — |
| | 62.0–64.0 | 49.1–52.0 | 10.8–12.0 | 4.3–4.5 | — | — | 10.9–11.6 | — |
| New Providence | 62.5 (16) | 49.5 (20) | 11.7 (26) | 4.6 (14) | 61.7 (11) | 48.1 (17) | 11.5 (22) | 4.5 (15) |
| | 60.0–65.0 | 44.1–52.6 | 11.0–12.7 | 4.3–5.0 | 60.0–63.0 | 45.5–51.4 | 10.7–12.1 | 4.2–4.8 |
| Eleuthera | 62.8 (10) | 50.2 (10) | 12.1 (19) | 4.5 (15) | 62.0 (10) | 48.9 (9) | 12.0 (13) | 4.5 (10) |
| | 60.0–65.0 | 47.3–51.8 | 11.2–13.0 | 4.2–4.7 | 60.0–64.0 | 46.8–50.5 | 11.2–12.9 | 4.3–4.8 |
| Cat | 63.3 (6) | 49.4 (6) | 12.1 (6) | 4.6 (6) | 62.0 (1) | 48.8 (1) | 12.0 (1) | 4.7 (1) |
| | 61.0–66.0 | 47.2–52.1 | 11.5–12.8 | 4.3–4.8 | — | — | — | — |
| Green Cay | 63.5 (2) | 49.2 (2) | 12.7 (1) | 4.5 (1) | 61.0 (3) | 47.2 (3) | 11.7 (3) | 4.6 (3) |
| | 63.0–64.0 | 47.2–51.2 | — | — | 58.0–64.0 | 46.2–49.0 | 11.2–12.2 | 4.4–4.8 |
| Exumas | 63.3 (8) | 48.5 (8) | 11.8 (7) | 4.7 (3) | 62.5 (3) | 47.6 (2) | 11.7 (3) | 4.6 (3) |
| | 60.0–65.0 | 45.2–51.0 | 11.1–12.7 | 4.5–4.8 | 62.0–63.0 | 45.8–49.4 | — | — |
| Rum Cay | 63.7 (3) | 49.9 (3) | 11.5 (3) | 4.5 (2) | 61.0 (4) | 46.9 (3) | 11.5 (6) | 4.4 (5) |
| | 63.0–64.0 | 49.6–50.1 | 11.5–11.6 | — | 60.0–64.0 | 44.5–48.4 | 11.1–12.0 | 4.2–4.5 |
| Crooked-Acklins | 63.0 (3) | 47.6 (3) | 12.1 (4) | 4.6 (2) | 62.0 (1) | 47.8 (1) | 12.8 (1) | — |
| | 62.0–64.0 | 45.8–48.2 | 11.1–13.0 | — | — | — | — | — |
| Great Inagua | 62.3 (3) | 48.8 (5) | 11.7 (11) | 4.7 (9) | 62.8 (4) | 46.5 (10) | 11.5 (14) | 4.6 (8) |
| | 61.0–64.0 | 47.3–50.3 | 10.6–12.5 | 4.3–5.0 | 60.0–64.0 | 44.2–48.1 | 10.5–12.3 | 4.4–4.7 |
| Caicos Bank | 59.4 (9) | 44.7 (13) | 11.5 (18) | 4.2 (15) | 59.0 (3) | 44.4 (6) | 11.5 (9) | 4.3 (7) |
| | 57.0–61.0 | 42.4–46.9 | 10.6–12.4 | 4.0–4.5 | 58.0–61.0 | 42.0–49.8 | 10.8–12.2 | 3.9–4.4 |
| Tortue | 62.0 (3) | 47.2 (5) | 10.9 (6) | 4.0 (2) | 59.0 (2) | 45.0 (2) | 10.8 (2) | 4.2 (2) |
| | 61.0–63.0 | 45.0–49.4 | 10.4–11.1 | 3.9–4.1 | 58.0–60.0 | 43.3–46.7 | 10.7–10.8 | 4.1–4.2 |
| Grand Cayman | 61.0 (4) | 48.1 (4) | 11.3 (6) | 4.5 (5) | 59.0 (2) | 46.3 (2) | 10.8 (5) | 4.2 (2) |
| | 60.0–63.0 | 45.0–54.0 | 10.8–11.8 | 4.3–4.8 | 58.0–60.0 | 45.0–47.6 | 10.2–11.8 | 4.1–4.3 |
| Little Cayman | — | — | 11.9 (5) | 4.6 (6) | — | — | — | — |
| | — | — | 11.2–12.6 | 4.3–4.9 | — | — | — | — |
| Cayman Brac | 62.7 (3) | 48.7 (3) | 12.0 (5) | 4.7 (5) | 60.0 (1) | 45.1 (2) | 11.8 (6) | 4.6 (5) |
| | 62.0–63.0 | 48.5–49.0 | 11.3–12.6 | 4.4–4.9 | — | 44.1–46.1 | 11.2–12.5 | 4.5–4.8 |
| Old Providence | 61.0 (5) | 49.5 (5) | 11.7 (4) | 4.2 (3) | 61.0 (1) | 48.7 (1) | 10.9 (1) | 4.1 (1) |
| | 60.0–62.0 | 46.2–51.5 | 11.1–11.9 | 4.0–4.4 | — | — | — | — |

*sirostris* and no marked differences in measurements among Bahaman samples of this species were reported by Ridgway (1904). However, many of Ridgway's samples were extremely small; measurements of only one male and three females from Inagua comprised his mensural data on specimens from the southern Bahamas. The means and sample sizes for the measurements wing length, tail length, bill length, and bill depth in Bahaman specimens that I examined are given in Table 1. There are no noteworthy differences among 10 of the 11 samples. However, with the exception of the measurement bill length, individuals of both sexes from the Caicos Islands average consistently smaller than those of any other Bahaman sample. The Caicos population may be known by the name.

### *Vireo crassirostris stalagmium,* new subspecies

*Holotype.*—LSUMZ 70838, adult male, Caicos Islands, North Caicos, along Flamingo Pond Road, east of Kew, collected 29 Feb 1972 by D. W. Buden.

*Characters.*—In comparison with the nominate subspecies, *stalagmium* differs by its smaller measurements of wing length, tail length and bill depth; differences are most marked in males. Nine male *stalagmium* range from 57.0 to 61.0 mm in wing length, whereas 63 male *crassirostris* (from throughout the Bahamas) range from 60.0 to 66.0 mm in this character. The 10 samples of male *crassirostris* each averages over 61.0 mm in wing length and the one sample of male *stalagmium* averages 59.4 mm. The sample of male *stalagmium* averages 44.7 mm in tail length, whereas each of 10 samples of male *crassirostris* averages greater than 47.0 mm in this character. In coloration, specimens of *stalagmium* tend to resemble many examples of *crassirostris* from the central and southern Bahamas, but in comparison with many of the individuals from the northern islands, they have more yellow pigment, especially on the venter.

In wing and tail measurements, examples of *stalagmium* average also smaller than do those of all other subspecies (*tortugae, alleni, approximans*), at least in males. Individuals of *stalagmium* differ from those of *tortugae* further in having (on the average) longer bills and in having more yellow on the venter with less buff color on the upper part of the breast and along the sides of the neck and throat. Examples of *stalagmium* tend to have paler bills than do those of *alleni.*

*Range.*—Known only from the Caicos Islands in the extreme southeastern Bahamas. Recorded from West Caicos, Providenciales, Bay Cay, Water Cay, Pine Cay, Parrot Cay, North Caicos, Middle Caicos, East Caicos, and South Caicos, and doubtlessly occurring on other of the many islands of the Caicos Bank.

*Etymology.*—From the Latin, *stalagmium,* a golden pearl pendant or earring, in allusion to the yellow ventral coloration of this subspecies and to the location of the Caicos Bank relative to the other islands in the Bahama chain; a noun in apposition.

### Specimens Examined

*Vireo crassirostris crassirostris.*—BAHAMA ISLANDS: Grand Bahama, AS (1M, 1F), FMNH (2M, 1F), MCZ (2M, 2F); Strangers Cay, MCZ (1M); Great Abaco and Little Abaco, AS (1M), FMNH (5M, 6F), USNM (6M, 1F); Elbow Cay, MCZ (1M); South Bimini, AS (1M, 2F); Berry Islands, MCZ (2M, 1F); Andros, AS (3M, 2F), MCZ (2M, 1F), USNM (1M); New Providence, LSUMZ

(1M), MCZ (24M, 20F, 4?), USNM (8M, 8F, 1?): Eleuthera (including Current Island), AS (6M, 3F), MCZ (4M, 1F), USNM (11M, 8F); Cat Island, USNM (6M, 1F, 1?); Exuma Cays—Cistern Cay, MCZ (1F), Farmer's Cay, MCZ (1M), Exuma (=Great Exuma?), MCZ (2M, 1F), Roseville, Great Exuma, MCZ (2M), Anna's Tract, off Exuma, MCZ (1M), Brigantine Cay, MCZ (1M), Conch Cut Cay, MCZ (2M), Green Turtle Cay, MCZ (1M), Refuge Cay, MCZ (1M); Green Cay, USNM (2M, 1F); Long Island, USNM (3M, 2F); Rum Cay, AS (1F), USNM (3M, 5F, 1?); San Salvador, AS (1M); Ragged Islands, Hog Island, USNM (1M); Crooked Island, LSUMZ (1M, 1F); Acklins Island, LSUMZ (2M), USNM (1M); West Plana Cay, USNM (1M); Mayaguana, LSUMZ (2M, 2F, 1?); Great Inagua, FMNH (8M, 12F), MCZ (3M, 2F); Little Inagua, USNM (1F); no other locality, MCZ (1?).

*Vireo crassirostris stalagmium.*—CAICOS ISLANDS: Providenciales LSUMZ (5M, 1F, 1?), USNM (1M, 1F); North Caicos, LSUMZ (5M, 1?); Middle Caicos, LSUMZ (1?), USNM (2F); East Caicos, LSUMZ (2M, 2F, 1?); South Caicos, MCZ (1M, 1?); no other locality, FMNH (5M, 3F).

*Vireo crassirostris tortugae.*—ILE DE LA TORTUE, AS (2M), MCZ (1M, 1F), USNM (3M, 1F).

*Vireo crassirostris alleni.*—CAYMAN ISLANDS: Grand Cayman, LSUMZ (3M, 1F, 1?), MCZ (3M, 4F); Little Cayman, MCZ (6M); Cayman Brac, FMNH (4M, 2F), MCZ (2M, 2F).

*Vireo crassirostris approximans.*—OLD PROVIDENCE, MCZ (5M, 1F, 1F?).

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# THE REINSTATEMENT OF *BATHYPOLYPUS FAEROENSIS* (RUSSELL, 1909) (OCTOPODA: BATHYPOLYPODINAE)

Ronald B. Toll

*Abstract.*—*Polypus faeroensis* Russell, 1909, is removed from the junior synonymy of *Bathypolypus arcticus* (Prosch, 1849) and is retained in *Bathypolypus* as a separate species. *Bathypolypus faeroensis* is further characterized and partially redescribed based on a female specimen from the Denmark Strait. The cephalopod type-material collected by the Fishery Cruiser *Goldseeker* and described by Russell (1909, 1922) is determined to be no longer extant and a neotype is designated for *P. faeroensis*. The systematic relationship of *Bathypolypus* Grimpe, 1921, and *Benthoctopus* Grimpe, 1921, is briefly discussed.

Russell (1909) described *Polypus faeroensis* based on two males and one female collected at a single trawl station by the *Goldseeker* in the Faeroe Channel. Russell separated this species from *P. arcticus* Prosch, 1849, by the shape of the mantle, length of the arms relative to the body, relative length of the hectocotylized portion of the right third arm, and dermal ornamentation. In a supplementary paper based on the same material Russell (1922) repeated his earlier description of *P. faeroensis,* gave illustrations of the radula, hectocotylus, and dermal ornamentation, and included a photograph of the dorsal aspect of the whole animal.

Robson (1932) tentatively placed *P. faeroensis* into the synonymy of *Bathypolypus arcticus* (Prosch, 1849). He noted, however, that the form described by Russell represented one extreme end of the range of variation with regard to total length, shape of the mantle, surface sculpture, and web morphology.

Jaeckel (1958) regarded *P. faeroensis* as a varietal form of *B. arcticus.*

Kumph (1958) suggested that the peculiarities represented by *P. faeroensis* are within the range of variation for *B. arcticus* based on his examination of 178 specimens and retained it in synonymy.

While examining the unidentified octopod holdings of the National Museum of Natural History I encountered a large specimen resembling *Bathypolypus* from the Denmark Strait that could not be attributed to either *B. arcticus* or *B. proschi* Muus, 1962. Further study demonstrated that it was attributable to *P. faeroensis* and that a reevaluation of that taxon was required.

Measurements and indices are as defined by Roper and Voss (1983).

## *Bathypolypus faeroensis* (Russell, 1909)
Figs. 1, 2

*Polypus faeroensis* Russell, 1909:446; 1922:5, pls. 1, 2, figs. 1, 4–6.—Robson, 1932:287.

*Bathypolypus faeroensis.*—Grimpe, 1921:300; 1922:40; 1925:93.—Robson, 1927: 252, fig. 7.—Muus, 1962:11.

*Octopus faeroensis.*—Robson, 1926:1330.

Table 1.—Measurements (in mm) of *Bathypolypus faeroensis* (Russell, 1909).

| | | | | | |
|---|---|---|---|---|---|
| ML– | 73 | | Sn– | 4.1 | |
| MW– | 49 | | WD*A– | 55 | |
| HW– | 30 | | B– | 60 | 61 |
| AL– | L | R | C– | 51 | 51 |
| I– | 163 | 145+ | D– | 48 | 50 |
| II– | 156 | 151 | E– | 4 | |
| III– | 142 | 132 | gills– | 9/10 | |
| IV– | 133 | 124 | FL– | 26.7 | |
| AW– | 10.2 | | TL– | 24 | |

* Approximate values.

*Bathypolypus arcticus* (pars).—Robson, 1932:286.—Kumph, 1958:13 (non Prosch, 1849).
*Bathypolypus arcticus* var. *faeroensis.*—Jaeckel, 1958:565.

*Material examined.*—NEOTYPE, 1 female (gravid), ML = 73 mm, FFS *Walther Herwig* 630/73, 67°21.5'N, 23°30'W, 480–485 m, 140' net, 9 Sep 1973, Institut für Seefischerei und Zoologisches Museum der Universität Hamburg (on extended loan to National Museum of Natural History).

*Description.*—The mantle is ellipsoid in outline, bluntly pointed posteriorly and widest posterior to its midpoint (MWI 67.1) (Table 1). The head is considerably narrower than the mantle and brachial crown and is separated from both by a weak constriction (HWI 41.1) (Fig. 1a).

The mantle aperture extends about one half of the circumference of the mantle. The funnel is moderately large (FLI 36.5) and stout. It is free for slightly less than half of its length. The funnel organ is VV-shaped and acutely pointed basally. The inner and outer limbs are subequal in length. The outer limbs are broader basally than the inner ones (Fig. 2a).

The web is damaged but appears shallow (WDI 37.8) and has the formula B.A.C. = D.E.

The arms are long (ALI 66.5), moderately stout basally (AWI 14.0), and taper to short acute points. The arm order is I.II.III.IV. The web extends dorsally and ventrally down the arms almost to the tips. The biserial suckers are small (SNI 5.6) and well separated along the midportion of several arms; the 2 sucker rows are particularly widely placed, with suckers only slightly elevated.

The gills are relatively small with nine primary lamellae on the outer demibranch of one, 10 on the other.

The viscera were partially dissected. The ovary is massive and completely occupies the ventro-posterior third of the mantle cavity (Fig. 2b). Proximally the oviducts are short and appear to connect by separate pores with the ovarian membrane. The oviducal glands are large, broader than long and completely darkened. Distally the oviducts are large, stout, and curved to form an inverted J-shape. The tips are expanded into a conical swelling. The ovarian eggs are large ($\bar{x}$ = 18 mm), with a smooth surface and a series of longitudinal lines (Fig. 2c). The eggs appear to be mature.

Midway along the esophagus is an enlarged crop that bears a prominent anterior

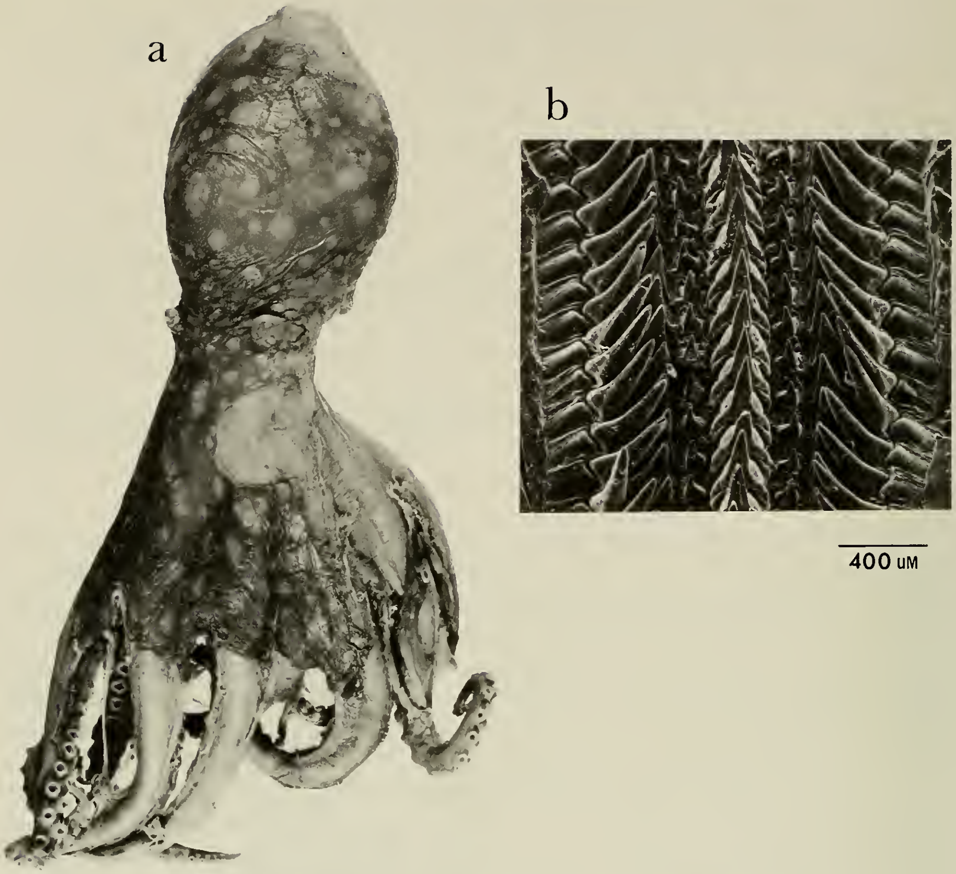

Fig. 1. *Bathypolypus faeroensis,* neotype: a, Dorsolateral whole view; b, Radula.

diverticulum (Fig. 2d). The liver is large and bulbous. When squeezed it exuded a greenish-amber colored oil.

The radula and mandibles are as figured (Figs. 1b, 2e–f). Neither is distinctive.

The color in alcohol is rust brown to purple with prominent, irregularly sized, subcircular, tan colored markings over the entire dorsal surfaces of the mantle, head, and brachial crown. These spots are loosely organized into a pattern of circlets of smaller ones surrounding a central larger one. The smaller spots are sometimes associated with a small, conical papilla.

A single, large, ocular cirrus is located above each eye. It is covered with smaller, irregular warty protuberances. Smaller wart-like papillae form an incomplete circlet around the small eyes.

*Discussion.*—While most closely resembling the genus *Bathypolypus,* the presence of a large and well developed diverticulum of the crop eliminated the possibility that the present specimen could be attributed to *Bathypolypus arcticus* (Prosch, 1849), *B. proschi* Muus, 1962, both from the North Atlantic, or any other recognized congener. The combination of a well developed supraocular cirrus and unicuspid rachidian further eliminated its placement in *Benthoctopus.*

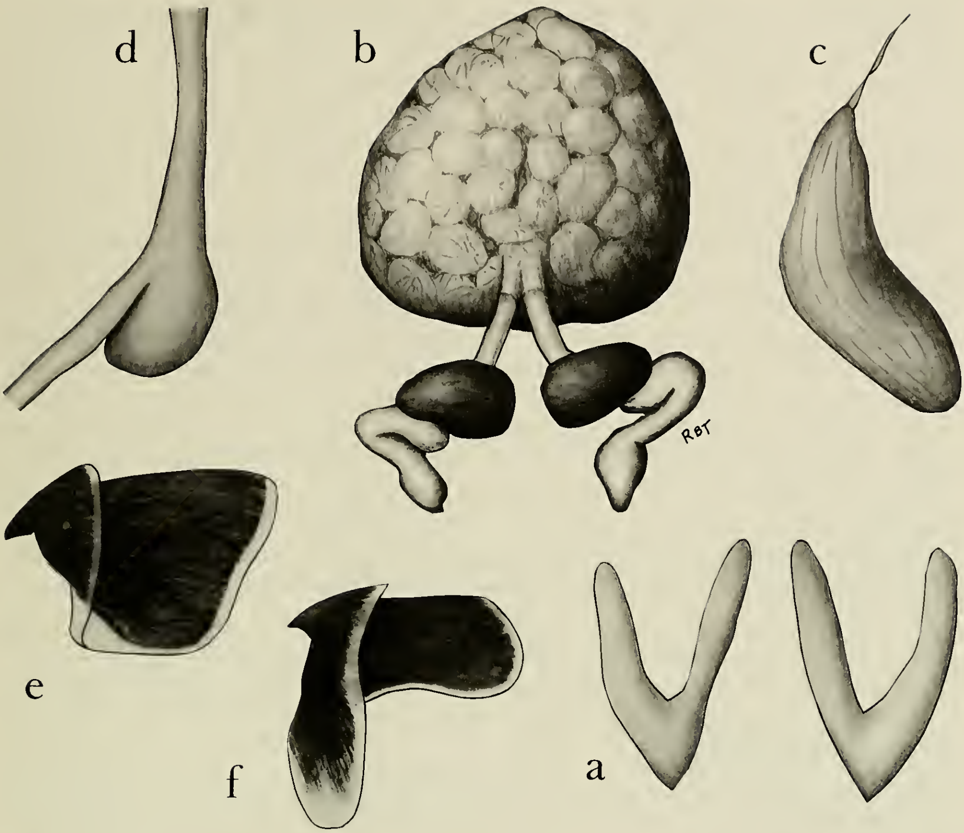

Fig. 2. *Bathypolypus faeroensis,* neotype. a, Funnel organ; b, Ovary; c, Ovarian egg; d, Esophagus with diverticulum; e, Upper mandible; f, Lower mandible.

A broader review of the literature, stimulated by this unusual combination of characters, resulted in comparison of the present specimen to *Bathypolypus faeroensis* (Russell), previously placed in synonymy of *B. arcticus* by Robson (1932) and Kumph (1958). I inquired about the location of Russell's cephalopod type-material taken by the *Goldseeker* at the Royal Scottish Museum (RSM) in the hope of obtaining the type-series of *Polypus faeroensis* for comparison with the present specimen. Dr. D. Heppell, curator of Mollusca, informed me that this material was no longer at the Aberdeen Marine Laboratory and had never been transferred to the RSM "although many of the *Goldseeker* marine invertebrates are housed here" (pers. comm., 18 Mar 1983). The types of *P. faeroensis* and those of two teuthoids described by Russell (1909: *Brachioteuthis bowmani* and *Taonidium pfefferi*) must be assumed to be lost or destroyed.

In the absence of type-material, Russell's accounts of *P. faeroensis* were critically evaluated for relevance to the present specimen. Morphometric comparison was difficult because of the small number of specimens in the syntypic series (three) and the difference in size between the present specimen (73 mm ML) and Russell's syntypes (40, 42, 48 mm ML). The more valuable characters including the relative length of the arms, length of the arms with respect to total length, web depth, web order, funnel size and sucker size are, nonetheless, compatible. Unfortunately Russell did not report on the crop morphology. The most substantial basis for comparison is Russell's description and photograph (Russell 1922, fig. 1) of the distinctive "papillary areas" found on the dorsal surface of the mantle. These are nearly identical in size, coloration, and distribution to the *Herwig* specimen. Based on these comparisons the present specimen is attributed to *Polypus faeroensis* Russell and is designated as the neotype.

Kumph (1958) stated that the form represented by *faeroensis* was within the range of variation he determined for *Bathypolypus arcticus* based on his examination of 178 specimens. A review of his data, however, indicates that differences do exist. Kumph reported that the LLI, based on a total of 96 animals, ranged from 9.5 to 49.2, thereby encompassing the value of 12.2 for the larger and sexually mature syntype of *faeroensis* (ML = 42 mm). Only a single specimen of Kumph's had a lower value (9.5). This specimen was the smallest that he had examined (ML = 7.8) and it is certainly immature. Kumph reported that the range of LLI for mature males is 18.1 to 44.8 with a mean of 32.9. The two species can, therefore, further be distinguished on the basis of ligula length.

I concur with Robson's (1932:293) suggestion that Russell's description of the spermatophores is erroneous. Specifically Russell confused broken or pinched off segments of the sperm rope as individual spermatophores and referred to the actual whole spermatophore as a "membranous bag." Also, his assessment of the distinctiveness of the radula of *faeroensis* appears to be based on an unusual orientation of the radular teeth as seen in his figure (Russell 1922, fig. 4) and not on actual morphology.

Muus (1962) reported on several large specimens of *B. arcticus* (TL = 145–220 mm) with multicuspid rachidian teeth and small ligulas (LLI 9.3–16.9). Based on Kumph's (1958) extensive comparative study, apparently unknown to Muus, it is unlikely that these specimens are correctly identified.

Based on the generic definitions given by Robson (1927, 1932) *Polypus faeroensis* cannot be accommodated by either *Bathypolypus*, because of the size of the ligula and the presence of a crop diverticulum, or *Benthoctopus*, because of the unicuspid condition of the rachidian teeth and presence of supraocular cirri. Wirz (1955) noted that "La stricte séparation des deux genres *Benthoctopus* et *Bathypolypus* faite par Robson en 1932 est sans aucun doute injustifiée, étant donné le très petit nombre de charactères différents." Creation of a new genus for the inclusion of *faeroensis*, placement of *Benthoctopus* in the synonymy of *Bathypolypus*, or redefinition of these two genera would be premature at this time and only add to the current confusion. In lieu of these alternatives, the writer chooses provisionally to maintain *faeroensis* as a separate species in *Bathypolypus* until these genera can be reviewed and their relationship established.

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Dr. D. Heppell, Royal Scottish Museum, kindly undertook the search for the types of *P. faeroensis* and made information available to me concerning their location. Dr. C. F. E. Roper read the manuscript and made many helpful suggestions.

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# REDESCRIPTION OF THE NEPHTYID POLYCHAETE *AGLAOPHAMUS MINUSCULUS* HARTMAN, 1965

Takashi Ohwada

*Abstract.*—The holotype of *Aglaophamus minusculus* has been redescribed to prevent the establishment of new species that will later have to be synonymized. Examination of the holotype has revealed discrepancies from the original description in two taxonomically important characteristics. The holotype has been found to have at least 12 pairs of interramal cirri rather than about six pairs as previously reported and only one kind of furcate setae, not two. The furcate setae with tines of distinctly unequal length, which were regarded as a second kind of furcate seta in the original description have been identified as damaged forms which originally had tines of almost equal length but one of which had broken near the base. The generic allocation of the present neotenic species in *Aglaophamus* is reviewed on the basis of findings on the morphology of juvenile nephtyids, and a description of the proboscis is provided, based on specimens from off Florida.

*Aglaophamus minusculus,* one of the smallest species of nephtyid polychaete so far reported, was originally described by Hartman (1965) as having about six pairs of interramal cirri and two kinds of furcate setae on both the notopodia and neuropodia among the postacicular fascicle of long and numerous setae. Dr. R. W. Virnstein and Ms. M. A. Capone of the Harbor Branch Foundation, Fort Pierce, Florida, collected approximately 1500 specimens of small nephtyid polychaetes from depths of about 200 m off Fort Pierce, on the east coast of Florida, from June 1978 to June 1979. Two hundred and thirty specimens from the Indian River Coastal Museum, Fort Pierce, were sent to the author for identification by Ms. Capone. Except for one *Nephtys* specimen, all of the specimens seemed to fit the description of *Aglaophamus minusculus* with the exception that they have 12–17 pairs of interramal cirri and only 'one kind' of furcate setae.

The holotype of *Aglaophamus minusculus,* collected from a depth of 200 m on the continental slope off New England, is deposited in the Allan Hancock Foundation, Los Angeles, California. This specimen was examined and found to have at least 12 pairs of interramal cirri and only 'one kind' of furcate setae. Since the distribution pattern of interramal cirri along the body and the setal types are important taxonomic characteristics of Nephtyidae, it is felt that a redescription of the holotype is necessary to prevent future descriptions of species that might eventually prove to be synonymous. There is no description of the proboscis in the original description; a description of the proboscis of the Florida specimens is provided here.

The following description is based on the holotype (AHF-Poly 0784). Although its proboscis is retracted, no dissection of the holotype for examination of the proboscis and parapodia was attempted to avoid further damage to the specimen since it is macerated and three parapodia are missing.

### *Aglaophamus minusculus* Hartman, 1965
Fig. 1a–e

*Description.*—The holotype (AHF-Poly 0784), which is complete, is 4.0 mm long with 28 setigers. The body is broad for its length and 0.6 mm wide excluding setae at the eighth setiger, its broadest point. The proboscis is completely retracted and eyes are absent.

The prostomium is longer than wide, the anterior corner is nearly right-angled, with the front and sides almost straight. The first and second antennae are of equal length and tapering (Fig. 1a). They are close together on the anterior corner of the prostomium with the second pair on the ventral side slightly behind the first pair on the dorsal side (Fig. 1b). Each antenna is about half as long as the prostomium is wide.

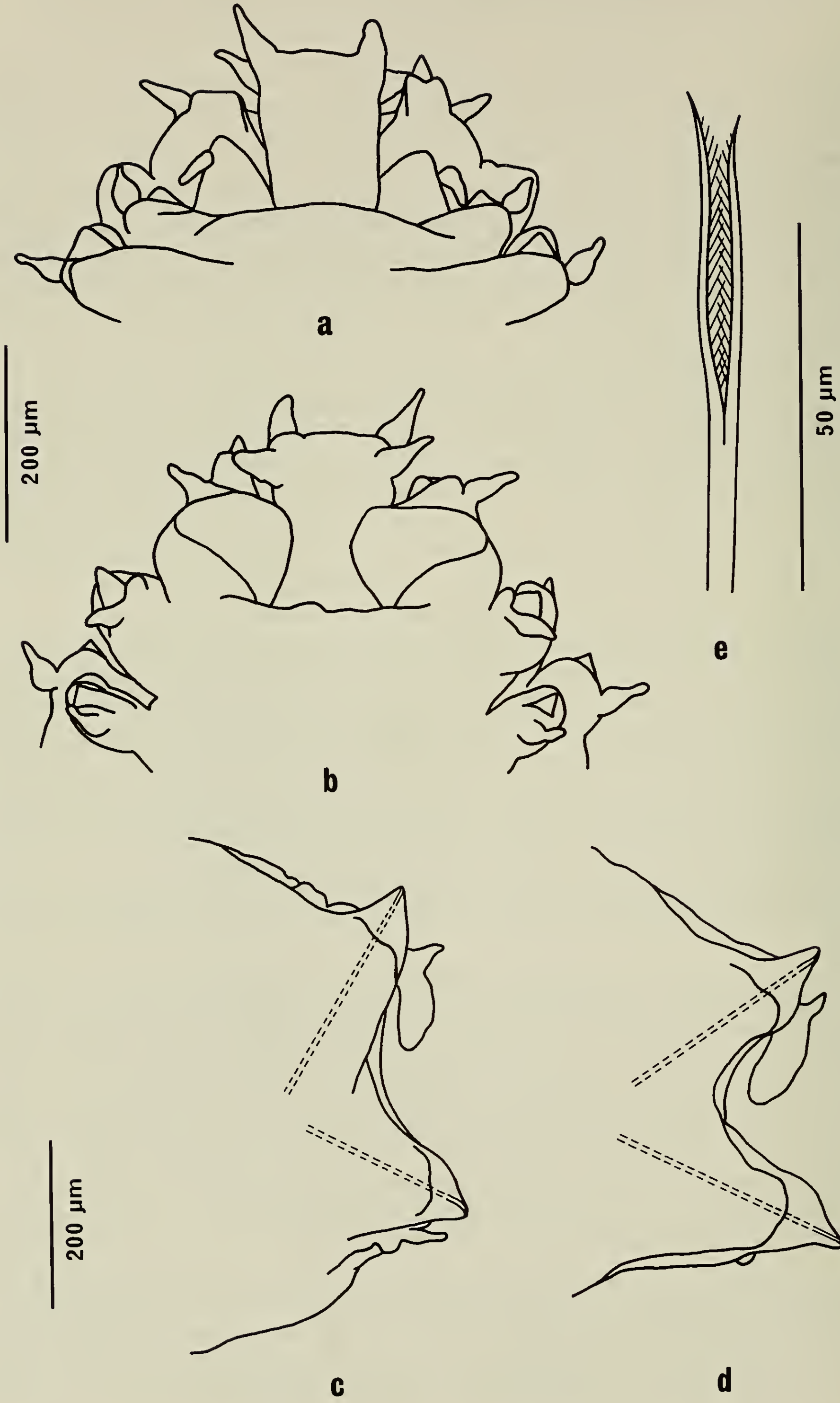
The first parapodium is reduced and directed forward (Fig. 1a). An acicular lobe supported by a curved-tipped aciculum is recognized in the first right neuropodium whereas it is missing in the left one. In the first neuropodium, only finely serrated capillary setae are present. A dorsal cirrus is present as a digitate or somewhat pyriform papilla arising backward from midway along the outer surface of the notopodium. The ventral cirrus is similar, but slightly longer than the dorsal one, arising anterolaterally from the outer surface of the neuropodium. The anterior edge of the second setiger on the ventral side forms the lower lip of the mouth, and the lateral lips are formed by the first setiger (Fig. 1b).

From the second setiger, parapodia are similar, and the preacicular and postacicular lobes are very small. The acicular lobes are much longer, nearly conical and very pointed, and are supported by acicula whose tips curve dorsad in the notopodia and ventrad in the neuropodia. The curved tips of the acicula are covered by a thin sheath. The dorsal cirri are tapered and in the anterior parapodia are pyriform, while in the middle and posterior parapodia they are often slightly constricted at the base. The ventral cirri are smaller and digitiform. Both dorsal and ventral cirri are present from the first to last (28th) setiger.

Possibly due to the age and small size of the specimen, most of the interramal cirri are macerated and the posterior interramal cirri are in especially bad condition.

Short and plump interramal cirri are present from the ninth setiger on the right side of the body, and at least from the tenth setiger on the left side (the ninth left parapodium is missing in the holotype). The interramal cirri are distinct and already almost fully developed in the ninth right and tenth left parapodia. The size of the interramal cirri increases slightly up to 13th to 14th setiger on both sides and then appears to decrease only slightly until the last few setigers. Even in the most developed interramal cirri, they are not developed enough to tell whether they are involute or recurved. They are short and almost straight.

On the right side, the interramal cirri are recognizable up to the 21st setiger, with the last two too macerated to tell whether they are reduced or broken off near the base. The interramal cirrus of the 19th right parapodium appears to be broken off at midlength. On the left side, interramal cirri are also recognized up to the 21st setiger, but the interramal cirrus of the 20th left parapodium is very small and that of the 21st left parapodium, even though distinct, is vestigial. This may be due to the macerated condition of these interramal cirri.


a
200 µm
b
50 µm
e
200 µm
c
d

The 29th segment, the pygidium, has no parapodium but acicula can be observed to project slightly over the epidermis of the pygidium and are covered by a thin sheath. One slender anal cirrus is present ventral to the anus.

Four types of setae are present in both the notopodia and neuropodia, 2 types in the preacicular fascicle and the other 2 in the postacicular fascicle. In the preacicular fascicle there are barred (laddered) setae and capillary setae showing very fine serration. The 2 types of setae are of about the same length. The majority of preacicular setae are barred, and a few capillary setae are present at the upper and lower end of the fascicle. The barred setae are thicker at the base than the capillary setae.

In the right notopodia, one capillary seta first appears at the upper end of the preacicular fascicle by at least the sixth setiger and at the lower end at the seventh setiger, and 1 to 3 (usually 2) capillary setae are present at each end of the fascicle except for the last 4 setigers in the case of the upper end and the last several setigers in the case of the lower end. In the left notopodia, capillary setae first appear at the seventh setiger, 1 at the upper end and 2 at the lower end. Posterior to the seventh setiger, 1 to 3 (usually 2) capillary setae are present at each end of the preacicular fascicle, except for the last 7 setigers in the case of the upper end and the last 6 setigers in the case of the lower end. In the right neuropodia, capillary setae are recognized at the upper end by at least the 13th setiger, and at the lower end 2 capillary setae first appear at the eighth setiger, and 1 to 2 setae are present at each end of the fascicle except for the last 8 setigers in the case of the upper end and the last 5 setigers in the case of the lower end. At the lower end of the right neuropodia, a maximum of 3 capillary setae are recognized. In the left neuropodia, capillary setae are recognized at the upper end by at least the 10th setiger and at the lower end one capillary seta first appears at the eighth setiger. Thereafter 1 to 2 setae, usually 2 at the lower end, are present at each end except for the last 8 setigers.

In the postacicular fascicle more numerous capillary setae of very fine serration and a few furcate (lyrate) setae are found. These capillary setae are slender and 1.5 to 2 times as long as the preacicular setae. Only one kind of furcate seta is present among the capillary setae, and they are longer than half the length of the preacicular barred setae, but less than the total length of the latter. These furcate setae have tines of slightly unequal length, and both tines are spinulose on the inner margins.

In the right notopodia, 1 furcate seta first appears in the fourth setiger and 2 to 4 (usually 3) furcate setae are present except in the case of the last 4 setigers. In the left notopodia, one furcate seta first appears at the fifth setiger and 2 to 4 furcate setae are present except in the case of the last 2 setigers. In the neuropodia, they first appear at the sixth setiger, 2 on the right neuropodium and one on the left. In the right neuropodia, 1 to 2 (usually 2) furcate setae are recognized except

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Fig. 1. *Aglaophamus minusculus*: a, Anterior end, dorsal view, proboscis completely retracted; b, Same, ventral view; c, Ninth left parapodium, anterior view; d, 16th left parapodium, anterior view; e, Furcate seta from 16th right parapodium (a, b, holotype (AHF-Poly 0784); c, d, from Florida (ORIUT-BEPL-M8407-1-1003); e, from Florida (ORIUT-BEPL-M8407-1-2011).

at the last setiger, but many of the setae observed on the neuropodia are broken. In the left neuropodia, 2 to 3 furcate setae are present except in the case of the last 3 setigers.

*Remarks.*—The furcate setae with two tines clearly of unequal length, only the longer one of which was spinulose on the inner margin, were regarded as a second sort of furcate seta in the original description (Hartman 1965; p. 90 and Pl. 13, fig. d). Such furcate setae are recognized in some parapodia of the holotype, but in this redescription, these setae are identified as broken forms which originally had tines of almost equal length (see discussion below).

## Discussion

The original description refers to the presence of two kinds of furcate setae in each postacicular fascicle. This, however, is not the case in the holotype. Furcate setae with tines of distinctly unequal length are observed to be present in some parapodia, but they occur intermittently along the length of the body, whereas furcate setae with tines of almost equal length (Fig. 1e) are recognized in nearly all parapodia except for the first few anterior and last few posterior setigers. I mounted furcate setae from the Florida specimens on slides and under a compound microscope I broke them deliberately by pressing down on the coverglass. In many cases, the broken setae looked like those with tines of distinctly unequal length described by Hartman (1965). In the present paper, therefore, the former type of furcate setae are regarded as damaged forms that originally had tines of almost equal length but one of which had broken near the base. It is, however, not known whether this breakage occurred during life or only after the specimens were fixed. Whatever the case, it is not reasonable to include damaged forms in the description of setal types.

Nearly all of the Florida specimens have 27 to 30 setigers and are 4 to 5 mm long (the holotype has 28 setigers and is 4.0 mm long). In the holotype and the Florida specimens, interramal cirri first appear on the seventh to tenth setiger (ninth in the holotype) and they are present until the 20th to 24th setiger (21st in the holotype). Twelve to 17 pairs of interramal cirri are present (13 in the holotype), not about six pairs as stated in the original description.

While the interramal cirri of the holotype and the Florida specimens are observed to be short, plump and almost straight, the figure of the 16th parapodium in the original description (Pl. 13, fig. b) shows an interramal cirrus which apparently bends inward at midlength, and is not plump. Since the holotype has the 16th parapodia on both sides, it appears that the figure might not have been drawn from the holotype. As dissection of the holotype was not conducted, the ninth left and 16th left parapodia of one of the Florida specimens (ORIUT-BEPL-M8407-1-1003) which are identical with those of the holotype are shown in Fig. 1c, d.

The interramal cirri are not well enough developed to tell whether they are involute or recurved. The interramal cirri of juveniles of *Nephtys caeca* and *N. polybranchia* have a slightly involute appearance during the process of development to adult recurved interramal cirri (Ohwada, unpublished observation). In a neotenic species, therefore, a slightly involute appearance for the interramal cirri does not negate the choice of *Nephtys,* which has recurved interramal cirri, as the correct genus for the species (Ohwada 1985).

Contrary to Fauchald (1968, 1977) who described the tip of the aciculum in *Nephtys* as straight and blunt, curved acicular tips have been recognized in some *Nephtys* (Ohwada 1985). In *N. caeca,* acicula were observed to change from curved to blunt-tipped form as the juvenile grew (Ohwada 1983). With growth, the shaft of the aciculum thickened without thickening of the curved tip and, as a result, the curved tip became practically negligible in size compared to the thick straight shaft. Thus, the presence of curved acicular tips in a neotenic species does not exclude *Nephtys* as the correct genus for the species. In the present paper, the placement of the present neotenic species within *Aglaophamus* is determined rather by the presence of interramal cirri, furcate setae and the first pair of antennae. *Micronephtys* lacks interramal cirri (Fauchald 1968, 1977), *Nephtys* lacks furcate setae (Day 1967) and *Inermonephtys* lacks the first pair of antennae (Fauchald 1968).

No description of the proboscis is given in the original description, and in the present study dissection of the holotype was not attempted. In the Florida specimens with everted proboscises, the proboscis was observed to have 20 bifid subequal papillae and two simple ones in the terminal region surrounding a dorsoventral slit, 10 bifid papillae on each side and a single simple papilla in both the middorsal and midventral position. The subterminal papillae are arranged in 22 longitudinal rows consisting of several conical papillae that decrease in size toward the base of the proboscis. No middorsal unpaired subterminal papilla is present.

In the original description, Hartman (1965) considered the present species to have affinity with *Aglaophamus malmgreni* (Théel) on the basis of similarities in the morphology of the parapodium. In the present study, this view is supported by the similarities in morphology of the anterior end of the body between these two species (Fig. 1a; for *A. malmgreni* see Fauchald 1963, fig. 1, F) Ohwada (1985) suggests the possibility that the similarities in morphology of the prostomium and the first setiger may indicate systematic closeness.

Twenty-six of the Florida specimens (ORIUT-BEPL-M8407-1-1001–1004, 2001–2011, 6-4001–4007, 9001–9004) are preserved in the Ocean Research Institute, University of Tokyo.

## Acknowledgments

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# *PINNOTHERES JAMESI* SYNONYMIZED WITH *P. RETICULATUS* (DECAPODA: BRACHYURA)

Timothy M. Green

*Abstract.*—The pea crab *Pinnotheres jamesi* is synonymized with *P. reticulatus.* Drawings of entire specimens are provided for the first time. The known range is extended from the tip of Baja California to the Pacific coast of Costa Rica. A host is recorded.

Upon reviewing several vials of pinnotherid crabs from the Muséum National D'Histoire Naturelle, Paris, I discovered that *Pinnotheres jamesi* Rathbun, 1923 (male) is identical with *P. reticulatus* Rathbun, 1918 (female). Both were taken from the host bivalve *Polymesoda inflata* Keene, 1971.

*Pinnotheres reticulatus* was described from a female only, while *P. jamesi* was described from a male. There may be great sexual dimorphism in the genus *Pinnotheres* (Rathbun, 1918) which was taken into account in synonymizing these two species.

Simple line drawings of both male and female *P. reticulatus* are provided for the first time. These include dorsal, ventral, and frontal views, as well as chelae and third maxillipeds. Comparison of the third maxillipeds is based partly on illustrations of these structures in the original descriptions.

The known range of *P. reticulatus* is extended from San Josef Island and Pichilinque Bay, Baja California, to the Pacific coast of Costa Rica. There are no published records of occurrences between these two points.

## *Pinnotheres reticulatus* Rathbun
Figs. 1, 2

*Pinnotheres reticulatus* Rathbun, 1918:93–94, pl. 21, fig. 1 & 2.—Glassell, 1934: 301, list.—Schmitt, McCain, and Davidson, 1973:83, list.

*Pinnotheres jamesi* Rathbun, 1923:625–626, pl. 9, fig. 1 & 2; text figs. 1 & 2.—Glassell, 1934:301, list.—Silas and Alagarswami, 1967:1200–1223, catalogue.—Schmitt, McCain and Davidson, 1973:50, list.

*Type-locality.*—Gulf of California: off San Josef Island, Lower (Baja) California, Mexico.

*Recorded range.*—San Josef Island and Pichilinque Bay, Baja California.

*Material examined.*—Pacific coast, Costa Rica (no further data) from host bivalve *Polymesoda inflata* Keene, 1971, A. Castaing, 2 females, 1 male. Holotype female of *P. reticulatus,* USNM 18217, San Josef Island, Baja California (25°02′15″N, 110°43′30″W), 17 fathoms. Holotype male of *P. jamesi,* USNM 57005, Pichilinque Bay, Baja California, by electric light.

*Remarks.*—In the description of *P. jamesi,* Rathbun mentioned similarity of the third maxillipeds to those of *P. reticulatus,* but dismissed any other similarities and the possibility of their being the same species. I have compared the Paris

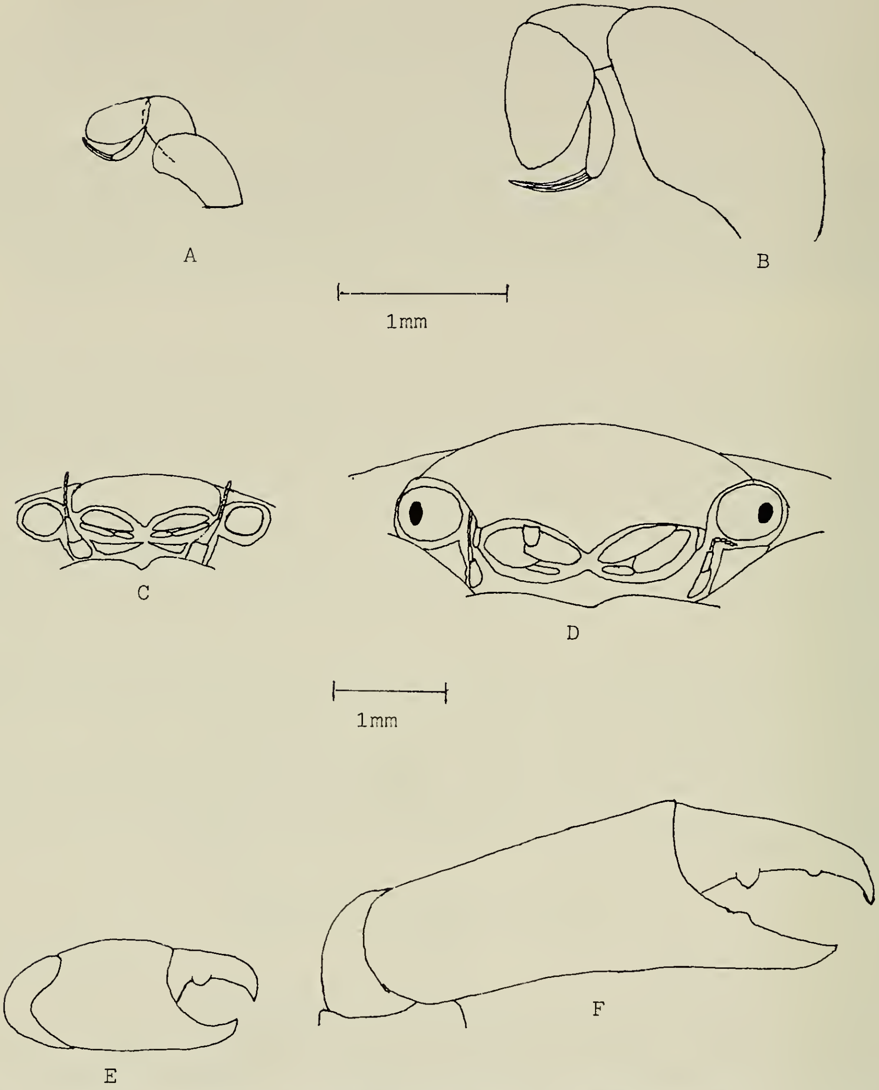

Fig. 1. *Pinnotheres reticulatus.* A, 3rd maxilliped male; B, 3rd maxilliped female; C, Front, male; D, Front, female; E, Right chela, male; F, Right chela, female.

Museum specimens with the type-specimens of those species. Similarities in the third maxillipeds among these specimens are based partly on published drawings of those structures, as they are missing from the *P. reticulatus* holotype (Rathbun, 1918, 1923). Additional drawings of the third maxillipeds are provided here. The dactyl, propodus, and carpus are identical in the specimens compared. There is a tuft of fused or densely packed, sickle-shaped, setae on the tip of the dactyl that extends well past the tip of the propodus. This feature is not seen in Rathbun's illustrations, but is present on the specimens I compared (Fig. 1A, B).

The general shape of the two sexes is similar (Fig. 2A, B, C, D). The front,

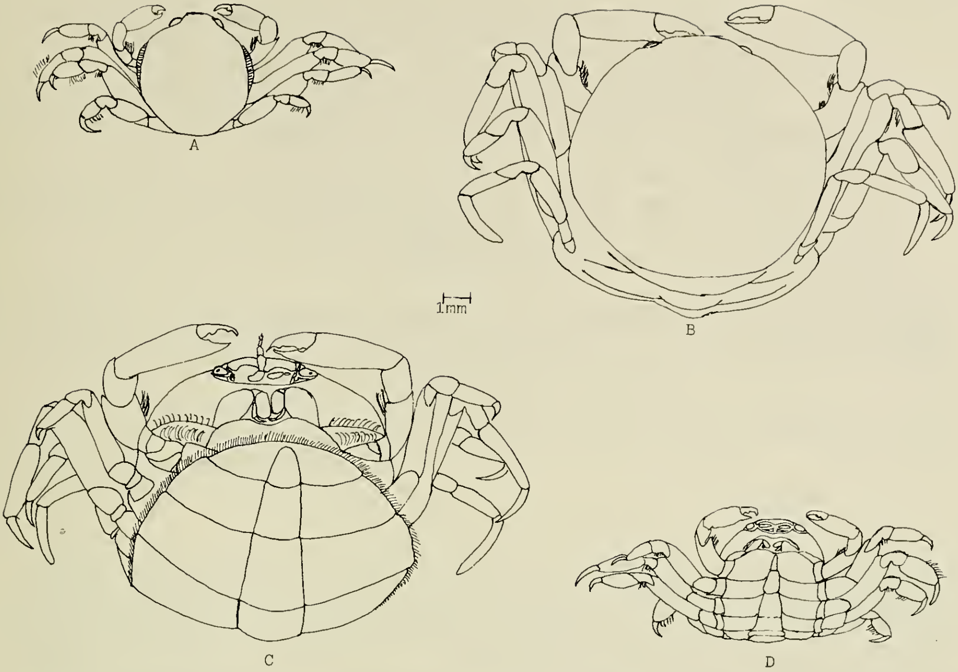

Fig. 2. *Pinnotheres reticulatus.* A, Male, dorsal view; B, Female, dorsal view; C, Female, ventral view; D, Male, ventral view.

abbreviated in the female and pronounced in the male, is similar in both (Fig. 1C, D). Leg shapes and length ratios are similar, relative lengths from first to last in the male being 2:3:1:4 and 2:4:3:1 in the female. The only major difference is that the fourth walking leg of the female is longest due to difference in the dactyl length and shape. Shapes of the limbs are similar, the male's being more stout and the female's more elongate. The chelae are sexually dimorphic (Fig. 1E, F), but between sexes are similar to each other in the carpal and meral segments (Fig. 2). The reticulated pattern of the chelae is not evident in the Paris Museum specimens, but is in the holotype female. There is no reticulated pattern on the chelae of male *P. reticulatus.*

## Acknowledgments

I would like to thank Dr. Mary K. Wicksten for obtaining specimens from Paris, for type-specimens from the USNM, for verification of identification, and for editorial assistance. I also thank Dr. Danièle Guinot for the loan of specimens from the Muséum National D'Histoire Naturelle.

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# FRESHWATER SHRIMPS FROM VENEZUELA III: *MACROBRACHIUM QUELCHI* (DE MAN) AND *EURYRHYNCHUS PEMONI,* N. SP.; (CRUSTACEA: DECAPODA: PALAEMONIDAE) FROM LA GRAN SABANA

Guido Pereira

*Abstract.*—*Macrobrachium quelchi* (De Man), not collected since the original description, is redescribed and the color pattern is given. *Euryrhynchus pemoni,* new species, the fourth species in the genus, is described.

The material comes from La Gran Sabana, a large highland plateau in the southeast Venezuela (6°15'N, 60°1'W), in the headwaters of rivers that discharge into the Orinoco River basin.

Freshwater palaemonid shrimps represent a large group of crustaceans that inhabit brackish and freshwater habitats throughout the tropics. American species living in brackish water and rivers discharging directly into the sea are, at present, well known (Holthuis 1952; Chace and Hobbs 1969). However, in South America, especially in the Amazon region, there are many tributary streams with almost no connection with the estuarine zone of the main river. Shrimp species from these rivers are not well known, and recent surveys have yielded several new species (Tiefenbacher 1978; Rodriguez 1982; Kensley and Walker 1982; Pereira, in press).

Several species of freshwater shrimps from southern Venezuelan rivers are not dependent on saline water for their development (Rodriguez 1981; Pereira 1982). La Gran Sabana, located in this zone, represents an altiplane (1200 m above sea level) consisting of a vast system of creeks and streams (of both black and clear waters) which drain into the Caroni River. This black-water river is one of the main tributaries of the Orinoco River basin.

This paper describes two interesting palaemonid shrimps from La Gran Sabana. *Macrobrachium quelchi* was known only from the original description in 1900 from the the Upper Mazaruni River (Esequibo River basin) Guyana. The other shrimp represents a new species of *Euryrhynchus,* a fairly homogeneous group of shrimps with an Amazonian distribution (Tieffenbacher 1978). Abbreviations tl and cl are used for total length and carapace length respectively, measured from tip of rostrum to tip of telson, and posterior orbital margin to posterior edge of cephalothorax. MBUCV, Museum of Biology, Central University of Venezuela. USNM, National Museum of Natural History, Smithsonian Institution.

## *Macrobrachium quelchi* (De Man)

Figs. 1, 2, 3, 4

*Palaemon* (*Macrobrachium*) *quelchi* De Man, 1900:57, pl. 6, figs. 1–8.

*Material examined.*—MBUCV (XI-2111) 3 ♂, 2 ♀; stream tributary of River Kama. La Gran Sabana, Bolivar State, Venezuela (6°15'N; 60°1'W), 29 Mar 1983,

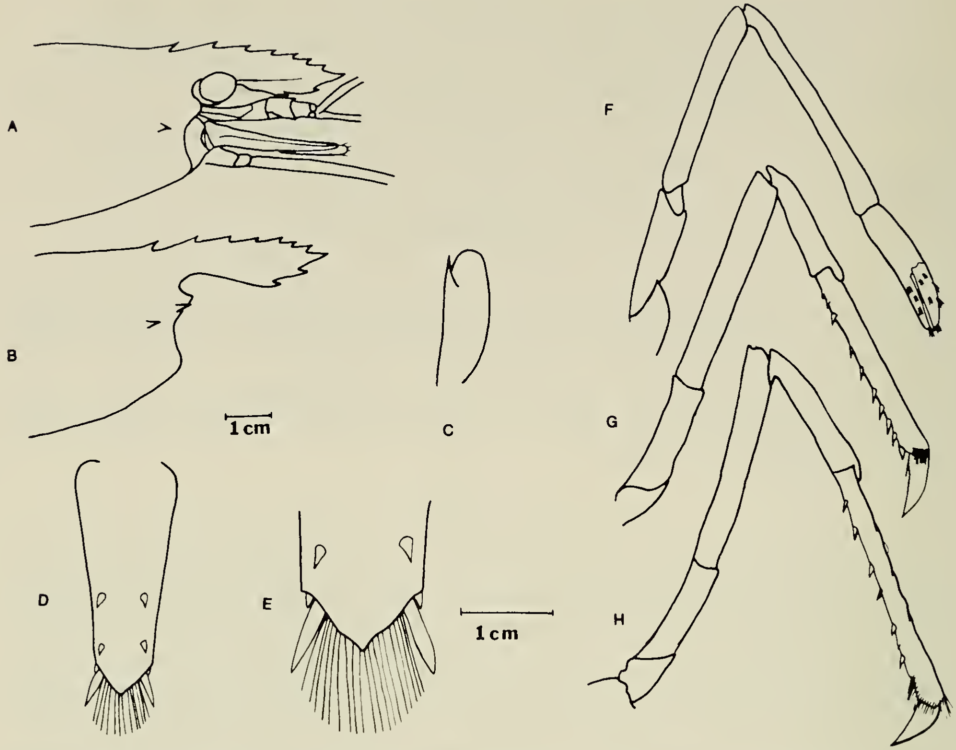

Fig. 1. *Macrobrachium quelchi*: A, Cephalothorax, lateral view; B, Cephalothorax, detail; C, Scaphocerite; D, Telson; E, Telson, detail; F, First pereiopod; G, Third pereiopod; H, Fifth pereiopod.

coll. Guido Pereira and Alfredo Paolillo; MBUCV (XI-2108) 6 ♂, 3 ♀; MBUCV (XI-2112) 3 ♂; same locality. 27 Mar 1983, coll. Guido Pereira and Alfredo Paolillo.

*Description.*—Rostrum straight, apex reaching distal margin of scaphocerite. Upper border bearing 6–8 regularly distributed teeth, first (proximal) always behind posterior limit of orbit. Lower margin with 2–3 teeth (commonly 2). Carapace smooth. Scaphocerite 3 times longer than wide. Abdomen smooth, posteroventral angle of fifth pleuron not acute. Sixth abdominal segment 1.25 times length of fifth, and 0.6 times length of telson. Telson, with 2 pairs of dorsal spines, situated at ⅔ and ⅖ of its length from base. Posterior margin with acute apex and bearing two pairs of lateral spines, inner pair overreaching median apex, and 18–20 plumose setae between the inner spines. First pereiopods slender, overreaching scaphocerite by ⅓ of distal carpus. Palm cylindrical, about 1.1 times length of dactyl. Carpus 3.2 times length of palm and 1.2 times length of merus. Second pair of pereiopods subequal in shape and length, major leg with distal part of merus reaching anterior border of scaphocerite. Fingers short and strong, gaping when closed; both fingers with conspicuous teeth. Dactyl with a strong tooth at distal third and row of 3–4 small teeth on proximal third. Fixed finger with strong tooth at midlength and row of 3–4 small teeth behind. Fingers without tubercles. Palm cylindrical, 3.5 times longer than high, about 1.8 times length of dactyl,

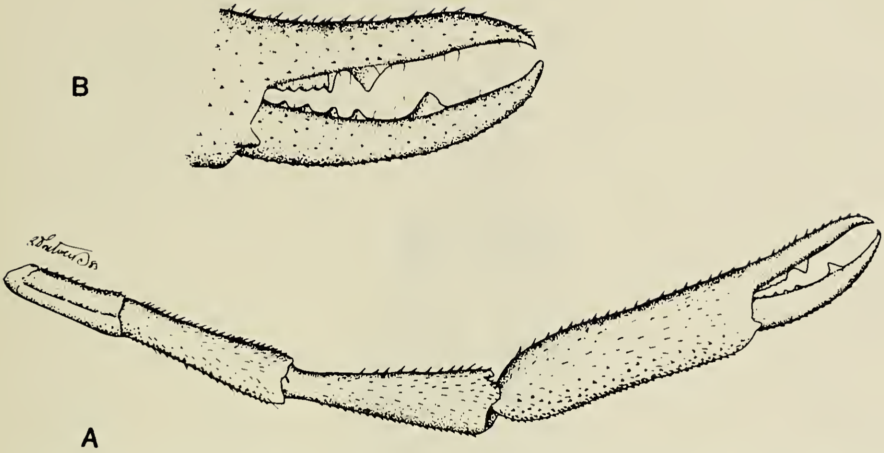

Fig. 2. *Macrobrachium quelchi*: A, Second pereiopod (5×); B, Second pereiopod, detail (10×).

with numerous longitudinal rows of short spines, those on lower surfaces longer. Carpus 0.75 times length of palm and 1.2 times length of merus, spinulation pattern as in palm. Ischium with only few ventral spines. Third pair of pereiopods with dactyl reaching distal border of scaphocerite. Propodus about 3.2 times length of dactyl and 1.75 times length of carpus, with longitudinal row of 15–17 spines on inner margin. Fifth pair of pereiopods with dactyl reaching border of scaphocerite. Propodus about 4.4 times length of dactyl and 1.7 times length of carpus, with longitudinal row of 15–17 spines on inner margin.

*Size.*—The largest male measures 52.7 mm tl and 15 mm cl. Females smaller than male.

*Fecundity.*—One ovigerous female, 50 mm tl and 13 mm cl with 15 oval eggs (2.5 mm largest diameter).

*Color.*—Adult males with a background pale green color, with non-uniform dark green spots scattered around the body in no definite pattern. Pereiopods 3–5 pale green, with 6–7 dark green horizontal stripes, 1 on ischium, 2–3 on merus

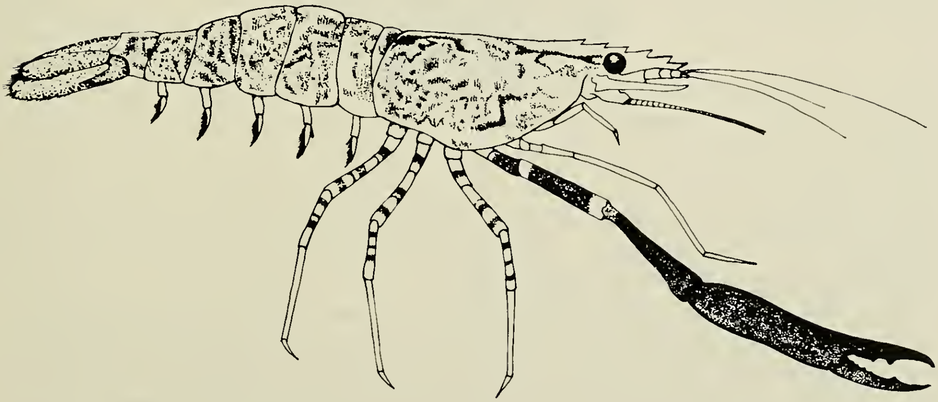

Fig. 3. *Macrobrachium quelchi*: lateral view (1.5×).

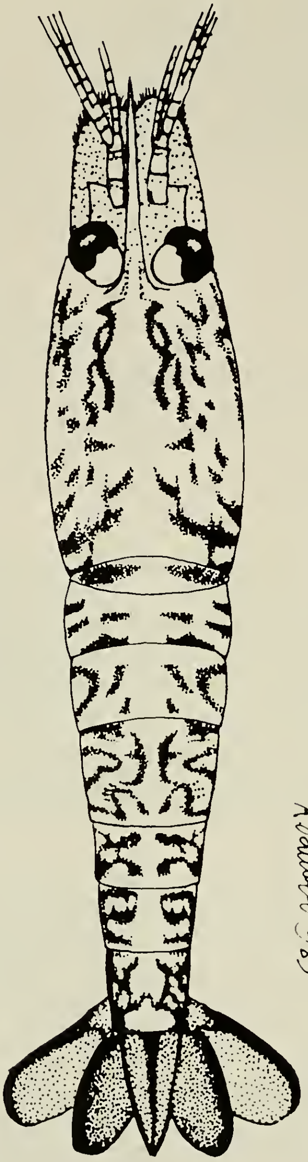

Fig. 4. *Macrobrachium quelchi*: dorsal view (1.5×).

and 3 on carpus. Second pair of legs, generally dark green (almost black), with 2 narrow stripes proximally and distally on merus. Some specimens with a clear green area on dorsal surface of propodus.

*Remarks.*—Two syntypes of *M. quelchi,* on loan from the British Museum, were studied. There are no major differences between these specimens from Guyana and those found in Venezuela. The palm of the second leg is more inflated in the syntypes, but these animals are larger, more robust and probably older than those from Venezuela.

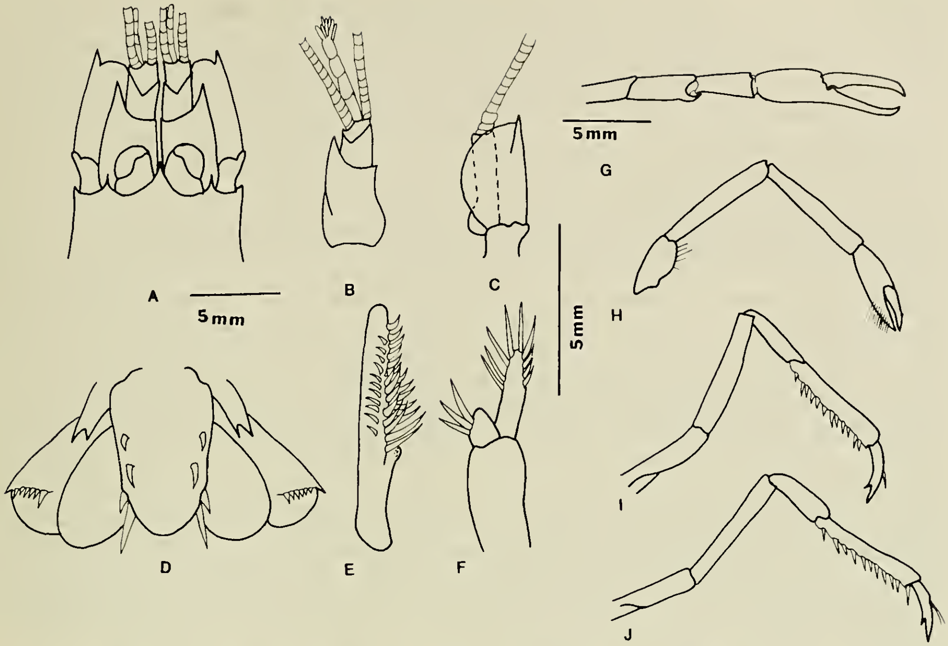

Fig. 5. *Euryrhynchus pemoni,* male paratype: A, Anterior part, dorsal view; B, Antennule; C, Antenna; D, Telson and Uropods; E, Appendix masculina; F, First pleopod; G, Second pereiopod; H, First pereiopod; I, Third pereiopod; J, Fifth pereiopod.

### Subfamily Euryrhynchinae Holthuis, 1951

### *Euryrhynchus pemoni,* new species

Fig. 5

*Material examined.*—Holotype ♂ tl 15.5 mm; cl 5.3 mm. USNM 216240, Creek in La Gran Sabana road, between Sn. Rafael Town and Kama Fall, Venezuela (6°15′N, 60°1′W), 27 Mar 1983, coll. Guido Pereira and Alfredo Paolillo. Paratypes: 3 ♀ USNM 216241; 1 ♂, 2 ♀ USNM 216242; 1 ♂ USNM 216243, same data as holotype. 2 ♂, 4 ♀ MBUCV (XI-1980). Creek near Chirimata indigenous town. La Gran Sabana, Venezuela (6°15′N, 60°1′W), 27 Mar 1983, coll. Guido Pereira and Alfredo Paolillo.

*Description.*—Rostrum depressed, triangular, ending acutely, failing to reach anterior border of eyes. Antennal spines conspicuous, placed slightly above lower orbital angle, tip reaching beyond posterior margin of cornea. Pterygostomian angle forward produced and sharp, failing to reach beyond tip of rostrum. Abdomen smooth, pleura of first 5 somites rounded. Sixth somite 1.6 times as long as fifth, 0.75 times length of telson. Telson broad, with 2 pairs of dorsal spines; anterior pair lying distally on first ⅓ and posterior pair on beginning of distal ⅓. Posterior pair longer than anterior pair, placed farther from lateral margin of telson. Posterior margin wide, rounded, with 2 pairs of lateral spines, inner larger than outer; 18–22 plumose setae around margin. Eyes with distinctly pigmented cornea. Antennule peduncle, trisegmented, anterolateral angle of first segment produced into sharp pointed process reaching distal part of second segment. Latter shorter than third segment, with anterolateral angles produced. Third segment shortest, with 3 antennular flagella, 2 long and slender, with numerous segments; third flagellum broader, short, with 4 similar segments; distal segment with numerous setae on apex. Scaphocerite slightly longer than antennular peduncle, about ⅓ longer than wide. Outer margin straight, with anterolateral spine slightly overreaching lamella. Mouth parts typical of genus (cf. Holthuis 1966).

First pereiopod, slender, reaching with ⅔ of carpus beyond scaphocerite, smooth, with only scattered hairs. Fingers 0.9 length of palm, without teeth on cutting edges. Carpus 2.5 times length of palm, about same length as merus. Second legs equal or subequal, reaching with ⅓ of carpus beyond scaphocerite, smooth, with only scattered hairs. Fingers ½ length of palm; cutting edges smooth except for small tooth basally on both; dactylar tooth less prominent and situated distal to that on fixed finger. Carpus 0.75 length of palm. Merus 1.2 times length of carpus, with prominent mesial spine situated anteromesially on lower surface. Third leg reaching with distal propodus to border of scaphocerite; dactyl bifid, bearing 2 distinct spines on anterior third of outer margin. Propodus 3.1 times length of dactyl, bearing longitudinal row of 9–11 spines on posterior margin. Carpus twice length of dactyl and 0.5 length of propodus. Merus same length as propodus. Fifth pereiopod reaching with dactyl to border of scaphocerite. Dactyl bifid, propodus 3.2 times length of dactyl, with longitudinal row of 9 spines on posterior margin. Carpus, 0.5 times length of propodus; merus same length as propodus.

Female: Similar to male but second legs not so strong.

*Size.*—Largest male 15.5 mm tl and 5.3 mm cl; largest female 18.5 mm tl and 6.9 mm cl.

*Fecundity.*—One ovigerous female, 16.6 mm tl and 5.5 mm cl had 11 eggs (oval in shape) with longest diameter 1.7 mm. Another female 15.2 mm tl and 5.3 mm cl has the pleura of the second abdominal segment especially enlarged, forming a brood pouch (sensu Holthuis 1966) containing only one egg with a well developed larva. This egg measured 1.9 mm largest diameter.

*Etymology.*—The name "pemoni" is derived from the word "Pemon," a general name for the indigenous people of this region.

*Remarks.*—The present species is closely related to *E. burchelli* Calman, and *E. wrzeniowskii* Miers. *Euryrhynchus pemoni* can be differentiated by the second legs which have no spines on the carpus and only one on the merus, while there are three spines in *E. burchelli,* one on the carpus and two on the merus, and no spines in *E. wrzeniowskii* (sensu Tiefenbacher 1978). Recently, Kensley and Walker (1982) compared gonopod morphology of the species of *Euryrhynchus.* The gonopod of *E. pemoni* resembles that of *E. burchelli* in that the lateral row of longitudinal spines does not reach the apex, but the present species has 3 rows of longitudinal spines compared to 2 in *E. burchelli.*

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# REVIEW OF THE FORAMINIFERAL GENUS *ORBIGNYNELLA* SAIDOVA, 1975

Drew Haman

*Abstract.*—*Orbignyella* Saidova, 1975, is rejected as a junior objective synonym of *Neoglabratella* Seiglie and Bermudez, 1965.

Saidova (1975) established the genus *Orbignynella* to accommodate Recent Pacific Ocean discorbid specimens. She selected *Discorbis wiesneri* Parr, 1950, as the type-species for this genus. *Orbignynella* was retained as a valid genus and included in a systematic review of Cainozoic benthic Foraminifera (Saidova 1981). *Discorbis wiesneri* Parr, 1950, had, however, been selected earlier by Seiglie and Bermudez (1965) as the type-species for their new genus *Neoglabratella.*

The species *Discorbis wiesneri* Parr, 1950, should be retained in the genus *Neoglabratella* Seiglie and Bermudez, 1965, and the genus *Orbignynella* Saidova, 1975, rejected as a junior objective synonym of *Neoglabratella* Seiglie and Bermudez, 1965 (ICZN Art. 61b).

## Acknowledgments

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# STUDIES IN NEOTROPICAL SENECIONEAE IV. NEW TAXA IN *SENECIO* AND *CABRERIELLA*

Jose Cuatrecasas

*Abstract.*—Two new species of *Senecio* (Compositae) from Peru are described. *Senecio dolichodoryius* from Chachapoyas belongs to section *Dendrophorbium,* and its relationship with the other members of the section are discussed; *S. kingsbishopii* is closely related and differentiated from *S. flacciifolius* Wedd. Also, a transfer of *S. oppositicordius* to *Cabreriella* is made.

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## *Senecio dolichodoryius* Cuatr. sp. nov.

Frutex ad 3 m alta caule ramisque viridibus medullosis. Rami terminales valde foliosi erecti vel ascendentes subteretes moderate striati intus medullosi extus pilis minutis patulis vel antrorsis plus minusve copiosis muniti et cum velo tenuiter membranaceo hyalino fragile ad modum squamarum partiale deciduo. Folia alterna crasse coriacea petiolata. Laminae longi-lanceolatae basi paulo angustatae subacutae vel subobtusae, vel praecipue distales acute cuneatae, ad apicem longi-attenuatae acutissimae, (16–)19–38 × (2.6–)2.9–7.6 cm, ratio (4.2)5–6.5(–7.3) : 1; margine argute dentatae dentibus triangularibus subacutis 0.7–1 mm longis cum minoribus 0.3–0.5 mm longis alternantibus, 2–4 inter se distantibus, apice calloso-incrassato submucronato (glanduloso); adaxiale virides tactu laeves, minutissime scrobiculatae, costa subplana bene notata nervis secundariis fere obsoletis, superficie glabra sed velo hyalino fragile irregulariter secedenti, ad costam sparsis pilis minutis glandulosis; abaxiale itidem squamoso-velatae visu argute discolore nervatae, costa valde prominenti striata laevi glabra sed hyalino-squamosa, nervis secundariis patulo-ascendentibus angustis sed prominentibus prope marginem curvatis tenuioribusque anastomosantibus, nervis alternantibus intermediis brevioribus, venulis minoribus in reticulum valde conspicum prominulum minute polygonalem anastomosatis; nervatio omnis brunnescens pseudo-pilosula cum squamis piliformibus irregularibus plus minusve tecta; alveolae pallidae planae laeves cereae. Petiolus 2–4.7 cm longus robustus sursum subplanus deorsum canaliculatus, abaxiale striatus, basi triangulare ampliatus et amplectens, ubique velato-squamosus.

Synflorescentiae monotelicae terminales corymboso-paniculatae, 15–30 cm longae, foliosae floribundae folia suprema paulo excedentes. Rami alterni robustiusculi striati proximales saepe valde longi ascendenti-fastigiati ceteri erecto-patenti omnes hyalini-squamosi et plus minus sparseque minute crassi-pilosuli. Ramuli numerosi ramificati striolati minute puberuli pilis subpatulis vel ascendentibus, ultimi teneri sed erecti. Pedicelli graciles longiusculi 5–30 mm longi recti vel paulo flexuosi. Folia subtendentia proximalia quam folia sterilia simillissima, sursum gradatim breviora; bracteae in ramis secundariis inferne foliaceae sursum bracteosae, lanceolatae in ramulis ultimis lanceolato-lineares acutissimae minute puberulae 5–1.5 mm longae.

Capitula cylindracea 9–11 mm longa radiata circulo ligulari expanso 16–20 mm diam. Involucrum cylindricum vel cylindro-campanulatum 6.5–7.5 mm altum 5–6 mm diametro, explanatum 14–16 mm diam. Phyllaria 13–12 in capitulo;

exteriora 6–7 mm longa 1.2–1.5(–2) mm lata, oblonga sursum attenuata acuminata apice acutissimo dorso crasso margine anguste membranaceo ad apicem papilloso-pilosulo papillis longiusculis saepe pyriformibus; interiora 5.5–6 mm longa 2–4 mm lata elliptica apice angustata acutaque dorso valde protrudo crasso marginibus late hyalino-membranaceis, omnia apice papilloso-pilosulo excepto glabriuscula. Bracteolae calyculares 4–6 herbaceae lineares acutae parce puberulae pilis minutis crassis apice papillosae, 1–4 mm longae, ad basim involucri et apicem pedicelli affixae. Receptaculum planum glabrum 3(–4) mm diam. alveolatum alveolis pentagonalibus moderate profundis marginibus ad angulos elevato-dentatis.

Flores radii ligulati 11–13. Corolla lutea 10–12 mm longa glabra, tubo 3.5–4.5 mm longo angusto ad faucem annulare incrassato, lamina 1.8–2.5 mm lata elliptica vel oblongo-elliptica basim attenuata apice obtusa minute 2–3-denticulata, conspicue 4-nervata nervis croceis notatis, adaxiale superficie mamillata. Stylus ramis circa 1.5 mm longis, faucem corollae paulo excedentibus lineis stigmaticis crassis conniventibus apice obtuso cum papillis crassioribus.

Flores disci hermaphroditi 20–36. Corolla lutea tubulosa glabra 6.5–7.5 mm longa, tubulo 3–3.5 mm, limbo tubuloso distale leviter ampliato, commisurale nervato, lobis oblongo-triangularibus mediale cum vena conspicua 1–1.2 mm longis apice incrassato papillosoque papillis crassis obtusis seu pryiformibus. Antherae 2.2–2.4 mm longae appendice apicale oblonga, lobis basi anguste breviterque auriculatis, cellulis endothecialibus oblongis in parietibus lateralibus seriate noduliferis. Collum 0.4–0.5 mm longum cum filamento valde crassius plus minusve lageniforme dilatatum cellulis subquadratis multiseriatis. Stylus 7–7.5 mm longus ramis circa 1.5 mm recurvis marginibus lineis stigmatibus duobus valde crassis adaxiale conniventibus, apice obtuso cum papillis crassulis paulo dilatato.

Ovaria circa 1.5 mm longa oblongo-ellipsoidea glabra conspicue 5-costata costis ductis resiniferis lutescentibus. Pappus albus 4.5–5 mm longus pilis strictis scabridis acutis 2–3-seriatis basi connatis.

*Type.*—Peru, Depto. Amazonas, Pcia. Chachapoyas: middle eastern Calla-Calla slopes, near km 411–416 of Leimabamba-Balsas road, 3100–3250 m, herb 1–3 m tall, locally frequent; rays and disc yellow; 11 Jul 1962, *J. J. Wurdack 1306* (US, holotype).

*Other collections.*—Peru, Depto. Amazonas, Pcia. Chachapoyas: Cerros Calla-Calla, 18 km above Leimabamba on road to Balsas, 3000 m, open forest below road ca. 1 km downhill from km 410, swampy, single stems 1½–2 m, rays golden yellow, 16 Jun 1964, *Hutchison & Wright 5684* (UC, paratype); 11 kms along road ascending mountain SE of Chachapoyas, 8700 ft., large shrub 3 m tall with rank odor, 20 Jan 1983, *Robert M. King & L. Earl Bishop 9261* (US, paratype); 58 km NE of Balsas on road to Chachapoyas, ca. 3400 m, shrub to 2 m, flowers yellow, 5 Jan 1979, *M. Dillon & B. L. Turner 1734* (US).

*Remarks.*—*Senecio dolichodoryius* belongs to section *Dendrophorbium* and is characterized by the combination of its leathery large, long-lanceolate, petiolate, minutely bidenticulate leaves which are adaxially smooth, by the radiate capitula of 13–12 medium-sized (6–7 × 1.8–4 mm) phyllaries, and by the similar size of disk corollas (7–7.5 mm). The branchlets and terminal inflorescences are very shortly puberulous with the cuticular velum or film covering almost every vegetative part at least at the earlier stage. This fragile film becomes fragmented and partially caducous and disintegrates, producing a kind of irregular, spreading pseudo-pubescence on the abaxial surface of the leaves.

The other species of the section can be easily distinguished from the new species as follows. The Bolivian species *S. tabacifolius* Rusby and *S. cabrerae* Cuatr. (including *S. myrianthus* Klatt, a discarded later homonym), have involucres with eight phyllaries and the first has, in addition, tuberculate, scabrous leaves. The Peruvian *S. castanaefolius* DC, and *S. submultinervis* Cuatr. and the Ecuadorian *S. ingens* Benoist have the involucre with 9–10 smaller phyllaries (3.5–5.5 mm). Two other Bolivian species, *B. conocephalus* Cabrera and *S. longilinguae* Cuatr., can also readily be separated by the 8-merous involucre, in addition to their sessile leaves. Among the majority of species with 13 (12–14) phyllaries there are the Bolivian *S. biserrifolius* Ktze. and *S. ayapoyensis* Cuatr. and the Peruvian *S. sandemanii* Cuatr. and *S. tergopurpureus* Cuatr. which have sessile leaves. The Colombian *S. moscopanus* Cuatr., *S. sibundoyensis* Cuatr. and *suazaensis* Cuatr. have leaves with broadly auriculate bases. *Senecio tipocochensis* Domke and *S. balsapampae* Cuatr. from Ecuador, *S. fortunatus* Cuatr. from Peru and *S. arboluco* Cuatr. from Colombia have involucres only 2.5–3.5 mm long. Conversely, *Senecio lloensis* of Ecuador is characterized by larger capitula with phyllaries 10–9 mm long. Of *S. chingualensis* Cuatr. and *S. dielsii* Domke, with 6–7(–8) mm long phyllaries, the first has rather thinner, broader and pubescent leaves and broad phyllaries, while the second possesses thicker, stronger branchlets and leaves with a scabrous upper surface, thicker capitula, harder phyllaries and overall white lanugineous, arachnoid indument. The remaining species *S. pururu* Cuatr. (Ecuador), *S. silvani* Cuatr. (Col.), *S. goodspeedii* Cuatr. (Peru), *S. multinervis* Sch. Bip., *S. unduavianus* Cuatr. (Bolivia), and *S. yalusay* Cabrera (Peru) have rather smaller heads with phyllaries 4–5 mm long, and, besides some other particular features, all have a more or less abundant lanate or arachnoid indument of thin, long, entangled trichomes which is completely lacking in *S. dolichodoryius*.

Few other species should probably join this section *Dendrophorbium*, and further study is necessary to improve the knowledge of its above-mentioned taxa. Many of those species are still only partially known through fragmentary specimens lacking complete mature vegetative leaves and branches. Much research is also needed on floral characters in order to help to define the limits of the sections and the closely related genera, like *Pentacalia*, into which the section *Dendrophorbium* might well be merged.

### *Senecio kingbishopii* Cuatr. sp. nov.

Suffrutex ad 1.5 m altus profuse ramosus et foliatus aspectu cinerascens. Rami ramulique alterni copiosi argute angulati vel striati densiuscule subadpresseque lanugineo-arachnoidei cinerei. Folia alterna cum lamina sessili crassiuscula lanceolato-oblonga apice acuta basi plus minusve ampliata auriculato-amplectenti, margine repando denticulata dentibus minutis mucroniformibus patulisque plana vel interdum revoluta; 40–60 × 4–13 mm; adaxiale tenuiter lanugineo-arachnoidea tantum costa magis lanata notata; abaxiale crasse densiuscule subadpresseque lanata pilis tenuissimis intricatis, costa infra indumentum prominenti striata sed leviter conspicua cum vestimento tecta, reliquis nervis obsoletis.

Inflorescentiae terminales corymbiforme paniculatae valde ramosae inferne foliatae et bracteosae, ramis ramusculisque striatis lanuginoso-cinereis. Folia subtendentes vel bracteae proximales hastato-lanceolatae, 5–2.5 cm longae 12–8 mm latae. Ramuli ultimi et pedicelli (1–8 mm longi) rigidi striati paulo arachnoidei plus copiosis pilis pluricellaribus crassiusculis tortuoso-flexuosis brunnescentibus valde conspicuis. Bracteae et bracteolae distales breves lineares acutae.

Capitula discoidea cylindracea 10–11 mm alta circa 6 mm diametro. Involucrum circa 9 mm longum, expansum 17–19 mm diam., viridi-grisaceum. Phyllaria 13–14(–17) in capulto tenuiter herbaceo-membranacea exteriora 8–9 × 1.2–1.5 mm, interiora 8 × 2 mm ad marginem late scariosa, omnia oblonga cum apice subite acutato et papilloso-piloso, abaxiale pilis albis strictissimis lanugineo-arachnoideis et pilis crassiusculis brunnescentibus flexuoso-tortuosis circa 1.5 mm longis valde motatis. Bracteolae calyculi 4–6 lineares vel anguste triangulares 2.5–5 mm longae etiam pubescentes. Receptaculum 2–2.5 mm diametro planum alveolatum alveolis pentagonalibus moderate profundis marginibus ad angulos dentibus triangulari-acutis.

Flores omnes hermaphroditi 27–45 in capitulo. Corolla lutea 6.5–7 mm longa glabra, tubulo circa 2.5 mm, limbo tubuloso sursum gradatim leviterque ampliato, lobis triangulare oblongis 0.8–1 mm longis apice marginibusque paulo incrassatis et minute papillosis. Antherae circa 2 mm basi attenuatae obtusaeque, appendice apicale oblonga 0.2–0.3 mm longa. Collum album crassum 0.5–0.7 mm longum cellulis quadratis longiseriatis. Ramuli styli curvati adaxiale lineis duobus stigmaticis marginalibus crassiusculis, apice obtuso minute papilloso cum papillis marginalibus longioribus patentibus radiatis. Ovarium circa 1.5 mm longum oblongum plus minusve conspicue 10-nervatum. Papus albus 6 mm longus pilis uniseriatis strictis acutis strigulosis.

*Type.*—Peru, Depto. Cajamarca: 62 km NE of Cajamarca along the road to Celendín, 10,000 ft. elevation; shrub ½ m tall, flowers yellow, 9 Jan 1983, *Robert M. King & L. Earl Bishop 9144* (US, holotype).

*Remarks.*—*Senecio kingbishopii* is closely related to *S. flaccidifolius* Wedd. from which it differs by the auriculate, amplectant leaves and by the lanate and arachnoid indument with additional thicker, brownish, flexuose, pluricellular trichomes which are conspicuous on branchlets and inflorescences.

*Senecio albotectus* Cuatr. Feddes Repert. 55(2/3):130. 1953.

This species had been erroneously transferred by the author to *Pentacalia* (Phytologia 49(3):252. 1981). It is to be kept in the genus *Senecio* and its section *Latiflorus,* as it was suggested in the original publication (l.c. pag. 131).

*Cabreriella oppositicordia* (Cuatr.) Cuatr., comb. nov.

*Senecio oppositicordius* Cuatr. Feddes Repert. 55(2/3):142–143. 1953.

*Type.*—*Grant 10862* (F, holotype; US, isotype).

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# A NEW ENTOCYTHERID OSTRACOD OF THE GENUS *DACTYLOCYTHERE*

Arnold W. Norden and Beth B. Norden

*Abstract.*—A new species of entocytherid ostracod, *Dactylocythere scotos,* is described from Pennsylvania and Maryland. Comparisons are made with its most closely related cogeners, *D. crawfordi* and *D. phoxa.*

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While surveying the entocytherid ostracods of Maryland, an undescribed species belonging to the genus *Dactylocythere* was found at a single locality in the mountainous western portion of the state. Subsequently, Dr. Horton H. Hobbs, Jr., obtained additional specimens of this ostracod from crayfish collected by A. E. Ortmann in Beaver County, Pennsylvania, in 1905. We thank Dr. Hobbs for allowing us to include the Pennsylvania material in this description, for critically reading this manuscript, and assisting us in other ways too numerous to mention.

### *Dactylocythere scotos,* new species
Fig. 1

*Description.*—Male: Eye pigmented, situated about one-fifth shell length from anterior end. Shell (Fig. 1d) ovate but ventral margin slightly concave, greatest height distinctly posterior to midlength, posteroventral prominence lacking. Marginal setae sporadic around entire shell, most abundant along posterodorsal margin. Sternal spine not discernible.

Copulatory complex (Fig. 1a) with peniferum tapering to acute apex directed anteroventrally; peniferal groove generally narrow but widening slightly toward tip. Penis situated approximately at base of ventral one-third of peniferum, distal to base of clasping apparatus. Finger guard relatively thin, almost straight, and with rounded distal extremity entire. Clasping apparatus (Figs. 1a, b) L-shaped with vertical ramus thickened and with massive, angular shoulder on postaxial border; preaxial border of horizontal ramus with four evenly spaced teeth, fourth tooth extending as ridge obliquely across ramus toward postaxial border; apex with two denticles. Accessory groove simple, extending dorsally to level of dorsal margin of spermatic loop.

Female: Eye pigmented, situated about one-fourth shell length from anterior end. Shell (Fig. 1e) ovate, with greatest height distinctly posterior to midlength. Submarginal setae disposed as in male.

Genital apparatus (Fig. 1c) with prominent, strongly curved J-shaped rod and flared amiculum supported by U-shaped thickenings.

*Size.*—The lengths (in μm) of ten males range from 457 to 492, average 471; the heights range from 265 to 293, average 279; corresponding measurements of ten females are 473 to 522, average 487, and 268 to 299, average 292.

*Type-locality.*—Baden, Beaver County, Pennsylvania; from *Cambarus* (*Lacunicambarus*) *diogenes* Girard, 1852, coll. A. E. Ortmann, 26 Jul 1905.

*Disposition of types.*—The holotypic male and allotypic female are deposited

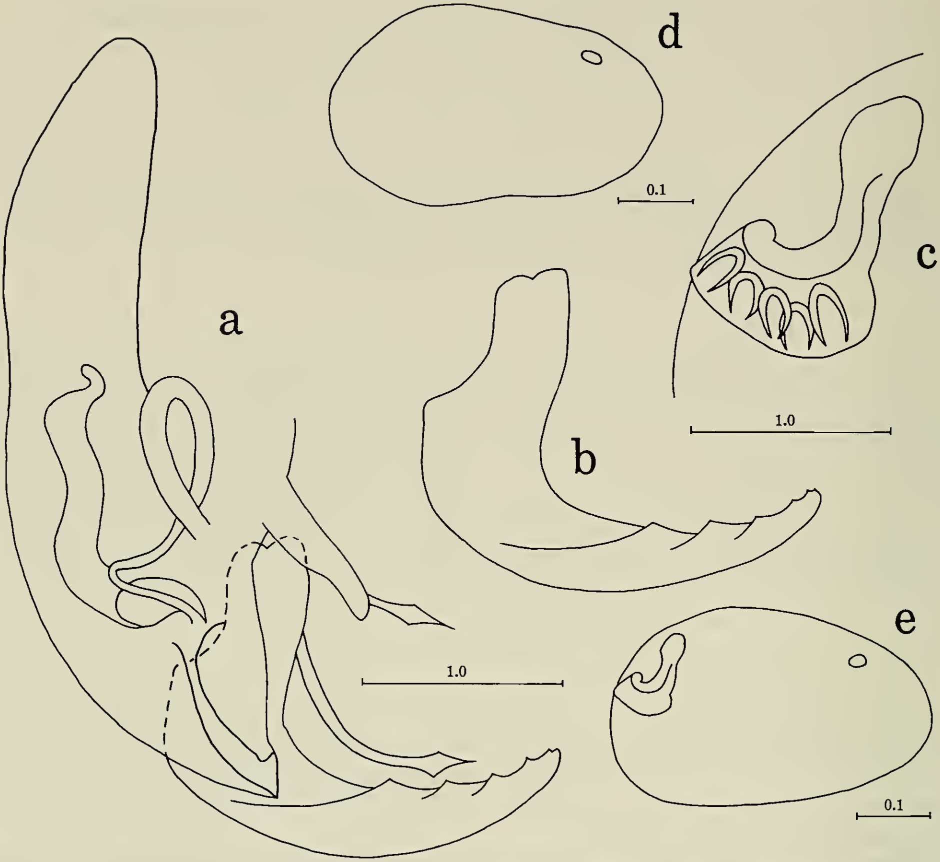

Fig. 1. *Dactylocythere scotos*: a, Copulatory complex of male; b, Clasping apparatus of male; c, Genitalia of female; d, Shell of male; e, Shell of female. (Scales in mm.)

in the National Museum of Natural History, Smithsonian Institution, USNM 210690. Paratypes are in the Smithsonian Instutition, and the collection of the authors.

*Range.*—In addition to the type-locality, *Dactylocythere scotos* has also been found on *Cambarus diogenes* taken from burrows around Deep Creek Lake at McHenry, Garrett County, Maryland, by A. Norden and B. Norden on 16 June 1976.

*Host.*—The host at both known localities was *Cambarus diogenes.* Also present at the Maryland locality were *Cambarus* (*Cambarus*) *bartonii bartonii* (Fabricius, 1798), *Procambarus* (*Ortmannicus*) *acutus acutus* (Girard, 1852), and *Orconectes obscurus* (Hagen, 1870). Although large series of each of these three species were examined, no *D. scotos* were recovered.

*Entocytherid associates.*—One *Donnaldsoncythere donnaldsonensis* was recovered from collections containing *D. scotos.*

*Relationships.*—*Dactylocythere scotos* appears to have its closest affinities with *D. crawfordi* Hart, 1965, and *D. phoxa* (Hobbs, 1967). The most striking similarity is in the clasping apparatus of the male in which the horizontal ramus is much longer than the short, heavy vertical ramus which bears a conspicuous shoulder on the postaxial margin. Similar also is the simple finger guard and the length of the accessory groove, which reaches the dorsal extremity of the spermatic loop. It and *D. phoxa* differ from *D. crawfordi* in possessing a heavier vertical ramus of the clasping apparatus and a subtriangular ventral part of the peniferum. It differs from *D. phoxa* in that the proximal tooth on the preaxial margin of the horizontal ramus is not digitiform, rather little different in size and shape from the second tooth, and the peniferal groove opens anteriorly rather than apically.

*Etymology.*—From the Greek, *scotos,* meaning darkness, in reference to the apparent restriction of this species to the burrowing crayfish, *C. diogenes.*

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# A NEW MARINE GENUS OF THE *MAERA* GROUP (CRUSTACEA: AMPHIPODA) FROM BELIZE

James Darwin Thomas and J. L. Barnard

*Abstract.*—A new genus and species, *Dumosus atari* of the *Maera* group from coral rubble at Belize is described. It is related to *Gammarella* and is probably cryptic. The eyes are reduced. *Dumosus* differs from *Gammarella* in the loss of medial setation on the maxillae, reduction of article 3 on the mandibular palp, loss of article 2 on the outer ramus of uropod 3, and in the loss of major spination on the plates of maxilla 1 and the maxilliped; in contrast to *Gammarella, Dumosus* retains the plesiomorphic uropod 3 typical of the *Maera*-group.

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## Legend for Figures

Capital letters in illustrations are explained in the following list; lower case letters to the right of capital letters or in the body of an illustration are explained also in the following list; lower case letters to the left of capital letters are provided for subsidiary figures to note illustrated specimens listed in "Material." For each page of figures one main specimen is called "unattributed" and lacks letter designation. B, body; C, coxa; D, dactyl; G, gnathopod; I, inner plate; L, labium; M, mandible; O, outer plate or ramus; P, pereopod; R, uropod; S, maxilliped; T, telson; U, labium; V, palp; W, pleon; X, maxilla; Y, gill; o, opposite; r, right.

## *Dumosus,* new genus

*Diagnosis.*—Head and antennae of *Elasmopus*-form, thus rostrum small, anteroventral antennal sinus small but notch absent, antenna 1 of medium length, article 2 nearly as long as 1, article 3 much shorter, accessory flagellum 3-articulate; antenna 2 very short, slightly exceeding article 2 of antenna 1, flagellum very short, not longer than article 5 of peduncle, 4-articulate.

Prebuccal mass weakly extended anteriorly, upper lip rounded below. Mandibular incisors toothed, laciniae mobiles and rakers present on both sides, molar triturative, with large seta on right, small seta on left, palp article 1 scarcely elongate, article 2 naked, article 3 about 70 percent as long as 2, slender, linear, with 1 D-seta, 2 E-setae. Lower lip with fleshy inner lobes and well developed mandibular lobes. Inner plate of maxilla 1 with 1 apical, 1 subapical medial seta, outer plate with 7 spines, palp article 1 elongate, armament of right and left palps asymmetrical. Plates of maxilla 2 slender, inner with one medial seta. Inner plate of maxilliped lacking thick spines, bearing only setae, outer plate with medial and apical spines, palp poorly setose, article 3 with apical hook, dactyl stubby, with medium nail.

Coxae of ordinary length, poorly setose, coxa 1 quadrate, unproduced anteriorly, coxae 1–2 with posteroventral tooth-notch, coxa 3 slightly the narrowest of coxae 1–4, posterodorsal excavation shallow, coxa 5 much shorter than 4, lobes of coxae 5–6 shallow. Simple gills on coxae 2–6; female unknown.

Gnathopod 1 small, of melitid form, carpus and propodus subequally long, carpus not lobed, propodus with stiff posterior setal-spines, palm oblique, weakly sculptured. Male gnathopod 2 greatly enlarged, metacarpus with posterodistal sharp tooth (thus almost metacarpochelate), carpus short, strongly lobate, hand large, pyriform, palm and hind margin continuous, palm undefined, armed with few spines and many long apically curved bulbar setae, dactyl much shorter than false palm.

Pereopods 3–4 ordinary, slender, pair of locking spines asymmetrical, dactyl with 2 main inner setules near base of nail, no outer tooth. Pereopods 5–7 of short form but increasingly elongate from 5 to 7, of reverted form, article 2 on pereopods 5–6 of narrow pyriform shape with weak posterior sinuosity, posteroventrally lobate, posterior serrations weak to moderate respectively, remaining articles slender; pereopod 7 with shield-like article 2 bearing medium castellations posteriorly.

Pleopods well developed, peduncle long, rami equally long. Pleon unarmed dorsally. Epimera diverse, third dominant, epimeron 1 with subventral ridge, naked ventrally, with small posteroventral tooth, epimeron 2 with lateral ridge, one facial spine, large posteroventral tooth; epimeron 3 nearly straight behind, with medium tooth and posteroventral serrations below main tooth, 1 facial spine.

Uropod 1 with strong basofacial spine, strong apicolateral spine; uropods 1–2 with long apical spines, outer ramus of uropod 1 lacking marginal spines, other rami with few marginal spines. Uropod 3 small, aequiramous, not exceeding uropods 1–2, peduncle short, rami lanceolate, sharp, inner only with tiny apical armament, outer similar apically also with 2 sets of lateral armaments. Telson short but longer than broad, deeply cleft, each apex bifid, with one spine and setule, each lobe with subapical lateral setule set.

*Type-species.*—*Dumosus atari,* new species.

*Etymology.*—Dumosus from "covered with thorn bushes" referring to gnathopod 2, and atari, a Carib Indian word for star.

*Relationship.*—The present genus differs from *Maera* in the *Elasmopus*-like male gnathopod 2 lacking defined palm. As far as we know, no species of *Maera* has a shield-like article 2 on pereopod 7, nor the degree of diversity of pereopods seen in this species.

This genus differs from *Elasmopus* in the linear article 3 of the mandibular palp, with lanceolate and poorly armed rami of uropod 3. It bears close resemblance to *Lupimaera* Barnard and Karaman (1982) (based on *Maera lupana* J. L. Banard, 1969) but the rami of uropod 3 are slender and poorly armed, coxa 5 is short, and article 2 of pereopods 5–7 is diverse, unlike *Lupimaera.*

Unlike *Meximaera* Barnard (1969), the new genus has enlarged and non-female-like gnathopod 2, poorly armed rami of uropod 3, poorly armed mandibular palp, and diverse pereopods 5–7.

A superficial resemblance occurs between this genus and the Caribbean cave genus *Paraweckelia* Shoemaker (1959). Although *Paraweckelia* appears less specialized in the presence of more medial maxillary setae, non-diverse pereopods 5–7, long and spiny rami of uropod 3, and longer antennae, *Paraweckelia* is more specialized in the apomorphic telson.

Because of the poorly developed rami of uropod 3 and diverse pereopods 5–7, *Dumosus* cannot be ancestral to hadziids and weckeliids.

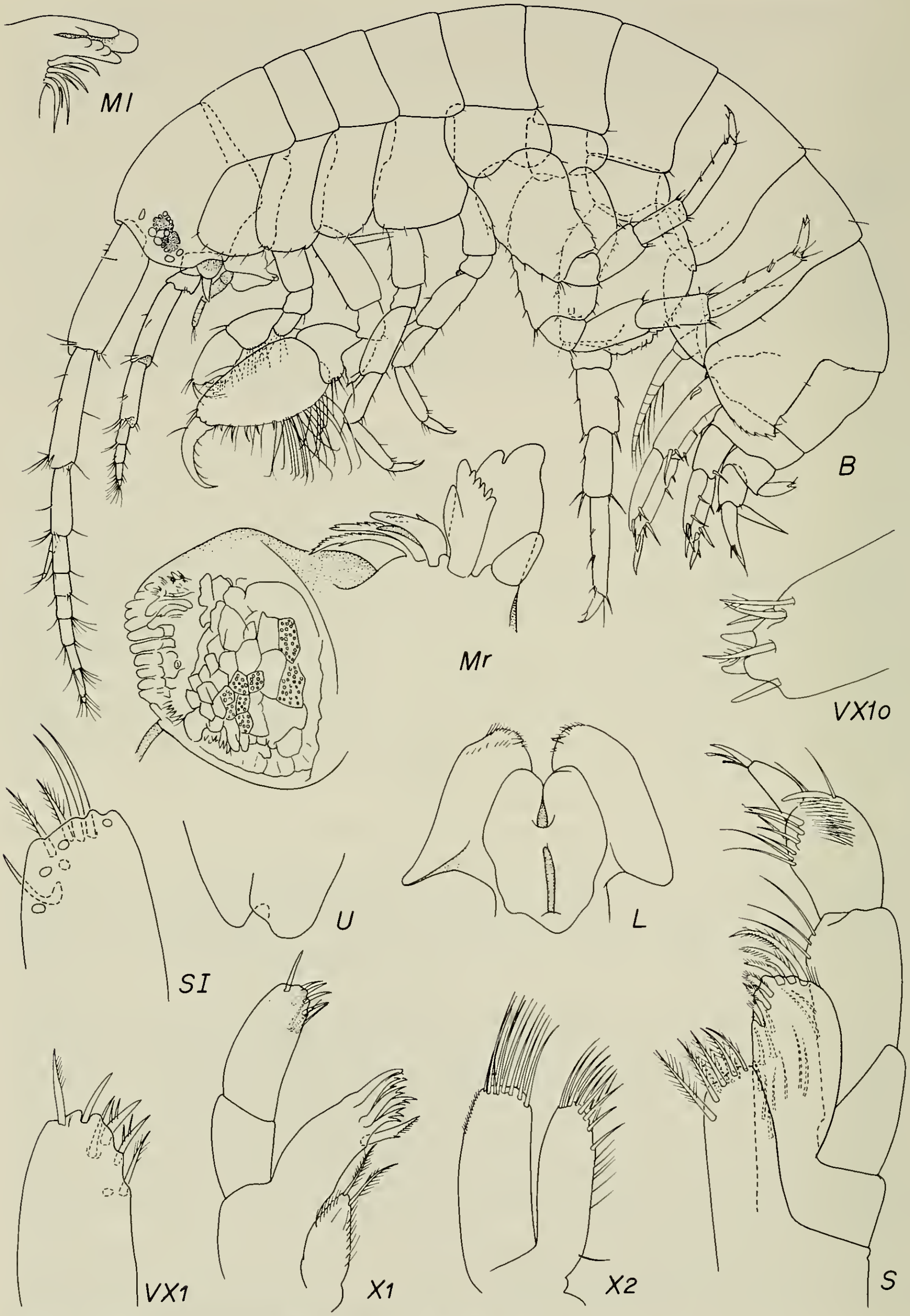

Fig. 1. *Dumosus atari,* new species, holotype, male "x."

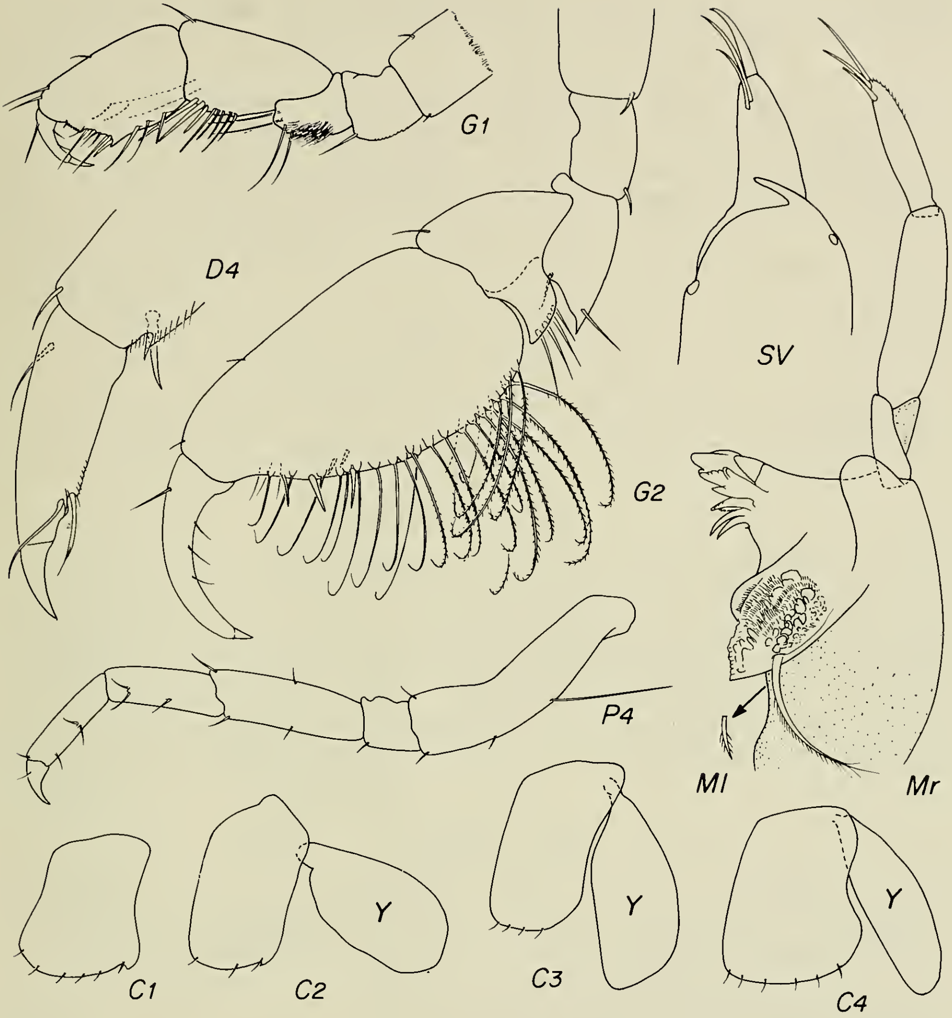

Fig. 2. *Dumosus atari,* new species, holotype, male "x."

The shield-like pereopod 7 is comparable to *Gammarella* Bate (see Chevreux & Fage 1925 as *Pherusa* [=*Nuuanu,* =*Cottesloe*] and *Tabatzius* McKinney and Barnard (1977), from the Caribbean Sea, but those genera differ from our new genus in the fully setose medial margins of the maxillae and the non-falcate article 3 of the mandibular palp lacking most D-setae. It is possible to build a plesiomorphic-apomorphic sequence of evolution from the base stock of *Gammarella* to *Dumosus* through loss of medial maxillary setae, reduction in mandibular palp article 3, loss of article 2 on the outer ramus of uropod 3, loss of major spines on inner plate of maxilliped, loss of several spines on the outer plate of maxilla 1 and retention of the primitive elongate inner ramus of uropod 3. The two genera (and the similar *Tabatzius*) share similar gnathopods, telson, pereopods, and many similarities in body form, head, antennae, mandibles, maxillipeds and pleon.

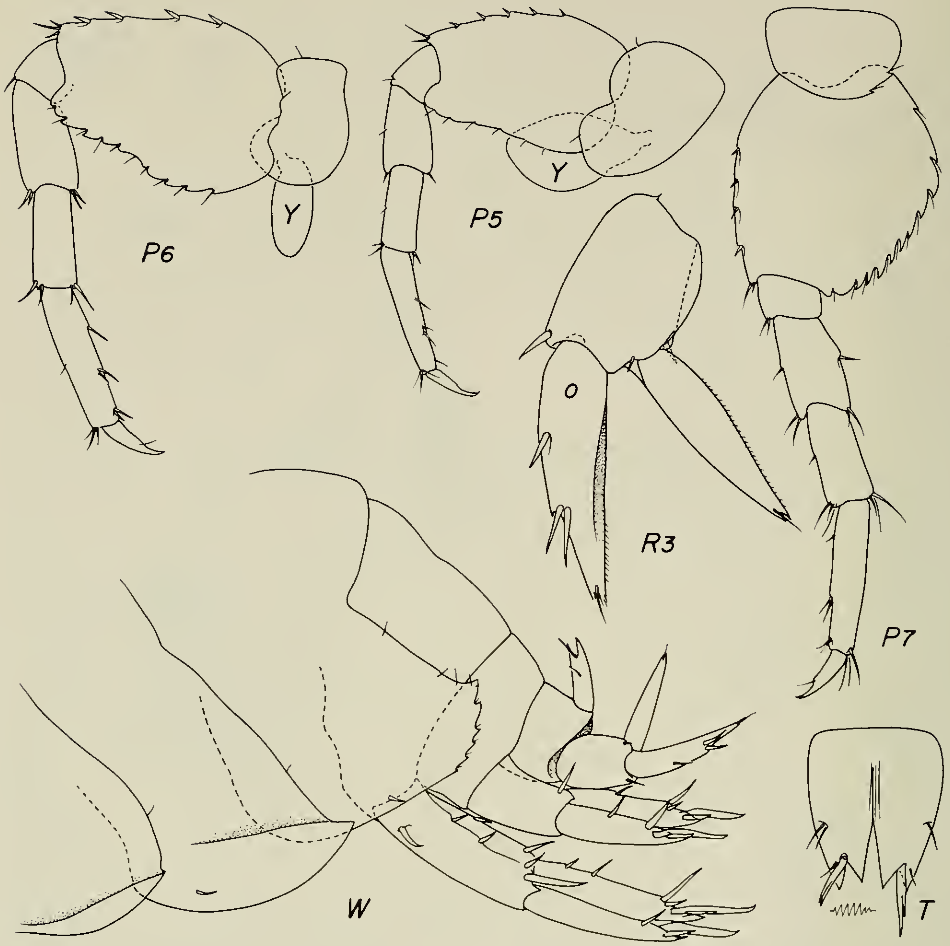

Fig. 3. *Dumosus atari,* new species, holotype, male "x."

There is a superficial resemblance of *Dumosus* to *Ceradocopsis* (see Barnard and Karaman 1982), from the southern hemisphere, in the shortness of uropod 3, form of head, antennae, gnathopods, mandibles, maxilliped, uropods 1–2 and telson, but *Ceradocospis* has more medial maxillary setae, less shield-like pereopod 7 and bears an article 2 on the outer ramus of uropod 3.

### *Dumosus atari,* new species
Figs. 1–3

*Description of unique male, 1.96 mm.*—Eyes composed of ochre-brown pigment mass with several clear, mostly anterior ommatidia extending outward, one detached gangliar ommatidium dorsally. Flagellum of antenna 1 shorter than articles 2–3 of peduncle combined. Article 4 of antenna 2 with weak apical hump; gland cone large, basal article small.

Mandibular incisors with articulate accessory tooth on medialmost edge, right and left rakers 3, with interrakers. Inner plate of maxilliped with scythe-like ventral coupling hook.

Article 4 of gnathopod 1 pubescent; dactyls of gnathopods with apical nail and inner setules. Pereopod 3 like illustration of pereopod 4 but slightly larger.

Peduncle of pleopods elongate, usually with one lateral seta, 2 coupling hooks, rami extending equally, as long as peduncle, 5-articulate. Peduncle of uropod 2 with one apicomedial spine.

*Holotype.*—USNM 195138, male, 1.96 mm. Unique specimen with left pereopod 5 missing.

*Type-locality.*—Carrie Bow Cay, Belize, 24 Jun 1982, formalin wash of coral rubble from back reef, 0.5–1.0 m, coll. J. D. Thomas.

*Remarks.*—We have searched for this species again at Belize several times and in many other Caribbean localities to no avail; its clearly distinct generic position, and the excellent condition of the specimen makes it possible to describe.

## Acknowledgments

We would like to thank the Scholarly Studies Program, administered by Assistant Secretary for Science, Dr. David Challinor, Smithsonian Institution, for support during this study. The first author was also supported by NSF grant DEB8121128. Dr. Klaus Rützler, Director of the Smithsonian Western Atlantic Mangrove Project (SWAMP) kindly provided field facilities in Belize. Mike Carpenter of the Smithsonian also provided the first author with invaluable assistance in the field. We would like to thank Linda B. Lutz, Mobile, Alabama, for inking the plates.

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# SCALPELLOID BARNACLES FROM THE UPPER CRETACEOUS OF SOUTHEASTERN NORTH CAROLINA

Victor A. Zullo and Norman F. Sohl

*Abstract.*—*Zeugmatolepas* sp. and *Virgiscalpellum inornatum,* new species, occur in the Upper Cretaceous (Campanian) Black Creek Formation at Donoho Creek Landing, Cape Fear River, North Carolina. These are the first barnacles to be described from the Cretaceous of the Atlantic Coastal Plain.

Capitular plates of two scalpelloid barnacles were collected from a medium- to coarse-grained sand near the top of the Upper Cretaceous (Campanian) Black Creek Formation at Donoho Creek Landing on the Cape Fear River in Bladen County, North Carolina (Fig. 1). One series of small plates, tentatively identified as carinae, rostra and lower latera, is from an undetermined species of *Zeugmatolepas* Withers. The only previous North American record of *Zeugmatolepas* is that of Hattin (1982) from the Smoky Hill Chalk Member of the Niobrara Formation in western Kansas. Otherwise, *Zeugmatolepas* is known from Europe, the South Georgia Islands, western South America and western Australia.

The larger and more abundant plates from Donoho Landing include carinae, scuta and terga of a new species of *Virgiscalpellum* Withers. This new species is similar to *V. gabbi* (Pilsbry) from the Ripley and Prairie Bluff Formations of Tennessee, Mississippi and Alabama, but is readily distinguished on ornamentation, location of umbones, and shape of plates. *Virgiscalpellum* is known only from Cretaceous rocks in western Europe and the Americas.

Although Cretaceous barnacles have long been known from the Western Interior and Gulf Coast regions of North America (see Collins 1973; Hattin 1977), the Black Creek specimens constitute the first Cretaceous barnacle records for the Atlantic Coastal Plain.

## Stratigraphic Setting

The barnacles were obtained during an investigation of the Black Creek-Peedee formational contact along the Cape Fear River (Sohl and Christopher 1983). The Black Creek Formation of Campanian age (*Exogyra ponderosa* Zone) is overlain disconformably by the Peedee Formation of Maestrichtian age (*E. costata* Zone). At Donoho Creek Landing (Fig. 2), units 1 through 4 represent the Black Creek Formation and contain *E. ponderosa erraticostata* (Stephenson), *E. costata spinosa* Stephenson and *Flemingostrea pratti* (Stephenson), indicating assignment to the uppermost part of the *E. ponderosa* Zone. Barnacle plates are abundant in unit 2 (USGS localities 31796, 31868), and are associated with a nearshore, marine megafossil assemblage of epifaunal suspension feeders.

*Locality description.*—U.S. Geological Survey (Mesozoic Invertebrate Collection) localities 31796, 31868. Black Creek Formation, unit 2, Donoho Creek Landing, milepost 50.25 on west bank of Cape Fear River, Bladen County, North

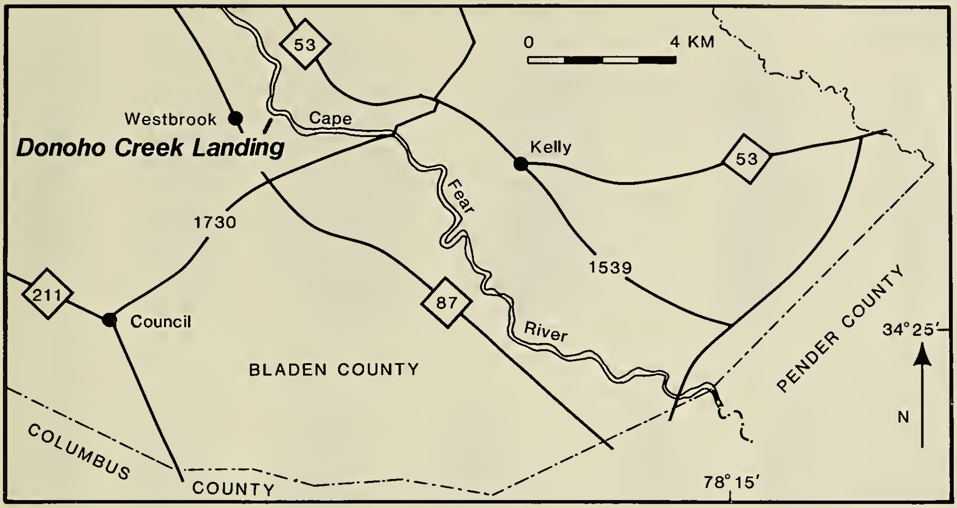

Fig. 1. Location of Donoho Creek Landing on the Cape Fear River, North Carolina.

Carolina 34°28'26"N, 78°24'40"W. Medium- to coarse-grained, subrounded to subangular, poorly sorted, fossiliferous sand. N. F. Sohl, collector.

## Systematic Paleontology

Subclass Cirripedia Burmeister, 1834
Order Thoracica Darwin, 1854
Suborder Lepadomorpha Pilsbry, 1916
Superfamily Scalpelloidea (Pilsbry) Zevina, 1980
Family Scalpellidae Pilsbry, 1916
Subfamily Calanticinae Zevina, 1978
Genus *Zeugmatolepas* Withers, 1913
*Zuegmatolepas* species indet.
Figs. 3a–m

*Material.*—Nine carinae, 15 rostra and 2 lower latera, USGS locs. 31796, 31868.

*Disposition of specimens.*—Hypotypes USNM 382778 through 382783 and hypotype lots 382784 and 382785 are deposited in the Division of Paleobiology, U.S. National Museum of Natural History, Washington, D.C.

*Discussion.*—A group of plates, ranging in size from 3.0 to 6.5 mm, appear to be from the lower whorls of a species of *Zeugmatolepas.* This genus is known to range from the Jurassic (Callovian) through the Paleocene (Danian), and is best known from numerous species in western Europe (Withers 1928, 1935, 1947). The Donoho Creek Landing specimens, although well-preserved, are difficult to relate to specific plate types and, in the absence of species-diagnostic terga and scuta, are insufficient for species recognition.

The carinae (Figs. 3a–b, f–g) range in size from 4.0 to 5.5 mm in height, are thick, and extremely narrow (five times higher than wide). These plates bear some resemblance to carinae of the European Campanian species *Z. cretae* (Steenstrup)

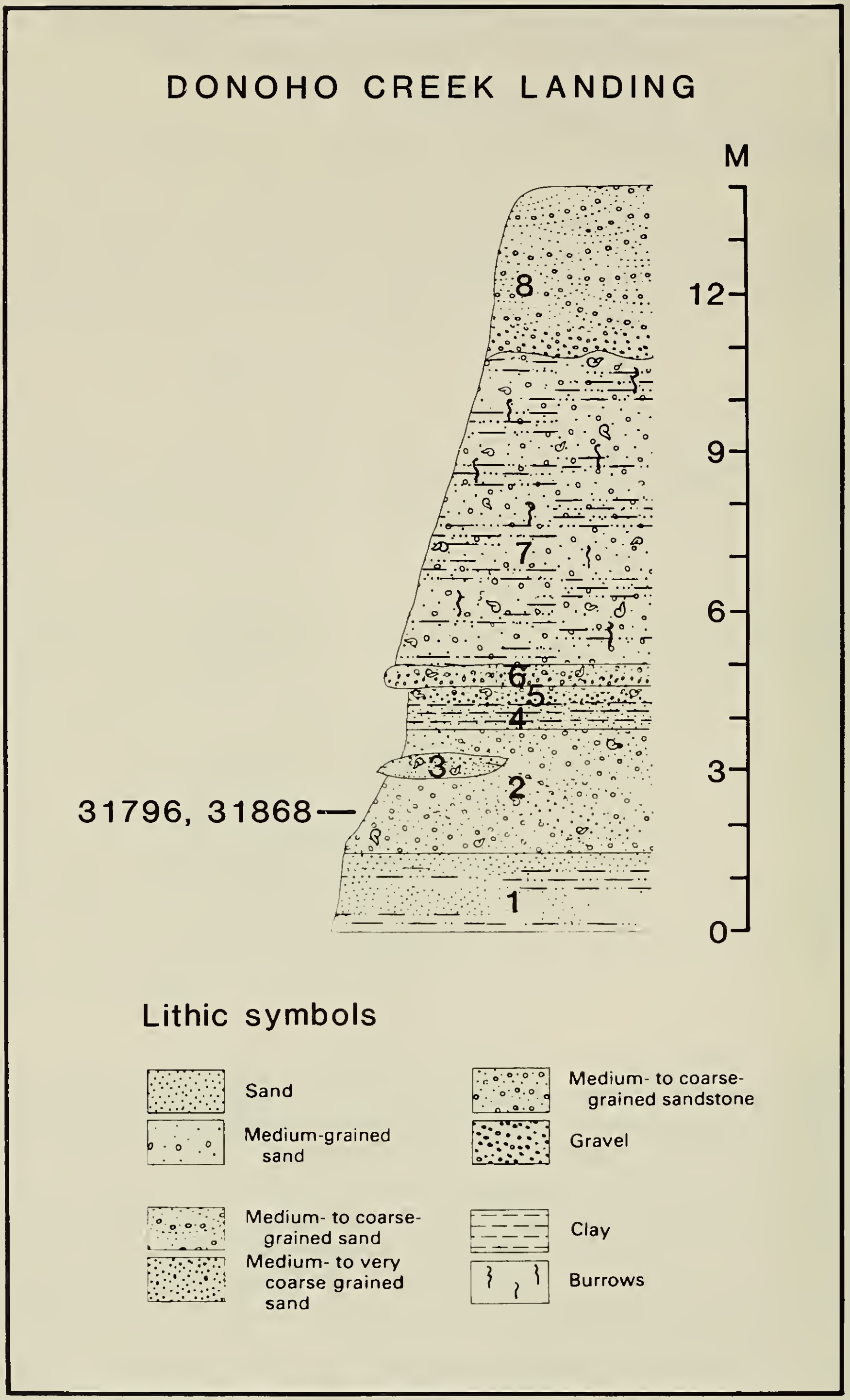

Fig. 2. Stratigraphic section of the column exposed at Donoho Creek Landing, showing barnacle localities in unit 2. Contact of Black Creek Formation with overlying Peedee Formation is at base of unit 5. Section modified from Sohl and Christopher (1983).

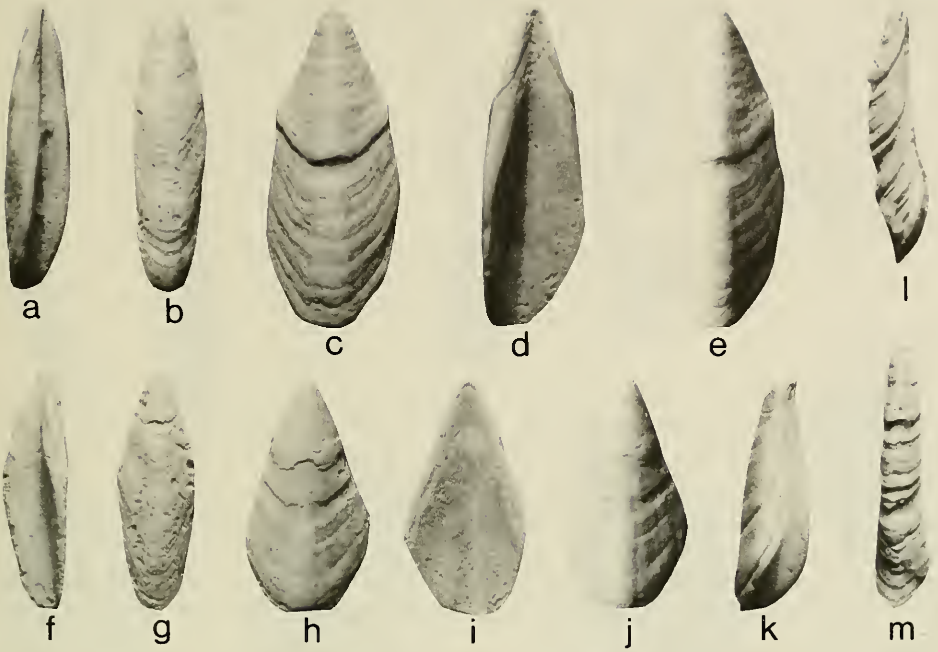

Fig. 3. *Zeugmatolepas* species: a–b, Oblique interior and exterior views of carina, hypotype USNM 382778; c–d, Exterior and oblique interior views of rostrum, hypotype USNM 382779; e, Rostrum of Fig. 3c overexposed to show fine radial striae; f–g, Oblique interior and exterior views of carina, hypotype USNM 382780; h–i, Exterior and interior views of rostrum, hypotype USNM 382781; j, Rostrum of Fig. 3h overexposed to show fine radial striae; k, Oblique side view of lower latus, hypotype USNM 382782; l–m, Side and exterior views of lower latus, hypotype USNM 382783. All illustrations ×7.

figured by Withers (1935, pl. 3, fig. 15, pl. 4, fig. 1). The tectum is narrow and in lateral view is nearly straight except for the apical part which is curved inwardly. The plate in cross-section is acutely V-shaped, with no apparent differentiation between tectum and parietes. In tectal view the carina is widest at or below the midline. The apex is acute and the basal margin is narrowly rounded. The lateral edges of the plate are thickened, especially in the upper half, but the inner surface is open from base to apex. A few specimens bear faint, oblique growth lines on the inner surface near the apex.

The rostra (Figs. 3c–e, h–j) are considerably thinner and broader than the carinae, and range in size between 3.0 and 6.0 mm in height. These rostra are remarkably similar to those of the European Cenomanian species *Z. mockleri* Withers (Withers 1935, pl. 2, figs. 9a–b). The rostra are sub-diamond-shaped, broadly V-shaped in cross-section, and bear a low, rounded, apico-basal ridge that broadens basally. In lateral view the plates are nearly straight to slightly convex. The apex is acute and the basal margin is truncate or narrowly rounded. The outer surface is ornamented by prominent growth ridges cut by fine, longitudinal striae on either side of the apico-basal ridge (Figs. 3e, j). The edges of the plate are slightly thickened, the inner surface is broadly concave, and the inner apical region bears oblique growth lines.

Two plates (Figs. 3k–m) appear to represent lower latera, particularly the type depicted for the European Lower Cretaceous species *Z.*(?) *hausmanni* (Koch and Dunker) by Withers (1935, pl. 3, figs. 5t–u). These plates are 4.0 to 5.0 mm in height, very narrow, are infilled in their upper halves, and are ornamented by prominent, imbricating growth ridges.

It is likely that the Black Creek *Zeugmatolepas* is a new species, but in the absence of upper whorl plates, specific identification is not warranted.

### Subfamily Arcoscalpellinae Zevina, 1978
### Genus *Virgiscalpellum* Withers, 1935
### *Virgiscalpellum inornatum,* new species
Figs. 4a–n

*Holotype.*—Carina, U.S. National Museum no. 382786.

*Type-locality.*—Upper Cretaceous, Black Creek Formation, Donoho Creek Landing, Bladen County, North Carolina, USGS loc. 31796.

*Diagnosis.*—Carina narrow, angular, with prominent umbo removed from apex and located on upper two-fifths of plate; surface of plate without radial ornament. Umbo of scutum markedly subcentral, one-third distance from rostral angle; surface ornamented by prominent growth ridges crossed by fine striae radiating from umbo. Tergum narrow, slightly curved towards carinae, with low, rounded, apico-basal ridge.

*Description.*—Carina (Figs. 4a–e) narrow in tectal view, thin in lateral view, obtusely angulate (130°–140°); largest specimen 8.0 mm in length; position of prominent umbo variable, but always below apex and never more than a distance equal to two-fifths length of plate; narrow, arched tectum not differentiated from broad, parallel-sided or moderately divergent parietes; parietes separated from moderately divergent intraparietes by obscure, low ridge; carina in tectal view broadest in lower half, with breadth of plate increasing between umbo and acutely rounded basal margin; carina narrowest near middle (waist), becoming slightly broader with nearly parallel sides to acutely rounded apex; interior of plate never infilled, broadly open between apex and base, except at waist; exterior surface without ridges or striae radiating from umbo, and ornamented solely by prominent growth ridges.

Scutum (Figs. 4f–k) up to 10.0 mm in height, twice as high as wide, subrectangular, moderately thick, with markedly subcentral umbo located on the occludent margin one-third the distance from the rostral angle; occludent margin straight to slightly concave above umbo, strongly convex below umbo to the acutely rounded rostral angle; a deep, narrow furrow, sometimes bordered inwardly by a low ridge, extends from the umbo to a point on the tergal margin one-quarter the distance from the acutely angulate apex to the broadly rounded basitergal angle; the intersection of the furrow with the tergal margin is marked by a sharp projection above the otherwise straight to slightly convex tergal margin; the basicarinal margin is straight to slightly convex and about equal in length to the tergal margin; exterior surface ornamented by prominent growth ridges and in the upper half of the plates, by fine, obscure, and irregularly-spaced striae radiating from the umbo; the interior of the scutum bears a large, deep, adductor muscle pit bordered on its upper, occludent margin by a prominent, straight ridge; the oc-

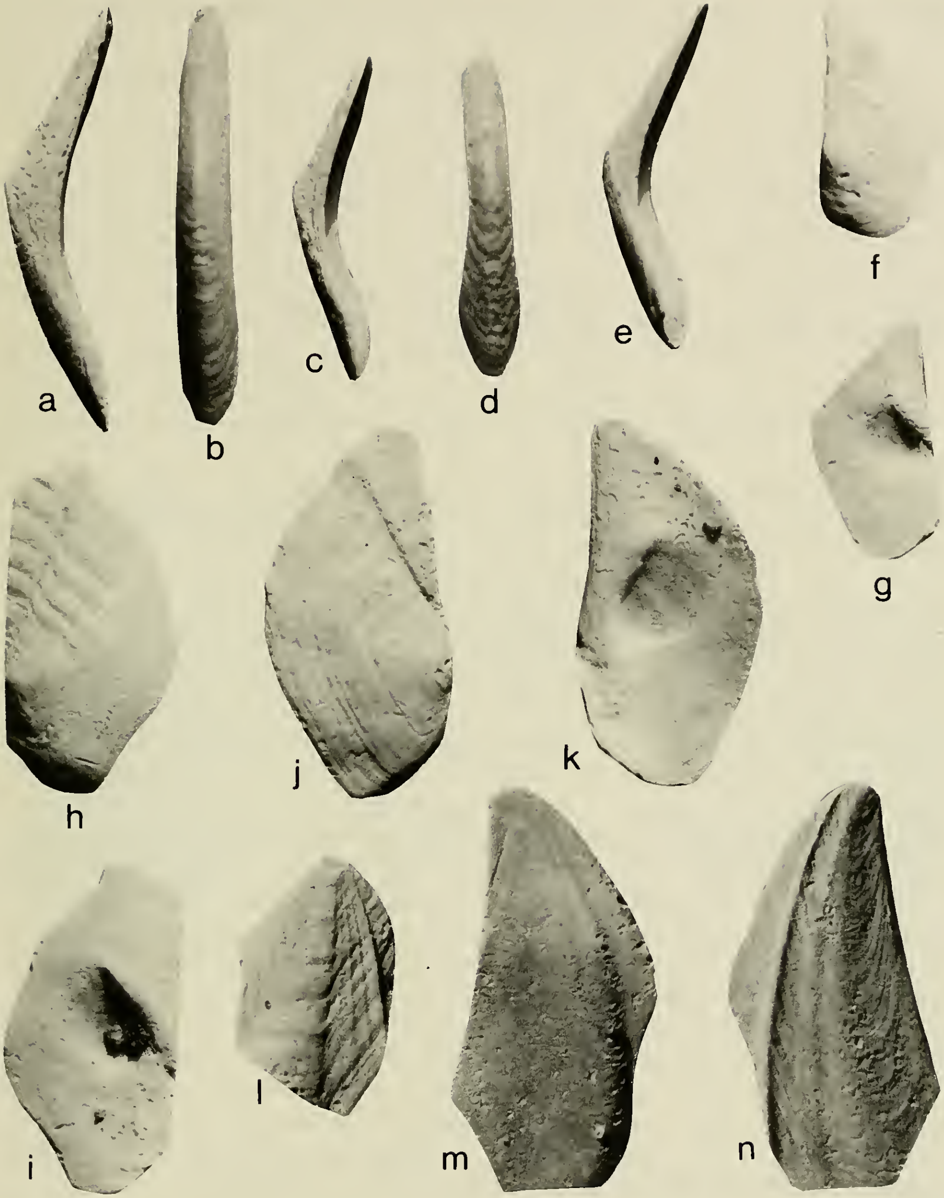

Fig. 4. *Virgiscalpellum inornatum*: a–b, Side and tectal views of carina, holotype USNM 382786; c–d, Oblique side and tectal views of carina, paratype USNM 382787; e, Oblique side view of carina, paratype USNM 382788; f–g, Exterior and interior views of scutum, paratype USNM 382789; h–i, Exterior and interior views of scutum, paratype USNM 382790; j–k, Exterior and interior views of scutum, paratype USNM 382791; l, Exterior of broken tergum showing radial threads, paratype USNM 382792; m–n, Interior and exterior views of broken tergum, paratype USNM 382793. All illustrations ×7.

cludent border often bears a small, shallow pit (for males?) immediately below the umbo.

Tergum (Figs. 4l–n) relatively thin, narrow, about 3 times higher than wide, the largest specimen (broken) 7.8 mm in height; apico-basal ridge broad, low, rounded; occludent margin broadly convex; carinal margin slightly concave; apex worn in all specimens, but probably acute; basal angle, based on growth lines, narrowly rounded; a narrow, sharp ridge extends from the apex to the scutal margin halfway between the apico-basal ridge and the occludent margin; 1 or 2 fine longitudinal threads may be present between the 2 main ridges.

*Material.*—Nine complete and 18 fragmentary carinae; 11 complete and 8 fragmentary scuta; 5 partial terga from USGS loc. 31796.

*Disposition of types.*—Holotype USNM 382786, paratypes USNM 382787 through 382793, and paratype lots USNM 382794 through 382796 are in the Division of Paleobiology, U.S. National Museum of Natural History, Washington, D.C.

*Etymology.*—The specific name *inornatum* is from the Latin *inornatus,* meaning unadorned, and refers to the absence of external radial ornament on the carina.

*Discussion.*—*Virgiscalpellum inornatum* most closely resembles *V. gabbi* (Pilsbry, 1933) from the Ripley and Prairie Bluff Formations in Tennessee, Mississippi and Alabama and particularly, *V. gabbi gabbi* as described by Collins (1973). The new species is distinguished by its carina which lacks external radial ornament and has its greatest breadth in the lower rather than the upper half of the plate; by its scutum whose umbo is well below the center of the occludent margin and whose shape is more rectangular than triangular; and by its tergum that is somewhat broader, less curved towards the carina, and bears a better developed apico-basal ridge. The tergum of *V. inornatum* approaches that of *Virgiscalpellum* sp. figured by Collins (1973, pl. 5, fig. 13) from the upper Ripley Formation in Mississippi, in breadth and in development of an apico-basal ridge, but differs in having a concave carinal margin and a more attenuated apical half. *Virgiscalpellum inornatum* is most readily distinguished from European species of *Virgiscalpellum* and from *V. paitense* (Pilsbry and Olsson, 1951) from the Upper Cretaceous Tortuga Formation of Peru by the absence of radial ornament on the carina and the subdued nature of the ornament on the scuta and terga. *Virgiscalpellum heteroplax* (Pilsbry and Olsson, 1951) and *V. euglyptum* (Pilsbry and Olsson, 1951), also from the Tortuga Formation, are known only from scuta. The shape of the scutum of *V. inornatum* differs markedly from that of *V. heteroplax,* and the position of the scutal umbo in *V. inornatum* is considerably lower on the occludent margin than the centrally-placed umbo of *V. euglyptum.*

The absence of radial ornament on carinae of *V. inornatum* is not the result of abrasion during transport and deposition. Such abrasion is present on the edges of the plates, but the preservation of growth ridges and umbones on several carinae clearly indicates that wear did not alter external ornamentation significantly. The plates of both *V. inornatum* and *Zeugmatolepas* sp. show signs of sorting. In the case of the former species, none of the plates is more than half the size of the larger plates of *V. gabbi* figured by Collins (1973), suggesting that the Black Creek examples are from young adults. Similarly, none of the larger, upper whorl plates where found for the Black Creek *Zeugmatolepas.*

The genus *Virgiscalpellum* ranges from the Aptian (Withers 1947, 1953) through the Maestrichtian (Withers 1935), with the greatest known species diversity being in Maestrichtian time. In North America *Virgiscalpellum* is now known from the upper Campanian and the Maestrichtian.

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# A NEW SPECIES OF *PSILOGOBIUS* FROM THE INDO-PACIFIC WITH A REDESCRIPTION OF *PSILOGOBIUS MAINLANDI* (PISCES: GOBIIDAE)

Ronald E. Watson and Ernest A. Lachner

*Abstract.*—The genus *Psilogobius* Baldwin is redescribed and now contains two species, *P. mainlandi* from the Hawaiian Islands and *P. prolatus,* new species, from the Great Barrier Reef, Australia and the Cocos-Keeling Islands, eastern Indian Ocean. Pronounced sexual dimorphism occurs in both species. In addition to the genital papilla, males have longer fins, longer filamentous first dorsal fin spines, longer upper jaws than the females, and differ in coloration. *Psilogobius prolatus* differs from *P. mainlandi* in having dark pigmentation on the upper jaw, the AITO sensory pore usually present, a small patch of tiny scales on upper operculum, pectoral fin rays less numerous, modally 15, longer dorsal, anal and caudal fins, a longer upper jaw and in certain sexual dichromatic marks or bars.

*Psilogobius mainlandi* was originally described by Baldwin (1972:125) as monotypic from specimens collected by G. B. Mainland in 1939 at Kaneohe Bay, Oahu, Hawaiian Islands. Mainland named the new species *Paroxyurichthys edmondsoni* and described it in his master's thesis that was never published. The name *Paroxyurichthys edmondsoni* was published by C. H. Edmondson (1946); however, Baldwin (1972:125) noted that there was no description or illustration and that the name constituted a nomen nudum. The first author, while examining recently captured *Psilogobius* from Hawaii, thought he had a new species. Further study revealed that these specimens were *P. mainlandi* but were not easily recognized since many important diagnostic features were overlooked or vague in Baldwin's account. A redescription of *P. mainlandi* from the Hawaiian Islands revealed a new species of *Psilogobius* from Australia and the eastern Indian Ocean.

## Methods

Methods follow those of Lachner and Karnella (1980), and Lachner and McKinney (1974, 1978), except where indicated. The pterygiophore formula of the spines of the dorsal fin in relationship with the underlying vertebrae is after Lachner and McKinney (1974:875). Measurements were made with dial callipers in mm, and counts were taken from the left side unless noted otherwise. Measurements of fins follow Hubbs and Lagler (1958:25) except for the caudal fin which is measured from the central hypural base to the posterior tip of the longest ray. All proportional measurements are expressed to the nearest tenth of a percent of the standard length (SL), except for certain tabular data. Osteological aspects of the study were accomplished with radiographs, and cleared and alizarin stained specimens.

In the descriptive accounts the values given for meristic characters are followed by the frequency in parenthesis; the holotypic value is italicized. Data in the material examined section include the following: type status (if any), catalogue number, number of specimens, sex, SL in parenthesis (range if more than one specimen), specific locality, date collected, and collector.

Abbreviations and terminology used to designate cephalic sensory pores follow Lachner and McKinney (1974:865): NA, nasal; AITO, anterior interorbital; PITO, posterior interorbital; AOT, anterior otic; SOT, supraotic; IT, intertemporal; POP, preopercular.

The following abbreviations are used to designate institutions and collections cited: AMS, Australian Museum, Sydney; ANSP, Academy of Natural Sciences, Philadelphia; BPBM, Bernice P. Bishop Museum, Honolulu; NTMA, Northern Territory Museum, Darwin, Australia; USNM, National Museum of Natural History, Smithsonian Institution, Washington, D.C.

### *Psilogobius* Baldwin
Fig. 1

*Psilogobius* Baldwin, 1972:125 (type-species: *Psilogobius mainlandi* Baldwin, 1972: 126 by original designation).

A small, tropical, marine, Indo-Pacific goby, body elongate, subcylindrical and somewhat compressed; branchiostegals 5; 6 spines in first dorsal fin; first dorsal fin free from second dorsal fin; pterygiophores 3 (22110); vertebrate (including urostyle) 10 + 16 = 26; gillrakers on outer arch 3 + 1 + 7 or 8. Ctenoid scales well developed on caudal peduncle, becoming progressively smaller anteriorly; ctenii in a single row, well developed, spike-like, and equal or subequal on each scale (regenerated scales may lack ctenii); a patch of tiny scales sometimes present on upper portion of operculum; nape, breast and belly naked. Teeth conical, recurved; upper jaw teeth in 4 or 5 rows anteriorly, and 2 rows laterally; lower jaw teeth in 3 or 4 rows anteriorly, and 2 rows laterally; teeth absent on vomer and palatines. Cephalic sensory pore system is limited to anterior oculoscapular canal, pores NA, PITO, and AOT always present. Gill opening moderate. Sexual dimorphism present in coloration and morphology.

### *Psilogobius mainlandi* Baldwin
Fig. 2

*Psilogobius mainlandi* Baldwin, 1972:126 (type-locality: Coconut Island, Kaneohe Bay, Oahu, Hawaiian Islands).

*Material examined.*—59 specimens, 32 males, 20 females and 7 juveniles or unsexed; size range 8.5–37.5 mm SL, largest male 37.5, largest female 34.3, smallest gravid female 22.6.

*Holotype.*—USNM 206174, male (30.9), Coconut Island, Kaneohe Bay, Oahu, Hawaiian Islands, 9 May 1968, W. Baldwin and J. Richards.

*Paratypes.*—BPBM 10862, female (34.3), Coconut Island, Kaneohe Bay, Oahu, Hawaiian Islands, 1 Apr 1968, J. E. Randall et al.; BPBM 10864, 26 (22.4–35.5), 17 males, 9 females (5 males cleared and alizarin stained), Kahaluu, Kaneohe Bay, Oahu, Hawaiian Islands, 7 Dec 1967, W. Baldwin et al.; BPBM 10865, 5 (10.0–20.3), 1 male, 2 females, 2 juveniles, Coconut Island, Kaneohe Bay, Oahu, Hawaiian Islands, 12 Jul 1968, W. Baldwin et al.; BPBM 22624, 4 unsexed (8.5–

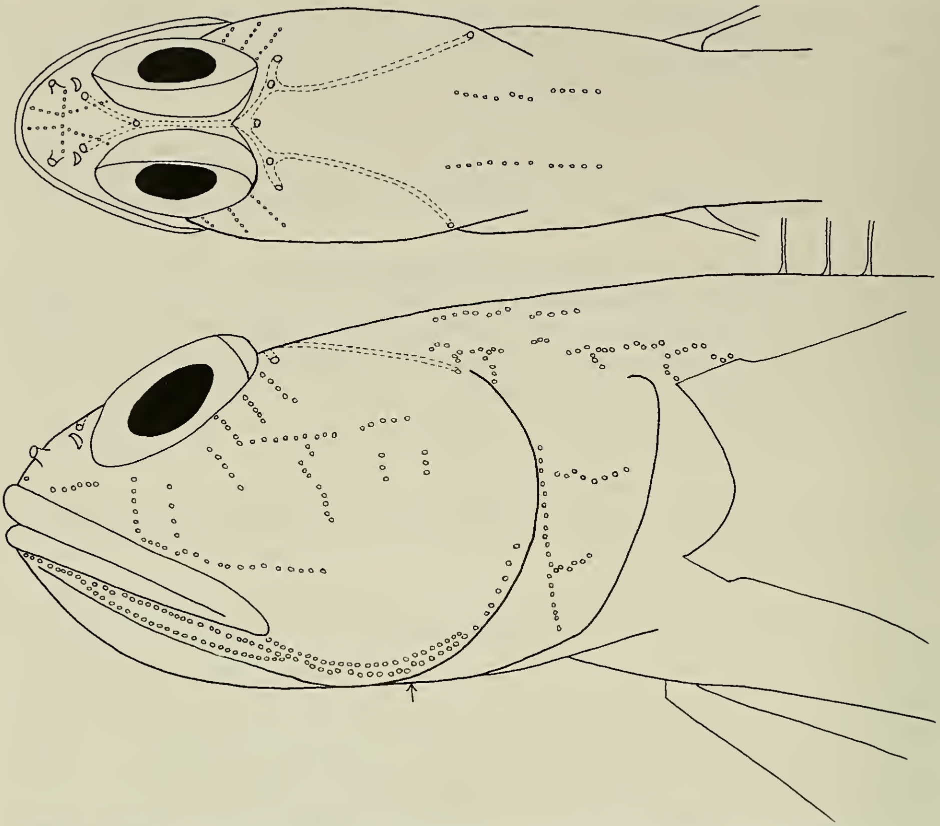

Fig. 1. Diagrammatic illustration of *Psilogobius* showing cephalic sensory pore system and cutaneous sensory papillae distribution on head. The arrow indicates the connection of the gill membrane with the isthmus.

23.5), Kaneohe Bay, Oahu, Hawaiian Islands, 13 May 1939, G. B. Mainland; USNM 206175, 21 (19.3–31.3), 12 males, 8 females, 1 unsexed, same collection data as holotype; USNM 202527, 1 male (37.5), same collection data as BPBM 22624.

*Diagnosis.*—Cephalic sensory pore AITO usually absent; pectoral fin rays modally 17; dorsal, anal and caudal fins and length of upper jaw shorter than in *Psilogobius prolatus*; patch of tiny scales on upper operculum absent; no dark pigmentation on upper jaw; males lack narrow, vertical silvery trunk bars; females have dark oblique band extending from notch between dorsal fins downward to anal aperture; silvery vertical trunk bars on females somewhat narrower than those on *P. prolatus*.

*Description.*—Dorsal rays VI-9 (1); VI-I,10 (*55*); VI-I,11 (1); anal rays I,8 (1); I,9 (*54*), I,10 (2); pectoral rays 15 (1), 16 (20), 17 (*27*), 18 (2), 19 (1),; counts for 1 specimen taken from right side due to deformed left pectoral fin; pelvic rays I,5 (*57*); segmented caudal rays 11 (1), 15 (*4*), 16 (13), 17 (34), 18 (2), 19 (1). First dorsal fin higher than second dorsal; first dorsal spines filamentous, second, third and fourth spines longest; third spine may reach base of tenth ray of second dorsal fin in mature males; origin of second dorsal fin over anus. Depressed

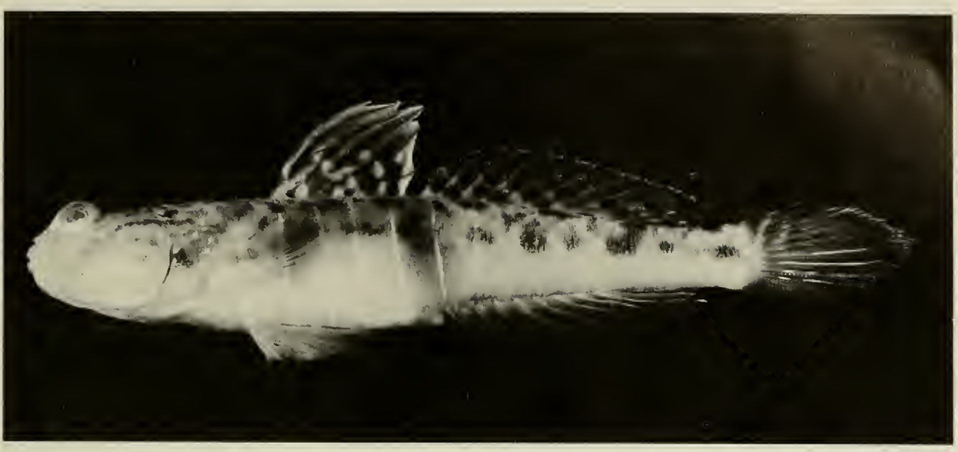

Fig. 2. *Psilogobius mainlandi,* paratype, 34.3 mm SL, female, Hawaiian Islands, BPBM 10862.

pectoral fin reaches to or beyond anus, posterior margin more or less rounded. Pelvic fins joined to form a cup-like oblong disk not adherent to body; pelvic fin frenum well developed between pelvic spines; pelvic fin rays branched with tips free; membrane between fifth medialmost rays complete along length of fin. Caudal fin oblong, equal to or shorter than head.

All scales ctenoid, extending from trunk to slightly onto caudal fin base; scales small, largest in area of hypural base; scales smallest in area of pectoral fin base. Ctenii on scales of hypural base range from 4 to 9 per scale with 8 or 9 radii; scales on midline of trunk between second dorsal and anal origin with 3 or 4 ctenii and 4 to 7 radii; scales in area of pectoral fin base with 1 to 3 ctenii and 3 to 4 radii. Scales in horizontal series highly variable, 32 to 78; their size and spacing vary considerably.

Head subcylindrical and somewhat compressed; bony interorbital very narrow with eyes nearly touching; snout short, less than diameter of eye; isthmus narrow, extending ventrally to base of pectoral fin. Mouth terminal, lower jaw not protruding and slightly oblique; upper jaw reaches posterior margin of eye in females and juveniles; well beyond posterior margin of eye in large males.

Cutaneous sensory papillae pattern poorly to moderately developed on head. Two or 3 transverse rows, and 1 or 2 longitudinal rows on cheek (see Fig. 1). No sensory ridges or barbels. Cephalic sensory pore system variable; AITO pore seldom present; IT pore often present (see Table 3).

Sexual dimorphic characters well developed. Male genital papilla tube-like, tapering and pointed at tip, about 4 times length of its base. Female genital papilla short, bulbous; about as long as length of its base. All fins of adult males longer than in females. Filamentous spines of first dorsal fin and upper jaw longer in males than females. Dimorphic differences not always obvious in small males.

*Color of preserved specimens.*—Trunk with 8 or 9 dark lateral spots that originate behind pectoral base and extend to hypural base. Spots tend to alternate in size with smallest at or near hypural base. Six to 8 dark spots dorsally on trunk extending from first dorsal fin to end of caudal peduncle. Trunk in females with 6 or 7 silvery, vertical, narrow bars separated by faint dusky areas; silvery bars not meeting ventrally, and usually not extending to dorsal fins; bars absent in males. Females with dusky band between origin of second dorsal fin and anus. Branchiostegal membrane of males always dark; immature males show this characteristic before other external sexual characteristics develop; females lack branchiostegal membrane pigmentation.

First dorsal fin with light spots and dark patches; second dorsal fin with dark spots arranged in oblique rows. Posterior tips of pectoral and pelvic fins, lower third of anal and caudal fins dusky; markings more intense on males. Peritoneum silvery.

*Color in life.*—Following description from color slide of a 34.3 mm SL female specimen (BPBM 10862). Overall body color light brown; arched band from near end of upper jaw to above opercle; 7 small blue-white spots on lower preopercle; 4 patches of melanophores on cheek; lower ⅔ of opercle orange, 7 small blue-white spots near preopercular margin, 8 small blue-white spots near posterior margin of opercle; patch of melanophores in center of opercle; dusky patch at upper pectoral base and one above anus, a small dark spot between these; 5 prominent, narrow, vertical white bands extending from behind pectoral base posteriorly to origins of first dorsal and anal fins. Weak, narrow white band originates above second anal ray and extends almost to second dorsal fin base; 7 dark spots with orange tinge in center, originating at weak white band on mid-trunk and extending to caudal fin base; spots alternate in size. Dorsal surfaces of body and upper trunk with scattered dark spots extending from just below first dorsal fin to upper caudal fin base; 2 or 3 blue-white spots found between these dorsolateral spots; lower half of first dorsal fin with oblique bands that alternate from brown to blue-white, upper half of fin brown; lower ⅔ of second dorsal fin with oblique alternating brown and blue-white bands (similar to first dorsal fin); upper half of fin brown, its outer margin blue; upper third of caudal fin with weak alternating brown and blue-white bands, lower portion translucent; pelvic spines whitish, rest of fin orange with scattered melanophores, posterior tip dark; anal fin clear next to body progressively darkening distally.

*Ecology.*—Specimens examined were reported from marine habitats up to depths of 15 meters, over sand and silt in shallow water, in sandy areas around living reef. This species may require waters of sheltered areas that are little affected by wave activity.

*Psilogobius mainlandi* is found in association with an alphaeid shrimp; this association has been reported in *Cryptocentrus*-like gobies of the genera *Amblyeleotris, Cryptocentroides, Cryptocentrus, Ctenogobiops, Eilatia, Flabelligobius, Mahidolia, Stonogobiops, Tomiyamichthys, Vanderhorstia,* and *Yongeichthys* (Hoese and Randall 1982; Hoese and Steene 1978; Klausewitz 1974; Polunin and Lubbock 1977; Yanagisawa 1978). This relationship may exist in *Myersina* as well (Akihito and Meguro 1983).

*Remarks.*—Baldwin (1972) overlooked important characters and briefly treated others. He noted taking scale counts in his methods section, but none were given. The illustrations (1972, Fig. 1) of scales show ctenii to be wedge shaped, whereas they are actually spike-like. He stated that the scales are embedded, but we found the scales to be firmly attached anteriorly, while they may fall out posteriorly. Baldwin gave a vertebral count of 10 + 15 = 25, but did not say if this includes the urostyle. Our examination of radiographs and cleared and stained specimens

Fig. 3. *Psilogobius prolatus,* paratype, 31.0 mm SL, female, Cocos-Keeling Islands, ANSP 131147.

shows the count to be 10 + 16 = 26, including the urostyle. Baldwin (1972:126, Figs. 3, 4) described and showed the POP pores as present on the preopercle margin, but an examination of 72 specimens of both species showed the POP pores and the associated canal to be lacking. He stated that the third and fourth spines of the first dorsal fin are longest, but we find the second and third spines of the first dorsal fin are longest as confirmed by Baldwin's illustration (1972, Fig. 4). He described the branchiostegal membrane as dusky to dark; our examination shows this to be a sexual dichromatic feature and that the membranes are unpigmented in females. He mentioned the abdominal bars and noted that they are occasionally absent, whereas the bars are absent in all males in preservation.

### *Psilogobius prolatus,* new species
Fig. 3

*Material examined.*—13 specimens totalling 8 males and 5 females; size range 27.5–36.1; largest male 36.1; largest female 35.0; no gravid material.

*Holotype.*—AMS I.20578-002, 1 male (34.2), patch reef, One Tree Island, Capricorn Group, Great Barrier Reef, Queensland, Australia, western Pacific Ocean, 23°30'S, 152°05'E, 30 Nov 1973, B. C. Russell et al.

*Paratypes.*—AMS I.20578-007, 2 (33.2, 35.4), 1 male, 1 female, same collection data as holotype; ANSP 131145, 1 male (33.7), West Island, Cocos-Keeling Islands, eastern Indian Ocean, 12°9'00"S, 96°50'15"E, 15 Mar 1974, W. F. Smith-Vaniz et al.; ANSP 131147, 5 (29.6–36.1), 2 males, 3 females, West Island, Cocos-Keeling Islands, eastern Indian Ocean, 12°7'40"S, 96°51'35"E, 18 Mar 1974, W. F. Smith-Vaniz et al.; USNM 265099, 2 (32.8, 34.5), 1 male, 1 female, same

Table 1.—Meristic, morphometric and color differences between the two species of *Psilogobius*. Proportional values include number of specimens, range in parenthesis, followed by mean value.

| Character | *P. mainlandi* | *P. prolatus* |
|---|---|---|
| Number of pectoral fin rays | modally 16–17 | modally 15 |
| Small scales on upper operculum | absent | present |
| AITO sensory pore | usually absent | usually present |
| Length of upper jaw in male | 29 (12.5–17.3) 15.0 | 8 (16.0–18.5) 16.8 |
| Length of upper jaw in female | 20 (10.3–15.2) 13.5 | 5 (14.3–16.6) 15.1 |
| Length of anal fin in male | 13 (37.7–45.4) 42.1 | 8 (43.4–51.2) 47.0 |
| Length of anal fin in female | 9 (36.3–41.4) 39.6 | 5 (38.7–44.6) 42.4 |
| Length of pectoral fin | 22 (21.2–26.0) 23.4 | 13 (19.4–24.4) 21.6 |
| Length of second dorsal fin | 22 (40.3–47.5) 43.6 | 13 (42.8–49.9) 45.9 |
| Length of caudal fin | 22 (24.3–34.1) 29.6 | 13 (29.4–40.4) 34.2 |
| Length of head | 22 (29.3–33.1) 31.6 | 13 (28.2–32.4) 30.3 |
| Upper jaw pigmentation | absent | posteriorly darkened; weak in female |
| Branchiostegal membrane | dark; male only | dusky; male only |
| Silvery trunk bars in male; in preservation | absent | 5–6 |
| Silvery trunk bars in female, in preservation | 6–7 | 6–7 |
| Dusky vertical bar from notch between dorsal fins downward to anal aperture | present; female only | absent |

collection data as ANSP 131147; USNM 266378, 2 males (27.5, 34.3), same collection data as holotype.

*Diagnosis.*—Cephalic sensory pore AITO usually present; pectoral fin rays modally 15; dorsal, anal and caudal fins and length of upper jaw longer than in *P. mainlandi*; small patch of tiny scales on upper portion of operculum; some dark pigmentation on upper jaw; males with 5–6 narrow, vertical, silvery trunk bars; females lack dark oblique band on middle of trunk that extends from notch of dorsal fins to anal aperture; silvery vertical trunk bars on females wider than in *P. mainlandi.* Other differences between these two species are shown in Tables 1–5.

*Description.*—Dorsal rays VI-I,10 (*13*); anal rays I,9 (*11*), I,10 (2); pectoral rays 14 (1), 15 (*12*); pelvic rays I,5 (*13*); segmented caudal rays 15 (1), 16 (1), 17 (*11*). First dorsal fin higher than second dorsal fin; spines filamentous with third spine longest. Depressed pectoral fin reaching to or slightly short of anus, posterior margin rounded. Pelvic fins joined to form oblong cup-like disk not adherent to body; pelvic frenum well developed; pelvic fin rays branched with tips free; membrane between fifth (medialmost) rays of pelvic fins complete along entire length. Caudal fin oblong, equal to or slightly longer than head. See Tables 1, 2 and 5 for fin differences in *P. mainlandi* and *P. prolatus.*

Table 2.—Number of pectoral fin rays in species of *Psilogobius.*

| | Pectoral fin rays | | | | | | |
|---|---|---|---|---|---|---|---|
| Species | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| *P. mainlandi* | | | 1 | 19 | *25* | 2 | 1 |
| *P. prolatus* | | 1 | *12* | | | | |

Table 3.—Number, distribution and variation in occurrence of cephalic sensory pores in species of *Psilogobius* based on 22 specimens of *P. mainlandi* and 13 of *P. prolatus* (n = number of specimens; 0 = pore absent; 1-1 = pore present on left and right sides; see "Methods" for names of pores).

| | Cephalic sensory pores | | | | | | |
|---|---|---|---|---|---|---|---|
| Species | N | NA | AITO | PITO | SOT | AOT | IT |
| *P. mainlandi* | *10* | 1-1 | 0 | 1 | 0-0 | 1-1 | 0-0 |
| | 10 | 1-1 | 0 | 1 | 0-0 | 1-1 | 1-1 |
| | 2 | 1-1 | 1 | 1 | 0-0 | 1-1 | 1-1 |
| *P. prolatus* | *7* | 1-1 | 1 | 1 | 0-0 | 1-1 | 1-1 |
| | 3 | 1-1 | 0 | 1 | 0-0 | 1-1 | 1-1 |
| | 2 | 1-1 | 1 | 1 | 1-1 | 1-1 | 1-1 |
| | 1 | 1-1 | 1 | 1 | 0-0 | 1-1 | 0-0 |

Head subcylindrical and somewhat compressed; bony interorbital region very narrow with eyes nearly touching; snout short, less than diameter of eye; isthmus narrow, extending ventrally to base of pectoral fin. Mouth terminal, lower jaw not protruding and slightly oblique; upper jaw normally reaching beyond posterior margin of eye in female, and well beyond posterior margin of eye in male. See Tables 1 and 4 for head differences between *P. mainlandi* and *P. prolatus.*

Various proportional measurements for *P. prolatus* are presented in Table 6.

Cutaneous sensory papillae pattern very similar to *P. mainlandi.* Cephalic sensory pore system variable with AITO and IT often present and SOT usually absent (see Fig. 1 and Table 3).

All scales ctenoid, extending from trunk slightly onto caudal fin; scales largest at hypural base; scales becoming progressively smaller anteriorly and not imbricate. Scales with single row of ctenii; scales at hypural base with 6 or 7 ctenii and 9 to 11 radii per scale; scales on trunk between second dorsal fin and anal fin origin with 6 or 7 ctenii and 6 to 8 radii, scales at pectoral base with 1 to 3 ctenii and 3 to 5 radii. Small patch of tiny scales above operculum, ctenii prominent.

*Color of preserved specimens.*—Five prominent dorsolateral dark spots extending from behind pectoral base to hypural base, smaller intermediate spots between

Table 4.—Morphometric differences in species of *Psilogobius* in percent of the standard length (M = male; F = female).

| | | Upper jaw length | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Sex | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| *P. mainlandi* | M | | | | 3 | 9 | *14* | 6 | 1 | | |
| | F | 1 | — | 1 | 5 | 6 | 3 | | | | |
| *P. prolatus* | M | | | | | | | *3* | 4 | — | 1 |
| | F | | | | | 2 | 2 | — | 1 | | |

| | Head length | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| *P. mainlandi* | | 1 | 2 | 7 | *7* | 5 | | |
| *P. prolatus* | 1 | 1 | *7* | 3 | 1 | | | |

Table 5.—Fin lengths in species of *Psilogobius* in percent of the standard length.

| Species | Pectoral fin | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| *P. mainlandi* | | | 2 | *5* | 3 | 8 | 3 | 1 |
| *P. prolatus* | 1 | *2* | 4 | 3 | — | 3 | | |

| | Second dorsal fin | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
| *P. mainlandi* | 1 | 1 | 2 | 2 | 5 | 3 | 3 | *2* | 3 | | | |
| *P. prolatus* | | | | | 1 | *2* | 3 | 2 | 2 | 2 | — | 1 |

| | | Anal fin | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sex | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 |
| *P. mainlandi* | M | | | 1 | 1 | 1 | 2 | 2 | 3 | — | *3* | | | | | | |
| | F | 1 | — | 1 | — | 5 | 2 | | | | | | | | | | |
| *P. prolatus* | M | | | | | | | | 1 | 1 | — | *2* | — | 2 | — | 1 | 1 |
| | F | | | | 1 | — | 1 | — | 1 | 1 | 1 | | | | | | |

| | Caudal fin | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| *P. mainlandi* | 3 | 4 | 2 | 6 | 5 | *1* | — | 1 | | | | | | |
| *P. prolatus* | | | 1 | 1 | 1 | — | 2 | *2* | 2 | 2 | — | — | 1 | 1 |

in some specimens; 5 to 7 narrow vertical, silvery bands on trunk from behind pectoral base to above anal spine; silvery bands extending close to dorsal fin base, not connecting on belly. Dark spots dorsally vary in size and number; 7 small spots from above pectoral fin base to below spine on second dorsal fin; four spots below base of second dorsal fin, evenly spaced and extend length of fin. Posterior portion of upper jaw dusky or finely pigmented, pigmentation weak in females; branchiostegal membrane dusky only in males, but not as dark as in *P. mainlandi.*

First dorsal fin filaments dusky, especially first spine; pectoral fins faintly dusky ventrally; anal fin dark distally; pelvic fins dark posteriorly. Basal half of first and second dorsal fins with few oblique markings; markings not as intense as in *P. mainlandi.*

*Color in life.*—The following description is from a color slide of a 31.0 SL female paratype (ANSP 131147). Overall background coloration light, cream; head almost white with many tiny orange bands arranged irregularly over cheek; opercle whitish with brown spots in middle portion; 6 narrow white bands (much wider than in *P. mainlandi*) extending from behind pectoral fin base to above anus; large dark pigment patches scattered among all 6 bands; weak white band (shorter than anterior bands) originating above second anal ray; 5 brownish orange spots near mid-trunk region from behind pectoral fin base to caudal fin base; 2 dark and 2 whitish bands on first dorsal fin; lower half of second dorsal fin with mottled oblique bands alternating whitish and brownish; outer margin of second dorsal fin bluish-white; pelvic fins light brown; anal fin opaque.

*Ecology.*—Specimens from Australia and Cocos-Keeling Islands were collected over white sands near reefs at depths ranging from 2 to 7.5 meters. There are no

Table 6.—Proportional measurements of type-specimens of *Psilogobius prolatus* expressed as a percentage of standard length. Data for paratypes include 7 males, 5 females, the range of measurements enclosed in parenthesis, followed by mean value.

| | Holotype | Paratypes | |
|---|---|---|---|
| | Male | Male | Female |
| Standard length (mm) | 34.2 | (27.5–36.1) | (29.6–35.0) |
| Head length | 30.4 | (29.5–32.4) 31.2 | (28.2–31.2) 30.3 |
| Head depth | 14.9 | (13.7–16.0) 14.7 | (13.8–15.2) 14.4 |
| Head width | 14.9 | (11.3–13.7) 12.6 | (12.0–14.3) 13.1 |
| Snout length | 3.8 | (2.5–4.8) 3.7 | (2.8–5.4) 4.4 |
| Predorsal length | 37.4 | (35.6–38.4) 36.8 | (35.1–36.9) 35.9 |
| Preanal length | 55.1 | (56.2–60.7) 58.4 | (56.5–62.4) 60.2 |
| Body depth at anal origin | 14.0 | (11.6–14.4) 13.2 | (12.0–14.9) 12.9 |
| Caudal peduncle length | 14.0 | (12.5–16.3) 14.6 | (12.6–15.2) 14.0 |
| Caudal peduncle depth | 8.5 | (7.7–9.0) 8.4 | (7.7–9.4) 8.3 |
| Upper jaw length | 16.4 | (16.0–18.5) 16.9 | (14.3–16.6) 15.1 |
| Pectoral fin length | 20.2 | (19.4–24.4) 21.8 | (20.6–24.1) 22.1 |
| Pelvic fin length | 21.3 | (21.6–24.2) 22.8 | (20.6–24.6) 22.2 |
| Second dorsal fin length | 43.7 | (44.0–49.9) 46.6 | (42.8–48.0) 45.4 |
| Anal fin length | 46.0 | (43.4–51.2) 47.2 | (38.7–44.6) 42.4 |
| Caudal fin length | 34.2 | (29.4–40.4) 35.5 | (29.7–35.2) 32.6 |

observations of this species in life. It is probable that *P. prolatus* will be found in association with an alphaeid shrimp as with *P. mainlandi.*

*Etymology.*—The specific name *prolatus* from the Latin for extended or elongated, refers to the longer jaw and longer dorsal, anal and caudal fins of this species when compared with *Psilogobius mainlandi.*

*Relationships.*—*Psilogobius* appears to be closely related to *Cryptocentrus* and *Mahidolia*; each have transverse and longitudinal rows of cutaneous sensory papillae over cheek; dorsal fin counts of VI-I,10 and anal fin I,9 are also shared. Both species of *Psilogobius, Cryptocentrus filifer,* and *Mahidolia mystacina* were found to have sexual dimorphic jaw lengths and silvery peritoneums. *Cryptocentrus callopterus, C. leptocephalus, C. lutheri, C. singapurensis, C. strigilliceps,* and *Yongeichthys criniger* possess blackish peritoneums and *Amblyeleotris periophthalmus, A. randalli,* and *Ctenogobiops crocineus* have whitish peritoneums. It is of interest that species with black peritoneums showed practically no sexual dimorphism in jaw lengths.

*Psilogobius* appears to differ from *Amblyeleotris, Cryptocentroides, Cryptocentrus, Ctenogobiops, Mahidolia, Myersina, Stonogobiops, Tomiyamichthys, Vanderhorstia,* and *Yongeichthys* in possessing only the anterior oculoscapular canal of the cephalic sensory pore system, while these other genera have greater elaborations of the canal system, usually the presence of the AT, PT, and POP pores. The anterior oculoscapular canal in *Psilogobius* extends from the SOT to the IT rather than from or near the AOT to the IT as is common for many *Cryptocentrus*-like gobies.

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# *VARICHAETADRILUS MINUTUS* (BRINKHURST, 1965) NEW COMBINATION FOR *PSAMMORYCTIDES* (?) *MINUTUS* (OLIGOCHAETA: TUBIFICIDAE)

Ralph O. Brinkhurst

*Abstract.*—*Psammoryctides minutus* is transferred to *Varichaetadrilus* because of the resemblance of the penis sheaths and penial setae to those of members of that genus.

*Psammoryctides minutus* was tentatively assigned to the genus *Psammoryctides* when first discovered (Brinkhurst 1965) and was listed incertae sedis in that genus by Brinkhurst (1971). The doubt about its generic placement was due to the lack of material which prevented a complete description of the male ducts. A dissection revealed one fragment of the male duct, which suggested that after the atrium narrowed to form the ejaculatory duct, a second enlarged section existed before the duct narrowed a second time to enter the base of the penis. This pattern resembles the form of the atria in other North American species of *Psammoryctides* reviewed by Loden (1978), and so it was assigned to the subgenus *Spencerius* by that author. This subgenus includes all of the North American species, the exception, *Psammoryctides barbatus* (Grube, 1861), is clearly an introduction to the St. Lawrence River from Europe.

The major obstacle to acceptance of this decision is the absence of the characteristic long, thin, spermathecal setae and the presence instead of penial setae. These penial setae are wider than normal ventrals (8 μm), and longer (147 μm versus 71–85 μm). They are very short distally, but have clearly bifid distal ends. Such penial setae have been described in *Varichaetadrilus* (Brinkhurst 1981, Brinkhurst and Kathman 1983).

Examination of the drawings of the penis of *P. minutus,* independently confirmed by Loden, show a small penis sheath set on the distal end of a large penial mass. This too is reminiscent of the form of the penis in *Varichaetadrilus,* in which the main body seems to be erectile.

The apparent difference in the terminal portion of the atrium and ejaculatory duct between *minutus* and the ducts of *Varichaetadrilus* species could be explained by stretching during the dissection process. Confirmation of the generic position of this species requires acquisition of new material of this scarce species, known only from one lake in Alberta and Lake Tahoe, but it is clearly much more appropriately placed in *Varichaetadrilus* than in *Psammoryctides.*

While *minutus* is quite similar to *V. pacificus* (Brinkhurst, 1981), the latter has more hair and pectinate setae anteriorly, the hair setae are found in postclitellar bundles, and there are more posterior ventral setae per bundle. The penis sheaths of *pacificus* are spool-shaped as opposed to conical.

*Varichaetadrilus nevadana* (Brinkhurst, 1965), transferred to this genus from *Isochaetides* (Brinkhurst, 1981), lacks genital setae but is otherwise quite similar to *minutus.* There are distinct differences in setal form and number, however. This species is restricted to Lake Tahoe. Another species with distinct setae, *V. israelis,* is restricted to Lake Tiberias, Israel.

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# NEW SPECIES OF FROGS FROM BORACÉIA, SÃO PAULO, BRAZIL

W. Ronald Heyer

*Abstract.*—Four new species of frogs are described from Boracéia, the University of São Paulo's field station in the Atlantic forests of Brazil: *Hyla hylax, Eleutherodactylus randorum, E. spanios,* and *Physalaemus franciscae.* In order to allocate *Eleutherodactylus* names, the status of *Eupemphix bolbodactyla, Basanitia gehrti, B. lactea, Hylaplesia nigriventris, Eleutherodactylus unistrigatus holti,* and *E. venancioi* are briefly discussed. Lectotypes are designated for *Basanitia lactea* and *Hylaplesia nigriventris. Eleutherodactylus holti* is recognized as a valid species from Itatiaia, Rio de Janeiro, Brazil.

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A summary of our knowledge of the frogs of Boracéia is being prepared (Heyer, Rand, Cruz, Peixoto, Nelson, in prep.). In the process of identifying the frog fauna from this locality in the Atlantic forests of coastal Brazil, several species have been studied that lack names. The purpose of this paper is to describe these new species before our larger report is published. A new species of *Hylodes* is the subject of a separate report (Heyer and Cocroft, in prep.).

## Species Descriptions

Carlos Alberto G. da Cruz, Oswaldo Peixoto, and I sorted out three members of the *Hyla circumdata* group from specimens collected at Boracéia: *Hyla astartea* Bokermann, 1967, *Hyla circumdata* (Cope, 1867), and a new species, to be known as

### *Hyla hylax,* new species
Fig. 1

*Holotype.*—MZUSP 59937, adult male from Brazil: São Paulo; Boracéia, approximately 23°38′S, 45°50′W. Collected by A. Stanley Rand, 4 Nov 1983.

*Paratopotypes.*—MZUSP 2357, 2535–41, 4030–31, 30875–78, 30892–94, 30901–03, 34571, 34576–77, 37801–03, 54499–501, USNM 208744, 208747, 208749, 208754, 208757, 208764–71, 208776, 208779, 208781–82, 243466–74, taken by various collectors on various dates.

*Diagnosis.*—*Hyla hylax* has in common a well developed prepollex and posterior face of thigh with dark vertical stripes with *Hyla astartea, H. carvalhoi, H. circumdata, H. izecksohni,* and *H. nanuzae*; these two characteristics distinguish this cluster of frogs from all other *Hyla* of eastern Brazil. The posterior thigh stripes are straight and bold, with some stripes connecting dorsally with stripes on the front of the thigh in *H. hylax*; the stripes are faint or discontinuous in *astartea, carvalhoi,* and *nanuzae. Hyla hylax* further differs from *astartea* and *nanuzae* in size, *hylax* having a SVL range 55–64 mm, *astartea* and *nanuzae* combined SVL ranges of 39–42 mm. *Hyla hylax* further differs from *carvalhoi*

Fig. 1. Holotype of *Hyla hylax,* dorsal view.

in that *hylax* has dark vertical stripes on the flanks, such distinct marks are absent in *carvalhoi*; *hylax* has a single, somewhat expanded vocal sac, *carvalhoi* has a bilobed subgular vocal sac. *Hyla hylax* is larger than *H. izecksohni* (SVL 34–51 mm), and the tympanum in *hylax* is noticeably smaller than in *izecksohni. Hyla hylax* is most similar to *H. circumdata,* from which it differs in having a moderate tympanum, its diameter just less than ½ the diameter of the eye (tympanum large

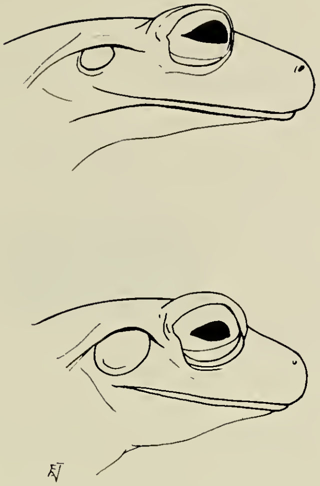

Fig. 2. Head profiles of *Hyla hylax* (above) and *Hyla circumdata* (below). Drawings based on specimens from Boracéia.

in *circumdata,* ⅗–¾ eye diameter) (Fig. 2), the head is narrower than long (broader than long in *circumdata*), and the male forearm is slightly hypertrophied (moderately to strongly hypertrophied in *circumdata*).

*Description of holotype.*—Snout shape rounded in dorsal outline, vertically rounded in profile; canthus rostralis indistinct; tympanum moderate sized, diameter about equal to ½ diameter of eye; vomerine teeth in arched series, contiguous medially, arching posteriorly, between choanae anteriorly, extending behind posterior edges of choanae posteriorly; vocal slits present; vocal sac single, barely expanded externally; finger disks large, disk on finger III equal to tympanum; finger web formula I trace II $2^{-}$–$3^{+}$ III 2½–$2^{+}$ IV; subarticular tubercles prominent, rounded, single; very faint brown nuptial pad between base of thumb and prepollex; forearm noticeably hypertrophied but not extensively so; prepollex well developed, spines not exposed; distinct tuberculate ulnar ridge; short, distinct supratympanic fold, weak glandular transverse fold above anus; dorsal texture smooth; throat smooth; belly areolate; toe disks moderately large, slightly smaller than finger disks; toe web formula I 1½–2 II 1¼–2¼ III $1^{+}$–2½ IV $2^{+}$–$1^{+}$ V; inner metatarsal tubercle large, ovoid; outer metatarsal tubercle small, indistinct, rounded; distinct inner tarsal fold extending length of tarsus; moderately large calcar on left heel, small calcar on right.

Color in preservative: Face almost uniform brown with darker brown washes, no distinct pattern; top of head light brown with darker brown anastomosing stripes; dorsum of body light brown with darker brown transverse cross bars; upper limbs also brown with dark brown cross bands; anterior flanks with incomplete vertical stripes, mid- and posterior flanks light cream and scattered brown dots (same as dorsal ground color) with distinct dark vertical stripes, light areas 2–4 times width of stripes; posterior face of thigh brown with distinct black vertical stripes, lighter areas 1–2 times width of stripes, about every other stripe continuous dorsally with stripes on front surface of thigh; throat cream and profused with brown melanophores; belly cream with a few scattered brown melanophores.

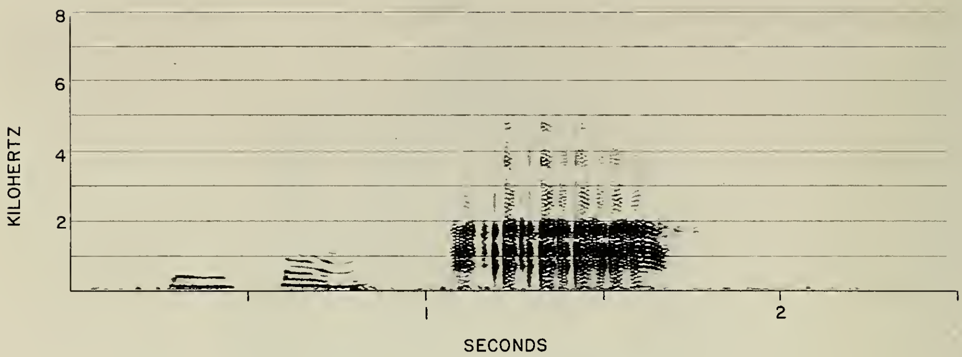

Fig. 3. Advertisement call of *Hyla hylax.* Recorded from holotype, 2011 h, 4 Nov 1983, 17.5°C air temperature.

Measurements in mm: SVL 58.5, head length 20.8, head width 20.4, femur 28.3, tibia 29.8, foot 25.1.

*Variation.*—Males range from 55–62 mm SVL. The two females available measure 60.0 and 63.4 mm, respectively. The larger female has an obviously more flared and broader head. Other than this female, there is relatively little variation in most morphological features including extent of digital webbing. The dorsal pattern ranges from uniform to a crossbar pattern. A mid-dorsal dark stripe extending from the tip of the snout to at least the scapular region is present in some individuals. Some individuals have bold dark outlined enamel cream spots on the elbows, the heel calcars and the anal fold. There may be slight to distinct demarcation of dorsal and ventral color along the ulnar fold and a light tan stripe on the outside edge of the foot and tarsus may extend to the calcar. The dark stripes on the flanks may equal the width of the light areas, or be only ⅓–¼ as broad as the light areas. In some individuals every other flank stripe is continuous with a dorsal cross band. The stripes on the posterior face of the thigh may be closely packed, such that the space between stripes is about equal to the stripe width, or spread out, such that the lighter areas between stripes are 2–3 times the stripe width.

Color in life: (From Rand and Rand notes on specimen MZUSP 30904) "Dirty tan with brown middorsal stripe from snout, fading out at vent. Few small cream blotches lower back. Legs and arms same color as back, banded with wide orange tan except for femur which has very narrow tan band above and is flesh colored on front and back with dark grey bands. This continues onto concealed surface of tibia. Sides yellow gold, deeper at groin with pale transverse banding. Chin and throat cream with tiny black flecks. Belly and under femur anteriorly pale orange cream. Under femur behind this dirty tan. Under arms, hands, behind shoulder and under legs flesh color."

*Advertisement call.*—(Description based on calls from several specimens.) Call duration about 0.5–1.0 s; calls given sporadically; calls pulsed, pulses grouped together forming notes within call initially, more continuous but still not even pulse rate at end of call; pulse rate about 100 per s; calls not noticeably frequency modulated; call intensity moderately modulated, first half of call loudest; dominant frequency range 400–2300 Hz; no apparent harmonic structure; distinct sidebands due to pulsatile nature of call (Fig. 3).

*Etymology.*—Latinized Greek for barker, in allusion to the distinctive dog bark-like advertisement call.

*Referred specimens.*—Brazil: Paraná; Praínha, MZUSP 36002; São Paulo; Boracéia; MZUSP 34578–80, 34588–91, 34599–601, 34603–04, 37795 (juveniles); São Paulo; Ferraz de Vasconcelos, MZUSP 34474; São Paulo; Paranapiacaba, MZUSP 8870, 9629, 10621–23, 10978, 13873–76.

There are four species of *Eleutherodactylus* from Boracéia to which names are readily applied: *E. binotatus, guentheri, hoehnei,* and *parvus.* In addition, there are other *Eleutherodactylus* specimens that are small in size as adults and their variation is considerable and difficult to interpret. Conservatively, these additional specimens represent a minimum of two species and possibly as many as six. I think at least four species are represented, one of which is represented only by a single juvenile specimen. For this specimen (USNM 243675), description is deferred until an adult is obtained. These small *Eleutherodactylus* all belong to the section of the genus that has at times been recognized as a distinct genus of its own, *Basanitia.* Several names have been proposed for members of this group; examination of the original descriptions, topotypic material, and most of the types indicates that only one name applies to the species from Boracéia. The names that could be or have been applied to the Boracéia frogs are *Eupemphix bolbodactyla, Basanitia gehrti, B. lactea, Hylaplesia nigriventris, Eleutherodactylus unistrigatus holti,* and *E. venancioi.* Each of these names is briefly discussed.

*Eupemphix bolbodactyla* A. Lutz, 1925.—Two cotypes, USNM 96542–43, are in very poor condition, owing in part from incisions made through the angle of the jaw and body wall almost to the groin. Several digit tips are missing in both specimens. USNM 96542, an approximately 16 mm SVL male with vocal slits, has the snout region destroyed. USNM 96543, a 14.5 mm specimen, shares with 96542 the following character states: disks not greatly expanded, vomerine teeth present, and pattern completely non-existent (due to fading, as Lutz described a color pattern for this species in the original description). The disks are small relative to the Boracéia species, indicating that the name *bolbodactyla* does not apply to any of the Boracéia species. Further clarification of *bolbodactyla* will depend on examination of well preserved topotypic material and the MNRio cotype. Designation of a lectotype at this time is premature.

*Basanitia gehrti* Miranda-Ribeiro, 1926.—The holotype and only known specimen of *B. gehrti* could not be located at either MNRio or MZUSP in May 1984. The MZUSP collection has been reorganized recently and it is unlikely that the type was missed but it is possible that it was missed during the search of the MNRio collection. Miranda-Ribeiro's description is brief. The characters that pertain to association with the Boracéia species are: tympanum small, barely evident; vomerine teeth present; three outer fingers with very large disks, the first without a disk; skin smooth; dorsum uniform black with a white cephalic-coccygeal line, under sides of disks, belly, and thighs, lighter. This combination of characteristics does not match any of the species from Boracéia; the most similar is the juvenile specimen USNM 243675. Bokermann (1966a:15) placed *gehrti,* from Alto da Serra, São Paulo, in the synonymy of *Basanitia nigriventris,* another species described in part from the same locality. The dorsal texture of *nigriventris* is tuberculate, but preservation differences could account for *gehrti* having been described as having a smooth skin. The identity of *gehrti* will not be resolved satisfactorily until the type specimen is located and examined. Nevertheless, the characters that Miranda-Ribeiro used to describe the animal differentiate it from the Boracéia species, with the exception of the above mentioned juvenile. Until evidence to the contrary is presented, I believe it best to allow *gehrti* to remain in the synonymy of *nigriventris.*

*Basanitia lactea* Miranda-Ribeiro, 1923.—Miranda-Ribeiro described *lactea* on the basis of two specimens, a 32 mm specimen from Iguape, São Paulo (MZUSP 828), and a 19 mm individual from Campo Grande (MZUSP 504). MZUSP 828 is the specimen described and figured by Miranda-Ribeiro. MZUSP 504, the second syntype, is an adult female *Eleutherodactylus parvus.* MZUSP 828 is hereby selected as the lectotype of *Basanitia lactea* Miranda-Ribiero. The lectotype is no longer in good condition—most of the finger disks have disintegrated and the feet are torn apart. A very faint pattern still persists, consistent with the pattern shown in Miranda-Ribeiro's illustration. The back of the thigh in particular is boldly mottled, and the front of the thigh has a faint suggestion that it, too, was boldly mottled. The tympanum is hidden, the dorsum is smooth, and there is no indication that the belly was ever dark. The specimen is an adult female with the following measurements: SVL 32.2 mm, head length 11.7 mm, head width 11.3 mm, femur 15.1 mm, tibia 14.9 mm, and foot approximately 14.5 mm. The size and pattern distinguish *lactea* from the species at Boracéia.

*Hylaplesia nigriventris* A. Lutz, 1925.—Lutz described *nigriventris* on the basis of more than one specimen (number not specified) from Itatiaia and Serra de Cubatão. Bokermann (1966a:65) stated that in the Adolpho Lutz collection he found two specimens (720, 721) labelled as types from Paranapiacaba (=Serra de Cubatão). Professor Antenor Leitão de Carvalho kindly located three specimens indicated as types for my examination: 719, 720, 721. All three specimens have the same locality data of Alto da Serra de Cubatão [=Paranapiacaba]. There is an additional cotype, USNM 96846, from the same locality. Thus, the Itatiaia specimen or specimens are probably lost. Based on zoogeography, it would not be surprising if the Itatiaia and Paranapiacaba specimens were different. The 21 mm SVL specimen Lutz described is apparently lost and may have been from Itatiaia. The remaining types are 17.8 mm SVL (AL 719), 8.2 mm (AL 720), 7.0 mm (AL 721) and 6.5 mm (USNM 96846). AL 720 is a juvenile *Eleutherodactylus guentheri.* The other three specimens appear to be conspecific and are used for application of the name *nigriventris.* The specimens are almost black, a coloration presumably artificially caused as the insides of the mouths are also black. As AL 719 is the largest specimen and easiest to compare with other specimens, it is hereby designated as the lectotype of *Hylaplesia nigriventris* A. Lutz. The lectotype has a series of warty tubercles on the dorsum and upper eyelid; a particularly prominent calcar, an indistinct tympanum, very large disks on the outer fingers and toes, and even though the bones have become decalcified, vomerine teeth are visible. As indicated above, the lectotype is dark and shows no indications of pattern. The lectotype shares all diagnostic character states with a 19.0 mm SVL male from Boracéia, MZUSP 37787; the two specimens are considered conspecific. The color pattern in preservative of MZUSP 37787 is: face with a dark brown mark in canthal region just behind nostril, rest of face brown with indistinct darker brown oblique bars below eye, dark supratympanic spot; dorsum a complex pattern of lighter and darker browns with large brown blocks; upper limbs brown with darker brown cross bands; anterior flank a meeting of dorsal and ventral patterns, in groin area a bold dark brown and cream mottle extending onto anterior surface of thigh; posterior surface of thigh with a light ovate cream area in midthigh to knee surrounded by more or less uniform brown, light area extending a bit more medially as a broken pattern; hidden and under surfaces of tibia with bold dark brown and cream mottle; throat uniform dark brown with very small, scattered light punctations; belly dark brown with light dots.

*Eleutherodactylus unistrigatus holti* Cochran, 1948.—The holotype, from "Alto Itatiaya," matches quite well with recently collected specimens of *Eleutherodactylus* from Brejo da Lapa, Itatiaia. At Brejo da Lapa, only one species of *Eleutherodactylus* has been collected. The species is common, however. The holotype matches recent specimens in: (A) body proportions, including relatively long fingers with large truncated, dorsally notched disks on fingers III and IV; (B) small vomerine tooth patches; (C) tympanum indistinct but externally visible; (D) areolate belly; (E) small calcar; (F) 2–3 distinct darkish tubercles on sole of foot. The holotype is in poor condition, and the pattern is no longer discernible. The figures Cochran drew showed some pattern details, which are matched in the recent specimens. The holotype is a male with vocal slits. Cochran gave the SVL as 19 mm; I measure no more than 17 mm, but the specimen is compacted.

There are proportional differences between the Itatiaia form and *E. unistrigatus,* most strikingly in head shape and finger lengths. The structure of the finger and toe disks is very different—*unistrigatus* with truncate or ovately truncate disks lacking a dorsal indentation; the Brejo da Lapa form has large, dorsally indented disks. The differences are of a magnitude more consistent with species level differentiation and are so considered.

With the name *nigriventris* restricted to the lectotype from Paranapiacaba, *Eleutherodactylus holti* is the available name for the species from the higher elevations of Itatiaia. *Eleutherodactylus holti* and *nigriventris* are distinct species, differing in body shape, degree of dorsal wartiness, and particularly in calcar size. The calcar of *nigriventris* is large and prominent; the calcar of *holti* is small and indistinct, if expressed.

*Eleutherodactylus venancioi* B. Lutz, 1959.—Recently collected topotypes agree well with Lutz's description and illustration. This large disked species differs from all Boracéia large disked species in having a combination of a long slender snout, a distinct face mask, and small size, males about 17 mm and females 24 mm SVL.

There remain three species of *Eleutherodactylus* from Boracéia lacking names. As indicated above, description of a juvenile specimen (USNM 243675) is deferred until associated adults are collected. The two species described below differ from all other *Eleutherodactylus* from coastal Brazil except *holti, lactea, nigriventris, parvus, pusillus,* and *venancioi* in having a hidden or indistinct tympanum in contrast to a distinct, exposed tympanum with the annulus obvious externally at least on the sides and ventrally (also see Heyer 1984, Table 19). Of these, *parvus* and *pusillus* have small, pointed finger disks in contrast to the large triangularly ovate disks on the outer fingers of *holti, lactea, nigriventris, venancioi,* and the

Fig. 4. Holotype of *Eleutherodactylus randorum,* dorsal and ventral views.

new species. For comparative purposes, the new species are diagnosed only between themselves and *holti, lactea, nigriventris,* and *venancioi.*

### *Eleutherodactylus randorum,* new species
Fig. 4

*Holotype.*—MZUSP 59936, an adult male from Brazil; São Paulo; Boracéia, approximately 23°38'S, 45°50'W. Collected by W. Ronald Heyer on 2 Nov 1983.

*Paratopotypes.*—MZUSP 23665–70, 23672–74, 23676–77, 34635, 36865, 37555, 49644, USNM 243475–78, 244635.

*Referred specimen.*—MZUSP 23675, a slightly morphologically distinct specimen from Boracéia.

*Diagnosis.*—*Eleutherodactylus randorum* differs from *holti, lactea, nigriventris, spanios,* and *venancioi* in lacking vomerine teeth; vomerine teeth are either visible or can be felt by probe in the other species.

*Description of holotype.*—Snout shape subovoid in dorsal outline, rounded-protruding in profile; canthus rostralis indistinct; tympanum hidden; no vomerine teeth; vocal slits present; vocal sac large, single, externally expanded from midthroat to just past posterior level of arm insertion; thumb lacking disk, large disk on finger II, very large disks on fingers III and IV, disks ovately triangular, upper surfaces medially indented; fingers free of web; subarticular tubercles indistinct; no nuptial asperities or other secondary sexual characteristics; no prepollex; no ulnar ridge; no distinctive body glands or folds; dorsum smooth except for few low tubercles on upper eyelid; throat smooth; belly weakly granular; toe disks large, but smaller than largest finger disks; toes free of web; inner metatarsal tubercle oval, outer small and round; no tarsal fold or tubercle; heel with single modest tubercle.

Color in preservative: Dark canthal stripe, dark outlined forwardly directed oblique bar under eye on upper lip, dark stripe from posterior corner of eye continuous with flank stripe; dorsum more or less uniform tan mid-dorsally with broad light dorsolateral stripes, light incomplete mid-dorsal pin stripe, light broad

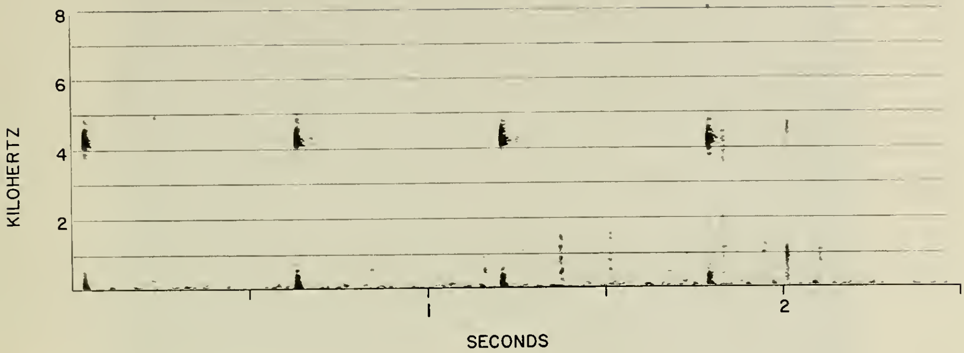

Fig. 5. Advertisement call of *Eleutherodactylus randorum*. Recorded from holotype, 2045 h, 2 Nov 1983, about 19°C air temperature.

dorsolateral stripe bordered above and below with dark brown stripe; upper limbs indistinctly cross banded; flanks with continuation of broad light dorsolateral stripe to groin; posterior surface of thigh mottled, faint dark seat patch, light transverse stripe under anus; more or less uniformly scattered melanophores on throat and belly, superimposed with scattered dark speckles.

Measurements in mm: SVL 14.8, head length 5.9, head width 5.1, femur 6.9, tibia 7.3, foot 6.5.

*Variation.*—There is considerable morphological and pattern variation among the specimens at hand. The upper eyelid varies from smooth to having several distinct tubercles. The tympanum is either hidden or indistinct, when indistinct of moderate size, about ½ diameter of eye. The male vocal sac begins either from under the nostril level or from a level under the posterior edge of the eye; the smallest male (11.8 mm) does not have an expanded sac. The dorsum is smooth to scattered with tubercles. The outer metatarsal tubercle is indistinct in some individuals. The heel tubercle ranges from indistinct to very distinct. The mid-dorsal area ranges from almost uniform brown or tan to mottled. Mid-dorsal and dorsolateral stripes are present or absent. The referred specimen, MZUSP 23675, has a broad light mid-dorsal area bordered laterally with dark pin stripes. The face pattern is either boldly demarcated or fuzzily so, but there is still a discernible pattern of dark oblique bars under the eye, except in referred specimen MZUSP 23675, which has a more or less uniform face pattern. One specimen has a light snout. In individuals lacking broad dorsolateral stripes, the posterior flank has a bold or subtle dark and light mottled pattern in the groin or a light uniform groin pattern. Referred specimen MZUSP 23675 has an almost uniform brown throat and chest and the belly is mottled but not quite distinctly speckled. The anterior and posterior surfaces of the thigh range from almost uniformly light to boldly mottled. The seat patch ranges from indistinct to noticeable. Males range from 11.8–15.0 mm SVL, females 15.0–18.2 mm.

Color in life: (Based on composite color notes of W. R. Heyer and A. S. Rand for several individuals.) Iris with transverse brown stripe, above which lemon yellow, below which duller yellow; dorsolateral stripes cream; light areas under

Fig. 6. Holotype of *Eleutherodactylus spanios,* dorsal view.

eye cream; 2 light brown bars under eye; dorsum olive drab, pin stripes yellowish; venter dirty white with black markings; posterior surface of thigh mottled dirty white and brown/black.

Life colors vary considerably. The dorsum ranges from light brown, orange-tan, red-brown, to deep rust. The groin is black and white, brass yellow, bright yellow, or orange. The tops of the legs are brown, orange-tan, or greenish-yellow. The belly is pale, white, cream, pearl, or bronze with dark brown or black markings.

The anterior and posterior surfaces of the thighs are black and indistinct white, bright yellow, or faint orange.

*Advertisement call.*—(Description based on several calls from one individual.) Call consisting of 3–8 notes and of about 2–5 s duration, intercall interval 4–8 s when actively calling; note duration 0.04–0.10 s; note rate about 2 per s; notes strongly partially pulsed, each note with 3–8 discernible pulses; note pulsatile rate about 280 per s; calls not noticeably frequency or intensity modulated; dominant frequency range 3800–5200 Hz; no apparent harmonics (Fig. 5).

*Etymology.*—Named for Patricia and Stanley Rand, who through their field efforts added appreciably to our knowledge of the natural history of the frogs from Boracéia.

### *Eleutherodactylus spanios*, new species
Fig. 6

*Holotype.*—MZUSP 23664, an adult male from Brazil; São Paulo; Boracéia, approximately 23°38′S, 45°50′W. Collected by Patricia and Stanley Rand, 13 Feb 1963.

*Paratopotype.*—MZUSP 23671.

*Diagnosis.*—*Eleutherodactylus spanios* is a small species, the known male 14.7 mm SVL and the known female 21.4 mm SVL; the known males and females of *holti, lactea, nigriventris,* and *venancioi* exceed 16 and 24 mm respectively. *Eleutherodactylus spanios* is most similar to *E. randorum,* from which it differs by having vomerine teeth and a non-expanded vocal sac in the males.

*Description of holotype.*—Snout shape subovoid in dorsal outline, rounded in profile; canthus rostralis indistinct; tympanum indistinct, about ½ eye diameter; vomerine teeth discernible by probe, not visible under low magnification, posterior and medial to choanae; vocal slits present; vocal sac single, not expanded; tip of thumb swollen, disk on finger II moderately large, disks on fingers III and IV large, just smaller than tympanum, ovately triangular, slightly medially indented dorsally; fingers free of web; subarticular tubercles indistinct; no nuptial asperities or other secondary sexual characteristics; no prepollex; no ulnar ridge or fold; dorsum smooth; throat and belly smooth; toe disks large, just smaller than finger disks; toes free of web; inner metatarsal tubercle oval, outer small, round, distinct; no tarsal fold or tubercle, tarsus smooth; heel with moderate sized tubercle.

Color in life: (Edited from Rand and Rand field notes.): Brown with lighter patterning and dark brown or black under eye, behind tympanum, over shoulders, at vent and heels; bright orange-red on concealed surfaces of legs and arms extending up onto belly where edges of red area blotchy; fingers and toes red; darker and lighter brown banding on legs and arms.

Color in preservative: Face with indistinct canthal stripe; indistinct, forwardly directed oblique bar under eye to upper lip; dark tympanic spot; dorsum with indistinct pattern of darker and lighter brown; limbs indistinctly cross banded; posterior flank light, patternless; posterior surface of thigh very light, not much pattern except for dark seat patch; throat almost uniform brown; belly mottled brown anteriorly, mostly plain posteriorly, not dark speckled.

Measurements in mm: SVL 14.7, head length 5.9, head width 4.9, femur 6.5, tibia 7.6, foot 6.5.

*Variation.*—The single, brittle female, 21.4 mm SVL, has one broken hind leg. The vomerine teeth are visible under low magnification. The tympanum is hidden. The belly is weakly granular. The groin is not much distinguished from the dorsal pattern. The posterior surface of the thigh is mottled, but with a lighter area toward the knee and the front of the thigh is patternless.

*Advertisement call.*—Unknown.

*Etymology.*—From the Greek *spanios,* rare, in allusion to its rarity of collection.

*Comparisons.*—This species is most similar to *randorum.* It differs in having vomerine teeth (absent in *randorum*), somewhat larger size, male with non-expanded vocal sac (greatly expanded in *randorum*), non-speckled belly (speckled in *randorum*), and bright orange-red flash colors (no flash colors or yellow or dull orange in *randorum*). The combined differences are interpreted to mean species level differentiation rather than intraspecific variation.

Four species of *Physalaemus* occur at Boracéia: *cuvieri, maculiventris, olfersi,* and a species that has been identified in collections and referred to in the literature as *signiferus.* The type locality of *Rhinoderma signifera* Girard, 1853, is Rio de Janeiro, Brazil. Comparison of topotypic specimens and calls of *signiferus* with the Boracéia specimens and calls indicates that the two are not conspecific.

### *Physalaemus franciscae,* new species
Fig. 7

*Holotype.*—MZUSP 59935, an adult male from Brazil; São Paulo; Boracéia, approximately 23°38′S, 45°50′W. Collected by W. Ronald Heyer, 8 Dec 1976.

*Paratopotypes.*—MZUSP 3947, 4084, 4114, 25831, 25853, 25856, 25857–70, 25872–82, 26036–37, 37565–68, USNM 243507–45, 244636, taken by various collectors on various dates.

*Diagnosis.*—Lynch (1970) delineated species-groups of *Physalaemus,* and he thought that all but the *signiferus* group were monophyletic. Members of the *signiferus* group were thought to be heterogeneous, but collectively could be differentially diagnosed from other *Physalaemus* by the following combination of characteristics: small to moderate size; slender build; smooth skin; finger I shorter than II; no inner tarsal tubercle; small, non-compressed metatarsal tubercles; small to large inguinal glands; lacking parotoid glands. The members of this group, which are diagnosed from *franciscae,* are *maculiventris* (A. Lutz, 1925), *nanus* (Boulenger, 1888), *obtectus* Bokermann, 1966, *olfersi* (Lichtenstein and Martens, 1856), and *signiferus* (Girard, 1853).

*Physalaemus franciscae* lacks the light stripe from eye to arm insertion ventrally bordering the dark flank stripe of *olfersi,* and is smaller than *olfersi* (adult *franciscae* no larger than 29 mm SVL, adult *olfersi* 30–35 mm SVL). *Physalaemus franciscae* has a few scattered light tubercles on the sole of the foot; the sole of the foot is smooth in *maculiventris* and *nanus.* The posterior belly is boldly mottled in *franciscae,* the posterior belly lacks pattern in *obtectus* and *signiferus.*

*Description of holotype.*—Dorsal outline of canthus rostralis and tip of snout pointed, of upper lip rounded; snout acutely rounded in profile; canthus rostralis sharp; tympanum indistinct, almost hidden, just less than ½ eye diameter; maxillary teeth not visible, but discernible by probe; vomerine teeth absent; vocal

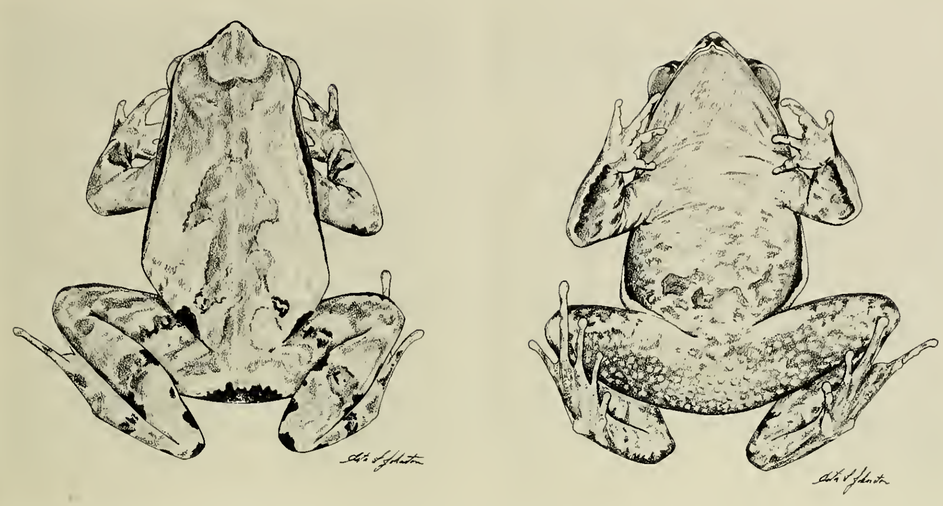

Fig. 7. Holotype of *Physalaemus franciscae,* dorsal and ventral views.

slits present; vocal sac single, slightly expanded externally, extending to border of chest with belly; finger tips barely swollen, not disked; fingers free, lacking fringe, ridge, or web; subarticular tubercles moderately large, rounded, not pungent; pair of brown nuptial pads on each thumb, narrowly separated from each other, ovoid pad at base of thumb associated with inner metacarpal tubercle, elongate pad covering rest of upper and inner thumb surface; no prepollex; no ulnar ridge; weak supratympanic fold; dorsolateral fold from eye to groin along demarcation of dorsal and flank color, large tear-shaped lumbar gland in groin, narrow portion directed anteriorly; dorsum smooth with scattered low glandular warts, tubercles warty, tubercles most noticeable on upper eyelids, throat and belly smooth; toe tips very slightly swollen, not disked; toes free, lacking web, sides of toes weakly ridged (left fourth toe missing); inner and outer metatarsal tubercles ovoid, outer about ¾ size of inner, outer slightly compressed; short, weak tarsal fold on distal ⅖ of tarsus, approaching but not contacting inner metatarsal tubercle, rest of tarsus smooth; left heel smooth, right heel with low glandular tubercle; foot smooth with few smallish light fleshy tubercles.

Color in preservative: Black canthal stripe extending to upper lip sharply delineated from dorsal color above, indistinctly set off from loreal pattern below, loreal region gray, upper lip cream with dark bars; dorsal ground color cream-tan on which a somewhat darker, continuous, almost symmetrical pattern consisting of an interorbital bar, a broad forwardly pointing arrowhead just past the shoulder region and another broken triangular pattern in the sacral region with the bases of the triangles extending to and joining the black groin spots, all outlined with cream pin stripes, faint indications of other darker markings paralleling the triangular marks; forelimb with a dark cross band, rest of upper surfaces of arms mottled light brown-tan; when leg folded, a single dark cross band continuous across femur, adjacent tibia and adjacent tarsus, rest of upper leg surfaces indistinctly mottled tan and brown; forearm with sharply demarcated line separating light dorsal and dark ventral pattern; inner and outer surfaces of tibia tan with

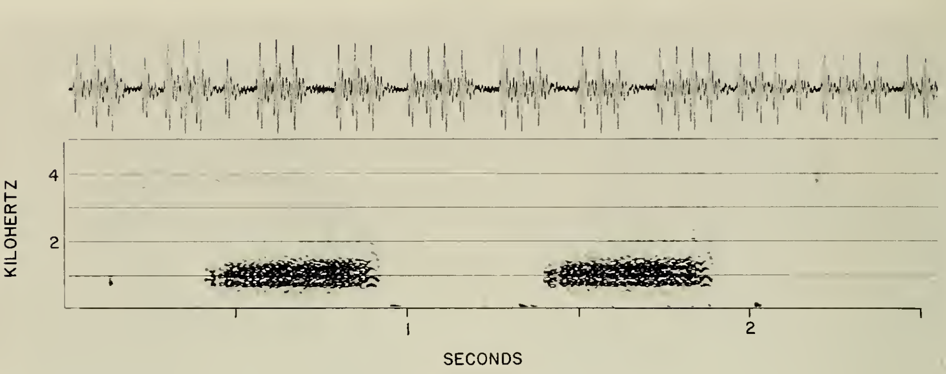

Fig. 8. Advertisement call of *Physalaemus franciscae.* Wave form signal length 0.214 s showing portion of call on left of audiospectrogram. Recorded from holotype, 8 Dec 1976, 21.5°C air temperature.

bold black spots; black flank stripe sharply demarcated from dorsal color above from posterior edge of eye to lower groin, not quite extending to femur, dark flank stripe fading into ventral color rather than being sharply defined from it; very distinct white outlined black spot in groin on lumbar gland, spot about ⅓ size of gland; dark seat patch bordered by filigree pattern; light dorsal pattern extending deeply onto posterior surface of thigh, lower distal portion of posterior surface of thigh with darker mottle, lower mid-portion with 1–2 distinct dark blotchy spots; throat dark gray-brown mottle extending onto chest; belly with bold dark gray and cream mottle, especially on posterior ½ of belly.

Measurements in mm: SVL 25.4, head length 8.5, head width 8.8, femur 11.5, tibia 11.9, foot 11.9.

*Variation.*—The tympanum ranges from hidden to almost distinct. The male vocal sac is either expanded from the tip of the chin through the chest or not expanded externally. The first finger is about the same length as the second, but may be either just shorter or just longer than second. The outer metatarsal tubercle ranges from about ⅓ to almost as large as the inner. The short tarsal fold contacts the inner metatarsal tubercle in a few specimens; the fold is usually distinct but sometimes indistinct. There is relatively little variation in color patterns, mostly involving intensity of patterns. The males range from 25.0–27.0 mm, females 24.8–28.2 mm.

Color in life: (From USNM 243520.) Iris bronze; throat with salmon cast; belly cream and black with brown cast; groin with salmon cast. (Rand and Rand color notes from MZUSP 25863–65.) Light khaki with patterning on back, edged with dark. Dark spots at end of belly and on tibia. Back of thighs and heels dark brown. Orange on groin. Belly and legs speckled.

*Advertisement call.*—Call duration 0.50–0.70 s; calls given frequently when calling; call of complex structure including harmonics and pulses, beginning and most of call with 22–28 pulses, call ending with short non-pulsed portion, pulse rate about 50 per s; calls with slight but noticeable frequency modulation (warble) throughout call; calls quiet, starting and ending with lower intensity; dominant frequency range 600–1600 Hz; several distinct harmonics (sidebands?) at a fundamental frequency of about 250 Hz (Fig. 8).

*Etymology.*—Named in honor of Francisca Carolina do Val, who for the last several years has been the administrator of Boracéia and has greatly facilitated research at the field station.

*Referred specimens.*—Brazil: São Paulo; Casa Grande, MZUSP 37327; São Paulo; Paranapiacaba, MZUSP 6477, 8851.

*Comparisons.—Physalaemus franciscae* is most similar to *P. obtectus* and *P. signiferus.* In addition to the belly pattern differences given in the diagnosis, the calls of the three differ from each other in terms of length and pulse structure. The call of *P. obtectus* is composed of 3 or 4 notes, each note comparable to the entire call of *franciscae* and *signiferus,* with a note duration of about 0.08 s. The calls of *signiferus* are longer in duration, about 0.30 s, and the calls of *franciscae* longest, about 0.60 s. Further, only the final portion of the call of *P. franciscae* is non-pulsed, whereas the entire calls of *obtectus* and *signiferus* seem to lack the pulsation of *franciscae.* The entire call of *signiferus* appears very similar to the final portion of the call of *franciscae.* (Comparative data for *P. obtectus* and *signiferus* from Bokermann 1966b.)

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Carlos Alberto Gonçalves da Cruz and Oswaldo L. Peixoto pointed out the distinctiveness of *Hyla hylax* to me and kindly allowed me to describe it. Charles W. Myers and George R. Foley, American Museum of Natural History (AMNH) allowed me to borrow the holotype of *Eleutherodactylus unistrigatus holti.* Antenor Leitão de Carvalho once again provided access to the collections in the Museu Nacional, Rio de Janeiro (MNRio). P. E. Vanzolini characteristically gave me complete access to the Museu de Zoologia da Universidade de São Paulo (MZUSP). Reginald B. Cocroft produced the audiospectrograms used for call analysis and entered and revised the text on the word processor. Esta Johnson drew the original illustrations for Figs. 2, 4, and 7. Stanley H. Weitzman kindly prepared the photograph for Fig. 6. George R. Zug, Smithsonian Institution (USNM), critically read the manuscript. Research leading to this paper was supported, in part, by the Museu de Zoologia da Universidade de São Paulo; a Scholarly Studies Award from the Smithsonian Institution; and the I.E.S.P. Neotropical Lowland Research Program, Smithsonian Institution.

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# *LOISETTEA AMPHICTENA*, NEW GENUS, NEW SPECIES, FROM THE SUBLITTORAL OF NORTHWESTERN AUSTRALIA (ECHINODERMATA: HOLOTHUROIDEA)

F. W. E. Rowe and David L. Pawson

*Abstract.*—*Loisettea,* new genus, differs from others in the dendrochirotid subfamily Colochirinae in possessing body wall ossicles in the form of deep complex cups, buttons, and large scales. *Loisettea amphictena,* new species, is distinctive in possessing conspicuous ventrolateral papillae; it occurs off the coast of northwestern Australia. *Colochirus gazellae* Lampert, from Sumbawa in the Sunda Islands and from northwestern Australia, is also referred to the new genus.

Over the past 25 years, largely through the dedicated collecting of Raymond W. George, Barry R. Wilson, and Loisette M. Marsh, the echinoderms of the Western Australian region, from the shore to upper bathyal depths, have become increasingly well known. The regional collections of the Western Australian Museum are now extensive, and include numerous echinoderms which represent new taxa, or are new records for the region. During our separate and joint investigations of Australian holothurians, we found that both the Australian Museum (AM) and the Western Australian Museum (WAM) collections contained specimens of a unique and distinctive holothurian—this new genus and species is described below.

We thank Loisette M. Marsh of the Western Australian Museum for making specimens and a photograph of this interesting animal available to us. John Miller, Harbor Branch Foundation, Inc., Florida, kindly and patiently led David L. Pawson through SEM preparation and photography of the ossicles, and reviewed the draft manuscript of this paper. Partial support for David L. Pawson was provided by Smithsonian Fluid Research Funds. Sequence of authors of the paper was decided by the toss of a coin.

### Order Dendrochirotida
### Family Cucumariidae Ludwig, 1894
### Subfamily Colochirinae Panning, 1949
### *Loisettea,* new genus

*Diagnosis.*—Tentacles 10, 2 ventral tentacles smaller than others. Calcareous ring with undulating posterior margin, lacking posterior projections. Body wall thick, brittle, packed with ossicles. Ventral radii with tube feet in zigzag rows, dorsal radii with single rows of widely spaced feet; smaller feet scattered in dorsal and ventral interradii. Ventrolateral and dorsal papillae present or absent. Ossicles lenticular plates or scales, knobbed buttons and deep complex cups.

*Type-species.*—*Loisettea amphictena,* new species.

*Other species included.*—*Colochirus gazellae* Lampert, 1889.

*Distribution.*—Both species occur off the northwestern coast of Australia; *C. gazellae* is also known from Sumbawa, Sunda Islands.

*Etymology.*—The genus-name is of feminine gender. We take great pleasure in naming the genus in honor of Loisette M. Marsh of the Western Australian Museum, Perth, who has contributed so much to our knowledge of Australian echinoderms, and who is a very good friend and colleague to both of us. The species-name is derived from the Greek *amphi*—both sides or double, and *ktenos*—a comb, in reference to the comb-like pattern of ventrolateral papillae in this species.

*Remarks.*—Within the Subfamily Colochirinae, some species in the genera *Aslia* Rowe, 1970, *Pentacta* Goldfuss, 1820, and *Trachythyone* Studer, 1876, possess deep baskets or cups in the body wall. The new genus diagnosed here differs from *Aslia* species in the disposition of the tube feet and in ossicle form, ossicles of *Aslia* comprising buttons and baskets with no evidence of lenticular plates. Body wall cups of *Pentacta* are generally shallow and simple; in *P. anceps* (Selenka) the cups are deep, but the body wall is thinner and softer than in *Loisettea.* Also, the ossicles of *P. anceps* include delicate hollow spheres, but lack lenticular plates. *Trachythyone* species possess smooth plates, a characteristic that immediately separates that genus from *Loisettea.*

Panning (1971) included *Colochirus gazellae* Lampert and *C. dispar* Lampert in the predominantly western Atlantic genus *Thyonella*; both species occur in northwest Australia, and the latter species is also known from the Somali Coast (Clark and Rowe 1971). These species differ from others in *Thyonella* in the form of the ossicles and in distribution of the tube feet. We believe that *C. gazellae* is congeneric with the new species described below, and we transfer it to the genus *Loisettea* herein. *Colochirus dispar* is provisionally referred to the genus *Pentacta* since in our opinion it is at least congeneric with *P. australis* (Ludwig).

### Key to species of *Loisettea,* new genus

1. Conspicuous ventrolateral papillae present ....... *amphictena,* new species
– No conspicuous ventrolateral papillae .................. *gazellae* Lampert

### *Loisettea amphictena,* new species

Figs. 1–3

*Diagnosis.*—Conspicuous ventrolateral papillae present.

*Material examined.*—HOLOTYPE: Australian Museum J1427, 17°38′S, 121°27′E, 78 m, 16 Jun 1980, collected by R. B. Martin on CSIRO *Soela.* PARATYPES: Australian Museum: J14283, 19°36′S, 118°37′E, 36 m, 4 Jun 1980, R. B. Martin on CSIRO *Soela,* 1 specimen; J14288, Timor Sea, 13°11′S, 129°43′E to 13°09′S, 129°43′E, 34–38 m, 7 Jul 1979, 1 specimen. Western Australian Museum: Catalogue No. 54-63, 36 miles SW of Adele Island, northwest Australia, 72 m, 17 Oct 1962, dredged by R. W. George on *Davena,* 1 specimen; 70-63, 3–4 miles off East Delambre Island, Dampier Archipelago, 18 m, 5 Jun 1960, rocky, B. R. Wilson on *Davena,* 1 specimen; 96-63, same data as 70-63, 1 specimen; 330-71, off Carnavon, Western Australia, Jul–Sep 1967, W. and W. Poole on *Bluefin,* 1 specimen; 332-71, Blocks 2–6, Shark Bay, Western Australia, Aug 1965,

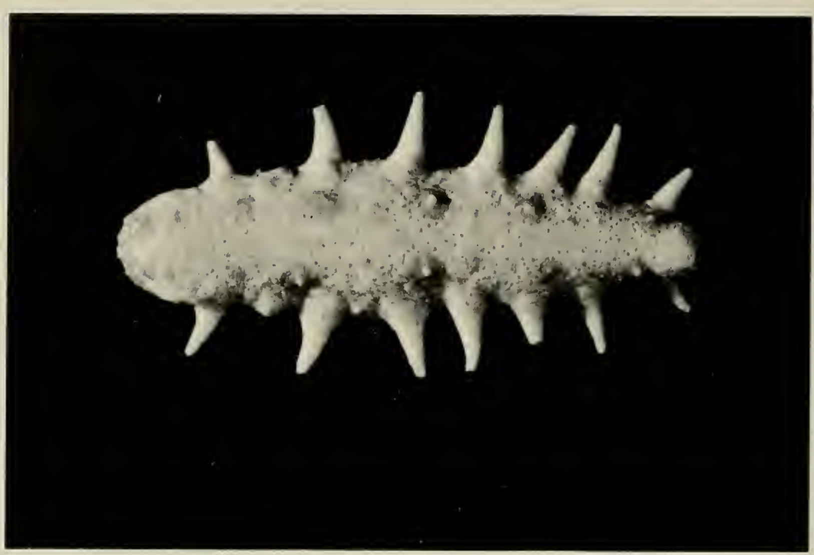


Fig. 1. *Loisettea amphictena,* live specimen, total length 70 mm, dorsal view.

FRV *Peron,* 1 specimen; 676-82, 38 nautical miles north of Port Walcott, Western Australia, 19°59′S, 117°16′E to 20°01′S, 117°16′E, 52–50 m, 15 Apr 1982, silty sand and bryozoa, triangle dredge towed for 15 minutes, L. Marsh on *Soela,* 1 specimen; 677-82, 36 nautical miles north of Port Walcott, Western Australia, 20°01′S, 117°08′E to 20°00′S, 117°10′E, 50 m, 16 Apr 1982, silty sand and large

Table 1.—*Loisettea amphictena*: Disposition and numbers of papillae and radial tube feet.

| Specimen | Length (mm) | Lateral papillae |  | Dorsal papillae | Other |
|---|---|---|---|---|---|
|  |  | Left | Right |  |  |
| AM J14287 | 94 | 9 | 8 | 4 per radius | 1* |
| AM J14283 | 80 | 7 | 8 | 6–8 per radius | — |
| AM J14288 | 92 | 5 | 6 | absent | — |
| WAM 54-63 | 56 | 7 | 6 | 6–8 per radius | — |
| WAM 70-63 | 77 | 7 | 9 | 4 left, 5 right | — |
| WAM 96-63 | 40.5 | 9 | 7 | 4 per radius | 2* |
| WAM 330-71(1) | 91 | 7 | 7 | absent | 3* |
| WAM 332-71 | 96.5 | 7 | 6 | — | — |
| WAM 676-82(1) | 63 | 6 | 7 | 3 left, 4 right | 4* |
| WAM 677-82(1) | 72 | 8 | 9 | 5 left, 7 right | — |
| BM(NH) 1892.1.16.99 | 53 | — | — | — | 5* |
| BM(NH) 1892.1.14.269–71 | 56 | 6 | 5 | — | — |
| BM(NH) 1892.1.14.269–71 | 36 | 7 | 5 | — | — |

1* tube feet in single row in lateral ventral radii, in double row in midventral radius.

2* ventral tube feet in single rows in ventral radii.

3* tube feet in irregular single row in each lateral ventral radius, in 2–3 rows in midventral radius.

4* tube feet in single row in each lateral ventral radius, 15 feet per row; in midventral radius 29 feet in zigzag single row (or 2 scattered rows).

5* tube feet in single row in each lateral ventral radius, 13–14 feet per row; in midventral radius approximately 20 feet scattered in single row.

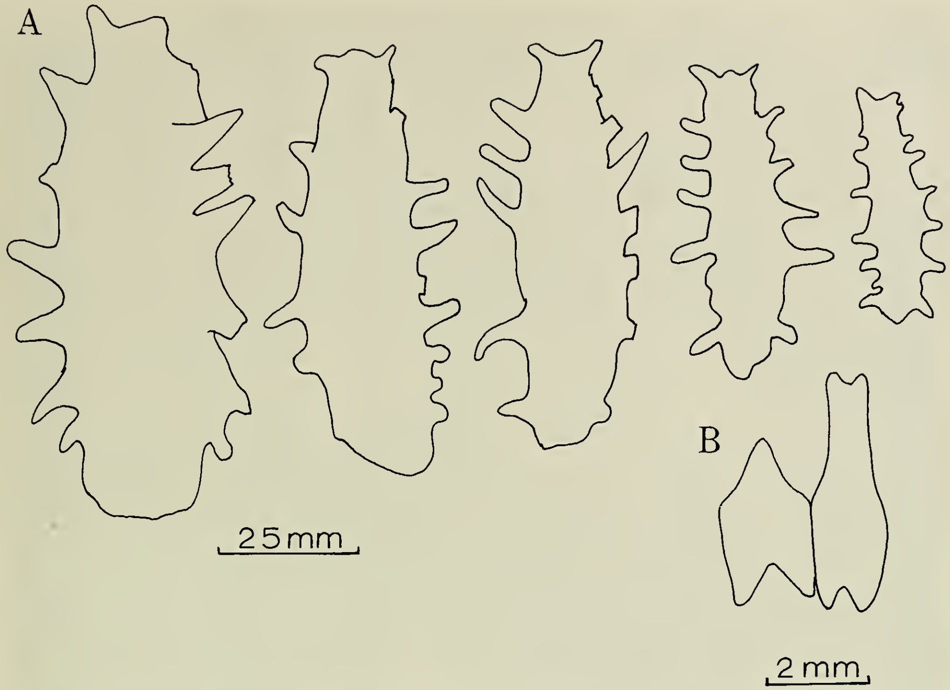
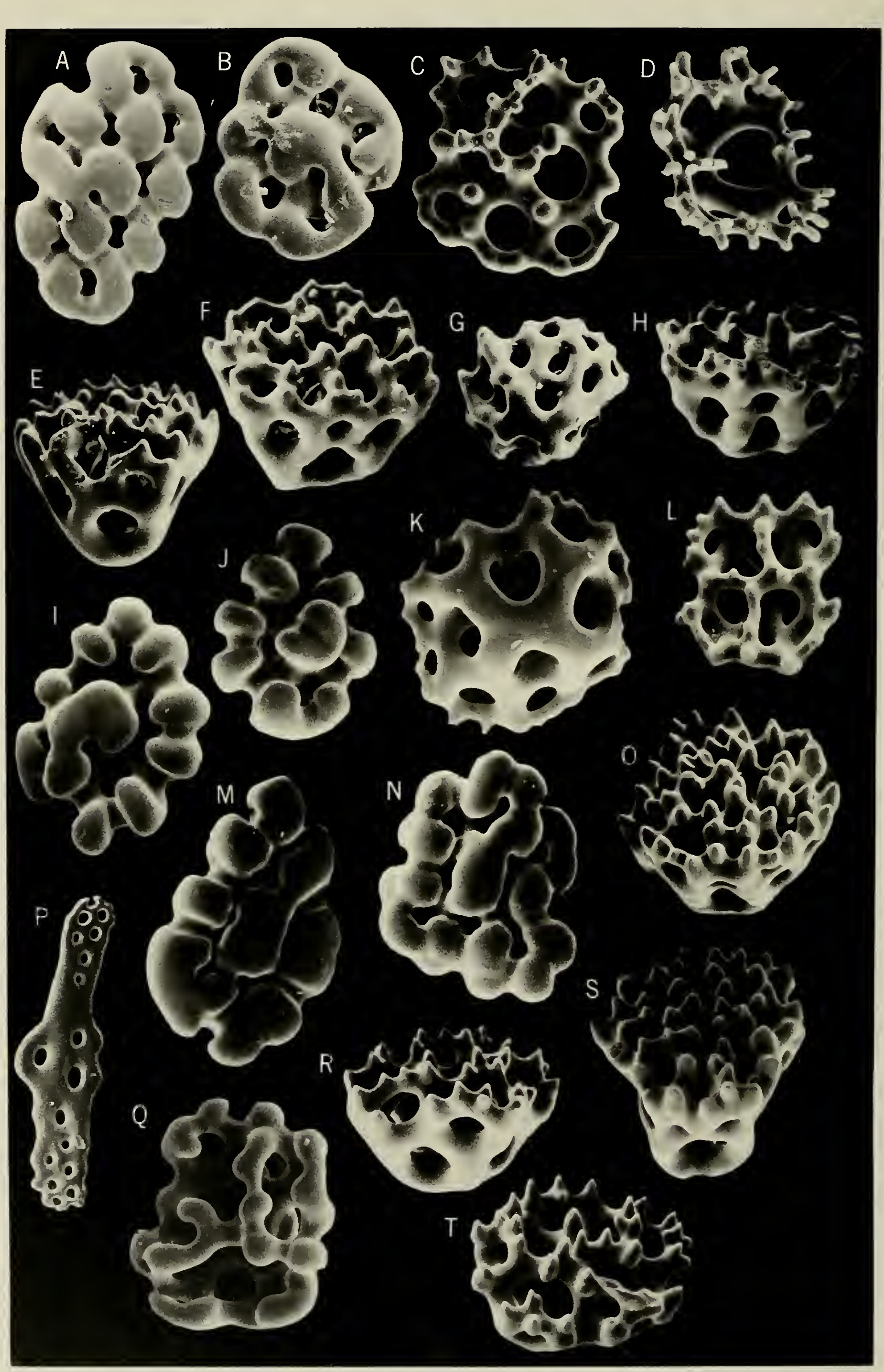


Fig. 2. *Loisettea amphictena.* A, Outline drawings of preserved specimens, ventral view. Holotype is at top left. B, Radial (right) and interradial (left) pieces of calcareous ring.

sponges, Engel trawl towed for 30 minutes, L. Marsh on *Soela,* 1 specimen. Additional material examined (not type-material): British Museum (Natural History): 1892.1.16.99, no locality, presented by The Admiralty, 1 specimen; 1892.1.14.269–71, Holothuria Bank, off Cape Londonderry, Western Australia, presented by The Admiralty, 2 specimens.

*Description.*—Body 36–96.5 mm long, approximately 4–5 times as long as broad, often quadrangular in cross-section, slightly flattened, tapering slightly anteriorly and posteriorly. Ventral margins with conspicuous concial lateral papillae (Figs. 1, 2A), 5–9 in each radius (see Table 1), longest papillae approximately 15 mm. Dorsal radii either unadorned or with up to 8 inconspicuous to prominent dorsal papillae. Body wall rigid, coriaceous, in larger specimens approaching 2 mm in thickness in midventral interradius. Oral area covered by 5 radially placed more or less conspicuous triangular oral valves. Ventral radii with scattered conspicuous tube feet (see notes to Table 1). Feet not extending to anterior and posterior extremities of radii, ending approximately 1 cm short of extremities; ventral and dorsal interradii with scattered smaller tube feet. Color in life more or less uniform orange-red, bases of dorsal papillae brick red. In alcohol, color fading to uniform dirty white.

Radial longitudinal muscles poorly developed broad thin straps. Two Polian vesicles. Gonad consisting of tufts of light orange unbranched tubules. Internal surface of body wall on ventral side having large holes for tube feet in radii and smaller holes for tube feet in interradii. Calcareous ring of 10 simple pieces (Fig.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2B) lacking posterior projections. Radials elongate, anterior projection with shallow notch. Interradials with bluntly pointed anterior projections.

Ossicles in body wall large multi-layered scales (lenticular plates) overlain by complex cups and by buttons of varying complexity. In larger specimens (WAM 330-71, total length 91 mm), oval to circular scales can reach diameter of 5 mm in dorsal and ventral body wall. Dorsal buttons 80–220 μm in length (Fig. 3A–B), simply knobbed, but often with more or less well developed secondary network of calcite, making them double-layered. Ventral ossicles tend to be smaller than dorsal. Ventral cups (Fig. 3H) average 69 μm in width and 56 μm in height, ventral buttons (Fig. 3I) approximately 90–150 μm in length. In smaller specimen (WAM 96-63, total length 40.5 mm), ossicles generally smaller and less complex; dorsal and ventral ossicles identical. Cups (Fig. 3D, 3K–L) average 63 μm in width and 47 μm in height. Buttons (Fig. 3C, 3J) greatly variable in size. Lateral papillae of larger specimen contain cups (Fig. 3O, 3S) and buttons (Fig. 3M–N) similar to those occurring elsewhere in the body wall. In smaller specimen, the cups (Fig. 3R, 3T) and buttons (Fig. 3Q) also similar to those from elsewhere in body wall, and simpler than their counterparts from larger specimens.

*Distribution.*—Currently known only from the continental shelf of northwestern Australia, where it ranges from Shark Bay to the vicinity of Darwin, in depths of 18–78 meters. The species has usually been collected from a silty sand bottom, where large sponges and other echinoderms are common.

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Fig. 3. *Loisettea amphictena,* body wall ossicles from large (91 mm total length) and small (40.5 mm total length) specimens: A, B, Dorsal buttons from large specimen, ×280; C, Dorsal button from small specimen, ×390; D, Dorsal cup from small specimen, ×780; E, F, Dorsal cups from large specimen, ×450; G, Dorsal cup from large specimen, ×280; H, Ventral cup from large specimen, ×390; I, Ventral button from large specimen, ×390; J, Ventral button from small specimen, ×340; K, L, Ventral cups from small specimen, ×560; M, N, Buttons from lateral papilla of large specimen, ×280; O, Cup from lateral papilla of large specimen, ×360; P, Rod from ventral body wall of small specimen, ×220; Q, Button from lateral papilla of small specimen, ×560; R, Cup from lateral papilla of small specimen, ×420; S, Cup from lateral papilla of large specimen, ×450; T, Cup from lateral papilla of small specimen, ×420.

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# A NEW SPECIES OF *SCOLELEPIS* (POLYCHAETA: SPIONIDAE) FROM LIZARD ISLAND, AUSTRALIA

Daniel M. Dauer

*Abstract.*—A new species of Spionidae, *Scolelepis hutchingsae* from Lizard Island, Australia is described. *Scolelepis hutchingsae* belongs to the *Scolelepis* species-complex having notosetae on setiger 1, posterior neuropodial lamellae bilobed, and hooded hooks principally or exclusively bidentate. The most distinctive characteristic of this new species is that notopodial hooded hooks begin in the same setiger or at most one setiger after the neuropodial hooded hooks; similar *Scolelepis* species have notopodial hooded hooks beginning as least 10 and usually 20 or more setigers after the appearance of the neuropodial hooded hooks.

As part of my research interest in the functional morphology and feeding behavior of spionid polychaetes (Dauer et al. 1981; Dauer 1983, 1984, 1985), I had the opportunity to collect and observe two spionid polychaete species from Lizard Island, Australia (14°40'S, 145°27'E). One of the spionids studied is an undescribed species of *Scolelepis* which is herein described. The most recent and important studies of Australian Spionidae are those of Blake and Kudenov (1978), Hartmann-Schröder (1980, 1981, 1982) and Hutchings and Turvey (1984).

Type-materials are deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C.

## *Scolelepis hutchingsae*, new species
Fig. 1

*Material examined.*—AUSTRALIA, Lizard Island, Ferrier's Creek, northern Great Barrier Reef, 19 Jul 1983, coralline sand, holotype (USNM 97629), 2 paratypes (USNM 97630, 97631).

*Description.*—Length of holotype approximately 14 mm, width 1 mm, 59 setigers, complete specimen. One paratype complete, 18 mm long, 77 setigers; other paratype incomplete, 8.5 mm long, 50 setigers.

Prostomium pointed anteriorly, slightly inflated laterally near junction with prostomium (Fig. 1A). No occipital antenna, no eyes. Prostomium extending to first setiger, dorsally elevated at posterior margin. Eversible pharynx saclike, highly ciliated. Peristomium well developed, partially overlapping prostomium. Palps removed from all specimens for scanning electron microscopy study of ciliary patterns (in preparation).

Branchiae begin on setiger 2, fused to notopodial lamellae for approximately half its length in anterior setigers (Fig. 1B) and for approximately one-third of its length in posterior setigers (Fig. 1C). Dorsal portion of notopodial lamellae forming slight lobate projection in posterior setigers (Fig. 1C). Anterior neuropodial lamellae rounded (Fig. 1B), becoming elongate and ridge-like on setigers with hooded hooks. Slight indentation in neuropodial lamellae beginning on setigers

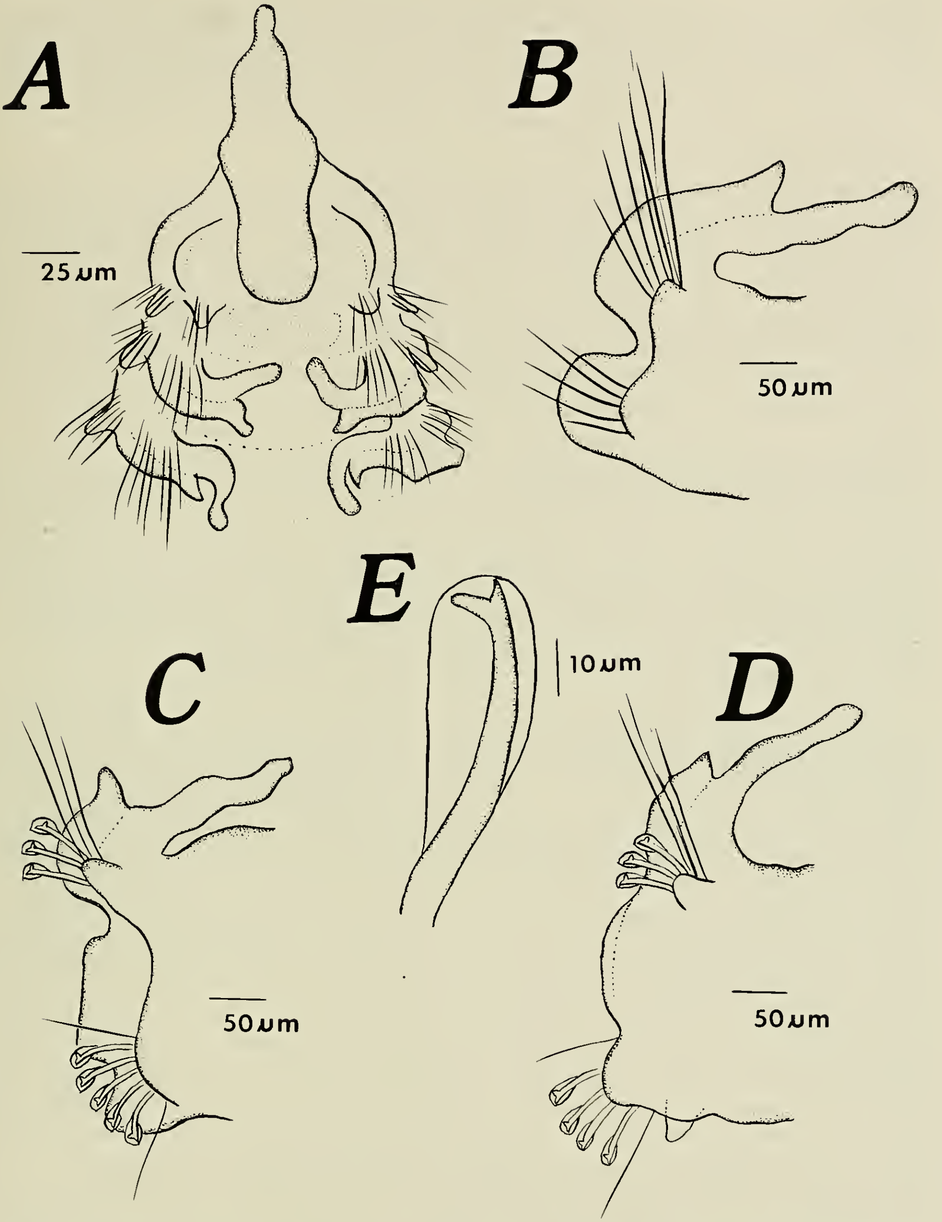

Fig. 1. *Scolelepis hutchingsae* (paratype, USNM 97630): A, Anterior end, palps omitted; B, Setiger 5 in anterior view; C, Setiger 35 in anterior view; D, Far posterior setiger in anterior view; E, Hooded hook, lateral view.

24–26. Small ventral cirrus present from setigers 45–50. Neuropodial lamellae gradually increase in transverse length (dorso-ventral axis) from average of 43.3 µm (range 37–58 µm) in first setiger to approximately 200 µm (range 153–232 µm) by setiger 10 or 11. Lamellar size remains same until appearance of hooded hooks in setigers 18–20 where lamellae increase greatly in size to average of 325 μm (range 280–428 μm); remaining this size for at least following 20 setigers. With appearance of hooded hooks, change in neuropodial lamellar size quite dramatic. For example, on right side of complete paratype, neuropodial hooks first appear in setiger 19 and neuropodial lamella increases in size from 240 μm to 400 μm from setiger 18 to 19.

Notosetae present on setiger 1. In anterior setigers 18–20 capillary setae in 2 transverse rows ranging from 180–400 μm in length and 6–7 μm in maximum width. Longest notosetae located dorsally and shortest ventrally in each fascicle. Notopodial hooded hooks bidentate (Fig. 1E), beginning in setigers 18–20 and continue to the end of the body. Notopodial fascicles of setigers with hooded hooks in single transverse row. Three to 4 hooded hooks and 4–8 capillary setae in notopodial fascicles of middle and posterior setigers. Notopodial capillary setae of setigers with hooded hooks usually long (up to 400 μm), thinner than anterior notopodial capillary setae (maximum width 4–5 μm).

Capillary setae only in neuropodia of anterior setigers in 2 transverse rows, bidentate hooded hooks beginning in setigers 18–20. Neuropodial fascicles of middle and posterior setigers in single transverse row, typically with 4–8 hooded hooks and 2 capillary setae—one in dorsal and one in ventral position of fascicle.

Pygidium ventral, a flat cushion around dorsal anus. One complete specimen with ciliated lobes located around anus, another complete specimen without any additional lobes. Lobes appear to be eversible rectal structures.

*Remarks.*—*Scolelepis hutchingsae* is most similar to *S. squamata* (Muller, 1806), *S. blakei* Hartmann-Schröder, 1980, and *S. bifida* Hutchings and Turvey, 1984 in (1) the presence of notosetae on setiger 1, (2) neuropodial lamellae bilobed posteriorly, and (3) hooded hooks principally or exclusively bidentate. *Scolelepis bifida* differs by the fusion of the notopodial lamellae along almost the entire length of the branchia, neuropodial hooded hooks that begin in setigers 32–36 and notopodial hooded hooks which were not present in the holotype which was 93 setigers long (no comment on notopodial hooded hooks in paratypes). *Scolelepis blakei* is easily separated by its trifid prostomium, neuropodial hooded hooks begin in setiger 29 and notopodial hooded hooks that are tridentate and begin around setiger 75. *Scolelepis squamata* (sensu Foster, 1971, with synonymies) differs in that neuropodial hooded hooks begin later, in setigers 25–40, notopodial hooded hooks are not always present, and when present they start at least 10 and usually 20 or more setigers after the neuropodial hooks. The interramal portion of the neuropodial lamellae of *S. squamata* projects from the body much more than *S. hutchingsae* and is a low ridge in posterior setigers of the latter.

*Etymology.*—This species is named for Dr. Pat Hutchings in recognition of her contribution to our knowledge of Australian polychaetes.

*Distribution.*—Known only from intertidal coralline sands on Lizard Island, Australia.

## Acknowledgments

I wish to thank Pat Hutchings for the opportunity to visit and use the facilities of the Lizard Island Research Station and to Barry and Louis Goldman for their help and hospitality during my stay at Lizard Island. I am grateful to Dr. James A. Blake for taxonomic advice and especially Dr. Nancy J. Maciolek for examining the present specimens and offering helpful taxonomic advice. Mike Ewing helped collect the specimens and provided useful comments and advice during the preparation of this manuscript.

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# A NEW SPECIES OF THE GENUS *SPINIANIRELLA* MENZIES (CRUSTACEA: ISOPODA: JANIRIDAE) FROM THE WESTERN ATLANTIC

Brian Kensley and Richard Heard

*Abstract.*—*Spinianirella serrata* is described from 350 m off Puerto Rico. This new species differs from *S. walfishensis* Menzies (from the south-eastern Atlantic) in the more spinose nature of the cephalic and pereonal processes, and in the pleonal and uropodal structure of the male.

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Menzies (1962) described the genus *Spinianirella* to accommodate a single female specimen taken in 1816 m in the Walvis Basin of the south-eastern Atlantic. Kensley (1984) recorded 14 specimens of the same species from off the east coast of South Africa, in depths of 150–850 m. To date, these two records constitute the entire record for the genus. The occurrence of a second species of the genus, *S. serrata,* from the western Atlantic off Puerto Rico, forms a significant extension to both the distribution and diagnosis of the genus.

## Family Janiridae
## *Spinianirella* Menzies

*Spinianirella* Menzies, 1962:171, fig. 55.—Wolff, 1962:34, 262, 271, 274, 275.—Kensley, 1984:283, fig. 37.

*Type-species.*—*Spinianirella walfishensis* Menzies, 1962, by original designation.

*Revised diagnosis.*—Janiridae with lateral margins of cephalon and pereon produced into spinous processes. Pleon consisting of single broad segment. Eyes absent. Mandibular palp of 3 articles. Pereopod 1 shorter than following pereopods, prehensile, with dactylus and propodus together folding against carpus. Pereopods 2–7 slender, ambulatory. Uropod uniramous, of 2 articles.

## *Spinianirella serrata,* new species
Figs. 1, 2

*Material.*—HOLOTYPE, USNM 211360, ♀, TL 3.2 mm, PARATYPE, USNM 211361, ♂, TL 5.0 mm, 17°49.9′N, 66°34.1′W, 350 m, Mar 1984, bottom substrate a mixture of sand, silt, and clay.

*Description.*—Body slightly more than 3 times longer than wide (excluding lateral spinous processes); widest at pereonite 3. Integument dorsally sclerotized, somewhat rugose, bearing scattered tubercles and setules. Anterior cephalic margin concave between antennal bases. Anterolateral elongate process of cephalon apically acute, bearing spine-like tubercles; lateral margin of cephalon convex posterior to spinose processes. Pereonites 1–3 increasing in length and width posteriorly, pereonites 4–7 decreasing in width and length posteriorly. Pereonite 1 with single lateral spinose process; spines on posterior margin and on lateral pereonite

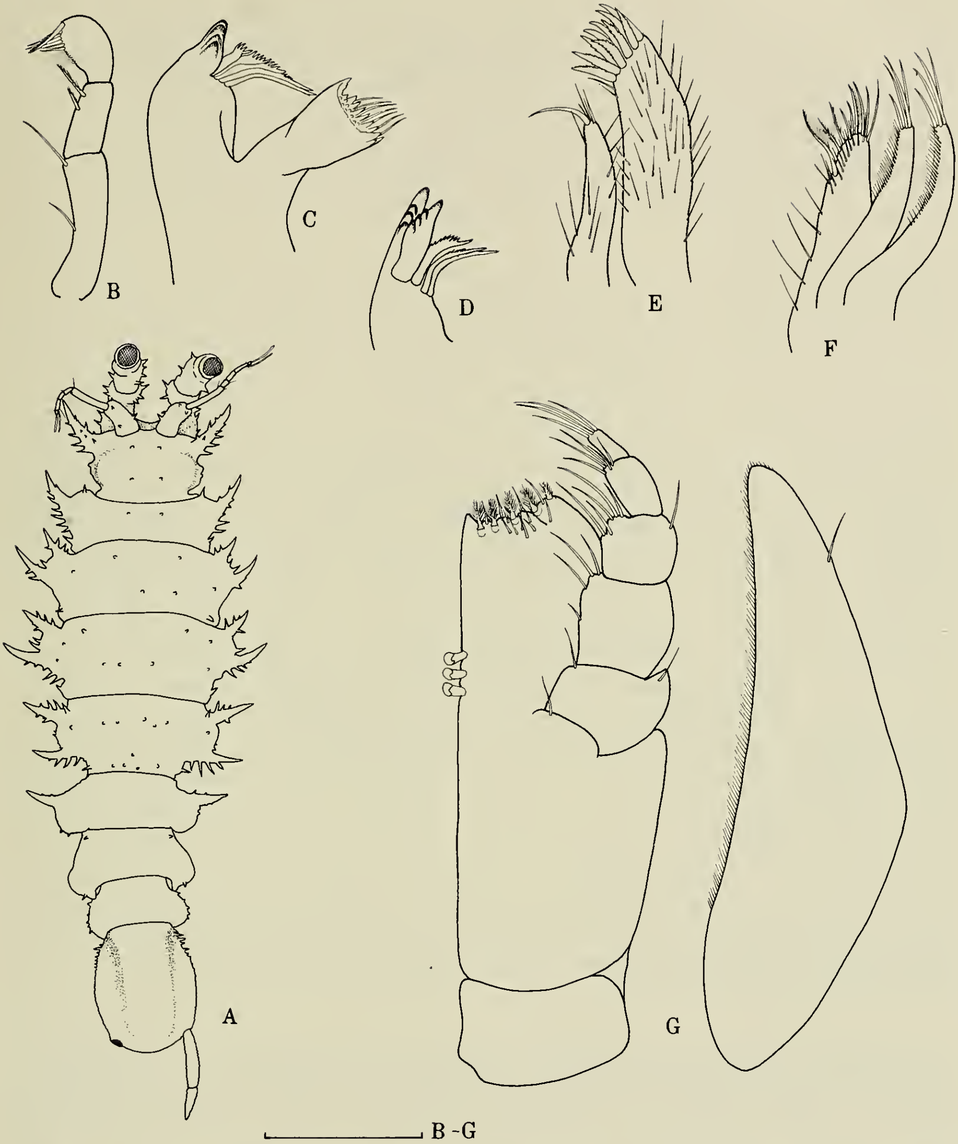

Fig. 1. *Spinianirella serrata*: A, Holotype ♂, dorsal view, TL 3.2 mm; B, Mandibular palp; C, Right mandible, palp not shown; D, Incisor and spine row of left mandible; E, First maxilla; F, Second maxilla; G, Maxilliped and epipod. Scale = 0.1 mm.

margin behind process becoming elongate. Pereonites 2–4 each with 2 lateral spinose processes. Pereonite 5 with single lateral process. Pereonites 6 and 7 lacking processes, with convex spinulose lateral margin. Pleon consisting of single segment, but with shallow anterodorsal transverse groove perhaps indicating single fused pleonite. Pleonal lateral and posterior margins gently convex. Pleon 1.3 times longer than wide, dorsally with raised and rounded central longitudinal area. Anterolateral margins spinose.

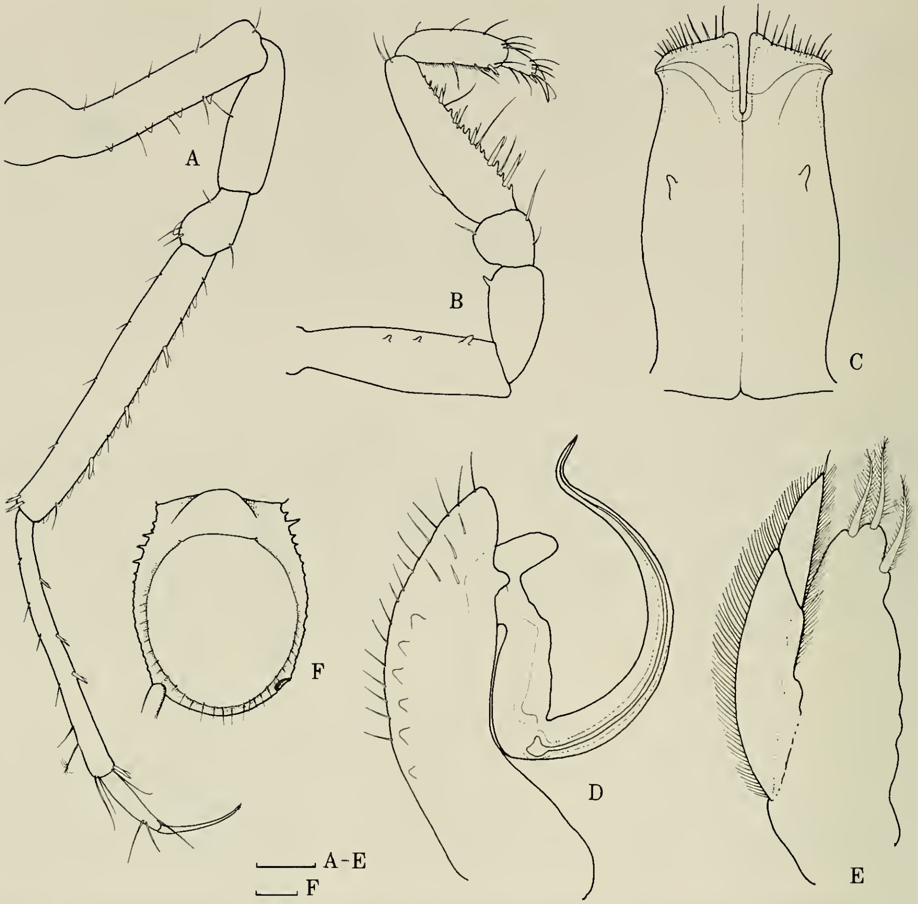

Fig. 2. *Spinianirella serrata*: A, Pereopod 3; B, Pereopod 1; C, Pleopod 1 ♂; D, Pleopod 2 ♂; E, Pleopod 3 ♂; F, Female pleon in ventral view, showing operculum. Scales = 0.1 mm.

Antennule consisting of 6 articles; basal article broad, with few scattered tubercles; 5 distal articles slender, article 2 subequal in length to remaining 4 distal articles; 2 distal articles each with single aesthetasc. Antenna with 3 basal peduncular articles short, bearing scattered acute tubercles; flagellum missing in both specimens. Mandibular palp of 3 articles, basal article 1.3 times length of article 2, bearing single spine at midlength and another at distal margin; article 2 with 2 distal fringed spines; article 3 almost semicircular in outline, half length of article 2, bearing 8 distal fringed spines becoming progressively longer distally; incisor with 4 strong cusps; lacinia mobilis of left mandible strong, sclerotized, distally broadened into 4 cusps; of right mandible short, resembling toothed spine; 4 spines in spine-row, 2 closest to incisor short and distally toothed, 2 closest to molar more elongate, fringed; molar process strong, distally truncate, triturative surface demarked by 2 strong teeth joined by ridge on outer surface, by row of short spines and elongate fringed setae on inner surface. Maxilla 1, inner ramus about half width of outer, bearing 1 stout, elongate, and 3 slender distal spines; outer ramus with 10 distal serrate spines. Maxilla 2, inner ramus broader than lobes of outer ramus, bearing numerous spines/setae mediodistally; lobes of outer ramus each bearing 4 elongate distal spines and fringe of 22–26 setules on mesial margin. Maxillipedal palp of 5 articles, 3 basal articles relatively broad, 2 distal articles narrower; article 2 with 3 strong mediodistal spines; articles 3 and 4 with 5 mediodistal spines; terminal article with 4 distal spines; endite broad, distally truncate-rounded, with 4 broadly fringed spines and several fringed spines and simple setae; 3 coupling hooks on mesial margin; epipod basally broad, tapering distally.

Pereopod 1, basis twice length of ischium, with 3 tubercles on anterodistal margin; ischium with single tubercle on anterodistal margin; merus with anterior margin strongly rounded; carpus elongate, 3 times length of merus, basally broad, distally tapering, with 7 sensory spines, several marginal serrations (acute tubercles) and few simple setae on posterior margin; propodus and dactylus together folding back on carpus to form subchelate structure; anterior margin of propodus strongly convex, posterior margin bearing finely fringed scales and 2 distal sensory spines; dactylus about ⅔ length of propodus, with strong terminal, and shorter accessory spine. Pereopod 3, basis about ⅓ longer than ischium, with 4 tubercles; merus about half length of ischium, with single distal tubercle; carpus elongate-cylindrical, 3 times length of merus, with 3 short sensory spines and several low transparent serrations on posterior margin; propodus half width and subequal in length to carpus, with 4 short sensory spines on posterior margin; dactylus ⅗ length of propodus, with unguis equal in length to rest of article.

Pleonal operculum in female broadly ovate, about ⅕ longer than wide, with sparse distal setae. Pleopod 1 ♂, rami with subparallel margins, fused for ¾ of length; distal margin truncate, bearing about 15 simple setae, laterodistal corner an obtuse angle. Pleopod 2 ♂, external margin of outer ramus evenly convex, with sparse elongate marginal setae and row of 6 submarginal tubercles; inner ramus tapering evenly to narrow apex. Pleopod 3 ♂, outer ramus of 2 articles, suture between proximal and distal articles oblique, distal article apically acute, both articles bearing fringe of setae on outer margin; inner ramus distally rounded, with 3 stout plumose setae. Pleopods 4 and 5 uniramous, each a membranous suboval structure. Uropod uniramous, cylindrical, of 2 articles, distal article slightly more than half length of proximal article, tapering to subacute apex.

*Discussion.*—The differences between the present species and the type-species, *S. walfishensis,* are few and relatively subtle, and are summarized in the following table:

| Character | *S. serrata* | *S. walfishensis* |
|---|---|---|
| TL adult | 3.2 mm | 4.7–5.2 mm |
| Integument | Few sparsely scattered small tubercles | Numerous relatively dense tubercles |
| Cephalic and pereonal processes | Strongly spinous | Non- to faintly spinous |
| Pleonal marginal spination | Short spines in anterior third | Regularly distributed from anterior margin to uropod |
| Pleopod 1 ♂ | Distolateral corner barely produced | Distolateral corner well produced |
| Pleonal operculum ♀ | Evenly ovate | Broader basally than distally |
| Uropod | Distal article shorter than proximal | Distal article subequal to proximal |

The present record provides yet another example of the supposedly widespread distribution of deepsea isopod genera, being separated from the original record of the genus by the north-west to south-east oblique width of the Atlantic Ocean. Although the only specimens of *S. serrata* came from 350 m, and specimens of *S. walfishensis* have been reported from 150–850 m (Kensley 1984), and 1816 m (Menzies 1962), the lack of eyes, or even of ocular peduncles would indicate that *Spinianirella* is a true deepsea genus. The Puerto Rican collecting site for *S. serrata* and the collecting site for *S. walfishensis* off South Africa are on, or immediately adjacent to, steep slopes into deep water.

Crustaceans occurring in the same sample with *S. serrata* included the amphipods *Byblis* sp. and *Ampelisca* sp., a tanaidacean, *Typhlotanais* sp., a cumacean, *Nannastacus* sp., and the decapods *Callianassa marginata* and *Automate* sp.

*Etymology.*—The specific epithet refers to the serrate nature of the cephalic and pereonal lateral processes.

## Acknowledgments

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# STUDIES OF NEOTROPICAL CADDISFLIES XXXV: THE IMMATURE STAGES OF *BANYALLARGA ARGENTINICA* FLINT (TRICHOPTERA: CALAMOCERATIDAE)

Oliver S. Flint, Jr. and Elisa B. Angrisano

*Abstract.*—The larva, pupa and case of *Banyallarga argentinica* Flint are described. Characteristics for distinguishing the immature stages of *Phylloicus* and *Banyallarga* are noted. The larvae are found in slowly flowing reaches of small streams in northwestern Argentina.

*Resumen.*—Se describen la larva, la pupa y el capullo de *Banyallarga argentinica* Flint. Se señalan las características para diferenciar los estadios inmaduros de *Phylloicus* y *Banyallarga.* Las larvas se encuentran en los márgenes de corriente lenta de los pequeños arroyos del noroeste de la Argentina.

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In the Neotropical Region, three genera of Calamoceratidae are currently recognized. The genus *Phylloicus* Müller, 1880 (with synonyms *Homeoplectron* Ulmer, 1905, and *Notiomyia* Banks, 1905) is widely distributed from the southwestern United States, through the West Indies, Central America, and South America as far as southern Chile. The larvae, pupae and cases of several species were made known with the original description, and several more species have been described subsequently (Müller 1880; Thienemann 1909; Ross 1959; Flint 1964; Wiggins 1977). The second genus from the neotropics, *Banyallarga* Navás, 1916 (with synonym *Loxinum* Navás, 1934), has had its status only recently clarified (Flint 1983). The name is applied to a group of neotropical species that had mostly been placed in *Ganonema* or *Anisocentropus.* We describe here, for the first time, the larva, pupa and case of a species of this genus (the larva of an unknown species from Venezuela was noted by Botosaneanu and Flint 1982:24 as *Phylloicus* sp.). The third genus *Muriella* Hogue & Denning was only described in 1983. It is limited to Central America and Jamaica, and its immature stages are undescribed. (Flint does possess the immature stages of *M. acutiterga* Denning & Hogue, 1983.)

During field work in northwestern Argentina in 1973 Flint collected at several localities adults of the species subsequently described as *Banyallarga argentinica.* At the same time and at many of the same localities, larvae and a few pupae of a calamoceratid were found inhabiting cases distinctly different from those of *Phylloicus.* It was believed that these were probably the immature stages of *B. argentinica,* but lacking firm association they were put aside. In 1982 Angrisano collected and reared larvae of this species to the adult stage, thereby associating the immature stages of a species of *Banyallarga* for the first time. We herein describe the larvae and pupae of this species and propose characteristics whereby these stages may be distinguished from those of *Phylloicus.*

### *Banyallarga* Navás

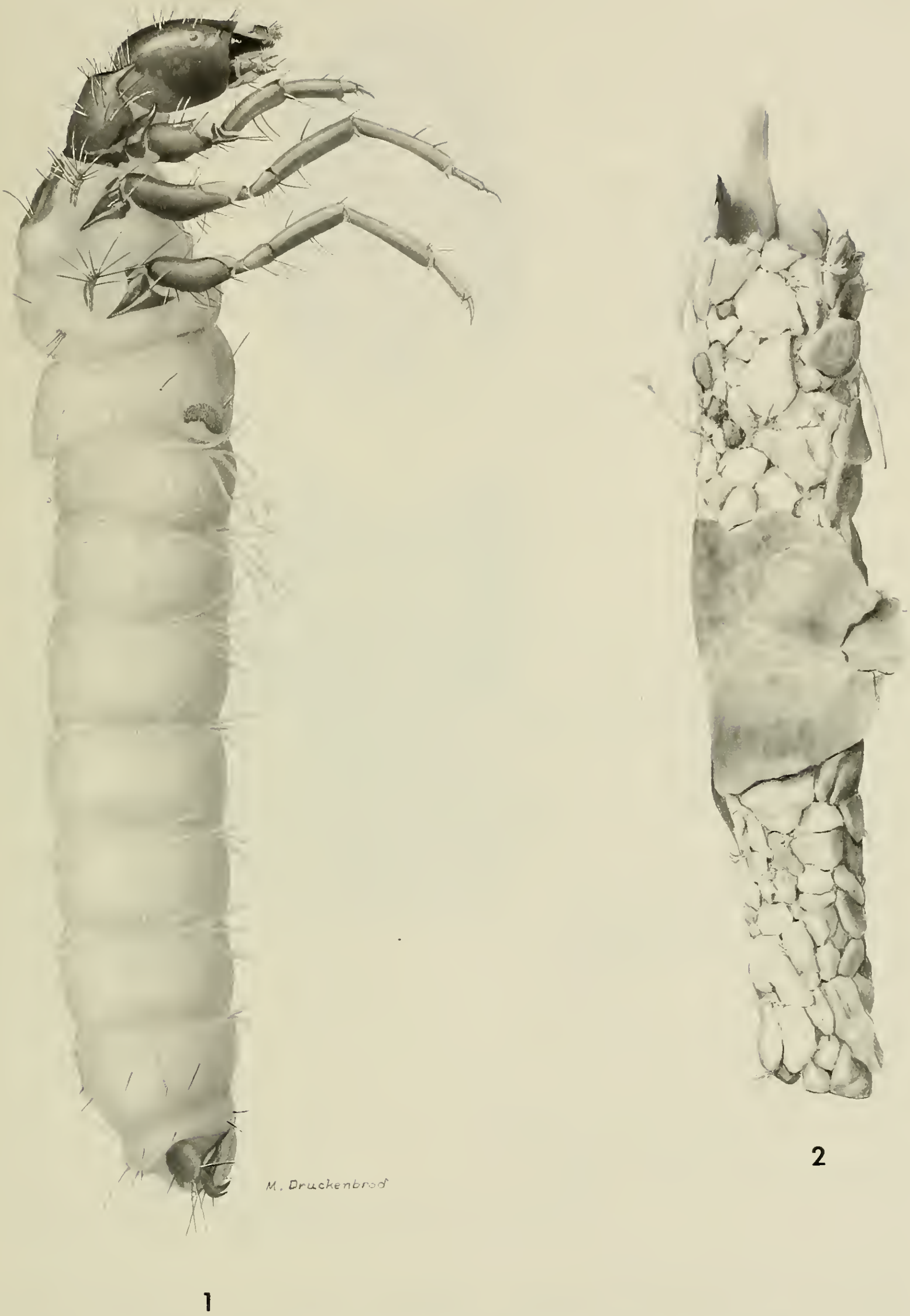
Currently the following nine species are placed in the genus: *aequatoria* (Navás) (Ecuador), *argentinica* Flint (Argentina), *columbiana* (Navás) (Colombia), *loxana* (Navás) (Ecuador), *mollicula* (McLachlan) (Venezuela), *testacea* Navás, (Colombia), *vicaria* (Walker) (Venezuela), *villosa* (Navás) (Ecuador), and *yungensis* Flint (Argentina and Peru). The overall range of the genus appears to be the Andean Mountain system of western South America from northern Venezuela to northwestern Argentina.

*Recognition.*—In addition to the larvae of the species herein described, Flint possesses larvae of several unknown species from Argentina, Bolivia, Peru, Ecuador and Venezuela. These have all been considered and compared to many lots of *Phylloicus,* consisting of many species from throughout its range, in order to give the greatest security to the following characteristics which are proposed to distinguish the immatures of the two genera.

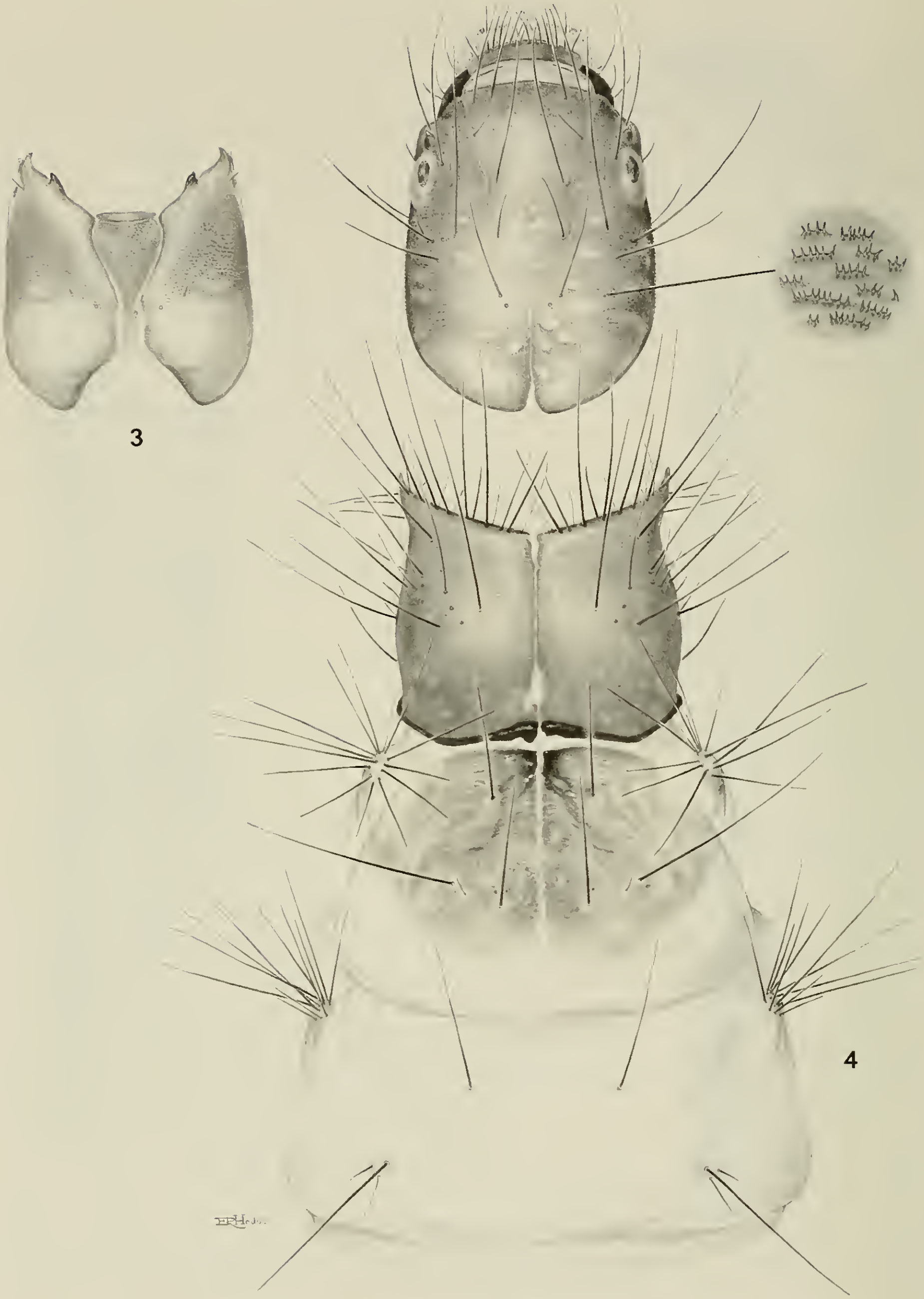
The general structure and shape of the larva in the two genera are virtually identical, but the following five differences appear to be consistent. The gular sclerite separating the genal halves ventrally is prolonged posteriad in *Banyallarga,* generally reaching the posterior margin of the head capsule. In *Phylloicus* this sclerite is shorter, rarely more than half or two-thirds the length of the ventral suture. The sclerite ends at, or before, the ridge separating the smooth posterior portion of the genae from the rougher anterior portion, whereas in *Banyallarga* it extends into this smooth section and generally through it to the posterior margin. All species of *Banyallarga* have a large number of setae along the anterior margin of the pronotum, generally a dozen and often several times that number. *Phylloicus* has reduced this number to about six. The trochanter of the hindleg (only) bears in *Banyallarga* a distinct brush of short hairs on the ventral margin. There is no brush in *Phylloicus.* The groove ventrally separating the metathorax from the first abdominal segment in both genera bears a small linear sclerite laterad that continues as a sclerotic area on the adjacent first segment. In *Banyallarga* this sclerotic area is very lightly sclerotized and of the same contour as the segment. In *Phylloicus,* however, it is more strongly sclerotized and generally produced into a distinct knob, or less commonly produced into an oval, elevated area; it is always produced well above the surrounding integument. Finally, and most easily seen, the gill clusters in the mature larva of *Banyallarga* consist of no more than three filaments. In *Phylloicus* the dorsal and ventral gill rows on the first few segments, at least, consist of clusters of four filaments.

In addition, the head dorsally of the larvae of *Phylloicus* is smooth. At first sight it appears to be rough, but careful orientation shows it to be smooth and shining. The cuticle, however, is composed of darker, apparently thicker, spots surrounded by paler, thinner rims. In *Banyallarga* the surface is densely covered with pointed asperites (see Fig. 4, inset). However, the larva of an unknown species from Argentina, Bolivia, and Ecuador appears to have the dorsum of the head with the same type rugosities as in *Phylloicus.*

The differentiation of the pupae in the two genera is less distinct, and the pupae of few species are known. The abdomen dorsally in *Phylloicus* bears rows of long hair along the posterior margins of segments 2 to 7, with the fringe most dense on segment 6 and only slightly less so on 7. In *Banyallarga* these fringes are lacking



Figs. 1–2. *Banyallarga argentinica*: 1, Larva, lateral; 2, Larval case, lateral. Drawings by Smithsonian staff artist, L. Michael Druckenbrod.



Figs. 3–4. *Banyallarga argentinica,* larva: 3, Head, ventral; 4, Head and thorax, dorsal with inset showing microstructure of cuticle. Drawings by Smithsonian staff artist, Mrs. Elaine R. Hodges.

on segments 2 to 5, but is well developed on 6 and consists of two pairs of fanlike arrays of stiff hairs on 7. The dorsum of segment 9 bears in both genera a pair of rather long, sclerotized processes arising from a sclerotized integumental area. In *Banyallarga* these paired processes are directed almost vertically from the integument, but in *Phylloicus* they are directed anteriad and lay parallel, and almost appressed to, the surface.

The cases of both genera are generally distinguishable from each other. *Phylloicus* makes a flat case of leaf fragments, sometimes a single oval fragment dorsally and another ventrally, in other species a series of overlaping fragments are used dorsally and ventrally. In *Banyallarga* the case is most frequently of small rock fragments or large sand grains, but often small plant fragments are substituted. The larger pieces are generally placed along the margin, creating a case that is slightly oval in cross section, but on occasion they are perfectly round. The cases taper toward the rear and are slightly bowed lengthwise. The case of an unidentified species from Argentina, Bolivia, and Ecuador, however, is identical to that of *Phylloicus.*

### *Banyallarga argentinica* Flint

*Banyallarga argentinica* Flint, 1983:77–79.

Although none of the congeneric larvae known to us is associated with their respective adults, we mention here some of the ways that they differ between the species. The head may be much shorter, barely longer than wide, and the surface is smooth in another species. The anterolateral angle of the pronotum varies greatly in shape between the species, in one species not being produced at all and in another the processes are nearly half as long as the head. The number and length of setae along the anterior margin of the pronotum also differs greatly between species. In one species the mid- and hindlegs are scarcely longer than the forelegs.

*Larva.*—Length to 17 mm, width to 3 mm. Sclerites of head and thorax dark reddish-brown; muscle scars of head appearing paler, smooth. Surface of head and pronotum densely covered with small raised ridges bearing row of short points, except for smooth areas over muscle scars, and posterior portion of head covered by pronotum.

Head hypognathous; lacking ridges and secondary setae; distinctly longer than wide. Labrum with well-developed anterolateral brushes; with dorsal row of about 15 erect setae. Mandibles massive, with large mesal brushes; left with 5, right with 4, poorly-developed, apical teeth. Maxilla with galeal brush well-developed; palpi short, segments subequal in length. Labium lightly sclerotized between submental setae; inner surface enlarged, with large brush. Gula with apex narrowly produced, almost completely dividing genal halves.

Pronotum with anterior margin bearing about 15 long, dark setae on each side, and equal number of shorter, paler setae; each anterolateral quarter of tergum bearing around 20 long setae; anterolateral angle produced into pointed spur; posterior margin produced into sharp carina, black. Mesonotum sclerotized dorsally, with lateral and posterior margins rather ill-defined, of characteristic shape and structure; sa1 consisting of 1 seta, sa2 of 2 long and 1 short setae, sa3 a separate anterolateral sclerite bearing around 12 long setae. Metanotum with sa1

Figs. 5–11. *Banyallarga argentinica,* larva: 5, Foreleg, lateral; 6, Midleg, lateral; 7, Hindleg, lateral; 8, Anal proleg, lateral; 9, Anal proleg, dorsal; 10, Anal proleg, posterior; 11, Anal claw, lateral.

bearing single large seta from small sclerotized base, sa2 with 1 large and 2 smaller setae from small sclerite, sa3 an anterolateral sclerite bearing around 12 long setae. Mesosternum with posterolateral, elongate sclerite. Foretrochantin produced into long, curved process, densely spiculate. Foreleg rather short, ventral margins of

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| | 3 | 3 | 3 | 3 | 3 | 2-3 | |
| | 3 | 3 | 3 | 3 | 3 | 3 | 2-3 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

Fig. 12. *Banyallarga argentinica,* schematic gill diagram of lateral aspect of larval abdomen showing segment number and number of filaments per cluster.

femur, tibia and tarsus with row of very short, pale setae; tibia with single, large, apical spur. Midleg much elongated, especially tibia and tarsus; ventral margins of femur, tibia and tarsus with row of short, pale setae; tibia with single, large, apical spur. Hindleg very elongate, especially tibia and tarsus; ventral margins of femur, tibia and tarsus with row of minute, pale setae, trochanter with dense brush of short setae midventrally.

Abdomen with gills in clusters of 3 or 2, as shown in Fig. 12. Lateral line of short, fine, pale hairs from posterior of segment 2 to posterior of segment 7. Bifid processes in curved line laterally on segment 8. Groove between metathorax and first segment ventrolaterally with small sclerotized area, not produced into any type of lobe. First segment dorsally with low, posteromesal hump; with low, ventrolateral humps, each bearing broad, crescentic band of small hooks; dorsally with 2 pairs of large setae, lateroventrally with 3 pairs. Eighth tergum with 2 pairs of large setae. Ninth tergite pale, inconspicuous, with pair of large, mesal setae, flanked by 3 or 4 pairs of smaller setae; single lateral and lateroventral pairs of short, dark setae. Anal proleg with 5 long, dark setae along posterior margin; with small, but distinct, posterodorsal carina; membranous ventral portion without setae, but densely spiculate, with row of small, flat, plates appressed to membrane on each side of anal opening.

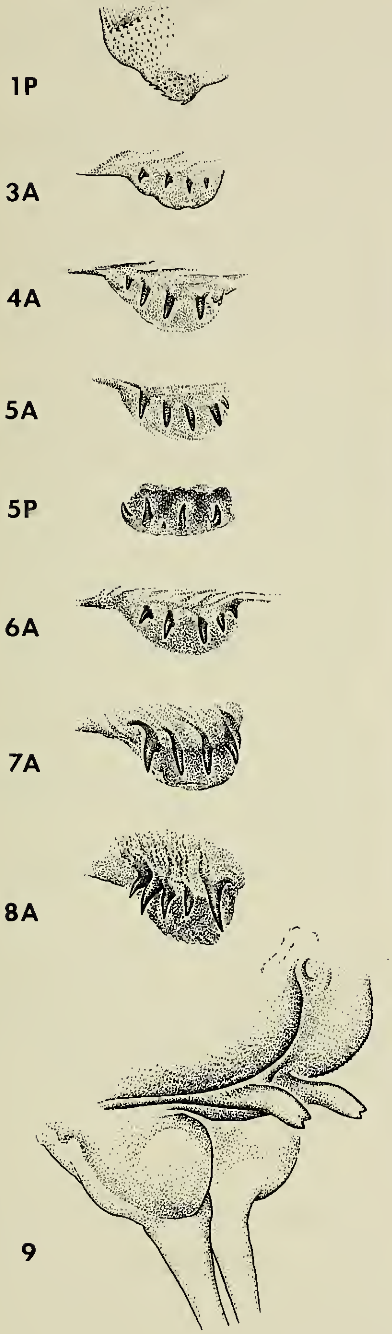
*Pupa.*—Length to 14 mm, width 3 mm; female larger than male. Mandible with inflated base, apex long, slightly hooked apicad, inner margin serrate; with 2 long setae externally near base. Labrum small, rounded; with basolateral cluster of 2 long and 2 short setae, and apicolateral cluster of about 10 straight setae. With 2 long setae between eye and base of mandible, 2 pairs of long setae on face, pair between antennae, another shorter pair just posteriad of antennae, and 3 pairs posterolaterally on dorsum. Basal antennal segment with row of 3–4 long setae dorsally and cluster of 6–8 shorter setae ventrolaterally.

Pronotum with 2 setae on each side dorsolaterally. Mesonotum with tegular area bearing cluster of about 12 setae; dorsum with 3 pairs of setae. Metanotum with 3 pairs of setae. Tarsus of midleg with well-developed swimming fringe.

Abdomen with gills essentially as in larva; dorsal gills often aborted. Lateral line of long, fine hair; from anterior of segment 3 to posteriad of segment 8 where

Figs. 13–20. *Banyallarga argentinica*: 13, Larval labrum, dorsal; 14, Larval mandible, lateral; 15, Larval mandible, mesal; 16, Larval maxillolabium, ventral; 17, Larval gular sclerite, ventral; 18, Pupal labrum, anterior; 19, Pupal mandible, anterior; 20, Apex of male pupal abdomen, ventral.

it curves ventrad and almost meets the other side midventrally, hairs longest posteriad. Hook plates anteriad on segments 3 to 8, on 5 posteriad; each plate broader than long with single row of 4–5 large hooks. First segment produced slightly posterolaterally, bearing band of small, posteriorly-directed points and small, ovoid sclerite with anteriorly directed points. Terga 1–8 and sterna 2–8 with lateral, band-like sclerites, those of terga with anteromesal extension connecting to hook-plates laterally. Tergum 6 with dense, posterior brush of long, fine setae; terga 7 with 2 pairs of fan-like arrays of long, stiff setae along posterior margin; other terga with only few scattered setae. Tergum 9 with middorsal sclerite



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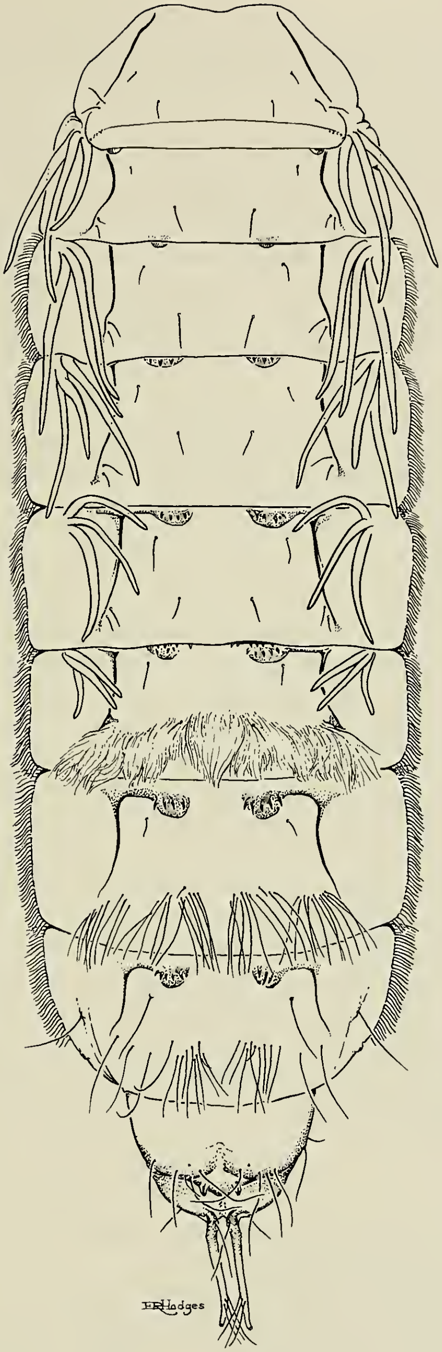

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Figs. 21–22. *Banyallarga argentinica,* pupa: 21, Hook plates, with abdominal segment number and anterior or posterior position; 22, Abdomen, dorsal. Drawings by Smithsonian staff artist, Mrs. Elaine R. Hodges.

bearing pair of upright sclerotized processes; segment 9 with scattered long setae. Apical processes long, slender, with single, long, subbasal, and 3 subapical setae; apex flattened and narrowed, scabrous, and upcurved.

*Case.*—Length to 25 mm, width to 5 mm. Constructed primarily of large sand grains or small rock fragments, often with scattered wood fragments; largest fragments generally placed laterally. Cross-section transversely ovoid; slightly bowed and tapered longitudinally.

*Material.*—Argentina, Pcia. Jujuy, Yala, Mar 1982 (reared in laboratory), E. B. Angrisano, 12 larvae (including first and second instars), 1 pupa, 8 ♂ pupa, 12 ♀ metamorphotypes, 1 cast skin.—Pcia. Catamarca, Arroyo El Pintado, near La Viña, 18 Oct 1973, O. S. Flint, Jr., 10 larvae.—Pcia. Salta, Payogasta, 13 Oct 1973, O. S. Flint, Jr., 13 larvae.—Salta, 17–18 May 1967, P. J. Spangler, 25 larvae. Cañada la Gotera, route 59, km 23.5, 16–17 Oct 1973, O. S. Flint, Jr., 100 larva.—Pcia. Tucuman, Hualinchay, 17 Oct 1973, O. S. Flint, Jr., 1 larva.—15 km west Tucuman, 22 May 1969, P. & P. Spangler, 1 larva.—Siambon, 10 Oct 1973, O. S. Flint, Jr., 1 larva, 1 ♀ metamorphotype.

*Biology.*—The larvae were found in various aquatic habitats with clean water of slight velocity with a sandy-stoney bottom, with organic matter, and with marginal vegetation. Typically, this is a situation found in slow streams of only 1 to 5 meters in width or along the margins or pools in rapid streams. They were also found tolerating extreme situations in overflow marshes, without water renewal and subject to daytime warming. In all cases they were abundant, being the numerically dominant trichopteran.

They are moderately active, and are found indiscriminately on the bottom or among the aquatic vegetation. They eat periphyton and organic detritus and show a liking for live food when it is offered. The adults were encountered in the vegetation immediately adjacent, in cooler and shadier spots.

An egg mass was found with about 100 eggs, which hatched—after being taken to the laboratory—about 15 days later.

Before pupating, the larvae cut the end of their case so that it takes on a more cylindrical aspect. In this stage they are most frequently on the bottom, until finally they attach themselves to stones and close the case, leaving the free end lightly interred in the sand. The duration of the pupal stage was 18 days (range 15–22), the adults emerged 110 days (95–120) after eclosion of the larvae.

Apparently they are found during the whole year.

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# *AZYGOCYPRIDINA LOWRYI,* A NEW SPECIES OF MYODOCOPID OSTRACODE FROM BATHYAL DEPTHS IN THE TASMAN SEA OFF NEW SOUTH WALES, AUSTRALIA

Louis S. Kornicker

*Abstract.*—*Azygocypridina lowryi,* a new species of myodocopid Ostracoda in the Cypridinidae, from the Tasman Sea, off N.S.W., Australia, at depths of 139–365.8 m is described and illustrated. The species differs from previously described species in having many more comb teeth on the 7th limb.

McKenzie (1968) referred a female collected at a depth of 180 m in the Tasman Sea off Australia (34°03′S, 151°31′E) to *Azygocypridina* sp. Additional specimens from the same general area provided me the opportunity to study the species, and to conclude that it is new, as previously surmised by McKenzie. The following description and illustrations are intended to supplement those of the female described by McKenzie.

Most specimens have been returned to the Australian Museum, Sydney, N.S.W.; those assigned USNM numbers have been retained at the U.S. National Museum of Natural History.

## *Azygocypridina lowryi,* new species
Figs. 1, 2

*Azygocypridina* sp. McKenzie, 1968:389–395, pls. 1–3.—Kornicker, 1970:10; 1975: 206.—Athersuch, 1980:140, 141.—Hiruta, 1981:56.

*Etymology.*—The species is named for Dr. J. K. Lowry.

*Material.*—1 paratype, register number P. 21032, collected by N.S.W. State Fisheries, N.E. of Wollongong, N.S.W., 34°16–22′S, 151°26–23′E, 365.8 m, 1975, sta K75-05-01, R.V. *Kapala*; 4 paratypes, register number P. 25021, collected by J. K. Lowry, W. F. Pender, F. W. E. Rowe, east of Double Island, Point, Queensland, 25°58.8′S, 153°51′E, dredged, 210–219 m, H.M.A.S. *Kimbla,* sta Q16, 10 Nov 1976; adult female holotype and 1 juvenile paratype, register number P. 25023, off Sydney, N.S.W., 200 m, 33°52.3′S, 151°40′E, BMR sta 1651, M.V. *San Pedro Strait,* 12 Mar 1972; 1 paratype, register number P. 25022, collected by P. Colman, 9 miles offshore, off Moreton Bay, Queensland, Tasman Sea, 139.0–146.3 m, large beam trawl, bottom of dead coral and shells, H.M.A.S. *Kimbla,* 15 Dec 1969; 6 paratypes, register number 25057, collected by J. K. Lowry, W. F. Ponder, F. W. E. Rowe, off south end of Fraser Island, Queensland, 25°57′08″S, 153°51′03″E, large dredge, 201 m, bottom of sand, brachiopods (extremely abundant), shells, bryozoans, H.M.A.S. *Kimbla,* 10 Nov 1977; 5 paratypes, USNM 193156a–c, dredge sta 43, 29.82 km east of South Head, Little Bay, Sydney, N.S.W., 33°54′48″S, 151°34′30″E, 192–303 m, 9 Aug 1973.

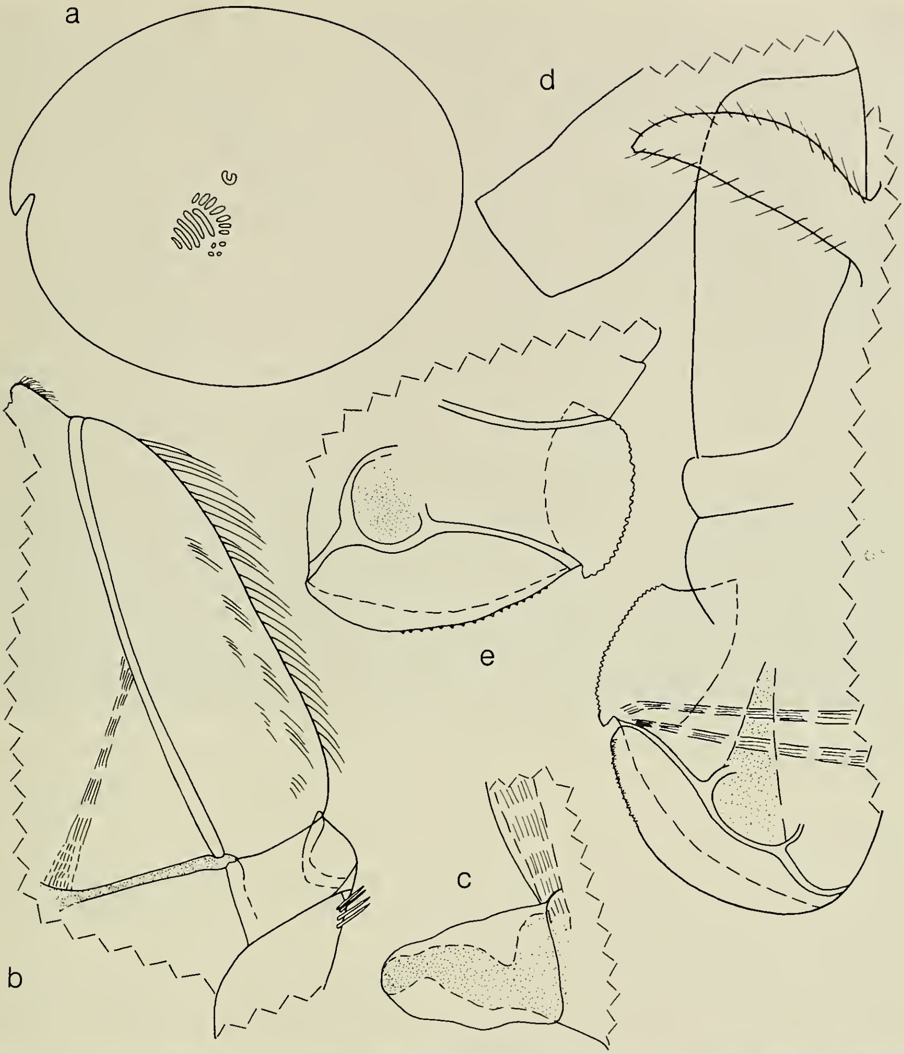

Fig. 1. *Azygocypridina lowryi,* adult female, holotype: a, Lateral view of complete specimen showing position of adductor muscle attachments, carapace length 11 mm; b, Posterior of body showing part of caudal furca (4 posterior claws shown), hirsute posterior margin, small hirsute dorsal process, Y-sclerite (stippled), girdle, and muscle attached to anterior end of Y-sclerite; c, Bellonci organ and muscle generally connected to medial eye of cypridinids; d, Anterior of body from left showing joints 1 and 2 of left 1st antenna (bristles of 2nd joint not shown), left lateral eye, and upper lip; e, Upper lip viewed from right side.

*Distribution.*—The species has been collected at depths of 139–365.8 m in the Tasman Sea off N.S.W. and Queensland, Australia.

*Description of female.*—Carapace oval in lateral view (Fig. 1a).

Size: Holotype, length, 11 mm, height 9 mm; 2 specimens (USNM 193156a), length 11 m, height 8.5 mm, length 11 mm, height 9 mm.

First antenna: 1st joint bare. 2nd joint with 22 dorsal bristles, 6 ventral bristles, and 1 lateral bristle; distal medial surface with minute spines forming short rows.

3rd joint with 11 dorsal and 6 ventral bristles. 4th joint with 5 distal dorsal bristles and 5 distal ventral bristles. Sensory bristle of 5th joint about same length as combined lengths of joints 3 to 8, with abundant long sensory bristles along proximal half, and short filaments along distal half. Medial bristle of 6th joint bare, about half length of sensory bristle of 5th joint. 7th joint: a-bristle slightly shorter than bristle of 6th joint, bare, tapering to point, appearing more heavily sclerotized than other bristles of limb; b-bristle slightly longer than twice length of a-bristle, with about 25 short marginal filaments; c-bristle about 3-times length of sensory bristle of 5th joint, with numerous short filaments along length. 8th joint: d- and e-bristles bare with blunt tips, slightly shorter than b-bristle; f- and g-bristles longer than c-bristle, with short filaments along length.

Second antenna: Protopodite with distal, medial, bare bristle. Endopodite 3-jointed; 1st joint with 4 proximal and 3 distal bristles; 2nd joint with 1 distal bristle; 3rd joint with 2 terminal bristles (1 long, about same length as combined lengths of joints 1–3, and 1 short, about equal in length to width of 3rd joint near proximal end). Exopodite: bristle of 2nd joint reaching just past 9th joint, with natatory hairs; joints 2–8 with basal spines increasing in length distally (spine of 8th joint about twice length of 9th joint); 9th joint with 2 minute lateral spines and 7 bristles (6 long, 1 short), all with natatory hairs; distal margins of joints 2–8 with minute spines forming rows.

Mandible: Coxale endite stout, spinous, and with bifurcate tip. Basale: proximal ventral corner area with 2 short, stout, pectinate bristles and 11 narrow bristles (some on ventral margin); distal ventral margin with long, stout, spinous bristle; dorsal margin distal to middle with 9 spinous bristles forming row extending onto medial surface and 2 long, stout, spinous, terminal bristles. Exopodite extending past distal edge of 1st endopodial joint, with 2 distal, spinous, ventral bristles (distal of these about ¾ length of other). Endopodite: ventral margin of 1st joint with 8 bristles (4 of these lateral to others, and much longer); 2nd joint with numerous dorsal bristles and 10 distal ventral bristles; 3rd joint with short dorsal claw, 2 long terminal claws, and 4 bristles.

Maxilla: Endite I with 18 spinous and pectinate terminal bristles (4 of these medial and small); endite II with medial spines and about 10 spinous terminal bristles; endite III with about 10 spinous terminal bristles and about 6 proximal lateral bristles in vicinity of exopodite. Basale with 1 short medial bristle near exopodite, 1 stout, hirsute dorsal bristle, and 5 slender bristles at distal anterior corner. Endopodite: 1st joint with 10 alpha-bristles and 5 beta-bristles (all except smallest of beta-bristles with stout marginal spines); end joint with 7 slender, bare a-bristles, 4 b-bristles, 5 c-bristles, and 4 d-bristles; inner 3 b-bristles and inner 3 d-bristles unringed, claw-like; all b-, c-, and d-bristles with stout marginal spines. Exopodite stout, hirsute, with 3 bristles (1 subterminal, 2 terminal).

Fifth limb: Endites 1–3 with numerous spinous bristles. Exopodite: main tooth of 1st joint with proximal spinous bristle followed by pointed peg and 6 pectinate teeth; anterior side of 1st joint with 6 spinous bristles forming row near outer edge and stout hirsute bristle near d-bristle of 2nd joint; 3 small bristles proximal to the stout hirsute bristle; 2nd joint with 6 a-bristles (all except proximal bristle pectinate), 7 b-bristles, and 1 c-, and 1 d-bristle; inner lobe of 3rd joint with 7 bristles (bare or with few spines), outer lobe of 3rd joint hirsute, with 2 spinous

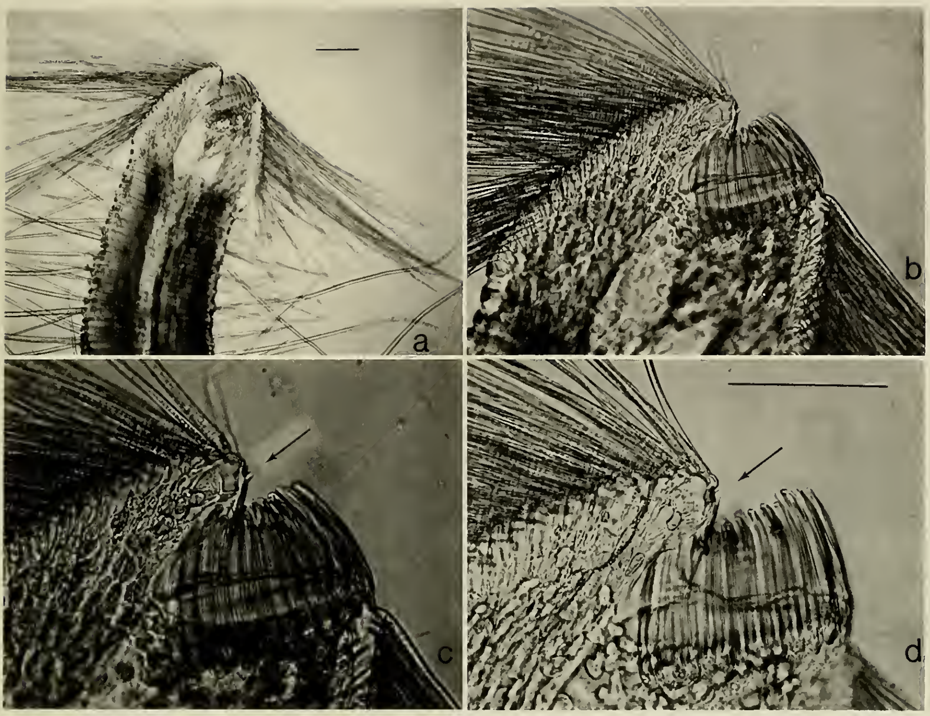

Fig. 2. *Azygocypridina lowryi,* adult female, holotype: a, Distal part of 7th limb; b, detail of tip of limb shown in a; c, Detail from b; d, Tip of opposite 7th limb. Length of scale bar 100 μm; arrows indicate tooth. Photographs taken by Dr. Robert P. Higgins.

terminal bristles; 4th joint with 10 bristles; 5th joint with proximal and distal lobes (proximal lobe with 7 bristles, distal lobe hirsute, with 12 bristles).

Sixth limb: Posterior edge of stem hirsute; 6 bristles in place of epipodial appendage. Endite I narrow, with 4 short, unringed, medial bristles with spine at tip, and 3 longer, spinous, ringed terminal bristles; endite II twice breadth of endite I, with 5 short, unringed, medial bristles with spine at tip, and 11 spinous ringed, terminal bristles; endite III about same width and length as endite II, with 2 ringed, medial bristles near ventral edge and about 20 spinous ringed, terminal bristles; endite IV slightly longer than endite III, with 6 slender, ringed, medial bristles near ventral edge and about 26 spinous, ringed, terminal bristles. End joint divided into broad anterior lobe and small posterior lobe; anterior lobe with over 100 ringed bristles (shorter bristles generally with only short marginal spines; longer bristles with rings of long spines proximally and short spines distally); posterior lobe with 9 ringed bristles along edge (proximal ¾ of bristles hirsute, distal ¼ with short marginal spines); lateral and medial surfaces of both lobes of end joint hirsute.

Seventh limb (Fig. 2): Limb with total of about 339 bristles: approximately 120 bristles in terminal segment (50 on comb side, 70 on jaw side), and 219 proximal bristles (102 on comb side, 117 on jaw side); bristles vary in diameter and length; small bristles with 2–4 bells; long, stout bristles with up to 13 bells; part of bristle proximal to bells with marginal spines. Terminal comb with 28 teeth with rounded tips and marginal spines; jaw opposite comb with minute terminal tooth close to base of bristle.

Furca (Fig. 1b): Claw 1 of right lamella anterior to claw 1 of left lamella; claw 1 shorter than claw 2. Right lamella of holotype with 25 claws, left with 27; starting with claw 2, claws arranged in 5 or 6 groups with claws decreasing in length and diameter in each group.

| | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|
| Left lamella | 4 | 2 | 2 | 3 | 2 | 13 |
| Right lamella | 3 | 4 | 3 | 2 | 12 | — |

Belloncі organ (Fig. 1c): Short, tapering to rounded tip.

Lateral eye (Fig. 1d): Each eye elongate, flap-like with marginal hairs and without ommatidia.

Upper lip (Fig. 1d, e): Anterior part with numerous minute glandular openings; ventral part consisting of 2 lobes bearing slender spines along anteroventral surface, minute spines forming clusters along lateral surfaces, and long hairs on posterior and posteroventral surfaces; lateral surface proximal to ventral margins of lobes with sclerotized frame near middle having incomplete ring; surface within incomplete ring with numerous minute glandular openings.

Posterior of body (Fig. 1b): Posterior surface proximal to furca hirsute. Posterior of body dorsal to end of sclerotized girdle with small hirsute process. Y-Sclerite broadening at anterior end but without ventral branch.

Eggs: USNM 193156a with well developed eggs, length 1.47 mm, height 1.00 mm.

*Description of adult male.*—Carapace similar in shape to that of adult female.

Size: USNM 193156b, length 10.5 mm, height 8.5 mm.

First antenna: 1st joint bare. 2nd joint with 17–21 dorsal bristles, 3 ventral bristles, and 1 lateral bristle. 3rd joint with 10–13 dorsal bristles, and 4 ventral bristles near middle. 4th joint with 4 distal, dorsal bristles and 5 distal, ventral bristles. Sensory bristle of 5th joint similar to that of female. Medial bristle of 6th joint bare. Bristles of 7th and 8th joints broken on specimen examined; bristles similar to those of female except for b- and c-bristles bearing filaments with spoon-like tips.

Second antenna: Protopodite with distal, medial, bare bristle. Endopodite 3-jointed: 1st joint with 4 proximal and 3 or 4 distal bristles; 2nd joint broad, slightly longer than 1st joint, with about 14 marginal bristles; 3rd joint narrow, curved, reflexed on 2nd joint, with 1 long proximal bristle and 2 minute subterminal bristles. Exopodite similar to that of female.

Seventh limb: Marginal bristles abundant but not counted. Terminal comb with about 20 teeth with rounded tips and marginal spines; jaw opposite comb with minute terminal tooth similar to that of female.

Lateral eye: Similar to that of female.

Remaining appendages: Not examined.

*Description of instar III female* (P. 25023).—Carapace oval in lateral view.

Size: Length 5 mm, height 4.2 mm.

First antenna: 1st joint bare. 2nd joint with 8 dorsal bristles, 2 ventral bristles, and no or 1 lateral bristle. 3rd joint with 2 dorsal and 2 ventral bristles on left limb and no bristles on right limb. 4th joint with 2 distal dorsal bristles and 2 distal ventral bristles on left limb and 2 dorsal bristles on right limb. Sensory bristle of 5th joint similar to that of adult. 6th joint with bare medial bristle. Bristles of 7th and 8th joints not studied in detail but, in general, similar type to those of adult female.

Second antenna: Protopodite similar to that of adult female. Endopodite similar to that of adult female, but with 2 bristles on 1st joint, 1 bristle on 2nd joint, and 1 long terminal bristle on 3rd joint. Exopodite similar to that of adult female but with only 4 bristles on 9th joint.

Mandible, maxilla, 5th limb: Not studied in detail but similar type to that of adult.

Sixth limb: Similar in type to that of adult, with numerous bristles.

Seventh limb: Elongate without bristles.

Furca: Claw 1 of right lamella anterior to claw 1 of left lamella; claw 1 shorter than claw 2; each lamella with 15 claws; starting with claw 2, claws arranged in 4 groups with claws decreasing in length and diameter in each group.

| | I | II | III | IV |
|---|---|---|---|---|
| Left lamella | 2 | 2 | 2 | 8 |
| Right lamella | 2 | 2 | 2 | 8 |

Lateral eye: Same shape as that of adult but with sparse hairs.

Posterior of body: Similar to that of adult female in having small, hirsute, thumb-like, dorsal process.

*Remarks.*—The specimen described by McKenzie differs in shape and color from those on hand. The McKenzie female is elongate (height 67% of length) and was bright red when caught (McKenzie 1968, pl. 3: fig. 24, p. 394). The specimens studied herein are more oval (height 77–82% of length), and a photograph received from the Australian Museum of a specimen (register number 21023) suggests that they are orange. Possibly, the orange specimen was originally red, and had faded before being photographed. The difference in shape of the specimens may be the result of intraspecific variation. The 3rd instar conforms with other genera in the Cypridinidae in having a bare 7th limb and well developed 6th limb.

*Comparisons.*—No previously described species of *Azygocypridina* bears as many finger-like teeth (20 male, 28 female) on the tip of the 7th limb.

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# *IDUNELLA SMITHI,* A NEW SPECIES OF MARINE AMPHIPOD (GAMMARIDEA: LILJEBORGIIDAE) FROM THE EAST COAST OF THE UNITED STATES

Eric A. Lazo-Wasem

*Abstract.*—A new species of liljeborgiid amphipod, *Idunella smithi,* is described from Beesley's Point, Cape May County, New Jersey. The species is distinctive in having pleonites 1–3 dorsally smooth and urosomites 1–2 each with one dorsomedial tooth.

The cosmopolitan genus *Idunella* (sensu Karaman 1982; also Lazo-Wasem, in press) is currently represented by four species in northeastern North American waters. *Idunella barnardi* (Wigley) and *I. clymenellae* (Mills) are both thought to be commensals in the tubes of polychaetes in shallow waters (Bousfield 1973). The recently described *Idunella bowenae* Karaman is known from coastal waters to depths of 136 m (Karaman 1979, 1982; see also *I.* sp. A. in Watling 1979, fide Watling, pers. comm.). *Idunella aequicornis* (Sars) has also been recorded from shelf waters of North America (Watling 1979).

During the latter part of the 19th century, A. E. Verrill and S. I. Smith of the Yale Peabody Museum made numerous trips to collect invertebrates along the northeast coast of the United States. Professor Smith described many species of amphipods from this material; several species were described from the vicinity of Great Egg Harbor, New Jersey. The present paper describes a new species of *Idunella* in Peabody Museum material collected by Verrill and Smith from Beesley's Point, New Jersey.

### *Idunella smithi,* new species
Figs. 1–3

*Diagnosis.*—Pleon segments 1–3 dorsally smooth, urosomites 1–2 each with 1 dorsomedian tooth. Gnathopod 1 larger than gnathopod 2; coxa 1 anteriorly produced, larger than coxa 2 or 3.

*Description.*—Female: Body strongly compressed, urosomites free, peraeon and pleonites 1–3 dorsally smooth, urosomites 1–2 with one dorsal tooth each. Coxa 1 anteriorly produced, larger than coxa 2 or 3. Coxa 4 subquadrate, posterior margin excavate. Pleonal epimera subquadrate, each hind corner produced into small tooth. Head, rostrum short, anterior cephalic lobe subrounded, inferior antennal sinus weak but distinct. Eyes medium, subovate, distinct in alcoholic specimens.

Antenna 1 less than 25% body length, extending to end of peduncle of antenna 2. Article 3 of peduncle small, less than ½ length of articles 1 or 2. Primary flagellum subequal to length of peduncle, composed of 11 articles, each provided with a cluster of setae and 1 aesthetasc; accessory flagellum composed of 5 articles.

Antenna 2 about 33% of body length, article 3 of peduncle less than 50% length

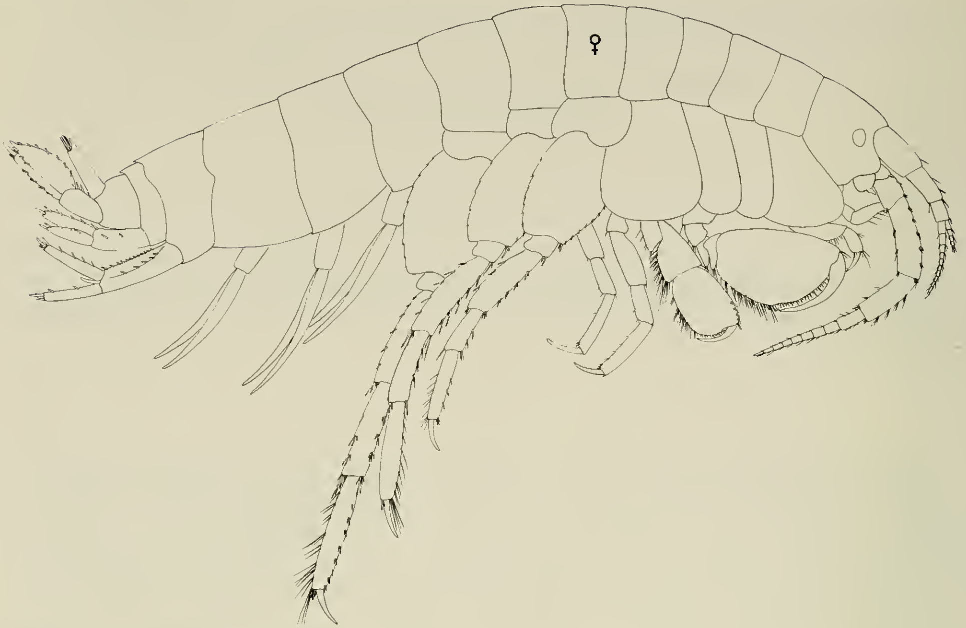

Fig. 1. *Idunella smithi,* female holotype.

of article 4. Flagellum composed of 10 articles, a little shorter than peduncle. Articles 2–5 of peduncle spinose at distal end.

Upper lip rounded, broader than long. Lower lip, inner lobes absent, outer lobes well developed, many small setae on distal margin.

Left mandible, incisor toothed, lacinia (accessory plate) 5-cuspate; margin adjacent to lacinia armed with 9 spines. Molar small, nontriturative; setulose and tuberculate. Palp strong, 3-articulate. Article 1 of palp greater than ½ length of article 2, with a few setae at distal end. Article 2 longer than article 3, with several marginal and many distal setae. Article 3 falciform, with row of short setae along posterior margin and several long distal setae. Right mandible, incisor toothed, lacinia bicuspate, adjacent margin with 8 small spines.

Maxilla 1, inner plate small, with several plumose terminal setae. Outer plate with 8 stout curved spines, some serrate. Palp 2-articulate, normal. Article 2 with numerous terminal setae. Maxilla 2, inner plate shorter than outer plate, distally with plumose and simple setae, inner margin with sparse medial setae. Outer plate with numerous setae along distal inner margins. Maxilliped normal; outer plate much larger than inner plate, extending farther than ½ length of palp article 2. Inside margin sparsely setose, distally armed with a few spines and several setae, some plumose. Palp composed of 4 articles, extending well beyond outer plate. Article 2 stout, setose along inner margin, longer than articles 3 and 4 combined. Article 3 with marginal and distal setae. Article 4 normal, a little shorter than article 3, with distal nail.

Gnathopod 1 subchelate, much larger than gnathopod 2. Article 2 with setae along both margins. Articles 3–5 short, with clusters of setae on posterior margins. Article 6 subovate, oblique, palm entire, convex, bearing row of straight or re-

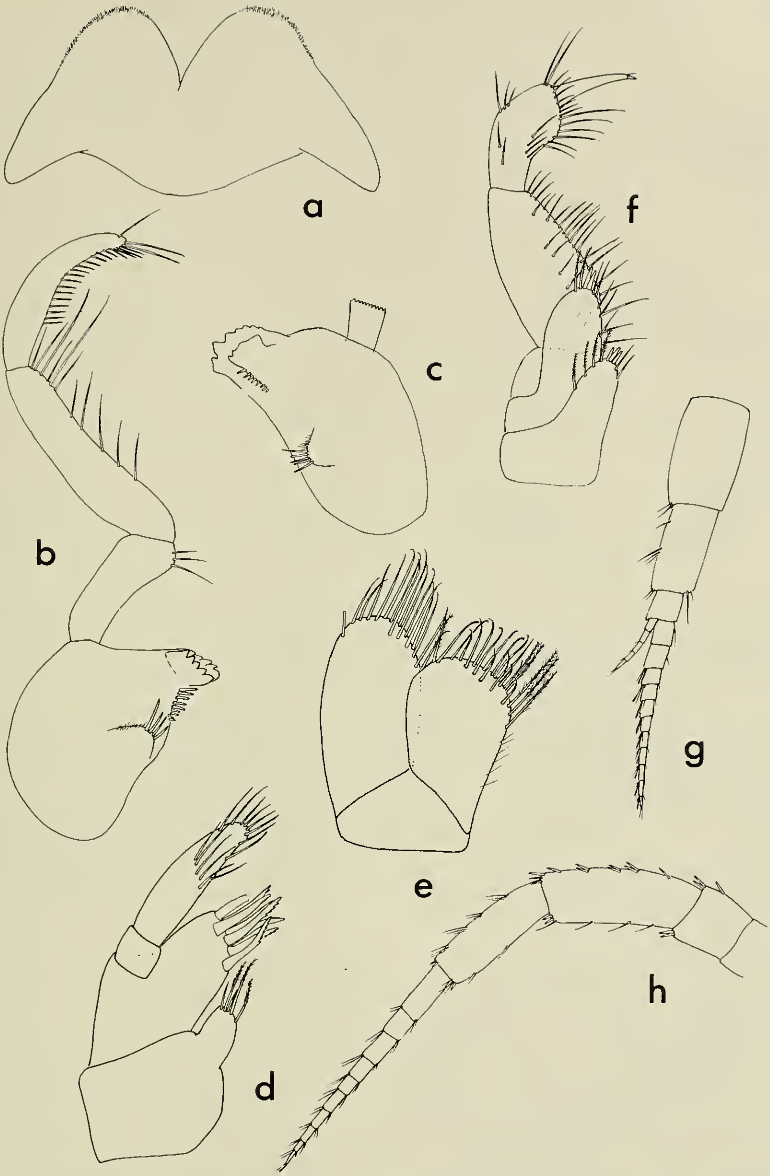

Fig. 2. *Idunella smithi,* female holotype: a, Lower lip; b, Left mandible; c, Right mandible; d, Maxilla 1; e, Maxilla 2; f, Maxilliped; g, Antenna 1; h, Antenna 2.

curved spines along inner and outer surface and row of plumose setae along inner margin. Posterior corner of palm with 2 small spines on outer margin and 1 large spine on medial surface. Facial setae sparse; posterior margin with several clusters of setae. Gnathopod 2 subchelate, anterior and posterior margin of article 2 with a few setae. Distal lobe of article 4 with cluster of spines. Article 5 slightly shorter than article 6, posterior margin setose. Article 6 longer than wide, subrectangular. Palm entire, transverse, convex, ornamentation as in gnathopod 1; clusters of

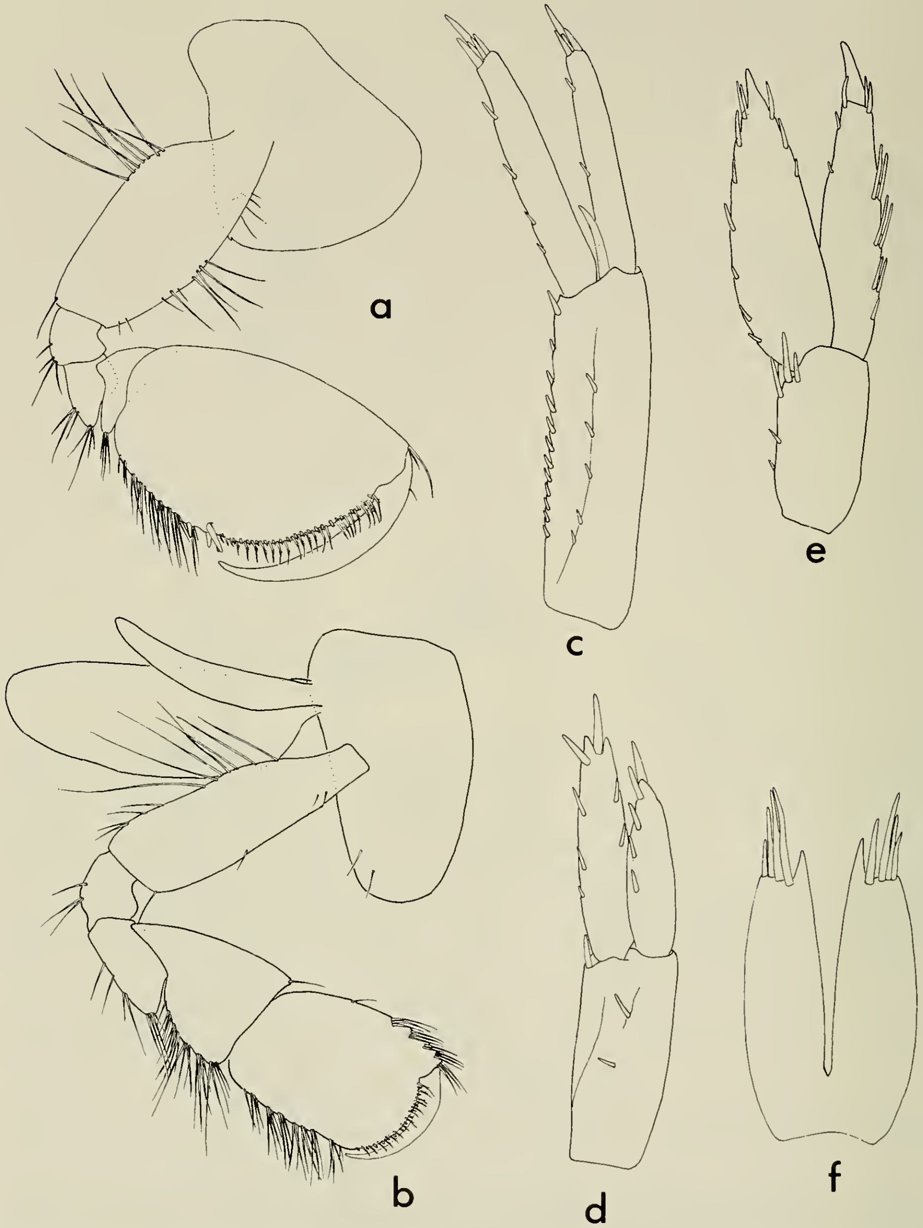

Fig. 3. *Idunella smithi,* female holotype: a, Gnathopod 1; b, Gnathopod 2; c, Uropod 1; d, Uropod 2; e, Uropod 3; f, Telson.

setae extending back along 80% of palmar margin. Dactyl closing against entire margin of palm.

Peraeopods 3–4 slender; peraeopod 4 slightly shorter than peraeopod 3. Article 2 of both peraeopods, anterior margin with few, and posterior margin with several setae. Article 3 short; article 4 longer than article 5, anterior margin with few short spines. Article 6 longer than articles 4 or 5, weakly spinose along posterior margin. Article 7 approximately ½ length of article 6.

Pleopods well developed, subequal. Rami of equal length, longer than peduncle, composed of 11–15 articles. Peduncles with 2 coupling hooks each.

Uropod 1 extending beyond apex of uropod 2 and beyond peduncle of uropod 3. Peduncle a little longer than rami, dorsal margin with row of short spines; several spines at distal end. Interramal spine extending about ⅓ length of rami. Rami with few dorsolateral spines and apical spine cluster, outer shorter than inner ramus.

Uropod 2 extending a little beyond peduncle of uropod 3, peduncle subequal to rami with few lateral and distal spines. Outer ramus shorter than inner ramus, both rami with row of spines along dorsal margin and cluster of apical spines. Uropod 3 extending well beyond uropod 1. Peduncle equal in length to uropod 2, much shorter than rami. Rami lanceolate, subequal in length, outer margins spinose. Outer ramus narrower than inner ramus, 2-articulate, second article 25% length of first.

Telson deeply cleft, extending to middle of uropod 3 rami. Inner margin of lobes distally pointed, lobes with 4 terminal spines each.

*Male.*—Unknown.

*Variability.*—The primary flagellum of antenna 1 and the flagellum of antenna 2 in the paratype have fewer segments (8 and 9 respectively) than in the holotype (11 and 10 respectively). The basis (article 2) of peraeopod 5 is more broadly expanded in the paratype than in the holotype.

*Material examined.*—YPM No. 1238, Beesley's Point, Cape May County, New Jersey, A. E. Verrill and S. I. Smith, Apr 1871, 1 holotype female (10.9 mm).—YPM No. 8060, Beesley's Point, Cape May County, New Jersey, A. E. Verrill and S. I. Smith, Apr 1871, 1 paratype female (8.8 mm).

*Etymology.*—This species honors Professor S. I. Smith of the Yale Peabody Museum, who contributed much to our knowledge of North American amphipod systematics.

*Remarks and discussion.*—*Idunella smithi* is similar to *I. bowenae* in the arrangement of dorsal teeth on the urosome. Both species have one dorsomedian tooth each on urosomites 1 and 2. Furthermore, the shape and form of the gnathopods (females) is quite similar between the two species. *Idunella smithi,* however, lacks the dorsomarginal teeth present on pleon segment 3 of *I. bowenae.* The dorsal tooth arrangement of *I. smithi,* i.e., 1 tooth each on urosomite 1 and urosomite 2, is unique with respect to all other *Idunella.* Also, the telson of *I. bowenae* has fewer apical spines (2 per lobe) than is found on *I. smithi* (4 per lobe). *Idunella barnardi* and *I. clymenellae,* also known from northeastern U.S. waters, are easily distinguished from *I. smithi* by their smooth urosomes. Furthermore, *I. barnardi* and *I. clymenellae* both have gnathopod 2 larger than gnathopod 1 (males and females) whereas the reverse is true (e.g., gnathopod 2 smaller than gnathopod 1) in *I. smithi.*

That only two specimens of *I. smithi* are known (none have been collected since the original material) is unfortunate. Also, the lack of any habitat data or more precise locality information allows one only to speculate on its ecology; still, some generalizations can be made. *Idunella smithi* is probably uncommon and most likely inhabits water below the tide marks, otherwise casual collecting would undoubtedly have turned up other specimens prior to these. Generally, major amphipod surveys have not concentrated on New Jersey waters; this may in part explain why *I. smithi* has been overlooked for so long. Furthermore, Beesley's Point, New Jersey may represent an extreme northerly occurrence of *I. smithi*; this species may be more common south of New Jersey.

## Acknowledgments

I am grateful to Dr. Les Watling, University of Maine, for critically reviewing the manuscript and providing useful information concerning *Idunella.*

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# *APONOMMA ELAPHENSE* PRICE, 1959 (ACARI: IXODIDAE): DIAGNOSIS OF THE ADULTS AND NYMPH WITH FIRST DESCRIPTION OF THE LARVA

James E. Keirans and William G. Degenhardt

*Abstract.*—The larva of *Aponomma elaphense* is described, diagnostic characters for the male, female, and nymph are given and scanning electron photomicrographs are provided for all stages. Range and habitat information is provided for the only known host of *A. elaphense, Elaphe subocularis,* the Trans-Pecos rat snake.

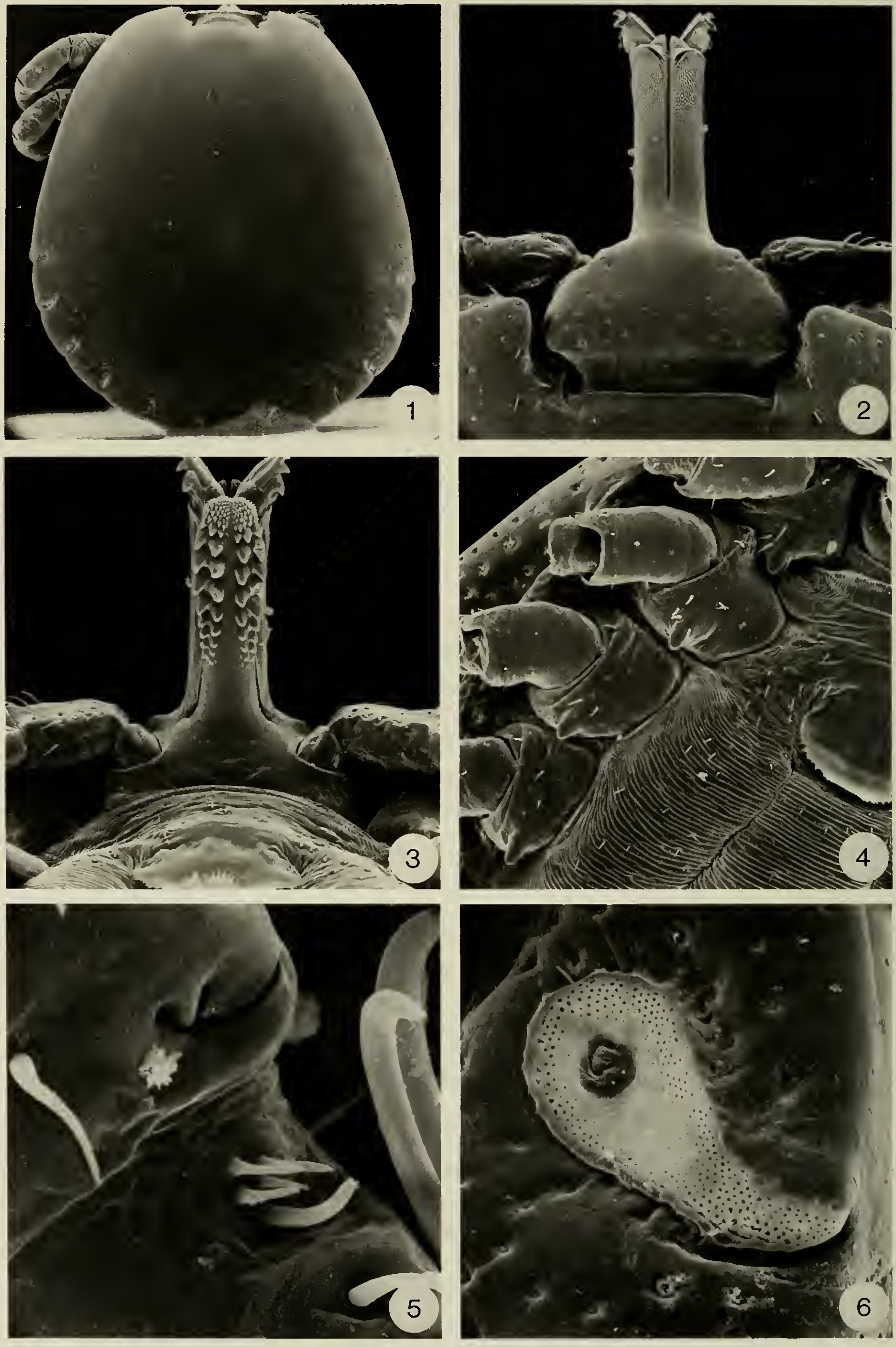
Worldwide, there are approximately 21 species in the genus *Aponomma,* only two of which are found in the Western Hemisphere, *A. quadricavum* Schulze, found in Haiti and Cuba (Schulze 1941; Cerný 1966), and *A. elaphense* Price, found in Texas, parts of New Mexico and northern Mexico (Price 1959; Degenhardt and Degenhardt 1965).

During examination of a series of the Trans-Pecos rat snake, *Elaphe subocularis,* the only known host of *Aponomma elaphense,* one of us (W.G.D.) collected numerous adults, nymphs, and previously undescribed larvae of that tick (Degenhardt, in press). We give a diagnosis of the male, female, and nymph of *A. elaphense,* illustrating key characters with scanning electron photomicrographs (SEM) and describe the previously unknown larva. Specimens were prepared for SEM by the method of Corwin et al. (1979).

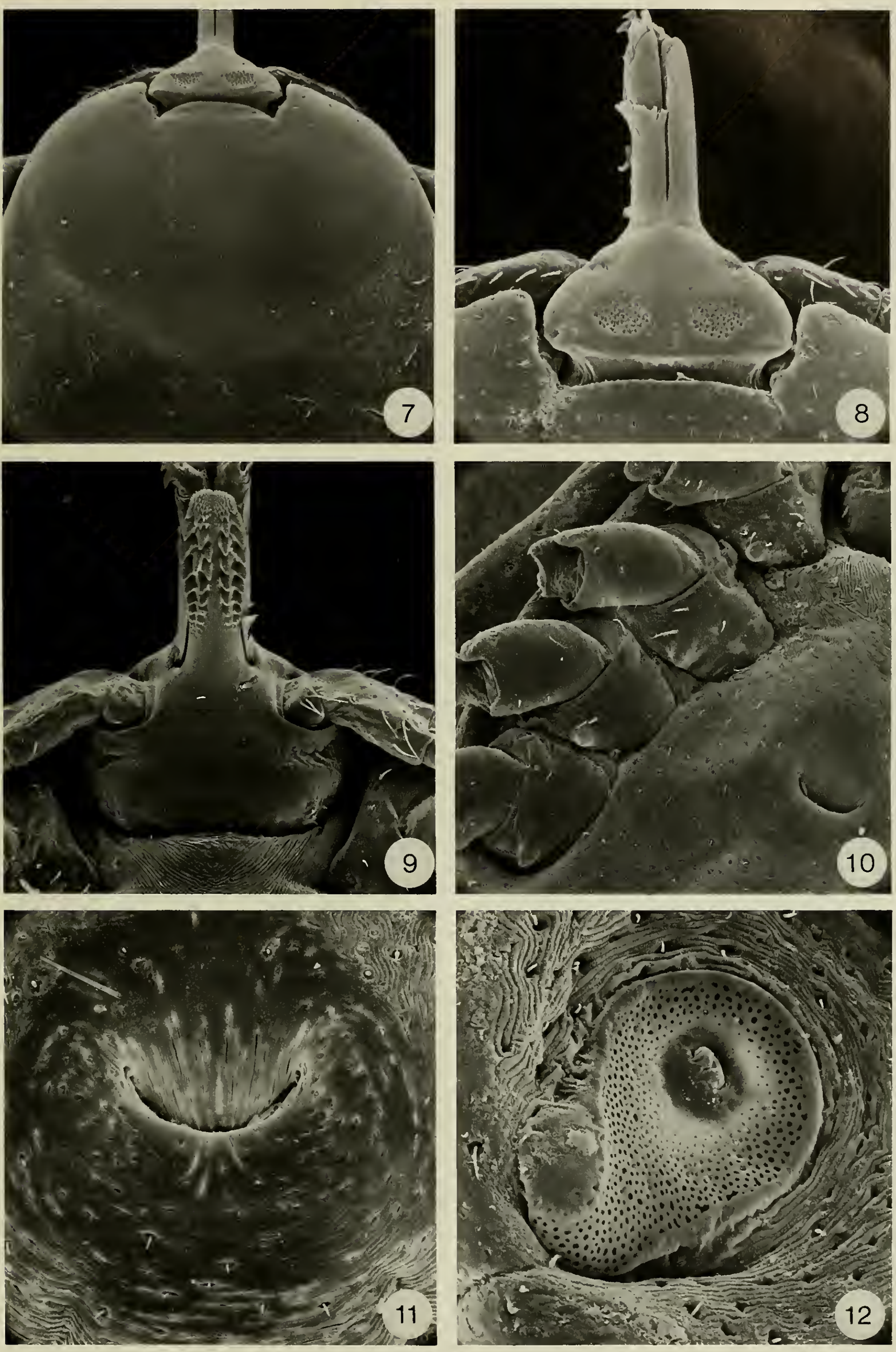
## *Aponomma elaphense* Price, 1959

*Diagnosis—male* (Figs. 1–6).—A very small *Aponomma,* ca. 2.00 mm long (excluding capitulum) ca. 1.85 mm wide; inornate, light brown. Scutum (Fig. 1) smooth, without cervical or marginal grooves, setae and punctations minute, inapparent under binocular microscopy. Capitulum dorsally (Fig. 2) subtriangular, lacking cornua; ventrally (Fig. 3) with hypostomal dentition 2/2 throughout, apically with a large corona of fine denticles; palpi elongate. Legs (Figs. 4, 5) each with a single triangular spur on coxae I–IV; Haller's organ roof slit-like and slightly bifurcate medially, 5 anterior pit setae. Spiracular plate (Fig. 6) suboval with a long narrow dorsal prolongation, goblet cells minute.

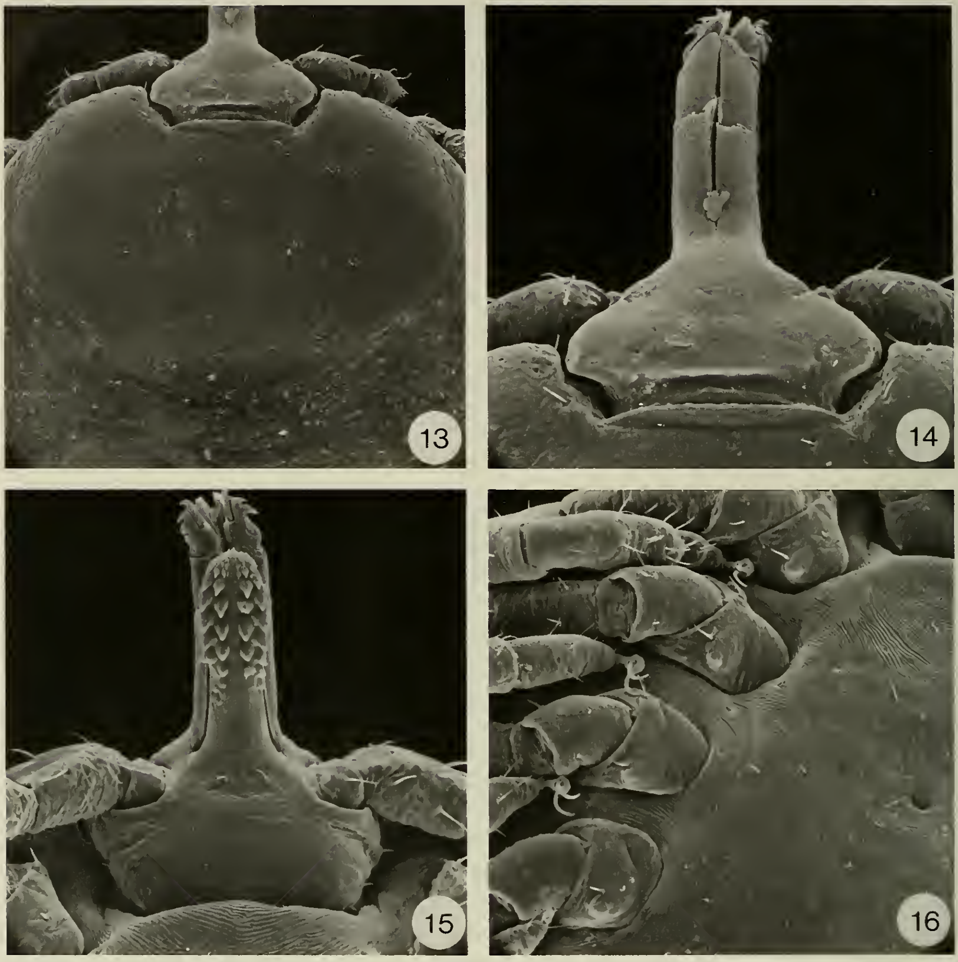
*Diagnosis—female* (Figs. 7–12).—Small, suboval, ca. 2.40 mm long (excluding capitulum) ca. 2.15 mm wide; inornate, light brown. Scutum (Fig. 7) broader than long, cordiform, smooth, without cervical grooves, setae and punctations minute. Capitulum dorsally (Fig. 8) subtriangular, cornua absent; porose areas subcircular, shallow; ventrally (Fig. 9) with hypostomal dentition 2/2 [although the hypostome figured has a single supernumerary tooth between file one and two on the left side of the hypostome as viewed from above]; palpi elongate. Legs (Fig. 10) with coxae as in male. Genital aperture (Fig. 11) at level of coxae II. Spiracular plate (Fig. 12) suboval with a short dorsal prolongation, goblet cells minute.



Figs. 1–6. *Aponomma elaphense* ♂ (RML117420): 1, Dorsal view (53×); 2, Capitulum, dorsal view (212×); 3, Capitulum, ventral view (212×); 4, Coxae I–IV (106×); 5, Haller's organ (1590×); 6, Spiracular plate (318×).



Figs. 7–12. *Aponomma elaphense* ♀ (RML117420): 7, Scutum (64 ×); 8, Capitulum, dorsal view (106 ×); 9, Capitulum, ventral view (106 ×); 10, Coxae I–IV (117 ×); 11, Genital aperture (318 ×); 12, Spiracular plate (318 ×).

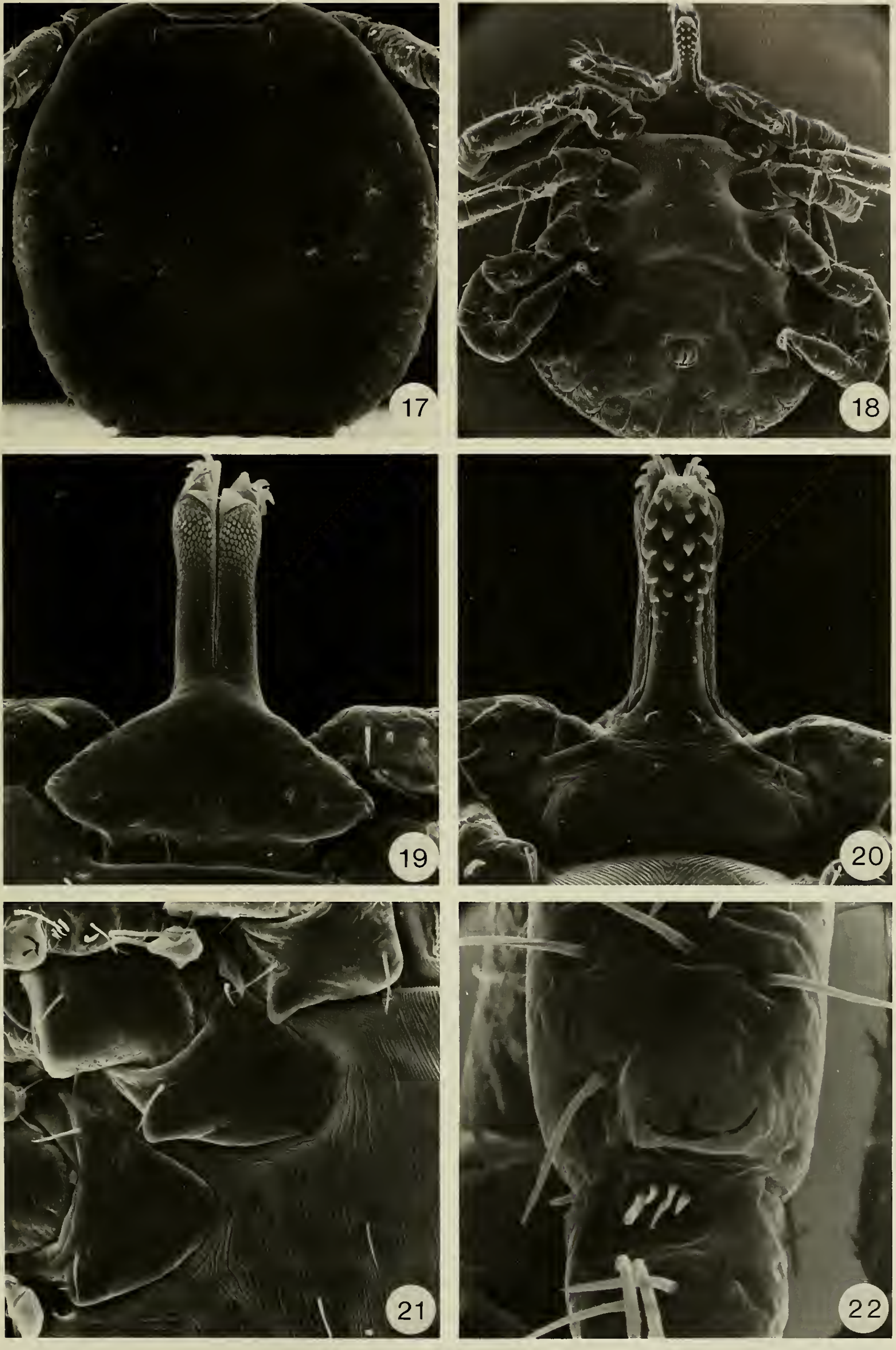


Figs. 13–16. *Aponomma elaphense* Nymph (RML117420): 13, Scutum (106×); 14, Capitulum, dorsal view (212×); 15, Capitulum, ventral view (212×); 16, Coxae I–IV (212×).

*Diagnosis—nymph* (Figs. 13–16).—Small, suboval, about as wide as long. Scutum (Fig. 13) with scale-like markings over the surface, otherwise as in female; capitulum dorsally (Fig. 14) broadly triangular, corona absent; ventrally (Fig. 15) with hypostomal dentition 2/2, a small cornua of minute denticles apically. Legs (Fig. 16) each with a very small bluntly rounded spur on coxae I–IV. Spiracular plate suboval, without dorsal prolongation.

*Description—larva* (Figs. 17–22).—Measurements (mm) based on 12 partially engorged specimens include a range and mean (in parenthesis).

Body (Fig. 17, 18): Length from scapular apices to posterior body margin 0.567–0.670 (0.617); width 0.549–0.622 (0.578), outline suboval, widest at midlength, with 11 festoons. Setae dorsally 13 pairs, all minute except for $SC_1$; 2 central dorsal pairs; 8 marginal dorsal pairs, 2 of which anterior to sensilla sagittiformia; supplementary setae absent; 3 scutal pairs. Ventrally 15 pairs; 3 sternal pairs; 2 preanal pairs; 4 premarginal pairs (one specimen with 5 pairs, with posteriormost



Figs. 17–22. *Aponomma elaphense* Larva (RML117420): 17, Dorsal view (212×); 18, Ventral view (212×); 19, Capitulum, dorsal view (424×); 20, Capitulum, ventral view (424×); 21, Coxae I–III (530×); 22, Haller's organ (1590×).

on right side doubled); 5 marginal ventral pairs; 1 pair on anal valves. Capitulum (Figs. 19–20) subtriangular 0.060–0.091 (0.077) long, 0.156–0.168 (0.164) wide. Dorsally with posterior margin straight, posterolateral margin angled, cornua absent; basis capituli ventrally broadly rectangular. Palpi 0.125–0.149 (0.137) long (because all larvae were collected while feeding the palpi are splayed back against the first pair of legs). Segments decreasing in the order 4, 1, 3, 2; setae number ca. 10 on segment 4, 3 dorsally, 1 laterally, 2 ventrally on segment 3; 3 dorsally, 1 laterally, 2 ventrally on segment 2; 0 on segment 1. Hypostome (Fig. 20) 0.108–0.122 (0.115) long, bluntly rounded apically with few minute hooklets; dental formula 2/2. Posthypostomal setae 1 pair; distance between PH, 0.026–0.031 (0.029). Scutum (Fig. 17) 0.293–0.311 (0.302) long, 0.372–0.409 (0.394) wide, outline as illustrated, unornamented; eyes absent, cervical grooves absent, punctations absent. Setae 3 pairs, $SC_1$ relatively long. Legs. Coxae I–III each with small triangular external spur (Fig. 21), internal spurs absent; setae: coxa I with 3, coxae II & III with 2 each. Tarsus I 0.151–0.187 (0.172) long. Haller's organ (Fig. 22) with roof bifurcate; anterior pit setae: 1 porose, 2 fine, 1 fine or perhaps setiform.

## Species Relationships

Kaufman (1972) considered the genus *Aponomma* to be a heterogenous assemblage and divided them into three groups; typical i.e., African-Asian reptile parasites, indigenous Australian species and "primitive" species. In the "primitive" group he included two species, *A. sphenodonti* Dumbleton, a parasite of the Tuatara, *Sphenodon punctatus,* found on Stephen Island, New Zealand, and *A. elaphense.* Males of *A. sphenodonti* have a 3/3 then 2/2 hypostomal dentition and marginal grooves, whereas males of *A. elaphense* have a hypostome entirely of 2/2 dentition and lack marginal grooves. The presence of a pair of large spurs ventrally on the capitulum of female *A. sphenodonti* easily separates it from female *A. elaphense.* Larvae of *A. sphenodonti* have large elongate cervical grooves which are absent in larvae of *A. elaphense.*

In addition to *A. elaphense,* two other species of *Aponomma* have been reported for the United States, *A. quadricavum* and *A. latum* (Koch). However, both these species were accidental imports and are not established here (Anderson et al. 1981, 1984). *Aponomma latum* is an African species found on a wide variety of snakes and *A. quadricavum* is a Caribbean species (Haiti and Cuba) found on *Epicrates striatus, E. angulifer,* and *Alsophis cantherigerus.*

Anderson et al. (1981) provided characters for separating adults of *A. quadricavum* and *A. elaphense.* Larvae of *A. quadricavum* and *A. elaphense* are quite similar, both having 2/2 hypostomal dentition, elongate palpi, a single spur on all coxae, and a similar chaetotactic pattern. However, *A. elaphense* lacks cervical grooves on the scutum, which are moderately deep and distinctive in *A. quadricavum.* Adult *Aponomma latum* have a hypostome with 3/3 dentition and two spurs on coxa I. Adult *A. elaphense* have 2/2 hypostomal dentition and a single spur on coxa I. Larvae of *A. latum* have palpal segment 4 subterminal and cervical grooves present. Larvae of *A. elaphense* have palpal segment 4 terminal and cervical grooves absent.

Adults and nymphs of *A. elaphense* attach most often in the pockets under the edges of the ventral scutes where these meet the dorsal scales. Usually larvae are found under the dorsal scales higher on the sides of the host. This distribution is probably size-related, as ventral scutes have deeper pockets than the dorsal scales, therefore affording better protection for larger ticks against being rubbed off during movements of the host. Photographs showing tick attachment were published earlier by Degenhardt and Degenhardt (1965).

*Elaphe subocularis* ranges from southcentral New Mexico south through Texas and east to the southwestern edge of the Edwards Plateau; then south into Mexico through eastern Chihuahua and Coahuila to northeastern Durango and western Nuevo Leon (Worthington 1980; Liner 1982). *Aponomma elaphense* is found throughout the range of the host, and its presence has been documented in most *E. subocularis* populations (Degenhardt and Degenhardt 1965).

Because the Greek combination apo- (away from) plus -omma (eyeless) is neuter, the ending for the specific epithet should be -ense rather than -ensis.

## Acknowledgments

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# A NEW SPECIES OF *NEOSTRENGERIA* (CRUSTACEA: DECAPODA: PSEUDOTHELPHUSIDAE) WITH NOTES ON GEOGRAPHICAL DISTRIBUTION OF THE GENUS

Martha R. Campos and Gilberto Rodríguez

*Abstract.*—*Neostrengeria charalensis,* new species, is described from Charalá, Departamento Santander, Colombia. It is most closely related to *N. macropa,* but the dactyli of the walking legs have only four to six spines in each of the five rows, instead of the 12 to 17 present in *N. macropa,* and the gonopod has different proportions. The geographical distribution of the species of *Neostrengeria* is more precisely defined with the help of several new records.

The genus *Neostrengeria* Pretzmann, 1965, comprises a group of small pseudothelphusid crabs from the Eastern Cordillera of Colombia. The group is homogeneous and well defined; the morphology of the male gonopod shows that these crabs derive directly from some of the most primitive members of the family (Rodríguez, in press). Although the systematics of *Neostrengeria* are well established (Rodríguez 1982), the geographical distribution of the species is rather confusing. With the aim of defining the ranges of the species more precisely, one of us (MRC) made extensive collections along the Eastern Cordillera. We also had access to the collections of freshwater crabs made in Colombian caves by Dr. B. Sket during the University of Ljubljana Colombia Expedition. Examination of these materials revealed the presence of a new species, as well as of all the species previously described from the area, except *N. libradensis* Rodríguez, 1980. The material is deposited in the Museo de Historia Natural, Instituto de Ciencias Naturales, Bogotá (ICN-MHN), the reference collection of the Instituto Venezolano de Investigaciones Científicas, Caracas (IVIC), and the Institute of Biology of the University of Ljubljana, Yugoslavia (UL). All the collections are by Martha R. Campos, except when the collector's name is indicated.

### *Neostrengeria botti* Rodríguez and Türkay, 1978

*Material.*—Quebrada El Peñón, Vereda Aposento, Municipio Nuevo Colón, Cundinamarca, 1700 m; 6 Jun 1984; 3 males, 1 female (ICN-MHN No. 0588).—Municipio Tena, Vereda El Rosario, Departamento Cundinamarca, 1500 m; 6 Jun 1984: 3 males, 3 females (ICN-MHN No. CR 0591).

There has been some uncertainty about the distribution of this species because the type and only previously known specimen was simply labelled "Bogotá," which covers a large area. The present records are from an area 50 km west of Bogotá, on the eastern margin of the Bogotá River.

### *Neostrengeria boyacensis* Rodríguez, 1980

*Material.*—Quebrada El Peñón, Vereda Aposento, Municipio Nuevo Colón, Departamento Boyacá, 2525 m; 2 Jun 1984: 7 males, 4 females (ICN-MHN No.

CR 0577).—Quebrada Caliente, Municipio Ventaquemada, Departamento Boyacá, 2625 m; 2 Jun 1984; 8 males, 6 females (ICN-MHN No. CR 0575).—Vereda Pavas, Municipio Umbita, Departamento Boyacá, 2550 m; 2 Jun 1984: 9 males, 24 females (ICN-MHN No. CR 0578).

The present localities are 150 km away from the type-locality, La Uvita, and on a different drainage basin. La Uvita is on the basin of the Sogamoso-Magdalena rivers, whereas the present localities are on the Upía-Meta-Orinoco river basin (Fig. 3). However, there are no obvious morphological differences among specimens from the two basins.

### *Neostrengeria charalensis,* new species

Fig. 1a, g

*Material.*—Municipio Charalá, Corregimiento Virolín, Departamento Santander, 1700 m; 29 Apr 1984; G. Galvis: 1 male holotype, cb. 29.9, cl. 17.8 mm, 2 females, cb. 31.5 and 30.3 mm, cl. 18.4 and 17.1 mm (ICN-MHN No. CR 0481).—Quebrada de Hormas, 7 km S of Moniquirá, 40 km NW of Tunja, Departamento Boyacá; 15 Jun 1977; H. Díaz: 1 male, cb. 29.2, cl. 16.4 mm (IVIC).—Cueva de los Indios, La Paz, Departamento Santander, 1995 m; Jun 1984; B. Sket: 1 male, cb. 23.5, cl. 13.7 mm (UL).

*Description.*—The cervical groove is almost obsolete, indicated only by a shallow depression near the proximal end. The anterolateral border is smooth, completely devoid of teeth. The frontal lobes are almost obsolete, their presence being indicated only by 2 small scars located behind the front. The median groove consists of a wide and shallow depression. The surface of the carapace behind the front is inclined anteriorly, but only slightly depressed towards the midline. The upper border of the front is strongly sinuous in dorsal view, devoid of tubercles. The lower margin is strongly sinuous in frontal view. The surface of the front between the upper and lower borders is very narrow, almost obsolete. The orbital border is smooth, devoid of papillae. The eyes are small in relation to the orbital cavity and do not fill it; the ocular peduncle tapers distally; the cornea is reduced and partly unpigmented, it does not widen distally. The surface of the carapace is smooth and polished, covered by small papillae and wrinkles not visible to the naked eye.

The chelae are elongate. The fingers are long (0.51 the length of larger chela, 0.57 of the smaller), slender and subcircular in section, with a large gape between them. The cutting surface of the dactylus of the larger chela is devoid of teeth for about the proximal ⅓ of its length; then a continuous series of teeth begins with 2 low papillae, followed by a large tooth, a low papilla, and another tooth about half the size of the largest tooth; the distal third is occupied by 8 small teeth. In the smaller chela the cutting surface of the dactylus is devoid of teeth for about the proximal ¼ of its length; the series of teeth begins with a low papilla, followed by a small tooth and a row of 10 small papillae.

The walking legs have the usual 5 rows of spines on the dactylus; the spines are small and diminish in size proximally, becoming small horny papillae over the proximal ⅓ of the article. The arrangement of these spines over the third left pereiopod is as follows: anteroventral row 5 spines, anterolateral row 6 spines plus 3 proximal papillae, upper row 6 spines plus 2 pairs of papillae, posterolateral

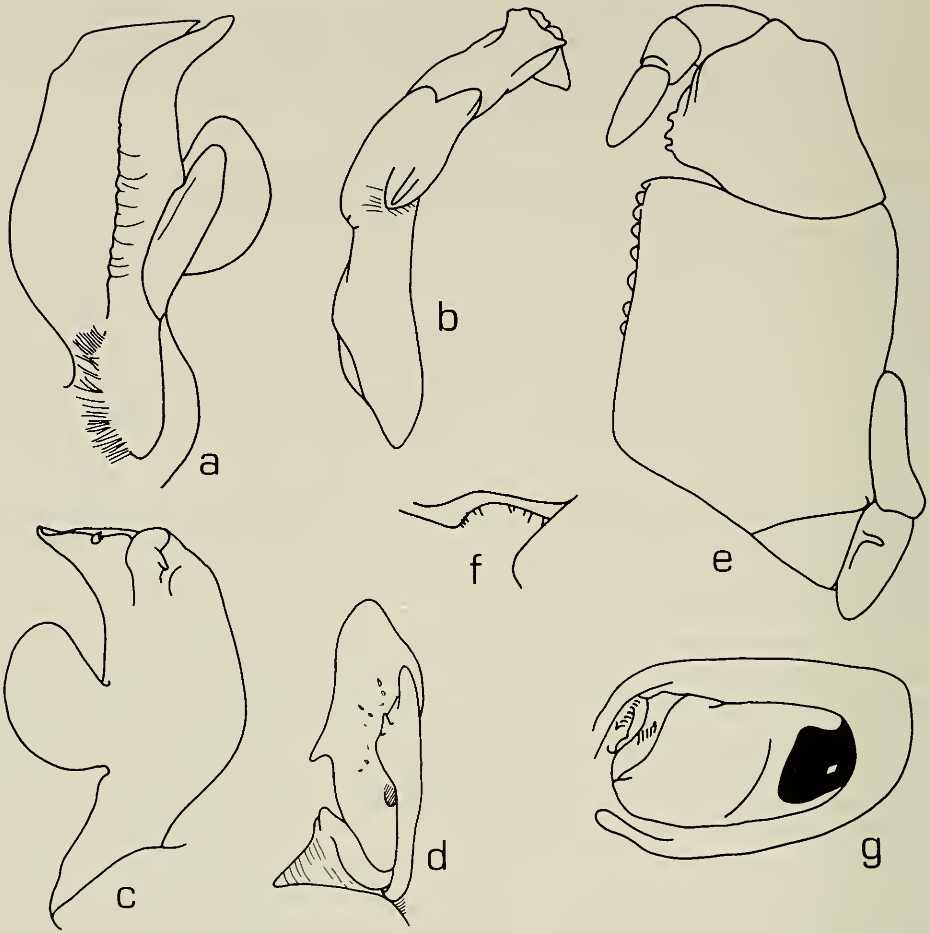

Fig. 1. *Neostrengeria charalensis,* holotype, ICN-0481: a, Left gonopod, caudal view; b, Lateral view; c, Mesial view; d, Apex in distal view; e, Third maxilliped; f, Left opening of branchial channel; g, Left eye.

row 5 spines plus 2 papillae, posteroventral row 5 spines. The merus of the third maxilliped has a low angle on the distal half of its external margin; the exognath is 0.4 the length of the ischium.

The lateral lobe of the male gonopod forms a semicircle and is inserted at an acute angle to the main axis of the appendage. The apex in distal view is oval-elongate with a cephalic spine near the middle of the lateral border directed mesially; the smaller papilla of the spermatic opening is well developed.

The additional specimens that we examined show several differences from the holotype. The male specimen from Moniquirá is closer to the holotype, but the anterolateral border has a series of small, undifferentiated lobes behind the cervical groove which become dentiform posteriorly; the upper border of the front in dorsal view is less strongly sinuous; the orbital border is obscurely crenulate. The chelipeds are similar to those of the holotype, with the fingers elongate (0.48 the length of the larger chela, 0.51 of the smaller), the empty space in both fingers is shorter, the teeth are larger and more defined, the larger teeth of the smaller chela are separated by 2–4 smaller teeth. The arrangement of spines on the dactylus of the third left pereiopod is as follows: 5 spines plus 2 papillae, 9 spines, 7 spines plus 2 pairs of papillae, 8 spines plus 1 papilla. The lateral projection in the apex of the gonopod is very wide, not acuminate as in the holotype; the cephalic spine of the apex is smaller.

The male specimen from La Paz differs more markedly from both the holotype and the specimen from Moniquirá. The anterior border of the cervical groove has a group of approximately 15 small papillae, irregularly placed; the rest of the anterolateral border is divided into approximately 20 small dentiform papillae. The upper border of the front is straighter in dorsal view, faintly bilobed; it has some ill defined tubercles toward the sides. The lower margin is less strongly sinuous and the surface of the front between both borders is higher; the orbital border is clearly crenulate. The eyes are large and fill the orbits; the ocular peduncle is cylindrical and does not taper distally; the cornea is well developed and pigmented. The chelipeds are different from those of the holotype, the fingers are long (0.54 the length of each chela) but do not gape, the space between the fingers being occupied by large teeth; there is almost no free space on the proximal end of the cutting edge of both fingers of the larger cheliped, each row of teeth consists of 1 small papilla, 2 very large teeth, 1 small papilla, 1 medium sized tooth, and 5 smaller distal teeth. The arrangement of spines on the dactylus of the third left pereiopod is as follows: 4 spines, 5 spines plus 1 papilla, 5 spines plus 1 pair of papillae, 5 spines plus 1 papilla, and 4 spines. The largest lateral lobe of the gonopod is more rounded and detached from the appendage, more transversely set in relation to the longitudinal axis; in lateral view the gonopod appears more contorted; the cephalic spine of the apex is larger and wider, implanted closer to the lateral border; the lateral projection of the apex is wider and more advanced distally; the smaller papilla of the sperm opening is rudimentary.

*Remarks.*—This species resembles *Neostrengeria macropa* (H. Milne Edwards, 1853) in the shape of the male gonopod, but the apex is narrower, its lateral spine stronger, and the lateral lobe larger and more regularly rounded. The dactylus of the present species has four to six spines in each of the five rows as is usual in other Pseudothelphusidae, with the exception of *N. macropa* which has 12 to 17 in each row.

The range of the species, as deduced from the type-locality and that for the two additional specimens, is the basin of the Río Suárez, and overlaps with the range of *N. niceforoi* (Schmitt, 1969). The character of the eyes in the holotype and in the specimen from Moniquirá, suggests a hypogean habit, but paradoxically, the specimen from La Paz, with normal eyes, comes from a cave.

### *Neostrengeria guenteri* (Pretzmann, 1965)

*Material.*—Municipio Acacías, Vereda Portachuelo, Departamento Meta, 1500 m; 23 Mar 1984: 11 males (ICN-MHN No. CR 0554).—Municipio Restrepo, Vereda Caney Alto, Río Caney Alto, Departamento Meta, 700 m; 24 Mar 1984: 3 males (ICN-MHN No. CR 0555).—Villavicencio, Vereda Quebrada Colorada, Departamento Meta, 1000 m; 26 Mar 1984: 12 males (ICN-MHN No. CR 0558).—Villavicencio, Vereda Buena Vista, Caño Blanco, Departamento Meta, 1300 m;

26 Mar 1984: 5 males, 3 females (ICN-MHN 0559).—Municipio Cumaral, Vereda Marayal, Departamento Meta, 825 m; 29 Mar 1984: 16 males, 8 females (ICN-MHN No. CR 0565).—Municipio Guayabetal, Quebrada San Miguel, Departamento Cundinamarca, 1500 m; 3 Mar 1984: 1 male (ICN-MHN No. CR 0542).

Pretzmann (1965) originally described this species from a male specimen ("locus typicus: Columbien, 160/623, Nikiforov coll."). Schmitt (1969) reviewed this material and published the first illustration of the male gonopod. Schmitt said of the male holotype: "This specimen (Niceforo No. 8) is from Bogotá" and added, "besides the holotype, Brother Niceforo collected two other specimens (No. 9, 26.6 × 44.3 mm and 28.4 × 49.9 mm) at Pennsylvania, Caldas." Later, Pretzmann (1972) mentioned the number USNM 120140 for this male holotype, and added 2 female paratypes "von Gleichem Fundort, Mus. Washington, Nr. 160/623."

Rodríguez (1982) assigned to this species one male from a locality near Villavicencio, and since the present material also comes from a locality 20 km NW of Villavicencio, it is very possible that the species is restricted to localities around this town in the Río Negro Valley. Hence, the assigning of the two females from Pennsylvania to *N. guenteri* is very doubtful, since that locality is in the Central Cordillera of Colombia, and lacks connections with the Río Negro Valley.

The material deposited at the U.S. National Museum (Manning, pers. comm.) consists of a male holotype USNM 120140, one female (Brother Niceforo No. 9) USNM 119876, and another female USNM 119875. All three jars bear Pretzmann's label: "*Potamocarcinus guenteri* n. sp.," and at least two bear labels by Schmitt: "*Pseudothelphusa bouvieri* Rathbun." The female in USNM 119875 also has a label in Schmitt's handwriting: "The crab in this bottle I believe was part of the No. 9 crab in 119867. Thus both would have same data Pennsylvania, Caldas, Colombia, Niceforo coll." Hence due to doubts concerning the origin of the two females and to the known difficulties in specific identification of female Pseudothelphusidae, these two specimens should be excluded from the type-material, as Pretzmann originally did (1965), and the range of the species restricted to the localities around Villavicencio. The locality "Bogotá" for the type-specimen rests only on Schmitt's (1969) statement.

### *Neostrengeria lasallei* Rodríguez, 1980

*Material.*—Finca Los Duraznos, Municipio Sutatenza, Vereda Boquerón, Departamento Boyacá, 1930 m; 22 Jul 1984: 8 males, 2 females (ICN-MHN No. CR 0593).

The present locality is 30 km SW of the type-locality, and within the same Guavio river basin.

### *Neostrengeria lindigiana* (Rathbun, 1897)

*Material.*—Municipio Bojacá, Vereda Chantilly, Departamento Cundinamarca; 6 Jun 1984: 8 males, 6 females (ICN-MHN No. CR 05787).

There are two other well established records of this species in the literature (Rodríguez 1982): Facatativa, like the present one from Bojacá, is in the Bogotá River basin, but the other, Choachí, is in the Negro-Guayuriba-Meta rivers basin.

### *Neostrengeria macropa* (H. Milne Edwards, 1853)

*Material.*—Municipio Chocontá, Vereda Saucío, Departamento Cundinamarca, 2575 m; 3 Jun 1984: 2 males, 3 females (ICN-MHN No. CR 0580).—Municipio Chocontá, Vereda Chinatá, Departamento Cundinamarca, 2250 m; 3 Jun 1984: 2 males, 1 female (ICN-MHN No. CR 0581).—Municipio Suesca, Río Funza-Bogotá, Departamento Cundinamarca, 2500 m; 3 Jun 1984: 3 males, 3 females (ICN-MHN No. 0582).—Municipio Gachancipá, Vereda El Roble, Quebrada Gachiná, Departamento Cundinamarca, 2550 m; 3 Jun 1984: 5 females (ICN-MHN No. 0584).—Municipio Tausa, Embalse del Neusa, Departamento Cundinamarca, 2900 m; 3 Jun 1984: 3 males (ICN-MHN No. CR 0585).—Municipio Sopó, Departamento Cundinamarca, 2650 m; 3 Jun 1984: 2 males, 2 females (ICN-MHN No. CR 0586).—Embalse del Sisga, Departamento Cundinamarca, 2200 m; 7 Aug 1984: 3 males, 2 females (ICN-MHN No. CR 0595).—Municipio Tabio, Finca Tejas Verdes, Departamento Cundinamarca, 2570 m; Aug 1984: 1 male, 2 females (ICN-MHN CR No. 0596).

### *Neostrengeria monterrodendoensis* (Bott, 1967)

*Material.*—Corregimiento Monterredondo, Municipio Quetame, Departamento Cundinamarca, 1350 m; 21 Mar 1984: 6 males, cb. 17.4, 20.1, 20.2, 21.2, 21.5, 24.3 mm, cl. 10.7, 12.3, 12.4, 12.7, 13.0, 14.1 mm, respectively, 3 females, cb. 20.9, 21.6, 22.2 mm, cl. 12.7, 13.2, 13.7 mm respectively (ICN-MHN No. CR 0549).—Municipio Guayabetal, Vereda El Naranjal, Departamento Cundinamarca, 1350 m; 27 Mar 1984: 6 males, 5 females (ICN-MHN No. CR 0560).

The type-locality given by Bott (1967) is "Monterrodendo," Colombia, which Rodríguez (1982) listed as an unidentifiable locality. The present records may help to fix the type-locality near Quetame, 30 km NW of Villavicencio, in the Río Negro Valley.

### *Neostrengeria niceforoi* (Schmitt, 1969)
Fig. 2a–d

*Material.*—Cueva del Páramo, San Gil, Departamento Santander, 1450 m; Jun 1984; B. Sket: 1 male, cb. 32.8, cl. 19.3 mm (UL).—Quebrada La India, Simacota, Departamento Santander, 1050 m; 16 Jul 1969; P. Cala: 9 males, cb. 17.5–32.5, cl. 10.6–18.0 mm, 6 females, cb. 15.0–35.9, cl. 9.5–20.5 mm (ICN-MHN No. CR 025).—Simacota, Departamento Santander, 1000 m; 15 Mar 1973: 1 male, cb. 30.5 mm, cl. 16.9 mm (ICN-MHN No. CR 063).—Municipio Charalá, Corregimiento Virolín, Río Luisito, Departamento Santander, 1750 m; 2 May 1983; G. Galvis: 1 male, cb. 30.5, cl. 17.0 mm, 3 females, cb. 27.3, 28.7 and 30.5, cl. 16.3, 17.1 and 18.2 mm (ICN-MHN No. CR 0482).

The species was previously known from a single male specimen from San Gil, 75 km south of Bucaramanga. Although in general the carapace, third maxilliped, and gonopod of our material correspond with the original description, the specimens available are not morphologically homogeneous. Schmitt (1969) omitted several characters in his description of the species. We give them below, together with the variability observed in well developed male specimens from different localities.

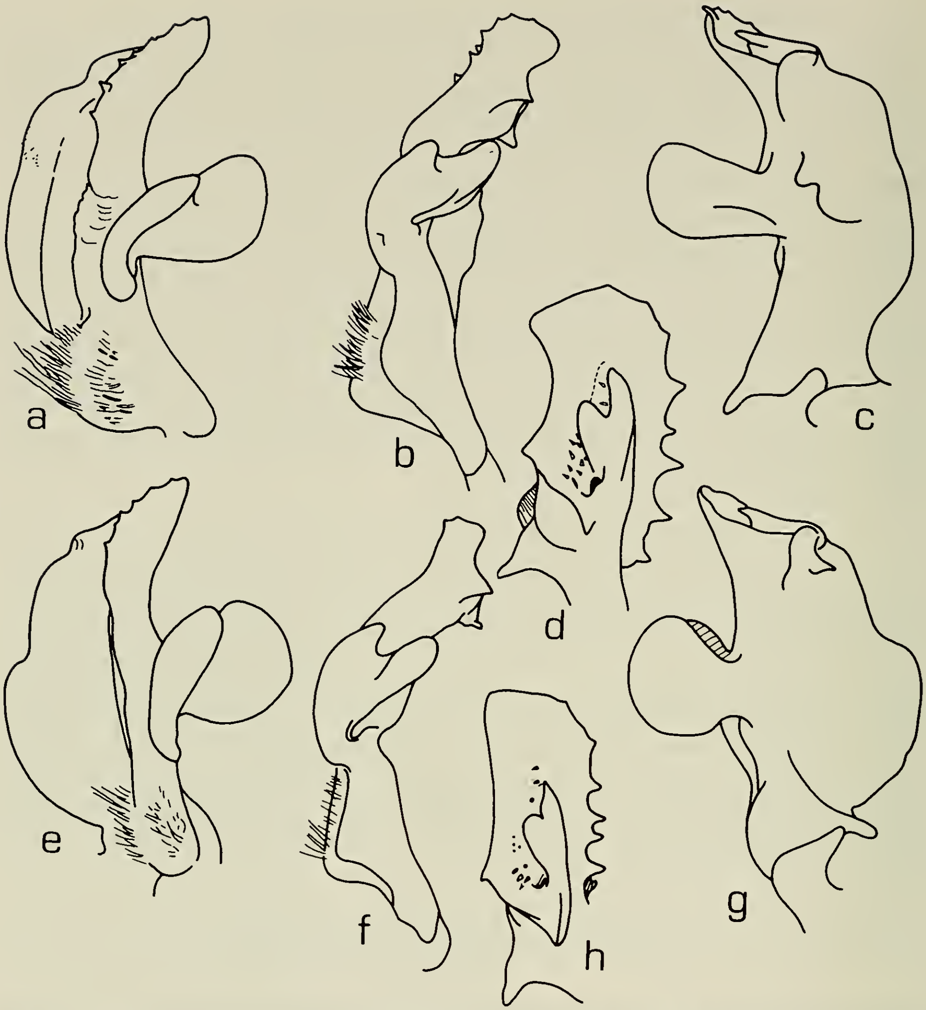

Fig. 2. *Neostrengeria niceforoi* (Schmitt, 1969), left gonopod, a, b, c, d, specimens from Simacota (ICN-063); e, f, g, h, specimens from Charalá (ICN-0482): a, e, Caudal view; b, f, Lateral view; c, g, Mesial view; d, h, Apex in distal view.

The cervical groove is wide, slightly bent backwards, shallow anteriorly and deeper proximally; it ends far from the lateral margin. The anterolateral border is smooth throughout (San Gil, 0492), crenulate (0025), or with small teeth towards the posterior border (0063). The postfrontal lobes are small, round, defined anteriorly by two transverse scars (San Gil). The median groove consists of a wide and shallow depression. The surface of the carapace behind the front is inclined anteriorly and towards the midline. The upper border of the front in dorsal view is convex (0025), or convex and more or less bilobed (San Gil, 0063, 0482); it is well marked, devoid of tubercles, or with inconspicuous tubercles (0025, 0063, 0482). The lower margin is strongly sinuous in frontal view; the margin of the front between the upper and lower borders is narrow, with the lower border more advanced than the upper.

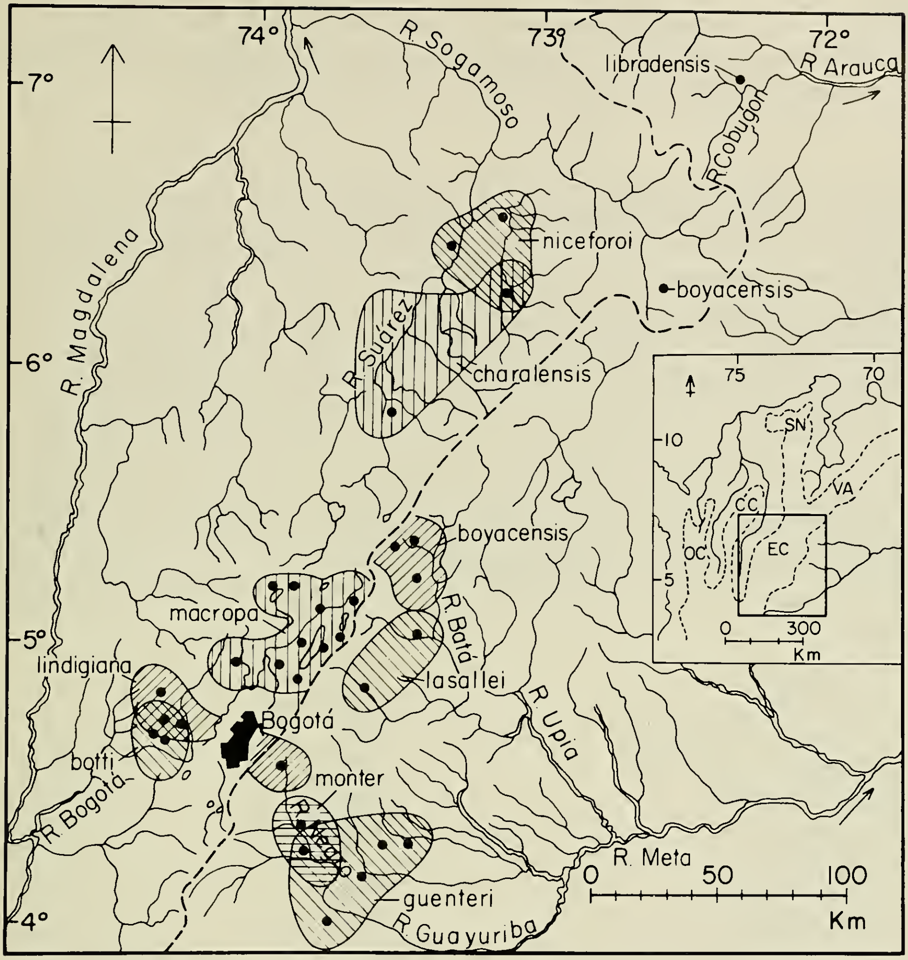

Fig. 3. Map of the Eastern Cordillera, Colombia, between Bogotá and the border with Venezuela, showing distribution of the species of *Neostrengeria.* The Orinoco and Magdalena are separated by a broken line. OC, Occidental Cordillera; CC, Central Cordillera; EC, Eastern Cordillera; VA, Venezuelan Andes; SN, Sierra de Santa Marta, monter, monterrodendoensis.

The chelipeds show considerable variability. In the specimen from Simacota (0025, 0063) and San Gil the fingers are relatively short (0.44–0.46 the length of the larger chela) and stout; the dactylus of the larger chela has a group of three large teeth near the base, plus smaller teeth interspaced with even smaller ones in the distal half; the fixed finger has two larger teeth, separated by a smaller one, near the middle of the cutting surface, in addition to smaller teeth towards the base and towards the tip; when the fingers are closed there are gaps between them. In the specimen from Charalá (0482) the chelae are more elongated and the fingers longer (0.51 the length of the larger chela) and slender. The teeth are very small and leave considerable gaps between them when the fingers are closed, particularly at the base of the fingers. The merus of the third maxilliped has a low angle on the distal half of its external margin; the exognath is 0.41–0.48 the length the ischium. The apex of the gonopod has on its caudal border a row of spines which diminishes in size to become rudimentary laterally; they number 14 in the specimen from San Gil, and 7 in those from Simacota and Charalá.

## Distribution of the Species

With the addition of the new species described above, the genus *Neostrengeria* comprises 10 species, the distribution of which is shown in Fig. 3. We have indicated on the map as the possible minimum range of each species an area around each recorded locality not larger than 10 km in radius and at similar altitudes. The genus covers both watersheds of the Magdalena and Orinoco rivers in the Eastern Cordillera of Colombia. Three species are in the Sogamoso basin which drains into the Magdalena (*N. niceforoi, N. boyacensis,* and *N. charalensis*). Three species of the Bogotá area (*N. macropa, N. botti,* and *N. lindigiana*) are also on the Magdalena watershed, but at least one of them (*N. lindigiana*) appears to be astride the Orinoco and Magdalena watersheds. One species to the North (*N. libradensis*) and three to the South (*N. lasallei, N. guenteri* and *N. monterrodendoensis*) are in the Orinoco watershed.

All species come from altitudes between 700 and 2900 m above sea level, as follows:

| | |
|---|---|
| *N. guenteri* | 700–1500 |
| *N. niceforoi* | 1050–1750 |
| *N. monterrodendoensis* | 1350 |
| *N. botti* | 1500–1700 |
| *N. charalensis* | 1700 |
| *N. lasallei* | 1930 |
| *N. macropa* | 2200–2900 |
| *N. lindigiana* | 2300 |
| *N. boyacensis* | 2525–2625 |

The vertical range of *N. libradensis,* the only species not dealt with in the present contribution, is unknown.

## Acknowledgments

We are indebted to Dr. Raymond B. Manning for information concerning the type-material of *Neostrengeria guenteri* deposited at the U.S. National Museum, and to Dr. B. Sket for allowing us to examine the freshwater crabs collected by him in Colombian caves. This research was supported in part by a Colciencias grant to M. R. Campos, Number 10 000-1-138-82, and was part of her thesis for the M.Sc. degree.

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# THREE NEW SPECIES OF STYLASTERIDAE (COELENTERATA: HYDROZOA)

Stephen D. Cairns

*Abstract.*—Three new species of stylasterid corals are described: a *Crypthelia* from the western Indian Ocean and two closely related species of *Lepidopora* from off New Zealand. Each of the three species has some unique character states which require a broadening of their respective generic diagnoses.

Stylasterid corals occur in all ocean basins from continental Antarctica to the Arctic Circle at depths between 0–2800 m; however, most of the approximately 200 species in the family (Cairns 1983b) occur at depths of 200–700 m. Because this environment is infrequently sampled, it is assumed that many of the stylasterid species remain to be collected and described. Based on recent faunistic revisions (Cairns 1983a; in press a, b), approximately half of the stylasterid species collected from deep water were undescribed. Every new collection thus affords an opportunity to describe and study new and often fascinating adaptations to the common requirements of life, such as defense and food getting. The description of new species, combined with new or previously unused methods of study (e.g., scanning electron microscopy, phylogenetic analysis, histological analysis, critical-point drying of decalcified tissue), are providing a greater understanding of stylasterid functional morphology as well as improving generic diagnoses and our knowledge of generic interrelationships.

The three new species described herein are of interest because they all require a modification of their respective generic diagnoses, which, in turn, should contribute in a small way to a subsequent evolutionary analysis of the family. The new species are members of the least derived genus, *Lepidopora,* and one of the most derived, *Crypthelia* (sensu Cairns 1984), and have several unique character states never before described for the stylasterids.

Station Data

| Station number | Latitude, south | Longitude, east | Depth, meters | Date |
|---|---|---|---|---|
| Anton Bruun 8-420A | 2°42′ | 40°53′ | 140 | 6 Nov 1964 |
| NZOI E305 | 34°10′ | 171°55′ | 282 | 9 Apr 1965 |
| NZOI P458 | 34°13.8′ | 171°56.4′ | 200 | Jun 1978 |
| NZOI P544 | 34°09.9′ | 171°49.5′ | 290 | Jun 1978 |
| NZOI P559 | 33°59.8′ | 171°41.6′ | 197 | Jun 1978 |
| NZOI P561 | 33°58.0′ | 171°28.0′ | 506 | Jun 1978 |
| NZOI P566 | 33°56.1′ | 171°27.2′ | 514 | Jun 1978 |

## *Lepidopora* Pourtalès, 1871

*Diagnosis.*—Coordination of gastro- and dactylopores usually lacking; however, in several species dactylopores are linearly arranged on branches in two or more longitudinal rows. Coenosteal texture variable, including reticulate-granular, linear-granular, linear-imbricate, and tufted. Abcauline gastropore lip present in some species. Gastro- and dactylopore tubes long. Gastrostyles unridged, with a moderately high H:W ratio and with robust, simple spination. Dactylopores apically perforate cones or flush with coenosteum, sometimes linked by ridges; dactylostyles lacking. Ampullae usually superficial. Type-species: *Errina glabra* Pourtalès, 1867, by subsequent designation (Boschma 1963:336).

*Discussion.*—*Lepidopora* is the least derived (Cairns 1984) and most variable (Cairns 1983b) of the stylasterid genera. Almost every character in the generic diagnosis has a broad range of variation, and the species now assigned to the genus are undoubtedly a polyphyletic assemblage. Three characters, none of them unique to *Lepidopora,* help to distinguish the genus: apically perforate dactylopore mounds, unridged gastrostyles, and long dactylopore tubes. No other genus has this combination of characters.

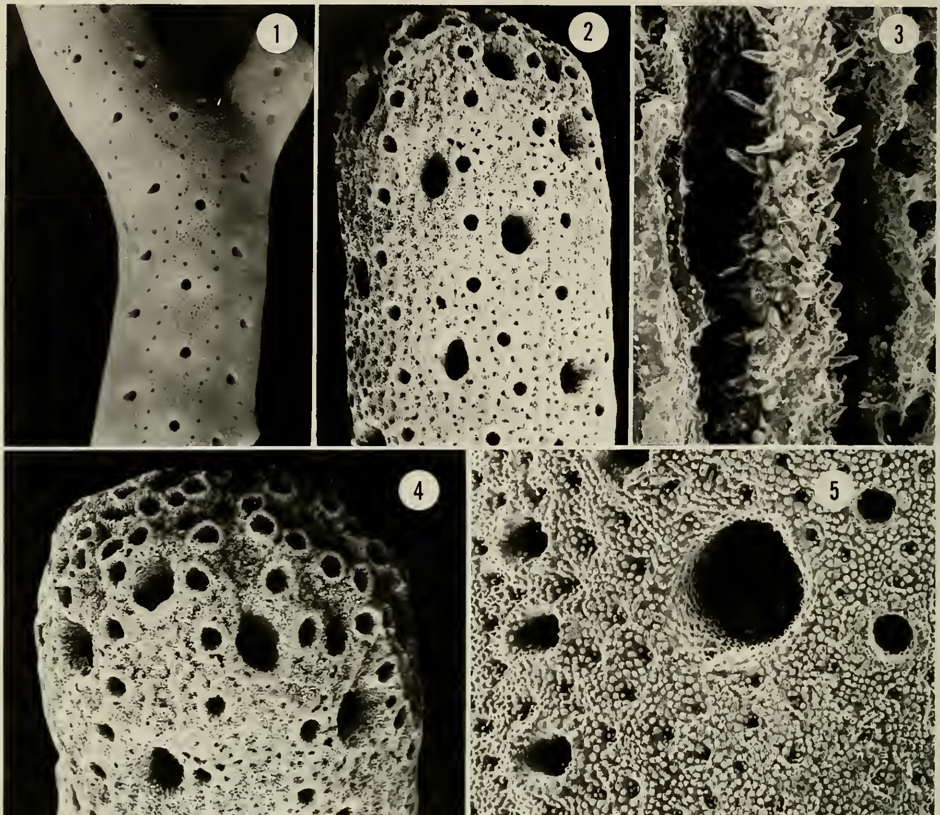
The two new species of *Lepidopora* described herein also serve to broaden the generic definition. They both have internal ampullae, which heretofore had not been reported in *Lepidopora,* and they both have multiple longitudinal rows of dactylopores, a level of coordination not achieved by any of the other species in the genus.

### *Lepidopora cryptocymas,* new species
Figs. 1–11

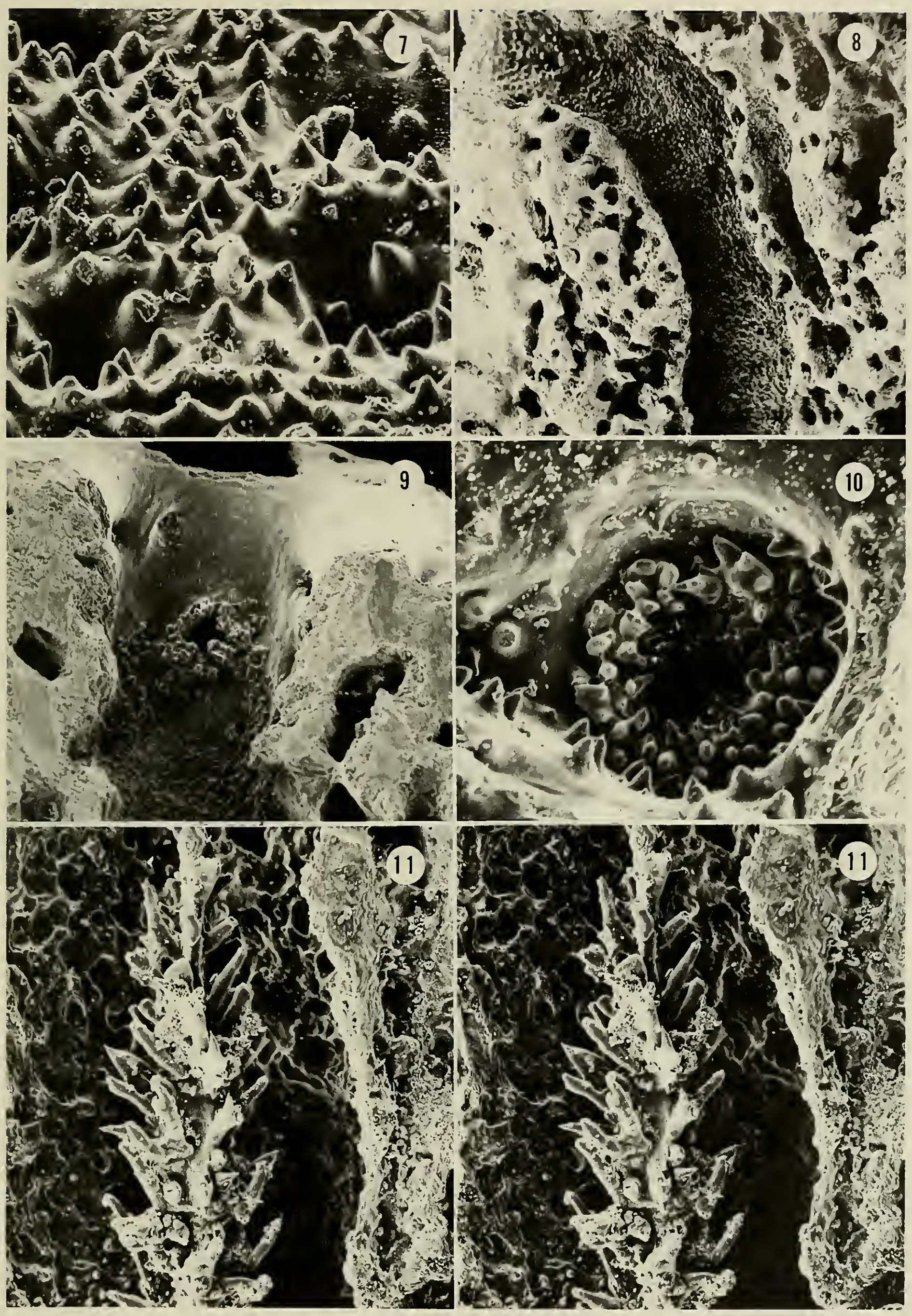
*Description.*—Colonies uniplanar, the largest colony fragment (holotype) 27.6 mm tall and 5.3 mm in basal branch diameter. All branches cylindrical, distal branches about 3.0 mm in diameter. Branch axils U-shaped. Coenosteum white or yellowish brown, composed of longitudinal strips 0.11–0.14 mm wide, which are delimited by round to elongate coenosteal pores about 50 μm in diameter. Strips and inner surfaces of coenosteal pores covered with broad, smooth, pointed spines 15–21 μm tall and about 17 μm in basal diameter.

Dactylopores aligned in straight to slightly meandering longitudinal rows, 6 to 8 rows around the circumference of a larger branch. Dactylopore rows delimit longitudinal bands of coenosteum, each band composed of 6 to 9 coenosteal strips. Gastropores aligned midway on coenosteal band defined by dactylopores, their centers 1.2–1.5 mm apart. Gastropores round to slightly elliptical, 0.35–0.40 mm in diameter, their tubes curving downward and running parallel to branch axis. Ring palisade and tabulae absent. Gastrostyles elongate and unridged. Styles about 0.10 mm in diameter and of indeterminate length (because the gastrostyles are so brittle none was exposed intact); however, H:W ratio estimated to be about 10. Styles covered by long, pointed, cylindrical spines up to 61 μm long and about 15 μm in diameter. Dactylopores round, about 0.12 mm in diameter, and flush with coenosteal surface, not elevated or linked by ridges. Dactylopores 0.2–0.6 mm apart.

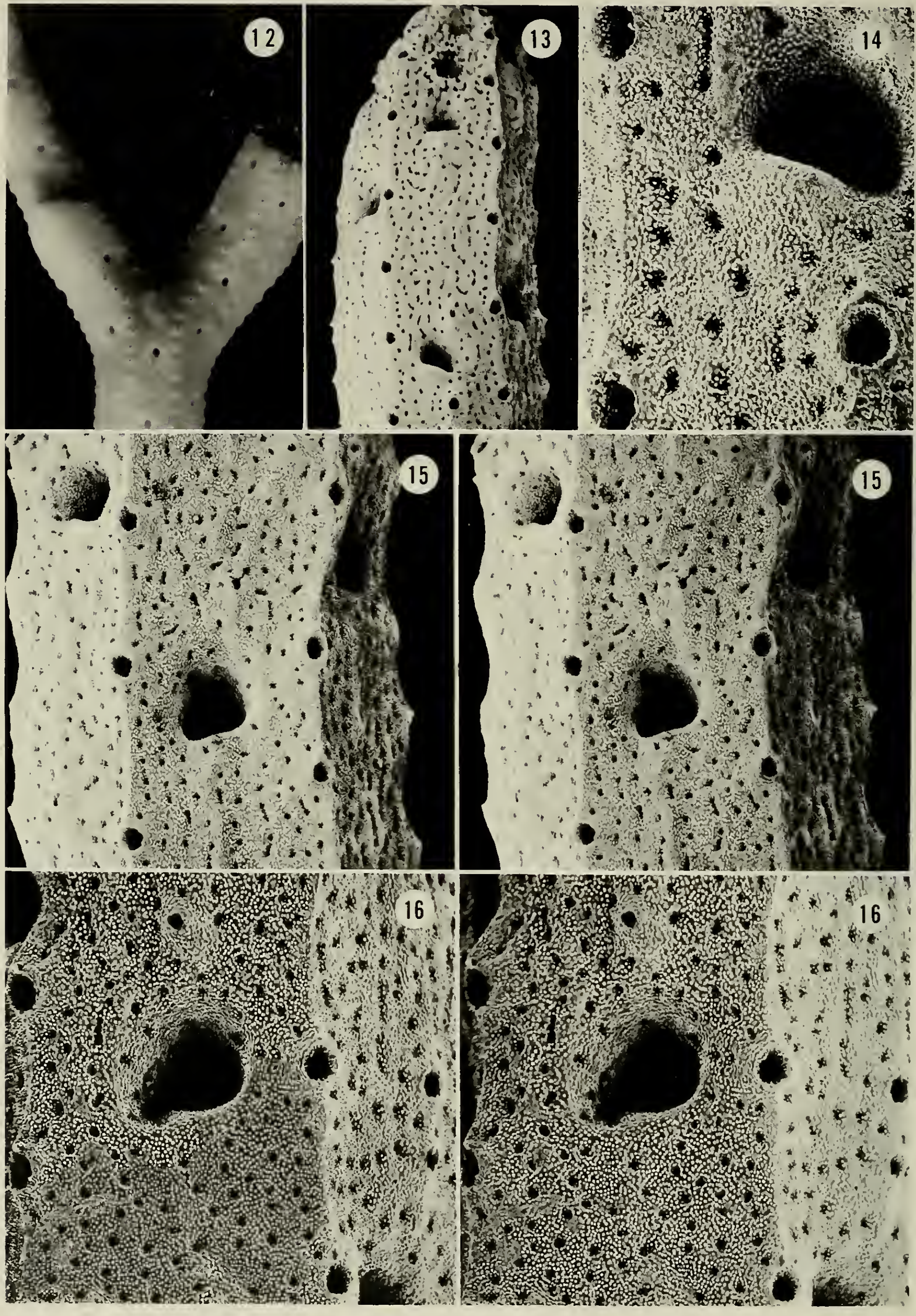
Female ampullae internal and ellipsoidal in shape, about 1.00 × 0.60 mm in diameter. Each female ampulla located just distal to a gastropore, opening into gastropore tube via slender efferent canal and pore, which penetrates upper distal wall of gastropore tube (Fig. 9). Mature efferent pore about 0.15 mm in diameter. Male ampullae also internal, spherical, and about 0.5–0.6 mm in diameter. Male



Figs. 1–6. *Lepidopora cryptocymas.* (1, Holotype; 2, 4, 6, paratype of unknown sex from NZOI P458; 3, 5, male paratype from NZOI E305): 1, Holotype colony, ×4.0; 2, 4, 6, Branch segments showing alignment of dactylopores, ×15, ×21, ×23, respectively (Fig. 6 is a stereo pair); 3, Segment of gastrostyle, ×105; 5, Portion of coenosteum including four types of pores: one large gastropore, seven smaller dactylopores, numerous small coenosteal pores, and one recessed male efferent pore (lower center), ×45.



Figs. 7–11. *Lepidopora cryptocymas.* (7–8, 10, male paratype from NZOI E305; 9, female paratype from NZOI P559; 11, paratype of unknown sex from NZOI P458): 7, Coenosteal granules, × 295; 8, Longitudinal section of curving gastropore tube (branch surface to left), ×42; 9, Aperture of female efferent pore opening into upper gastropore tube, ×97; 10, Male efferent pore, ×265; 11, Gastrostyle, ×210, stereo pair.



Figs. 12–16. *Lepidopora polystichopora*. (12, Holotype; 13–16, male paratype from NZOI E305): 12, Holotype colony, ×3.6; 13, Branch tip, ×14; 14, Detail of coenosteum showing three dactylopores, and one larger gastropore with a small abcauline lip, ×63; 15–16, Distal branch coenosteum showing alignment and linkage of dactylopores, in both cases an elevated male efferent pore is present just above the central gastropore, ×25, ×39, respectively (both are stereo pairs).

efferent pores 40–50 μm in diameter, opening into shallow coenosteal depression about 0.12 mm in diameter and 40 μm deep, located directly above ampulla.

*Discussion.*—*Lepidopora cryptocymas* is distinguished from the other eight species (Cairns 1983b) in the genus by its multiple, continuous, linearly arranged rows of dactylopores; its internal ampullae; and its very low, virtually flush, dactylopores. *Lepidopora glabra* (Pourtalès, 1867) has linearly arranged dactylopores, but they occur only on the lateral branch edges; in addition, there are many more differences between the two species regarding coenosteal texture and presence of ring palisades and gastropore lips (Cairns 1983b). *Lepidopora acrolophos* (Cairns 1983a), known only from off South Georgia, also has linearly arranged dactylopores; however, its dactylopore rows are short, and they often bifurcate and rejoin. Furthermore, *L. acrolophos* has superficial ampullae, a bushy corallum, and a very different coenosteal texture. Comparisons to the closely related *L. polystichopora* are made in the discussion of that species.

*Etymology.*—The specific name *cryptocymas* (Greek *cryptos* for "concealed" or "hidden" + *cymas* for "pregnant woman") refers to the internal female ampullae, whose efferent pores are even hidden from view within the gastropore tube.

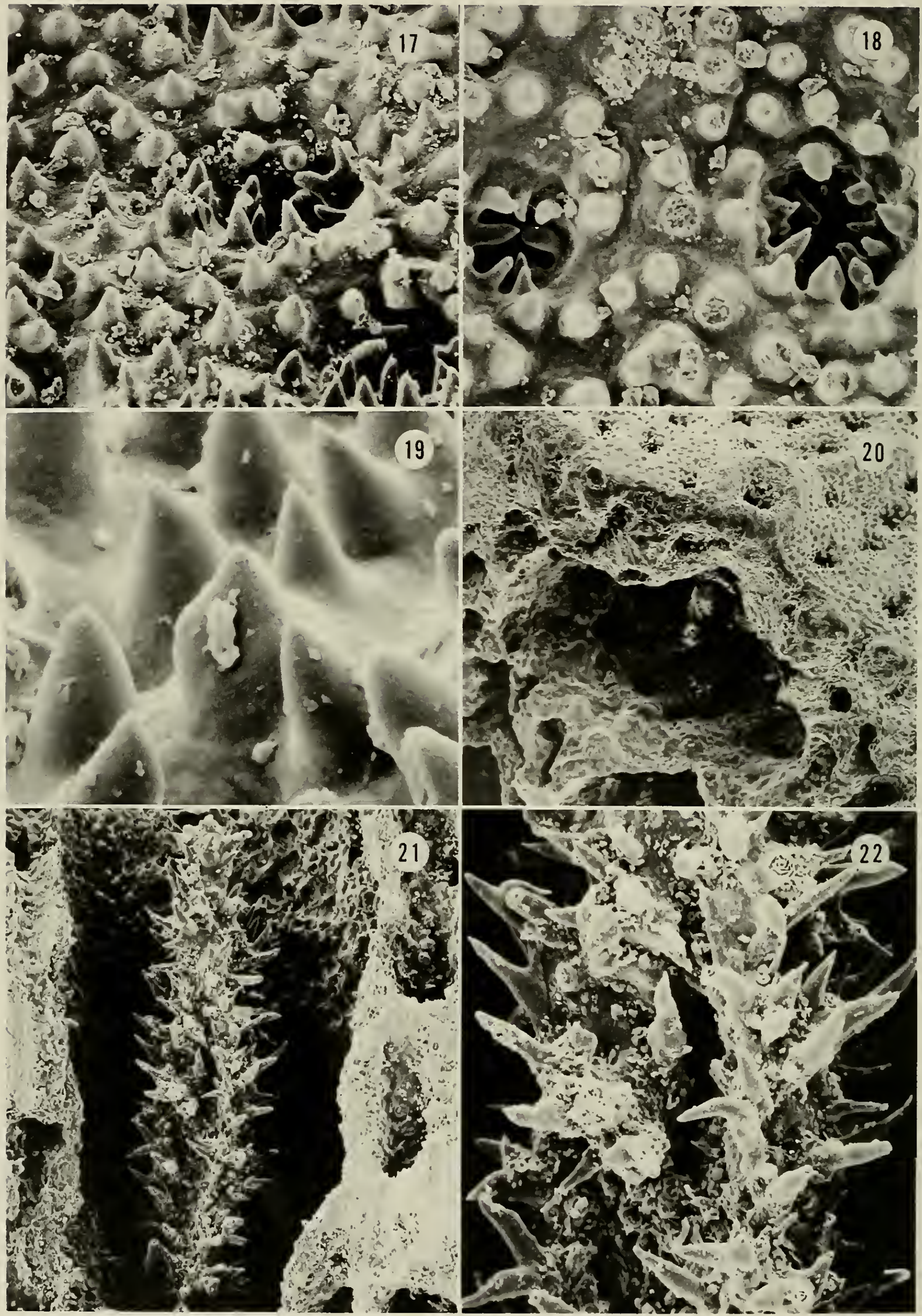
*Types.*—Holotype: NZOI E305, male, NZOI.—Paratypes: NZOI E305 (1 male, 1 sex indeterminate branches) USNM 72342, (2 male, 1 female, 3 sex indeterminate branches) NZOI; NZOI P458 (1 female, 1 sex indeterminate branches) USNM 72343, (3 female, 14 sex indeterminate branches) NZOI; NZOI P544 (1 branch, sex indeterminate) NZOI; NZOI P559 (1 female, 1 male branches) USNM 72345, (5 female, 1 male, 4 sex indeterminate branches) NZOI; NZOI P561 (1 female, 1 sex indeterminate branches) USNM 72346, (3 female, 13 sex indeterminate branches) NZOI. Type-Locality: 34°10′S, 171°55′E (west of Three Kings Island, New Zealand), 282 m.

*Distribution.*—Known only from west of Three Kings Island, New Zealand; 197–506 m.

### *Lepidopora polystichopora*, new species
Figs. 12–22

*Description.*—Colonies uniplanar, largest colony fragment (holotype) 20.5 mm tall and 4.0 mm in basal branch diameter. Distal branches strongly flattened, e.g., 2.9 × 1.8 mm, but larger diameter branches rounded. Branch axils U-shaped. Branch cross section consisting of larger diameter gastropore tubes surrounding central bundle of smaller diameter dactylopore tubes, both types of pores quite elongate. Coenosteum white, composed of longitudinal strips 0.10–0.12 mm wide, which are delimited by round to slightly elongate coenosteal pores 35–40 μm in diameter. Strips and inner surfaces of coenosteal pores (Fig. 18) and inner surfaces of dactylopores densely covered with robust, smooth, sharp spines 10–13 μm tall and about 7 μm in basal diameter.

Dactylopores arranged in straight longitudinal rows, 6 or 7 rows around circumference of branch, which delimit longitudinal bands of coenosteum, each band composed of 6 to 9 coenosteal strips. Gastropores aligned midway on coenosteal bands defined by dactylopores, their centers 1.2–2.0 mm apart. Gastropores round to elliptical, 0.32–0.38 mm in diameter, some with very slight abcauline lip (Fig. 14), which alters shape of gastropore. Ring palisade and tabulae absent. Gastrostyles elongate and unridged. Styles about 0.085 mm in diameter and of indeter-



Figs. 17–22. *Lepidopora polystichopora,* male paratype from NZOI E305: 17, 19, Coenosteal granules, ×530, ×1875, respectively; 18, Two coenosteal pores, ×555; 20, Cross section of male ampulla with intact efferent pore, ×90; 21–22, Gastrostyle, ×155, ×465, respectively.

minate length; however, H:W ratios estimated to be about 10. Styles covered by elongate, tapered spines up to 36 μm long and about 6 μm in diameter at mid-height. Dactylopores round, 0.08–0.10 mm in diameter, and elevated about 0.12 mm. On distal branches, low ridges unite dactylopores, these ridges absent on larger diameter branches. Low ridges of same size sometimes also link gastropores. Dactylopores spaced about 0.40 mm apart.

Only one type of ampulla was noted: by analogy to the previously described species and based on the diameter of the efferent pores, presumably a male. Ampullae internal, 0.45–0.50 mm in diameter, communicating to surface by narrow efferent pore about 50 μm in diameter, pore elevated on small mound about 0.16 mm in diameter and 0.07 mm tall. Efferent pores located about midway between dactylopore rows, sometimes up to three between adjacent gastropores.

*Discussion.*—*Lepidopora polystichopora* and *L. cryptocymas* are known from the same localities and are so similar that they are hypothesized to be sister species. Points of similarity include: colony shape, coenosteal texture, unique coordination of gastro- and dactylopores, and internal ampullae. They differ, however, in at least five ways. *Lepidopora polystichopora* has: 1) strongly flattened distal branches, not round in cross section, 2) small abcauline lips on some of the gastropores, 3) prominent dactylopores linked by ridges, producing a polygonal cross section of distal branches, not flush dactylopores as in *L. cryptocymas,* 4) shorter, more attenuate gastrostyle spines, and 5) male efferent pores elevated above the coenosteal surface, not ending in concavities as in *L. cryptocymas.*

*Etymology.*—The specific name *polystichopora* (Greek *polys* for "many" + *stichos* for "row" + *poros* for "pore") refers to the multiple longitudinal rows of dactylopores.

*Types.*—Holotype: NZOI E305, male, NZOI.—Paratypes NZOI E305 (1 male fragment) USNM 72348, (1 male) NZOI; NZOI P458 (1 male branch) NZOI; NZOI P559 (1 branch, sex indeterminate) NZOI; NZOI P561 (1 branch, sex indeterminate) NZOI; NZOI P566 (1 branch, sex indeterminate) USNM 72352, (1 branch, sex indeterminate) NZOI. Type-Locality: 34°10′S, 171°55′E (west of Three Kings Island, New Zealand), 282 m.

*Distribution.*—Known only from west of Three Kings Island, New Zealand; 197–514 m.

### *Crypthelia* Milne Edwards and Haime, 1849

*Diagnosis.*—Gastro- and dactylopores arranged in cyclosystems, which occur exclusively on anterior branch faces. Cyclosystems of at least one sex covered partially or entirely by one or more fixed lids. Coenosteum linear-imbricate and often spinose. Nematopores common, especially on cyclosystem lids, pseudosepta, and ampullae. Gastropore double chambered; gastro- and dactylostyles absent. Ampullae usually superficial and large, occurring in variety of positions and with variety of efferent pore locations. Female ampullae usually occur singly on cyclosystem lid and proximal cyclosystem wall; male ampullae usually clustered, often in a compartmentalized ring around cyclosystem or in cyclosystem lid and proximal cyclosystem wall. Type-species: *Crypthelia pudica* Milne Edwards and Haime, 1849, by monotypy.

*Discussion.*—The description of *C. micropoma* requires a broadening of the generic diagnosis to include species that are sexually dimorphic with regard to lid development, allowing one sex, the male, to be lacking lids entirely. The very rudimentary lid of the female serves as a continuation of the proximally located ampulla, just as it functions in many other species of *Crypthelia.* On the other hand, in other species of *Crypthelia* the lid is well developed and flat, without an ampullar cavity. The function of these flat lids is presumed to be purely defensive. It is tempting to speculate that the lid first evolved as an extension of the female ampulla from the adjacent proximal cyclosystem wall, as it is in *C. micropoma,* and later developed into a broader canopy, which often supports the female ampulla as well as serving as a defensive barrier to predators.

In most species of *Crypthelia* there is a large cylindrical cavity about 0.1 mm in diameter running along the branch axis (Fig. 28). This structure appears to be unique to the genus *Crypthelia* and is herein termed the central canal.

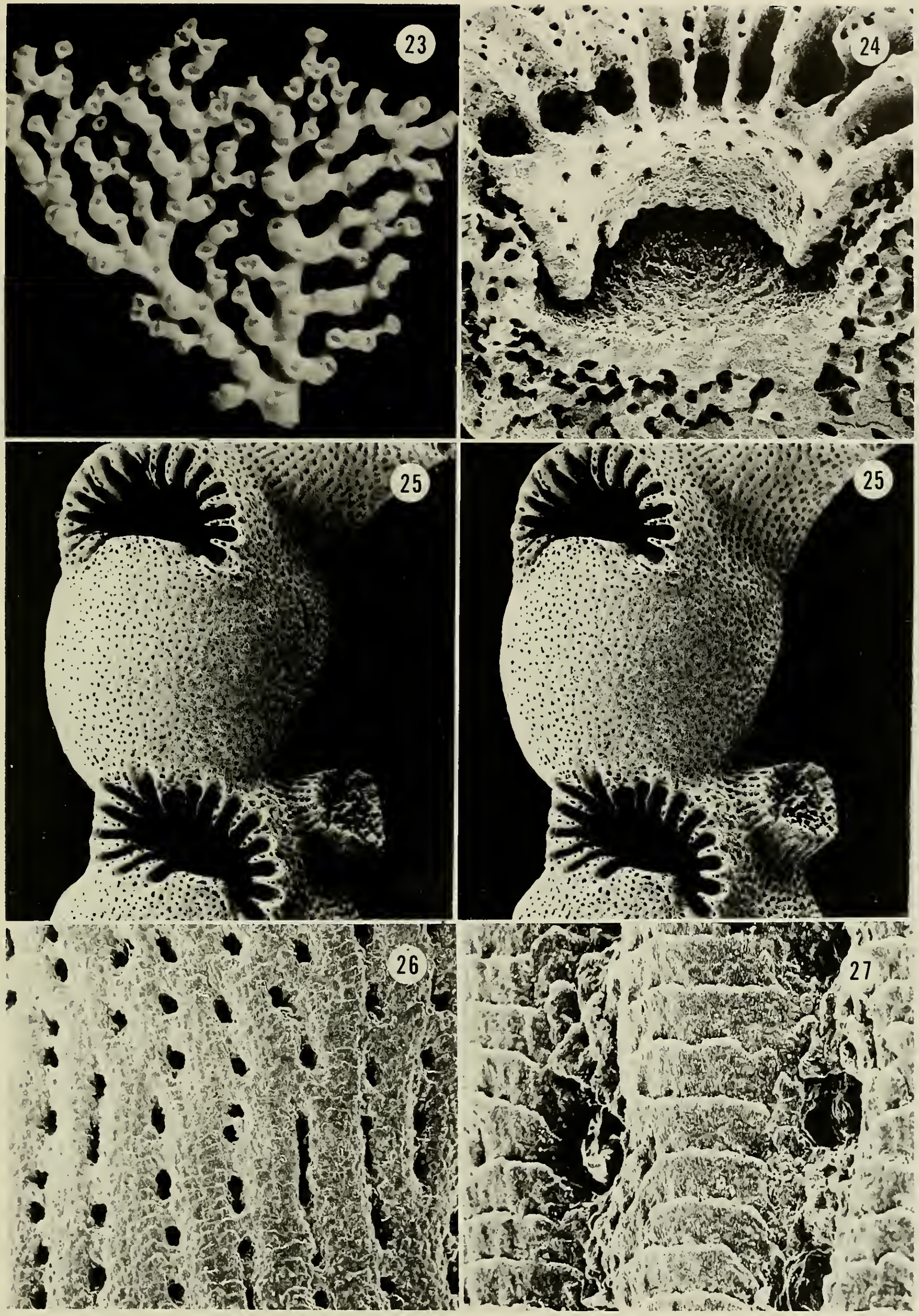
### *Crypthelia micropoma,* new species
Figs. 23–31

*Description.* —Largest colony (holotype) 36.2 mm tall and 38.8 mm broad, with a basal branch diameter of 3.1 mm. Branches moderately anastomotic. Central canal about 0.1 mm in diameter. Coenosteum composed of linear-imbricate strips 50–90 $\mu$m broad bordered by thin discontinuous slits about 9 $\mu$m wide. Platelets broad (each extending across width of strip), slightly convex, and longitudinally ridged; not spinose. Nematopores absent.

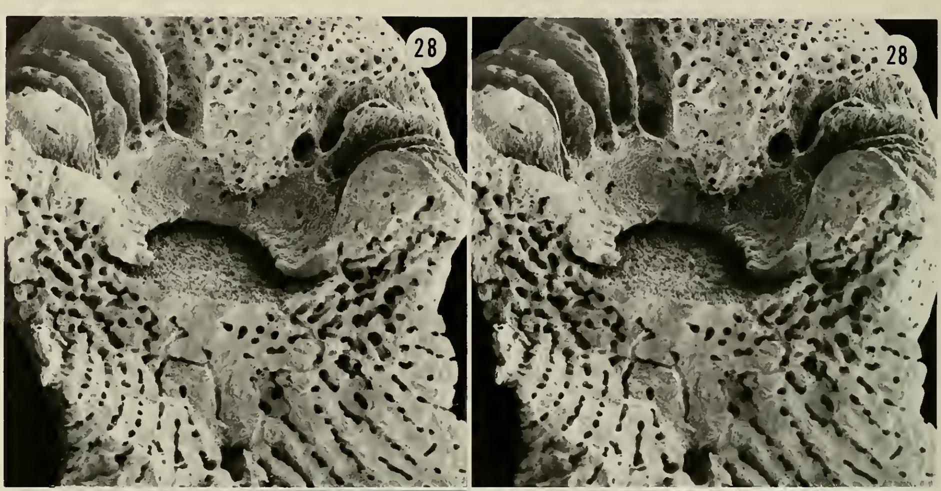
Cyclosystems elliptical to irregular in outline, a typical cyclosystem 1.7 × 1.2 mm in diameter. There is sexual dimorphism regarding number of dactylopores per cyclosystem. Based on 25 female cyclosystems, there was a range of 14–21 dactylopores per cyclosystem, average = 18.20 ($\sigma$ = 1.78), and mode = 19. Of 25 male cyclosystems, there was a range of 20–24 dactylopores per cyclosystem, average = 21.00 ($\sigma$ = 1.15), and mode of 20.

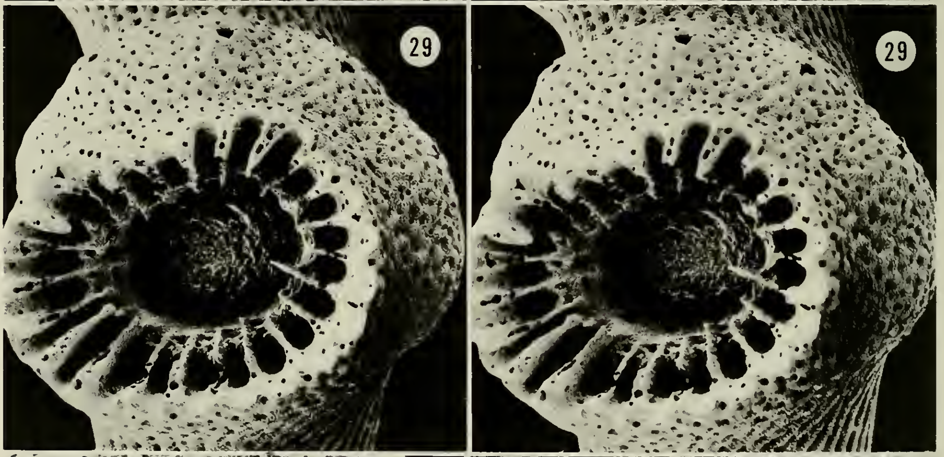
Upper gastropore chamber spherical, about 0.65 mm in diameter; aperture to lower chamber about 0.50 mm in diameter; lower chamber flat and broad, about 0.85 mm wide and 68 $\mu$m tall (Fig. 28). Floor of lower chamber spinose, spines up to 25 $\mu$m tall and 5 $\mu$m in diameter. Cyclosystem lid present only on female cyclosytems having large ampullae. These lids small, triangular to rectangular, covering only a small part of cyclosystem. Lids 2 to 5 pseudosepta in width, explaining why there are slightly fewer dactylopores per cyclosystem on female cyclosystems. Dactylopore slits 0.11–0.13 mm wide. Within each dactylopore is an amorphous skeletal secretion attached to all sides of the pore, which can be clearly seen in an undamaged cyclosystem. This structure is not considered to be a dactylostyle. Pseudosepta slender, 0.80–0.90 mm wide at outer edge, narrowing to about 45 $\mu$m width at inner edge. Upper pseudoseptal edges slightly concave and very porous.

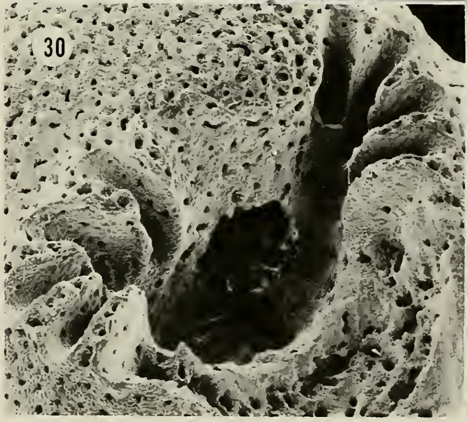
Female ampullae massive irregular spheres up to 2.2 mm in diameter located in proximal cyclosystem wall and branch coenosteum proximal to cyclosystem. Female efferent pores up to 0.33 mm in diameter, opening into upper gastropore chamber adjacent to lid (Fig. 30). Male ampullae about 0.60 mm in diameter, occurring unilinearly or slightly alternating in an incomplete ring surrounding a cyclosystem. Up to 12 ampullae may encircle a cyclosystem, the first ampullae occurring in the proximal cyclosystem wall region, with subsequent ampullae

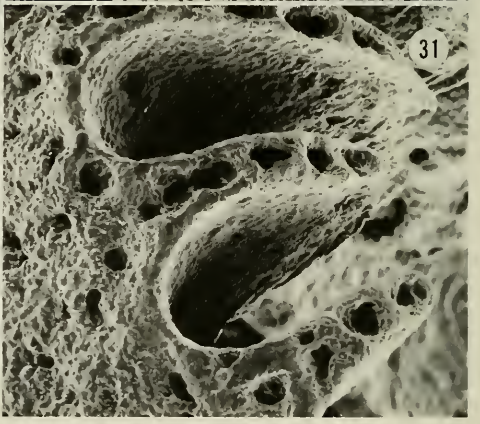


Figs. 23–27. *Crypthelia micropoma.* (23, Holotype; 24–27, female paratype from Anton Bruun 8-420A): 23, Holotype colony, ×1.65; 24, Longitudinal section of cyclosystem, ×45; 25, Female cyclosystems, ×17, stereo pair; 26–27, Imbricate coenosteum, ×97, ×375, respectively.









Figs. 28–31. *Crypthelia micropoma.* (28, 30–31, female paratype from Anton Bruun 8-420A; 29, male paratype from Anton Bruun 8-420A): 28, Longitudinal section of female cyclosystem showing spiny lower chamber and central canal (lower center), ×32, stereo pair; 29, Cyclosystem surrounded by male ampullae, ×29, stereo pair; 30, Damaged cyclosystem revealing female efferent pore just beneath rudimentary lid, ×39; 31, Porous pseudosepta, ×125.

occurring on either side leading toward the distal cyclosystem edge. Male efferent pores apical and flush with surface, about 60 μm in diameter.

Large nematocysts 17 × 3 μm occur individually in the coenosarc and in clusters in the pseudosepta, but not concentrated in nematophores. Dactylozooid nematocysts about 6.0 × 2.5 μm.

*Discussion.*—*Crypthelia micropoma* is distinguished from the other 15 known species in the genus (Cairns 1983b) by two unique features: 1) only mature female cyclosytems have lids, male cyclosystems do not have lids, and 2) the dactylopores contain a spongy deposit of calcium carbonate. Other characteristics of *C. micropoma* shared with only one or two other species in the genus are its lack of nematopores, and its porous upper pseudosepta, and spiny lower gastropore chamber.

Because of its very inconspicuous lids, *C. micropoma* is superficially similar to *Conopora,* a slightly less derived cyclosystemate genus having a double-chambered gastropore and lacking gastro- and dactylostyles (Cairns 1983a, 1984). However, it is clearly more derived than *Conopora* based on its: 1) unifacially arranged cyclosystems, 2) more highly integrated female ampullae (having one ampulla per cyclosystem and efferent pores opening into the upper gastropore chamber), and 3) cyclosystem lid, present on at least some of the female cyclosystems.

*Etymology.*—The specific name *micropoma* (Greek *micros* for "small" + *poma* for "lid") refers to the rudimentary cyclosystem lids of this species.

*Types.*—Holotype: Anton Bruun 8-420A, female, USNM 72353.—Paratypes: Anton Bruun 8-420A (1 female colony, 1 male colony) USNM 72354, (1 male branch) BM 1985.00.00.00. Type-locality: 2°42′S, 40°53′E (off Malindi, Kenya), 140 m.

*Distribution.*—Known only from the type-locality.

## Acknowledgments

I would like to thank Sandra L. Jordan (University of Waikato) for the loan of the specimens of *Lepidopora* from off New Zealand. I am grateful to Helmut Zibrowius for his careful reading of the manuscript. This paper is based on work supported by the National Science Foundation under Grant Number BSR-8217278.

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# NEW GENERA AND SPECIES OF DEEP-SEA MACELLICEPHALINAE AND HARMOTHOINAE (POLYCHAETA: POLYNOIDAE) FROM THE HYDROTHERMAL RIFT AREAS OFF THE GALAPAGOS AND WESTERN MEXICO AT 21°N AND FROM THE SANTA CATALINA CHANNEL

Marian H. Pettibone

*Abstract.*—*Levensteiniella kincaidi*, n. gen., n. sp. and *Macellicephala galapagensis*, n. sp., in the Macellicephalinae, and *Harmothoe macnabi*, n. sp., in the Harmothoinae, from the hydrothermal vent areas on the Galapagos Rift and off the East Pacific Rise at 21°N are described, as well as a deep-water pelagic macellicephalin, *Natopolynoe kensmithi*, n. gen., n. sp., from the Santa Catalina Channel. A summary of the polynoid polychaetes collected during *Alvin* dives by the Galapagos Rift Biology Expedition in 1979 and the OASIS Expedition to the East Pacific Rise in 1982 is included, along with a key to the species.

The present paper covers the remaining polynoid polychaetes collected in the hydrothermal vents of the Galapagos Rift and the East Pacific Rise at 21°N off Western Mexico, during dives of the DSRV *Alvin* by the Galapagos Rift Biology Expedition in 1979 and the OASIS Expedition in 1982. Included in this report are specimens referred to the subfamily Macellicephalinae, represented by a new genus and species from both vent areas, and a new species of *Macellicephala* from the Galapagos Rift, and to the Harmothoinae, a new species of *Harmothoe* from the Galapagos Rift. The specimens were sent to me by J. F. Grassle and I. Williams of the Woods Hole Oceanographic Institution. The major part of the collection has been dealt with previously in six papers (Pettibone 1983, 1984a, b, 1985b, c, d). A summary of the identifications on this material is given at the conclusion of this paper, including a key to the subfamilies, genera, and species.

Also included is the description of a new genus and species of Macellicephalinae, collected during a dive of the *Alvin* in 1979 in the Santa Catalina Channel by K. L. Smith using a slurp gun-respirometer. The specimen was sent to me by Susan Hamilton and K. L. Smith of Scripps Institution of Oceanography, along with some observations on the habitat of the species.

The types are deposited in the National Museum of Natural History, Smithsonian Institution (USNM).

## Subfamily Macellicephalinae Hartmann-Schröder, 1971, emended Pettibone, 1976

### *Levensteiniella*, new genus

*Type-species.*—*Levensteiniella kincaidi*, new species. Gender: feminine.

*Diagnosis.*—Body short, flattened, fusiform; segments up to 25 (first achaetous). Elytra and prominent elytrophores 11 pairs, on segments 2, 4, 5, 7, alternate segments to 21. Elytra delicate, without tubercles. Prostomium deeply bilobed, anterior lobes triangular, with frontal filaments; median antenna with small ceratophore in anterior notch and short style; paired palps moderately long; without lateral antennae and eyes. First or tentacular segment not visible dorsally; tentaculophores lateral to prostomium, achaetous, with 2 pairs of tentacular cirri. Segment 2 with buccal cirri longer than following ventral cirri, attached to basal part of parapodia lateral to mouth. Parapodia biramous, both rami well developed, conical, with projecting acicular processes; notopodia shorter than neuropodia. Notosetae very numerous, stouter than neurosetae, with spinous rows and blunt tips.

Neurosetae very numerous, spinous, with slightly hooked and tapered tips (not flattened). Dorsal cirri with bulbous cirrophores and moderately long styles; dorsal tubercles nodular. Ventral cirri short. With or without elongate ventral papillae on segments 11 and 12. Pygidium small, rectangular, with pair of anal cirri. Pharynx with 7 pairs of papillae (none enlarged) and 2 pairs of jaws (not denticled).

*Etymology.*—The genus is named for Raisa J. Levenstein, in recognition of her interesting studies on deep-sea polychaetes, including members of the Macellicephalinae.

*Remarks.*—*Levensteiniella* differs from the other genera of Macellicephalinae in having 11 pairs of elytra and up to 25 segments. Among the genera added to this subfamily, Levenstein (1982:1293–1294, figs. e–h) added *Bathynotalia perplexa* from the Tasman Sea, with 11 pairs of elytra and 21 segments (elytra with an unusual distribution: on segments 2, 4, 5, 7, alternate segments to 17, 18, and 20). On the figure of the prostomium (fig. e), she showed the presence of long lateral antennae inserted ventrally (not mentioned in the text). Thus it should be referred to Harmothoinae, rather than Macellicephalinae.

### *Levensteiniella kincaidi*, new species
Figs. 1–3

*Material examined.*—Pacific Ocean off Western Mexico, 20°50′N, 109°06′W, *Alvin* dives in 1982: Dive 1213, 19 Apr, 2617 m, scoop sample near black smokers, paratype (young, USNM 97455).—Dive 1214, 20 Apr, 2633 m, vestimentiferan wash, 13 paratypes (10 young, USNM 97456).—Dive 1215-5b, 21 Apr, 2616 m, slurp sample, 2 paratypes (young, USNM 97457).—Dive 1218-15, 24 Apr, 2618 m, clam and crab trap wash, 4 paratypes (3 young, USNM 97458).—Dive 1219, 25 Apr, 2612 m, 10A & B, *Riftia* and clam wash, coarse and fine fractions, 1A & B, slurp samples in *Riftia* habitat, 10 paratypes (9 young, USNM 97459).—Dive 1221-15, 4 May, 2618 m, *Riftia* and *Calyptogena* wash, coarse and fine fractions, holotype (USNM 97452), 4 paratypes (USNM 97453) and 72 paratypes (65 young, USNM 97454).—Dive 1222-5b, 6 May, 2614 m, rubble sample from *Calyptogena* residue, 12 paratypes (young, USNM 97460).—Dive 1223-11, -17, 7 May, 2616 m, rubble, 13 paratypes (11 young, USNM 97461).—Dive 1226-7, 10 May, 2616 m, *Riftia, Calyptogena* and *Alvinella* wash, 2 paratypes (young, USNM 97462).—Dive 1227, box core 2, 11 May, 2616 m, very loose black sediment, paratype (young USNM 97463).

East central Pacific, from dives of the *Alvin* on 3 vent areas along the Galapagos Rift in 1979: MUSSEL BED, 00°47′53″N, 86°09′12″W: Dive 880, 21 Jan, 2493

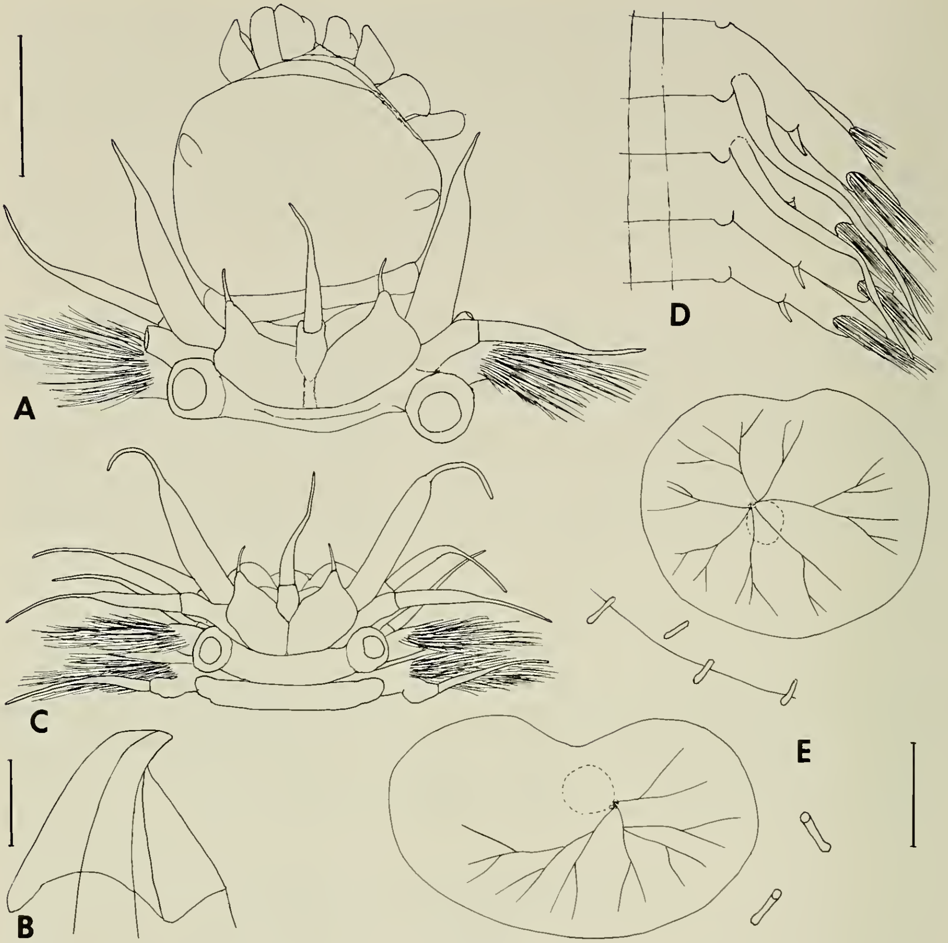

Fig. 1. *Levensteiniella kincaidi,* A, B, Holotype, USNM 97452; C, D, Paratype, USNM 97453; E, Paratype, USNM 97454: A, Dorsal view of anterior end, with pharynx fully extended; B, Isolated jaw; C, Dorsal view of anterior end; D, Ventral view of right side of segments 11 to 14, showing elongate ventral papillae on segments 11 and 12; E, Left first and right middle elytra, with detail of micropapillae. Scales = 1.0 mm for A, C, D; 0.2 mm for B; 0.5 mm for E.

m, mussel washings, 9 paratypes (8 young, USNM 97464).—ROSE GARDEN, 00°48′15″N, 86°13′28″W: Dive 894, 19 Feb, 2457 m, amphipod trap, 9 paratypes (young, USNM 80640-1).—Dive 983-113, 30 Nov, 2457 m, washings, 3 paratypes (young, USNM 97467).—Dive 984-32, 1 Dec, 2451 m, 5 paratypes (4 young, USNM 97468).—GARDEN OF EDEN, 00°47′41″N, 86°07′44″W: Dive 883, 25 Jan, 2493 m, slurp sample in mussel area, 6 paratypes (young, USNM 97465).—Dive 884, 25 Jan, 2482 m, clam bucket with mussels, 3 paratypes (young, USNM 97466).

*Description.*—Length of holotype 12 mm, width 5 mm with setae, segments 25, last one small. For additional adults with more than 21 segments and full number of 11 pairs of elytra, lengths 5 to 11 mm, widths 4 to 6 mm, segments 22 to 24.

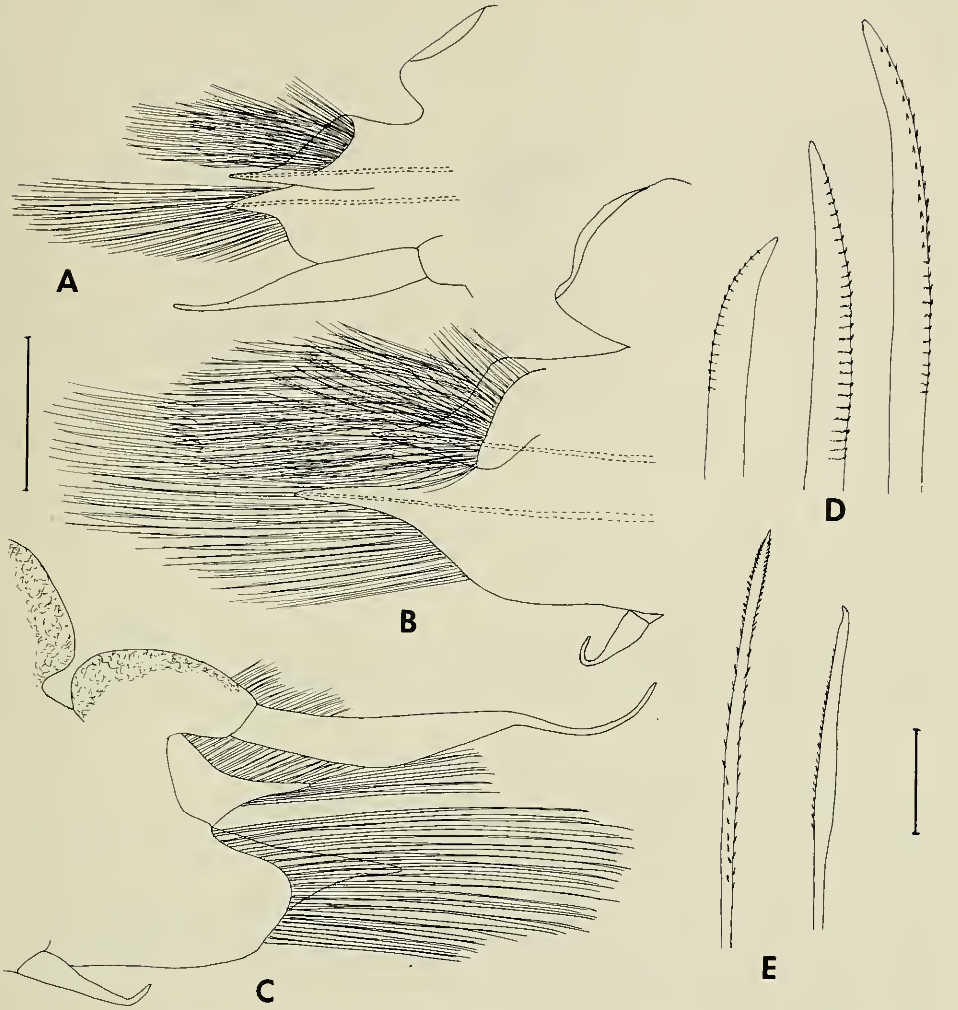

Fig. 2. *Levensteiniella kincaidi,* holotype, USNM 97452: A, Right elytrigerous parapodium of segment 2, anterior view, acicula dotted; B, Same of segment 9; C, Right cirrigerous parapodium of segment 10, posterior view; D, Short and long notosetae; E, Supra-acicular and subacicular neurosetae. Scales = 0.5 mm for A–C; 0.1 mm for D, E.

The body is oval, flattened, tapering slightly anteriorly and posteriorly, with parapodia longer than the body width. The 11 pairs of elytra cover the dorsum. They are round to subreniform, delicate, with "veins" and scattered micropapillae near the border and on the surface (Fig. 1E). The elytrophores are large and prominent (Figs. 1A, C, 2A, B). Dorsal cirri, on the segments lacking elytra, have cyclindrical cirrophores, bulbous basally, attached to the posterodorsal sides of the notopodia; the styles, with long slender tips, extend to the tips of the setae or beyond; the dorsal tubercles are nodular (Figs. 1C, 2C). Transverse ciliated bands, 2 per segment, extend on the bases of the elytrophores and dorsal tubercles.

The prostomium is oval, bilobed, wider than long; the anterior lobes are triangular and extended laterally, with delicate frontal filaments; the short cerato-

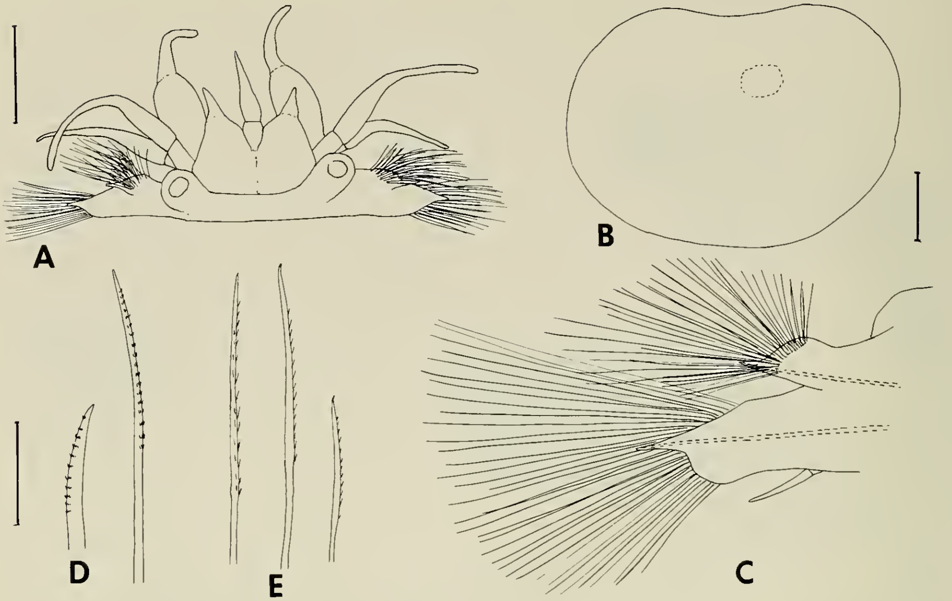

Fig. 3. *Levensteiniella kincaidi,* young paratype of 14 segments, 2 × 1.5 mm, USNM 97468: A, Dorsal view anterior end; B, Right elytron; C, Right elytrigerous parapodium, anterior view, acicula dotted; D, Short and long notosetae; E, Upper, middle and lower neurosetae. Scales = 0.2 mm for A; 0.1 mm for B, C; 0.1 mm for D, E.

phore of the median antenna is inserted in the anterior notch; in the style is short, subulate, with a long terminal filament; the palps are stout, tapered, with long slender tips; lateral antennae and eyes are lacking (Fig. 1A, C). The tentaculophores lateral to the prostomium lack setae; the 2 pairs of tentacular cirri, with long slender tips, are slightly shorter than the palps, the dorsal pair longer than the ventral pair. The low bilobed facial tubercle occupies the space between the anterior lobes of the prostomium.

The second or buccal segment bears the first pair of elytrophores, biramous parapodia, with the rami equal in length, and buccal cirri, similar to the tentacular cirri, attached basally on the neuropodia lateral to the ventral mouth (Figs. 1A, C, 2A). The everted pharynx usually has 7 pairs of similar papillae around the opening (Fig. 1A; one specimen with 7 dorsal and 6 ventral; one with 7 dorsal and 9 ventral). The 2 pairs of jaws are entire, not denticled (Fig. 1B).

Both rami of the biramous parapodia are well developed, the notopodia slightly shorter than the neuropodia, except for the buccal segment (Fig. 2B, C). The notopodia are round with a projecting acicular process on the lower side. The golden notosetae are very numerous, of 3 to 4 lengths, none as long as the neurosetae; the shortest anterior group projects dorsally. The notosetae are stouter than the neurosetae, slightly curved with spinous rows and short tapered bare blunt tips (Fig. 2D). The neuropodia have conical presetal lobes with a projecting acicular process and shorter rounded postsetal lobes. The neurosetae are very numerous, golden-colored, and slender (none extra wide or flattened); the supra-acicular ones have longer spinous regions, more prominent spines and tapered,

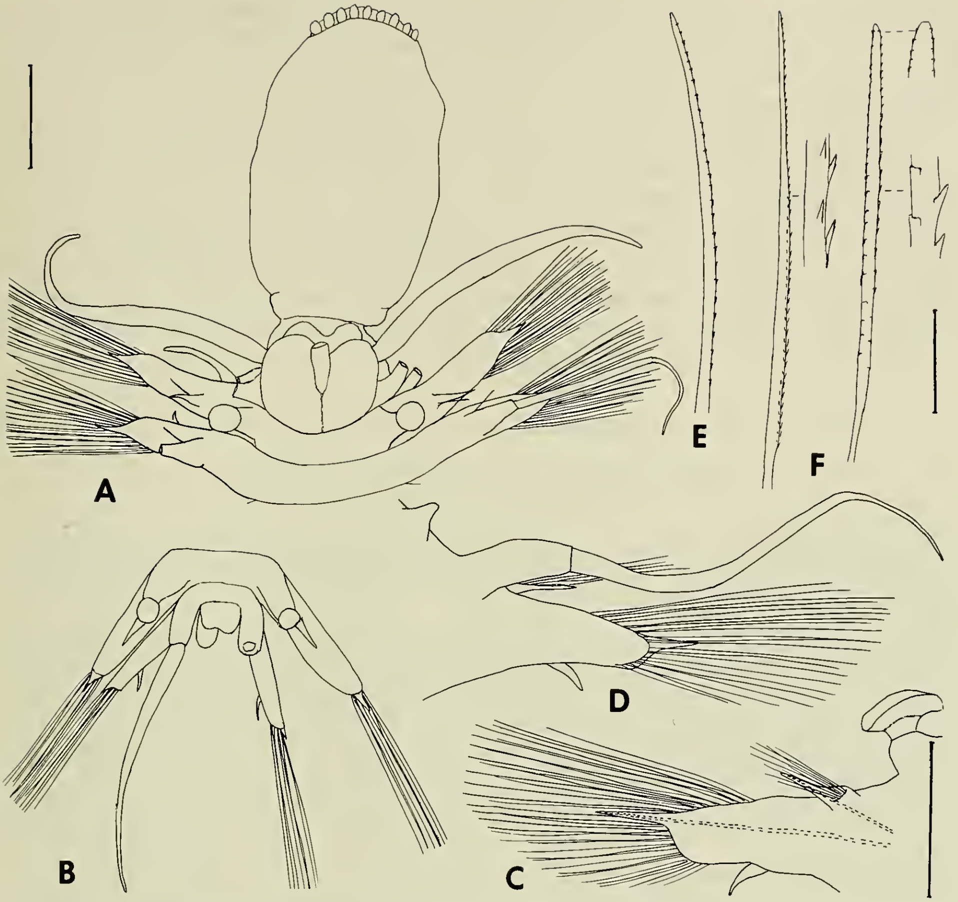

Fig. 4. *Macellicephala galapagensis,* holotype, USNM 80638: A, Dorsal view of anterior end, pharynx extended; styles of median antenna, right and left tentacular cirri, and left dorsal cirrus of segment 3 missing; B, Dorsal view of posterior end, styles of right dorsal cirrus of segment 18 and anal cirri missing; C, Right elytrigerous parapodium, anterior view, acicula dotted; D, right cirrigerous parapodium, posterior view; E, Notoseta; F, Neurosetae, with detail of part. Scales = 0.5 mm for A, B; 0.5 mm for C, D; 0.1 mm for E, F.

flattened, finely spinous tips; the subacicular ones are finely spinous with slightly hooked tips (Fig. 2E). The ventral cirri are short, tapered, attached on the middle of the neuropodia (Fig. 2B, C).

The pygidium is small, rectangular, with a pair of small anal cirri (mostly missing). Some of the adult paratypes have 2 pairs of very long ventral papillae (containing a whitish secretion) on segments 11 and 12 (Fig. 1D). They were found on adults 5.5 to 11 mm in length, 3 to 5 mm in width, with 22 to 24 segments. Some smaller young individuals (3 to 3.5 mm in length, 3 mm in width, with 16 to 19 segments) had a pair of long ventral papillae on segment 11 only.

Numerous young specimens were collected, with lengths of 1 to 4 mm, widths of 1 to 3 mm, and segments 10 to 20. They show the general characters of the adult. A small one, 2 mm long, 1.5 wide, with 14 segments, is shown on Fig. 3.

The styles of the median antenna and tentacular cirri and the palps are more bulbous basally (Fig. 3A). The delicate oval elytra lack micropapillae (Fig. 3B). The notopodia are not as well developed and the setae are more slender (Fig. 3C–E).

*Etymology.*—The species is named for the late Trevor Kincaid, Professor at the University of Washington, who first suggested that I work on my chosen field of polychaetes.

*Distribution.*—Eastern Pacific in the Galapagos Rift area in 2457–2493 meters, associated with deep-sea mussels and giant clams and in the East Pacific Rise at 21°N in 2612–2633 meters, associated with vestimentiferans (*Riftia pachyptila* Jones), giant clams (*Calyptogena magnifica* Boss and Turner) and ampharetid polychaetes (*Alvinella pompejana* Desbruyères and Laubier).

### Genus *Macellicephala* McIntosh, 1885, emended Pettibone, 1976

### *Macellicephala galapagensis*, new species

Fig. 4

*Material examined.*—East central Pacific, from *Alvin* dive in Galapagos Rift in 1979: ROSE GARDEN, 00°48′15″N, 86°13′28″W, Dive 894, 19 Feb, amphipod trap, holotype (USNM 80638).

*Description.*—The holotype, a male with sperm, is 6 mm long, 4 mm wide with setae, with 18 segments, the first achaetous. The body is subrectangular, flattened, with long and well separated parapodia, longer than the body width (Fig. 4A, B). No color remains. There are 9 pairs of very small elytra, firmly attached on prominent elytrophores on segments 2, 4, 5, 7, 9, 11, 13, 15, and 17 (Fig. 4A–C). The elytra are rather thick, without tubercles or papillae. The dorsal cirri, attached on the posterodorsal sides of the notopodia, have long cylindrical cirrophores and long, slender, smooth styles extending beyond the tips of the setae; the dorsal tubercles are small, conical, beginning on segment 6 (Fig. 4A, B, D).

The prostomium is bilobed, the anterior margins rounded, without peaks or filaments; the median antenna has a long ceratophore in the middle of the prostomium, the style is missing; the palps are long, stout, smooth and tapered; lateral antennae and eyes are lacking (Fig. 4A). The first or tentacular segment is not visible dorsally; the tentaculophores lateral to the prostomium lack setae and bear 2 pairs of tentacular cirri; the styles are missing; the facial tubercle is large and bilobed (Fig. 4A). The second or buccal segment bears the first pair of small elytra, biramous parapodia and ventral buccal cirri longer than the following ventral cirri (Fig. 4A). The ventral mouth is enclosed in segments 1 and 2. The pharynx is completely extended, with the opening encircled with 9 pairs of equal dorsal and ventral papillae, with 2 pairs of entire jaws (Fig. 4A).

The long parapodia are biramous, with the notopodia much shorter than the neuropodia (Figs. 4C, D). The notopodium is conical with a projecting acicular process on the lower side. The neuropodium has a conical presetal lobe abruptly tapering to a prominent acicular process, the postsetal lobe is shorter and rounded. The notosetae are few (0–7), a single one on the parapodia of segments 2 and 3; they are slender, about as stout as the neurosetae, with widely-spaced spinous rows and rounded tips (Fig. 4E). The neurosetae are numerous, forming fan-shaped bundles; they are delicate, flattened, with double rows of widely-spaced spines and tapered rounded tips (Fig. 4F). The ventral cirri are short, tapering, attached to the middle of the neuropodia (Figs. 4C, D).

The nephridial papillae are indistinct, none enlarged. The pygidium is a rounded lobe wedged between the long parapodia of the last segment, with a pair of anal cirri, only the base of the left one remains (Fig. 4B).

*Etymology.*—The species is named for the type-locality, the Galapagos Rift.

*Remarks.*—*Macellicephala galapagensis* is distinguished from the other species of *Macellicephala* by the very small and firmly attached elytra. Where known in other species of the genus, the elytra are large and easily broken off. The tentacular segment is not visible dorsally, as it is in other members of *Macellicephala.* The parapodia of the last segment are large and not reduced, as they are in other species of *Macellicephala.*

### *Natopolynoe,* new genus

*Type-species.*—*Natopolynoe kensmithi,* new species. Gender: feminine.

*Diagnosis.*—Body short, flattened, fusiform; segments 17 (perhaps more?). Elytra and small elytrophores 9 pairs, on segments 2, 4, 5, 7, 9, 11, 13, 15, and 17; elytra delicate, without tubercles. Prostomium deeply bilobed, rounded, without frontal filaments; median antenna with slender ceratophore in anterior notch, with long style; paired palps very long; without lateral antennae and eyes. First or tentacular segment visible dorsally; tentaculophores lateral to prostomium, achaetous, with 2 pairs of tentacular cirri. Parapodia biramous, both rami well developed, with projecting acicular processes. Both notosetae and neurosetae delicate, transparent, flattened, serrated on sides. Dorsal cirri with cylindrical cirrophores and very long styles; dorsal tubercles indistinct. Ventral cirri short. Pygidium small, rounded, with anal cirri (?). Pharynx with 9 pairs of equal papillae and 2 pairs of entire jaws.

*Etymology.*—*Nato* (Latin), swim, plus *polynoe,* referring to the swimming polynoid worm.

### *Natopolynoe kensmithi,* new species

Fig. 5

*Material examined.*—California, Santa Catalina Channel, 33°18′24″N, 118°35′37″W, *Alvin* dive 929, 19 Jun 1979, 1300 m, K. L. Smith, collector, holotype (USNM 97450).

*Description.*—The holotype, with 17 segments, has a length of 7 mm, a width of 1.5 mm without parapodia, 4 mm with parapodia, and 6 mm with setae. The body is flattened ventrally and arched dorsally, with very long parapodia, much longer than the body width. The integument is delicate and transparent, revealing the dark pharynx and intestine, as well as the white ventral nerve cord. The 9 pairs of elytra are oval, delicate, somewhat inflated, without tubercles and papillae, the last pair very small (Fig. 5B). The elytrophores are small (Fig. 5A, C). The dorsal cirri on the segments lacking elytra have long cylindrical cirrophores attached on the posterior sides of the notopodia, with very long, slender, delicate styles; dorsal tubercles are indistinct (Fig. 5A).

The bilobed prostomium is formed of 2 rounded lobes, without anterior extensions or frontal filaments; the median antenna has a slender cylindrical cera-

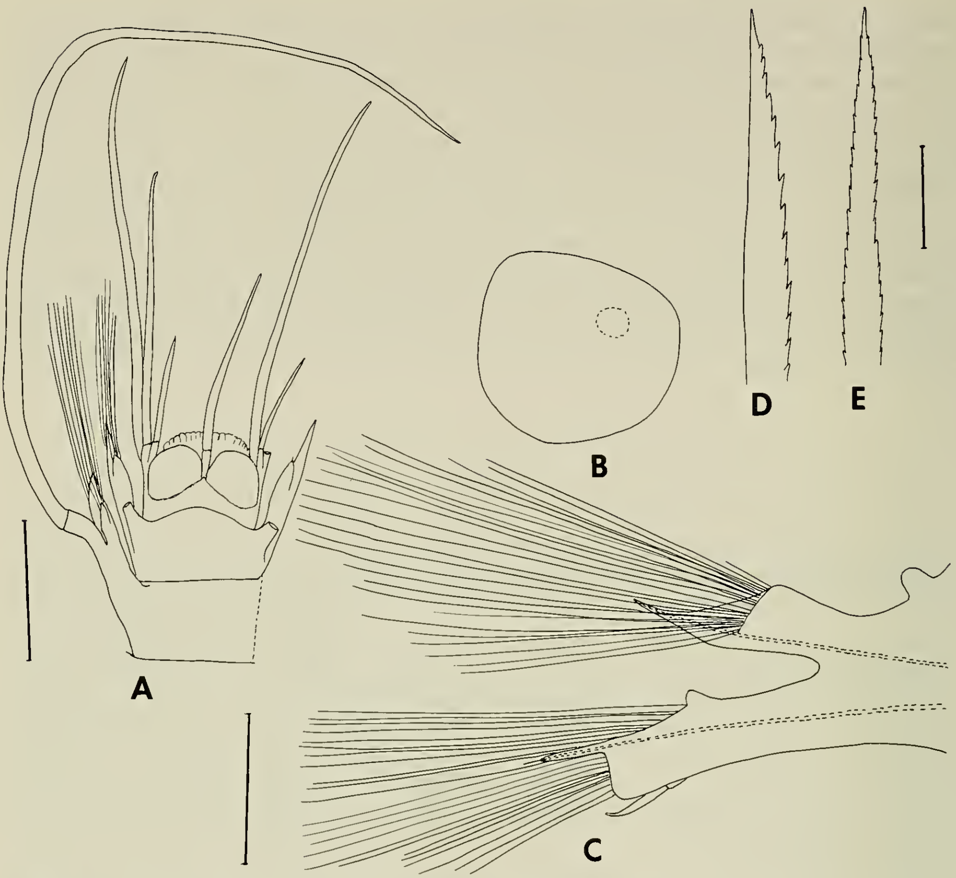

Fig. 5. *Natopolynoe kensmithi,* holotype, USNM 97450: A, Dorsal view of anterior end, pharynx partially extended, right ventral tentacular cirri and right parapodium of segment 3 missing; B, Elytron; C, Right elytrigerous parapodium, anterior view, acicula dotted; D, Tip of notoseta; E, Tip of neuroseta. Scales = 1.0 mm for A; 0.5 mm for B, C; 0.1 mm for D, E.

tophore inserted in the anterior notch, with a moderately long style; the very long palps are inserted ventrolaterally (Fig. 5A). The first or tentacular segment is visible dorsally, extending anteriorly between the lobes of the prostomium and laterally forming the achaetous tentaculophores for the 2 pairs of tentacular cirri, the ventral pair shorter than the palps but longer than the median antenna, and the dorsal pair shorter than the median antenna (Fig. 5A). The second or buccal segment bears the first pair of elytrophores, long biramous parapodia extending anteriorly and enclosing the prostomium, and ventral buccal cirri (broken off). The ventral mouth is enclosed in segments 1 and 2. The pharynx was not extended; when dissected out, it revealed 9 pairs of small oval dorsal and ventral papillae and 2 pairs of smooth amber-colored jaws.

Both rami of the biramous parapodia are very well developed, the notopodia only slightly shorter than the neuropodia, with both rami furnished with very numerous, long, transparent, flattened setae extending to the same level (Fig. 5C). The notopodium is conical, extending into a prominent acicular process. The upper half of the neuropodium is diagonally truncate, extending into a prominent acicular process, the lower half truncate, with the short ventral cirrus attached near the distal end of the neuropodium. The delicate, flattened, transparent notosetae are slightly wider than the neurosetae, with more prominent serrations along one side, tapering to pointed tips (Fig. 5D). The flattened neurosetae have less prominent serrations on both sides and taper to sharp tips (Fig. 5E).

The pygidium is a small rounded lobe medial to the small parapodia of the last 2 segments; anal cirri were missing. Ventral nephridial papillae are indistinct.

*Biology.*—The holotype was collected during a dive of the *Alvin* in the Santa Catalina Channel in 1300 meters by Kenneth L. Smith using a slurp gun-respirometer. According to Dr. Smith (in litt., from Susan Hamilton), the worms were abundant not only on the bottom but also swimming in the water column up to about 10 meters above the sediment. Their long setae in motion were quite striking in the light of the camera's strobe. Other abundant organisms included holothurians, ophiuroids, chaetognaths, euphausiids, and a large medusa.

*Etymology.*—The species is named for Dr. Kenneth L. Smith of Scripps Institution, who managed to collect the holotype and made observations on the habitat of the species.

*Remarks.*—*Natopolynoe kensmithi* shows adaptations to a pelagic existence: the long biramous parapodia with numerous long flattened swimming setae in both rami and the delicate transparent integument of the body and elytra. Unfortunately, only a single specimen was collected. There is a possibility that the species may have more than 17 segments, with the last pair of small elytra on the last segment. The usual pattern in the Polynoidae is to have at least a few cirrigerous segments following the last elytrigerous segment.

In most features, *Natopolynoe kensmithi* agrees with the general characters of the genera and species of Macellicephalinae. It is closest to the recently described pelagic macellicephalinine collected in a cave in the Bahamas, *Pelagomacellicephala iliffei* (Pettibone 1985a:131). In the latter species, the tentacular segment is not visible dorsally, rather than distinctly visible; the pharynx has 5 pairs of unequal papillae and the jaws have numerous basal teeth, rather than 9 pairs of equal papillae and entire jaws; and the notosetae are few, short, and not flattened, rather than very numerous, long, and flattened.

### Subfamily Harmothoinae Horst, 1917
### Genus *Harmothoe* Kinberg, 1856
### *Harmothoe macnabi*, new species
Figs. 6, 7

*Material examined.*—East central Pacific, from *Alvin* dive in the Galapagos Rift in 1979: MUSSEL BED, 00°47′53″N, 86°09′12″W, *Alvin* dive 895-32, 20 Feb, 2482 m, clam box washings, holotype (USNM 97451).

*Description.*—Length of holotype 33 mm, width with setae 14 mm, segments 28 plus 3 small regenerating segments and pair of long anal cirri (no doubt more than 32 segments and longer than 33 mm). The body is flattened, slightly tapering anteriorly and posteriorly. The elytra are located on the usual segments for *Harmothoe*: 2, 4, 5, 7, alternate segments to 23, 26, 29 (small developing elytra; and no doubt on 32 with few posterior segments with dorsal cirri). The elytra are large,

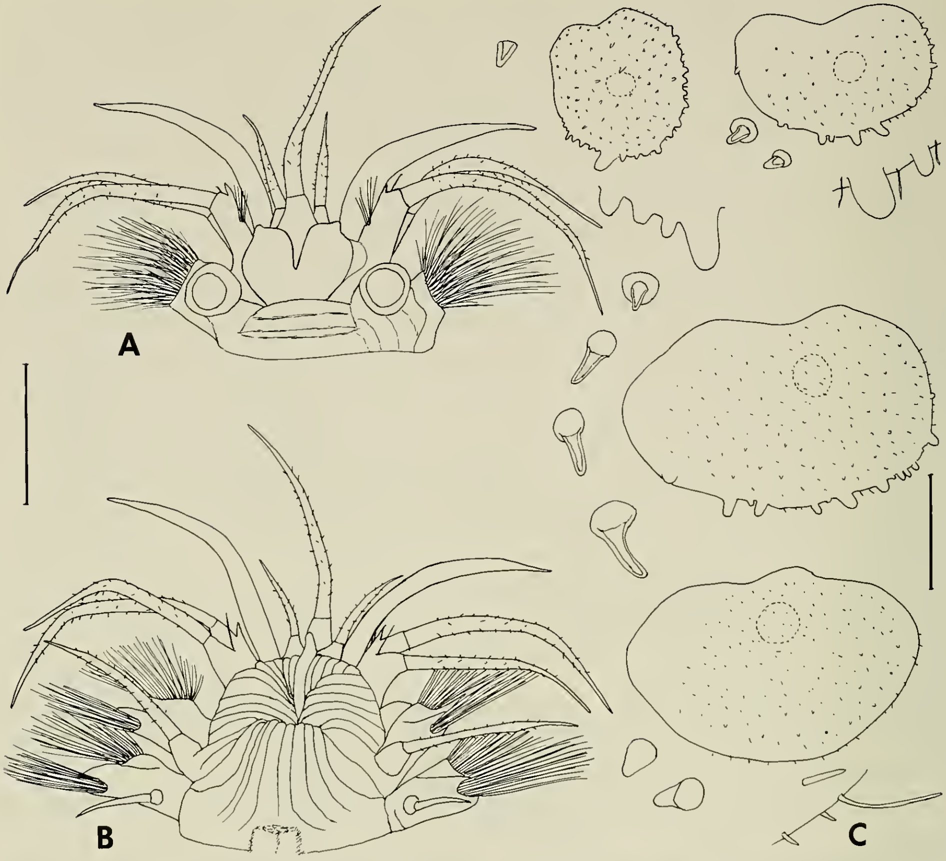

Fig. 6. *Harmothoe macnabi,* holotype, USNM 97451: A, Dorsal view of anterior end, turned slightly to left; B, Ventral view of anterior end; C, Right 1st, 2nd, middle, and posterior elytra, with detail of macrotubercles, microtubercles and micropapillae. Scales = 2.0 mm for A, B; 2.0 mm for C.

covering the dorsum, round to oval, thick, white, opaque, with some macrotubercles along the posterior border, variable in size and not set off from the surface (absent from more posterior elytra), with scattered conical microtubercles and long papillae on the surface and posterolateral borders but without a thick fringe of papillae (Fig. 6C). The elytrophores are large and bulbous (Figs. 6A, 7B). On the segments lacking elytra, the dorsal cirri have long cylindrical cirrophores attached to the posterior sides of the notopodia, with long papillate styles extending far beyond the tips of the setae; the dorsal tubercles are conical (Fig. 7A). The dorsal tubercles are more elongated on segments 24, 25 and especially elongated and flattened, extending posterolaterally on segments 27 and 28.

The prostomium is bilobed, wider than long, with cephalic peaks; the median antenna has a large ceratophore inserted in the anterior notch, with a long papillate style about twice longer than the prostomium; the ceratophores of the lateral antennae are inserted ventrally and converge midventrally, with short papillate styles about half as long as the median antenna; the palps are stout, tapered,

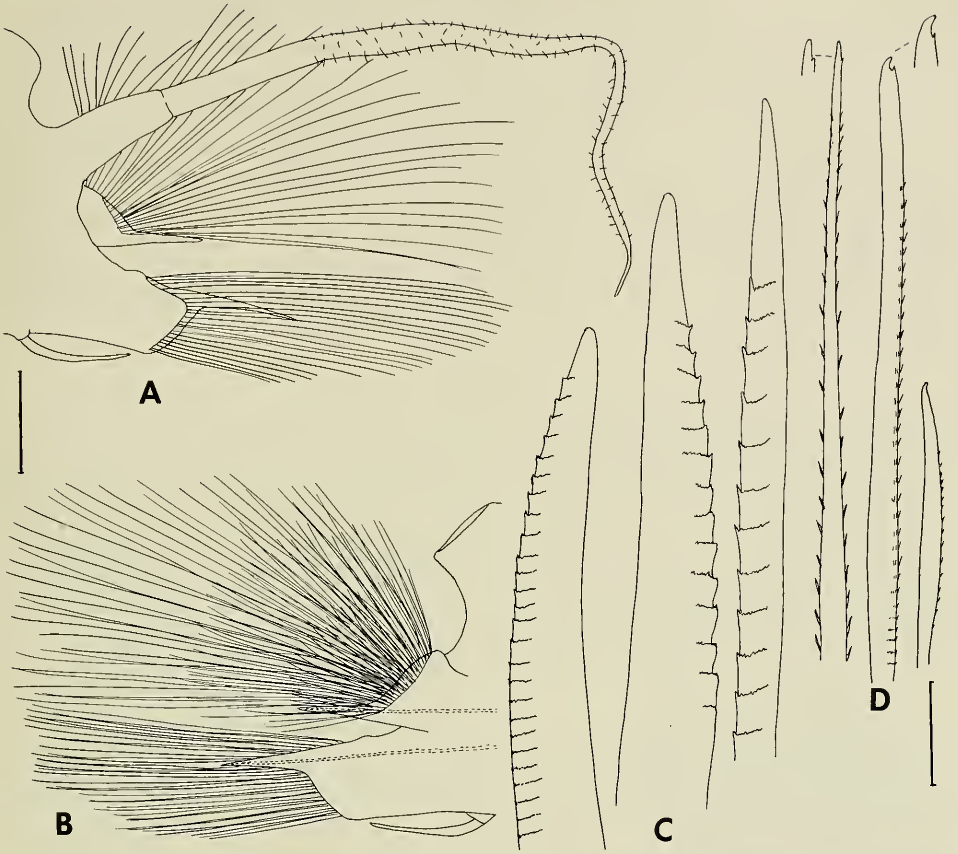

Fig. 7. *Harmothoe macnabi,* holotype, USNM 97451: A, Right cirrigerous parapodium of segment 12, posterior view; B, Right elytrigerous parapodium of segment 13, anterior view, acicula dotted; C, Short and long notosetae; D, Upper, middle and lower neurosetae, with detail of tips. Scales = 1.0 mm for A, B; 0.1 mm for C, D.

smooth, slightly longer than the median antenna; eyes are lacking (Fig. 6A, B). The tentaculophores of the first segment are lateral to the prostomium, each with a small acicular lobe on the inner side, a pair of tentacular cirri similar to the median antenna, a group of 5–6 setae on the base of the dorsal tentacular cirrus and 1–2 setae on the base of the ventral tentacular cirrus; ventrally it forms the anterior and lateral lips of the mouth, with a distinct conical facial tubercle projecting anteriorly from the medial facial ridge (Fig. 6A, B). The second or buccal segment has a slightly-developed nuchal lobe and bears the first pair of elytrophores, well-developed biramous parapodia, and ventral buccal cirri with distinct ceratophores attached lateral to the posterior lip of the mouth, with long styles similar to the ventral tentacular cirri (Fig. 6A, B). The pharynx was not extended; when dissected, it showed the usual 9 pairs of papillae and 2 pairs of strong jaws.

The parapodia are biramous, both rami well developed with sharply pointed acicular processes (Fig. 7A, B). The notopodia are shorter than the neuropodia, rounded, with the acicular process on the lower side; the neuropodia have conical

Table 1.—Summary of identifications of polynoid polychaetes collected by DSRV *Alvin* in the areas of the Galapagos Rift (GR) in 1979 and in the East Pacific Rise (EPR) at 21°N in 1982, with number of specimens and references indicated.

| | No. specimens (young) | | Pettibone references |
|---|---|---|---|
| | GR | EPR | |
| Polynoidae Malmgren, 1867 | | | |
| Harmothoinae Horst, 1917 | | | |
| *Harmothoe* Kinberg, 1856 | | | |
| *H. macnabi,* n. sp. | 1 | | Present paper |
| Iphioninae Baird, 1865 | | | |
| *Iphionella* McIntosh, 1885 | | | |
| *I. risensis* Pettibone, 1985 | | 7 (4) | 1985d |
| Macellicephalinae Hartmann-Schröder, 1917; emend. Pettibone, 1976 | | | 1976 |
| *Macellicephala* McIntosh, 1885; emend. Pettibone, 1976 | | | |
| *M. galapagensis,* n. sp. | 1 | | Present paper |
| *Levensteiniella* n. gen. | | | |
| *L. kincaidi* n. sp. | 45 (43) | 124 (105) | Present paper |
| Lepidonotopodiinae Pettibone, 1983 | | | 1983 |
| *Lepidonotopodium* Pettibone, 1983 | | | |
| *L. fimbriatum* Pettibone, 1983 | | 4 (1) | 1983 |
| | | 50 (31) | 1984b |
| *L. riftense* Pettibone, 1984 | 112 (29) | 313 (many) | |
| *L. williamsae* Pettibone, 1984 | 6 | 81 (many) | |
| Branchipolynoinae Pettibone, 1984 | | | 1984a |
| *Branchipolynoe* Pettibone, 1984 | | | |
| *B. symmytilida* Pettibone, 1984 | 77 (26) | | |
| Branchiplicatinae Pettibone, 1985 | | | 1985b |
| *Branchiplicatus* Pettibone, 1985 | | | |
| *B. cupreus* Pettibone, 1985 | | 26 (12) | |
| Branchinotogluminae Pettibone, 1985 | | | 1985c |
| *Branchinotogluma* Pettibone, 1985 | | | |
| *B. hessleri* Pettibone, 1985 | 3 | 33 (6) | |
| *B. sandersi* Pettibone, 1985 | 15 (3) | 6 (1) | |
| *B. grasslei* Pettibone, 1985 | 1 | 24 | |
| *Opisthotrochopodus* Pettibone, 1985 | | | |
| *O. alvinus* Pettibone, 1985 | 6 (2) | 43 (14) | |

presetal lobes abruptly tapering to the acicular process (without a supra-acicular digitiform process) and shorter rounded postsetal lobes. The notosetae are very numerous, forming radiating bundles, as long as or longer than the neurosetae; they are much stouter than the neurosetae, short, slightly curved to long and straight, with spinous rows and blunt bare tips (Fig. 7C). The neurosetae are also very numerous, forming fan-shaped bundles, with bare slightly hooked tip and very small subterminal tooth; some lower ones with entire tips; with elongate spinous regions, the upper neurosetae with more prominent spines (Fig. 7D). The ventral cirri are short, smooth and tapered (Figs. 6B, 7A, B).

The small pygidium bears a pair of long anal cirri. The ventral nephridial papillae are small, beginning on segment 6.

*Etymology.*—The species is named for Professor James Macnab, my teacher at Linfield College, who first sparked my interest in the invertebrates of the Oregon coast.

*Remarks.*—This deep-sea eyeless species of *Harmothoe* from the Galapagos Rift in 2492 meters is closest to the recently described eyeless *H. vagabunda* from the North Atlantic off the Bahamas and Virgin Islands in 2066 and 3995 meters, from burrows of wood-boring bivalves (Pettibone 1985a:146). *Harmothoe vagabunda,* however, has very small or indistinct cephalic peaks; a distinct facial tubercle is lacking; the elytra lack macrotubercles; and all the neurosetae have bifid tips, with a long slender secondary tooth, thus differing from *H. macnabi.*

## Summary

Over a thousand specimens of polynoid polychaetes, including many young ones, were collected during *Alvin* dives in the hydrothermal vents by the Galapagos Rift Biology Expedition in 1979 and the OASIS Expedition to the East Pacific Rise off Western Mexico at 21°N in 1982. They were sent to me for identification by J. F. Grassle of the Woods Hole Oceanographic Institution and K. L. Smith of Scripps Institution of Oceanography. Most of the collection has been dealt with the six papers (Pettibone 1983, 1984a, b, 1985b, c, d). The few remaining groups are covered in the present paper. The specimens are referred to seven subfamilies of Polynoidae, four of them new; nine genera, five new; and 13 new species, summarized in Table 1.

Of the 13 species, three were found only in the area of the Galapagos Rift: *Harmothoe macnabi* (single specimen), *Macellicephala galapagensis* (single specimen), and *Branchipolynoe symmytilida* (commensal with the deep-sea mussels). Three species were found only in the East Pacific Rise: *Iphionella risensis, Lepidonotopodium fimbriatum,* and *Branchiplicatus cupreus.* The other seven species were found in both localities. They may be separated by the following key.

## Key to the Subfamilies, Genera, and Species of Polynoidae from the Galapagos Rift and East Pacific Rise at 21°N

1. Prostomium bilobed, with cephalic peaks; median antenna with ceratophore in anterior notch; lateral antennae with ceratophores inserted ventrally; with paired palps; without eyes. Tentaculophores of first segment lateral to prostomium, each with few setae and pair of tentacular cirri. Segments about 35. Elytra and bulbous elytrophores 15 pairs, on segments 2, 4, 5, 7, alternate segments to 23, 26, 29, and 32. Elytra thick, white, opaque, with scattered conical microtubercles on surface and some macrotubercles along posterior border, not set off from surface. Both rami of biramous parapodia with pointed acicular processes. Notosetae much stouter than neurosetae, with spinous rows and blunt bare tips. Neurosetae with spinous rows and bare slightly hooked tips with small subterminal tooth. Pharynx with 9 pairs of papillae and 2 pairs of jaws .................... Harmothoinae: *Harmothoe macnabi,* n. sp. (figs. 6, 7)

– Prostomium bilobed, forming two separate rounded lobes, with anterolateral bulbous extensions and paired palps; without lateral and median antennae and eyes. Tentaculophores of first segment lateral to prosto-

mium, each with few capillary setae and pair of tentacular cirri. Segments 29. Elytra and bulbous elytrophores 13 pairs, on segments 2, 4, 5, 7, alternate segments to 23, and 26. Elytral surface divided into polygonal areas with secondary areolae and lateral fringe of papillae. Rami of biramous parapodia conical, closely allied. Notosetae bipinnate, capillary. Neurosetae stout, with close-set spinous rows and long bare slightly hooked tips, upper few slender, feathered. Pharynx with 9 pairs of papillae and 2 pairs of jaws ........................................
........... Iphioninae: *Iphionella risensis* (Pettibone, 1985c, figs. 12–14)

– Prostomium with median antenna and paired palps, without lateral antennae and eyes. Tentaculophores of first segment lateral to prostomium, each with pair of tentacular cirri, without setae .................... 2

2. Body with paired segmental branchiae ......................... 3

– Body without branchiae ........................................ 8

3. Prostomium truncate anteriorly, not bilobed, without frontal filaments; median antenna with ceratophore in middle of prostomium. Segments up to 35, first achaetous. Elytra 12 pairs, on segments 2, 4, 5, 7, alternate segments to 23. Elytra large, oval, covering dorsum. Branchiae beginning on segment 3, flattened elongate sacs, deeply folded and convoluted, attached to flattened elytrophores and dorsal tubercles, both with extra lobes. Parapodia biramous, both rami with projecting acicular processes. Notopodia without well-developed bracts. Paired palps, tentacular, buccal and dorsal cirri all long. Pharynx with 5 pairs of unequal papillae and 2 pairs of minutely denticled jaws .........................
... Branchiplicatinae: *Branchiplicatus cupreus* (Pettibone, 1985b, figs. 1–4)

– Prostomium bilobed, anterior lobes with minute or filiform frontal filaments. Segments 21, first achaetous. Elytra 10 pairs on segments 2, 4, 5, 7, alternate segments to 19. Branchiae arborescent, in 2 main groups lateral to elytrophores and dorsal tubercles and on dorsal sides of notopodia. Elytrophores and dorsal tubercles not flattened, without extra lobes ................................................ 4

4. Bilobed prostomium with minute frontal filaments; ceratophore of median antenna indistinct, with short style. Elytra small, leaving middorsum uncovered. Parapodia subbiramous, notopodia small, digitiform, without bracts; notosetae few, stout, acicular; neuropodia short, truncate, without projecting acicular processes. Arborescent branchiae beginning on segment 2, with long terminal filaments. Paired palps, tentacular, buccal and dorsal cirri all short. Pharynx with 5 pairs of subequal papillae and 2 pairs of smooth jaws. Associated with deep-sea mussels .......
.................. Branchipolynoinae: *Branchipolynoe symmytilida*
(Pettibone, 1984a, figs. 1–8)

– Bilobed prostomium with filiform frontal filaments; median antenna with distinct ceratophore in anterior notch. Elytra large, covering dorsum. Parapodia biramous, both rami with projecting acicular processes; notopodia with prominent bracts on elytrigerous segment 2 or on all elytrigerous segments. Notosetae numerous, stout, acicular. Arborescent branchiae beginning on segment 3, compact, with short terminal filaments. Paired palps, tentacular, buccal and dorsal cirri all long. Pharynx with 5 papillae: 3 dorsal and 2 ventral; 2 pairs of minutely denticled jaws. Branchinotogluminae (Pettibone, 1985c) .................... 5

5. Posterior 4 segments (18–21) compressed, with parapodia greatly modified, including wheel organs on segment 20. Notopodia with prominent rounded bracts on elytrigerous segments 2–17. Arborescent branchiae on segments 3–17, with rather long terminal filaments. Dorsal tubercles elongate, tapered. Notosetae stout, acicular, smooth or with 1–2 rows of spines. With pair of elongate ventral papillae on segment 12, and 5 pairs of short rounded lamellae on segments 13–17 ...................... ................ *Opisthotrochopodus alvinus* (Pettibone, 1985c, figs. 7–9)

– Posterior 4 segments not compressed or only posterior 3 segments (19–21) slightly modified, without wheel organs on segment 20. *Branchinotogluma* (Pettibone, 1985c) ........................................ 6

6. Prominent notopodial bracts on all elytrigerous segments. Arborescent branchiae with rather long terminal filaments. Posterior segments not modified, with branchiae on all segments from segment 3 on. Dorsal tubercles projecting posteriorly. Notosetae stout, acicular, smooth or with 2 rows of spines. With 6 pairs of small, rounded lamellae on segments 11–16 .......... *Branchinotogluma hessleri* (Pettibone, 1985c, figs. 1, 2)

– Notopodial bracts on elytrigerous segment 2 only. Arborescent branchiae with short terminal filaments. Dorsal tubercles inflated, indistinct. Notosetae stout, acicular, smooth ................................... 7

7. Posterior 3 segments slightly compressed and modified, with branchiae absent from segments 19–21. With 4 pairs of elongate ventral papillae on segments 12–15 and 3 pairs of rounded lamellae on segments 16–18 ................. *Branchinotogluma sandersi* (Pettibone, 1985c, figs. 3, 4)

– Posterior segments not compressed or modified, with branchiae on all segments from segment 3 on. Without elongate ventral papillae; with or without 5 pairs of small, squarish papillae on segments 11–15 ....... ................. *Branchinotogluma grasslei* (Pettibone, 1985c, figs. 5, 6)

8. Biramous parapodia with well-developed bracts encircling notopodia anteriorly and dorsally. Neuropodia diagonally truncate, deeply notched dorsally. Segments up to 30, first achaetous. Elytra 11 pairs, on segments 2, 4, 5, 7, alternate segments to 21. Prostomium deeply bilobed, with small frontal filaments on anterior lobes, with ceratophore of median antenna inserted in anterior notch. Lepidonotopodiinae: *Lepidonotopodium* (Pettibone, 1983, 1984b) .................................. 9

– Notopodia of parapodia without bracts. Both rami of parapodia with projecting acicular processes. Macellicephalinae (sensu Pettibone, 1976) ........................................................ 11

9. Prostomium with prominent cylindrical anterior lobes. Elytral surface covered with numerous conical microtubercles and scattered micropapillae, without raised macrotubercles. Notosetae much stouter than neurosetae, with spinous rows on distal part. Upper neurosetae with 2 rows of prominent spines; lower neurosetae minutely spinous. Pharynx with 7 pairs of subequal papillae; 2 pairs of jaws with 5–7 basal teeth. With or without 4 pairs of elongate ventral papillae on segments 12–15 .......... *Lepidonotopodium williamsae* (Pettibone, 1984b, figs. 5, 6)

– Prostomium with subtriangular anterior lobes. Notosetae similar in width to neurosetae, with relatively few (4–9) widely-spaced spines along one side. Upper neurosetae not markedly differing from lower ones. With or without long ventral papillae on segments 11 and 12 ............ 10

10. Elytra with 2 raised macrotubercles per elytron and numerous microtubercles and scattered globular micropapillae. Pharynx with 7–9 pairs of papillae, unequal in size; jaws with few basal teeth (5–9) ......... .. *Lepidonotopodium fimbriatum* (Pettibone, 1983, figs. 1–5; 1984b, fig. 1)

– Elytra without raised macrotubercles, with scattered clavate micropapillae, with or without variable number of small projections. Pharynx with 7–9 pairs of equal papillae; jaws with numerous basal teeth .... .................*Lepidonotopodium riftense* (Pettibone, 1984b, figs. 3, 4)

11. Prostomium bilobed, with lobes rounded, without frontal filaments. Segments 18, first achaetous. Elytra 9 pairs, on segments 2, 4, 5, 7, alternate segments to 17. Elytra very small, thick. Notosetae few, about as stout as neurosetae, with widely spaced spinous rows and rounded tips. Neurosetae delicate, flattened, with double rows of widely spaced spines. Ventral papillae indistinct. Pharynx with 9 pairs of equal papillae; jaws entire ........... *Macellicephala galapagensis,* n. sp. (fig. 4)

– Prostomium deeply bilobed, with anterior lobes triangular, with frontal filaments. Segments up to 25, first achaetous. Elytra 11 pairs, on segments 2, 4, 5, 7, alternate segments to 21. Elytra large, covering dorsum, delicate. Notosetae numerous, stouter than neurosetae, with spinous rows and blunt tips. Neurosetae spinous, with slightly hooked and tapered tips, not flattened. With or without elongate ventral papillae on segments 11 and 12. Pharynx with 7 pairs of equal papillae; jaws entire ...................... *Levensteiniella kincaidi,* n. gen., n. sp. (figs. 1–3)

## Acknowledgments

I wish to thank J. F. Grassle and I. Williams of the Woods Hole Oceanographic Institution and K. L. Smith and S. Hamilton of Scripps Institution of Oceanography, as well as the members of the Galapagos Rift Biology Expedition in 1979 and the OASIS Expedition of Scripps Institution in 1982, for the material on which this study is based, and for the careful sorting and helpful information. The manuscript benefited from the review of K. Fauchald.

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# INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE

% British Museum (Natural History)
Cromwell Road
London SW7 5BD
Tel. 01-589 6323, Ext. 387

2 April 1985

The Commission hereby gives six months notice of the possible use of its plenary powers in the following cases, published in the *Bulletin of Zoological Nomenclature,* volume 42, part 1, on 2 April 1985 and would value comments and advice on them from interested zoologists.

Correspondence should be addressed to the Secretary at the above address, if possible within six months of the date of publication of this notice.

*Case No.*

2340 *Spiroglyphus* Daudin, 1800 and *Stoa* De Serres, 1855 (Mollusca, Gastropoda, Vermetidae): proposed suppression of two equivocal generic names.

2277 *Carpophaga aurorae* Peale, 1848 and *Serresius galeatus* Bonaparte, 1855 (Aves): proposed conservation by the suppression of *Columba R. Forsteri* Wagler, 1829.

2374 *Humerobates* Sellnick, 1928 (Arachnida, Acari): misidentification of the type species *Notaspis humaralis* Hermann, 1804.

2390 *Hatschekia* Poche, 1902 (Crustacea, Copepoda): proposed conservation by the suppression of *Pseudoclavella* Bassett-Smith, 1898.

1156 *Hymenolepis* Weinland, 1858 (Cestoda): proposed designation of type species.

2498 *Anoplocephala* Blanchard, 1848 (Cestoda): proposed confirmation of entry on Official List.

2331 Homonymy in the families HARPIDAE Hawle & Corda, 1847 (Trilobita) and HARPIDAE Bronn, 1849 (Mollusca, Gastropoda).

1481 *Argyrodes* Simon, 1864 and *Robertus* O. Pickard-Cambridge, 1879 (Arachnida, Araneae): proposed conservation by the suppression of *Argyrodes* Guénée, 1845 and *Ctenium* Menge, 1871.

2484 *Olpium* L. Koch, 1873 (Arachnida, Pseudoscorpionida, Olpiidae): proposed designation of type species and related problems.

2377 *Ichnotropis* Peters, 1854 (Reptilia, Sauria): proposed conservation by the suppression of *Thermophilus* Fitzinger, 1843.

2480 *Erigone* Audouin, 1826 (Arthropoda, Araneae): proposed designation of type species.

2491 *Actia* Robineau-Desvoidy, 1830 (Insecta, Diptera): request for designation of type species.

R. V. MELVILLE
Secretary

# INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE

% British Museum (Natural History)
Cromwell Road
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Tel. 01-589 6323, Ext. 387

2 April 1985

The following Opinions have been published by the International Commission on Zoological Nomenclature in the *Bulletin of Zoological Nomenclature,* volume 42, part 1, on 2 April 1985:

*Opinion No.*
1288 (p. 17) *Sphinx tipuliformis* Clerck, 1759 (Insecta, Lepidoptera): conserved.
1289 (p. 19) *Mesoplodon* Gervais, 1850 (Mammalia, Cetacea): conserved.
1290 (p. 21) *Leptinotarsa* Chevrolat, 1837 (Insecta, Coleoptera): conserved.
1291 (p. 24) *Antilope zebra* Gray, 1838 (Mammalia): conserved.
1292 (p. 27) *Voluta papilio* Link, 1807 (Gastropoda): conserved.
1293 (p. 29) *Scolia quinquecincta* Fabricius, 1793 is the type species of *Heterelis* Costa, 1887 (Insecta, Hymenoptera).
1294 (p. 31) *Edwardsia* de Quatrefages, 1841 (Coelenterata, Actiniaria): conserved.
1295 (p. 34) *Actinia* Linnaeus, 1767 and ACTINIIDAE Rafinesque, 1815 (Coelenterata, Actiniaria) and *Pentacta* Goldfuss, 1820 (Echinodermata, Holothurioidea): conserved.
1296 (p. 37) Request for the use of the plenary powers to conserve *Nettastomella* Carpenter, 1865 (Bivalvia) refused.
1297 (p. 39) *Xenocrepis pura* Mayr, 1904 designated as type species of *Xenocrepis* Foerster, 1856 (Insecta, Hymenoptera).

Direction 116
(p. 41) PAPILIONIDAE Latreille, [1802] (Insecta, Lepidoptera): revision of Official List entry.

Direction 117
(p. 43) Correction of Entry No. 462 in the Official List of Generic Names in Zoology concerning *Sphaerium* Scopoli, 1777 (Mollusca, Bivalvia) (Correction to Opinion 94).

The Commission regrets that it cannot supply separates of Opinions.

R. V. MELVILLE
Secretary

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# POCKET GOPHERS OF THE GENUS *THOMOMYS* (RODENTIA: GEOMYIDAE) FROM THE PLEISTOCENE OF FLORIDA

Kenneth T. Wilkins

*Abstract.*—Fossil material of *Thomomys* pocket gophers from the Pleistocene of Florida is reported from three new sites. Mandibular material of *T. orientalis* from its type-locality is described for the first time. Comparison of *Thomomys* specimens indicates conspecificity of material from all four sites. Findings of this study extend the geographic range of extinct *T. orientalis* over much of northcentral peninsular Florida; the species is known chronologically from the late Irvingtonian to the middle Rancholabrean.

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The modern distribution of pocket gophers of the genus *Thomomys* is restricted to western and central North America (Hall 1981). However, *Thomomys* species of the subgenus *Plesiothomomys* ranged more widely eastward during the Pliocene and Pleistocene epochs (Kurten and Anderson 1980). Simpson's 1928 paper on the mammalian fauna of the Sangamonian Sabertooth Cave in Citrus County, Florida, contained the first report of *Thomomys* in the eastern United States. Simpson described the Sabertooth Cave species as *T. orientalis.* Extinct *T. potomacensis* material from the Irvingtonian Trout Cave locality in West Virginia and from the Irvingtonian Cumberland Cave in Maryland marks the apparent northeastern limits of the genus.

Recent field activities and re-examination of materials in the Florida State Museum Vetebrate Paleontology Collection at the University of Florida (catalogue numbers preceded by UF) have yielded specimens that allow a better understanding of the systematics and biogeography of Florida *Thomomys.* Additional *T. orientalis* material from Sabertooth Cave was found in the Florida Geological Survey Collection (catalogue numbers preceded by V; housed at the Florida State Museum); this material includes mandibular fragments and lower teeth. Because these materials were not available to Simpson, his description of *T. orientalis* was based solely on upper dentition and cranial features. This paper contains the description of the mandible and lower dentition of *T. orientalis.* Additionally, this paper reports *Thomomys* material from three other fossil localities in Florida.

## Localities of *Thomomys* in Florida

*Thomomys* fossils are now known from four deposits in northcentral peninsular Florida, including Sabertooth Cave. The other three deposits, briefly reported by Webb and Wilkins (1984), include the late Irvingtonian Coleman IIA locality (Sumter Co.) and the Rancholabrean sites Williston IIIB (Levy Co.) and Rock Springs (Orange Co.).

Martin (1974) described the geological setting and the mammalian fauna of the Coleman IIA locality, and Ritchie (1980) presented additional paleoecological information for this site. Martin noted the presence in this fauna of one species

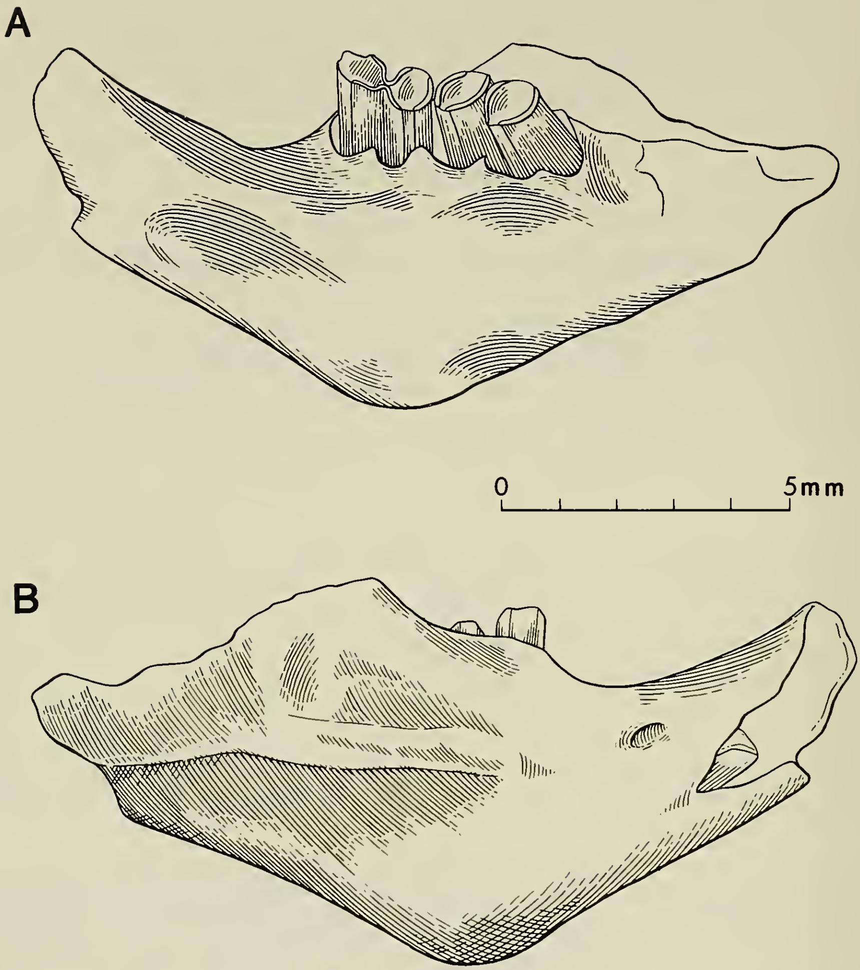

Fig. 1. Medial (A) and lateral (B) views of a right mandibular fragment (V-8657) of *Thomomys orientalis* from the Pleistocene type locality, Sabertooth Cave, Citrus Co., Florida.

of pocket gopher, *Geomys pinetis* (see Wilkins 1984), but not of *Thomomys.* Reexamination of the Coleman IIA geomyid material revealed a left mandibular fragment possessing $I_1$ and $M_1$–$M_2$ (UF 46569) which is referable to the genus *Thomomys* due to the presence of enamel bands on the anterior surfaces of the lower molars (Russell 1968). All other Coleman IIA geomyid material is *Geomys pinetis* with the possible exception of a fragmented edentulous dentary (UF 46570) for which generic identification is not possible. No upper dentition or other cranial material is available for the Coleman IIA *Thomomys.*

Both upper and lower skull material documents *Thomomys* from Williston IIIB, a deposit previously unreported in the literature. Robert A. Martin, who discovered the deposit in 1974 (pers. comm.), states that Williston IIIB was located in the same limerock mining pit as the Williston IIIA deposit described by Holman

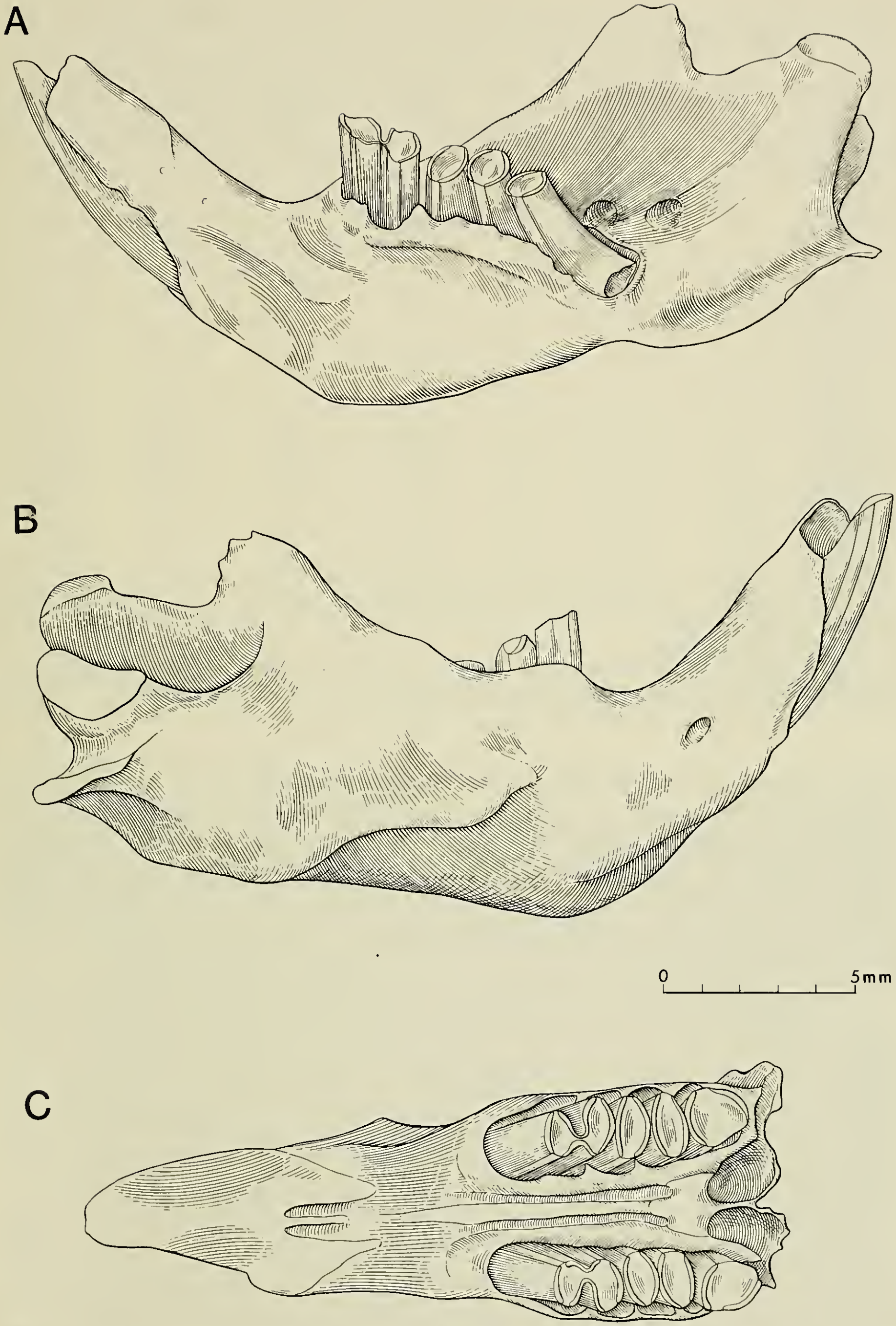

Fig. 2. Medial (A) and lateral (B) views of a right mandible (UF 46572), the most complete mandibular material known for *Thomomys orientalis,* from the Pleistocene Rock Springs locality, Orange Co., Florida. C: a rostral-palatal fragment of *T. orientalis* with complete maxillary dentition (UF 46567); from the Pleistocene Williston IIIB deposit in Levy Co., Florida.

Table 1.—Measurements (mm) of mandibles and lower dentition for 10 specimens of Pleistocene *Thomomys* pocket gophers from Florida.

| Site and catalogue number | Length diastema | Dentary width at P4 | Width I1 | Width ant. P4[1] | Width post. P4[2] | Length ant. P4 | Length P4 |
|---|---|---|---|---|---|---|---|
| Sabertooth Cave | | | | | | | |
| V-8656 | 7.2 | 4.9 | 1.62 | — | — | — | — |
| V-8657 | 4.9 | 3.8 | — | 0.97 | 1.30 | 0.91 | 1.88 |
| Coleman IIA | | | | | | | |
| UF 46569 | 7.9 | 4.9 | 1.67 | — | — | — | — |
| Williston IIIB | | | | | | | |
| UF 46568 | 6.4 | 4.7 | 1.45 | 1.18 | 1.67 | 1.10 | 2.08 |
| Rock Springs | | | | | | | |
| UF 46572 | 7.0 | 5.3 | 1.4 | 1.29 | 1.69 | 1.27 | 2.40 |
| UF 46573 | 7.1 | 5.2 | 1.4 | 1.21 | 1.82 | 1.30 | 2.40 |
| UF 46574 | 5.5 | 4.5 | 1.4 | 1.29 | 1.80 | 1.37 | 2.47 |
| UF 46576 | 6.2 | 4.5 | 1.5 | 1.21 | 1.79 | 1.27 | 2.43 |
| UF 46571 | 7.7 | 4.8 | 1.4 | — | — | — | — |
| UF 46575 | 5.1 | 3.9 | 1.1 | — | — | — | — |
| Range | 5.1–7.7 | 3.9–5.3 | 1.1–1.5 | 1.21–1.29 | 1.69–1.82 | 1.27–1.37 | 2.40–2.47 |

[1] "ant." denotes anterior.

[2] "post." denotes posterior.

[3] "RMF" denotes retromolar fossa, the depression located posterior to M3 and medial to the ascending ramus into which the temporalis muscle inserts.

(1959). Mining operations destroyed both sites after recovery of fossils. One left mandible with I$_1$–M$_1$ (UF 46568) is assigned to the genus *Thomomys* due to the presence of an anterior enamel band on M$_1$. Presence of a complete enamel band on the posterior surface of the P$^4$'s, as well as the nearly circular occlusal outlines of the M$^3$'s, indicates that a rostral-palatal fragment with left and right P$^4$–M$^3$ (UF 46567) should also be referred to *Thomomys. Geomys pinetis* is also present among the Williston IIIB fossils excavated by Martin (Wilkins 1984).

Two pocket gopher genera also occurred in the fauna of the Rock Springs stream deposits (Wilkins, in press). A single P$^4$ (UF 49205) documents the presence of *Geomys pinetis. Thomomys* was perhaps the more abundant gopher at Rock Springs as suggested by its representation by a greater number of specimens: six mandibles with partial to complete dentition (UF 46571–46576). Other papers treating aspects of the Rock Springs fossil vertebrate fauna include Gut (1939), Woolfenden (1959), Auffenberg (1963), Ray et al. (1963), and Webb (1974).

The holotype of *Thomomys orientalis* from Sabertooth Cave is the "front part of" a "skull with incisors and first two cheek teeth on each side" (Simpson 1928). Simpson's description did not address lower dentition or mandibular features. *Thomomys* specimens recovered from Sabertooth since the original species description include fragments of two right mandibles (V-8656 possessing only the incisor and V-8657 with P$_4$–M$_2$), five isolated M$^3$'s (V-8651–8655), nine isolated P$^4$'s (V-8660–8668), and eight isolated P$_4$'s (V-8669–8676). The more complete of the two Sabertooth Cave mandibles, V-8657, is depicted in Fig. 1. The molars

Table 1.—Extended.

| Length M1 | Width M1 | Length M2 | Width M2 | Length M3 | Width M3 | Alveolar distance P4–M2 | Depth RMF$^3$ | Age |
|---|---|---|---|---|---|---|---|---|
| — | — | — | — | — | — | 4.9 | 0.5 | adult |
| 0.90 | 1.52 | 1.06 | 1.43 | — | — | 4.0 | — | subadult |
| 1.12 | 1.85 | 1.28 | 1.78 | — | — | 4.8 | c. 0.4 | adult |
| 1.06 | 1.82 | — | — | — | — | 4.4 | c. 0.4 | adult |
| 1.11 | 1.86 | 1.23 | 1.79 | 1.17 | 1.42 | — | 0.5 | adult |
| 1.18 | 2.00 | 1.30 | 1.92 | — | — | — | — | adult |
| 1.13 | 1.86 | 1.36 | 1.84 | — | — | — | 0.8 | adult |
| 1.17 | 1.94 | — | — | — | — | — | — | adult |
| 1.17 | 2.21 | — | — | — | — | — | 0.9 | adult |
| — | — | — | — | — | — | — | 0.8 | subadult |
| 1.11–1.17 | 1.86–2.21 | 1.23–1.36 | 1.79–1.92 | | | | 0.5–0.9 | |

of this subadult specimen possess anterior enamel bands, a feature distinguishing *Thomomys* from *Geomys,* which is also represented at this site.

## Comparison of Florida *Thomomys* Material

*Thomomys* specimens from these four Pleistocene sites are similar in qualitative features. All specimens are consistent with the patterns of enamel band deployment on cheekteeth diagnostic of the genus *Thomomys* (Russell 1968). Furthermore, occlusal surface outlines of the cheekteeth from all four deposits demonstrate the smooth ovate ("sub-crescentic") outline of the subgenus *Plesiothomomys* rather than the labial (upper cheekteeth) or lingual (lower) constrictions (i.e., "pear shape") characteristic of the subgenus *Thomomys* (see Russell 1968:519).

Mensural comparison of mandibular and lower dentition features also indicates great similarity of specimens from these four deposits. Using a Gaertner measuring microscope or Helios dial calipers as appropriate, as many as possible of fifteen characters (see Wilkins 1984) were measured for ten mandibular specimens (Table 1). Rock Springs offers the largest sample (n = 6). The small size of the other three samples coupled with the fragmentary nature of most specimens precludes statistical analysis of data. Yet, there is high similarity and, in some features, considerable overlap in values among some or all samples. The greatest discrepancies, shown by Sabertooth specimen V-8657 and Rock Springs specimen UF 46575, can be attributed to their younger ontogenetic ages as indicated by incisor width and by other features. Using incisor width as an indicator of ontogenetic age in pocket gophers, Wilkins (1984) demonstrated the necessity of making quantitative morphological comparisons only among samples containing individuals of similar age because many osteological and dental features vary significantly with age.

Although the two subadult specimens differ quantitatively from the adult specimens, the subadults are similar to each other in mensural values. Sexual dimorphism is another likely contributor to the variation seen among these samples.

The preceding comparisons suggest that the *Thomomys* specimens from Coleman IIA, Williston IIIB, and Rock Springs are not morphologically distinct from the Sabertooth Cave material. All *Thomomys* material from these four Pleistocene sites is, therefore, referred to *Thomomys orientalis.* The most complete mandibular material of this species that is currently available from the Florida Pleistocene is a nearly complete right dentary (lacking only a portion of the coronoid process) with full dentition (UF 46572; Fig. 2A, B). The complete left and right upper cheektooth dentition of *T. orientalis* is represented in the rostral-palatal fragment (UF 46567) of an adult from Williston IIIB (Fig. 2C); features shared by this specimen and the holotype (AMNH 23441) from Sabertooth Cave are very similar. Therefore, the range of *T. orientalis* is extended geographically to include much of north-central peninsular Florida. The chronological distribution of *T. orientalis* spans at least that portion of the Pleistocene from the late Irvingtonian to the middle Rancholabrean.

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# *COLUMBINIA VASQUEZI*, A NEW CLAUSILIID LAND SNAIL FROM BOLIVIA

Fred G. Thompson

*Abstract.*—*Columbinia vasquezi,* new species, is described from Bolivia. It belongs to a species-complex that includes *C. bartletti* (Adams), *C. reyrei* (Jousseaume), *C. huancabambensis* (Rolle), *C. binkiae* (Pilsbry) and *C. juninensis* (M. Smith). The complex is distributed along the eastern slope of the Andes from Ecuador to Bolivia. The generic radiation of the South American Clausiliidae, Subfamily Neninae is characterized, in part, by reproductive specialization.

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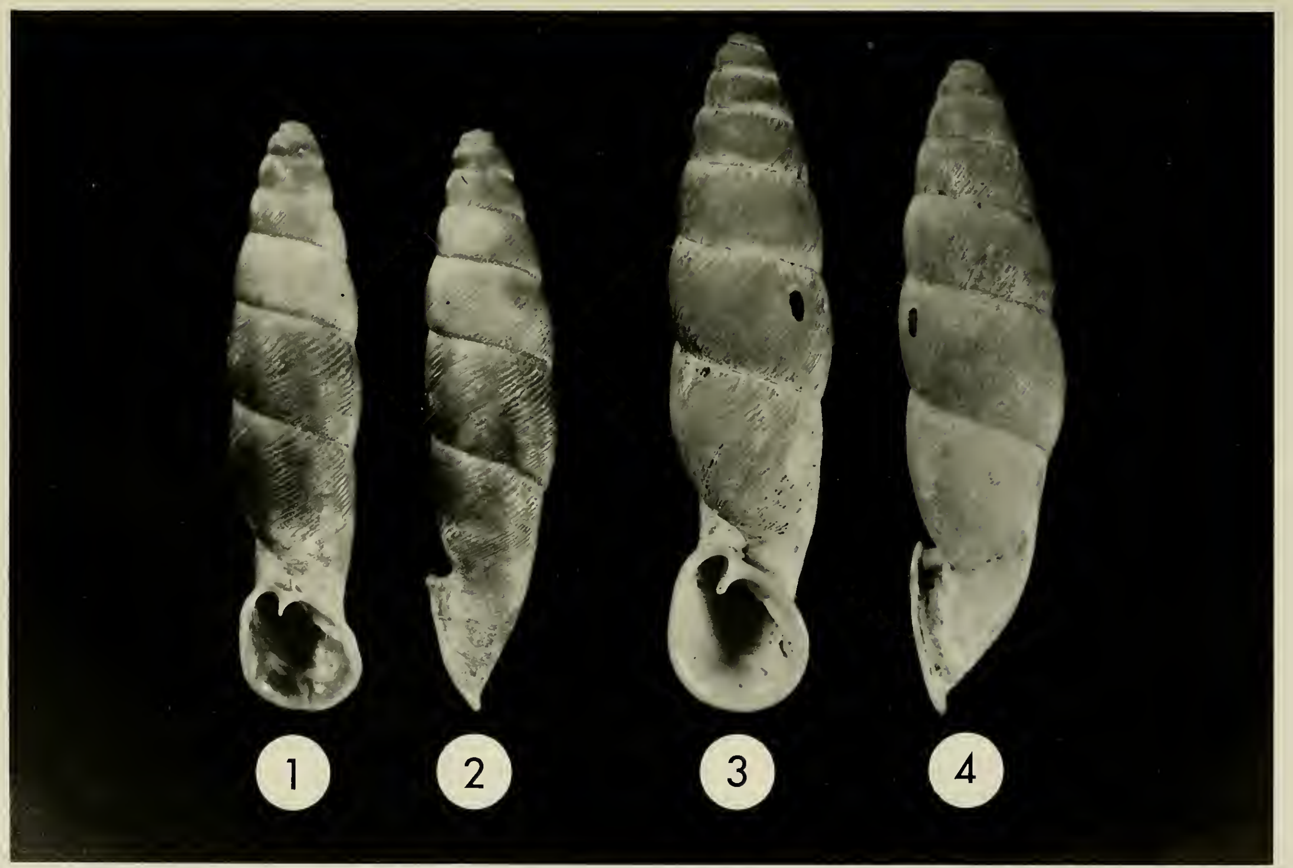
Recently, while conducting field work in central Bolivia, I collected an undescribed species of clausiliid land snail in the lowland rainforests near Villa Tunari. I take great pleasure in naming this interesting species after Sr. Roberto Vasquez of Santa Cruz, Bolivia, a well known authority on Bolivian Orchidacea and Cactacea. Sr. Vasquez was highly instrumental in the success of my field work, and was a generous and courteous host.

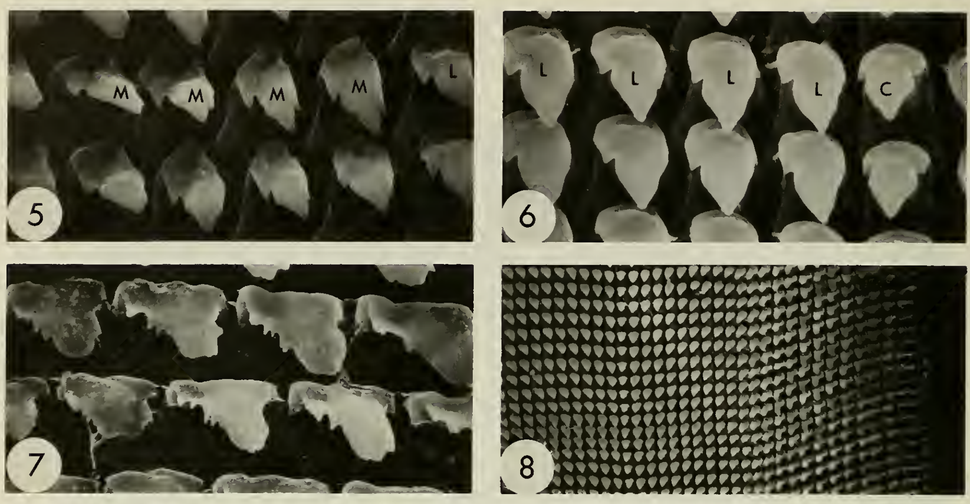
## *Columbinia vasquezi,* new species

*Shell* (Figs. 1, 2).—Moderately obese; fusiform with bluntly pointed apex. Moderate sized for genus, about 23–28 mm long, and 0.24–0.26 times as wide as high. Surface shiny. Color light brown. Interior of aperture and lamella light brown. Peristome white. Whorls 7.2–7.9. Suture moderately impressed. Embryonic whorls 2.2. First whorl smooth; next embryonic whorl with fine arcuate striations. Following postembryonic whorls sculptured with fine oblique riblets tending to be slightly wavy and occasionally broken. Riblets diminishing in size near upper suture. Spaces between riblets densely sculptured with minute granules. Riblets closely spaced, about 3/mm on middle of shell. Penultimate whorl with 31–55 riblets (31 in holotype). Neck of last whorl broad and relatively short compared to most species in genus (Fig. 2); with elongate indentation externally between superior and inferior lamella.

Aperture ovate in shape, narrower than shell. Aperture 0.79–0.84 times as high as wide; 0.25–0.28 times length of shell. Plane of aperture oblique; projecting forward 2–3 mm beyond periphery of shell (Fig. 2). Peristome moderately reflected. Superior lamella high, concave along its peripheral curvature; extending to edge of peristome; forming rather wide sinus with posterior corner of aperture. Superior lamella continued by slight flex with spiral lamella. Spiral lamella moderately high and thin; separated from principal plica by narrow gap about 0.5 mm wide. Inferior lamella thick and high internally, sloping to inner wall of outer lip. Subcolumellar lamella visible from aperture. Lunella strongly arched; highest near principal plica; diminishing as it approaches end of subcolumellar lamella, two barely in contact. Principal plica high and narrow, about one-half whorl in length; extending almost to peristome. Clausilium generalized in shape, spatulate, concave along outer surface; attached to columella one whorl below aperture.



Figs. 1–4. 1, 2, *Columbinia vasquezi* Thompson, new species, holotype (UF 40309); 3, 4, *Nenia juninensis* Smith [=*Columbinia juninensis* (Smith)]; holotype (UF 47868).



Figs. 5–8. *Columbinia vasquezi* Thompson, new species, radula (UF 40322, SEM mount): 5, Marginal teeth (M), ×735; 6, Central teeth (C) and lateral teeth (L), ×735; 7, Outer marginal teeth, ×735; 8, Hemisection of radula showing weakly arched transverse tooth rows, ×106.

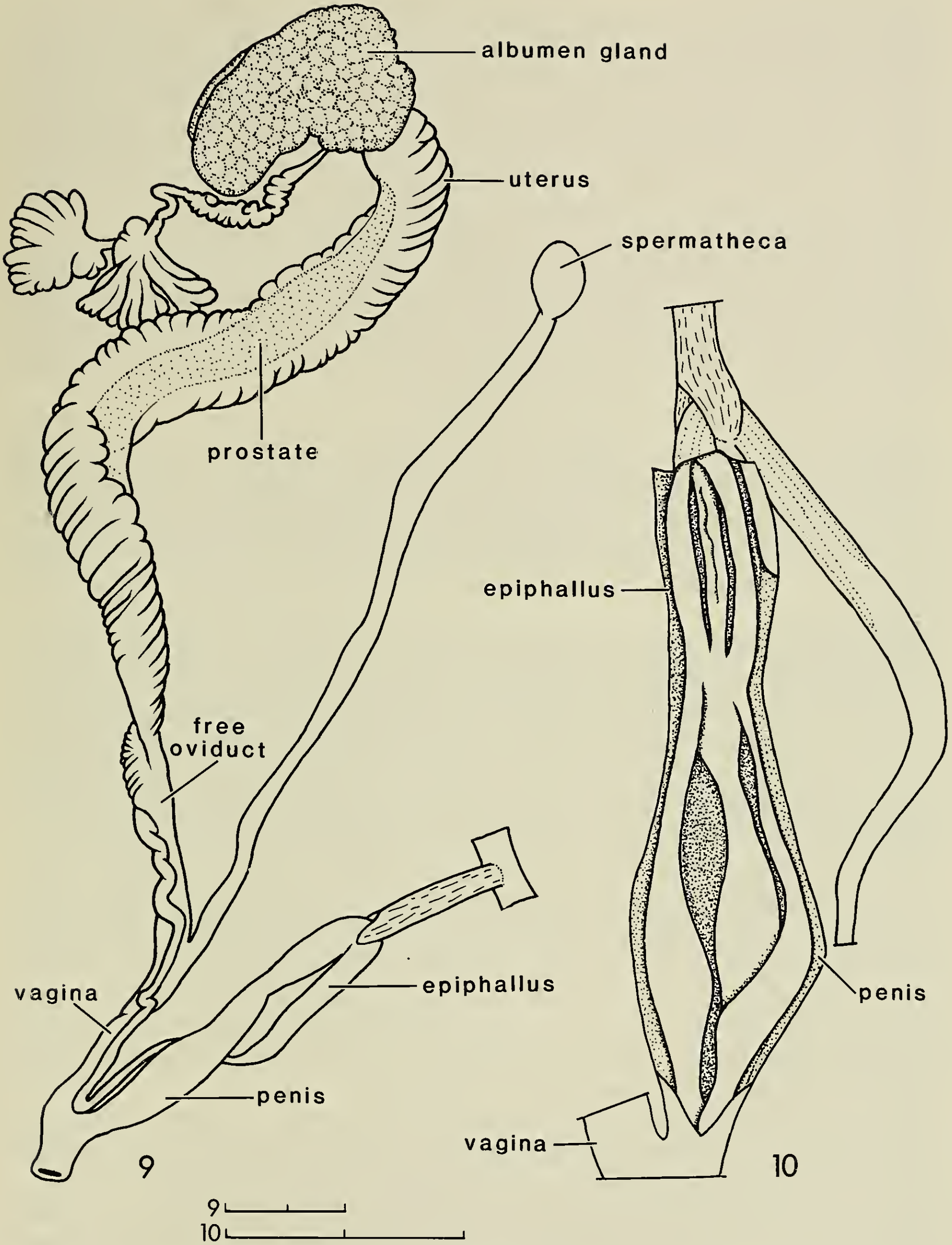
Measurements in mm for *C. vasquezi* and the holotype of the closely related *C. juninensis* (M. Smith) (UF47868) are given below.

| *C. vasquezi* | length | width | apert. h. | apert. w. | whorls |
|---|---|---|---|---|---|
| holotype | 27.3 | 6.6 | 6.9 | 5.3 | 7.9 |
| paratype | 23.7 | 6.2 | 6.3 | 5.0 | 7.2 |
| paratype | 24.9 | 6.4 | 6.9 | 5.8 | 7.2 |
| *C. juninensis* | 30.4 | 7.7 | 7.8 | 6.2 | 7.8 |

*Radula* (Figs. 5–8).—One specimen examined. Ribbon 2.36 mm long by 0.74 mm wide. Teeth arranged in 144 weakly arched transverse rows (Fig. 8). Central tooth (Fig. 6C) tricuspid with large broadly pointed mesocone and small ectocone on each side near base. Lateral teeth (Fig. 6L) 10 per half row; bicuspid with large mesocone similar to central tooth, and with single small ectocone. Marginal teeth (Fig. 5M) 16 per half row; essentially tricuspid, but cusps weakly differentiated except for mesocone; accessory cusps and indentations may be present on outermost teeth (Fig. 7).

*Reproductive system* (Figs. 9, 10).—The following description is based on a single specimen (UF 40322) from the type locality. Fragments of its shell are catalogued with the paratypes (UF 40598).

Left ocular retractor muscle passing through atrium of reproductive system. Ovotestis a large compact mass imbedded in digestive gland 3 whorls above albumen gland; consisting of multiple bifurcate and trifurcate alveoli. Hermaphroditic duct strongly convoluted along lower half near albumen gland. Talon and carrefour completely imbedded in albumen gland. Albumen gland relatively large, massive, 4.7 mm long. Uterus with strongly differentiated convolutions. Spermathecal sac oval, 1.1 mm long, lying along columellar side of prostate just below albumen gland. Spermathecal duct slender, 13.5 mm long, without diverticulum; entering vagina about ⅖ of distance below. Free oviduct 2.3 mm long. Vagina 2.9



Figs. 9, 10. *Columbinia vasquezi,* new species, reproductive system: 9, Entire reproductive anatomy; 10, Male system showing internal structure of penis and epiphallus. Scales = 2 mm.

mm long, slender. Appendix absent on free vagina or oviduct, such as occurs in *Hericena and Steeriana* (Loosjes and Loosjes-Van Bemmel 1966). Lower ⅔ of penis bulbous, separated by slight constriction about ⅓ of distance from penis retractor to base. Upper ⅓ slender and nearly uniform in width. Penis tightly folded back along itself as epiphallic segment at insertion of penis retractor muscle.

Epiphallus above penis retractor cylindrical and rapidly tapering into vas deferens at top of bulbous penis base. Total length of penis 9.0 mm; epiphallic segment 3.2 mm. Interior of penis bulb with 3 large pilasters arranged slightly spiral to each other (Fig. 10). Upper ⅓ of penis above constriction with 4 similar but smaller pilasters continuing into middle of epiphallic segment. Remainder of ephiphallic segment interior covered with small papillae. Penis retractor muscle short, originating on lower surface of lung; bifurcate where it inserts on penis. Penis sheath absent, such as occurs in *Nenia* (Thompson, in press).

*Type-locality.*—Bolivia, Departamento de Cochabamba, Providencia de Chapare, 15 km southwest of Villa Tunari, 440 m alt. The type-locality is at the base of a hill in a secondary rainforest. Snails were found on bushes in a dense thicket. HOLOTYPE: UF 40309, collected 10 Dec 1982 by Fred G. Thompson. PARATYPE: UF 40598, same data as the holotype.

*Remarks.*—*Columbinia vasquezi* is most similar to *C. juninensis* (M. Smith, 1943) (Figs. 3, 4). The latter differs from *C. vasquezi* by its larger size, its shallower suture, particularly along the upper whorls, its vertical aperture, and its sculpture. In *C. juninensis* the sculpture consists of fine, poorly differentiated wavy riblets that anastomose freely. Granular sculpture, such as occurs in *C. vasquezi* is absent, but the holotype of *C. juninensis* is worn, and the finer sculpture may have been obscured.

The original illustration of *C. juninensis* does not depict correctly the shell, and one would have difficulty identifying the species by referring to the original description. In most respects it is similar to *C. vasquezi* except as noted above. The holotype of *C. juninensis* (UF 47868) is illustrated for the purpose of comparing it with the new species. Smith (1943) mentions two specimens in addition to the holotype. One paratype (UF 49361) is in his collection, which was transfered recently from the University of Alabama to the Florida State Museum.

Weyrauch (1956:114–115) suggests that *C. bartletti* (Adams, 1866), *C. reyrei* (Jousseaume, 1887), *C. huancabambensis* (Rolle, 1904), *C. binkiae* (Pilsbry, 1949), and *C. juninensis* (M. Smith, 1943) all may be related subspecifically because of similarities in shape. They come from widely scattered localities in Ecuador and Peru. I do not agree on the basis of published data that they are so overwhelmingly similar. All are known from only a few specimens, intergradation between any two of these taxa has not been demonstrated, and their differences are not clinal. *Columbinia vasquezi* is a member of this complex.

This is the first detailed description of the reproductive anatomy of species of *Columbinia* (s.s.). Too little is known about the anatomy of neotropical clausiliids to permit interspecific comparisons. Loosjes and Loosjes-van Bemmel (1966:45) report on the anatomy of *C. bryantwalkeri* (Pilsbry). Their description is incomplete because of the state of preservation of their material. The information they provide is consistent with the following description of *C. vasquezi,* except that they do not give measurements for various structures. It is apparent that considerable diversity in the male and the female reproductive systems exists at the generic level, indicating that reproductive specialization has been a major factor underlying generic radiation within the subfamily Neniinae. *Columbinia* is a highly specialized genus that has undergone simplification of the female system through loss of the diverticulum from the spermathecal duct, along with elaboration of the male system through the development of enlarged and size-differentiated pilasters within the penis and epiphallus. In more generalized genera, such as *Nenia* and *Nenisca* (Baker 1961; Loosjes and Loosjes-van Bemmel 1966; Thompson, in press) the spermathecal duct bears a large diverticulum, the penis has a penis sheath, and the pilasters within the penis are nearly uniform in size and continue uninterrupted through the length of the epiphallus.

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I wish to thank Kurt Auffenberg for the SEM micrographs that comprise Figs. 5–8 and for other assistance in completing this manuscript. Norris H. Williams and Charlotte M. Porter assisted me with field work in Bolivia. Much of the success of our work in Bolivia would not have been possible without the help of Sr. Roberto Vasquez, to whom we are all grateful.

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# THE SYSTEMATIC STATUS OF *SYRRHOPHUS JUNINENSIS* SHREVE (ANURA: LEPTODACTYLIDAE)

David C. Cannatella

*Abstract.*—*Syrrhophus juninensis* Shreve is shown to be referable to the genus *Phrynopus* of the tribe Eleutherodactylini, rather than its current placement in *Telmatobius* of the Telmatobiini. The species is known from the departments of Junín and Pasco in central Andean Peru.

Shreve (1938) described *Syrrhophus juninensis* and *Syrrhophus montium* from Cascas, Peru. He noted that both species possessed a broad cartilaginous sternum and T-shaped terminal phalanges, but lacked prevomerine teeth. At that time, these characters defined the genus *Syrrhophus.*

Most of the South American *Syrrhophus* were referred to *Eleutherodactylus* in the years that followed the publication of Gorham's (1966) checklist. The species *montium* was placed in *Niceforonia* by Lynch (1968) and ultimately in *Phrynopus* (Lynch, 1975). However, the history of the species *juninensis* is more confused. Lynch (1968) transferred the species to *Eupsophus,* noting that it was similar to *Eupsophus peruanus* and *E. wettsteini.* He cited several osteological and morphological characters to support his opinion, but did not list any specimens examined. He followed this opinion in his 1970 revision of the genus *Syrrhophus,* and in his monograph of the Leptodactylidae (1971). However, in Lynch (1969) he had previously moved *wettsteini* to the genus *Niceforonia* without explanation, retaining *juninensis* and *peruanus* in *Eupsophus.*

Lynch's (1972) redefinition and partition of *Eupsophus* retained *juninensis* in the genus and supported the transfer of *wettsteini* to the genus *Niceforonia* on osteological features. The poorly known species *peruanus* was retained provisionally in *Eupsophus.* Lynch stated that he had examined skeletons of *juninensis,* presumably MCZ 24360. In his 1975 revision, Lynch placed the genus *Niceforonia* under the synonymy of *Phrynopus,* thus the species *wettsteini* became *Phrynopus wettsteini.* The species *peruanus* was also transferred from *Eupsophus* to *Phrynopus.*

Finally, Lynch (1978) transferred *juninensis* to *Telmatobius* in his analysis of relationships of the lower telmatobiine frogs. He provided no data to support this conclusion, other than the statement (page 51) "Osteologically, *juninensis* agrees with *Telmatobius* rather than *Alsodes* or *Eupsophus.*"

I have examined the holotype and some paratypes of *Syrrhophus juninensis,* and conclude that it is referable to the genus *Phrynopus.* Fourteen of the species in the genus were discussed by Lynch (1975), and two more were described by Cannatella (1984).

### *Phrynopus juninensis* (Shreve), new combination
Fig. 1

*Holotype.*—MCZ (Museum of Comparative Zoology) 22851, male, snout–vent length (SVL) = 30.6 mm, from "Cascas near Huasihuasi, Department of Junin, Peru."

Fig. 1. Dorsal and ventral views of *Phrynopus juninensis,* female, KU 138880, SVL = 41.3 mm.

*Paratypes.*—MCZ 22852–7, same locality data as the holotype. I have examined MCZ 22852–53; José Rosado of the MCZ informed me that 22854–57 were traded to the Field Museum of Natural History, E. H. Taylor, the University of Michigan Museum of Zoology, and the British Museum (Natural History), respectively.

*Referred specimens.*—MCZ 24360–61, 24009–10; KU 138880-81.

*Diagnosis.*—(format of Lynch, 1975) A large species of *Phrynopus* (male SVL 22.0–30.6 mm, female 41.3 mm); skin of dorsum smooth or barely areolate; venter smooth; thumb about equal in length to second finger; toes lacking basal webbing and lateral fringes; two metatarsal tubercles, outer much smaller than inner; tarsus lacking tubercles or fold; tympanum, tympanic annulus, and middle ear structures absent; snout rounded in lateral profile; vocal slits absent; prevomerine teeth absent, dentigerous ramus thin, sliver-like; frontoparietals widely separated, lacking crests; nasals small, separated medially; anterior ramus of parasphenoid not reaching level of palatines; median ramus of pterygoid narrowly separated from parasphenoid ala; in life, dark brown above and below with tan spots above and silvery-white flecks below; lips pale grayish tan with dark brown bars; iris bronze (KU 138880–81).

*Justification of taxonomy.*—The above systematic rearrangement requires some explanation, especially because *Telmatobius* is in the tribe Telmatobiini and *Phrynopus* is a member of the tribe Eleutherodactylini. Lynch (1971) noted there are no morphological features that define the Eleutherodactylini; however, those genera for which data are available have direct development. Many of the genera have T-shaped terminal phalanges. The Telmatobiini as conceived by Lynch (1978) is one of the three tribes of "lower" telmatobiines: the Calyptocephalellini, Batrachylini, and Telmatobiini. The latter tribe is paraphyletic with respect to the Batrachylini and is defined by primitive features. All members of the Telmatobiini have knobbed, rather than T-shaped terminal phalanges.

Shreve (1938) noted the presence of a cartilaginous sternum and "more-or-less" T-shaped terminal phalanges in the description of *Syrrhophus juninensis.* Examination of a cleared and stained specimen and radiographs of the holotype have confirmed the phalangeal condition. Removal from the genus *Telmatobius* is justified because only knobbed terminal phalanges are present in that genus. Furthermore, the skulls of the several species of *Telmatobius* that were examined all have very long, recurved fang-like teeth, small, sickle-shaped nasals, long frontoparietals with medial borders that are parallel, the median ramus of the pterygoid abutting squarely on the otic capsule, and a reduced otic process of the squamosal.

In *Phrynopus juninensis,* the teeth are slightly pointed, but nevertheless are short and pedicellate. The nasals are rounded, and the frontoparietals are much shorter and diverge anteriorly. The median ramus of the pterygoid does not contact the otic capsule, and the otic process of the squamosal is well-developed.

Lastly, as Lynch (1978) noted, *juninensis* has no webbing on the feet; the many species of *Telmatobius* all have webbed feet. From the above evidence there is no basis for assignment to the genus *Telmatobius.*

According to Lynch (1971, 1975) the following genera of leptodactylids have T-shaped terminal phalanges: *Batrachyla, Crossodactylus, Eleutherodactylus, Hylodes, Lithodytes, Megaelosia,* some *Phrynopus* species, *Sminthillus, Syrrhophus, Thoropa,* and *Tomodactylus.* These genera can be separated from *Phrynopus juninensis* as follows (the states of *juninensis* are in parentheses): *Sminthillus* has partially fused epicoracoid cartilages (completely overlapping in *juninensis*). *Lithodytes,* a leptodactyline, has a bony sternum (cartilaginous). *Batrachyla* lacks a quadratojugal (present) and *Thoropa* has dilated sacral diapophyses (narrow). The Elosiinae (*Crossodactylus, Hylodes,* and *Megaelosia*) have dermal scutes present on the dorsal surfaces of the digits (absent). *Eleutherodactylus, Syrrhophus* and *Tomodactylus* have circumferential grooves on digital pads.

Moreover, the species *juninensis* fits easily among the species currently assigned to *Phrynopus,* as evidenced by the following: the presence of T-shaped terminal phalanges, lack of circumferential grooves on the digital pads, cartilaginous sternum, and non-fused epicoracoid cartilages. Lastly, on an admittedly subjective basis, the species looks very much like a *Phrynopus,* and not at all like most of the genera discussed above.

*Distribution.*—The species is known from the departments of Pasco and Junín in central Andean Peru.

*Remarks.*—The holotype (a non-reproductive male) agrees very well with Shreve's original description, and a redescription is not necessary. The dorsal markings of the holotype and two paratypes that were examined are noteworthy. There is a dark brown interorbital bar, to which is connected a middorsal bar that extends to the level of the suprascapula. There is also a dorsal x-shaped blotch. The other three non-typical MCZ specimens lack the dorsal markings.

The KU specimens have the same dorsal markings as the type-series. These frogs have a dark brown stripe along the canthus, upper eyelid, and supratympanic fold that is more evident than in the type-series. A dark suborbital bar is present and the supratympanic fold is very distinct. The ventral ground color in preservative is the same as that of the dorsum, with the exception of scattered tan flecks in the pectoral and chin regions. KU 138880 is an adult female with highly coiled oviducts.

The KU specimens were collected under rocks in a grassy area of the valley floor. *Bufo spinulosus* and *Gastrotheca griswoldi* were collected sympatrically (W. E. Duellman field notes, 23 Jan 1971).

*Other specimens examined.*—PERU: Junín: Maraynioc (=Marainiyoc), 45 miles NE Tarma, 12,000′, MCZ 24360 (cleared and stained), 24361; Jachahuanca, MCZ 24409–10; Pasco: 14 km SW Paucartambo, 3650 m, KU 138880–81.

Osteological material of *Telmatobius*: *arequipensis,* KU 164078; *barrioi,* KU 128880; *cirrhacelis,* KU 165989; *jelskii,* KU 164081; *hintoni,* KU 160190–91; *marmoratus,* KU 135903, 164079; *niger,* KU 131796; *peruvianus,* KU 162114; *schreiteri,* KU 160885; *simonsi,* KU 160139; sp., KU 164083, 181536.

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# *CABIROPS MONTEREYENSIS,* A NEW SPECIES OF HYPERPARASITIC ISOPOD FROM MONTEREY BAY, CALIFORNIA (EPICARIDEA: CABIROPSIDAE)

Clay Sassaman

*Abstract.*—*Cabirops montereyensis* is described on the basis of cryptoniscus larvae and immature females from Monterey Bay, California. This cabiropsid isopod is a parasite of the bopyrid isopod *Aporobopyrus muguensis* Shiino, and is the first member of the genus described from the northeastern Pacific Ocean. The cryptoniscus of *C. montereyensis* is very similar in morphology to those of *C. codreanui* Bourdon and *C. orbionei* Bourdon, species from the North Atlantic and Indian Oceans respectively, and generally resembles other species parasitic on pseudionine bopyrids.

*Cabirops* Kossmann (1884) is the type-genus of the Cabiropsidae, a family of Cryptoniscina* parasitic upon other isopods. *Cabirops* species are typically parasitic within the marsupia of bopyrid isopods which are branchial parasites of decapod shrimps and crabs. The genus is presently known from eleven named species (for recent reviews see Lemos de Castro 1970; Restivo 1975) and four partially described species which have been assigned to the genus but not named (Bonnier 1900; Shiino 1942; Romano 1953; Bourdon 1966). No *Cabirops* species have yet been described from North American waters or from any part of the eastern Pacific Ocean. Markham (1979), however, has indicated the presence of one species in Bermuda (on the basis of an immature female).

Cryptoniscus larvae typical of the Cryptoniscina have occasionally been encountered in collections of the bopyrid isopod *Aporobopyrus muguensis* Shiino from Monterey Bay, California. In two instances these larvae were associated with female hyperparasites within the brood pouch of *A. muguensis* (a branchial chamber parasite of the porcellanid crabs *Pachycheles rudis* Stimpson and *P. pubescens* Holmes). The morphology of the females and the cryptoniscus stage individuals identify this form as a *Cabirops.* It differs from all known species of the genus, and is here described as a new species, *Cabirops montereyensis.*

A brief review of the valid species of *Cabirops* suggests two groups on the basis of coxal plate dentition patterns and the morphology of the dactyli of the anterior two pairs of peraeopods. The first of these groups (to which *C. montereyensis* is assigned) is associated with pseudionine and orbionine hosts; the second is associated with ionine and bopyrine hosts.

## *Cabirops montereyensis,* new species
Figs. 1A–G, 2A–G, 3A–B

*Cryptoniscus*: *General body form.*—1.0–1.2 mm long by 0.40–0.48 mm wide. Body tear-drop shaped and widest at peraeonal segment IV. Head length ap-

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* I retain here the classification of Nielsen and Stromberg (1965) rather than the recently proposed unification of their 7 families within Liriopsidae (Bowman and Abele 1982).

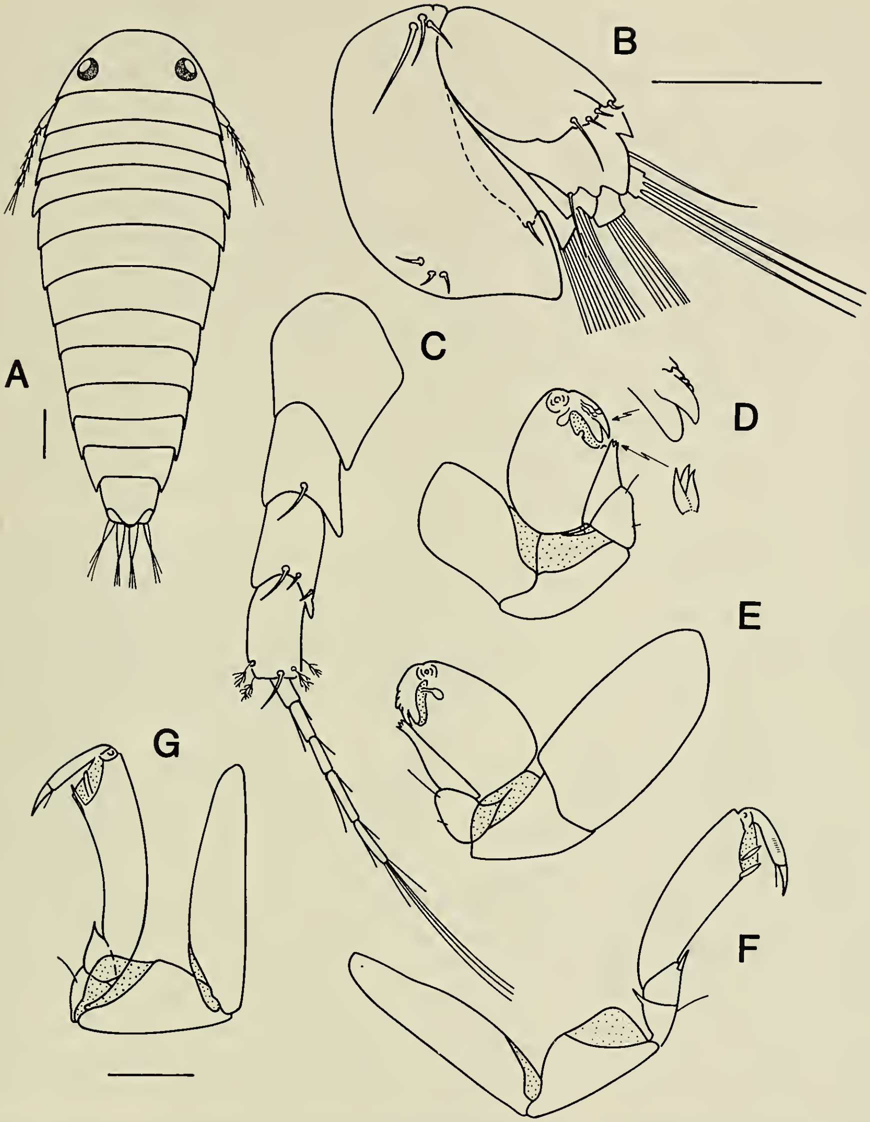

Fig. 1. *Cabirops montereyensis* n. sp. Cryptoniscus stage larva. A, Dorsal aspect of the entire larva (scale bar is 0.1 mm); B, First antenna in ventral view (scale is 0.05 mm); C, Second antenna; D, Peraeopod I; E, Peraeopod II; F, Peraeopod III; G, Peraeopod IV. (C–G are to the scale shown at the bottom of the figure—0.05 mm.)

proximately ⅐ total body length. Most cuticular surfaces marked by distinct striations, especially visible on dorsum, coxal plates, and basal articles of peraeopods I and II. Second antenna (excluding terminal setae) reaches to posterior border of peraeonal segment III. Pericardium in pleonal segments 3 and 4.

*Cephalon.*—Anterior margin broadly rounded. Eyes in form of crystalline cup surrounded by pigment. Oral cone directed toward anterior. Antenna 1 of 3 articles with bifurcate flagellum. First article crescent-shaped and broadly touching contralateral one. Six ventrally directed setae, 3 at anterolateral corner and 3 along posteromedial border. Anterolateral setae differ in size, medial seta longest and lateral seta shortest. Setae along posteromedial border smaller than those at anterolateral corner. Second article of antenna 1 with complex pattern of cuticular ridges or shelves elaborated into posterolateral teeth. Four setae in row along lateral border of most ventral shelf, 2 located medially on more dorsal shelves, one of these setae beneath first article in ventral view. Dorsal to second article are flagellar processes bearing groups of setae, and large aesthetasc bundle. First 2 articles of antenna 1 overlap (in ventral view) basal article of antenna 2. Antenna 2 with 4 peduncular and 5 flagellar articles. First peduncular article broadly rounded at anterior margin and bearing distinct apophysis on posteromedial edge. Second article with strong apophysis and one stout ventral seta. Third article with smaller process in form of wide spine and with 3 stout setae. Fourth article with one ventral stout seta and 2 medial and 2 lateral sensory setae near distal tip. Proximal flagellar article much shorter than distal 4. Distal end of first, third, and fourth flagellar articles with 2 setae, second with only one apparent, fifth with 3 long terminal setae and 2 short lateral setae.

In live animals the antennae are normally held perpendicular to the long axis of the body. The outer flagellar articles of the first antenna are held laterally and the aesthetasc bundle is periodically erected as a fan-shaped cone. The second antennal peduncle is held horizontally, with the flagellum at an angle of about 45 degrees to the vertical. The antennae are periodically pulled ventrally; this action is accompanied by stroking or grooming of the antennal processes by the first three peraeopods.

*Peraeon.*—Peraeonal segments with toothed coxal plates. Number of denticles in successive plates as follows: 1:2, 2:3, 3:3, 4:3, 5:3, 6:1, 7:1. Outer tooth in first plate and middle tooth of second plate broadly spatulate. Peraeopods I and II gnathopodal, with massive propodi and complex dactyli. Tips of dactyli bifid, outer branches pointed, inner branches bluntly rounded. Outer edges of dactyli rugose. Peraeopods III–VII ambulatory, with bases and propodi long and thin. Propodi with long axes curved, but with inner and outer edges diverging only slightly toward distal end in peraeopods III–V. Propodi of peraeopods VI and VII tapering toward distal tip. Dactyl of PIII with comb of small setae, other dactyli without. Dactyli of PIII–V with terminal claw and one small seta on inner margin. Dactyli of PVI and PVII bifid, one branch recurved. Outer edge of dactyl of PVI broadly rounded, on PVII slightly sinusoidal in outline.

*Pleon.*—Pleopods natatory with sympod, endopod and exopod. Sympod with 2 medially directed smooth setae, exopod with 5 plumose setae (4 posterior, one on posterolateral edge). Posterolateral seta of exopod minute on pleopod 1, well-developed on pleopods 2–5. Endopod with 5 plumose setae on pleopods 1–4, 3 on pleopod 5. In life, pleon occasionally flexed ventrally, at which time pleopods groomed by inner faces of peraeopods VI and VII. Pleotelson quadrangular, posterior edge entire. Uropodal basis with minute hairs along lateral border and with 2 posterior spines. Endopod slightly less than twice length of exopod, bearing 5 or 6 sensory setae set in shallow groove near dorsolateral corner of its base. Fringe of setae along medial margin of endopod. Exopod of uropod with 2 long, one medium, and 2 short terminal spines. Exact pattern of terminal spination of

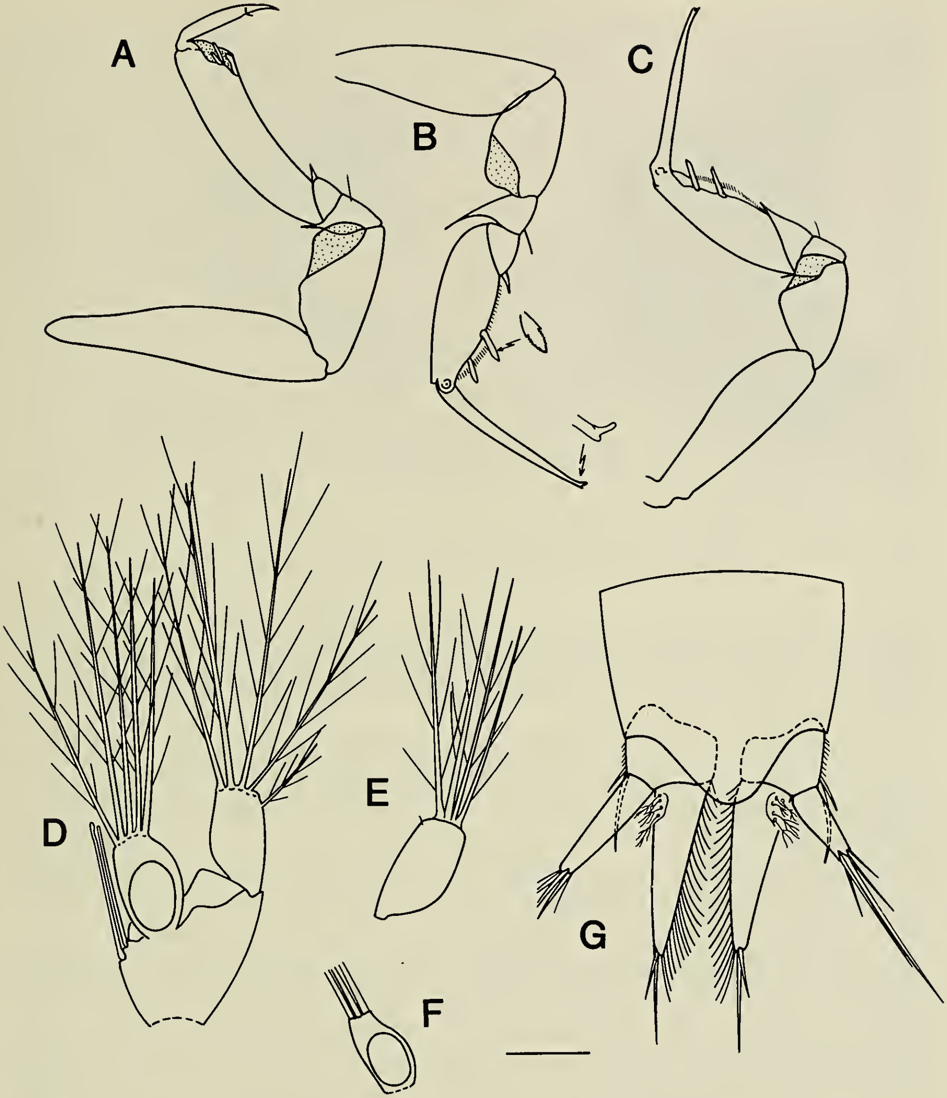

Fig. 2. *Cabirops montereyensis* n. sp. Cryptoniscus stage larva. A, Peraeopod V; B, Peraeopod VI; C, Peraeopod VII; D, Pleopod 2; E, Exopod of pleopod 1; F, Endopod of pleopod 5; G, Pleotelson (Dorsal aspect). All to the same scale (0.05 mm).

endopod obscured by medial fringe of setae, but several short terminal spines apparent.

*Female*: *Immature stage A.*—Body only slightly curved ventrally, broadly crescent-shaped in lateral aspect. Cephalon in form of distinct, hood-shaped rostrum. No appendages evident. Peraeon indicated by series of deep, ventral furrows and 7 large, fleshy, dorsal lobes. First dorsal lobe indented and hood-shaped, remaining lobes approximately conical. Lobes IV–VI larger than others. No trace of peraeonal

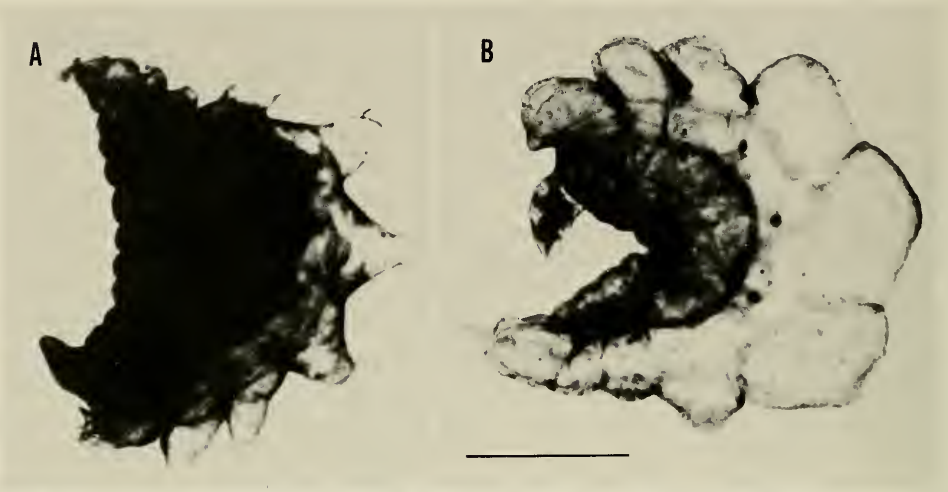

Fig. 3. *Cabirops montereyensis* n. sp. Females. A, Immature female—Stage A, paratype (USNM 205285); B, Immature female—Stage B, paratype (USNM 205283). Scale bar is 0.5 mm.

appendages. Longitudinal tracks of chitinous ribbing along bases of dorsal lobes. Transverse tracks along ventrolateral margins of peraeonal segments. Pleon indicated by 4 ventral furrows and 4 weakly defined dorsal lobes, followed by fleshy, conical tail piece.

*Immature stage B.*—Body in lateral aspect highly recurved into characteristic U-shape of *Cabirops* females. Dorsal peraeonal lobes more inflated than in previous stage, ventral furrows less distinct. Chitinous ribbing more distinct. No appendages.

*Host.*—*Aporobopyrus muguensis* Shiino. In branchial cavity of the porcellanid crabs *Pachycheles rudis* Stimpson and *Pachycheles pubescens* Holmes.

*Type-locality.*—On pilings on Wharf #2, Monterey Bay, California.

*Disposition of types.*—National Museum of Natural History, Smithsonian Institution. Holotype cryptoniscus (USNM 205282), accompanying paratype female (USNM 205283), and their hosts (USNM 205284) collected 4 Mar 1983. Paratype female and three accompanying cryptoniscus larvae (USNM 205285) and their hosts (USNM 205286) collected 12 Nov 1982. All specimens from type-locality.

*Etymology.*—The specific name refers to the type-locality.

*Variation.*—Discrete variation in the cryptoniscus was seen only in pleopodal setation. One individual had two posterolateral plumose setae on one exopod; the contralateral pleopod was normal.

*Remarks.*—Several characters of the *C. montereyensis* cryptoniscus have rarely or never been described in *Cabirops.* The presence of sensory setae on the fourth peduncular article of the second antenna (Fig. 1C) has been described only in *C. marsupialis* (Caroli) (Restivo 1975), whereas those on the uropodal endopod (Fig. 2G) of *C. montereyensis* represent new characters for the genus. *Cabirops montereyensis* is only the second species in which a setal comb has been reported on the dactyl of peraeopod III (in *C. orbionei* Bourdon it is also found on the dactyli of peraeopods IV and V). The bifid dactyli of peraeopods VI and VII (Fig. 2B, C) are apparently unique.

In those species of *Cabirops* in which a developmental sequence of females has been described, there are profound morphological changes from the cryptoniscus to the mature female (Attardo 1955; Restivo 1971, 1975). Comparisons between the females of different species are hampered by the lack of information on this developmental progression in most species; the females of *C. montereyensis* (Fig. 3) can be compared only with those few species in which the earliest immature forms have been described. Relative to these other species, *C. montereyensis* differs in having a larger rostrum, and in the greatly inflated dorsal lobes and more pronounced ventral furrows of the peraeon. Other general features of the genus, such as the well-developed lateral plates and the marsupium, typically develop at a later stage than so far encountered in *C. montereyensis.*

Cryptoniscus larvae of *Aporobopyrus* were not found in any material from Monterey Bay. They were, however, occasionally found in samples collected in southern California. These larvae have the typical characteristics of bopyrid cryptoniscus larvae and are easily differentiated from those of *Cabirops montereyensis* by the following features:

1. Smaller size and narrower body (0.76 mm long × 0.24 wide).
2. Second antenna with 8 articles (4 peduncular and 4 flagellar).
3. All peraeopods gnathopodal.
4. Posterior margin of coxal plates entire.
5. Basis of uropod massive and exopod about 3 times the length of the endopod.
6. Posterior margin of pleotelson with denticles.

## Affinities and Relationships within the Genus

The genus *Cabirops* presents a number of taxonomic and nomenclatural problems. Although the species have been reviewed several times recently (Nielsen and Stromberg 1965; Lemos de Castro 1970; Restivo 1971, 1975), there are differences of opinion about what species constitute the genus. It currently contains one species generally believed to belong elsewhere, and some reviews do not include species described under other names, but subsequently added to *Cabirops.*

*Cabirops serratus* Bourdon has a number of characteristics unknown in other species of the genus (Nielsen and Stromberg 1973), most notably: teeth on the posterior margin of first-antennal article 1, an indentation on the posterior margin of the telson, and medioventral tubercles on the pleon. The species is being transferred to a new genus (Bourdon, pers. comm.) and will not be treated as a *Cabirops* here.

The relationship of *Cabirops* and *Paracabirops* Caroli has been historically troublesome. Reverberi (1950, 1952) first indicated the presence of several species of *Cabirops* in Italy parasitic on *Bopyrina ocellata* (Czerniavsky) [as *B. virbii* (Waltz)] and *Phryxus virbii* (Giard and Bonnier). Caroli (1953) instituted the new genus *Paracabirops* for *P. marsupialis,* to which he ascribed these hosts and added *Gyge branchialis* Cornalia and Panceri and another *Phryxus* sp. Unfortunately, Caroli's description was based solely on the female morphology of the *Gyge* parasite, and provided no information on the cryptoniscus. Romano (1953) incompletely described (without a name) the *Cabirops* from *B. ocellata,* and Attardo (1955) subsequently synonymized *Paracabirops* with *Cabirops,* also on the basis of individuals from *B. ocellata.* Subsequent description of the parasite from *Gyge*

(Reverberi and Catalano 1963) suggested specific differences between this form and that on *Bopyrina,* although the justification for a distinct genus was questioned (Nielsen and Stromberg 1965; Bourdon 1966). The junior synonymy of *Paracabirops* has recently been established by Restivo (1975), who provided the first complete description of the parasite of *Gyge.* She further suggested (Restivo 1975) that the *Gyge* parasite is distinct from that on *Bopyrina.* Unfortunately, the parasite of *Bopyrina* has generally been designated as *Cabirops marsupialis,* although that nomenclature is inaccurate (Nielsen and Stromberg 1965). The reduction of *Paracabirops* to a junior synonym of *Cabirops* requires that *C. marsupialis* (Caroli) be reserved for the *Gyge* parasite. The *Bopyrina* parasite is therefore without a valid name, and furthermore cannot be attributed to Attardo (1955), since she clearly regarded it as synonymous with the species described by Caroli. I will refer to the *Bopyrina* parasite as *Cabirops* sp. Romano, since she was the first to describe it. Still unsettled is the status and identity of the form(s) reported from *Phryxus* spp. (Reverberi 1950, 1952; Caroli 1953). Restivo (1975) has suggested that this parasite may represent another species, as yet undescribed.

The parasite of *Bopyrina* joins three other species which have been described and assigned to *Cabirops* but never named. Giard and Bonnier (1888) described a form from Dutch Malaysia (probably Amboine Island) which they thought was the bopyrid cryptoniscus of one of their new genera—*Probopyrus* or *Palaegyge.* Bonnier (1900) later assigned it provisionally to *Cabirops,* and Carayon (1942) and Shiino (1942) independently concurred. The host is uncertain since the cryptoniscus was in a bottle containing two species. Modern opinion is that *Palaegyge* is a junior synonym of *Probopyrus* (reviewed by Markham 1974); therefore, the host can be identified at least to *Probopyrus.* Indeed, one of the potential host species was *P. ascendens* (Semper), from which the female of *C. lernaeodiscoides* (Kossmann, 1872) was originally described from the Philippines (Caroli 1953). It is possible, although by no means certain, that the *Cabirops* described by Giard and Bonnier (1888) represents the unknown male of *C. lernaeodiscoides.* Another species, described by Stebbing (1910) as a parasite of *Trapezicepon amicorum* (Giard and Bonnier), was subsequently added to *Cabirops* by Shiino (1942). Finally, Bourdon (1966) described an unnamed species from *Scyracepon levis* Barnard which is similar in many respects to the species described by Stebbing, but which must for now be regarded as unique.

Excluding *C. serratus,* the genus is currently represented by 15 species, four of which are not named. Cryptoniscus larvae are known for all but *C. lernaeodiscoides.* In an effort to infer systematic relationships within the genus, and the probable affinities of *C. montereyensis,* I have surveyed the morphological data available on the 14 species known as larvae. Although a number of characters vary within *Cabirops,* much of this variation probably represents incomplete or inaccurate description. For example, the setation of the uropodal endopod (specifically the medial fringe and the dorsolateral setae) varies in its presence or absence. The distinction, however, is primarily between descriptions prior to Bourdon's (1966) study and those made more recently. There are also differences reported in the number of setae on the pleopodal endopods, although most recent descriptions indicate setation typical of the superfamily (c.f. Nielsen and Stromberg 1973). In contrast to these characters, however, some of the morphological variation in *Cabirops* may provide insight into intrageneric relationships. I have concentrated on three characters in the present summary: the coxal plate dentition formulae for the seven peraeonal segments, the relative development of the internal apophysis of the second peduncular article of antenna 2, and the dactyli of peraeopods I and II. These characters, along with the classification of both the bopyrid and decapod hosts of each species of *Cabirops* are summarized in Table 1. The bopyrid classification follows the general scheme of Shiino (1965), with subfamily names following more recent conventions (e.g. Markham 1974); the decapod classification follows Bowman and Abele (1982).

Two characters, the coxal plate dentition formulae and the nature of the gnathopodal dactyli, suggest that the currently known *Cabirops* fall into two basic groupings of species (Table 1). The first grouping is of those species in which the coxal plates of the anterior peraeonal segments have multiple teeth, 2–3, but the latter segments (particularly PVI and PVII have only a single process. The second grouping includes those species in which multiple teeth (2–3) are found along the entire sequence of peraeonal segments. Additional evidence for these groupings comes from information on the gnathopodal dactyli; all known species of the first group have bifid dactyli, whereas three of four species in the second group have simple dactyli. It is, furthermore, noteworthy that all of the species classified in the first group are parasites of bopyrids of the subfamilies Pseudioninae and Orbioninae, whereas those classified in the second group are all described either from Ioninae or Bopyrinae.

It is interesting, however, that not all characters show this pattern of species distribution. In particular, the strength of development of the antennal apophyses varies. This variation is not correlated with the previous two characters (and hence bopyrid host distribution), but instead shows a strong association with the decapod host (Table 1). Well-developed antennal apophyses are associated with crab hosts, whereas the processes are weak or absent in species from Thalassinidea and shrimps. At present, it is unclear whether this latter pattern reflects differentiation within the primary groupings (Table 1), or vice versa. Alternatively, these patterns may be spurious; other, as yet undescribed, characters may better reflect the systematics of the genus. There are likely to be many more species added to *Cabirops* (Markham 1974, 1979; Restivo 1975; Bourdon and Bruce 1979; Bourdon, pers. comm.), and attempts to define intrageneric relationships may be premature. At present, however, the distribution of coxal plate denticles and the morphology of the anterior dactyli suggest a pattern of relationships that is attractive, particularly in its correspondence with the known host-parasite relationships.

On the basis of coxal plate dentition, *C. montereyensis* is indistinguishable from two previously described species, *C. codreanui* and *C. orbionei*. There are further similarities between these three species in characters of the second antenna, and of the peraeopods (Table 1). Indeed, the setal comb on the dactyl of PIII (Fig. 1F) of *C. montereyensis* is a character shared only with *C. orbionei* as far as is currently known. Nevertheless, there are distinct characters separating these species in the first antenna (particularly the second article), the second antenna (articles 2, 3 and 4), and the peraeopods (especially 6 and 7).

## Incidence of *Cabirops montereyensis* on *Aporobopyrus muguensis*

Collection records for *C. montereyensis* from Monterey Bay are summarized in Table 2. The species was obtained on five occasions, generally whenever the

Table 1.—Morphological characters and host distributions of *Cabirops* species cryptoniscus larvae.

| | Coxal plate dentition | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Plate number | | | | | | | | | | |
| Species | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Dactyli of P I and P II | Bopyrid subfamily | Antenna 2 article 2 internal apophysis | Decapod infra-order |
| *C. codreanui* Bourdon, 1966 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | bifid | Pseudioninae | strong | Anomura |
| *C. montereyensis* n. sp. | 2 | 3 | 3 | 3 | 3 | 1 | 1 | bifid | Pseudioninae | strong | Anomura |
| *C. perezi* Carayon, 1942 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | ? | Pseudioninae | strong | Anomura |
| *C. ibizae* Bourdon, 1966 | 2 | 3 | 3 | 1 | 1 | 1 | 1 | bifid | Pseudioninae | strong | Anomura |
| *C. reverberii* Restivo, 1971 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | bifid | Pseudioninae | none | Thalassinidea |
| *C. pseudione* Lemos de Castro, 1970 | 3 | 2 | 1? | 1? | 1? | 1? | 1? | bifid | Pseudioninae | none | Thalassinidea |
| *C. marsupialis* (Caroli, 1953) | 3 | 3 | 1 | | | | | bifid | Pseudioninae | none | Thalassinidea |
| *C. orbionei* Bourdon, 1972 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | bifid | Orbioninae | weak | Penaeoidea* |
| *C. tuberculatus* Shiino, 1942 | 2 | 3 | 3 | 3 | ≥2 | ≥2 | ≥2 | simple | Ioninae | strong | Brachyura |
| *Cabirops* sp. Bourdon, 1966† | 2 | 3 | 3 | 3 | 3 | 3 | 3 | bifid | Ioninae | strong | Brachyura |
| *Cabirops* sp. (Stebbing, 1910)† | 2 | 3 | ? | 3 | 3 | 3 | 2? | ? | Ioninae | strong | Brachyura |
| *Cabirops* sp. (Giard and Bonnier, 1888)† | 3 | 3 | 3 | 3 | 3 | 3 | 3 | simple | Bopyrinae | none | Caridea |
| *C. lobiformis* Lemos de Castro, 1970 | | | 3? | 3? | | | | ? | Bopyrinae | ? | Caridea |
| *Cabirops* sp. Romano, 1953† | | | | | | | | simple | Bopyrinae | none | Caridea |

* Superfamily of the suborder Dendrobranchiata; all other decapod hosts are in the suborder Pleocyemata.

† See text for discussion.

Table 2.—The incidence of *Cabirops montereyensis* on *Aporobopyrus muguensis* at Monterey Bay. Unless otherwise noted, the hosts were removed from the branchial chambers of *Pachycheles rudis* collected amongst *Phyllochaetopterus prolifica* Potts tubes.

| Date | No. of *A. muguensis* | No. with *Cabirops* larvae | Total no. of *Cabirops* larvae | No. of hosts with *Cabirops* females |
|---|---|---|---|---|
| 4 January 1982 | 10 | 2 | 6 | 0 |
| 1 February 1982 | 4 | 0 | 0 | 0 |
| 8 March 1982* | 9 | 4 | 11 | 0 |
| 12 November 1982 | 2 | 1 | 6 | 1 |
| 7 January 1983 | 1 | 0 | 0 | 0 |
| 4 March 1983 | 10 | 3 | 13 | 1 |
| 29 May 1983 | 1 | 0 | 0 | 0 |
| 10 September 1983 | 2 | 0 | 0 | 0 |
| 1 March 1984 | 1 | 1 | 21 | 0 |
| Totals | 40 | 11 | 57 | 2 |

* Crabs from a kelp holdfast, 3 of 9 *Aporobopyrus* were from *Pachycheles pubescens,* 2 of 3 were parasitized.

host was relatively common. No *Cabirops* were found infesting 27 individuals of *Bopyrella calmani* (Richardson) parasitizing *Synalpheus lockingtoni* Coutière in the same set of samples (Sassaman et al. 1984). To date, *C. montereyensis* is known only from the type-locality; no individuals were obtained among two hosts collected at Point Piedras Blancas (San Luis Obispo Co.) or among 19 *A. muguensis* collected at Venice (Los Angeles Co.) and Laguna Beach (Orange Co.) in southern California. In the Monterey collections, there was no significant difference between the incidence frequencies among the nine samples (G-statistic) and the overall incidence of cryptoniscus stage larvae was 28%, quite comparable to the incidences of *C. codreanui, C. ibizae,* and the *Cabirops* from *Bopyrina* (Bourdon 1968). However, only two of the 40 hosts from Monterey contained female *Cabirops.*

The number of cryptoniscus larvae per host was quite variable, ranging from one to 21, and the distribution was non-random when tested against an expected Poisson distribution. Larvae were aggregated in their occurrence in selected hosts, most often in those hosts containing a *Cabirops* female. Medium-sized hosts (2.5–3 mm in length) were most commonly infected. Six of the eleven occurrences of *Cabirops* were with female *Aporobopyrus* which lacked their own male partner; however, both of the *Cabirops* females were found in *Aporobopyrus* which were paired with their males. In other species of *Cabirops,* female parasites often are found only in female hosts that are unaccompanied by males (Bourdon 1966; Restivo 1971).

Eight parasites and the host female collected in March 1984 (Table 2) were maintained in vitro (at 11°C) to determine whether the cryptoniscus larvae would transform in the laboratory. Several larvae maintained continuous contact with the host for several days, remaining within the marsupium or burrowed among the oostegites, while the other larvae swam about the culture dish. None of the larvae transformed or molted. After about five days, the host female was moribund and was removed, and after two more days the *Cabirops* themselves were moribund.

## Acknowledgments

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# A NEW SUBSPECIES OF COMMON GROUND-DOVE FROM ÎLE DE LA TORTUE, HAITI, WITH TAXONOMIC REAPPRAISAL OF BAHAMAN POPULATIONS (AVES: COLUMBIDAE)

Donald W. Buden

*Abstract.*—*Columbina passerina umbrina* is described as a new subspecies from Île de la Tortue, off the northern coast of Haiti. It differs from immediately adjacent populations in the Bahamas and Antilles chiefly in its darker coloration, at least in males. Bahaman populations of *C. passerina* vary clinally in size and coloration; *C. p. volitans* is treated as a synonym of *C. p. bahamensis.*

The Common Ground-Dove (*Columbina passerina*) is widespread in the West Indies where it occupies a broad range of habitats (Bond 1956, 1971). Bond (1956) recognized nine subspecies in this region and Schwartz (1970), in the most recent review of Greater Antillean and northern Bahamas populations, resurrected the additional name *C. p. aflavida* Ridgway for those on Cuba. Recent examination of specimens from the southern Bahamas (including Turks and Caicos Islands—geographically and geologically a part of the archipelago, but politically distinct) and from Île de la Tortue, off the northern coast of Hispaniola, together with comparative Antillean-Bahaman material provides evidence for other taxonomic changes suggested herein. All specimens I collected from the southern Bahamas have been deposited in the Louisiana State University Museum of Zoology (LSUMZ).

## Methods

All linear measurements are in millimeters and were taken in the following manner: wing length as chord measured with a rule; tail length as the distance from base of tail to tip of longest rectrix, bill length as exposed culmen—both measured with dial calipers. Mensural data are in Table 1 and Fig. 1.

Color comparisons were made largely by eye but some samples were also analyzed with an Applied Color System Spectrosensor II Reflectance Spectrophotometer coupled to a DEC PDP 11/23 Mini Computer and the data processed via an ACS proprietary Chroma-Pac program. L, a, and b color values were obtained from three areas (each 1 cm in diameter) on each of 29 study skins—the middle of the back (=dorsum), the lower flank and/or abdomen (=venter), and the forehead (including part of the crown). The "L" scale measures paleness (0 = black, 100 = white), the "a" scale measures redness along a positive gradient and greenness along a negative gradient (0 = gray), and the "b" scale measures yellowness when positive and blueness when negative (0 = gray). Spectrophotometry data are in Fig. 2.

Comparisons between males are discussed at greater length than are those between females as I have examined far more of the former. Specimens identified as "male?" or as "female?" on museum labels have been included in the samples of those sexes, respectively.

## Bahaman Populations

Bond (1942) reported that the ground-doves in the extreme southern Bahamas are grayer and smaller than those on the northern islands; he later (Bond 1945) proposed the name *Columbigallina* (=*Columbina*) *passerina volitans* for populations on the Inaguas and the Turks and Caicos Islands retaining the name *C. p. bahamensis* (Maynard) for all other Bahaman populations. Common Ground-Doves from Great Inagua previously were included in the subspecies *C. p. exigua* Riley, along with those from Mona, a small island between Hispaniola and Puerto Rico (Hellmayer and Conover 1942). Specimens from Mona and the southern Bahamas are similar in paleness of coloration but the former are distinguished by their smaller size, especially in wing length (Bond 1945; Table 1, this account).

Mensural data for pooled samples from the "northern" Bahamas (New Providence, Fig. 1B; Eleuthera, Fig. 1C; and the Exumas, Fig. 1D, part) are given separately from those of the extreme southern islands (Great Inagua, Fig. 1G, and the Turks and Caicos Islands, Fig. 1H) in Table 1. The Crooked-Acklins district and Mayaguana (Fig. 1F) are intermediate geographically between the islands of these pooled samples. Bond (1945) indicated that a male and a female *C. passerina* he examined from this geographically intermediate region more closely resembled individuals from northern islands. However, the means in wing length and tail length for six males I examined from Crooked-Acklins and Mayaguana (81.9 and 56.3, respectively) are closer to those of my southern samples (Table 1). Individuals from this geographically intermediate region also are more similar to the southern birds in coloration. Furthermore, in comparing ground-doves from Rum Cay (also geographically intermediate between the pooled northern and southern samples—Fig. 1E, part) with those from New Providence, Todd (1913) stated that the former "are somewhat paler throughout—verging thus toward *C. p. exigua.*"

Figure 1 shows that variation in wing length among Bahaman males is clinal; those from the northern islands have longer wings, on the average, than do those from the south, though individuals from the Turks and Caicos Islands average slightly larger than expected from the trend in variation. Variation in tail length among these samples is more irregular, but southern birds average slightly smaller in this character too. There are no consistent differences in bill length between northern and southern samples; the base of the bill tends to be darker in southern birds but this difference is not constant.

I suggest that all populations of *C. passerina* in the Bahamas be included under *C. p. bahamensis* (Maynard), distinguished from all immediately adjacent subspecies by paler coloration and from those of Florida and Cuba by small size as well. Although specimens from the northern Bahamas tend to average darker and slightly larger than those from the southernmost islands, adjacent populations in the Bahamas overlap broadly in size and coloration. In this taxonomic interpretation, *C. p. volitans* (Bond) is merged with *bahamensis.* I follow Todd (1913) and others in treating *C. p. bermudiana* (Bangs and Bradlee) from Bermuda also as a synonym of *C. p. bahamensis.* These taxonomic conclusions based largely

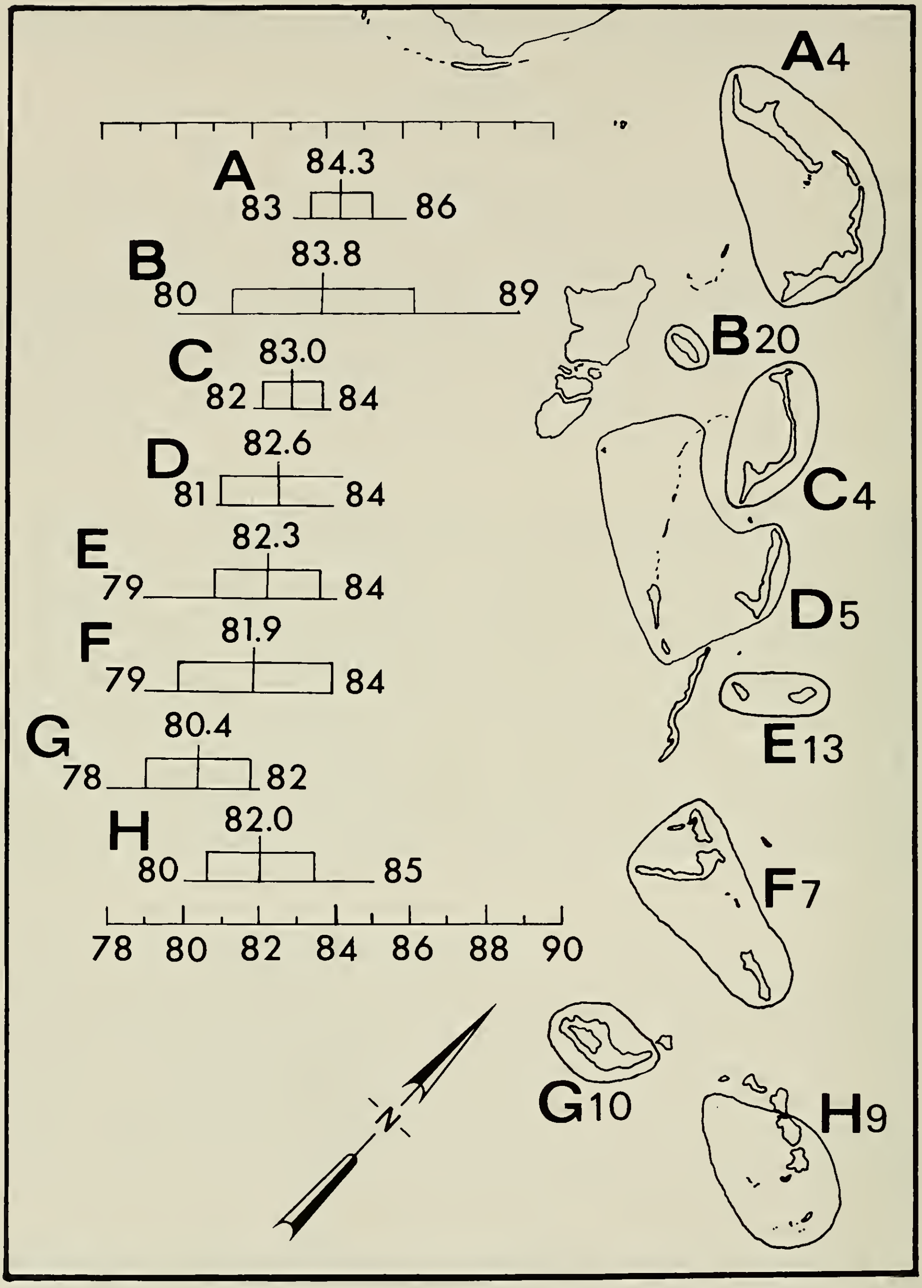

Fig. 1. Population-range diagram showing wing length in males of *Columbina passerina* from the Bahamas; horizontal line = range, vertical line = mean, open rectangle = one standard deviation on either side of the mean, numbers adjacent to encircled sample localities are sample sizes. Names of islands and number of specimens from each as follows: A—Grand Bahama 2, Abaco 2; B—New Providence 20; C—Eleuthera 4; D—Green Cay 1, Exumas 3, Cat Island 1; E—Rum Cay 9, San Salvador 4; F—Crooked Island 1, Acklins Island 2, Mayaguana 4; G—Great Inagua 10; H—Middle Caicos 4, East Caicos 1, French Cay 1, Grand Turk 3. All measurements in millimeters.

Table 1.—Measurements (in millimeters) of three characters for nine samples of *Columbina passerina* (males only). Each set includes range and sample size (row 1) and mean and twice the standard error of the mean (row 2). N. (northern) Bahamas = New Providence, Eleuthera, and Exumas; S. (southern) Bahamas = Great Inagua and Turks and Caicos Islands.

| Location | Wing length | Tail length | Bill length |
|---|---|---|---|
| Florida | 84.0–90.0 (11) | 57.7–66.0 (13) | 11.4–12.4 (12) |
| | 88.2 ± 1.04 | 62.9 ± 1.46 | 11.8 ± 0.20 |
| N. Bahamas | 80.0–89.0 (27) | 53.2–61.7 (23) | 10.0–11.9 (27) |
| | 83.6 ± 0.80 | 58.4 ± 0.96 | 10.9 ± 0.18 |
| S. Bahamas | 78.0–85.0 (19) | 52.5–59.4 (20) | 9.5 ± 11.8 (18) |
| | 81.2 ± 0.74 | 56.6 ± 0.86 | 10.9 ± 0.24 |
| Cuba | 83.0–89.0 (34) | 56.2–65.4 (32) | 10.1–12.6 (23) |
| | 85.9 ± 0.58 | 60.2 ± 0.78 | 11.0 ± 0.26 |
| Jamaica | 80.0–85.0 (18) | 52.4–61.5 (16) | 10.6–12.0 (15) |
| | 82.8 ± 0.78 | 56.7 ± 1.28 | 11.5 ± 0.22 |
| Hispaniola | 79.0–87.0 (25) | 50.5–60.0 (18) | 10.0–11.4 (21) |
| | 82.7 ± 0.72 | 55.5 ± 1.28 | 10.7 ± 0.20 |
| Tortue | 82.0–85.0 (6) | 52.9–58.1 (6) | 10.5–11.2 (4) |
| | 83.3 ± 0.84 | 55.7 ± 1.60 | 10.7 ± 0.34 |
| Mona | 75.0–79.0 (13) | 51.5–56.5 (12) | 9.8–11.8 (14) |
| | 77.5 ± 0.80 | 54.4 ± 1.02 | 10.7 ± 0.26 |
| Puerto Rico | 79.0–85.0 (11) | 53.3–61.2 (12) | 9.7–11.2 (10) |
| | 81.9 ± 1.08 | 56.7 ± 1.52 | 10.6 ± 0.36 |

on comparisons between males are not contradicted by the data from the relatively small samples of females.

## The Tortue Population

Île de la Tortue, second largest of the Hispaniolan satellite islands, is about 35 km long and 7 km wide, the long axis roughly parallel to the northern coast of mainland Haiti, which is as near as 8 km to the south. Tortue is about 100 km south of Great Inagua in the Bahamas and about 120 km east of the easternmost tip of Cuba.

Wetmore and Swales (1931) reported that specimens of *C. passerina* from Tortue that they examined are darker than those from Hispaniola and they attributed this difference as due seemingly to wear and stain. They included the ground-doves of the immediate Hispaniolan region (excluding Navassa, a United States Island possession ca. 55 km west of Cap des Irois, Haiti) as well as those from Cuba and the Cayman Islands all in the subspecies *C. p. insularis* Ridgway. Schwartz (1970) treated the Cuban populations as members of a separate subspecies, *C. p. aflavida* Ridgway, followed Bond (1956) in treating *C. p. navassae* (Wetmore) as a synonym of *C. p. insularis,* and listed the specimen from Tortue that he examined also under *insularis.* Recently, I examined all of the Tortue material of *C. passerina* available to Wetmore and Swales (1931)—six males and one female collected by W. L. Abbott in the period 30 January–4 February 1917. I am not aware of any other specimens of *C. passerina* from Tortue.

The specimens from Tortue and Hispaniola resemble each other mensurally but there are differences in coloration confirmed by reflectance spectrophotometry (Fig. 2) that I do not ascribe to wear or stain. Males from Tortue are darker than are "mainland" males. In the former, the dorsum is more brown and less gray, the venter is more deeply vinaceous, and the forehead is darker and tinged more with buff (USNM 250544 from Tortue, with a matted, discolored crown, has been omitted in forehead comparisons). Also, make of skin notwithstanding, the pale, blue-gray, squamate pattern on the nape appears less extensive and generally not so bright in specimens from Tortue as in those from Hispaniola and Cuba. In Cuban males, the pale area of the forehead tends not to be so extensive nor so well demarcated as in specimens from Tortue and Hispaniola. Cuban males are somewhat variable in depth of coloration; some are as pale as Bahaman or Hispaniolan birds. But on average the Cuban sample is darker than those from the Bahamas and Hispaniola, though not so dark (at least on the venter) as those from Tortue.

Specimens from Île de la Gonâve resemble those from the Haitian mainland (as do those from Navassa) but one from Isla Beata is more reddish-brown than are the other MCZ specimens from the Hispaniolan area. I have not seen specimens from the other satellite islands whence *C. passerina* has been reported (Île-à-Vache, Catalina, and Saona).

Hispaniolan specimens analyzed by spectrophotometry all are from "north island" localities as follows: Haiti: Rivièr Bar (=Rivière des Barres) 1, Moustique 1, 1 mi S Ft. Libertè 1, 2 mi S San Rafael (=St. Raphael) 1, 4 mi SE Cerca-la-Source 2, 1 mi E St. Marc 1, Montrouis 1, 3 mi NW L'Arcahaie 1; Dominican Republic: Sosúa 4, Sânchez 1. With the exception of USNM 573635, taken at Montrouis in 1971, and MCZ 41849, an H. Bryant skin from Cuba probably taken in the middle 1800's, all in Fig. 2 were collected in the years 1904 to 1931, the Tortue specimens all in 1917.

The males from Tortue are much darker (dorsally and ventrally) than are those from the Bahamas. Mensurally and chromatically, they are very similar to examples of *C. p. portoricensis* from Puerto Rico and the Virgin Islands. The dark spotting on the breast tends to be slightly more prominent in examples of *C. p. portoricensis*, but this is at best a slight average difference when series are compared; greater differences in coloration are evident between the female from Tortue and those from the Puerto Rican Bank.

The female from Tortue is similar (chromatically and mensurally) to those from Hispaniola. It matches well examples from the Bahamas although many of the latter have less buff on the venter and are paler and more gray on the dorsum. The Tortue female is paler on the venter (more white and buff, less gray and brown) than are females of *C. p. portoricensis* from the Virgin Islands and of *C. p. aflavida* from Cuba and the Isle of Pines—MCZ specimens from the Isle of Pines tend to average slightly darker (in both sexes) than do those from Cuba. The Tortue female is paler and less buffy on the venter than are females from Jamaica and the proximal half of its bill lacks the pale coloration eminent in skins of both sexes from that island.

For the population of *C. passerina* on Tortue, distinguished from adjacent populations by differences in size (at least in wing length) and/or coloration, I propose the name

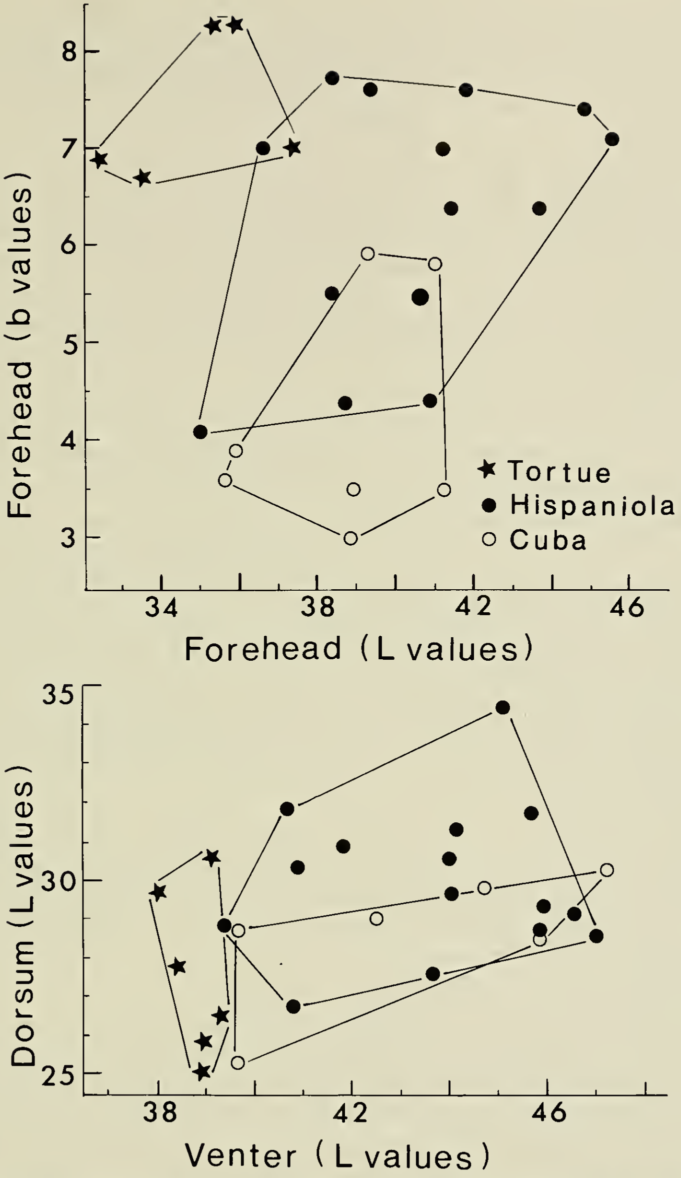

Fig. 2. Spectrophotometry data for male *Columbina passerina* from three islands in the Greater Antilles; instrumentation and terminology explained under methods.

## *Columbina passerina umbrina*, new subspecies

*Holotype.*—USNM 250356, male, Île de la Tortue, Haiti, collected 2 Feb 1917 by W. L. Abbott.

*Characters.*—Males of *Columbina passerina umbrina* differ from those of related subspecies in the Greater Antilles and the Bahamas as follows: darker (more brown, less gray) dorsally and more deeply vinaceous ventrally than *bahamensis* and *insularis*; larger and darker (above and below) than *exigua*; dorsum darker than in *jamaicensis,* and with proximal half of bill (in study skins) much darker; smaller than *aflavida,* with more reddish-brown hue on venter, with base of bill usually paler, and with blue-gray, squamate pattern on nape usually not so bright nor so extensive.

Although males of *umbrina* are similar to those of *portoricensis,* chromatically and mensurally, females of *portoricensis* are darker (more brown and more gray) below than is the female *umbrina,* which is similar to females of *insularis* and matches well also examples of *bahamensis,* though many of the latter tend to have less buff on the venter and are paler (more gray, less brown) on the dorsum. The female *umbrina* is less buffy below and is darker on the basal half of the bill than are females of *jamaicensis,* and it has more white (less gray) and more buff ventrally than do female *aflavida.*

*Range.*—Known only from Île de la Tortue, off the northern coast of Haiti.

*Etymology.*—From the latin word *umbra,* a shadow, an area of dark color, in allusion to the darker coloration of males of this subspecies when compared with those from immediately adjacent islands.

*Remarks.*—None of 28 species of land birds (Falconiformes and Columbiformes through Passeriformes) recorded from Tortue, and that breed or possibly breed there, is endemic to the island. But *Columbina passerina umbrina* brings to four the number of subspecies of birds known only from Tortue. Among them, *C. p. umbrina, Coereba flaveola nectarea,* and *Loxigilla violacea maurella* almost certainly were derived from populations on adjacent Hispaniola, whereas the Bahamas are the most likely source (on geographic grounds) of the population of *Vireo crassirostris tortugae,* a species found nowhere else in the Hispaniolan region.

*Columbina passerina, Coereba flaveola,* and *Loxigilla violacea* all are widespread and common in the Greater Antilles and the Bahamas. In the Hispaniolan region, each occurs on several satellite islands as well as on the main island, and the weight of available evidence indicates that the most distinctive population there, mensurally and/or chromatically, in each case is on Tortue. Individuals from Tortue differ from their "mainland" relatives, at least in part, by their darker coloration—*Columbina passerina umbrina* is darker brown and more deeply vinaceous than is *C. p. insularis, Coereba flaveola nectarea* has a darker gray throat than does *C. f. bananivora,* and *Loxigilla violacea maurella* has a deeper and more glossy black plumage than does *L. v. affinis.* Also, *Vireo crassirostris tortugae* has more buff or brown color (and less white) on the venter than do related subspecies.

Examples of *Chordeiles gundlachii* from Tortue also differ from those on Hispaniola, though in this case the Tortue specimens are paler; they have been assigned to the "Bahaman subspecies" *Ch. minor* (=*gundlachii*) *vicinus* by Wetmore and Swales (1931).

## Specimens Examined

*Columbina passerina passerina.*—FLORIDA: MCZ (13M).

*Columbina passerina bahamensis.*—BAHAMA ISLANDS: Grand Bahama MCZ (2M); Abaco USNM (1M); Great Guana Cay MCZ (1M); Andros AS (1M); New

Providence AMNH (8M 5F), FMNH (1M), MCZ (8M 8F), USNM (4M); Eleuthera (including Current Is.) FMNH (1M), MCZ (1F), USNM (3M); Cat Is. USNM (1M); Exumas, Highborne Cay MCZ (1M), Farmer's Cay MCZ (2F), Great Exuma MCZ (2M); Green Cay USNM (1M); Ragged Is., Nurse Cay USNM (1M); San Salvador USNM (4M); Rum Cay USNM (9M); Crooked Is. LSUMZ (1M 1F); Acklins Is. USNM (2M); Mayaguana LSUMZ (4M); Great Inagua AMNH (2M 1F), FMNH (7M), MCZ (2M 1F), USNM (1M). TURKS AND CAICOS ISLANDS: North Caicos LSUMZ (1F); Middle Caicos LSUMZ (4M? 1F), USNM (1M); East Caicos LSUMZ (1M?); South Caicos MCZ (1F); French Cay USNM (1M); Grand Turk LSUMZ (2M 1M? 1F). BERMUDA ISLANDS: MCZ (5F).

*Columbina passerina aflavida.*—CUBA (by province): Pinar del Rio USNM (1M); La Habana FMNH (3M), UMRC (1M), USNM (1M), YPM (2M); Matanzas FMNH (2M); Cienfuegos MCZ (1M), YPM (1M); Villa Clara MCZ (2M), YPM (2M); Las Tunas UMRC (2M); Holguin MCZ (4M 3F), USNM (2M); Santiago de Cuba USNM (1M); Guantánamo MCZ (3M 1F), USNM (7M). Province not indicated—Cuba (no other locality) MCZ (1M 2F). Isla de Pinos: MCZ (4M 4F).

*Columbina passerina jamaicensis.*—JAMAICA: FMNH (1M), MCZ (14M 4F), PB (1M), USNM (1M), YPM (1M).

*Columbina passerina insularis.*—HISPANIOLA: Haiti AS (3M), FMNH (1M), MCZ (1F), USNM (14M), YPM (1M); Dominican Republic AS (1M), FMNH (9M), MCZ (7M, 4F), USNM (1M). ÎLE DE LA GONÂVE: UF (1M), USNM (6M), YPM (1M). ISLA BEATA: MCZ (1M). NAVASSA: MCZ (1M), UF (1M). CAYMAN ISLANDS: Grand Cayman AS (1M), MCZ (6M), Little Cayman AS (1M), Cayman Brac MCZ (4M).

*Columbina passerina umbrina.*—ÎLE DE LA TORTUE: USNM (6M 1F).

*Columbina passerina exigua.*—MONA ISLAND: AS (1M), FMNH (10M), USNM (3M).

*Columbina passerina portoricensis.*—PUERTO RICO: MCZ (2M), USNM (10M). VIRGIN ISLANDS: St. Thomas MCZ (3M 1F); Tortola MCZ (4M 1F); Anegada MCZ (1F).

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# *HYPHESSOBRYCON ELACHYS,* A NEW MINIATURE CHARACID FROM EASTERN PARAGUAY (PISCES: CHARACIFORMES)

Marilyn Weitzman

*Abstract.*—*Hyphessobrycon elachys* is described as new from the Río Paraguay drainage basin. The adult males of this species are readily recognized by the elongate filaments of the dorsal and pelvic fins and the broad lobular shape of the anterior portion of the anal fin. Both sexes have a tooth-cusp pattern unknown in other characids. The species is compared with other *Hyphessobrycon* occurring in the region. The presence in *Hyphessobrycon maxillaris* Fowler of caudal squamation which would place it in *Hemigrammus* Eigenmann is noted.

In material collected in 1981 by Larry Naylor of the United States Peace Corps as part of the Biological Inventory of Paraguay carried out under the auspices of the Servicio Forestal Nacional de Paraguay were many small silvery fish with prominent black caudal spots belonging to several characid genera. Portions of these collections were sent to the United States National Museum (USNM) and to the University of Michigan Museum of Zoology (UMMZ) by the Museo de Historia Natural de Paraguay (MHNP) in Asunción. Among the fishes sent to the USNM was a very small species (12.9–16.6 mm SL) with a broad lobe-shaped anal fin and elongate filamentous rays of the dorsal and pelvic fins unlike any other known species of characid. Although of very small size, they turned out to be mature males. The type-locality of this new species is a swampy area of the Río Aguaray-guazu with quiet turbid water and floating plants. It is part of the Río Jejui system which flows into the Río Paraguay in northeastern Paraguay. More specimens from the type-locality were in the collections sent to UMMZ. A single male was found in a collection made by Naylor in the Parque Nacional Ybycui. All separated were males. In 1979 R. Bailey, J. N. Taylor and party made extensive collections throughout eastern Paraguay and a search through their material revealed many additional specimens collected in the Río Aguaray-mi about 25 km north of the type-locality.

Females were finally identified after close inspection of some of the unidentified small silvery characids with black caudal spots from these localities. As the males, the females have the dentary teeth and inner-row premaxillary teeth with a cusp pattern unknown in other characids. Otherwise, the females look much like those of several other small species present in these collections. Their fins have the usual characid shape rather than the lobed anal fin or filamentous dorsal or pelvic fins possessed by the males. This small species, following Eigenmann (1917), is placed in the genus *Hyphessobrycon* Durbin on the basis of its possession of the characters used to define this genus.

The methods used here for counting and measuring specimens are those described for characiforms by Fink and Weitzman (1974) except where noted. Morphometric values are expressed as a percentage of standard length (SL) except where otherwise designated.

## *Hyphessobrycon elachys*, new species
Figs. 1–5

*Holotype.*—USNM 232393, 16.1 mm SL, male, Paraguay, Departamento San Pedro; swamp 3 km northwest of Lima, Río Aguaray-guazu system, 23°55′S, 56°29′W, 31 Oct 1981, by N. Scott, L. Fitzgerald.

*Paratypes.*—79, USNM 268474, 12.9–16.6 mm SL (4, 14.4–16.6 mm SL, adult males A–D, cleared and stained).—16, UMMZ 212725, 13.3–15.8 mm SL.—2, Academy of Natural Sciences of Philadelphia, ANSP 153539, 14.4–14.5 mm SL.—2, British Museum (Natural History), BMNH 1984.12.21:2–3, 13.9–15.0 mm SL.—2, California Academy of Sciences, CAS 56018, 14.4–14.8 mm SL.—2, MHNP, 13.9–14.9 mm SL.—4, Museu Zoologia da Universidade de São Paulo, MZUSP 28655, 13.9–14.9 mm SL, all of preceding with same data as holotype.—26, UMMZ 206595, 14.0–19.7 mm SL, Paraguay, Departamento San Pedro; Río Aguaray-mi and ditch, Guazu at bridge, Rte. 3, 23°37.9′S, 56°30′W, 22 Jul 1979, by J. N. Taylor.—1, USNM 232381, male, 15.5 mm SL, Paraguay, Departamento Paraguari; Parque Nacional Ybycui, near 26°S, 57°W, 21 Jan 1981, by O. Romero and L. Naylor.

*Diagnosis.*—Distinguished from other species of *Hyphessobrycon* by unique form in both sexes of teeth of dentary and inner-row premaxillary bones in which central cusp is offset toward center of tooth while 2 to 3 cusps of each side compressed, placed along anterior border of each tooth on dentary and along posterior border of premaxillary teeth; large, almost black caudal spot nearly covering at least posterior half of caudal peduncle and basal portion of caudal fin, not extending anteriorly as part of lateral stripe, but extending posteriorly on median portion of caudal fin to middle of fin in females and to distal border of fin in mature males. In mature males anal fin with broad anterior lobe with rays thickened and flattened medially; in mature males first branched rays of dorsal and pelvic fins elongated into filaments up to ½ body length. The small size (13.8–19.7 mm SL) distinguishes this species from most other species of *Hyphessobrycon*.

*Description.*—See Table 1 for morphometric values. Body elongate, sides compressed. Greatest depth usually at pelvic-fin origin which is one vertical scale row anterior to dorsal-fin origin. Predorsal body profile slightly convex, from above eye to anterior of dorsal-fin origin. Body profile along dorsal-fin base nearly straight and almost straight to slightly concave from rear of fin posteriorly to caudal-fin base. Dorsal-fin origin almost equidistant from snout tip and caudal-fin base. Ventral body profile somewhat convex from symphysis of lower jaw to pelvic-fin origin, body profile concave between pelvic-fin origin and anal-fin origin, straight to slightly convex across base of anal fin, and almost straight from rear of anal fin along ventral caudal peduncle to caudal-fin base. Caudal peduncle slender. Head moderate in length, relatively deep, compressed. Eye large. Snout short, rounded, mouth terminal, tip of snout slightly anterior to dentary. Mouth gape narrow, almost horizontal. Maxilla slender, moderately long, its posterior tip extends to or slightly beyond vertical through anterior border of eye. Ventral border of maxilla about parallels ventral mandibular profile with mouth closed.

Due to small size of this fish, only teeth of 4 cleared and stained specimens were examined closely but counts were made of many additional specimens,

Table 1.—Measurements of *Hyphessobrycon elachys*, new species. Standard length is expressed in mm; measurements through bony head length are percentages of standard length; measurements below bony head length are percentages of bony head length.

| | Holo- | Paratypes | | | | | |
|---|---|---|---|---|---|---|---|
| | type | n | Males range | $\bar{x}$ | n | Females range | $\bar{x}$ |
| Standard length | 16.1 | 44 | 12.9–16.6 | 14.9 | 15 | 14.2–17.9 | 15.5 |
| Body depth at pelvic-fin origin | 35.4 | 40 | 31.7–38.5 | 34.5 | 15 | 32.9–37.3 | 35.0 |
| Body depth at dorsal-fin origin | 34.2 | 44 | 31.0–40.4 | 34.0 | 15 | 31.6–38.0 | 34.5 |
| Snout to dorsal-fin origin | 52.2 | 44 | 50.3–55.9 | 53.3 | 15 | 52.0–56.2 | 54.4 |
| Dorsal-fin origin to caudal-fin base | 52.2 | 44 | 50.0–54.8 | 52.8 | 15 | 49.0–55.1 | 52.2 |
| Snout to pelvic-fin origin | 49.7 | 44 | 45.6–52.1 | 49.1 | 15 | 47.1–53.3 | 50.3 |
| Snout to anal-fin origin | 62.1 | 44 | 59.6–63.8 | 62.1 | 15 | 61.8–67.8 | 64.7 |
| Caudal peduncle depth | 11.8 | 44 | 9.3–13.2 | 11.1 | 15 | 9.2–11.8 | 10.5 |
| Caudal peduncle length | 15.5 | 44 | 13.0–17.5 | 15.3 | 15 | 13.2–16.7 | 14.8 |
| Adipose-fin origin to caudal-fin base | 17.4 | 40 | 14.2–18.9 | 16.6 | 15 | 14.1–17.6 | 15.6 |
| Dorsal-fin base | 14.9 | 43 | 12.2–17.8 | 15.6 | 15 | 13.4–16.0 | 14.6 |
| Longest dorsal-fin ray length | 57.1 | 41 | 32.4–51.3 | 40.7 | 14 | 28.2–34.7 | 31.0 |
| Anal-fin base | 29.8 | 44 | 25.0–32.4 | 28.6 | 15 | 23.3–30.7 | 25.8 |
| Longest anal-fin ray length | 16.8 | 41 | 13.9–19.3 | 16.9 | 13 | 19.0–24.1 | 21.2 |
| Pelvic-fin length | 43.5 | 42 | 23.2–50.0 | 36.2 | 15 | 17.1–20.8 | 19.3 |
| Pelvic-fin origin to anal-fin origin | 14.3 | 39 | 13.3–19.4 | 15.8 | 15 | 15.6–19.0 | 17.3 |
| Pectoral-fin origin to pelvic-fin origin | 21.1 | 40 | 19.1–24.0 | 21.2 | 15 | 19.6–24.7 | 22.5 |
| Pectoral-fin length | 22.7 | 44 | 19.3–24.3 | 22.2 | 14 | 18.4–24.2 | 21.3 |
| Snout to pectoral-fin origin | 29.2 | 44 | 27.0–30.3 | 28.9 | 15 | 27.2–30.8 | 29.0 |
| Bony head length | 27.3 | 44 | 26.2–29.5 | 27.5 | 15 | 26.2–29.6 | 27.7 |
| Horizontal eye diameter | 45.5 | 43 | 39.0–48.8 | 44.2 | 15 | 42.9–48.9 | 46.7 |
| Snout length | 27.3 | 39 | 21.8–27.9 | 24.8 | 15 | 22.5–28.0 | 25.1 |
| Width least bony interorbital | 34.1 | 44 | 28.9–37.3 | 32.3 | 15 | 28.6–35.7 | 31.9 |
| Width upper jaw | 25.0 | 40 | 22.5–30.2 | 25.8 | 15 | 23.8–30.1 | 26.9 |
| Length upper jaw | 34.1 | 44 | 28.0–39.5 | 34.3 | 15 | 33.3–39.5 | 35.9 |
| Length lower jaw | 35.2 | 40 | 32.4–39.5 | 35.1 | 15 | 32.6–40.0 | 35.8 |
| Length maxilla | 27.3 | 40 | 22.7–31.4 | 27.5 | 14 | 24.4–29.1 | 27.3 |

especially the females and the specimens from the Aguaray-mi. Maxilla, Fig. 4, usually with 1 small tooth, compressed, with 3 to 5 almost equal cusps in large adult males. Tooth absent on one (specimen C) or both sides (specimen D) in smaller specimens. Maxillary teeth very difficult to see in unstained specimens even at 50× magnification. Premaxilla, Fig. 4, bearing 2 tooth rows. Outer row with 2 or 3 teeth, round in cross section with main central cusp and 2 small cusps on each side. In some specimens 1 or 2 of these teeth missing, apparently due to tooth replacement in progress. Inner premaxillary tooth row with 5 teeth. First, medial, tooth slender, rounded in peduncular cross section, heavy main central cusp set somewhat anterior to lateral side cusps which are set along posterior border of tooth, 2 medial and 3 lateral. Second, third, and fourth teeth broader, with large central cusp set somewhat anterior on tooth relative to more compressed lateral cusps (3 each side) which are set along posterior border of tooth, essentially opposite to their positions on dentary teeth. Fifth, lateralmost, tooth smaller, compressed in cross section (more incisor like), with 6 or 7 cusps nearly equal in height. Dentary, Fig. 4, with 4 large teeth across anterior of bone. All are heavy, ovate in peduncular cross section, flaring laterally distally; central cusp broad,

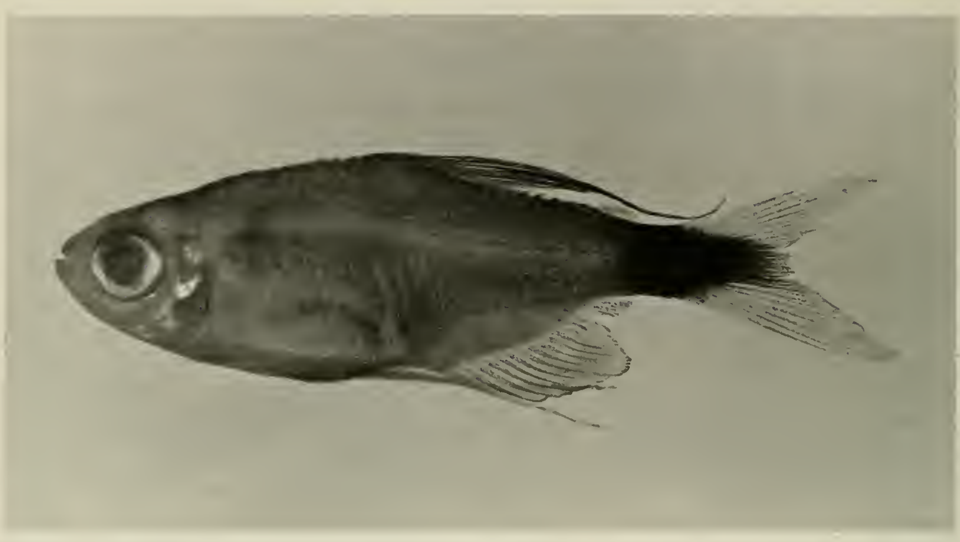

Fig. 1. *Hyphessobrycon elachys,* new species, USNM 232393, male, 16.1 mm SL, holotype. Paraguay, swamp 3 km northwest of Lima, Río Aguaray-guazu system.

offset toward center of tooth, somewhat posterior to flanking cusps. Tip of medial cusp directed posteriorly into mouth while adjacent cusp on each side directed slightly anterodorsally. Lateral cusps 3 each side, set along anterior border of tooth. Four or 5 small teeth posterolateral to large anterior dentary teeth. Small dentary teeth almost conical but with 1 or 2 small lateral cusps on first 2 to 4 teeth.

Branchiostegal rays 4. Gill rakers 5 or 6/11 to 13 in 4 cleared and stained specimens.

Antorbital and infraorbitals 1, 2, and 3 present, well ossified. Third infraorbital bone not in contact with laterosensory tube of preopercle, leaving moderate naked margin. Fourth infraorbital bone apparently absent (or at least not ossified). Fifth and sixth infraorbital bones present in 2 cleared and stained specimens, 16.5 and 16.6 mm SL, absent in other 2.

Dorsal-fin rays ii,9; iii,8,i; ii,8,i; ii,7,ii; ii,7,i (usually ii,8,i). Second to fourth branched rays elongate in adult males; in some specimens rays extend posteriorly almost to vertical through termination of middle caudal-fin rays.

Pectoral-fin rays i,8 to i,10, usually i,9. Fin located low on body, posterior tip usually extends slightly beyond vertical through pelvic-fin origin.

Pelvic-fin rays i,5 to i,7, usually i,6. Second ray elongate and in a mature male, such as holotype (Fig. 1) extends posteriorly just beyond a vertical drawn through posterior base of anal fin. Muscles for pelvic fins large but bones of pelvic girdle not especially modified. Fin rays without hooks.

Anal-fin rays iii,16 to iii,20, usually iii,18. Last ray, which is divided to base into two branched rays, is counted as two. In males, first or second through sixth to eighth branched rays of almost equal length. These rays broadened medially, remainder of rays shorter, giving fin a distinctive outline compared to other known species of *Hyphessobrycon*; a broad anterior lobe followed by a deeply concave border. See Figs. 1, 3, and 5. No hooks found on any anal-fin rays, absence perhaps

Fig. 2. *Hyphessobrycon elachys,* new species, USNM 268474, female, 15.0 mm SL, paratype. Paraguay, swamp 3 km northwest of Lima, Río Aguaray-guazu system.

seasonal. See Fink and Weitzman (1974:22) for discussion of seasonality of fin hooks in *Cheirodon affinis.* Females of *Hyphessobrycon elachys* have a more "usual" characid anal-fin shape (Fig. 2), strongly concave in distal outline with anterior rays longest and following rays becoming abruptly shorter. Basal sheath of anal fin short, 3 scales on anterior basal portion of fin.

Adipose fin present, small, situated slightly anterior of vertical through insertion of posterior anal-fin ray.

Caudal-fin rays i,9/8,i in most specimens. One of cleared and stained specimens with 2 unbranched principal rays in dorsal caudal lobe and 2 specimens with i,8/7,i rays. Caudal-fin lobes almost equal in length, rather narrow and deeply forked. Caudal fin naked with only 3 to 5 large scales covering central basal portion of each lobe (these scales easily deciduous and usually missing).

Scales 30 to 32 in lateral series to hypural joint. Four to 6 perforated lateral-line scales anteriorly on sixth horizontal scale row from dorsal-fin origin. Four scale rows ventral to lateral-line row to pelvic-fin origin. Usually 9 or 10 scales in predorsal median series but series sometimes incomplete with 1 to 3 overlapping or paired scales, usually at anterior or just anterior to dorsal-fin origin; in some specimens overlapping or paired scales in middle of series.

Supraoccipital crest short, usually 2 scales along its border.

Vertebrae counted only in cleared and stained specimens, 32 (14 + 18) in three and 31 (13 + 18) in one.

*Color in alcohol.*—Color description based on holotype, a mature male, Fig. 1 (see also Fig. 3). Females and immature specimens usually paler overall but with same general color pattern, Fig. 2. Ground color pale yellowish tan, slightly darker dorsally. Dorsally and anteriorly head with small to medium dark brown chromatophores. Large dark brown chromatophores on anterior portion of lower jaw, darkest along border of mouth. Maxilla with scattered small dark chromatophores.

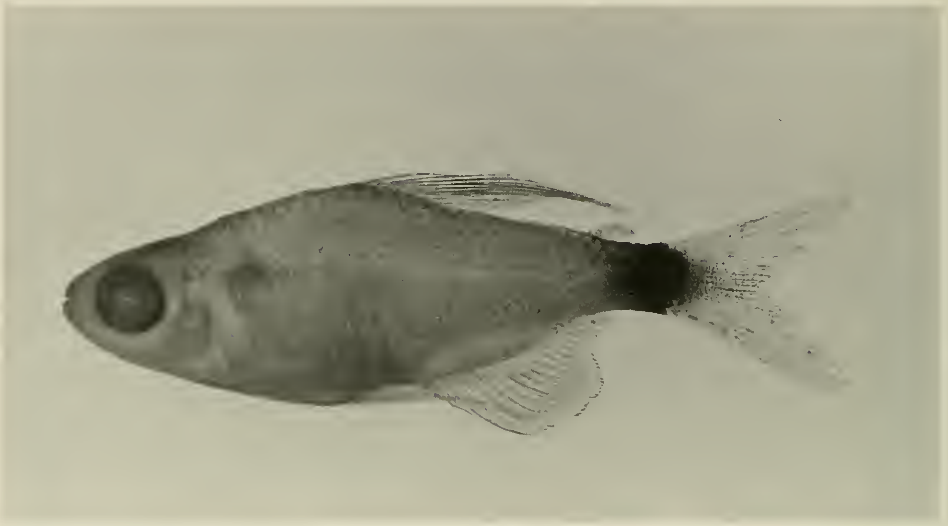

Fig. 3. *Hyphessobrycon elachys,* new species, USNM 232381, male, 15.5 mm SL, paratype. Paraguay, Parque Nacional Ybycui.

Connective tissue surrounding brain with very large dark brown chromatophores; small black chromatophores in skin over this area. A few tiny black chromatophores on head posterior to middle of orbit. Dorsal half of iris with much black pigment, remainder of iris iridescent gold. Head pale silvery-yellow ventrally.

Small dark chromatophores evenly spaced on scales of predorsal region. Scales along base of dorsal fin with large medium brown chromatophores over all but pale anteromedial portion and light brown outer border. Postdorsal scales with small dark chromatophores spaced farther apart and thus lighter, much like pattern on scales of horizontal scale rows 1 to 3 anterior to dorsal fin and on scales of most of body posterior to dorsal fin.

Small anterior humeral spot present, rounded and pale; barely discernible on some specimens, tympanum visible underneath. Humeral spot located on third and fourth scales of fifth horizontal scale row. Humeral spot extends dorsally into fourth horizontal scale row and ventrally through sixth, lateral-line, row into second scale of seventh horizontal scale row. Scales within spot all with evenly scattered small dark chromatophores.

Most specimens with lateral band of widely scattered small dark chromatophores which extends across body from just posterior to dorsal border of opercle to anterior border of caudal peduncle. Narrow dark stripe between epaxial and hypaxial muscles of body visible, especially posterior to vertical through anal-fin origin. Row of large brown chromatophores present on body in region where proximal radials of anal-fin pterygiophores approach haemal spines. Sometimes a broad band of large soft brown chromatophores on body just posterior to humeral spot and ventral to previously described lateral band. These extend to near vertical drawn through dorsal-fin origin. Scales on body in region dorsal to anal-fin base with small evenly spaced chromatophores in a pattern along external borders hypaxial musculature. Anterior portion of caudal peduncle pale, to about half in female and immature specimens, but essentially absent in holotype as caudal spot extends nearly across the caudal peduncle.

Caudal spot present; large, almost black, covering most of caudal peduncle in adult males (Figs. 1, 3), covering posterior half of caudal peduncle in female and immature specimens (Fig. 2), and muscular portion of caudal-fin base in all. Anteriorly, caudal spot usually with rather rounded, convex margin. Posteriorly, on caudal fin, spot narrows and on mature males extends across caudal fin in region of fin rays 7 to 12. On most other specimens posterior border of caudal spot tapers to a point on middle rays about one half distance to distal border at fork.

Dorsal fin of mature male dusky gray with small black chromatophores over most of fin except along somewhat enlarged proximal half of fin rays 2 to 5. Dorsal fin in this region rather translucent. Dorsal fin of female and immature lighter, fin rays not enlarged. Anal fin of mature male light dusky brown across anterior proximal ½ to ⅔ of fin in region of broad fin rays. Posterior portion of fin with scattered small black chromatophores. Distal border of anal fin dusky black. Anal fin of immature males pale. Anal fin of females light dusky gray with anterior rays bordered with dusky gray in middle portions. Scattered small dark chromatophores on distal quarter of membrane between anterior rays, fewer on membrane between rays 7 to 12, but basal to distal; posteriorly a few chromatophores basally. Posterior rays otherwise pale. Pectoral and pelvic fins with scattered small black chromatophores. Caudal fin of mature male dusky black across middle rays 7 to 12. Center basal portion of each caudal-fin lobe translucent and remainder of caudal fin a lighter dusky gray than on dorsal fin. Caudal fin of females and immature males similar but dusky black of caudal spot tapers to point on middle rays, see description of caudal spot above.

Color in life unknown. Some specimens retain chromatophores that suggest red pigment present on side in region of humeral spot. Also pale spots on basal portion of caudal-fin lobes probably have color in life.

*Sexual dimorphism.*—Sexual dimorphism obvious in extension of dorsal- and pelvic-fin rays especially in mature males and in lobular shape of anterior portion of anal fin in males. In females these fins have shapes very like those of other *Hyphessobrycon* species. There are some morphometric differences but none that would suggest additional sexual dimorphism.

*Etymology.*—The specific name *elachys* from the Greek, little or small, is in reference to the small adult size of the species.

*Relationships.*—The relationships of this species to other species of characids remain unknown. It is placed in *Hyphessobrycon* Durbin on the basis of its possession of the characters used by Eigenmann (1917) to define that genus. These are: few, if any teeth on maxilla, adipose fin present, incomplete series of lateral-line pores, third orbital bone (2nd suborbital in Eigenmann's terminology) not in contact with sensory tube of preopercle, two series of premaxillary teeth, and caudal fin naked of scales except at its base. See Weitzman (1977:355–356) for a discussion of the problem of recognizing *Hyphessobrycon* and putatively related genera, and Weitzman and Fink (1983) for a discussion of the phylogenetic relationships of small characiforms.

*Hyphessobrycon elachys* does not key satisfactorily to any species in Eigenmann (1918:172–175). If one follows the key to *Hyphessobrycon* in Géry (1977:455–

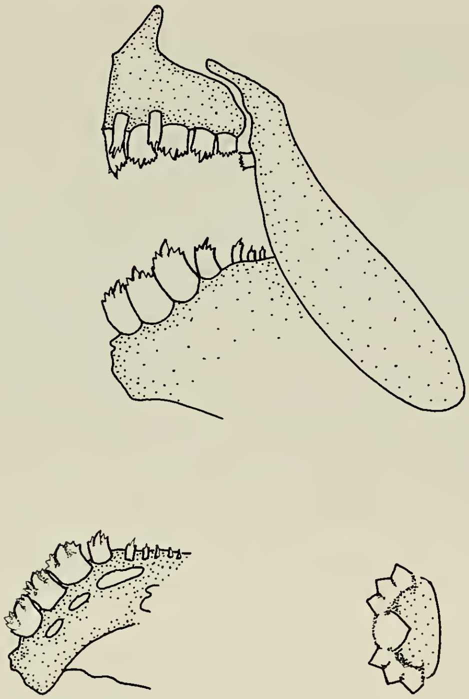

Fig. 4. *Hyphessobrycon elachys,* USNM 268474, male, 16.6 mm SL, cleared and stained spm A. Lateral view of premaxillary, maxillary, and dentary bones. Medial view of dentary. Diagram of tooth-cusp arrangement, posterior border of premaxillary tooth to left but anterior border of dentary tooth to left.

486), one proceeds to *Hyphessobrycon anisitsi* (Eigenmann) because both have the dorsal fin near midbody, one narrow maxillary tooth, as well as humeral and caudal spots present. *Hyphessobrycon anisitsi* also occurs in Paraguay, but it is a large species, reaching at least 60 mm SL, looking similar to some species of *Astyanax.* The teeth of the dentary and premaxillary bones have similar counts and comparable size in the two species, but these characters are shared with many other *Hyphessobrycon* species. However, *H. anisitsi* lacks the unique shape of the dentary and premaxillary teeth of *H. elachys.* See Fig. 4.

Another species of *Hyphessobrycon, H. callistus* (Boulenger), occurs in the same part of Paraguay as *H. elachys* but apparently the two are not closely related. *Hyphessobrycon callistus* "belongs" to a deeper-bodied "group" with one or two vertical humeral bars, a black spot on the dorsal fin and usually without black on the caudal peduncle.

Among other small fish which were collected with *Hyphessobrycon elachys* in Paraguay, there were at least two with very similar color pattern and size. One is evidently *Hemigrammus tridens* Eigenmann (in Eigenmann and Ogle 1907). The only difference between *Hemigrammus* and *Hyphessobrycon* according to Eigenmann (1917) is the possession of scales on the caudal fin of the former genus. In practice, this character can be difficult to use because the scales on these small fishes are easily lost due to various hazards during collection and preservation;

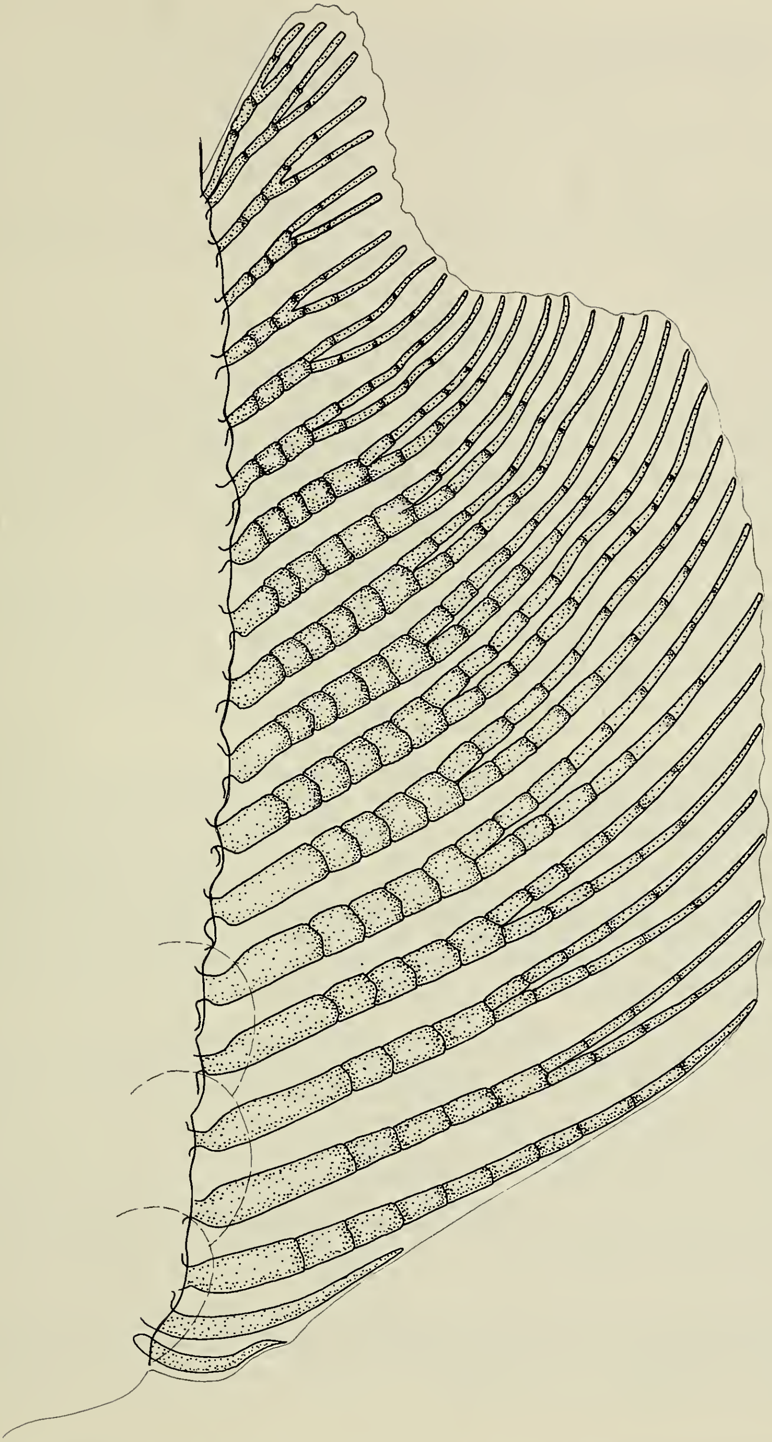

Fig. 5. *Hyphessobrycon elachys,* USNM 268474, male, 16.6 mm SL, cleared and stained spm A. Anal fin. Dotted lines indicate three scales of anal-fin sheath.

however, the small scales which extend along the dorsal and ventral borders of the caudal fin in *Hemigrammus* appear to be less easily lost.

Another species, *Hyphessobrycon maxillaris* Fowler (1932:354) was examined during the search for close relatives to *Hyphessobrycon elachys.* Reexamination of the types, ANSP 53660–53663, and of specimens from USNM and UMMZ has revealed that the species is a *Hemigrammus,* as currently defined, because of the possession of small scales along the basal one-third or so of the dorsal and ventral borders of the caudal fin and should be referred to as *Hemigrammus maxillaris* (Fowler).

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I wish to thank Richard Vari for passing this new fish over to me for description and especially Stanley Weitzman, for then suggesting that I should describe this miniature from Paraguay since I have been studying the species of *Hyphessobrycon* in southeastern Brazil. I am grateful to the Division of Fishes, Department of Vertebrate Zoology, Smithsonian Institution for providing space and facilities for my studies and to the Neotropical Lowland Research Program of the Smithsonian Institution for granting contracts for the continuation of my studies. William L. Fink loaned the material from the University of Michigan Museum of Zoology. Stanley H. Weitzman made the photographs for Figs. 1–3 and offered much additional technical assistance.

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# A REVISION OF THE GENERA *PHASCOLION* THÉEL, AND *ONCHNESOMA* KOREN AND DANIELSSEN (SIPUNCULA)

Edward B. Cutler and Norma J. Cutler

*Abstract.*—The two closely related sipunculan genera, *Phascolion* and *Onchnesoma* are reviewed and the species reevaluated in light of a critical examination of historically used morphological characters. Wherever possible, type-material was examined and the accuracy of original descriptions verified. Of the 52 putative species in *Phascolion,* 23 species and two subspecies are retained as valid and are arranged into five subgenera (two new ones: *Villiophora* and *Isomya*). The four *Onchnesoma* species and one subspecies are retained but one new subspecies is added. The known distribution of each species is given and a brief zoogeographical analysis is offered. Keys to all the species are included.

The sipunculan genus *Phascolion* was erected by Théel in 1875 to contain three species. An interesting history of this taxon is presented in Hendrix (1975). In their monograph, which we use as the starting point for this work, Stephen and Edmonds (1972) include 34 species names. Since then 18 new species have been described.[1]

In the same year, the closely related genus *Onchnesoma* was created by Koren and Danielssen (1875) for three species which had many of the same character states as *Phascolion.* Their *Onchnesoma* work had already been submitted to the publisher when Théel's *Phascolion* paper was published (see appendix in Koren and Danielssen 1877:152) so at the outset there was no comparison of these two taxa. Also, the characters used by the original authors differed from those used by 20th century writers, especially in not mentioning the single nephridium and actual anal location in the generic diagnoses. Koren and Danielssen's *Onchnesoma* diagnosis read: "Body small, pear-shaped, proboscis long, anal aperture a little in front of the base of proboscis, no tentacles, no vascular system, one retractor." Selenka (1885) contributed to this construct by moving what had been *Phascolosoma squamatum* into *Phascolion* but Théel (1905) moved it on to *Onchnesoma.* Selenka's six reasons for moving *squamatum* helped clarify the issue but as Théel (1905:97) pointed out, Selenka repeated some of Koren and Danielssen's mistakes by looking only at their description, not the worms.

As we worked with these genera, it became increasingly difficult to maintain their separate generic status. The "gap" became less and less clear especially when working with *Phascolion* species lacking hooks and holdfasts and with the retractor muscles fused for most or all of their length. At one point we had concluded that *Onchnesoma* should be ranked at the subgeneric level but have subsequently decided to not propose such a change at this time. They are clearly closely related

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[1] The endings of six species names have been changed in this paper to comply with the ICZN. The genus name is neuter and all adjectival species names should be in the neuter form. We are indebted to Dr. G. Steyskal, Washington, D.C. for these corrections.

and data from developmental or biochemical analyses would help resolve this uncertainty.

Stephen and Edmonds (1972) list the two species of *Onchnesoma* found in Théel (1905). An additional two species and one subspecies have been described since then (here we add one new subspecies).

This report is one in a series of efforts to apply the Cartesian methodology of doubt, analysis, synthesis and enumeration to the currently accepted species of sipunculans. The process involves: 1) a familiarization phase that includes an analysis of written descriptions to look for subsets of related species within a subgenus or genus. 2) A comparative study of characters presumed to have taxonomic significance. To determine the extent of variation present within one gene pool, series of individuals of different sizes from relevant populations are studied. During this phase we also look for new characters which may be potentially useful. 3) An examination of type-material and other reference material to validate or correct (if necessary) the original description. 4) With these data we then make decisions about meaningful differences and species validity culminating in a redefinition of the taxa as required. The organization of this report reflects that process addressing first *Phascolion* then *Onchnesoma.* Table 1 lists all species considered with any status changes resulting from this study.

## *Phascolion* Théel, 1875

*Type-species.*—*Sipunculus strombus* Montagu, 1804.

*Diagnosis.*—Species with trunks less than 4 cm in length, many inhabiting mollusc shells. Introvert one-half to 4 times trunk length, usually with hooks. Trunk often with chitinized 'holdfast' papillae. Body wall with continuous muscle layers. Oral disk carrying tentacles arranged around mouth, reduced in a few species. Introvert retractor muscle system modified by fusion of dorsal and partial (rarely complete) fusion of ventral pair. Further fusion to form single retractor column may occur. Except in *P. cirratum,* contractile vessel without villi but may be vesicular. Gut with spiral coil and loops or just loose loops. Spindle muscle absent. One nephridium.

## Morphological Characters of *Phascolion*

1. *Holdfast or attachment papillae.*—The epidermal papillae in the genus *Phascolion* are large and diverse. Those in the mid region of the trunk (sometimes posterior) may secrete chitinoid material to form hardened structures which are referred to as holdfast or attachment papillae—the name suggesting their function. This assumed function has not been demonstrated but Hylleberg (1975) has observed that they do scrape the bacteria from the inside of the empty shells used for shelter. Perhaps the term cleaning papillae or scrapers would be more descriptive of their structure.

Much of the taxonomic literature treats these as if they were fixed, static and uniform in size, shape and distribution within a species. While some writers have described the variations within populations (Théel 1875a; Wesenberg-Lund 1929), others have ignored these works. It is clear that whatever the genetic potential might be, its expression may be modified by environmental factors such as 1) the physical nature of the shelter (hard, soft, loose or tight fitting (Gerould 1913); 2) the availability of certain chemical elements (e.g., iron, Gibbs 1985), or 3) the material (sediment, mucus, etc.) deposited on the inside of the shell (Hylleberg 1975). The other variable is the ontogenetic stage, i.e., no member of this genus is known to have chitinized holdfasts in very young juveniles. In populations of *P. strombus* holdfasts are present in 3–4 mm worms, but not yet evident in 1–2 mm worms. Therefore, when one has a 1 or 2 mm worm without chitinized holdfasts, it is very risky to assert that this is the adult condition, unless gametes are also present. However, if the specimen is more than 3 or 4 mm and lacks holdfasts, one can be fairly certain that this represents reality for the adult.

The number, form, and distribution of these holdfasts, when present, are very difficult to describe with confidence. As noted above, several authors have addressed this problem. How much plasticity exists within any one gene pool is yet to be unequivocally determined, but on a single animal (one genotype), the size, degree of pigmentation and shape is so variable that we seriously question its use in species diagnoses except in a very general way. There are three general conditions: 1) a few species exhibit no large glandular papillae in the midsection of the trunk (e.g., *P. lutense*); 2) some have large glandular papillae which appear as flattened spheres but with no solid chitinous deposits around their border (e.g., *P. tuberculosum*); and 3) most species have these papillae and a few to many of them secrete a border of chitin which may be pale brown to black, from 30–300 μm across the base of the chitinized portion, and the shape being some variant of a crescent or U-shape, sometimes appearing with a tooth or spine. Within populations having condition 3 (holdfasts) one must be careful to note that what is seen in a particular individual or series of specimens may not represent all of the phenotypic possibilities for that species.

To use the shape or size of a glandular papilla and its secretory products as an exclusive property is unwise. Rather, these should be considered as examples of what is within the range of possibilities for a particular species with the understanding that in smaller or larger worms living in a different microhabitat these parameters may vary. In other words, the number, type, and size varies among subsets so that while the genetic potential for producing these units exists, environmental factors modify their expression (Gibbs 1977). Figures 1 and 2 show some of the variety in a series of holdfast papillae present in this genus.

2. *Introvert retractor muscles.*—In larval *Phascolion* there are two pairs of introvert retractor muscles, the primitive, plesiomorphic condition in the phylum (Åkesson 1958). Very early in their ontogeny each pair (dorsal and ventral) fuse together for most or all of their length giving the appearance of only two muscles, the ventral often with two origins near the posterior end of the trunk (Gerould 1913). In a few species the fusion is more extensive, with the dorsal and ventral set coming together to form a single muscle. A model would be to think of there being three zippers closing from anterior to posterior along these muscles: the one between the dorsal pair almost always closing down all the way, the one between the ventral pair usually remaining unzipped for the last millimeter or so, then the third zipper between this newly formed pair (fused dorsal and fused ventral) usually closing only a short distance (*P. strombus* and *P. tuberculosum,* Fig. 3A, B), sometimes closing about ½–¾ the distance (*P. lutense,* Fig. 3C) and occasionally closing all the way (*P. cryptum,* Fig. 3D). This latter condition also exists in the genus *Onchnesoma.*

When two muscles are evident, biologists have used certain attributes as diagnostic characters. One which is useful is whether they are of equal or unequal

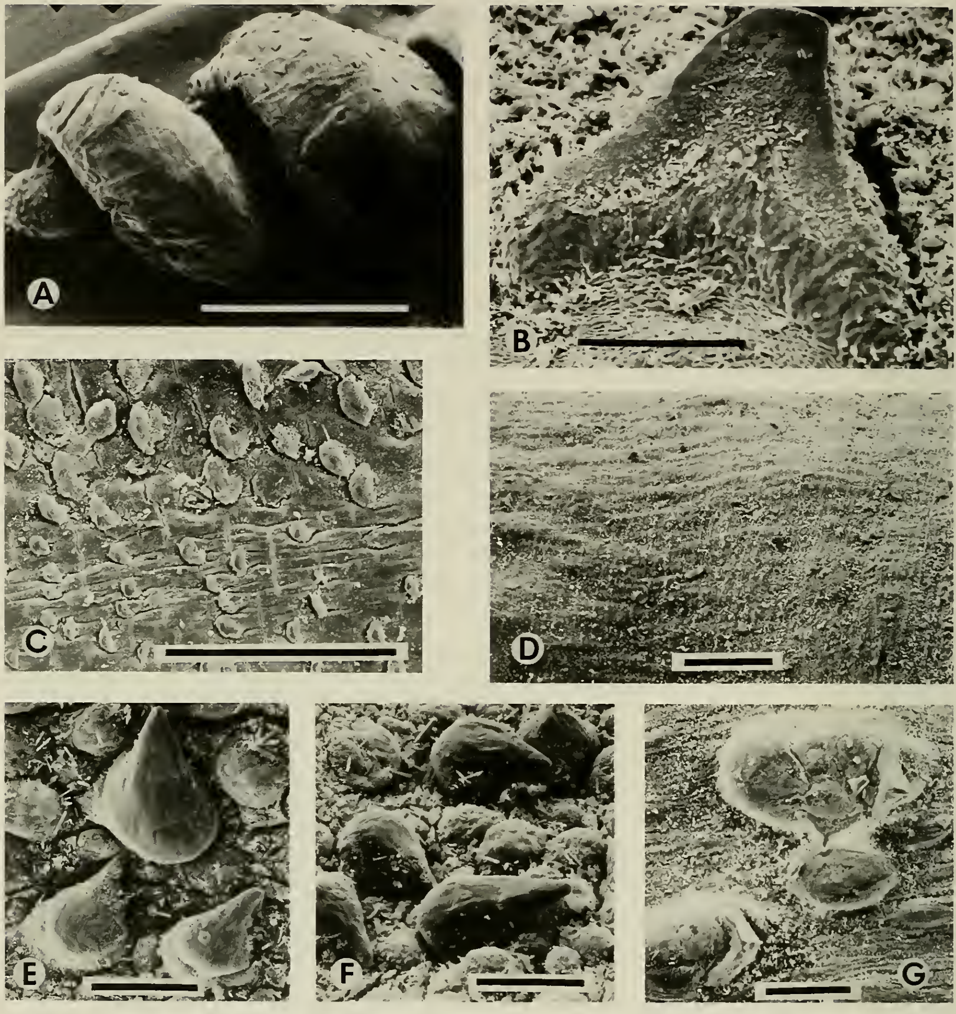

Fig. 1. Scanning electron micrographs of *Phascolion* skin and holdfast papillae: A, *P. strombus* from gastropod shell showing V-shaped holdfasts on upper right coil and epizoans on posterior end (scale line = 1 mm); B, Chitinous holdfast papilla of *P. strombus* (scale line = 20 μm); C, Ventrolateral section of *P. strombus* showing variety of sizes and shapes of holdfast papillae (scale line = 1 mm); D, Skin of *P. lutense* showing complete absence of holdfast papillae; E, F, *P. caupo*'s large holdfast papillae from two different angles (scale line = 0.1 mm); G, *P. collare* showing 0, 1, and 2 teeth on holdfast papillae (scale line = 0.1 mm).

size. In some species the ventral muscle is slender, the dorsal being 2.5–10 times the thickness of the ventral. This difference is only true for worms exceeding 2 mm in trunk length. In smaller individuals the two muscles are of almost equal size. This ontogenetic series is illustrated in Fig. 4 with *P. strombus* over a range of sizes. In those species with retractors of equal size the dorsal may occasionally be larger (1.3×) or slightly smaller (0.7×) than the ventral but there is a clear gap between these two groups (when trunk is over 2 mm long).

It is possible to overlook the ventral retractor muscle when it is thin (as in *P.*

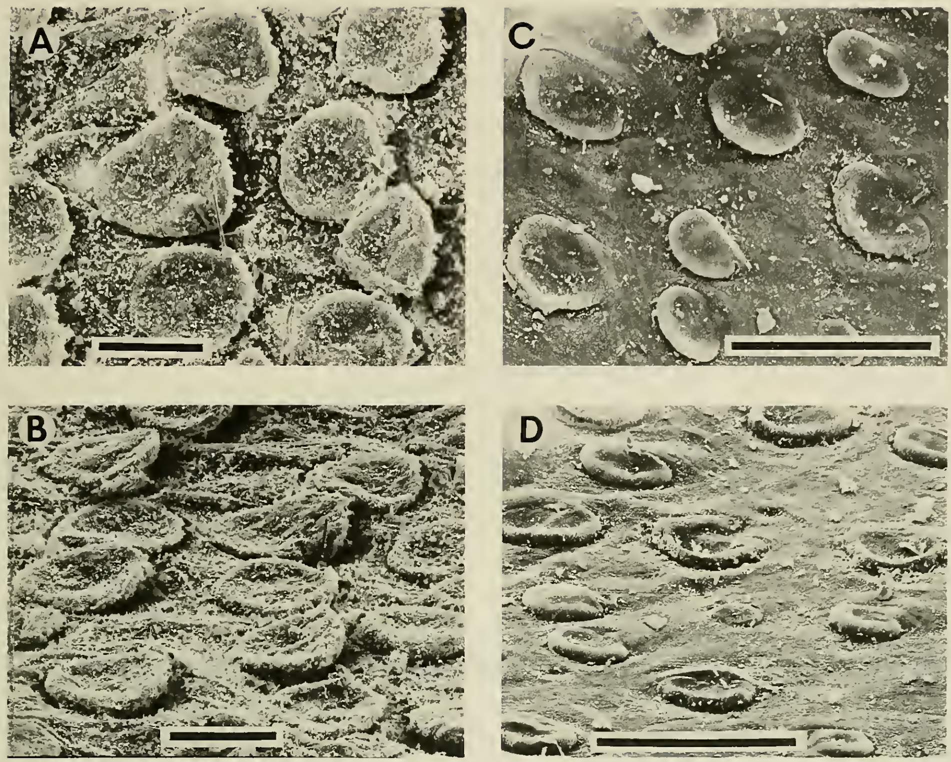

Fig. 2. Scanning electron micrographs of *Phascolion* holdfast papillae at two different angles: A, B, *P. tuberculosum*'s bulbous non-chitinized papillae; C, D, *P. hedraeum*'s papillae with border slightly chitinized. (Scale lines = 200 μm.)

*strombus*) and conclude that only one muscle is present. This mistake has been made by biologists of current, as well as past eras, especially when the ventral muscle is very thin and has the esophagus attached to and covering a portion of it. This is especially difficult in the contracted state when only 1–2 mm of the muscle is visible at the posterior end. When the coelom is filled with gametes or sediment from a ruptured intestine this is further obscured. It may be more like a spindle or fixing muscle in appearance and can be easily broken when small. Additionally, in species said to have only one muscle but where the esophagus is not shown connected to this muscle, it may be that it is attached to the overlooked and possibly broken ventral retractor.

A less useful attribute is the position of the origins (roots) with respect to one another. It has been claimed that in some species they are at the same anterior/posterior level, while others are described as being at different levels. An examination of this hypothesis suggests it should be abandoned. In 70 specimens from several *P. strombus* Atlantic Ocean populations, when calculated as a percentage of trunk length, this distance ranged from 0–15%, rarely greater than 5%, many being at the same level (0%) especially, but not exclusively, the smallest worms. This species has historically been described as having its retractor origins at different levels. Plainly, this is not consistently true. On the other hand, *P. tu-*

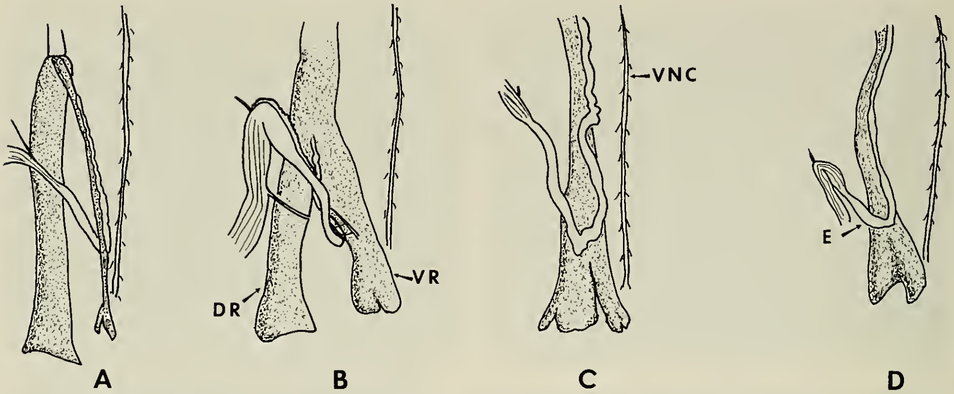

Fig. 3. Schematic drawing of introvert retractor muscles and esophagus in *Phascolion* subgenera: A, *P.* (*Phascolion*), ventral muscle considerably thinner than dorsal; B, *P.* (*Isomya*), dorsal and ventral muscles approximately equal size; C, *P.* (*Montuga*), muscles partly fused with esophagus leaving before any split; D, *P.* (*Lesenka*) and *P.* (*Villiophora*), completely fused retractor column. (DR = dorsal retractor muscle; E = esophagus; VNC = ventral nerve cord; VR = ventral retractor muscle.)

*berculosum,* with its origins allegedly at the same level, showed a range from 0–13% (most of the 20 specimens being between 1–6%). Similar variations can be found in other species, therefore, this character has little systematic value. A final aspect is the relationship between the origins of the ventral retractor and the ventral nerve cord. Whether the retractors straddle the nerve cord or are to the left of the midline, and whether the origins are anterior, at the level of, or posterior to the end of the nerve cord has been historically considered as constant within a species. Our data do not support this assumption. It is true that in most of the Atlantic *P. strombus* the retractors are slightly posterior (0.1–0.5 mm which is 0.3–4%, a few are up to 8%, of the trunk length) and offset to the left. However, there are a significant number where these points coincide and a few in which the retractors originate anterior to the termination of the ventral nerve cord by 1.5–4%, sometimes to the left and sometimes straddling it. In very small worms this relationship is difficult to ascertain with certainty. The norm in this genus seems to be that the ventral retractor origins are posterior and slightly to the left of the nerve cord, but they occasionally are located anteriad and/or on the midline. No correlation with the degree of coiling is apparent. Finally, six of the 70 Atlantic *P. strombus* (9%) showed complete fusion of the ventral retractors so that there was a single origin.

3. *Contractile vessel.*—The tentacular coelom is continuous with a blind tube which is attached to the esophagus and probably functions in gas exchange. This so-called contractile vessel (its contractile capability has not been demonstrated) is thin walled and generally is about one-quarter the diameter of the esophagus. As in other genera (e.g., *Siphonosoma,* Cutler and Cutler, 1982) there is confusion about contractile vessel villi. Contrary to some assertions there is only one species in *Phascolion* which has true villi (*P. cirratum*). What is present in some others are folds or vesicular pouches along some portion of the tube, perhaps due to the relative inelasticity when the adjoining retractor muscle is contracted. The size of this vessel and extent of folding or vesicle formation does seem to be correlated

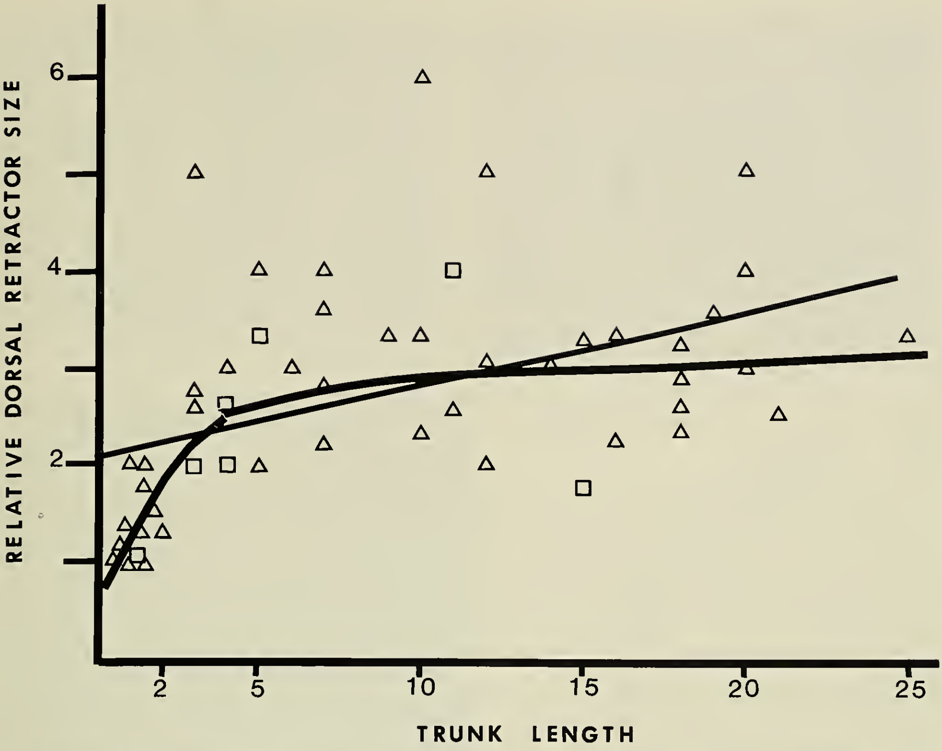

Fig. 4. Relative size of introvert retractor muscles in a population of *P. strombus* ranging in trunk length from 0.6–25 mm. Values on Y axis are the width of dorsal retractor divided by width of ventral retractor muscle. N = 59; curve is a hyperbolic function Y = x/(a + b*x). a = 0.51, b = 0.32 and Index of Determination = 0.69; squares represent 2 individuals. The straight line represents linear regression with a poor fit (Index of Determination = 0.2).

with the number of tentacles. As in *Themiste* and *Thysanocardia,* this is probably an adaptation to low oxygen tension and larger size. *Phascolion cirratum* is known only from the Red Sea where the temperature is high and the oxygen tension is low. It has many tentacles and an elaborate array of villi. We consider this to merit subgeneric rank.

4. *Introvert hooks.*—The presence of scattered hooks on the introvert just behind the tentacles is characteristic of most members of this genus. When an individual is reported as lacking hooks it may be the result of: 1) genotypic change for the species; 2) loss of deciduous hooks as part of ontogeny; 3) delayed replacement during regeneration of lost introvert; 4) oversight on the part of the observer (some hooks are very small and pale and, especially when working with a withdrawn introvert, may be hard to find). When conditions 2, 3, or 4 are operative, it can be misleading and create unnecessary taxonomic confusion.

It is our conclusion that the real condition #1 is uncommon and found in only a few derived forms, all with completely fused retractor muscles (*P. cirratum, P. cryptum, P. hupferi, P. rectum, P. valdiviae sumatrense,* and the genus *Onchnesoma* are all without hooks as adults).

Hook morphology has only been used to a minimal degree as a taxonomic character in *Phascolion.* There are, however, three general types and, while this division is somewhat artificial, it may help with species identification. Type I hooks (size 20–250 μm) have been called "claws" or "spines." They have pointed non-recurved tips and many have narrow bases. The spines are more perpendicular to the surface of the skin than are the claws. These include *P. bogorovi, P. hedraeum, P. lutense, P. microspheroidis, P. pacificum, P. strombus, P. ushakovi,* and *P. valdiviae.* Type II hooks (size 40–220 μm) are broad-based, heavy, with a recurved pointed tip. They also show an internal light triangle under the light microscope. These are *P. convestitum, P. hibridus, P. pharetratum,* and *P. tuberculosum.* Type III hooks (size 20–70 μm) are also broad-based and recurved but with a round tip. Included species are *P. abnorme, P. caupo, P. collare, P. lucifugax, P. medusae, P. megaethi,* and *P. robertsoni.* These types are illustrated in Figs. 5 and 6. When observing hooks on a slide one must be careful to account for distortion caused by the orientation of the hook to the plane of the slide (Fig. 5B).

5. *Intestinal loops and coils.*—The prevailing myth is that most members of this genus lack the usual sipunculan double helix gut coil, this having been replaced by a series of loose loops in all but a few species. *Phascolion strombus* is by far the most commonly collected member of this genus and it often lacks a gut coil. This condition must have been assumed to be common for the genus. A survey of the literature showed this to be in error, only ten putative species have been described as lacking the spiral coil, i.e., less than one-quarter of the described species. Of the 23 remaining valid species, only eight lack the gut coil.

6. *Intestinal fastening muscles.*—In this phylum, there are two different kinds of threadlike muscles used for fastening the intestine in place: the spindle and the fixing muscles. There has been some inconsistency in the application of these terms in this genus. A spindle muscle has its origin either in the body wall just anterior to the anus or on the distal part of the rectum. It extends along the rectum, through the gut coil and either terminates within the coil near the most posterior coil, or extends through the whole spiral and inserts on the posterior tip of the body. Fixing muscles are much shorter and go from the body wall (at a variety of points) to the wall of the esophagus or intestine. These are therefore much shorter, and their numbers (often 2–5) and particular points of origin or insertion seem variable but this is difficult to ascertain with precision due to their small and fragile nature.

In the literature five species are said to have spindle muscles, two of Fischer's (*P. valdiviae* and *P. sumatrense*) and three of Murina's (*P. pacificum, P. sandvichi* and *P. ushakovi*). Our inspection of these types showed a strong fixing muscle from the posterior end of the gut coli but no spindle muscle. Most authors use fixing or fastening muscles but in Stephen and Edmonds (1972) there are five species in which the term mesenteries, not muscle is used. This seems to be a matter of the translator's choice because in the same work they say that *P. abnorme* and *P. hupferi* have spindle muscles while in the original the term 'Befestiger' is used, not 'Spindelmuskel,' so that translation is misleading. Only one species is said to lack any fasteners but for six species no mention is made as to their presence or absence.

We have found no evidence of a true spindle muscle in any of the *Phascolion* material we have examined. Therefore, we conclude that it is absent in the genus; fixing muscles, however, are usually present.

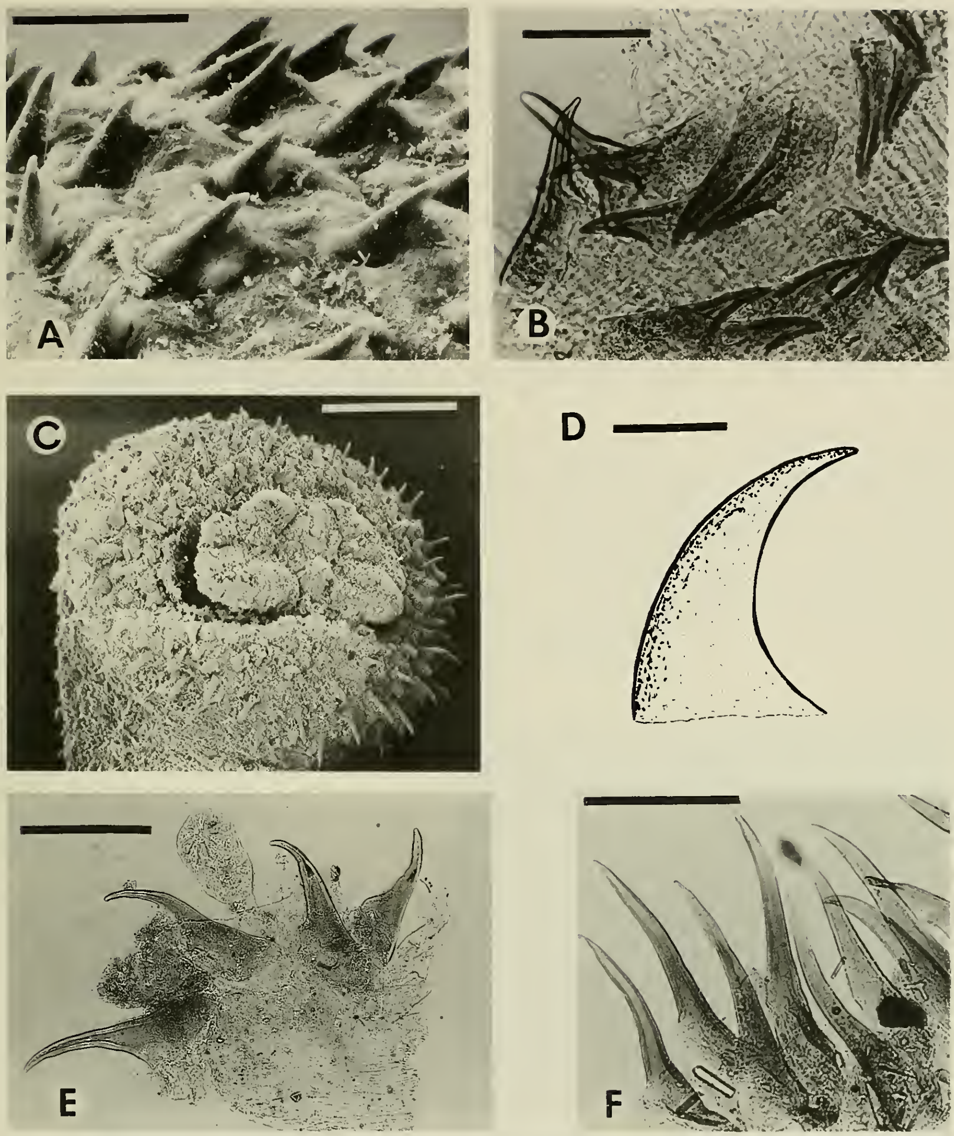

Fig. 5. *Phascolion* introvert hooks (Type I): A, B, *P. strombus* (scale = 100 μm), B showing how orientation of hook on slide affects appearance; C (scale = 200 μm), D (scale = 20 μm), *P. microspheroidis,* C also showing tip of introvert with tentacular lobes; E, *P. bogorovi* (scale = 200 μm); F, *P. ushakovi* (scale = 200 μm).

7. *Tentacular crown.*—It is difficult to determine with certainly whether there is a genetically determined upper limit on the number of tentacles in a given species. In other genera this appears to be somewhat indeterminate, the number of tentacles continuing to increase throughout the life of the worm. However, in *Phascolion* there appears to be, if not a fixed number, at least a small range.

In general, one sees four types of tentacular crowns in this genus: 1) no distinct tentacles but only a few (less than 10 lobes) (e.g., *P. lutense,* Fig. 7B). As the production of tentacles occurs after settling of the larvae (Åkesson 1958; Gibbs

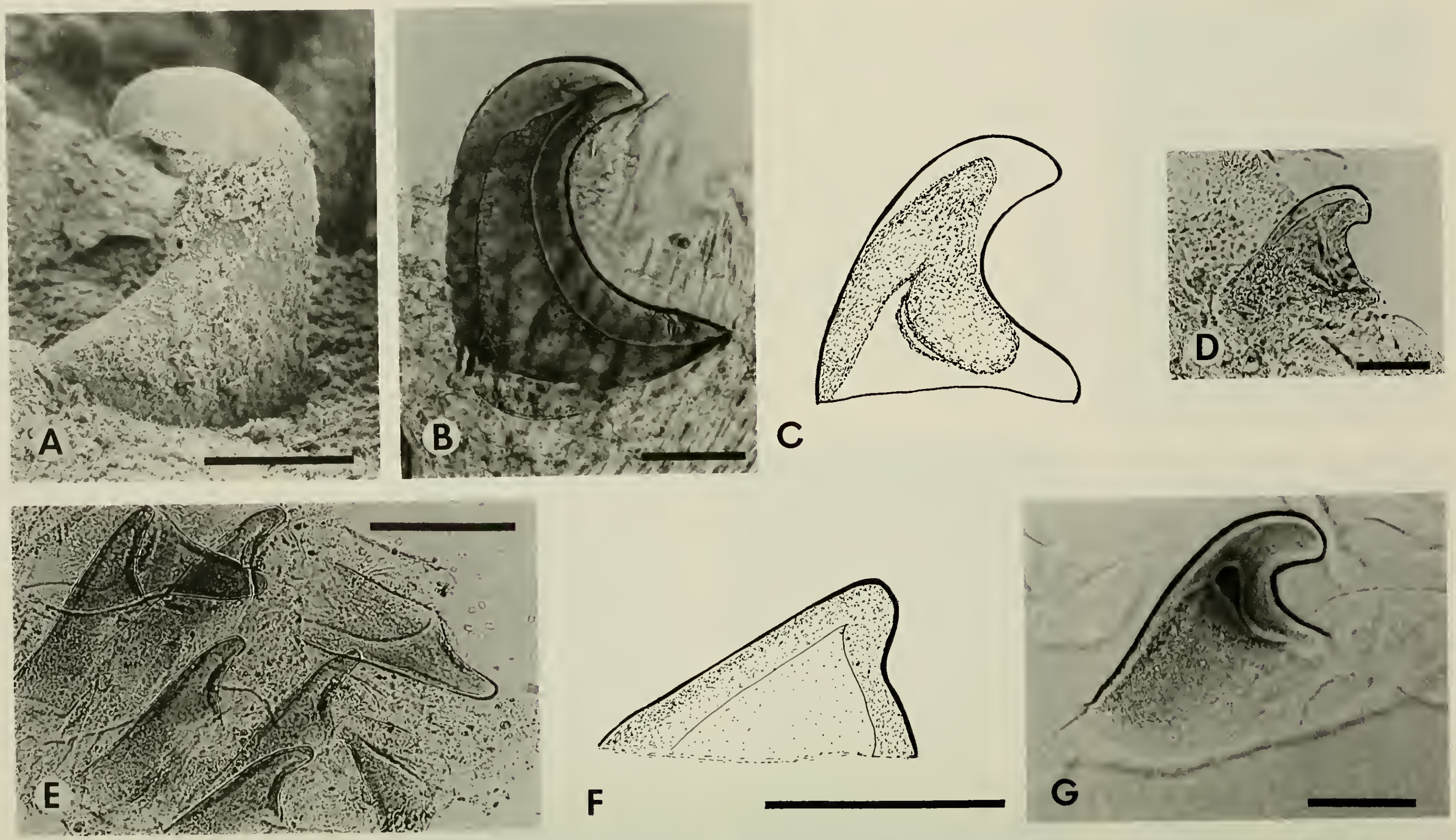

Fig. 6. *Phascolion* introvert hooks (A–D, Type II; E–G, Type III): A, B, SEM and photograph of *P. tuberculosum*; C, *P. pharetratum* (after Sluiter 1902, fig. 3); D, *P. convestitum*; E, *P. medusae*; F, *P. collare*; G, *P. lucifugax*. (Scale lines = 50 μm.)

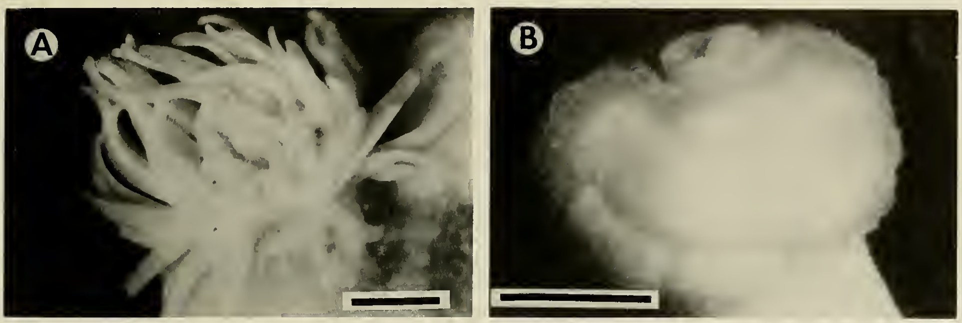

Fig. 7. Distal tip of introvert with tentacles showing the two extreme conditions in *Phascolion*: A, *P. robertsoni* with many tentacles; B, *P. lutense* with reduced lobes. (Scale lines = 0.5 mm.)

1977) the presumed absence of tentacles may sometimes be due to the juvenile condition of the specimen; 2) in adults there are 15–28 well defined tentacles of varying shape but usually broad and digitiform (e.g., *P. strombus* and *P. tuberculosum*; see Théel 1905, pl. VI, figs. 82–86); 3) adults with 40–60 slender, digitiform tentacles (e.g., *P. robertsoni,* Fig. 7A and *P. medusae*); 4) a reduction to the four primary tentacles but each of these branching in a dendritic pattern (*P. cryptum*). This species has "accessory tentacles" on the bulbous area below the tentacles where hooks are commonly found in most species.

It is very difficult to determine this number in small specimens with introverts withdrawn and therefore is of limited taxonomic value. Additionally, tentacle number is not species specific in the sense of being different from all other species or in the sense of each member of the population having exactly the same number. In a broad sense, as part of a suite of characters, tentacle number can be useful to the taxonomist.

8. *Nephridium.*—When species descriptions are constructed authors often make reference to a suite of characters relating to the single nephridium. 1) Position of nephridiopore with respect to the anus is almost always mentioned. For the genus *Phascolion* this is always posterior to the anus. The two stated exceptions are unsupportable (see discussions of *P. abnorme* and *P. ikedai*). Whether it is 1 mm or 6 mm posterior does not seem to be a species-specific character but more a factor of size with much individual variation within a population. 2) Size of nephridium is often mentioned (as ¼, ⅓ or ½ the trunk length) but again, in any one population this is quite variable and usually correlated to the size of the animal. The trunk seems to grow faster than this organ so that, as a percentage of trunk length, the nephridium becomes "smaller" as the animal gets bigger. In *P. strombus* the nephridium length ranges from 50–20% in 4–27 mm worms while in *P. tuberculosum* worms 3–36 mm long, these values range from 35–18%. In both groups there is a general trend but with much deviation, especially in the mid-size range, similar to *Phascolosma* species (Cutler, Cutler, and Nishikawa 1984). 3) Degree of attachment of the nephridium to the body wall has had significance for earlier systematists. The attachment in this genus consists of a series of very fine, fragile thread-like mesenteries extending between the nephridium and the adjacent body wall. The ontogeny of these strands is unclear but they are present in all of the recently collected and previously undissected specimens we have examined and, in general, the whole nephridium is anchored.

Occasionally, the distal 10–20% may appear "unattached" but in an organ commonly 2–6 mm long, this is insignificant especially since these strands can be broken even by the force of a stream of alcohol directed on the organ to clear away gametes.

In summary, except in a very general way or in unusual cases, these three character-states are of no value in differentiating species of *Phascolion.*

9. *Rectal caecum.*—This small appendix is usually found at the intestine/rectum junction but may be further anteriad along the rectum. Its presence/absence is usually reported and presumed to be taxonomically significant. While this may be truly absent in some individuals, it is also possible easily to overlook it. It is also likely that during the dissection of these small worms, especially the coiled ones from gastropod shells, that the fragile gut can be torn, potentially destroying the caecum.

In Stephen and Edmonds (1972) the rectal caecum is asserted to be absent in seven species. Upon reading the original descriptions one finds that in five cases no mention was made about its presence or absence. In the other two, the statement was to the effect that a caecum was not seen and it was probably absent. In both of these latter cases the sample size was one specimen (*P. heteropapillosum* and *P. sumatrense*). It is probable that most members of this phylum have a rectal caecum and its apparent absence in an occasional worm has no taxonomic meaning.

## Subgenera

Gibbs (1985) has proposed three subgenera based on the nature of the retractor muscles and the relationship of the esophagus to them. We accept his construct but modify it in two ways. The presence of numerous well-defined contractile vessel villi and numerous tentacles in *P. cirratum* justifies the erection of a separate taxon for this species. The subgenus *Phascolion* s.s. we here subdivide into two sets: one with retractor muscles of equal size, the second with dorsal retractor significantly larger than the ventral.

### Subgenus *Phascolion* s.s. Théel, 1875

*Diagnosis.*—Retractor column divided for most of its length. Esophagus detaching from retractor column at point posterior to first separation of retractor muscles. Diameter of dorsal retractor muscle at least twice that of ventral muscle.

*Type-species.*—*Sipunculus strombus* Montagu, 1804.

*Species included.*—*P. abnorme, P. bogorovi, P. caupo, P. hibridus, P. medusae, P. megaethi, P. pharetratum, P. robertsoni, P. strombus, P. ushakovi.*

### Subgenus *Isomya,* new subgenus

*Diagnosis.*—As for subgenus *Phascolion* s.s. except that diameters of dorsal and ventral retractor muscles equal or nearly so.

*Type-species.*—*Phascolion tuberculosum* Théel, 1875.

*Species included.*—*P. convestitum, P. hedraeum, P. lucifugax, P. microspheroidis, P. tuberculosum.*

### Subgenus *Montuga* Gibbs, 1985

*Diagnosis.*—Retractor column divided only at posterior end. Esophagus detaching from retractor column at point anterior to first separation of retractor muscles.

*Type-species.—Phascolion lutense* Selenka, 1885.

*Species included.—P. lutense, P. pacificum.*

### Subgenus *Lesenka* Gibbs, 1985

*Diagnosis.*—Retractor muscles completely fused over whole length to give entire retractor column.

*Type-species.—Phascolion cryptum* Hendrix, 1975.

*Species included.—P. collare, P. cryptum, P. hupferi, P. rectum, P. valdiviae.*

### Subgenus *Villiophora,* new subgenus

*Diagnosis.*—As for subgenus *Lesenka* but contractile vessel with numerous distinct, true villi.

*Type-species.—P. cirratum* Murina, 1968.

*Species included.—P. cirratum.*

*Remarks.*—The villi, as a morphological character-state, are heavily weighted in other families. By using it at this subgeneric level (not generic) we are being conservative.

### Key to *Phascolion* Species

| | | |
|---|---|---|
| 1. | Separate dorsal and ventral retractor muscles; esophagus continues along one of these posterior to subdivision | 2 |
| – | Retractor muscles fused for most or all of length; esophagus separating from retractor prior to any subdivision | 16 |
| 2. | Dorsal and ventral retractor muscles of equal size; holdfast papillae weakly chitinized, if at all | Subgenus *Isomya* . . . 3 |
| – | Ventral retractor muscle much thinner than dorsal ($\frac{1}{10}$–$\frac{1}{2}$); many with distinct chitinized borders on holdfast papillae | Subgenus *Phascolion* s.s. . . . 6 |
| 3. | Holdfast papillae large but with no chitinized borders | 4 |
| – | Holdfast papillae with weak border of chitin | 5 |
| 4. | Hooks 70–220 μm, broad, recurved; 10–30 tentacles | *P. tuberculosum* |
| – | Hooks 60–70 μm, blunt, strongly curved; more than 35 tentacles | *P. lucifugax* |
| – | Hooks 25–50 μm, slightly recurved and sharp point; tentacles absent or reduced | *P. microspheroidis* |
| 5. | Bluntly pointed, spine-like hooks, 30–90 μm | *P. hedraeum* |
| – | Hooks broad based and recurved | *P. convestitum* |
| 6. | Slender, digitiform tentacles, usually more than 35 | 7 |
| – | Broadly based, tapering tentacles, usually less than 35 | 8 |
| 7. | U-shaped, chitinized holdfast papillae | *P. robertsoni* |
| – | Bulbous holdfast papillae with no chitinized borders | *P. medusae* |

8. Chitinized holdfast papillae absent ... 9
– Chitinized holdfast papillae present ... 11
9. Tall, spine-like, Type I hooks ... *P. ushakovi*
– Broad based, Type II hooks ... 10
10. Anterior of trunk with large, compact papillae, usually chitinized; no helical coil in gut, loops only ... *P. hibridus*
– Anterior of trunk without chitinized papillae; helical coil of gut present ... *P. pharetratum*
11. Chitinized border of holdfast composed of discontinuous, granular units ... *P. bogorovi*
– Chitinized border of holdfast forming continuous, smooth margin ... 12
12. Hooks claw-like, pointed (Type I) ... 13
– Hooks curved, bluntly rounded (Type III) ... 14
13. Ventral retractor less than ½ dorsal, usually at different anterior/posterior levels; anterior papillae with single tips ... *P. strombus strombus*
– Ventral retractor ½–¾ width of dorsal, at same level; anterior trunk papillae with 1–4 tips ... *P. strombus cronullae*
14. Holdfast papillae few and entirely covered by cone of chitin ... *P. caupo*
– Holdfast papillae with thin border of chitin; no cone ... 15
15. U-shaped holdfast papillae; ventral retractor origin anterior to dorsal ... *P. abnorme*
– V-shaped holdfast papillae on posterior tip of trunk; ventral retractor origin posterior to dorsal ... *P. megaethi*
16. Fusion of retractor muscles incomplete with 3, rarely 4, separate origins apparent ... Subgenus *Montuga* ... 17
– Retractors fused into single column but cleft in origin sometimes apparent ... 18
17. Chitinized holdfast papillae present ... *P. pacificum*
– Chitinized holdfast papillae absent ... *P. lutense*
18. Contractile vessel villi present; more than 40 tentacles ... Subgenus *Villiophora* ... *P. cirratum*
– Contractile vessel villi absent; less than 30 tentacles ... Subgenus *Lesenka* ... 19
19. Chitinized holdfast papillae present ... 20
– Chitinized holdfast papillae absent ... 22
20. Four primary tentacles plus many accessory ones ... *P. cryptum*
– More than 15 normal tentacles; no accessory tentacles ... 21
21. Holdfast papillae with pale, chitin borders of U- or V-shape .. *P. valdiviae*
– Holdfast papillae with 1–4 tall strongly chitinized and collapsed teeth/points ... *P. collare*
22. Anus on anterior end of trunk ... *P. rectum*
– Anus on distal half of introvert ... *P. hupferi*

## Systematic Section of *Phascolion*

### *Phascolion abnorme* Fischer, 1895

*Phascolion abnorme* Fischer, 1895:15–16, fig. 12.—Stephen and Edmonds, 1972: 169–170.

*Phascolion heteropapillosum* Wesenberg-Lund, 1963:135–138, figs. 11–12.—Stephen and Cutler, 1969:116–117.—Murina, 1970:67; 1971a:82.—Stephen and Edmonds, 1972:177–178. (Not Cutler, 1977b:153.)

*Material examined.*—*P. abnorme*: ZMUH—Fischer's holotype and only specimen #2124. *P. heteropapillosum*: ZMUH—type cannot be found; ZIAS—Murina's stations 652 and 665 from Red Sea and Gulf of Aden.

This uncommon species has two retractors of unequal size, chitinized holdfast papillae, 10–30 tentacles, hooks which are rounded and recurved (Type III) and the intestine with both loops and a spiral. It is not well founded. The name *P. abnorme* speaks well to the condition of Fischer's worm. It is clear that prior to his examination of the specimen both its retractor muscles underwent severe damage, the dorsal subdividing into three longitudinal components along its midsection. He mistakenly asserted that the anus was posterior to the nephridiopore. The anus is actually placed in the normal location about 4 mm anterior to the nephridiopore.

It is clear that Wesenberg-Lund (1963) misinterpreted the dorsal and ventral retractors in *P. heteropapillosum.* Analysis of her fig. 12 (1963) now makes it clear that it has the normal *P. strombus* configuration of a large dorsal retractor and a small ventral with two origins. Also the apparent loss of the type (and only specimen) weakens its foundation. This uncertainty led Cutler (1977b) to misidentify some Australian specimens (see *P. hedraeum*). The two records of Murina (1970, 1971a) from the Gulf of Aden and Red Sea are questionable. She does say that hers do not have an "underdeveloped" dorsal retractor but makes no mention of the ventral muscle. Our inspection of these worms showed them to be small and in poor condition, and the ventral retractor could not be seen. However, with reservations we are leaving the record in this species.

It is clear that *P. heteropapillosum* is conspecific with *P. abnorme* and is the more commonly used name. However, it now becomes the junior synonym despite the poor description and condition of *P. abnorme.*

*Known distribution.*—Off South Africa and in the Red Sea and Gulf of Aden, at depths of 30–180 m.

### *Phascolion bogorovi* Murina, 1973

*Phascolion bogorovi* Murina, 1973:66–68, fig. 1.

*Material examined.*—ZIAS—Murina's holotype.

While there is only a single specimen of this deep-water taxon, it is well preserved, 28 mm long, and from a region not well sampled. The hooks are large (height 200–250 μm), slender and black (Fig. 5E). The holdfast papillae have granular chitinized deposits which sometimes separate, appearing as 'teeth' (1–4) on the posterior papillae. The anterior end of the trunk is black with large, clear, lemon-shaped papillae. The dorsal retractor is 2–3 times wider than the ventral and the gut has both loops and coils. With reservations, we propose no change in the status of this species; however, its morphology matches *P. strombus* except for the large, slender hooks and granular holdfast papillae. Additional collections in the area may show it to only merit subspecific rank.

*Known distribution.*—Peru-Chile Trench at 3960 m.

### *Phascolion caupo* Hendrix, 1975

*Phascolion caupo* Hendrix, 1975:133–135, pl. 1, fig. B, pl. 4.

*Material examined.*—USNM—two paratypes, #39002; several previously unreported specimens from 100 m off Cape Lookout, North Carolina.

When Hendrix described this species he unfortunately overlooked the ventral retractor muscle. This is not hard to do if one opens the worm from the dorsal side as the large dorsal muscle (5–7 times broader than the ventral in most 8–16 mm worms) covers the small ventral one. If one looks under the dorsal, the thin ventral muscle can be seen with the attached esophagus and its two short origins just posterior to the end of the ventral nerve cord. In other ways the internal anatomy matches that of *P. strombus.*

Externally, the introvert is about the same length as the trunk and bears Type III hooks (20–35 μm tall). The holdfast papillae are dark, few (as low as 12 in a narrow band) and tall, and when flattened, appear to have an elongate shape (Fig. 1E, F). Hendrix (1975) asserted that these are not associated with epidermal papillae. Our observations suggest that the papillae have been completely covered by the secreted chitin. Some are transparent on these small worms. This differs from the common *P. strombus* in zoogeography and hook and holdfast morphology.

*Known distribution.*—SE United States, intertidal to shelf depths.

### *Phascolion cirratum* Murina, 1968

*Phascolion cirratus* Murina, 1968a:1724, fig. 1; 1971a:82.

*Material examined.*—ZIAS—Murina's types; 36 newly collected specimens from the Arabian Gulf.

This species was based on four well-preserved, intact specimens which are well-described in Murina (1968a). The tentacles are very numerous and although not completely extended, appear to be dendritically branched—very unusual for this genus. It also possesses numerous digitiform contractile vessel villi. These two character-states are correlated and probably an adaptation to low oxygen tension in the shallow warm waters of the Red Sea.

On one individual with a 12 mm trunk (measured from nephridium), the introvert is 17 mm long and the anus is 2 mm from the tentacular crown (90% of distance). Although somewhat rugose it lacks chitinized holdfast papillae, has a single fused retractor muscle and scarce, small papillae on the introvert bulb. We saw no 100 μm hooks as Murina described.

In 1981 Saudi Arabian Tetra Tech, Ltd. conducted a study of the intertidal and subtidal benthos of the Arabian Gulf. We have identified 36 specimens of this species from sand, 6 ft depth in Monifa Bay and off Bandar al Mishab at 8 ft in grass beds. Unfortunately, they are poorly preserved, slightly dried out and all from gastropod shells. We found no true chitinized hooks, only scattered papillae. These all have many tentacles, a single fused retractor muscle and numerous contractile vessel villi. As in the type also, the anus is located very near the mouth (2–5 mm), well anterior to the nephridium.

*Known distribution.*—Red Sea and Arabian Gulf, from 1–70 m.

### *Phascolion collare* Selenka, de Man, and Bülow, 1883

*Phascolion collare* Selenka et al., 1883:45–46, pl. 6, figs. 71–74.—Fischer, 1922a: 12.—Stephen and Edmonds, 1972:173–174.—Cutler, 1977a:144–145.—Cutler and Cutler, 1979a:105.—Edmonds, 1980:29–30, fig. 52.

*Phascolion tridens* Selenka et al., 1883:46–47, pl. 6, figs. 75–79.—Stephen and Edmonds, 1972:189.—Cutler, 1977b:153–154.

*Material examined.*—MNHU—syntype of *P. collare,* #967; specimens from 1961–62 *Calypso* cruise to South America and recently collected unreported specimens from 100 m off Cape Lookout, North Carolina. The type of *P. tridens* appears to be lost.

This species has a fused retractor column, blunt hooks, and well-defined holdfast papillae with chitinized borders. The alleged difference between this and *P. tridens* is the presence of holdfasts with three points in the latter. The form the chitin takes is sometimes unusual (similar to *P. caupo*) resulting in a tall cone, which has a long pointed apex. It is clear that in this population holdfast papillae usually have a single point but may produce 2, 3, or 4 points on a single individual papilla (Fig. 1G; see also Cutler 1977b; Cutler and Cutler 1979a). Therefore, the use of this single character-state to separate two species is erroneous. The hooks (Fig. 6F) are much like Selenka drew but on the syntype they seem more worn down and blunter. Internally the intestine consists of loose loops only, not a spiral.

The only specimen of Selenka's in Berlin was still in its gastropod shell, the introvert is withdrawn and it is about 22 mm long. The skin is thin and the internal organs are not well preserved. It is clearly not what Selenka looked at but is part of that original collection, so we have designated it a syntype.

*Known distribution.*—Malaysian Archipelago, Western Australia, East Africa, Brazil, and North Carolina, from 5–2000 m.

### *Phascolion convestitum* Sluiter, 1902

*Phascolion convestitus* Sluiter, 1902:32–33, text-fig. 1, pl. 3, figs. 6–9.—Murina, 1971a:82.

*Phascolion convestitum* Stephen and Edmonds, 1972:175–176.

*Phascolion mediterraneum* Fischer, 1922b:20–22, text-figs. 13–20.—Stephen and Edmonds, 1972:181–182.—Saiz Salinas, 1980:61–63.—Gibbs, 1985:318.

*Phascolion beklemischevi* Murina, 1964a:65–68, figs. 14–15.—Stephen and Edmonds, 1972:172.

*Material examined.*—ZMUA—Sluiter's type-material, V.Si 48-2, 48-3. ZIAS—3 specimens identified by Murina from Gulf of Aden plus the holotype of *P. beklemischevi.* NHRS—#65 and 95, Fischer's types of *P. mediterraneum* plus two co-types from ZMUH.

This species has two retractor muscles of approximately equal size with the dorsal slightly larger in a few individuals. The dorsal retractor muscle has a single origin (may be artificially subdivided) and the ventral has two which usually straddle the ventral nerve cord just anterior to its termination. The esophagus on at least two worms is connected to the dorsal not the ventral retractor muscle. The holdfast papillae are variable, large and bulbous, down to small and compact

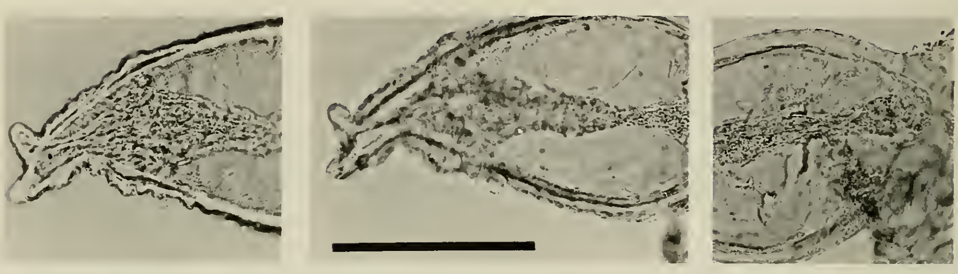

Fig. 8. Epizoa from anterior end of trunk of *P. convestitum*; different focal planes and at right, basal attachment to host. (Scale line = 0.1 mm.)

and only very weakly chitinized. Some have granular material around the border in disjunct units while others are without chitin and still others seem to have a slightly darker, smooth edge. There are about 20–25 normal tentacles and broad-based, recurved, pointed hooks, 50–100 μm tall (Fig. 6D). The gut is in loops with a few loose coils. There is a short, strong fixing muscle at the posterior end of the coil attached to the body wall between the roots of the ventral retractor which gives the misleading appearance of a spindle muscle.

*Phascolion beklemischevi* was described on the basis of one 4 mm specimen from the eastern Mediterranean. Our analysis of the holotype suggests that the presumed differences are not significant. This is a juvenile specimen in which the distal tip of the introvert has been damaged or torn; therefore, the alleged absence of tentacles is misleading. Hooks, however, are present and match those of *P. convestitum.* The two specimens from Mozambique (Cutler and Cutler 1979b) were re-examined and determined to be small *P. tuberculosum,* not *P. beklemischevi.*

*Phascolion mediterraneum* was described in 1922 on the basis of six specimens. In all of its major characters (hooks, retractors, holdfasts) it is like *P. convestitum.* The single alleged difference is in the form of the papillae on the anterior end of the trunk. Most of these are uni-tipped, mammiform or lemon-shaped glandular structures. However, in the *P. convestitum* population some have two or four "arms" or lobes projecting from the tip (Fig. 8). On one of Murina's specimens there are present on the posterior end of the trunk. It is our judgement that these are probably not papillae but rather small epizoans, common in this genus.

This species is similar in many ways to *P. tuberculosum* and may only deserve subspecific rank but at this time we shall not propose any more change. The name *P. convestitum* now includes the two junior synonyms, *P. beklemischevi* and *P. mediterraneum.*

*Known distribution.*—Mediterranean, Red Sea, Gulf of Aden, and Indonesia, from 25–275 m.

### *Phascolion cryptum* Hendrix, 1975

*Phascolion cryptus* Hendrix, 1975:127–133, pl. 1, fig. a, pls. 2–3.

*Material examined.*—USNM—10 paratypes, #39004; a few unreported specimens from 100 m off Cape Lookout, North Carolina.

This species with auxiliary tentacles where hooks are normally found, only four primary tentacles, pale V-shaped chitin on holdfast papillae, and a fused retractor column is unique and well founded. When the introvert is drawn in, this form is externally very similar to *P. strombus* so one must examine the tip of the introvert and/or the retractor column. Ecologically it is distinct from *P. strombus* but is sympatric with *P. caupo.*

*Known distribution.*—SE United States, from 1–100 m.

### *Phascolion hedraeum* Selenka, de Man and Bülow, 1883

*Phascolion hedraeum* Selenka et al., 1883:49–50, pl. 6, figs. 87–92.—Stephen and Edmonds, 1972:177.—Cutler and Cutler, 1979a:105; 1980c:2.

*Phascolion dentalicola* Sato, 1937:165–167, pl. 4, figs. 20–21, text-figs. 10–14.

*Phascolion dentalicolum* Stephen and Edmonds, 1972:172.—Murina, 1978:124.—Cutler, 1977a:145.—Cutler and Cutler, 1980b:194; 1981:72.—Cutler, Cutler and Nishikawa, 1984:274.

*Phascolion kurchatovi* Murina, 1974a:233–234, fig. 4.—Cutler and Cutler, 1980b: 194.

*Phascolion heteropapillosum.*—sensu Cutler, 1977b:153.

*Phascolion tuberculosum.*—sensu Cutler and Cutler, 1980b:196.

*Material examined.*—BMNH—Selenka's types, plus 2 co-types in MNHU, #969; ZMUH—Fischer's specimen #V2120; 5 specimens of *P. dentalicolum* from locations in Northern Japan near type-locality (see Cutler and Cutler 1981); ZIAS—Murina's type of *P. kurchatovi* plus one specimen from South Atlantic (see Cutler and Cutler 1980b).

This now seems to be a distinct species based on a moderate number of individuals. It is generally less than 20 mm long and inhabits gastropod and scaphopod shells. The co-types at both museums were still in scaphopod shells but in good condition. Many of the shells still had scaphopods, not *Phascolion* in them.

The holdfast papillae are round with chitin around the anterior margin of the larger ones (80–300 μm) usually as a thin, pale border (Fig. 2C, D). A few from the Antarctic have a darker border. This denser material occasionally extends around the whole margin of the papillae. The bluntly pointed, slightly bent, spine-like hooks are 30–90 μm tall (Type I, very similar to that pictured for *P. strombus*; see also Fig. 2, Cutler and Cutler 1981). There are usually 20–30 tentacles. The two retractor muscles are of equal size and originate at the same level, posterior to the end of the ventral nerve cord at the end of the trunk. The dorsal has one, the ventral may have one but usually two origins. The esophagus follows the ventral retractor and the gut has one or two loops plus the spiral.

When Sato (1937) described *P. dentalicolum* he compared it to *P. mediterraneum* but made no reference to *P. hedraeum* or Fischer's record of it from Japan in his original or later more general papers.

When Cutler and Cutler were working with Brazilian collections they used a Brazilian name (Cutler and Cutler 1980c) but when in Japan they fell into a familiar trap of using a Japanese name without doing enough comparison with *P. hedraeum.*

Murina's (1974a) differential diagnosis of *P. kurchatovi* emphasized the well-developed holdfasts and retractors with one root each. While our analysis of the holotype confirms these observations, they are within the total range of variation for the population. All other characters match those of *P. hedraeum.* The only other use of the name *P. kurchatovi* is in Cutler and Cutler (1980b) describing a specimen without hooks. However, it should also be considered *P. hedraeum.*

An uncritical interpretation of Wesenberg-Lund's (1963) description of *P. heteropapillosum* caused Cutler (1977b) to misidentify some Australian specimens which are here determined to be *P. hedraeum.* A re-examination of Cutler and Cutler's (1980b) "Vema" material in this genus showed a misapplication of the name *P. tuberculosum* to one specimen which is hereby corrected.

From a reevaluation of the literature and an analysis of the above material, we conclude that the three species, *P. hedraeum, P. dentalicolum* and *P. kurchatovi* are conspecific and thus *P. hedraeum* becomes the senior synonym.

*Known distribution.*—Several southern hemisphere records from 65°S up to South Africa, Uruguay, and Brazil in the Atlantic; in the S. Pacific including the Great Australian Bight and Tasman Sea, and also off Japan, generally at shelf and slope depths ranging from 7–4610 m.

### *Phascolion hibridus* Murina, 1981

*Phascolion hibridus* Murina, 1981:348–349, 6 figs.

*Material examined.*—ZIAS—Murina's holotype and paratypes.

This species is characterized by having retractor muscles of unequal size (the origin of the larger dorsal is incompletely fused). The Type II hooks are broad-based (like *P. tuberculosum*) but pale and about 40 μm tall. The midtrunk is smooth, lacking any holdfast papillae. On the anterior end of the trunk are large, mammiform, single-tipped papillae which appear to be chitinized. These do not, however, form a compact unit which would appropriately be called a shield, although Murina used this term. We consider this a unique and valid species.

*Known distribution.*—Malaysia and Samoa, at 1530–2380 m.

### *Phascolion hupferi* Fischer, 1895

*Phascolion hupferi* Fischer, 1895:16–17, figs. 16–18; 1914:77.—Stephen and Edmonds, 1972:179.

*Phascolion indicus* Murina, 1974b:282–283, fig. 1.—Cutler, Cutler, and Nishikawa, 1984:275–276.

*Material examined.*—ZMUH—Fischer's syntypes, #V2036, V2037; recently collected material from Japan and the Ivory Coast; ZIAS—Murina's holotype of *P. indicus.*

With one major exception Fischer's description is accurate. We examined several of his worms which had not been removed from their mollusc shells and the nature of the papillae is more variable than he described. The anus is located about 50–75% of the way towards the mouth and, while difficult to count accurately due to retracted introverts, there are more than 12 tentacles. It seems unlikely that these would have 40 tentacles as Fischer reported. The fusion of the retractor muscles into a single column seems to be complete in most, but in a few worms it exhibits two origins (a small cleft) or is torn or shredded towards the posterior. This muscle does originate from the posterior end of the trunk, not the middle as was originally stated (the major flaw in Fischer's description).

When Murina (1974b) described *P. indicus* she differentiated it from *P. hupferi* on the basis of its retractor origin (posterior vs middle of trunk) and longer papillae at the end of the trunk. Cutler, Cutler, and Nishikawa (1984) concluded that the two entities were distinct but it is now clear, as a result of this study, that they were mistaken and that these two are conspecific. The differences really are superficial, external and not significant or consistent.

*Known distribution.*—Japan, S. of Java, and W. Africa, from 10–1010 m.

### *Phascolion hedraeum* Selenka, de Man, and Bülow, 1883

*Phascolion lucifugax* Selenka et al., 1883:43–44, pl. 5, figs. 64–66.—Stephen and Edmonds, 1972:180.

*Material examined.*—MNHU—Selenka's syntype #966.

This species is represented by three animals. The one from Hokkaido, Japan, is now completely dried. The two from Bohol, Philippines, were still in their gastropod shells and therefore not really examined by Selenka; one of these, when removed from the shell was still in good condition. It is about 40 mm long with the introvert entirely withdrawn. The intestine is in loops only, exhibiting no coils. The two retractor muscles are each about 1.5 mm broad and the esophagus, which carries a large vesicular contractile vessel is attached to the ventral muscle. Both retractors have their origins about 6 mm from the posterior end of the trunk, the ventral origin is slightly divided and posterior to the dorsal.

Externally the medium-sized (65–70 μm), blunt hooks (Fig. 6G) are of Type III. The holdfast papillae have not produced chitin (*tuberculosum* type) and there are more than 30 long, slender tentacles. This combination of characters is closest to *P. tuberculosum* but different enough (tentacle number, hook shape, retractor origins) so that, with some reservations due to the small sample size, we propose no change in the rank of this taxon.

*Known distribution.*—Philippines and N. Japan, at unknown but probably shelf depths.

### *Phascolion lutense* Selenka, 1885

*Phascolion lutense* Selenka, 1885:16–17, pl. 4, figs. 22–23.—Fischer, 1928:484.—Murina, 1957:1781–1790, figs. 4a–b, 5a–d; 1961:140–142, fig. 1; 1971b:43; 1972:305–306; 1974a:235; 1978:124.—Stephen and Edmonds, 1972:180–181.—Cutler, 1977b: 145–146.

*Phascolion canum* Cutler and Cutler, 1980a:454–456, fig. 2.—Gibbs, 1985:321.

*Phascolion* species.—Cutler and Cutler, 1980b:197.

*Material examined.*—BMNH—Selenka's type; 8 of Murina's specimens from the Pacific Ocean; USNM—type of *P. canum* plus newly collected Northeast Atlantic specimens.

The original description was based on three individuals but subsequent collections of many worms (by Murina among others) have established a firm foundation for this species. As in other populations, some individuals lack hooks (Selenka's 15–20 mm worms) but most have pale, Type I hooks, 40–150 μm. This species has the retractor muscles fused for much of their length, leaving three, sometimes four distinct origins, and the esophagus leaves the retractor column on the fused portion. Externally the smooth body surface (with small, densely-packed papillae at the anterior end and inconspicuous skin bodies in the mid trunk of some but no holdfast papillae) is characteristic. This may be associated with their life in clay/mud tubes and not mollusc shells.

Selenka (1885:17) said that "The tentacles are short and small . . . are few in number, at most 16." His three specimens had completely retracted introverts. In some recently collected material from the Northeast Atlantic Ocean we found one worm with an extended introvert showing what appears to be a continuous folded membrane surrounding the mouth but it may be several lobes like in *P. pacificum* (Fig. 7B).

When *P. canum* was originally described the retractor muscles were interpreted as "two in number united for about half their length, the dorsal with two long branches and the ventral with two short ones." It was compared to species with two retractor muscles and not to *P. lutense* which was said to have one muscle with three roots. This difference is a matter of semantics, as well as the variability that is present in this population, and partially a reflection of the state of contraction of the introvert. It is now clear as the result of this analysis that these two forms are the same. The holotype of *P. lutense* is larger and a little rougher-skinned than other specimens and lacks the grey mud cap, probably due to being in alcohol since 1885.

*Known distribution.*—This deep water species (1820–6860 m) is found in the southern hemisphere (36–66°S) in the Pacific Ocean, off Argentina, and in the SE Indian Ocean. It has also been found in the NW Pacific and the Bay of Biscay but is apparently absent in the lower latitudes.

### *Phascolion medusae* Cutler and Cutler, 1980

*Phascolion medusae* Cutler and Cutler, 1980c:2–4, figs. 1–3.

*Material examined.*—AMNH—type-specimens #4023.

We have nothing to add to the recent description of this species except to figure the hook (Fig. 6E). It has a dorsal retractor several times larger than the ventral, introvert hooks, many slender tentacles, and large holdfast papillae without chitinous borders. The comment about the esophagus paralleling the dorsal retractor (Cutler and Cutler 1980c:3) could be misleading. It is attached to and masks most of the ventral muscle which does parallel the dorsal. There are a number of similarities between this and *P. robertsoni.*

*Known distribution.*—S. Brazil, from 166–338 m.

### *Phascolion megaethi* Cutler and Cutler, 1979

*Phascolion megaethi* Cutler and Cutler, 1979b:961–964, figs. 10–12.

*Material examined.*—MNHN—type material #AH-413.

There is nothing new to add to the recent description of this species except the small (30–35 μm), blunt hooks are of Type III like those in Fig. 6F. Its separation from other members of the *P. strombus* group is based on the fused ventral retractor originating posterior to the dorsal, the large red anterior trunk papillae, smooth trunk except for a few, small, chitinized, V holdfasts at the posterior tip and its hooks.

*Known distribution.*—S. Madagascar, intertidal.

### *Phascolion microspheroidis* Cutler and Duffy, 1972

*Phascolion microspheroidi* Cutler and Duffy, 1972:71–76, figs. 1–3. Not *Phascolion microspheroides* Cutler and Cutler, 1980a:456.

*Material examined.*—USNM—type-material; recently collected North Atlantic specimens.

This small species (trunk usually less than 5 mm) with two retractors of equal size, no chitinized holdfast papillae and small pointed hooks (Fig. 5C, D) remains distinct. The ventral retractor pair may remain unfused for about one-fourth its length (longer than in most species).

So far this is not known to occur outside the western North Atlantic. Those from the Bay of Biscay and Mediterranean reported in Cutler and Cutler (1980a) have been reexamined and in light of our present understanding have been transferred to *P. tuberculosum.* Small *P. tuberculosum* (less than 3 mm) strongly resemble *P. microspheroidis* in many ways but the former has larger anterior papillae and the hooks are distinctive.

*Known distribution.*—East Coast of United States from 31–40°N, at 490–1700 m.

### *Phascolion pacificum* Murina, 1957

*Phascolion pacificum* Murina, 1957:1777–1781, text-figs. 2a–b, 3a–e; 1971b:43; 1972:306; 1973:70; 1974a:235; 1978:125.—Stephen and Edmonds, 1972:184.—Cutler, 1977a:146.—Cutler and Cutler, 1980b:194.—Cutler, Cutler, and Nishikawa, 1984:276–277.—Gibbs, 1985:319–321.

*Material examined.*—ZIAS—Murina's holotype plus other material collected and identified by her; recently collected material from Japan.

This species with retractor muscles fused for most of their length into a single column with two, three, or four separate origins, Type I hooks and holdfast papillae with a thin chitin border is well founded. The extent of fusion of the retractor muscles is quite variable but the esophagus always separates before any split. Externally it has many similarities to *P. strombus* with pale U or V shaped holdfasts of variable thicknesses which may have led to some misidentifications in the past. For instance, reexamination of some *P. strombus* from the Gulf of Gascone (Cutler and Cutler 1980a) showed some to be *P. pacificum.* The chitinous holdfasts appear thinner and paler than most *P. strombus.* Internally this is also very similar to *P. lutense* but the latter lacks chitinized holdfast papillae. Murina described this species as having 16 tentacles. All her specimens which we saw at ZIAS had retracted introverts, were small and not in prime condition. We saw nothing that looked like a normal array of tentacles. On our recently collected material from Japan and Gibbs' from the Bay of Biscay, the tentacles are found to be reduced to lobes.

*Known distribution.*—This bathyal and abyssal species (300–6860 m) is widespread at high latitudes in the northwest and southwest Pacific, the southeast and South Atlantic, and the sub-Antarctic Indian Oceans. The only records at lower latitudes are in the Peru-Chile Trench at depths from 5760–6860 m.

### *Phascolion pharetratum* Sluiter, 1902

*Phascolion pharetratum* Sluiter, 1902:31–32, pl. 3, figs. 3–5.—Stephen and Edmonds, 1972:186.—Cutler and Cutler, 1979b:964.

*Material examined.*—ZMUA—Type-material, V.Si. 48-4, 48-5.

The absence of chitinized holdfast papillae, introvert retractor muscles of unequal size originating from some distance anterior to the back end of the trunk, and the hook shape (Fig. 6C) seem to set this taxon apart. In many ways the written description resembles *P. medusae.*

Between 1982, when we made a preliminary examination of the damaged specimens in Amsterdam, and 1984, the material had been misplaced and unavailable for closer examination. However, despite this problem we propose no change in the status of this species. Our Madagascar specimens fit Sluiter's description fairly well except that the hooks are somewhat more bent as in *P. lucifugax.*

*Known distribution.*—Indonesia and S. Madagascar, from 1–91 m.

### *Phascolion rectum* Ikeda, 1904

*Phascolion rectus* Ikeda, 1904:15–18, text-figs. 45–49.—Sato, 1939:413.
*Phascolion rectum* Stephen and Edmonds, 1972:186–187.—Cutler and Cutler, 1981:74.—Cutler, Cutler, and Nishikawa, 1984:277–278.

*Material examined.*—Eleven specimens from Honshu, Japan; the type cannot be located.

There is nothing new to add to our earlier comments on this species. It has the fused retractor muscles and lacks both hooks and chitinized holdfast papillae. The gut has a spiral and there are fewer than 12 tentacles. Except for the anus location on the anterior trunk it is very similar to the sympatric *Phascolion hupferi.*

*Known distribution.*—Central Japan, at 30–2600 m.

### *Phascolion robertsoni* Stephen and Robertson, 1952

*Phascolion robertsoni* Stephen and Robertson, 1952:439–441.—Stephen and Cutler, 1969:117.—Stephen and Edmonds, 1972:187.

*Material examined.*—RSM—two paratypes #1958.23.76–79.

This uncommon species is distinct and well founded, despite an error in the original description of the retractor muscles. There are two, not one, retractor muscles, of unequal size. The dorsal is about three times larger than the ventral and originates a few millimeters anterior to the ventral which is at the posterior end of the trunk. The esophagus follows the ventral retractor and the gut has only loops, no spiral. The nephridiopore is posterior to the anus.

Externally there are about 40 slender tentacles (Fig. 7A) and many small (30–40 μm) blunt, Type III hooks. The holdfasts on the trunk are scattered, pale, 100–200 μm wide, U or V shaped and associated with large, bulbous papillae. Additionally, there are pale, chitinized papillae on the basal part of the introvert—a unique feature of unknown function.

*Known distribution.*—E. and S. Africa, from 1–60 m.

### *Phascolion strombus* (Montagu, 1804)

*Sipunculus strombus* Montagu, 1804:74–76.
*Phascolion strombi* Stephen and Edmonds, 1972:187–189 (see this for records and synonomy before 1969).—Stephen and Cutler, 1969:117.—Murina, 1970:

67; 1978:123; 1971a:83; 1972:306.—Cutler, 1973:168–173; 1977a:146.—Zavodnik and Murina, 1975:127; 1976:84.—Gibbs, 1977:22–23.—Cutler and Cutler, 1980a:456; 1980b:194–195.—Ocharon, 1980:116–117.—Saiz Salinas, 1980:63–66.—Frank, 1983:21–22.—Cutler, Cutler, and Nishikawa, 1984:278–279.

*Phascolion strombi africanum* Cutler and Cutler, 1979b:964–965; 1980b:196.

*Phascolion africanum* Fischer, 1923:5.—Wesenberg-Lund, 1963:134–135.—Stephen and Cutler, 1969:117.—Stephen and Edmonds, 1972:170.

*Phascolion anomalus* Murina, 1981:349–352, 4 figs.

*Phascolion alberti* Sluiter, 1900:9–10, pl. 1, figs. 1–2, pl. 3, figs. 1–2; 1912:17–18.—Gerould, 1913:416.—Murina, 1964a:63–65, fig. 12.—Stephen and Edmonds, 1972:170–171.—Gibbs, 1985:317.

*Phascolion artificiosus* Ikeda, 1904:18–20, text-figs. 50–55.—Sato, 1939:413.

*Phascolion artificiosum.*—Stephen and Edmonds, 1972:171–172.—Cutler and Cutler, 1981:70–71.—Cutler, Cutler, and Nishikawa, 1984:273–274.

*Phascolion brotzkajae* Murina, 1964a:68–70, figs. 16–17.—Stephen and Edmonds, 1972:172.—Murina and Zavodnik, 1979:251–252.

*Phascolion tortum* Edmonds, 1976:218–222, figs. 7–11.—Murina, 1978:125.

*Material examined.*—ZIAS—Murina's holotypes of *P. anomalus* and *P. brotzkajae*; two reference specimens of *P. tortum* from the type-locality identified by S. Edmonds; many recently collected specimens from the Atlantic, Arctic, and Pacific Oceans.

This species has two retractor muscles of unequal size, the ventral being significantly smaller than the dorsal, holdfast papillae with chitinized borders (Fig. 1A–C), 10–30 well-developed tentacles, and sharp, claw-like hooks (Fig. 5A, B). It has the longest and most complex history with the most junior synonyms of any species in this genus. It is very widespread and common. Many authors have discussed its extreme plasticity of form, notably Théel (1875a, 1905, where he also presented excellent illustrations), Gerould (1913) and Fischer (1923). An analysis of 2700 specimens from the U.S. East Coast supported these earlier assertions of variability within a population (Cutler 1973).

As part of this present work we made more detailed measurements of internal and external characters to attempt a more objective approach. The material we had from several parts of the world's ocean (80°N to 60°S) was even now disconcerting because of the apparent, superficial differences. One can easily see why Théel (1875b) thought *P. spitzbergenense* was a separate form only to withdraw that viewpoint 30 years and many worms later. A particularly interesting problem was presented by our Japanese collections (Cutler, Cutler, and Nishikawa 1984). There are two morphs there, differing in holdfast shape, hook size, and origin of the ventral retractor. In all cases these character states fall within the range of the North Atlantic population but one towards one extreme, the second towards the other. Our present view is that these may represent the two terminal points in a "Rassenkries" assuming a center of origin in the North Atlantic and one population going eastward over the Siberian/Asian Arctic, the second dispersing westward over the Canadian Arctic to meet in the North Pacific. The data base is inadequate to test this hypothesis so it remains speculative for the present. The concept of a polytypic species would easily apply to *P. strombus.* Gene frequencies have clearly shifted as dispersal occurred over the globe but until breeding experiments or at least some biochemical or cytogenetic work can be done, we have only our 20 years of experience with the group to aid us.

*Junior synonyms of Phascolion strombus.*—Gerould (1913) changed the status of *P. tubicola* to that of a subspecies but Stephen and Edmonds (1972), while leaving it as a subspecies (p. 188) also resurrected it to specific rank with no explanation (p. 190). In addition, Gerould named six varieties which Stephen and Edmonds elevated to subspecific rank with the comment, "We are not certain if they are all true subspecies . . . ." Both Wesenberg-Lund (1929) and Cutler (1973) noted that these varieties have little systematic value, ". . . we do not have seven constant combinations of characters; the characters may be found in numerous different combinations even from any one locality" (Cutler 1973:170). We reaffirm that position and treat these names as junior synonyms.

*Phascolion africanum*: The essence of this taxon is elusive. The apparent geographic isolation, lack of pointed holdfasts and a larger number of tentacles led us to retain the name at the subspecies level (Cutler and Cutler 1979b, 1980b). Based on our current knowledge we conclude that these presumed differences are not significant and *P. africanum* is now considered a junior synonym of *P. strombus* without subspecific status.

*Phascolion alberti*: In Cutler's (1973:169) discussion of *P. strombus* he stated ". . . *P. alberti* is not a distinct biological entity, but merely a form of *P. strombi.*" Gibbs (1985) formally synonymized this taxon under *P. strombus* and we concur.

*Phascolion anomalus*: This was described from the Bay of Biscay on the basis of a single 10 mm worm. The peculiar dorsal retractor muscle is the only character which would distinguish this from *P. strombus.* It is our conclusion that the partitioning of this large muscle into what Murina called 'supplemental muscles' is the result of some trauma or ontogenetic anomaly, not a natural condition.

*Phascolion artificiosum*: The 18 worms reported in the literature presumably differ from *P. strombus* in lacking hooks. As noted in the section on morphological characters this character state can be misleading. Ikeda (1904) unfortunately had also confused the dorsal and ventral retractor muscles and his fig. 55 is misleading; the esophagus comes off the ventral, not dorsal retractor so that it has the typical *P. strombus* morphology. We now believe this entity represents only a few hookless individuals in the large sympatric *P. strombus* population.

*Phascolion brotzkajae*: This single 4 mm worm with retracted introvert was differentiated from *P. strombus* on the basis of two presumed differences: the absence of tentacles and the split in the dorsal retractor. The original description was brief and the report of a second worm (Murina and Zavodnik 1979) added nothing to the description. If tentacles were present they would be extremely hard to see in such a small worm with its introvert not expanded. We were unable to verify presence or absence due to size and condition of the holotype. The dorsal retractor is as described but could be due to unfinished ontogeny. Whether real differences or artifacts, we believe these two worms are representatives of a *P. strombus* population.

*Phascolion tortum*: When Edmonds (1976) described *P. tortum* he used three characters to differentiate it from *P. strombus*: the ventral retractor was more slender, was shifted anteriorly (mid-third), and it had a large contractile vessel. We affirm the last condition but suggest that a similar situation exists in many *P. strombus* populations and is not diagnostic. The ventral retractor muscle in the two worms we had (5 and 9 mm long) originated only 15% of the distance from the posterior end of the trunk, not the mid-third (33–67%). The dorsal is 4 and 5 times the size of the ventral. Both of these states are within the range of the Eastern Atlantic and Japanese populations, not necessarily in the same individuals.

*Known distribution.*—This is a very common and eurytopic North Atlantic and Arctic species also found in deep water in the Caribbean. There are scattered reports from the Mediterranean, Red Sea, Gulf of Aden, Madagascar, and South Africa. There are two Antarctic records plus off Argentina and Chile. Other Pacific Ocean records come from the South Pacific, New Zealand, and Japan. It is known from depths of 1–4030 m.

### *Phascolion strombus cronullae* Edmonds, 1980, new status

*Phascolion cronullae* Edmonds, 1980:30–32, figs. 46–51.

*Material examined.*—Three reference specimens from the type-locality, identified by S. Edmonds.

When Edmonds erected this taxon he assigned it to the species category, weighting heavily the anterior trunk papillae which may have 2, 3, or 4 tips or points. While it is true that some (about 25%) of the anterior papillae have multiple tips, most have a single point like that found in *P. strombus.* Perhaps a more significant difference is the relationship between the size of the dorsal and ventral retractor muscles: the dorsal is 1.5–2 times the size of the ventral and originates at about the same level very near the posterior end of the trunk thus being the only known "bridge" between the "strombus" and "tuberculosum" morph as discussed earlier. Its hooks, holdfast papillae, and other characters still match well that of the nominate form. It is geographically isolated and the differences in retractor and papillae morphology are considered sufficient for subspecific rank.

*Known distribution.*—New South Wales, Australia.

### *Phascolion tuberculosum* Théel, 1875

*Phascolion tuberculosum* Théel, 1875b:15–16, pl. 1, fig. 1, pl. 3, fig. 16.—Stephen and Edmonds, 1972:190.—Cutler and Cutler, 1980a:456–457.—not Cutler and Cutler, 1980b:196.—Gibbs, 1985:317–318.
*Phascolion beklemischevi.*—sensu Cutler and Cutler, 1979b:961.
*Phascolion hirondellei* Sluiter, 1900:7–9, pl. 2, figs. 1–6.—Stephen and Edmonds, 1972:178.—Gibbs, 1985:318.
*Phascolion pallidum* Koren and Danielssen, 1877:132–134, figs. 22–24.—Selenka et al., 1883:42–43.—Leroy, 1936:425.—Stephen and Edmonds, 1972:184.
*Phascolion temporariae* Edmonds, 1976:217–218, figs. 1–6.
*Phascolion microspheroides.*—sensu Cutler and Cutler, 1980a:456.

*Material examined.*—*P. tuberculosum*: NHMS—Théel's type, #233; numerous recently collected specimens from the North Atlantic. *P. hirondellei:* MOMV—four of Sluiter's syntypes (St. 66, 112, 184). *P. pallidum:* ZMUB—Koren and Danielssen's type. *P. temporariae:* reference material from type-locality identified by S. Edmonds.

This is one of the better known species in this genus and is characterized by

Fig. 9. Papillae on anterior end of trunk of *P. tuberculosum* showing variable number of tips on a single worm. (Scale line = 200 μm.)

the large (70–220 μm), broad, recurved hooks (Fig. 6A, B show its massiveness and internal structure). The holdfast papillae are large (80–330 μm), spherical and without chitinous borders (Fig. 2A, B), but occasionally one sees some granular material gathered along the anterior margin. The two retractor muscles originate near the posterior end of the trunk at nearly the same level. The ventral may originate 1–6% (rarely up to 10%) of the trunk length anterior to the dorsal (this distance is commonly 0.5–2 mm) and could be easily overlooked). These are usually of equal width but may vary so that the ventral is from 0.75–1.25 times the dorsal muscle. The large mammiform papillae around the anterior end of the trunk usually have one protruding tip but some have two (others up to 4) tips (Fig. 9). The frequency of multiple-tipped papillae varies from specimen to specimen. Commensal epizoans are also common here.

The similarity of *P. hirondellei* to *P. tuberculosum* is obvious despite the poor condition of the syntypes. The description of *P. hirondellei* was misleading in that the retractors are of equal size (although traumatized); the hooks measure 100–200 μm of a typical *P. tuberculosum* morphology, and the "thread-like papillae" are in fact epizoic hydrozoans.

*Phascolion temporariae* was presumed to be distinct because of having only single-tipped anterior papillae; however, some *P. tuberculosum* also have only single-tipped papillae. It is also described as having holdfasts while *P. tuberculosum* has none. This is a matter of perception and semantics. A side-by-side comparison shows no significant differences—both have large holdfast papillae which may occasionally show aggregation of denser material along one border. This Australian population may deserve subspecific rank but we would have difficulty defining it.

*Known distribution.*—Common in the NE Atlantic including the Azores, Mid-Atlantic Ridge, Bay of Biscay, and Scandinavian waters at bathyal depths (25–2700 m). A few specimens from Japan and New Zealand from 93–300 m suggest a presence in the Pacific also. The sole Caribbean record cannot be confirmed and is doubtful.

### *Phascolion ushakovi* Murina, 1974

*Phascolion ushakovi* Murina, 1974b:284–285, figs. 1–3.

*Material examined.*—ZIAS—Murina's type material.

This species has several distinctive characters: 1) the many tall, black, spine-like hooks (Fig. 5F); Murina's fig. is misleading as it is not a side view; 2) the very thin ventral retractor muscle ($\frac{1}{5}$ to $\frac{1}{10}$ the size of the dorsal) and 3) the external papillae. On the anterior and posterior ends are large, dark, mammiform papillae (like *P. tuberculosum*) but in the mid-trunk there are no holdfast papillae, only flattened skin bodies. The gut coil is attached by several fixing muscles, the posterior one, coming from inside the gut coil and having a large diameter, was incorrectly called a spindle muscle.

*Known distribution.*—W. Australia at 330 m.

### *Phascolion valdiviae valdiviae* Fischer, 1916

*Phascolion valdiviae* Fischer, 1916:16; 1922a:13, pl. 2, figs. 7a–g.—Stephen and Edmonds, 1972:191–193.—Cutler and Cutler, 1979b:965.

*Material examined.*—MNHU—Fischer's type, #6073.

This species has been reported from four disjunct locations in or near the Indian Ocean and was based on a total of five specimens prior to Cutler and Cutler (1979b). It has retractor muscles which are almost entirely or entirely fused into a single column and holdfast papillae with variably formed chitinized margins present. The pale, Type I hooks (70–90 $\mu$m) are usually but not always present. This subspecies has hooks and holdfast papillae with little chitin, mostly semicircular in shape.

*Known distribution.*—St. Paul's Island and off Durban.

*Remarks.*—When Fischer first described *P. valdiviae* he created two subspecies, *P. valdiviae valdiviae* and *P. valdiviae sumatrense* but a few years later elevated each to specific rank (1922a). Twenty years later Stephen (1941) found one worm and with no reference to *P. valdiviae* or any other species named a new species, *P. murrayi*. Internally it cannot be differentiated from *P. valdiviae.* The nature of the holdfast papillae does appear to differ in the amount of chitin produced. Two of the taxa (four specimens with 15–25 mm trunks) lack introvert hooks. From their overall similarity and geographic proximity we conclude that they are conspecific and return to Fischer's original treatment of *P. valdiviae sumatrense* as a subspecies placing *P. murrayi* in synonymy with it.

### *Phascolion valdiviae sumatrense* Fischer, 1916

*Phascolion valdiviae var sumatrense* Fischer, 1916:17.

*Phascolion sumatrense* Fischer, 1922a:13–14, pl. 2, fig. 7a.–Stephen and Edmonds, 1972:191.

*Phascolion murrayi* Stephen, 1941:407, pl. 2, fig. 5.—Stephen and Edmonds, 1972: 183–184.

*Material examined.—P. v. sumatrense:* MNHU—Fischer's type, #6074; *P. murrayi:* BMHN—type.

This subspecies differs from the nominate form by having chitinized holdfast papillae more variable with U, V and circular shapes on the posterior half of the trunk (except the last 10%), seeming to lack hooks (in larger worms), and being known from a different part of the Indian Ocean.

*Known distribution.*—Sumatra and Gulf of Aden at 750–1295 m.

## Species Placed in Incertae Sedis or Species Inquirendum

### *Phascolion botulus* Selenka, 1885

*Phascolion botulus* Selenka, 1885:18, pl. 4, fig. 20.
*Phascolion botulum* Stephen and Edmonds, 1972:173.

*Material examined.*—BMNH—Selenka's holotype.

This species was described on the basis of a single, damaged, incomplete individual said to have two retractor muscles of unequal size, holdfasts, but lacking hooks (like *P. artificiosum* and *P. sandvichi*). The type-material in London consists of the partially dehydrated introvert and about 10% of the trunk. It is therefore impossible to answer several critical questions and this name must be placed on the list of *incertae sedis.*

### *Phascolion ikedai* Sato, 1930

*Phascolion ikedai* Sato, 1930:20–23, pl. 3, figs. 13–17, text-figs. 6–9.—Stephen and Edmonds, 1972:179–180.—Cutler and Cutler, 1981:74.—Cutler, Cutler, and Nishikawa, 1984:274–275.

*Material examined.*—ZITU—4 specimens identified as this by Sato but still in shells.

When Cutler and Cutler (1981:74) discussed this species they concluded by making no change in its status but were not completely comfortable with it. After this examination of the genus, our discomfort has increased and we can no longer consider this a valid taxon. The type-material is lost and the four worms we found identified by Sato had never been removed from their coral-encased mollusc shells. Their poor state of preservation makes it impossible to answer the critical questions, i.e., because he did not figure or mention esophagus on retractor column, did Sato overlook a small ventral retractor muscle with esophagus attached? If he had, then it would be the same as *P. strombus* (see Cutler and Cutler 1981). What about nephridiopore/anus relationship? If the nephridiopore were actually anterior it would be the only one in this genus.

It now seems most prudent to transfer this untestable entity to the status of *species inquirendum* pending future clarification.

### *Phascolion manceps* Selenka, de Man and Bülow, 1883

*Phascolion manceps* Selenka et al., 1883:44–45, pl. 1. fig. 2, pl. 5, figs. 67–70.—Shipley, 1899:154.—Stephen and Edmonds, 1972:181.

*Material examined.*—None.

Neither the type-material nor Shipley's specimens can be located. The original description is not clear about the location of the anus or the length of introvert. Stephen and Edmonds' (1972) translation further confuses the description of the nephridium. Our interpretation of the original is that the anus is located posterior to the mouth (on the introvert); the introvert is short only if measured from the anus to tentacles; and the nephridium is in the trunk, far behind the anus, not extending from the posterior of the trunk to near the anus. The contractile vessel tubules are also peculiar, unlike other members of this genus (except *P. cirratum*). Théel (1905:12–13) clearly thought it should be an *Onchnesoma.* Being unable to verify any of these features, we place this taxon the list of *Incertae sedis.*

### *Phascolion moskalevi* Murina, 1964

*Phascolion moskalevi* Murina, 1964b:255–256, figs. 2–3.—Stephen and Edmonds, 1972:183.

*Material examined.*—ZIAS—Murina's holotype.

Although this single specimen has only one nephridium and fused retractor muscles, other characters indicate that it does not belong in this genus. These are: hooks in rings, a spindle muscle present, although unattached posteriorly, and the complete absence of holdfast papillae. Also the retractor muscles are obviously two fused ventrals originating from mid-trunk, unlike *Phascolion.* Hendrix (1975) discussed this species and suggested it might be a *Golfingia.* Upon examination of the holotype we found that the description of the tentacles (only 5 on one side) is correct but due to damage, not the natural array. The fusion of retractors and presence of one nephrium suggests some teratogenetic or ontogenetic anomaly. We place this species on the list of *species inquirendum* until further material is found.

### *Phascolion parvum* Sluiter, 1902

*Phascolion parvus* Sluiter, 1902:30–31, pl. 3, figs. 1–2.
*Phascolion parvum* Stephen and Edmonds, 1972:185.

*Material examined.*—ZMUA—V.Si. 48-3, 48-4, 48-6 containing shells and a total of four incomplete, fragile specimens.

Due to the incomplete and/or damaged nature of this material it is impossible to verify Sluiter's description. On one animal the retractor muscles are about equal sized but seem to originate from the posterior end of the trunk not the middle as Sluiter stated. Hooks are absent on one worm and present in a second vial on a free floating piece of tissue.

No subsequent collections of this species have been made. The foundation for this species is not sound so until and unless additional specimens are collected to provide a tangible basis, we place this name on the list of *species inquirendum.*

### *Phascolion sandvichi* Murina, 1974

*Phascolion sandvichi* Murina, 1974b:283–284, fig. 2.

*Material examined.*—ZIAS—Murina's holotype.

This single 9 mm worm appears to have a peculiar suite of characters: the retractors are approximately of equal size (dorsal 1.25 times ventral) but the dorsal appears to have 3 origins; hooks are absent; the holdfast papillae have granular borders, some appearing as discrete bumps; and the posterior fixing muscle is unusually well developed looking like a spindle muscle, but it begins (ends?) within the gut coil.

Because of this combination of characters which may not be natural, and the inadequate sample size, we place this species on the list of *species inquirendum* pending further study if more specimens become available.

### Genus *Onchnesoma* Koren and Danielssen, 1875

*Type-species.*—*Onchnesoma steenstrupii* Koren and Danielssen, 1875.

*Diagnosis.*—Species small-sized (trunk less than 1 cm in length). Introvert much longer than trunk. Body wall with continuous muscle layers. Oral disk carrying tentacles (less than 10) arranged around mouth but tentacles may be reduced in size or entirely absent. Introvert retractor muscle system highly modified by complete fusion to form single retractor muscle. Anus situated on distal half of introvert. Contractile vessel rarely apparent and without villi. Spindle muscle apparently absent. One nephridium.

### Morphological Characters

The following are comments on four troublesome characters used in the descriptions of *Onchnesoma* species.

1. *Introvert length and position of anus.*—The introvert in these species is always longer than the trunk, sometimes several times this length. To measure accurately this structure should be completely extended, but this is rarely the case in preserved material. Measurements made on fully or partially contracted introverts can give deceptively short values. Likewise, when attempting to locate the anus, it is difficult to measure accurately its position unless the introvert is fully extended. In *O. steenstrupii* the anus is 90–95% of the distance towards the mouth, while in others it is 70–85%.

2. *Introvert retractor muscle origin.*—In all these species, the retractor is long and appears as a single muscle (probably due to fusion during its ontogeny) which originates from the posterior tip of the body. Whether there is complete fusion so that there is a single origin (root) or incomplete fusion so that there are two origins is sometimes important. To determine this, one must dissect the posterior end of the trunk, being careful not mechanically to cause a split to occur in an otherwise undivided muscle. The division between the two roots is much easier to see if the introvert (and retractor muscle) is extended.

3. *Tentacles.*—The small tentacles in all species except *O. steenstrupii* can be more easily seen if the introvert is completely extended. Otherwise, one must attempt to open the introvert at the appropriate location. This is an extremely difficult task on such a small diameter cylinder. Care must be taken to not mistake torn tissue for tentacles.

4. *Papillae.*—The presence, size and distribution of these epidermal structures is one of the most easily seen characters and therefore, one useful as an aid in identification. There are distinct differences between taxa but there is also some variation within and between populations of the same taxon.

In *O. steenstrupii* the papillae are small (12–18 μm diameter) and arranged in rows radiating out from the posterior end forming the "keels" of earlier authors (Fig. 10E). In the subspecies *O. steenstrupii nudum* these keels remain but are folds in the skin, not papillae (Fig. 10D). Similar non-papillated keels exist in *O. magnibathum* (Fig. 10A) and the posterior may occasionally be strongly contracted accentuating these ridges (Fig. 10B). *Onchnesoma squamatum* is uniformly covered with large irregular papillae 80–120 μm in diameter (Fig. 10C). In the subspecies *O. squamatum oligopapillosum* these papillae are smaller and more scattered. The variation within this species is great and abrasion during collection or subsequent washing and sorting may result in the removal of some of these structures. *Onchnesoma intermedium* has ridges posteriorly but bears large papillae similar to *O. squamatum* on the remainder of the trunk.

In general, these papillae and keels are helpful in the identification process, but must be used in conjunction with the entire suite of characters to avoid mistakes.

## Key to the *Onchnesoma* Species and Subspecies

1. Trunk with papillae . . . . . . . . . . 2
– Trunk with no papillae but with radiating folds of skin (keels) on posterior end . . . . . . . . . . 5
2. Posterior of trunk with well-defined radiating ridges or keels . . . . . . . . . . 3
– Posterior of trunk without well-defined radiating ridges or keels . . . . . . . 4
3. Trunk with large papillae on anterior but not posterior and tentacles present . . . . . . . . . . *O. intermedium*
– Trunk with papillae on posterior, sometimes anterior; oral disk instead of tentacles . . . . . . . . . . *O. steenstrupii steenstrupii*
4. Trunk covered with many large papillae . . . . . . . *O. squamatum squamatum*
– Trunk with few, small, scattered papillae (may be absent in posterior or mid-trunk . . . . . . . . . . *O. squamatum oligopapillosum*
5. Trunk cylindrical, tapering gradually into narrower introvert (½–⅓ trunk width); introvert not more than 2 times trunk length; found at depths greater than 2500 m . . . . . . . . . . *O. magnibathum*
– Spherical with abrupt transition to very thin introvert (⅕–⅒ trunk width); introvert greater than 4 times trunk length; found at depths less than 1000 m . . . . . . . . . . *O. steenstrupii nudum*

## *Onchnesoma*: Systematic Section

### *Onchnesoma intermedium* Murina, 1976

*Onchnesoma intermedium* Murina, 1976:63–64, fig. 2.

*Material examined.*—ZIAS—Murina's co-types.

This species is based on a collection of six specimens. It is reported to have 6–8 tentacles, similar to *O. squamatum,* but differs from it in that the papillae are only distributed over the anterior half to two-thirds of the trunk (not all over). The location of the anus in the mid-region of the introvert (not ¾ of the way to the tip) was determined on incompletely expanded introverts. On the co-types we examined, it was very difficult to determine the position of the distal end of the introvert; however, on one specimen the anus appeared to be at least 80% of the distance to the distal end. The non-papillated posterior region of the trunk

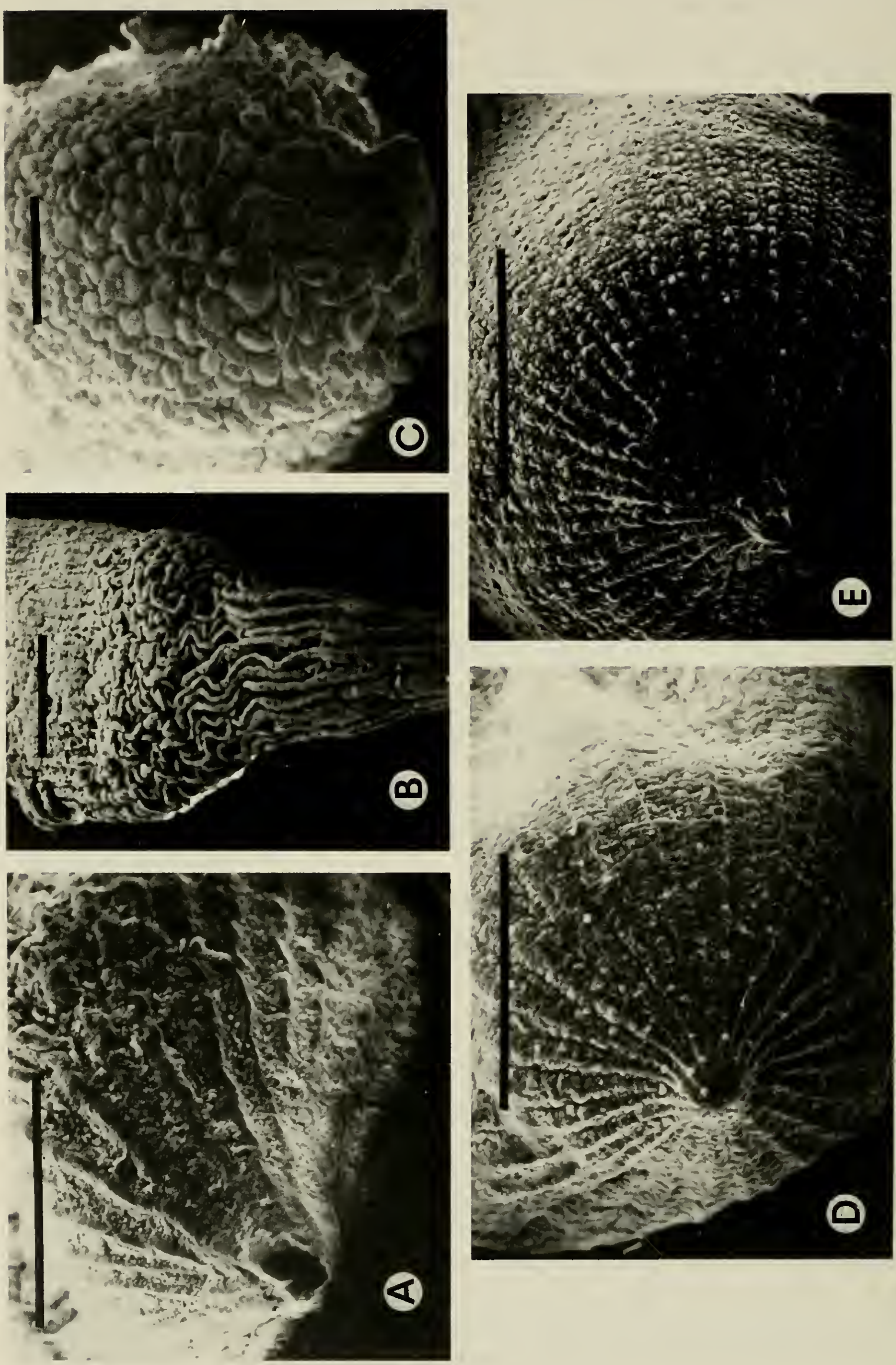

Fig. 10. Scanning electron micrographs of posterior of four *Onchnesoma* taxa: A, B, *O. magnibathum* in two different states of contraction; C, *O. squamatum*; D, *O. steenstrupii nudum* with keels of skin-folds but no papillae; E, *O. steenstrupii steenstrupii* with keels of separate wart-like papillae. (Scale lines = 0.5 mm.)

has longitudinal ridges and furrows. This taxon is not based on a solid foundation and may represent a subset of *O. squamatum.* For the present its separate status is retained but with reservations.

*Known distribution.*—East China Sea at 500 m.

### *Onchnesoma magnibathum* Cutler, 1969

*Onchnesoma magnibatha* Cutler, 1969:71–76; 1973:167–168.—Cutler and Cutler, 1980a:454; 1980b:204–205.—Murina, 1973:70.
*Onchnesoma steenstrupii.*—sensu Murina, 1968b:198.

*Material examined.*—USNM—type; many recently collected specimens from the North Atlantic.

This deep water species is now well known from the Atlantic Ocean. It is cylindrical, pointed at the posterior end with radiating keels. The introvert is about two times the trunk length and the anus is 70–80% of the distance out towards the mouth. The retractor column has two short origins.

*Known distribution.*—This is largely an Atlantic Ocean species with one record from the Peru-Chile Trench in the Southeastern Pacific. Generally it lives at depths between 3000–5000 m with a few records as shallow as 2300 m.

### *Onchnesoma squamatum squamatum* (Koren and Danielssen, 1875)

*Phascolosoma squamatum* Koren and Danielssen, 1875:129; 1877:130–131, pl. 14, figs. 11, 14–15.
*Onchnesoma squamatum* Stephen and Edmonds, 1972:163 (see this for records and synonymy before 1970).—Cutler, 1973:166–167.—Gibbs, 1977:24–25.

*Material examined.*—ZMUB—Type-material; many recently collected specimens from the North Atlantic Ocean.

This is a well established North Atlantic species. It has the typical ball-on-a-string appearance, the trunk is covered with papillae, and the anus is 70–80% of the distance toward the mouth. The retractor column has two origins at the posterior end of the trunk and possesses tentacles. See Stephen and Edmonds (1972), Cutler (1973), or Gibbs (1977) for a complete description. One recent collection (27°45'N, 14°13'W, 1934 m) is unique in that the trunks are cylindrical to spindle shaped, not spherical as is common, and they gradually taper into the narrower introvert unlike the ball-on-a-string appearance. The body wall is covered with irregular evenly distributed golden tan papillae somewhat less dense than in the northern population.

*Known distribution.*—This species appears restricted to the North Atlantic and Mediterranean Sea generally from depths of 150–1400 m. On the eastern side it has been reported from the Canary Islands (27°N) to Iceland (63°N), while on the western side it is found from Florida to North Carolina (24–34°N). The Mediterranean records are very shallow (10–55 m; Murina 1964a)

### *Onchnesoma squamatum oligopapillosum* Cutler, Cutler, and Nishikawa, 1984

*Onchnesoma squamatum oligopapillosum* Cutler et al., 1984:281–282.

*Material examined.*—USNM—type-material.

This Japanese population is the only Pacific Ocean record of this taxon. It differs from the nominate form by having fewer, smaller, scattered papillae.

*Known distribution.*—Pacific side of Honshu, Japan, 14–250 m.

### *Onchnesoma steenstrupii steenstrupii* Koren and Danielssen, 1875

*Onchnesoma steenstrupii* Koren and Danielssen, 1875:133; 1877:142, pl. 15, figs. 28–36.—Stephen and Cutler, 1969:118.—Murina, 1971:82; 1972:304–305; 1978: 124.—Stephen and Edmonds, 1972:163–164 (see this for records and synonomy before 1969).—Cutler, 1980b:205–206.—Zavodnik and Murina, 1975:128.

*Phascolion dogieli* Murina, 1964a:70–71.—Stephen and Edmonds, 1972:176.

*Material examined.*—ZMUB—Type-material; recently collected specimens from the North Atlantic Ocean.

This is a well established and common species. It is spherical with a very long introvert at the end of which is an oral disk, not tentacles. The anus is 90–98% of the distance toward the mouth. It has radiating keels on the posterior end and completely fused retractor column. See Stephen and Edmonds (1972), Cutler (1973), or Gibbs (1977) for a complete description.

*Known distribution.*—In general this species inhabits cool to cold waters at bathyal depths on continental slopes. It is common in the North Atlantic but present in the Southeastern Atlantic, higher latitudes of the Western Pacific and the Southwestern Indian Ocean. There are very few records from depths less than 100 m or greater than 1600 m. Reports that seem atypical include the Mediterranean at 40 m (Zavodnik and Murina 1975), and three very deep (2135–2988 m) unpublished records in the eastern Atlantic Ocean (Cutler and Cutler, in prep.).

### *Onchnesoma steenstrupii nudum,* new subspecies

*Material examined.*—273 specimens from H. Sanders, cruise 42 of Atlantis II to Walvis Bay/Luanda; Sta 185–190 at 22°56′ to 23°05′S and 12°45′ to 13°05′E, 16–17 May 1968.

This group of worms from this restricted geographical region in the Southeastern Atlantic Ocean forms a distinctive population. The morphological distinction from the nominate form is the nature of the epidermis. When viewed under the dissecting microscope the epidermis has a unique ridged appearance. However, microscopic examination of skin mounted in glycerine reveals that the ridges are not made up of scales, papillae or plates as in other *Onchnesoma.* When transverse sections of the body wall are made, it appears to be only small folds or wrinkles in the epidermis giving this effect. Scanning electron micrographs corroborate this (Fig. 10D).

The introvert is at least 5–6 times the trunk length (trunks 0.5–2.0 mm) and terminates in a modified tentacular apparatus reduced to a disk as in *O. steenstrupii.* However, there is one specimen that has about six subdivisions or tentacular lobes. Internally the retractor muscles are completely fused with a single origin at the posterior tip of the trunk. The single nephridium is about ⅓–½ the trunk length, unattached and on the right side at the anterior end of the trunk. The gut has a regular spiral and is attached by three fixing muscles to the body wall. The anus is located 90–95% of the distance toward the distal end of the introvert.

The name of this new subspecies reflects the absence of radiating, scale-like papillae on the posterior of the trunk which characterize the nominate form. The epidermal ridges which replace these papillated rows make this taxon easily recognizable. The general shape, size, and internal organization are comparable. This apparently restricted range (around 23°S and 13°E with a vertical range of 460–1011 m) may be unreal. *Onchnesoma steenstrupii steenstrupii* is found in nearby but deeper water (2100–2500 m).

The holotype from St. 188 is deposited in the National Museum of Natural History, Washington, D.C., USNM 081987; the paratypes from the same station are USNM 081988.

## Discussion

Our analysis shows one major evolutionary trend within this pair of genera (fusion of introvert retractor muscles) sometimes paralleling other changes. The least derived form is exhibited by the *P. tuberculosum* group having two muscles (a dorsal and a ventral) of equal size, separated for most of their length. From this morph two lines are evident. One leads to the *P. strombus* condition, i.e., a marked reduction in the relative size of the ventral muscle. The second involves the fusion of dorsal and ventral muscles going through the *P. pacificum* morph (partial) to the *P. cryptum* and *Onchnesoma* morph of a single retractor column.

The tentacular crown has also undergone two basic changes. The primitive state is 15–25, well-developed tentacles (*P. strombus*). From this, one trend is toward a reduction to a few lobes or only an oral disc as in *O. steenstrupii.* A second (rare) trend is toward an increasing number (more than 35), thinner, elongate tentacles (*P. medusae*).

A third character of interest is hooks. There are three evident trends away from the common thin, pointed spine-like form (Type I). One group of species developed a more massive, recurved structure (Type II), a second group developed small hooks with rounded tips and a more circular base (Type III). There is a fourth group of eight species which appears to have no hooks.

The zoogeographical picture that we have of the species in these genera is not presented in detail here. We have a large number of unpublished records from several parts of the world's oceans which contain *Phascolion* and *Onchnesoma* species and we believe it premature to make a detailed statement. However, there are a few interesting generalizations one can make:

1. *P. strombus* is very widely distributed in cool water from shelf and slope depths generally at latitudes higher than 30°N and S.

2. As a group, these genera seem adapted for cool or cold water but are largely absent from abyssal depths and lower latitudes at shallow depths except in upwelling regions off West Africa. When species are present in non-upwelling areas and shallow water (*P. cryptum, P. cirratum, P. robertsoni*) they appear to be very localized. The one exclusively abyssal species (*O. magnibathum*) is widely distributed in the Atlantic Ocean only.

3. Between *P. strombus* and those with very localized distributions, there are

Table 1.—Species considered with summary of proposed taxonomic changes.

| Present name | Proposed name |
|---|---|
| *Phascolion abnorme* Fischer, 1895 | no change |
| *Phascolion africanum* Fischer, 1923 | *Phascolion strombus* |
| *Phascolion alberti* Sluiter, 1900 | *Phascolion strombus* |
| *Phascolion anomalus* Murina, 1981 | *Phascolion strombus* |
| *Phascolion artificiosum* Ikeda, 1904 | *Phascolion strombus* |
| *Phascolion beklemischevi* Murina, 1964 | *Phascolion convestitum* |
| *Phascolion bogorovi* Murina, 1973 | no change |
| *Phascolion botulus* Selenka, 1885 | incertae sedis |
| *Phascolion brotzkajae* Murina, 1964 | *Phascolion strombus* |
| *Phascolion canum* Cutler and Cutler, 1980 | *Phascolion lutense* |
| *Phascolion caupo* Hendrix, 1975 | no change |
| *Phascolion cirratum* Murina, 1968 | no change |
| *Phascolion collare* Selenka et al., 1883 | no change |
| *Phascolion convestitum* Sluiter, 1902 | no change |
| *Phascolion cronullae* Edmonds, 1980 | *P. strombus cronullae* |
| *Phascolion cryptum* Hendrix, 1975 | no change |
| *Phascolion dentalicolum* Sato, 1937 | *Phascolion hedraeum* |
| *Phascolion dogieli* Murina, 1964 | *Onchnesoma steenstrupii* |
| *Phascolion hedraeum* Selenka et al., 1883 | no change |
| *Phascolion heteropapillosum* Wesenberg-Lund, 1963 | *Phascolion abnorme* |
| *Phascolion hibridus* Murina, 1981 | no change |
| *Phascolion hirondellei* Sluiter, 1900 | *Phascolion tuberculosum* |
| *Phascolion hupferi* Fischer, 1895 | no change |
| *Phascolion ikedai* Sato, 1930 | species inquirendum |
| *Phascolion indicus* Murina, 1974 | *Phascolion hupferi* |
| *Phascolion kurchatovi* Murina, 1974 | *Phascolion hedraeum* |
| *Phascolion lucifugax* Selenka et al., 1883 | no change |
| *Phascolion lutense* Selenka, 1885 | no change |
| *Phascolion manceps* Selenka et al., 1883 | incertae sedis |
| *Phascolion mediterraneaum* Fischer, 1922 | *Phascolion convestitum* |
| *Phascolion medusae* Cutler and Cutler, 1980 | no change |
| *Phascolion megaethi* Cutler and Cutler, 1979 | no change |
| *Phascolion microspheroidis* Cutler and Duffy, 1972 | no change |
| *Phascolion moskalevi* Murina, 1964 | species inquirendum |
| *Phascolion murrayi* Stephen, 1941 | *P. valdiviae sumatrense* |
| *Phascolion pacificum* Murina, 1957 | no change |
| *Phascolion pallidum* Koren and Dan., 1877 | *Phascolion tuberculosum* |
| *Phascolion parvum* Sluiter, 1902 | species inquirendum |
| *Phascolion pharetratum* Sluiter, 1902 | no change |
| *Phascolion rectum* Ikeda, 1904 | no change |
| *Phascolion robertsoni* Stephen and Robertson, 1952 | no change |
| *Phascolion sandvichi* Murina, 1974 | species inquirendum |
| *Phascolion strombus* Montagu, 1804 | no change |
| *Phascolion sumatrense* Fischer, 1916 | *P. valdiviae sumatrense* |
| *Phascolion temporariae* Edmonds, 1976 | *Phascolion tuberculosum* |
| *Phascolion tortum* Edmonds, 1976 | *Phascolion strombus* |
| *Phascolion tridens* Selenka et al., 1883 | *Phascolion collare* |
| *Phascolion tuberculosum* Theel, 1875 | no change |
| *Phascolion tubicolum* Verrill, 1873 | *Phascolion strombus* |
| *Phascolion ushakovi* Murina, 1974 | no change |
| *Phascolion valdiviae* Fischer, 1916 | no change |
| *Onchnesoma intermedium* Murina, 1976 | no change |
| *Onchnesoma magnibatha* Cutler, 1969 | no change |
| *Onchnesoma squamatum* Koren and Dan., 1875 | no change |
| *Onchnesoma steenstrupii* Koren and Dan., 1875 | no change |

only four species of *Phascolion* (*tuberculosum, hedraeum, lutense, pacificum*) recorded from wide areas. These four species are also taxa with non-specialized morphological character states. In *Onchnesoma* three of the four species are distributed over a fairly broad range.

4. The Eastern Pacific Ocean and the coasts of India seem to lack representatives of these genera.

5. Being common in the Arctic and Antarctic Oceans makes *Phascolion* a subject of interest in discussions of bipolarity.

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# A NEW GENUS OF TROPICBIRD (PELECANIFORMES: PHAETHONTIDAE) FROM THE MIDDLE MIOCENE CALVERT FORMATION OF MARYLAND

Storrs L. Olson

*Abstract.*—Three associated bones from the Middle Miocene (Langhian) Calvert Formation of Maryland are described as a new genus and species of tropicbird, *Heliadornis ashbyi.* This constitutes the only Tertiary record for the previously monotypic family Phaethontidae. The morphology of the humerus of *Heliadornis* was more specialized than in the extant genus *Phaethon,* hence it probably represents an extinct lineage not ancestral to living tropicbirds.

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The modern tropicbirds, long so called because "they are never seen far without either Tropick" (Dampier 1697:53), comprise three species in the monotypic family Phaethontidae. They are highly pelagic, plunge-diving birds that usually nest in rocky cliffs and have such reduced hindlimbs that they are incapable of true walking locomotion. In most respects, tropicbirds are so different from other members of the Pelecaniformes that their affinities have frequently been questioned (Sibley and Ahlquist 1972). Nevertheless, apparently derived characters shared with the Pelecaniformes, such as the totipalmate foot, salt glands situated within the orbit, and the lack of an incubation patch, indicate that the Phaethontidae should be included in that order.

Although the tropicbirds are in many respects primitive (Olson 1977b) and may be expected to be at least as old as other families of Pelecaniformes, several of which are known as far back as the early Eocene (Olson 1985), there has hitherto been no Tertiary fossil record of the Phaethontidae. *Prophaethon shrubsolei* Andrews (1899), from the Lower Eocene London Clay of England was originally described in the Phaethontidae, but was later elevated to the rank of a separate family and order by Harrison and Walker (1976). Ordinal separation of *Prophaethon* is not justified, but the differences between it and *Phaethon,* particularly in the pelvis and hindlimb, warrant the recognition of the family Prophaethontidae (Olson 1977b, 1985). Thus, the three associated bones from the middle Miocene Calvert Formation in Maryland described here, which are referable to the Phaethontidae, constitute the only fossil record of the family apart from Quaternary remains of extant species.

## Order Pelecaniformes Sharpe
## Suborder Phaethontes Sharpe

Within the Pelecaniformes, the Calvert fossil can be referred to the suborder Phaethontes by the retention of a procoracoid foramen (lacking in the other suborders), a well developed pectoral crest and a poorly developed acromion process of the scapula (both conditions also occur in the Fregatae but not in the Pelecani or Sulae).

### Family Phaethontidae Bonaparte, 1853

The only skeletal element that can be compared among *Phaethon, Prophaethon,* and the Calvert fossil is the coracoid; all the fossil specimens, however, are imperfect. The Calvert fossil resembles the Phaethontidae and differs from the Prophaethontidae in having a larger, more expanded procoracoid process and a more robust shaft of the coracoid.

### *Heliadornis,* new genus

*Type-species.*—*Heliadornis ashbyi,* new species; the only included species.

*Diagnosis.*—Differs most markedly from *Phaethon* in the size and shape of the pectoral crest of the humerus, which is smaller, more distally situated, with more prominent muscle scars, and in dorsal view has the proximal margin more nearly parallel with the shaft. In addition, the intumescence of the bicipital crest is more proximo-distally elongate, being more ovoid than circular in shape, the impression for M. coracobrachialis cranialis is longer, wider, and incises the bicipital intumescence more deeply, so that the proximo-dorsal corner of the latter is more sharply defined and pointed.

*Etymology.*—Greek, *Heliades* + *ornis,* bird. In Greek mythology the three Heliades were the daughters of Helios and the sisters of Phaëthon; the name, which is masculine, thus reflects the likelihood of the Miocene fossil being the "sister group" of the modern genus *Phaethon.*

### *Heliadornis ashbyi,* new species
Figs. 1–2

*Holotype.*—Left humerus lacking distal end and ventral tubercle, left coracoid lacking sternal end and part of procoracoid process, left scapula lacking posterior half, vertebrate paleontological collections of the National Museum of Natural History, Smithsonian Institution, USNM 237226. Collected in association on 24 Dec 1954 by Wallace L. Ashby.

*Locality.*—40 m north of south end of second cliff south of Parker Creek, Calvert County, Maryland.

*Horizon.*—Zone 11 (of Shattuck 1904), about 60 cm below the base of Zone 12, Calvert Formation, Middle Miocene (Langhian).

*Measurements of holotype.*—Humerus: distance from head to distal extent of scar for M. pectoralis, 30.2 mm; depth through head, 5.3; proximo-distal extent of bicipital intumescence, 16.0; width and depth of shaft at approximate midpoint (at level of nutrient foramen), 6.4 × 5.3. Coracoid: dorso-ventral depth through head, 11.0 mm; length and width of glenoid facet, 8.8 × 5.2; width and depth of shaft at approximate midpoint, 5.1 × 4.4. Scapula: width of articular end, 10.0 mm; width and depth of shaft 20 mm from tip of acromion, 3.4 × 1.8.

*Etymology.*—Dedicated to Mr. Wallace L. Ashby, Jr., who over the past three decades has collected numerous valuable specimens of fossil birds from the Calvert Formation and kept indispensible records of most of his finds (see Olson 1984). Recognition of his considerable contribution to knowledge of the Calvert avifauna is long overdue.

*Diagnosis.*—As for the genus. The species was approximately the size of the living species *Phaethon aethereus* Linnaeus or perhaps slightly smaller.

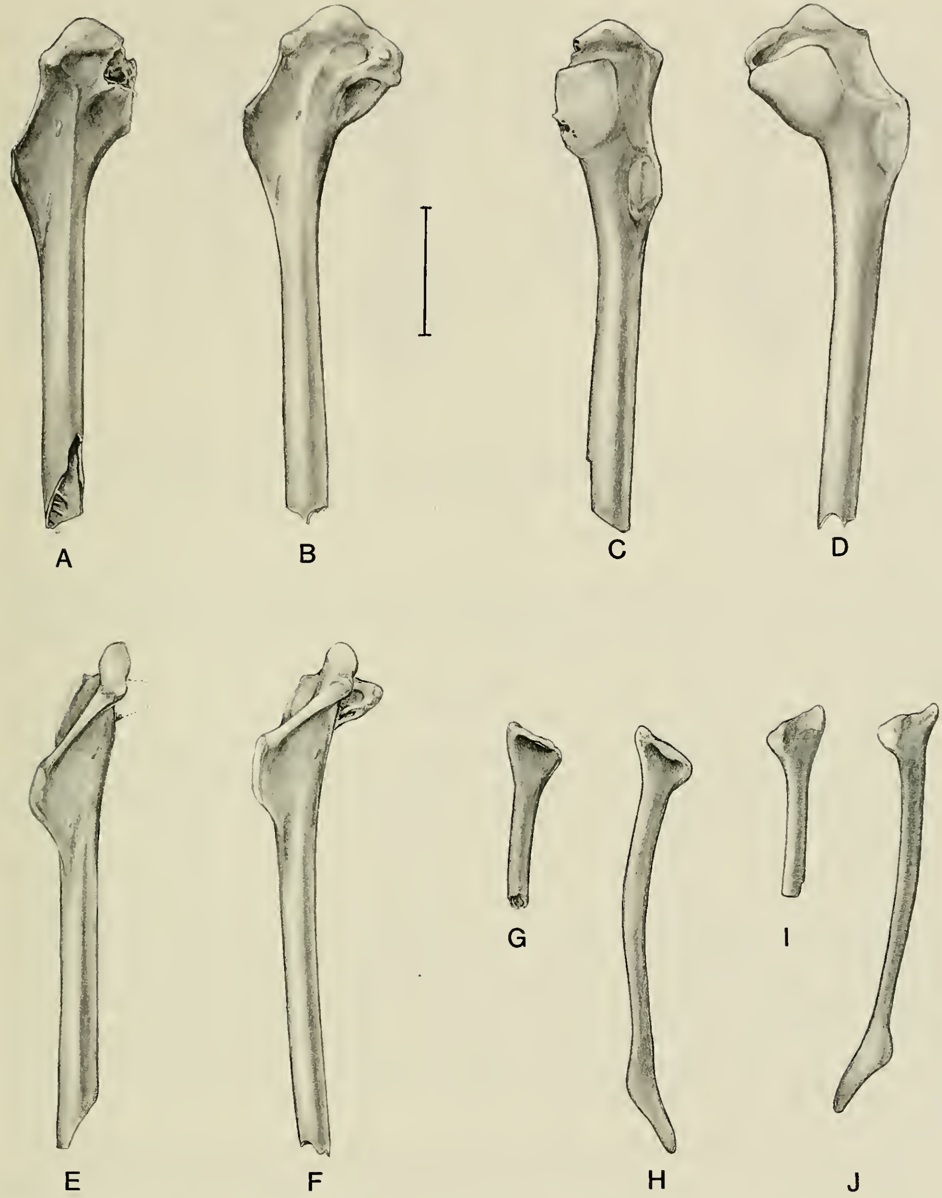

Fig. 1. Humerus (A, C, E) and scapula (G, I) of holotype of *Heliadornis ashbyi,* new species (USNM 237226), compared with the same elements of the modern tropicbird *Phaethon aethereus* Linnaeus (B, D, F, H, J). A–B, Humeri in anconal (cranial) view; C–D, Same in palmar (caudal) view; E–F, Same in dorsal view; G–H, Scapulae in ventral view; I–J, Same in dorsal view. Scale = 2 cm.

*Description.*—Although damaged, there remains enough of the tricipital area of the humerus to ascertain that a distinct, circular, pneumatic foramen was present. The small oval scar for M. latissimus dorsi caudalis is situated dorsal to the midline of the shaft, as in *Phaethon* and other Pelecaniformes except the Fregatidae, in which it is on the midline (Olson 1977b:21).

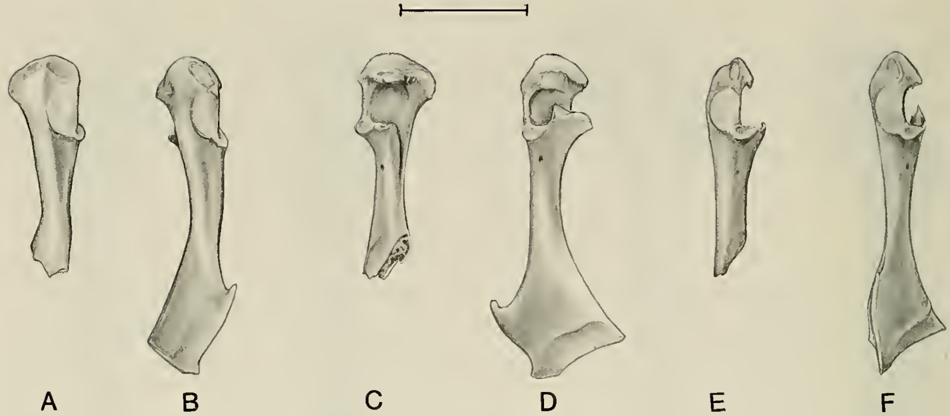

Fig. 2. Coracoid (A, C, E) of holotype of *Heliadornis ashbyi,* new species (USNM 237226), compared with the same element of the modern tropicbird *Phaethon aethereus* Linnaeus (B, D, F). A–B, Ventro-lateral view; C–D, Dorsal view; E–F, Lateral view. Scale = 2 cm.

Details of the scapular end of the coracoid in *Phaethon* are quite variable individually, so that comparisons with the fossil are difficult. In *Heliadornis* the head is not as pointed, and the area of clavicular articulation is not as heavily ossified along the distal margin of ligamental attachment as in *Phaethon.* Such increased ossification in living versus fossil forms is commonly observed in various parts of the skeleton in diverse groups of seabirds and probably has little systematic significance. The scapula of *Heliadornis* differs from that of *Phaethon* only in having the shaft somewhat more robust and the acromion slightly less developed.

*Remarks.*—The highly distinctive reduction and distal displacement of the pectoral crest of the humerus in *Heliadornis* represents an exaggeration of a trend also evident in *Phaethon,* in which the pectoral crest is somewhat reduced and distally displaced as compared with the probable primitive condition seen in the Eocene frigatebird *Limnofregata* (Olson 1977b, fig. 19). Because the humerus of *Heliadornis* appears to be more specialized than that of *Phaethon,* the fossil genus cannot be ancestral to modern tropicbirds. Therefore, *Heliadornis* represents an extinct lineage in the Phaethontidae and can probably be regarded as the "sister-group" of *Phaethon.*

Functional correlates of the humeral morphology of *Heliadornis* are difficult to discern. The reduction of the pectoral crest might represent a trend toward the condition in the Pelecani and Sulae in which there is no deltoid expansion of the humerus into a crest at all. Distal displacement of the pectoral crest is also seen in the gigantic pelecaniform pseudodontorns (Pelagornithidae), but in this instance the crest is greatly enlarged, probably in connection with the assumed sustained gliding flight of these birds (Olson 1985). An even more extreme example of reduction and distal displacement of the pectoral crest occurs in the skimmers of the genus *Rynchops* (Rynchopidae, Charadriiformes), which feed in level flight just at the surface of the water, so the wings cannot be depressed below the horizontal. In the absence of more nearly complete fossil material, it would be of little use to speculate on the mode of life of *Heliadornis.*

Mainly because of their cliff-nesting habits, modern tropicbirds occur very infrequently in Quaternary deposits, even on islands where they are known to breed (Olson 1975, 1977a). The holotype of *Heliadornis* is the only Tertiary specimen of tropicbird yet known, despite the fact that in recent years thousands of fossils of marine birds have been recovered from Miocene and Pliocene deposits along the middle Atlantic coast of eastern North America, and in Florida, California, and South Africa. No Tertiary fossil deposits containing marine birds have yet been found in what would have been truly tropical waters. The great rarity of the Phaethontidae in the fossil record would be understandable if Tertiary tropicbirds were also restricted to low latitudes and were as extremely pelagic in their habits as the modern birds.

## Acknowledgments

For their valuable contributions and not inconsiderable patience I thank Wally Ashby, who waited more than 30 years for this specimen to be described, and Anne Curtis, who waited more than 10 years to see her illustrations of it put to use. I am grateful to Cyril A. Walker, British Museum (Natural History) for lending the coracoid from the holotype of *Prophaethon shrubsolei* for comparison in this and other studies. For bibliographic assistance I thank Leslie Overstreet, and for comments on the manuscript, Ralph Eschelman and Clayton E. Ray.

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# *CHRYSOPETALUM, BHAWANIA* AND TWO NEW GENERA OF CHRYSOPETALIDAE (POLYCHAETA), PRINCIPALLY FROM FLORIDA

Thomas H. Perkins

*Abstract.*—The Chrysopetalidae are compared with other families in the order Phyllodocida. *Treptopale,* n. gen., and *Hyalopale,* n. gen., are proposed. *Chrysopetalum hernancortezae, C. heteropalea, C. floridanum, C. eurypalea, Treptopale rudolphi,* and *Hyalopale bispinosa,* all new species, are described from Florida. *Chrysopetalum remanei,* n. sp., is described from the Red Sea. *Chrysopetalum debile* (Grube), *C. occidentale* Johnson, *C. elegans* Bush, *Bhawania goodei* Webster, and *B. heteroseta* (Hartman), n. comb., from various areas are additionally described. The status of *Chrysopetalum elongatum* (Grube) from the Virgin Islands is discussed. Important characters of the above genera plus *Paleanotus* Schmarda, *Dysponetus* Levinsen, and three unnamed generic groups are discussed. A generic key and keys to Floridan species of *Chrysopetalum* and *Bhawania* are provided.

This report is based on examination of available specimens of Chrysopetalidae from several important collections from Florida, as well as miscellaneous specimens from Bermuda, California, the Mediterranean Sea, and the Red Sea. A species of *Paleanotus* and single species of two undescribed genera from Florida cannot be included in this report, but it is anticipated that at least one of these will be described soon (Charlotte Watson Russell, in litt.).

Types and other material for study are deposited in the Allan Hancock Foundation, University of Southern California (AHF); British Museum (Natural History) (BMNH); California Academy of Sciences (CAS); Invertebrate Collection of the Florida Department of Natural Resources, Bureau of Marine Research (FSBC I); Indian River Coastal Zone Museum, Harbor Branch Foundation, Inc., Fort Pierce, Florida (IRCZM); Marine Environmental Sciences Consortium, Dauphin Island, Alabama (MESC); National Museum of Natural History, Smithsonian Institution (USNM); Peabody Museum of Natural History, Yale University (YPM); Universitetets Zoologiske Museum, Copenhagen (ZMC); and Zoologisches Institut und Zoologisches Museum, Hamburg University (ZMH).

Included are specimens collected from September 1971 to July 1973 in an environmental baseline study of marine biota near the Florida Power and Light Company nuclear power plant at Hutchinson Island, St. Lucie County, Florida, funded in part by Florida Power and Light Company. The study area and methods were described by Gallagher and Hollinger (1977). Sediments were described by Gallagher (1977). Other aspects of the physical and chemical environment were reported by Worth and Hollinger (1977). This area has been the subject of several faunal reports including five on the Polychaeta (see Perkins 1984).

Chrysopetalids of the Hourglass Cruises were obtained by the Florida Department of Natural Resources at ten stations on two transects in the eastern Gulf of

Mexico sampled monthly from August 1965 to November 1967. The rationale and pertinent data for these collections were reported by Joyce and Williams (1969). Many groups from these collections have been described in the *Memoirs of the Hourglass Cruises* published by the Florida Department of Natural Resources, Bureau of Marine Research.

Chrysopetalids associated with the coral *Oculina varicosa* (Lesueur) collected off southeastern Florida by Harbor Branch Foundation in depths from about 3 to 80 m during 1975–1979 using *Johnson-Sea-Link* (J-S-L) submersibles I and II and SCUBA were provided by John K. Reed. Reed (1980) reported on the distribution and structure of deep-water reefs of that study, and Reed et al. (1982) provided additional information.

Chrysopetalids collected from over 400 estuarine benthic stations in Tampa Bay during June 1963–August 1964 by John L. Taylor and Carl H. Saloman of the U.S. National Marine Fisheries Service were studied. Polychaetes of that study were reported by Taylor (1971) and Hall and Saloman (1975), and examples of most species were deposited in the USNM by Taylor.

Collections of chrysopetalids made during October 1981-September 1983 as part of the Biscayne Bay Restoration and Enhancement Program, Dade County, Florida, were funded by the Florida Department of Environmental Regulation (DER) and administered by the Dade County Department of Environmental Resource Management (DERM). More than 350 species of tropical estuarine polychaetes were identified from 180 collections (Richard Walesky, in litt.). Permission to use the specimens was granted by Edward A. Swakon and Gary R. Milano, both of Dade County. Patsy A. McLaughlin of Florida International University and Peter Schroeder of Biosystems Research, Inc., Miami, Florida, provided additional information. Specimens were tentatively identified by Harvey D. Rudolph (DER), who also provided specimens from his personal collections associated with reefs of *Phragmatopoma lapidosa* Kinberg and miscellaneous other specimens.

Chrysopetalids from Looe Key National Marine Sanctuary, Monroe County, Florida, 24°32′N, 81°24′W, an offshore bank coral reef, were provided by Kristian Fauchald (USNM). Specimens were collected during 25–29 Sep 1982 by K. Fauchald, B. Kensley, and M. Schotte under Contract No. NA82AAA00962, Sanctuary Program, Office of Ocean and Coastal Resource Management, U.S. Department of Commerce, to the Smithsonian Institution. Fauchald also loaned miscellaneous specimens. R. J. Helbling (DER), Norman J. Blake, University of South Florida, and Thomas Hopkins (MESC) also provided specimens.

Voucher specimens of chrysopetalids from the Gulf of Mexico reported by Gathof (1984) were examined. Specimens were collected for the U.S. Bureau of Land Management, now Minerals Management Service, during the Mississippi, Alabama, Florida Study (MAFLA), South Florida Study (SOFLA), South Texas Outer Continental Shelf Study (STOCS) and Ixtox Oil Spill Assessment Study (IXTOX). Voucher specimens are deposited in the National Museum of Natural History (USNM). Other MAFLA specimens were also examined.

The type of *Chrysopetalum elegans* Bush from Bermuda was loaned by Willard Hartman (YPM). Specimens of *Chrysopetalum debile,* the new *Chrysopetalum* from the Red Sea, and comparative material of *Paleanotus chrysolepis* Schmarda were loaned by Gesa Hartmann-Schröder (ZMH). Susan J. Williams (AHF) loaned

specimens of *Chrysopetalum occidentale.* Barbara Weitbreicht (CAS) loaned comparative material of *Paleanotus bellis* (Johnson). Marian H. Pettibone (USNM) and Mary Petersen (ZMC) provided copies of papers not available to me. Mary Petersen also provided information on the specimen in the Copenhagen Museum examined by Augener (1925) and discussed herein under the name *Chrysopetalum elongatum* Grube. William G. Lyons critically read the manuscript, and it was thoroughly reviewed by Marian H. Pettibone.

## Abbreviations on Figures

| | | | |
|---|---|---|---|
| ca | caruncle | pl | paleae, lateral group |
| cd | cirrophore of dorsal cirrus | pm | paleae, middle group |
| dl | dorsal lamella (covering prostomium) | pml | paleae, midline group |
| gl | gland | roman numeral | segment number |
| la | lateral antenna | s | spine |
| ma | median antenna | segment no. + d | dorsal ramus (or cirrus) |
| mc | mouth cover | segment no. + dc | dorsal cirrus |
| mo | mouth opening | segment no. + v | ventral ramus (or cirrus) |
| P | palp | segment no. + vc | ventral cirrus |
| pa | paleae, anterior | | |

Under his group Aphroditea, Savigny (1820:16) described *Palmyra aurifera.* Audouin and Milne Edwards (1832:445, 446, pl. 10, figs. 1–6) supplemented the description, added figures and placed *P. aurifera* in the tribe Aphroditisiens Nus (where the body is lacking elytra). Kinberg (1858:1) established the family Palmyridae (as Palmyracea) for *P. aurifera* with the diagnosis: elytra lacking; paleae on all segments; tubercles and dorsal cirri alternating.

Schmarda (1861:162) included *Palmyra* Savigny and two new genera, *Paleanotus* and *Bhawania,* in the family Palmyridae Kinberg, 1858. This arrangement has been followed by Day (1967:115) and others.

Ehlers (1864:115) established the family Chrysopetalidae (as Chrysopetalea) for the new genus *Chrysopetalum,* the two genera of Schmarda, and questionably *Palmyra* Savigny.

The following authorities have indicated that *Palmyra* should not be linked with Chrysopetalidae and that it is closely allied with Aphroditidae Kinberg, 1856, only lacking elytra: Racovitza (1896:209, 216–217), Augener (1913:80–83), and Horst (1917:136).

In her catalogue, Hartman (1959:125–127) included Palmyridae Kinberg, 1858, and Chrysopetalidae Ehlers, 1864, as separate families. In more recent classifications of the Polychaeta, Mileikovsky (1977:515) placed both families under the order Phyllodocemorpha; Fauchald (1977a:8) placed them both under the order Phyllodocida: suborder Aphroditiformia: superfamily Chrysopetalacea; and Pettibone (1982:5) placed Chrysopetalidae as an aberrant family in the order Phyllodocida. In her revisionary studies in progress, Pettibone (in litt.) is including *Palmyra,* along with some other genera, in a subfamily of Aphroditidae, showing its close relationship to the elytrigerous Aphroditidae and not to the Chrysopetalidae.

However, the position of Chrysopetalidae in the order Phyllodocida has not been clarified. Among other families of the Phyllodocida, chrysopetalids share the character of internally chambered setae with Nereididae (shafts of compound setae), Nephtyidae (preacicular "laddered" capillaries), most Hesionidae (shafts of compound setae, notosetae, acicula of some), some Aphroditidae (paleate setae; see *Pontogenia chrysocoma.*—Claparède, 1868:368–371, pl. 1, fig. 3), and some Sigalionidae (blades of compound setae; see *Sthenelais simplex* Ehlers, 1887:60–63, pl. 13, figs. 2, 3, pl. 4, figs. 1–6). Chrysopetalids share the character of paleate setae, which may not be internally chambered, with other Aphroditidae (*Palmyra aurifera*). However, relationships among families indicated by internally chambered setae and paleae may not be close but very old, extending back to the Middle Cambrian *Canadia* Wolcott: Canadiidae (see Conway Morris 1979:240–251).

Among families of the order Phyllodocida, chrysopetalids share the character of a single pair of bilateral jaws with Nereididae, Nephtyidae and some Hesionidae; they share a very similar muscular attachment of the jaws with Nereididae; they have simple notosetae and compound neurosetae and the same number of antennae and palps as some Hesionidae. Finally, some chrysopetalids (e.g., *Chrysopetalum caecum* Langerhans) have acicula in cirrophores of segment 1 as do some Hesionidae. However, cirri of segments 1 and 2 of the aberrant anterior end of chrysopetalids are only slightly modified, if not slightly reduced, and it is difficult to compare them with tentacular cirri of Hesionidae and Nereididae which are distinctly longer than dorsal cirri of following segments. I suspect that cirri of segments 1 and 2 of chrysopetalids have the same function as longer tentacular cirri of nereidids and hesionids, and they are here so defined, although, for brevity, they are not designated as such in the text. This suggests that Chrysopetalidae are related to Nereididae and Hesionidae (and perhaps Nephtyidae), although the relationships might not be especially close. However, they seem to be more closely related to these families than to other Phyllodocida.

It is also noted that the musculature of the pharynx of some Chrysopetalidae (e.g., *Dysponetus* and *Hyalopale,* n. gen.) resembles that of Syllidae; however, there are few other distinct similarities, suggesting that this character may have evolved separately in these families.

## Chrysopetalidae Ehlers, 1864
Fig. 1

*Diagnosis.*—Body small to moderately large, usually slender, with segments less than 20 (*Dysponetus*) to more than 300 (*Bhawania*), 2–3 to 50 mm in length. Prostomium usually surrounded laterally or retractile within anterior segments, with 3 antennae, 2 palps, usually with 4 eyes, with or without bulbous caruncle. Parapodia biramous, rami well-developed, supported by acicula, with notosetae and neurosetae. Dorsal cirri on all segments; ventral cirri on all segments, absent on segment 2 or on segments 2 and 3. Notosetae beginning on segment 2, simple, including paleae and spines, only paleae, or only spines; usually directed posteriorly after first few segments, arranged in lateral bundles or long transverse groups, completely or incompletely covering dorsum. Neurosetae beginning on segment 2 or 3, compound or simple and compound. Notosetae and shafts of neurosetae internally chambered; chambers in paleae in rows forming 2 to many internal ribs, solitary in spines and in shafts of neurosetae except tips, latter usually with 2–3 ribs. Pygidium usually with anal cirri. Proboscis with anterior part cylindrical, posterior part strongly muscular, with bilateral, chitinous jaws or stylets.

*Remarks.*—Chrysopetalidae include the following four genera: *Chrysopetalum*

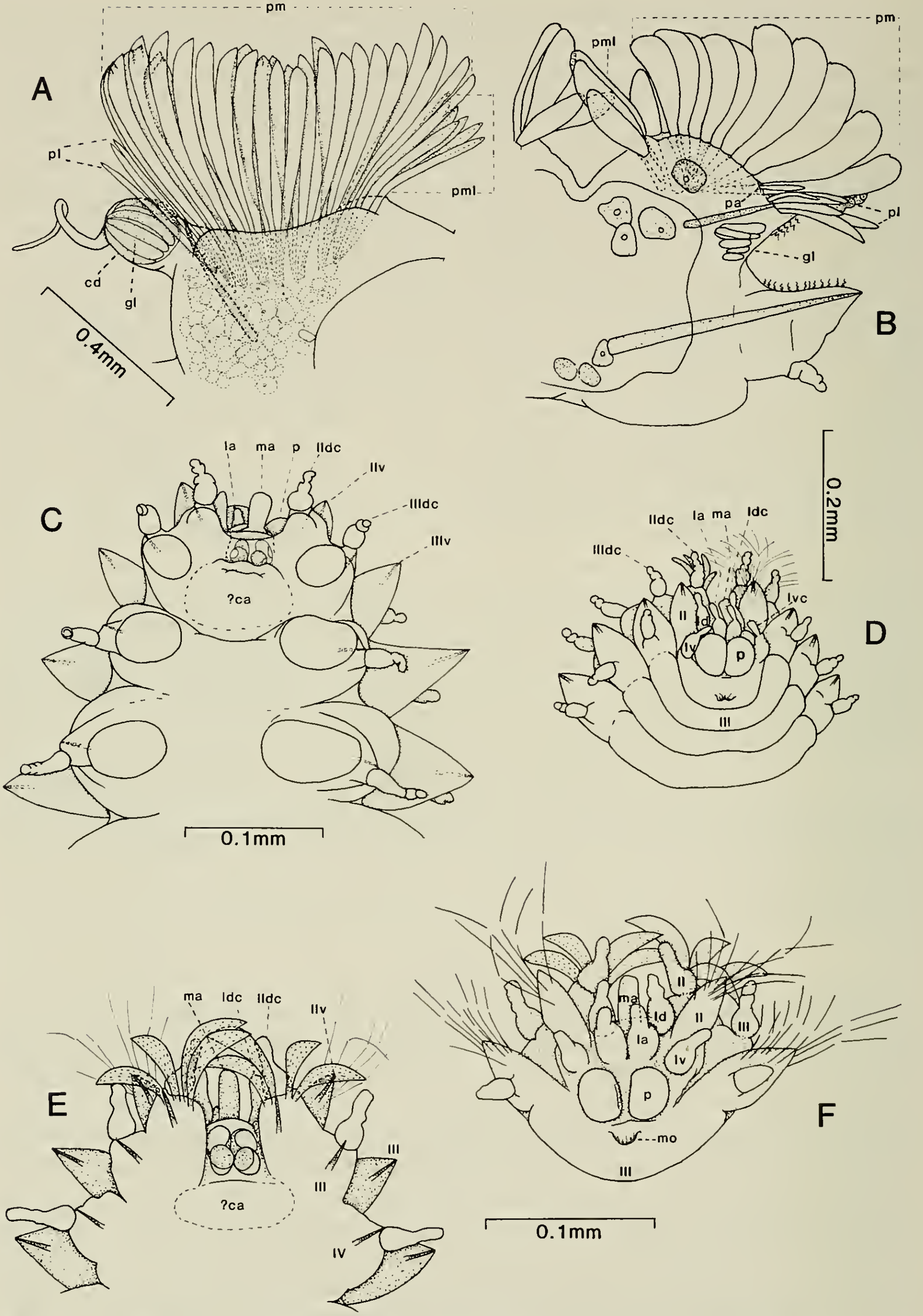

Fig. 1. *Chrysopetalum* sp., Biscayne Bay, Florida (FSBC I 31376); A, Left notopodium, middle segment, anterior view. *Paleanotus bellis,* Dillon Beach, California (CAS 9448): B, Right parapodium of middle fragment of large female, anterior view; C, Anterior end of small specimen, dorsal view; D, Anterior end of gravid female, ventral view. *Paleanotus* sp., NE Gulf of Mexico (FSBC I 23715): E, Anterior end of small specimen, dorsal view; F, Same, ventral view.

Ehlers, 1864; *Paleanotus* Schmarda, 1861 (*Heteropale* Johnson, 1897); *Bhawania* Schmarda, 1861; *Dysponetus* Levinsen, 1879 (*Taphus* Webster and Benedict, 1887). Two new genera, *Treptopale* and *Hyalopale,* are added here. Three additional genera are needed for: 1) species similar to *Chrysopetalum caecum* Langerhans, 1880; 2) species similar to *Bhawania reyessi* Katzmann, Laubier, and Ramos, 1974; and 3) *Paleanotus schmardai* Mileikovsky, 1962. These are discussed and included in the key below.

Important generic characters include: retractility of the prostomium within anterior segments (Figs. 21A–C, 23A–D) and dorsal cirri within cirrophores of notopodia (Figs. 21E, 23F, G); position of the median antenna with respect to the eyes (Figs. 1C, 3A, 16A, 23A); presence of a bulbous caruncle (Fig. 3A) and a distinct lobe or appendage covering the mouth (Fig. 3B); arrangement of setae and dorsal and ventral cirri on the anterior two or three segments; presence of a distinct cirrophore of dorsal cirri (Fig. 11H); shape of the pygidium; number of segments; arrangement, type, and number of notosetae in various groups; and type, shape, and number of internal, chambered ribs in paleae, if present.

Notosetae may be produced in single groups of spines (*Dysponetus*) or various arrangements of spines and paleae in distinct lateral (preacicular; pl), middle (pm), midline (pml), and anterior groups (pa). Paleae of a middle group (pm) may be produced from a single developmental center resulting in a fan-shaped group (*Paleanotus*; Fig. 1B), from several such centers resulting in several, although indistinct, fans of setae (*Chrysopetalum*; Fig. 1A), or separately resulting in a broad, imbricate transverse row (*Bhawania*; Fig. 21E, 24A). Lateral paleae may be similar to paleae of the middle group or distinctly different. Midline group paleae, when present, have a characteristic shape in each genus, and may differ in thickness from those of the middle group. Anterior group notosetae number up to about six widely spaced slender paleae and spines on *Chrysopetalum*: there are single anterior paleae in notopodia of *Paleanotus* and *Treptopale,* n. gen.; they are absent in *Bhawania* and *Hyalopale,* n. gen.

*Chrysopetalum caecum* Langerhans (1880:278, 279, pl. 14, fig. 9a–c), redescribed by Laubier (1968:81, figs. 1, 2), was earlier referred to *Dysponetus* by Augener (1913:78, 79). It differs from typical *Dysponetus* in having antennae, palps, and dorsal cirri of different shapes, an appendage on the posterior rim of the mouth, and compound setae with bidentate blades and bifid shafts. This species belongs to an apparently undescribed genus which also includes *Dysponetus bidentatus* Day, 1954, an undescribed species from south Florida, and possibly *Dysponetus bulbosus* Hartmann-Schröder, 1982.

*Paleanotus schmardai* Mileikovsky (1962:651, 652, fig. 2) appears similar to *Chrysopetalum* in some characters; it is certainly not a *Paleanotus.* It differs from *Chrysopetalum* in having dorsal cirri resembling those of *Paleanotus,* paleae of the middle group produced in two transverse rows from two developmental centers, and middle group paleae with symmetrical tips, the larger ones having about 40 internal, longitudinal ribs. The short paleae of the anterior row of the middle group (both figures of parapodia appear to be the usual posterior views) appear to be homologous with midline paleae of most other genera. Thus the generic status of *P. schmardai* is undefined.

The unidentified species reported as *Bhawania* by Jorge (1953:103) and later described as *Bhawania reyessi* by Katzmann, Laubier, and Ramos (1974) is not a member of *Bhawania* Schmarda but is a species of a new genus being described by Charlotte Watson Russell (in litt.). This genus also includes a species from Florida waters (*Paleanotus* sp. A—Gathof, 1984:26-9, figs. 26-5, 26-6). Species of the genus have paleae of the middle group similar to those of *Bhawania*. However, they differ from *Bhawania* in having an anterior dorsum resembling that of *Paleanotus* Schmarda, except that a distinct caruncle is present, an anterior ventrum resembling that of *Chrysopetalum* Ehlers, paleae of the midline group which are very stout, paleae of the lateral group nearest the aciculum resembling those of the middle group but diminishing anteromedially, and notopodial cirri resembling those of *Paleanotus*.

The first segment of chrysopetalids is always considered to have two pairs of cirri. Observations by Katzmann, Laubier, and Ramos (1974) on *Bhawania reyessi* showed that the first pair of ventral cirri superficially associated with the second segment, were actually cirri of the first segment. This agrees with my observations on the similarity of cirri lateral to the palps and superficially associated with the second segment of some genera to ventral cirri of the first segment of *Chryospetalum* species. There is no question as to which are ventral cirri of the first segment of *Chrysopetalum*, and they are similar in position and may be identical in shape to those of some other genera. Finally, examination of the undescribed species from Florida similar to *Chrysopetalum caecum* Langerhans and *Dysponetus bidentatus* Day, shows ventral cirri to be absent from segment 2: they are present on all segments of *C. caecum* but are stated to be absent from segments 2 and 3 of *D. bidentatus*. In this case, it appears that when ventral cirri are lost during cephalization, they are lost from segment 2 or segments 2 and 3, rather than from segment 1. However, this is not obvious for *Bhawania* (Figs. 21A–C, 23A–D) and some species of *Paleanotus* (Fig. 1C–F) and deserves further study.

Along with asetigerous segment 1, segment 2 has notosetae or both notosetae and neurosetae and is considered to be a tentacular segment. This is based on observations by Laubier (1968:80–83) on *Chrysopetalum debile* and *C. caecum* and on observations that, when ventral cirri are present on this segment, they are longer than those of following segments and similar to dorsal cirri. However, tentacular segments cannot be defined based on lengths of dorsal cirri: dorsal cirri of segments 1 and 2 are similar to those of following segments.

Because of retraction of the anterior end, or contraction during preservation, it is often difficult to determine the segment number of a dorsal or ventral ramus or cirrus of an anterior segment. This can usually be done by starting toward the middle of the body and counting forward.

Besides problems of determining homologies or correct segment numbers of various anterior cirri and parapodial parts, it is often difficult to observe the prostomium and anterior segments because they are usually obscured by paleae. Except where these are retracted (e.g., *Bhawania*), this can usually be done by very carefully spreading apart the paleae under a dissecting microscope or by observation under a compound microscope. Removal of paleae usually results in damage to these parts and should be done only when absolutely necessary or when specimens are available with which to practice.

Another aspect of observation which should be emphasized is that some parapodial characters, such as the surface detail of paleae and the arrangement of paleae in the various groups, are best observed on a parapodium in anterior view. Most authors have published figures of parapodia and paleae in posterior view, and these characters often have not been noted. Dorsal cirri, ventral cirri, and some other parapodial characters are best observed in posterior view.

### Key to Genera and "Unnamed Genera" of Chrysopetalidae

1. Notopodia of middle segments with paleae or paleae and spines ....... 3
– Notopodia of middle segments with only spines ..................... 2
2. Compound neurosetae with unidentate blades; appendage absent on posterior rim of mouth (ventral cirri of segment 1 may approach each other to form analogous structures) [no known Floridan species] ............ ............................................ *Dysponetus* Levinsen
– Compound neurosetae with bidentate blades; appendage present on posterior rim of mouth ............... "*Chrysopetalum caecum* Langerhans"
3. Lateral and midline groups of notosetae of middle segments consisting of only spines (Fig. 29B, C) ............................ *Hyalopale,* n. gen.
– Lateral and midline groups of notosetae of middle segments consisting of paleae or paleae and spines ........................................ 4
4. Four pairs of cirri on first 2 segments; middle group paleae of middle segments produced in several bundles (Figs. 1A, 11A–E) ............ ............................................ *Chrysopetalum* Ehlers
– Three pairs of cirri on first 2 segments; middle group paleae of middle segments produced otherwise ........................................ 5
5. Middle group paleae of middle segments produced in fan-shaped groups from 1 or 2 developmental centers ................................ 6
– Middle group palea of middle segments produced separately, forming broad imbricate row ........................................... 8
6. Caruncle distinct; middle group paleae of middle segments produced from 2 developmental centers in fan-shaped rows, one behind other; compound neurosetae of middle segments with spinigerous blades .............. .... [no known Floridan species] .... "*Paleanotus schmardai* Mileikovsky"
– Caruncle absent or greatly reduced; middle group paleae of middle segments produced in single, fan-shaped, imbricate row from single developmental center; compound neurosetae of middle segments with falcigerous blades ................................................ 7
7. Caruncle absent; middle group paleae of middle segments nearly symmetrical, with symmetrical tips (Fig. 26A, F) ........... *Treptopale,* n. gen.
– Caruncle, if present, reduced to flattened structure; middle group paleae of middle segments distinctly asymmetircal, with margins convex laterally and concave medially (Fig. 1B–F) .................. *Paleanotus* Schmarda
8. Caruncle and mouth cover present; prostomium not retractile within anterior segments; dorsal cirri not retractile within cirrophores; midline group paleae of middle segments very stout; most lateral group paleae similar to middle group paleae but curved oppositely ...................... ..................... "*Bhawania reyessi* Katzmann, Laubier, and Ramos"
– Caruncle and mouth cover absent; prostomium retractile within anterior

segments; dorsal cirri retractile within cirrophores; midline group paleae of middle segments broad but thin; lateral group paleae distinctly different from middle group paleae (Figs. 21–25) .............. *Bhawania* Schmarda

### *Chrysopetalum* Ehlers, 1864

*Palmyra.*—Grube, 1855:90 [in part; not Savigny, 1820].
*Chrysopetalum* Ehlers, 1864:80.—Quatrefages, 1866a:296.—Augener, 1913:79, 80.—Fauvel, 1923:122 [in part]; 1932:42; 1936a:16; 1953a:78.—Jorge, 1953: 103, 104.—Uschakov, 1955:146.—Mileikovsky, 1962:653.—Rullier, 1964: 142.—Laubier, 1968:80–83 [in part].—Orensanz, 1972:489–491 [in part].—Fauchald, 1977a:72.
*Palmyra* (*Palmyropsis*) Claparède, 1864:583.—Quatrefages, 1866b:655.
*Paleanotus.*—Day, 1962:635, 1967:116 [in part; not Schmarda, 1861].

*Type-species.*—*Chrysopetalum fragile* Ehlers, 1864 [*Chrysopetalum debile* (Grube, 1855); synonomy by Racovitza 1896:209]; by monotypy.

*Diagnosis.*—Body relatively long, slender, up to 65 segments. Prostomium visible dorsally, separated dorsolaterally from anterior segments, with 2 pairs of eyes, with short median antenna behind anterior eyes, with caruncle attached on posterior dorsal margin of prostomium, with elongate palps, mouth opening under rounded or triangular cover (mc). Segments 1 and 2 each with 2 pairs of elongate dorsal and ventral cirri, similar to dorsal cirri of following segments. Segment 2 uniramous, with paleate notosetae and acicula. Parapodia biramous from segment 3 on, with notopodial paleae and compound spinigerous neurosetae on anterior few segments, changing to compound falcigers on middle and posterior segments. Middle notopodia with long cirrophores, with cirrostyles long, with oval bases and filiform tips. Neuropodia with broadly rounded postsetal lobes; ventral cirri on short cirrophores medial to setae, shorter than dorsal cirri. Paleae of middle segments comprised of at least 3 groups arranged in broad, semicircular to almost straight rows, usually completely covering dorsum, extending from bundles occupying ½–⅔ of segmental width, distinctly and equally serrate on both margins. Broad posterior paleal group, middle group (pm), consisting of 2–3 irregular transversely arranged rows or tiers of long, slender paleae spreading from up to 8 developmental centers; lateral and medial ones with tips asymmetrically bent toward middle of group; medial ones symmetrical, each with up to 12 internal ribs. Preacicular paleal group, lateral group (pl), consisting of up to 10 more slender, symmetrically-tipped, laterally-oriented paleae. Midline group paleae (pml) arranged in longitudinal to slightly oblique row of up to 6; each bent medially and posteriorly, shorter, more slender than those of middle group, with almost symmetrical tips. Compound falcigers with blades longer above, shorter below, serrate on margins, with hooked, unidentate tips. Pygidium with pair of anal cirri similar to dorsal cirri.

*Additional characters.*—The posterior margin of the prostomium extends to about the posterior margin of segment 4 and the bulbous, ciliated caruncle to about the posterior margin of segment 5 (Fig. 16A). The arrangement of cirri on segments 1 and 2 is shown on Fig. 11A–E and other figures. Upper, anterior, dorsal cirri are dorsal cirri of segment 2 (IId, IIdc). Cirri originating more proximally and below dorsal cirri of segment 2 are dorsal cirri of segment 1 (Idc, Id).

Ventral cirri of segment 2 (IIvc, IIv) originate below dorsal cirri of segment 3 (IIIdc, IIId). Ventral cirri of segment 1 (Ivc, Iv) originate ventral or ventrolateral to palps. Paleae of segments 2 and 3 are produced in inverted cones from apparently single developmental centers. They are slender, resembling lateral group paleae of middle segments on segment 2, gradually broader and more numerous on segment 3 and produced in an arc by segment 4. Lateral group paleae are first visible on segment 4 and well-developed by segment 6. Midline group paleae first appear on segment 5, but are biserrate. Triserrate midline paleae develop on segment 6 in those species which have them in middle segments. Lateral group and midline group paleae are produced from single developmental centers. The few upper compound falcigers, with shafts originating above or behind the aciculum, have blade margins oriented ventrally and usually distinctly longer and more slender than others. Blades of other falcigers are usually shorter and stouter, with blade margins oriented dorsally and gradually shorter ventrally. Additionally, some falcigers in the middle of each bundle have blades with long serrations (Fig. 2I). Further, parapodia of middle segments have glands containing spindles of fibers interspaced with granules in dorsal cirrophores (Fig. 11H), in posterior sides of neuropodia (Fig. 7B), and in bases of ventral cirri (Fig. 16F). Such glands also occur ventrally in the body between neuropodial lobes and longitudinal muscle bands. Interramal and dorsal interparapodial regions are ciliated.

*Remarks.*—*Chrysopetalum* was incorrectly referred to *Paleanotus* Schmarda by Day (1962:635). *Paleanotus* differs from *Chrysopetalum* in several characters. In *Paleanotus* the median antenna is anterior and originates in front of the anterior pair of eyes; palps are short and cushion-shaped; the mouth opening is simple and not covered by a rounded or triangular flap; a caruncle, if present, is poorly defined; there are only three pairs of cirri on the first two segments; large paleae of middle segments usually number only ten or fewer, are all similar with the medial margin straight or concave and usually lightly serrate, the lateral margin strongly convex and strongly serrate, the dorsal surface ornamented with longitudinal rows of cusps, and the internal structure being formed of usually more than 15 chambered ribs. In this regard, *Chrysopetalum macrophthalmum* Hartmann-Schröder (1959:94–96) is a *Paleanotus.*

Fauvel (1923:123) included *Chrysopetalum caecum* Langerhans from Madeira and *Palmyra* (*Palmyrides*) *portusveneris* Claparède from southern France in his account of *Chrysopetalum debile* (Grube). *Chrysopetalum caecum* is apparently a member of an undescribed genus. *Palmyra* (*Palmyrides*) *portusveneris* is a *Paleanotus,* according to Augener (1913:76, footnote).

Characters of specific importance include the degree to which the prostomium is turned anteriorly (Figs. 3A, 16A); the arrangement of the eyes; the presence of well-developed glands between parapodial rami containing bundles of rods (Figs. 5B, 7A); shapes, relative lengths, and detail of blades of neurosetae (Figs. 4K, L; 17J–L); type and degree of ornamentation of the dorsal surface of paleae (Figs. 2B, 12A, 15C); the shape of tips of paleae (Figs. 2B, 9D, 12A), whether blunt, obtuse or acute, hooded, with or without hood remnants, entire or bifid; presence or absence of a midrib on paleae of the midline group (Figs. 2C, 10A); the presence of spines (simple, biserrate notosetae having only one internal cross-barred rib) and small paleae aligned between lateral and midline paleae on the anterior side of the middle group (Fig. 3C, D); and differences in size and shape of paleae within the lateral group (Fig. 14D). Specimen size, number of segments, and number of paleae in the middle group vary within broad limits and should be used with caution.

The overall shape, shape of the tips and number of internal ribs of paleae of the middle group seems to be fairly conservative, escecially if ones of similar position and size are compared. The number of internal ribs is sometimes difficult to determine because of the difficulty in getting paleae to lie completely flat, thus obscuring the narrowest ribs which occur bilaterally. The presence of hoods or hood remnants on tips of fully emergent paleae seems to be related to their initial development. They seem to persist in species in which they are well developed upon emergence. Hooded tips may not occur on newly emerging paleae of all species. None were observed on *C. hernancortezae,* n. sp. However, a fragile hood was observed on an emerging palea of a single specimen of *C. elegans* Bush, and no hoods or hood remnants were observed on fully emergent paleae of the species.

## Key to Floridan species of *Chrysopetalum*

1\. Paleae ornamented with transverse ridges (Fig. 15C–E); anterior group paleae and spines lacking (Fig. 14D) ................ *C. heteropalea,* n. sp.

– Paleae ornamented with knobs; anterior group paleae and spines present .............................................................. 2

2\. Parapodia with interramal glands containing spindles of fibers (Fig. 7A); lateral and medial paleae of middle group with long, tapered tips ...... ................................................. *C. elegans* Bush

– Parapodia without interramal glands; lateral and medial paleae of middle group with shorter, acute to obtuse, tips ........................... 3

3\. Long middle group paleae broad, with 12 internal ribs, symmetrically-tipped ones with almost blunt tips, lateral and medial ones with tips only slightly exceeding convex margins (Figs. 18H, I, 19C) .. *C. eurypalea,* n. sp.

– Long middle group paleae more slender, with up to 10 internal ribs, all with more pointed, obtuse to acute tips .......................... 4

4\. Hoods or remnants of hoods absent on fully emergent paleae (Fig. 12A–E); distal serrations on falcigers long, extending about to tips (Fig. 13A–C) ........................................ *C. hernancortezae,* n. sp.

– Hoods or hood remnants present on paleae (Fig. 17A–C); distal serrations on falcigers not extending to tips (Fig. 17J–L) ........ *C. floridanum,* n. sp.

## *Chrysopetalum debile* (Grube, 1855)

Fig. 2

*Palmyra debilis* Grube, 1855:90, 91, pl. 3, figs. 3–5.

*Chrysopetalum fragile* Ehlers, 1864:81–92, pl. 2, figs. 3–9.—Quatrefages, 1866a: 296.—Claparède, 1868:417–418.—Marion and Bobretzky, 1875:9, 10.

?*Chrysopetalum debile.*—Ehlers, 1864:80 [*P. debilis* questionably referred to *Chrysopetalum*].

*Palmyra* (*Palmyropsis*) *evelinae* Claparède, 1864:586, 587, pl. 8, fig. 6.—Quatrefages, 1866b:655.

*Chrysopetalum debile.*—Quatrefages, 1866a:296.—Racovitza, 1896:209–216, pl.

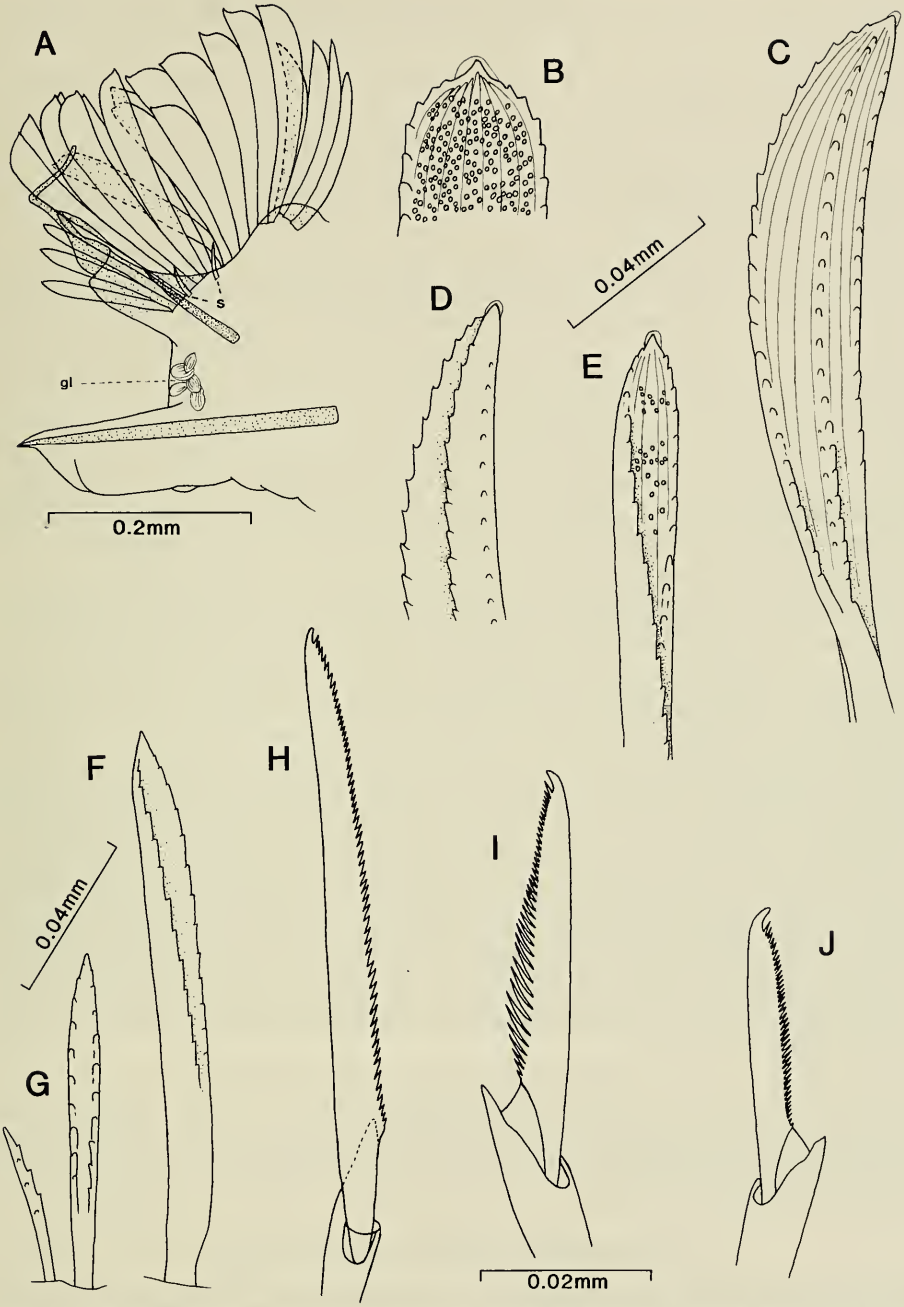

Fig. 2. *Chrysopetalum debile,* middle segments (ZMH P-14047): A, Left parapodium, anterior view; B, Tip of symmetrical palea, center of middle group, showing surface knobs and internal ribs, dorsal view; C, Palea, midline group, showing surface midrib and internal ribs; D, Same, turned; E, Palea, lateral group; F, Shortest lateral group palea, small specimen; G, Small lateral group palea and spine, right side of another parapodium of same; H, Upper compound falciger; I, Middle compound falciger; J, Lower compound falciger.

3, fig. 27, pl. 4, figs. 28–34.—Fauvel, 1923:123, fig. 44r–u [in part].—Laubier, 1968:80, 81.

*Chrysopetalum.*—Jorge, 1953:103, 104, figs. 5–7, 10 [species name not given but apparently *C. debile*].

*Material examined.*—FRANCE, MEDITERRANEAN SEA: Banyuls-sur-Mer, "*Otoplana*: Turbellaria zone" (lowest intertidal zone sensu Adolph Remane), 2 specimens (ZMH P-14047).

*Description.*—Body with about 40 segments. Anterior eyes circular, separate, of moderate size. Notosetae consisting of paleae and spines (Fig. 2A–G). Tips of paleae hooded, entire; dorsal surface moderately to strongly knobbed; paleae of middle group numbering 20 to 25; symmetrical ones in middle with obtuse tips and 8 internal ribs; palea of midline group about 4, with denticulate surface midrib; preacicular paleae all slender, often diminishing anteromedially to small palea and spine. Anterior notosetae consisting of up to 3 spines. Blades of compound falcigers (Fig. 2H–J) moderately long; upper few blades distinctly longer than adjacent ones, gradually shorter below; distal serrations of blades of upper falcigers extending about to tips, shorter below. Anterior side of parapodia apparently with interramal glands containing spindles of fibers, but not well developed.

*Remarks.*—On borrowing these specimens from Banyuls for examination, I assumed, as have others (Laubier 1968), that only one species of *Chrysopetalum* occurs in the Mediterranean area. After descovering several species among specimens from Florida, I have some doubt that my assumption was correct and conclude that the types, if extant, should be examined.

The two specimens examined were collected near the type-localities of *Palymra debilis,* Villafranche, and *Palmyra* (*Palmyropsis*) *evelinae,* Port-Vendres, on the south coast of France. The type-locality of *C. fragile* is Quarnero (=Kvarner), Yugoslavia, in the northwestern Adriatic Sea. All the types probably came from shallow water or intertidal areas, as did the specimens examined. It is probable that all belong to the same species and are the same as specimens examined. Even the detail of the tips of the paleae is no indication to the contrary. In his discussion of specimens from Australia referred to *C. occidentale* Johnson, Augener (1913: 79) noted that paleae of *C. debile* (no locality stated, but probably Mediterranean) were hooded.

I examined parts of a single parapodium of a specimen from South Africa identified as *Paleanotus debilis* (=*Chrysopetalum*) by J. H. Day. Middle Group paleae of the specimen appeared to have completely smooth dorsal surfaces, so the specimen is probably not the same species as *C. debile.*

### *Chrysopetalum elongatum* (Grube, 1856)

*Palmyra* (?) *elongata* Grube, 1856:51, 52.—Quatrefages, 1866a:298.—Augener, 1925:5.

?*Chrysopetalum* spec.—Augener, 1925:5, 45 [questionably = *C. elongatum,* fide Augener].

*Remarks.*—Because *C. elongatum* was described from St. Croix, Virgin Islands, near the area of study, it seems prudent to discuss the current status of the species. The original description was very brief, without figures and based on a single, poorly preserved specimen of 48 segments and 6 lines (approx. 13 mm) long. The specimen was supposedly collected by Örsted at St. Croix. Grube stated that the species might be a member of a new genus and inserted a (?) between names of the genus and species to indicate this. Augener (1925:5) did not find the holotype in the Copenhagen Museum and stated that the description was adequate only to indicate that the specimen was a Chrysopetalidae. However, because of of Grube's remarks that the species resembled *Palmyra debilis* Grube and that it differed from *Palmyra aurifera* [=Aphroditidae] in the form of the ventral setae, Augener continued to maintain the species as *Chrysopetalum elongatum.* Grube's description also stated that basal articles of dorsal cirri were very stout and suboval, and this further suggests that his specimen was a *Chrysopetalum.*

In the same species account, Augener (1925) reported on a *Chrysopetalum* specimen from St. Croix in the University Zoological Museum, Copenhagen, under the name of *Palmyra fragilis* Grube. He thought the specimen might be an example of *P. elongata* but did not conclude that it was the type. There are two original labels in the vial containing the specimen. One is very small, showing "St. Croix" and "Kr" (=Krøyer). The other is a postage stamp-sized label with the information: "11/3–57; 18/9–45; *Palmyra fragilis* Ørst. Gr.; St. Croix; Krøyer" (Mary Petersen, in litt.) and is probably the "hand written note of Krøyer" mentioned by Augener. The name *P. fragilis* is an obvious misidentification; however, it is possible that it was subsequently applied as a museum name to the type of *Palmyra elongata.* The name "Ørst." on the tag may be an indication that this was the specimen examined by Grube, and the specimen is apparently the only one which may possibly be the type of *Palmyra elongata.* However, this cannot be confirmed because, in addition to the conflicting information on the jar tags, the specimen differs from the one originally described by Grube in having 58 segments and being fairly well preserved (Augener 1925:5; Mary Petersen, in litt.). Further, records of the Copenhagen Museum indicate that the specimen was collected by Krøyer (Mary Petersen, in litt.) and not by Örsted, as stated in Grube's account. According to Augener, paleae (i.e., paleae of the middle group) of the *Chrysopetalum* spec. are more pointed on the tip and more slender than those of *Chrysopetalum debile.* I have not been able to examine the specimen and thus cannot comment further or propose any action which might clarify its status.

### *Chrysopetalum occidentale* Johnson, 1897
Figs. 3, 4

*Chrysopetalum occidentale* Johnson, 1897:161, pl. 5, figs. 15, 16, pl. 6, figs. 17–19.—Monro, 1933:19.—Hartman, 1961:56, 57; 1968:185, 186, figs. 1–5.—Fauchald, 1977a:71, fig. 18a–c; 1977b:10.
*Chrysopetalum paessleri* Augener, 1912:163, 164, pl. 5, figs. 1, 2.

*Material examined.*—CALIFORNIA: Catilina Is., White Cove, shore, from (algal) holdfasts, *Velero* III Sta 1370-41, 20 specimens (AHF).—Same, 1 mi NW of White Cove, 2–3 fms, from *Eisenia* holdfasts, *Velero* III Sta 1378-41, 10 specimens (AHF). MEXICO: Cedros Is., Mar 1959, 1 specimen (plus 10 young specimens; AHF N-14111).

*Description.*—Largest specimen (Velero III Sta 1378-41) 14 mm long, 1.6 mm wide without setae, tapered anteriorly and posteriorly, 66 segments; specimen

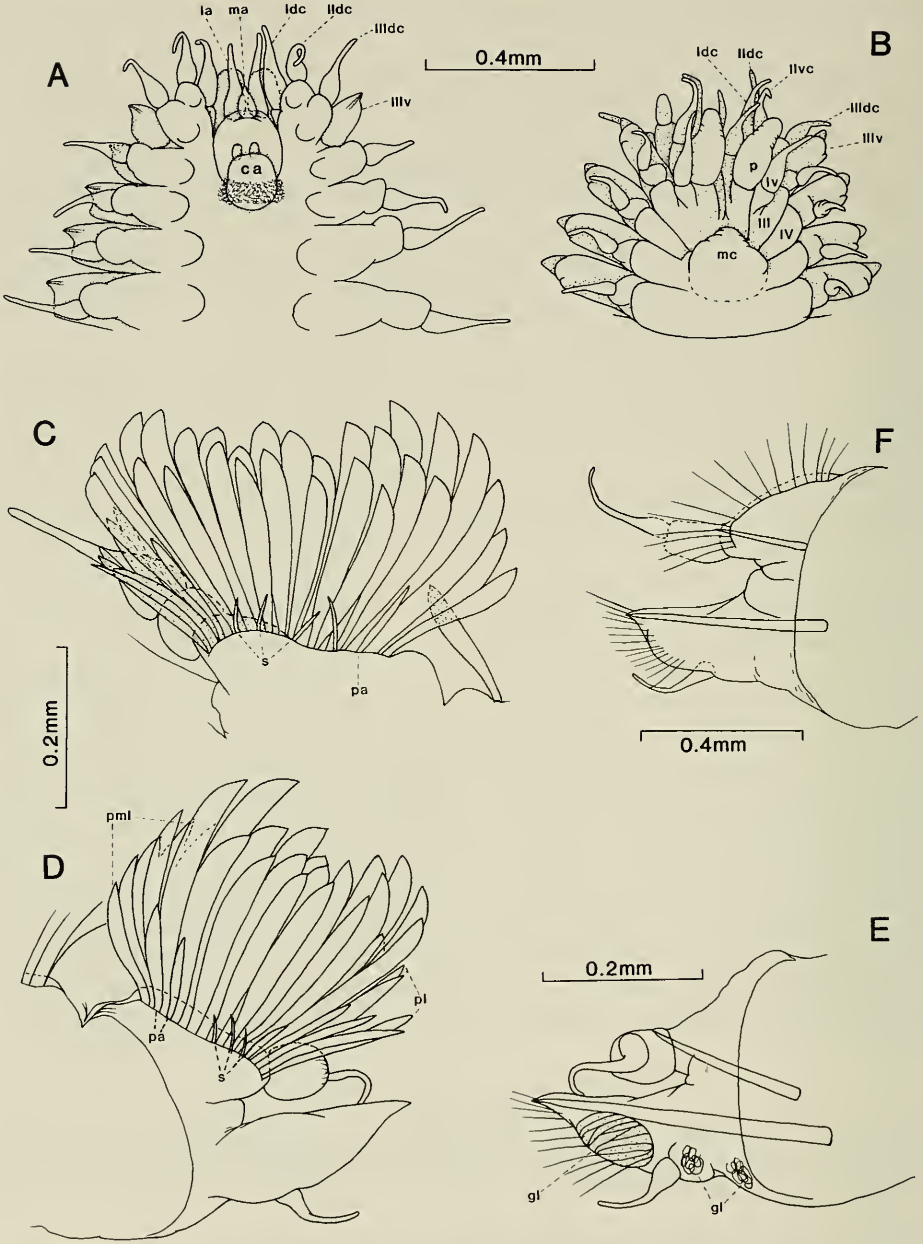

Fig. 3. *Chrysopetalum occidentale*: A, Anterior end, dorsal view; B, Same, ventral view; C, Left notopodium, middle segment, anterior view; D, Right parapodium, middle segment, anterior view; E, Same, left side, paleae omitted; F, Same, right side, posterior view (A, B, E, *Velero* III 1378-41; C, D, F, Cedros Is., AHF).

from Cedros Is. (AHF N-14111) 5 mm long, about 50 segments. Prostomium of mature specimens (Fig. 3A) turned anteriorly; anterior eyes visible through dorsal integument, facing anteriorly, oval, about 2 times longer than wide, closely appressed, line separating them almost straight, together forming large single pigment spot; posterior eyes separated, oval, in about middle of dorsal surface; median antenna originating on anterior margin of dorsal surface, directed anteriorly; lateral antennae originating below, partly covered by anterior part of prostomium; caruncle large, overlying about posterior ⅓ of prostomium; palps originating ventrally well back from anterior margin (Fig. 3B). Parapodia as figured (Fig. 3C–E). Notosetae consisting of paleae and spines (Figs. 3C, D, 4A–J). Tips of paleae entire, with remnants of hoods on middle and midline groups; dorsal surface of paleae moderately to strongly knobbed; middle group paleae of middle parapodia of mature specimens from California numbering 35–40, about 30 on smaller specimen from Cedros Is., Mexico; longer symmetrical ones in middle of group with obtuse tips, with 8–10 internal ribs; anterior (older) paleae much shorter than posterior (later formed) paleae. Midline group paleae about 6, each with denticulate surface midrib. Lateral group paleae all slender, diminishing to spine anteromedially. Anterior group notosetae including 3–4 spines and 1, rarely 2, small, biserrate paleae near to but separated from triserrate midline paleae. Blades of compound falcigers (Fig. 4K, L) moderately long, upper few distinctly longer than adjacent ones, gradually shorter below, each with distal serration well short of tip. Interramal region on anterior side of parapodia ciliate, without glands containing spindles of fibers.

*Remarks.*—The original description of *Chrysopetalum paessleri* Augener from Nicarauga is in good agreement with specimens of *C. occidentale* from southern California, and I see no reason to maintain that name.

Specimens from the northwest Pacific Ocean reported as *C. occidentale* by Uschakov (1955), and Imajima and Hartman (1964) are apparently a different species. Laubier (1968) examined specimens from that area loaned to him by Uschakov and stated that notosetae began on segment 1 and neurosetae began on segment 2. Notosetae begin on segment 2 and neurosetae begin on segment 3 on all specimens of *Chrysopetalum* that I have examined.

*Chrysopetalum occidentale* was also reported from Australia by Augener (1913). Hartmann-Schröder (1982) reported specimens of *Paleanotus debilis* [=*C. debile* (Grube)] from Australia, and noted that paleae of the specimens were hooded; she referred Augener's Australian specimens to that species. The presence of well-developed hoods on the specimens from Australia certainly indicates that they differ from *C. occidentale.*

Elimination of northwest Pacific and Australian specimens limits *C. occidentale* to northeast Pacific areas from southern California to Panama (Fauchald 1977b). Specimens of *Chrysopetalum occidentale* of Gathof (1984) from the Gulf of Mexico are referred to *C. hernancortezae,* n. sp.

### *Chrysopetalum elegans* Bush, 1900
Figs. 5–7

*Chrysopetalum elegans* Bush in Verrill, 1900:668, 669.—Hartman, 1942:15.

*Material examined.*—BERMUDA: 1–3 ft, colls. A. E. Verrill and party, 1898, 1 complete and 1 middle fragment, syntypes (YPM 1154). FLORIDA: near S Palm Beach-Broward County line, on *Phragmatopoma,* 1.3 m, coll. H. Rudolph, Jan 1975, 4 specimens (USNM 97347; FSBC I 31381; H. D. Rudolph).—Dade County, S. Biscayne Bay, near E end of Florida Power and Light Turkey Point power plant channel, 50 ft NW of channel marker No. 2, in *Thalassia* bed, colls.

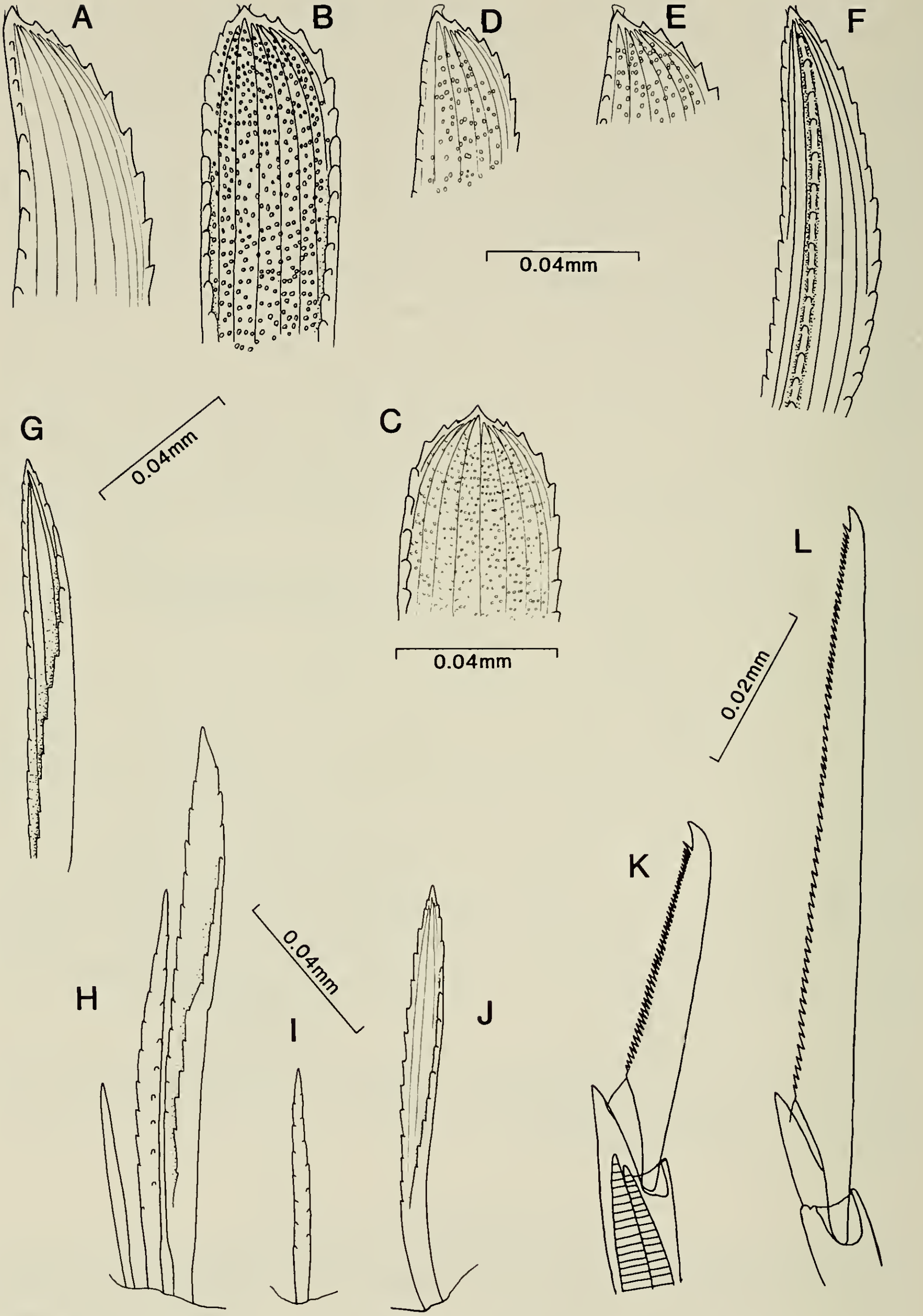

Fig. 4. *Chrysopetalum occidentale,* setae, middle segments; A, Lateral palea, middle group; B, Center palea, middle group, showing knobbed surface; C, Symmetrically-tipped palea from center of middle group; D, E, Tips of newly emerging paleae, middle group; F, Palea, midline group; G, Palea, lateral group; H, Smaller paleae and adjacent spine, lateral group, right notopodium; I, Spine, anterior group; J, Small palea, anterior group; K, Lower compound falciger: L, Upper compound falciger (A, C, H–J, *Velero* III 1378-41; B, D–G, Cedros Is; K, L, *Velero* III 1370-41).

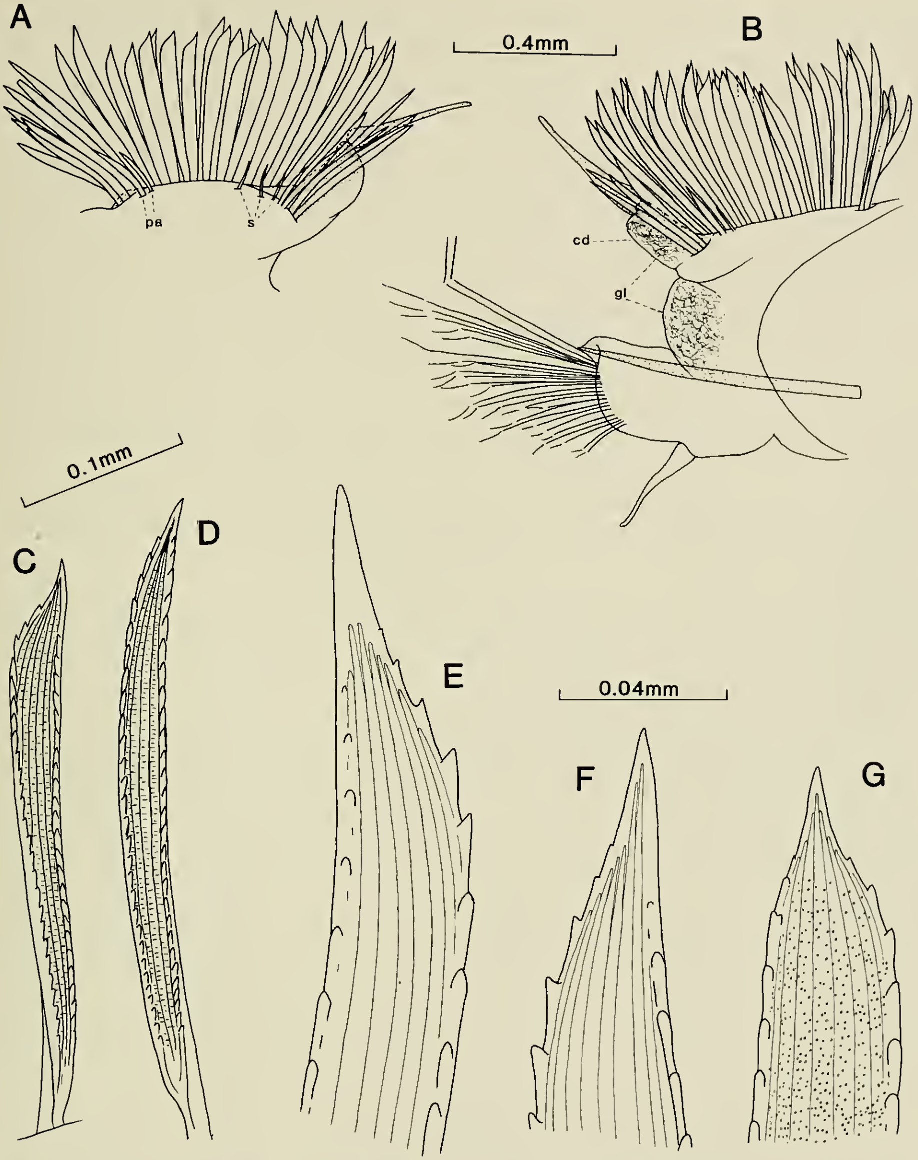

Fig. 5. *Chrysopetalum elegans,* middle segments of syntypes: A, Right notopodium, anterior view; B, Left parapodium anterior view; C, D, Paleae, middle group; E, F, Tips of same, from lateral part; G, Same, from central part, dorsal surface showing surface knobs (A–E, G, Middle fragment; F, complete specimen).

DER personnel, Nov 1978, 1 specimen (USNM 97346).—Same, DERM Sta 16, Ragged Keys, at edge of channel between 2 keys, 25°32′01″N, 80°10′17″W, 2–3 m, scoured hard bottom from high current flow, 1 specimen (USNM 97348).—Florida Keys (Monroe County): exact locality unknown, colls. DER personnel, 1 specimen (YPM). Looe Key National Marine Sanctuary, reef crest, coralline covered rubble, less than 1 m, Sta FLK-2, 1 specimen (USNM 97521).—Same, Sta

FLK-3, 1 specimen (USNM 97522).—Same, rubble with low scattered algal growth, Sta FLK-5, 4 specimens (USNM 97523).—Same, clumps of *Halimeda,* Sta FLK-6, 1+ specimens (FSBC I 31756).—Same, clumps of *Halimeda* growing on buttress in spur and groove zone, 2–6+ m, Sta FLK-13, 2 specimens (USNM 97524).—Same, lagoon in front of reef crest, 1+ m, Sta FLK-23, 1 specimen (USNM 97525).—Same, at base of upper spur and groove buttress, coral rubble, 6+ m, Sta FLK-25, 5 specimens (USNM 97526).—Northeast Gulf of Mexico, 100 mi S of Panama City, on pelagic *Sargassum,* R/V *Hernan Cortez,* coll. B. Presley, Aug 1966, 1 young specimen (FSBC I 31382).

*Description.*—Complete syntype curled, 12 mm long, 2 mm wide, 65 segments [15 mm long according to Bush]; Florida specimens much smaller, up to 6 mm long, 50 segments. Prostomium appearing oval, longer than wide. Eye pigment not conserved on syntype; apparently 2 pairs [Bush reported 3 pairs of black spots; the intermediate "second pair" she reported were apparently pigment spots visible on freshly collected specimens; seen on some other species from Florida]; anterior eyes large, oval, closely appressed on some specimens, smaller, round, separated on others; median antenna short, fusiform. Notosetae consisting of paleae and spines (Figs. 5A–G, 6A–F, 7A, C–F). Middle group paleae slender on syntypes, symmetrical middle ones and perhaps others slightly broader on most Florida specimens; tips entire, without hoods or hood remnants; dorsal surface lightly knobbed; middle group paleae of middle parapodia numbering 20–30, with internal ribs numbering 6–8 on lateral ones, 8–10 on central ones; longer symmetrical ones in center of middle group with long, tapered tips on syntypes, with acute tips on most Florida specimens; lateral and medial paleae of middle groups of all specimens with long, tapered tips. Midline group paleae up to about 6, each with denticulate surface midrib. Lateral group paleae more numerous, all similar, slender, gradually diminishing to spine anteromedially. Anterior group notosetae consisting of about 2 short, slender, biserrate paleae without denticulate surface midrib, slightly separated from midline paleae, and 2–3 spines. Blades of compound falcigers (Figs. 6G–I) moderately long, upper few distinctly longer than adjacent ones, gradually shorter below, each with distal serration back from tip and distinct projection or knob at proximal end of serrate margin; upper blades with short, stout serrations; several in middle of bundle with moderately long serrations; lower ones with short, fine serrations. Interramal region on anterior side of parapodia with large gland containing spindles of fibers (Figs. 5B, 7A).

*Remarks.*—*Chrysopetalum elegans* differs from other species of the genus in having a well-developed gland containing spindles of fibers in the interramal region. Notosetae of *C. ehlersi* Gravier, 1901, from Djibouti, Gulf of Aden, are similar to those of *C. elegans,* but blades of neurosetae are much more slender. Interramal glands are not known for *C. ehlersi.* A fragile hood was observed on the tip of an emerging palea of the middle group of one specimen (USNM 97522); however, no evidence of hoods or remnants was observed on fully emergent paleae.

### *Chrysopetalum remanei,* new species
Figs. 8–10

*Chrysopetalum debile.*—Hartmann-Schröder, 1960:71 [not *Palmyra debilis* Grube, 1855].

*Material examined.*—RED SEA, EGYPT: Hurghada (Ghardqua), colls. A. Re-

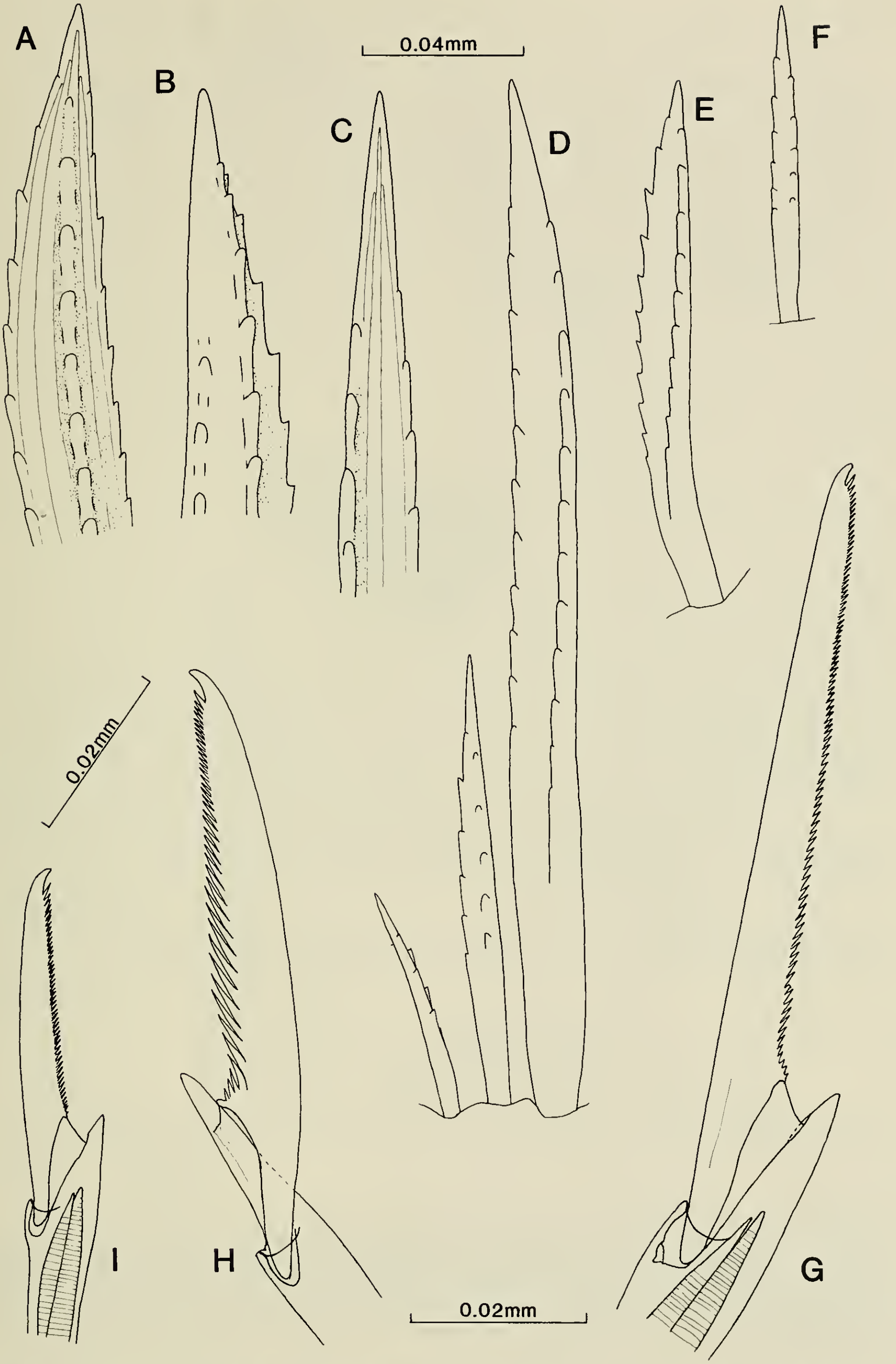

Fig. 6. *Chrysopetalum elegans,* middle segments of syntypes: A, Tip of palea, midline group; B, Same, turned; C, Tip of palea, lateral group; D, Smaller paleae and adjacent spine, lateral group of right notopodium; E, Palea, anterior group, near midline; F, Same, slightly more lateral; G, Upper compound falciger; H, Middle compound falciger I, Lower compound falciger (B, complete specimen; remainder, middle fragment).

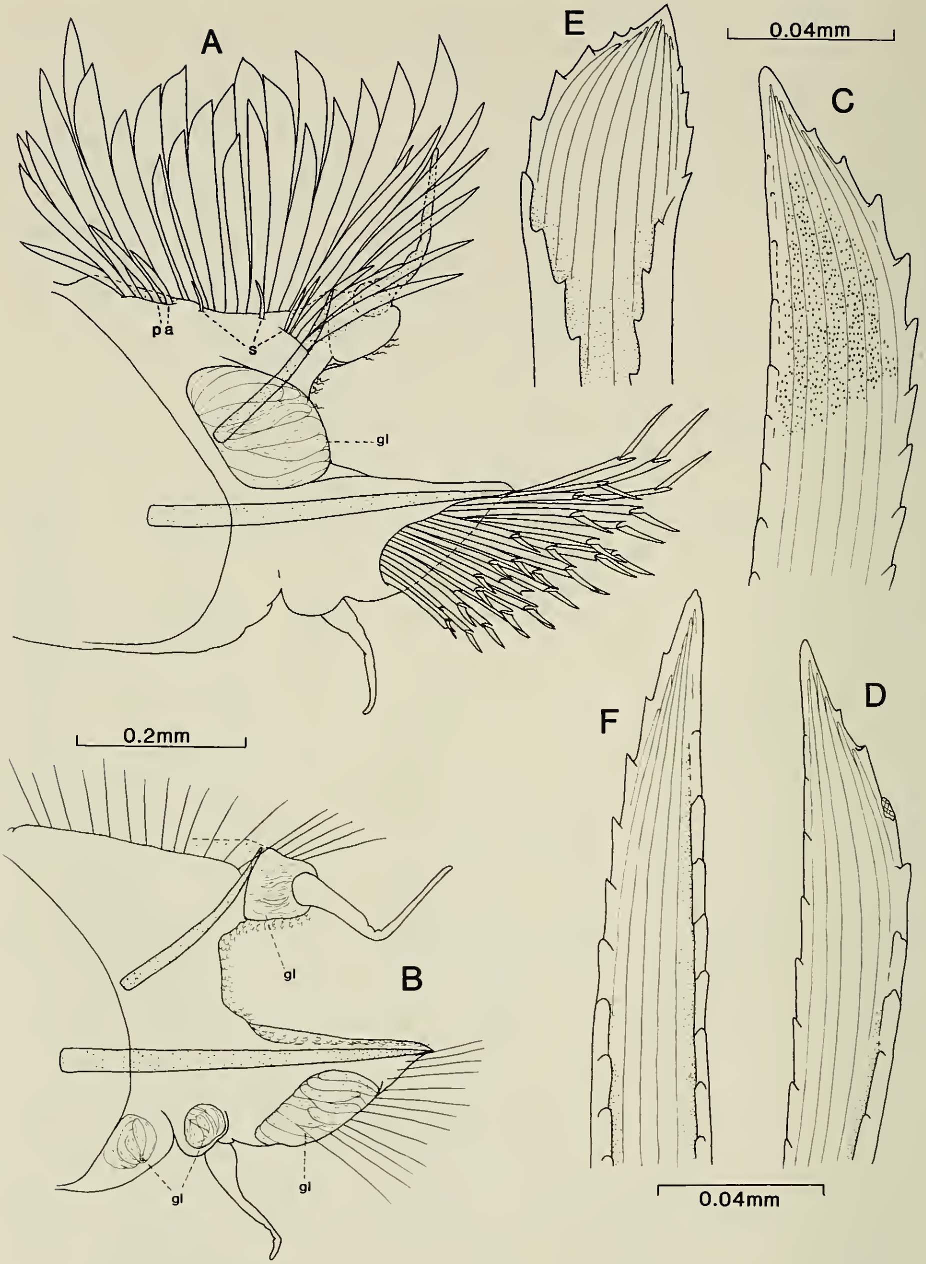

Fig. 7. *Chrysopetalum elegans,* Biscayne Bay, Florida, middle segments (USNM 97348): A, Right parapodium, anterior view; B, Same, left side, posterior view, tips of setae omitted; C, Palea, middle group, from near lateral part; D, Same, small, from lateral part; E, Same, from central part; F, Same, from medial part.

mane and E. Schulz, 18–29 Mar 1956, holotype (ZMH P-14048), 6 paratypes (ZMH P-18231), paratype (USNM 97349), 7 segments (FSBC I 31374).

*Description.*—Holotype complete, 23 segments, 1.8 mm long; paratypes incomplete, fragmented, largest probably less than 5 mm long, 0.9 mm wide excluding setae, probably with fewer than 40 segments. Prostomium about as wide as long, with anterior ⅓ turned ventrally and facing anteriorly (Fig. 8B, D); eyes in rectangular arrangement, anterior ones larger, separated from each other; median antenna short, pyriform; lateral antennae perhaps extending farther than palps and shorter than cirri of segments 1 and 2; palps (Fig. 8A, C, E) attached anteroventrally on prostomium below lateral antennae, twice longer than wide. Mouth cover extending from anterior part of segment 4, semicircular when proboscis inverted. Caruncle nearly as wide as prostomium, with cilia visible around margin. Notosetae consisting of paleae and spines (Figs. 9A, D, 10A–E); tips of paleae hooded, bifid; dorsal surface moderately to strongly knobbed; middle group paleae of middle segments numbering up to 25, longer symmetrical ones in center of group with obtuse tips; midline group paleae numbering 4 or 5, without denticulate, surface midrib; lateral group paleae numbering 6–9, all slender, diminishing to spine anteromedially. Anterior group notosetae consisting of about 2 spines near lateral group and single 2-ribbed palea near midline group. Blades of upper few compound falcigers (Fig. 10G) relatively short, not distinctly longer than adjacent ones and only about twice longer than lowest ones; blades gradually shorter ventrally (Fig. 10H, I); serrations on upper blades short, with distal one extending to near tip; several blades in middle of bundle with moderately long serrations, with distal serration removed from tip; remainder with similar tips and short serrations. Interramal regions of middle parapodia ciliate on anterior side, without glands containing spindles of fibers (Fig. 9B, C); spindles of fibers possibly produced in notopodium proximal to dorsal cirrophore.

*Remarks.*—*Chrysopetalum remanei* differs from other species of the genus in having paleae with bifid tips and paleae of the midline group without a denticulate, surface midrib.

*Etymology.*—The species is named in honor of the late Adolf Remane, former Director of the Zoological Institute of the University of Kiel, who collected the specimens.

### *Chrysopetalum hernancortezae,* new species
Figs. 11–13

*Chrysopetalum occidentale.*—Gathof, 1984:24-6, figs. 26-1, 26-2a–c [not Johnson, 1897].

*Material examined.*—FLORIDA (Gulf of Mexico): off Dunedin, Pinellas County, EGMEX 70, Sta 22, 28°04′N, 84°41′W, 77 m, R/V *Hernan Cortez,* colls. J. Williams et al., May 1970, 8 paratypes (USNM 97354).—Hourglass Sta C, 38 nmi W of Egmont Key, 27°37′N, 83°28′W, 37 m, 1 specimen (FSBC I 31327).—Same, Sta D, 65 nmi W of Egmont Key, 27°37′N, 83°58′W, 55 m, 9 paratypes (USNM 97351; FSBC I 31328), 66 specimens (FSBC I 31329–31345).—Same, Sta E, 78 nmi W of Egmont Key, 27°37′N, 83°13′W, 73 m, holotype (USNM 97350), 3 paratypes (USNM 97353; FSBC I 31346), 10 specimens (FSBC I 31347–31353).—Same, Sta K, 51 nmi W of Sanibel Is. Light, 26°24′N, 82°58′W, 37 m,

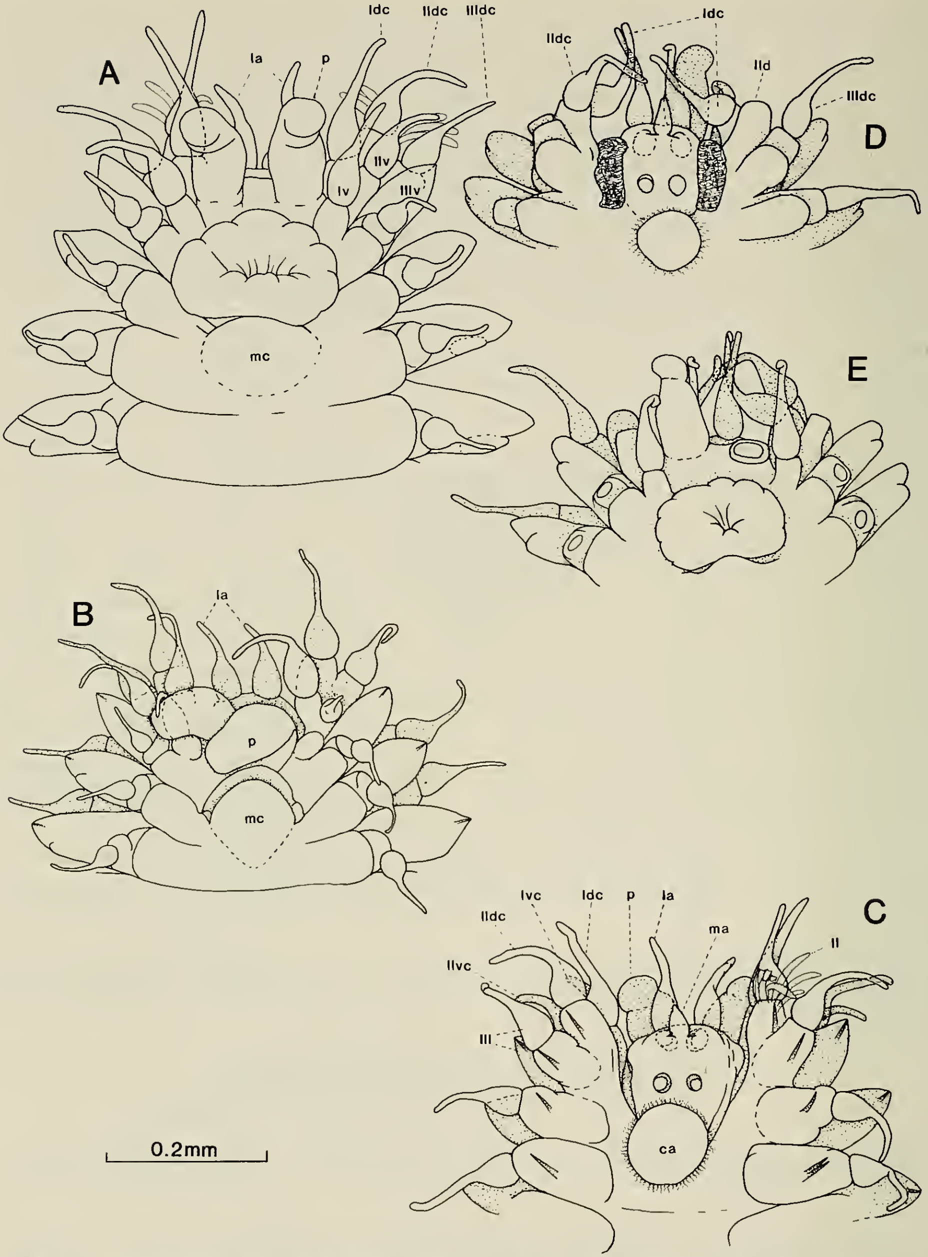

Fig. 8. *Chrysopetalum remanei,* anterior ends: A, B, E, Ventral views; C, D, Dorsal views (A, C, paratype, B, holotype, ZMH; D, E, paratype, USNM).

2 specimens (FSBC I 31354, 31355).—Same, Sta L, 73 nmi W of Sanibel Is. Light, 26°24′N, 83°22′W, 55 m, 109 specimens (FSBC I 31356–31367, 31369, 31370).—Same Sta M, 92 nmi W of Sanibel Is. Light, 26°24′N, 83°43′W, 73 m, 4 paratypes (USNM 97352; FSBC I 31371).—About 80 mi W of Fort Myers Beach, 52.5–54

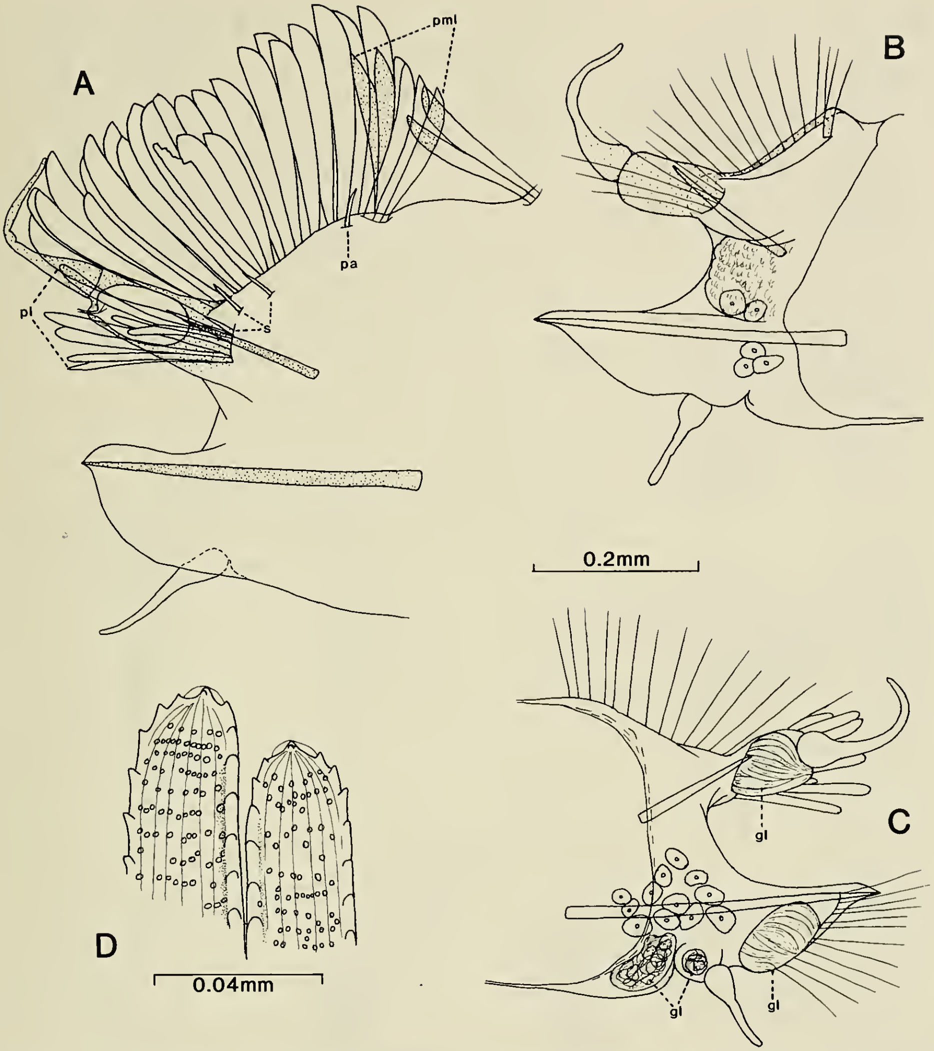

Fig. 9. *Chrysopetalum remanei,* middle segments (FSBC I 31375): A, Left parapodium, anterior view; B, Same, tips of paleae omitted; C, Same, posterior view; D, Tips of paleae from near center of middle group.

m, 1 specimen (FSBC I 31373).—MAFLA Sta 2958, 25°40′N, 83°50′W, 120 m, Nov 1977, 1 specimen (USNM 75181).—SOFLA Sta 4, 26°45′49″N, 83°32′07″W, 56 m, Jul 1981, 3 specimens (USNM 90632).—Same, Sta 28, 24°47′07″N, 83°13′05″W, 58 m, Aug 1981, 1 young, 1 segment (USNM 90633). FLORIDA (Atlantic): On *Oculina,* ENE of Fort Pierce, Jeffs Reef, 27°32.8′N, 79°58.8′W, 80 m (Site A of Reed, 1980, fig. 1), 19 specimens (USNM 97355, 97356; FSBC I 31374; IRCZM 50:993–996).

*Description.*—Holotype 8 mm long, 46 segments; largest specimen about 10 mm long, 1.2 mm wide excluding setae, 48 segments. Prostomium (Fig. 11A) as wide as long, anterior half turned ventrally with anterior eyes facing anteriorly;

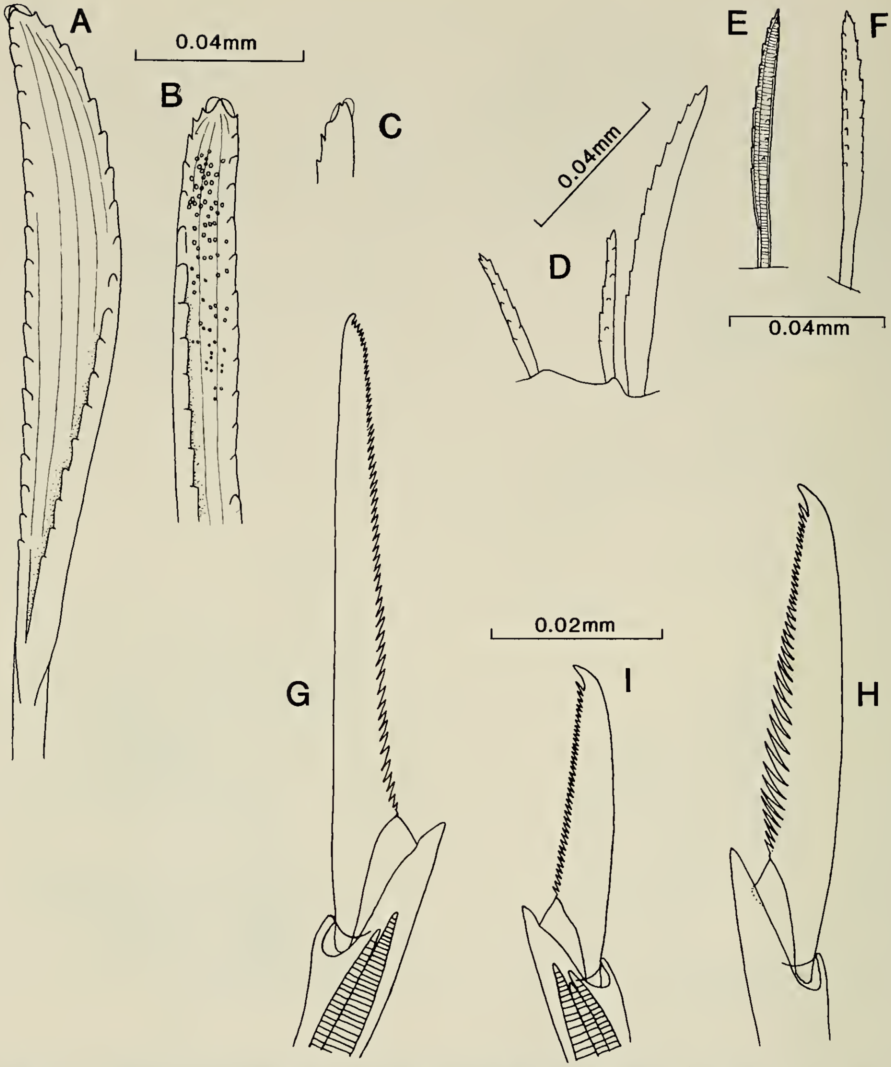

Fig. 10. *Chrysopetalum remanei,* setae from middle segments (FSBC I 31375): A, Palea, midline group; B, Palea, lateral group, showing surface knobs; C, Same, turned, showing hood and bifid tip; D, Smallest palea and spine, lateral group, and adjacent spine of anterior group, right notopodium; E, Slender palea, anterior group, showing internal structure; F, Same, internal structure omitted; G, Upper compound falciger; H, Middle compound falciger; I, Lower compound falciger.

eyes in rectangular arrangement, anterior ones larger than posterior ones, appressed, round or slightly oval; median antenna pyriform; lateral antennae similar to dorsal cirri; palps (Fig. 11B, C) attached at about middle of ventral surface of prostomium, appearing near anterior margin on contraction, 2–3 times longer than wide. Mouth cover extending from anterior margin of segment 5, semicircular, triangular when proboscis inverted. Caruncle slightly flattened, with long, dense ciliation around lateral and posterior margins. Notosetae consisting of paleae and spines (Figs. 11D–F, 12A–J); tips of paleae entire, without trace of hood; dorsal surface lightly to moderately knobbed. Middle group paleae of middle

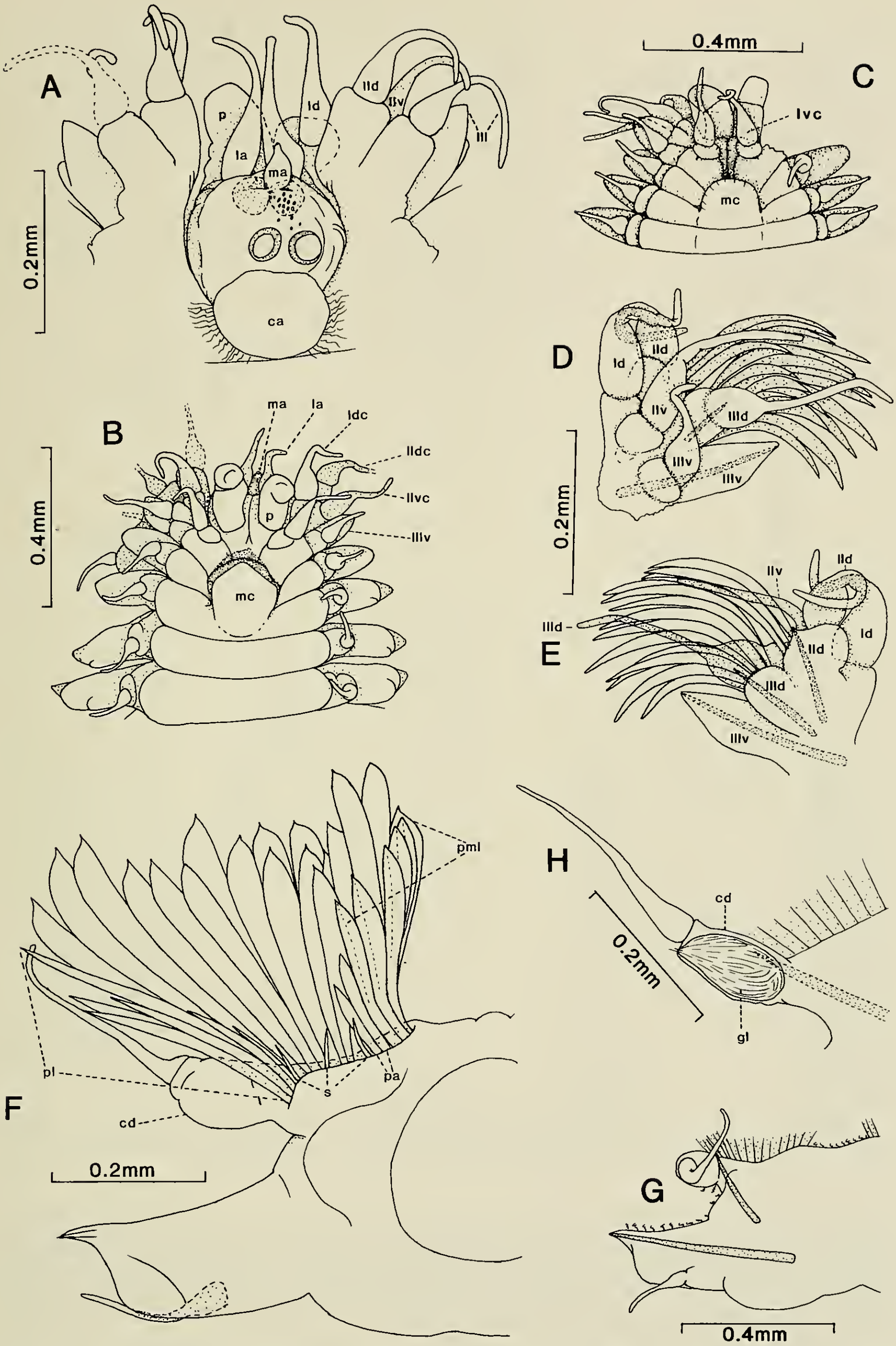

Fig. 11. *Chrysopetalum hernancortezae*: A, Anterior end, dorsal view; B, Same, ventral view; C, Same, left parts of first 3 segments removed, except for ventral cirrus of segment 1; D, Anterior 3 segments, left side, removed from C above, slightly turned ventral view; E, Same, dorsal view; F, Left parapodium, middle segment, anterior view; G, Same, right side, posterior view, tips of paleae omitted; H, Tip of right notopodium with dorsal cirrus, posterior view (A, C–G, USNM 97354; B, USNM 97351; H, IRCZM 50:993).

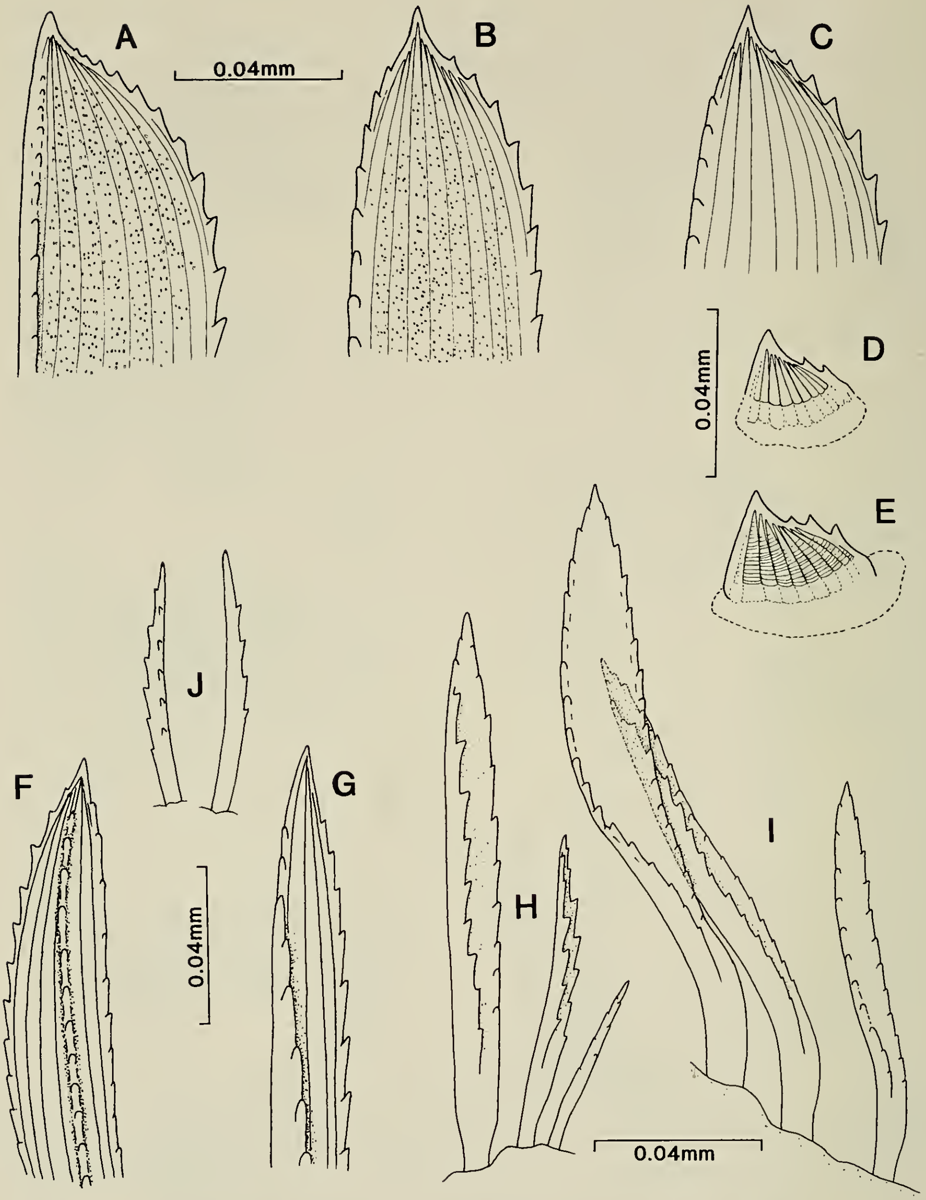

Fig. 12. *Chrysopetalum hernancortezae,* notosetae, middle segments: A, Tip of palea, from lateral part of middle group; B, C, Same, from central part; D, E, Newly forming paleae, posterior side of middle group; F, Palea, midline group; G, Palea, lateral group; H, Small paleae and spine, lateral group, left notopodium; I, Paleae, anterior group, right notopodium, large one near midline paleae; J, Spines, anterior group (A, D, E, H, FSBC I 31328; B, C, F, G, USNM 97354; I, FSBC I 31329).

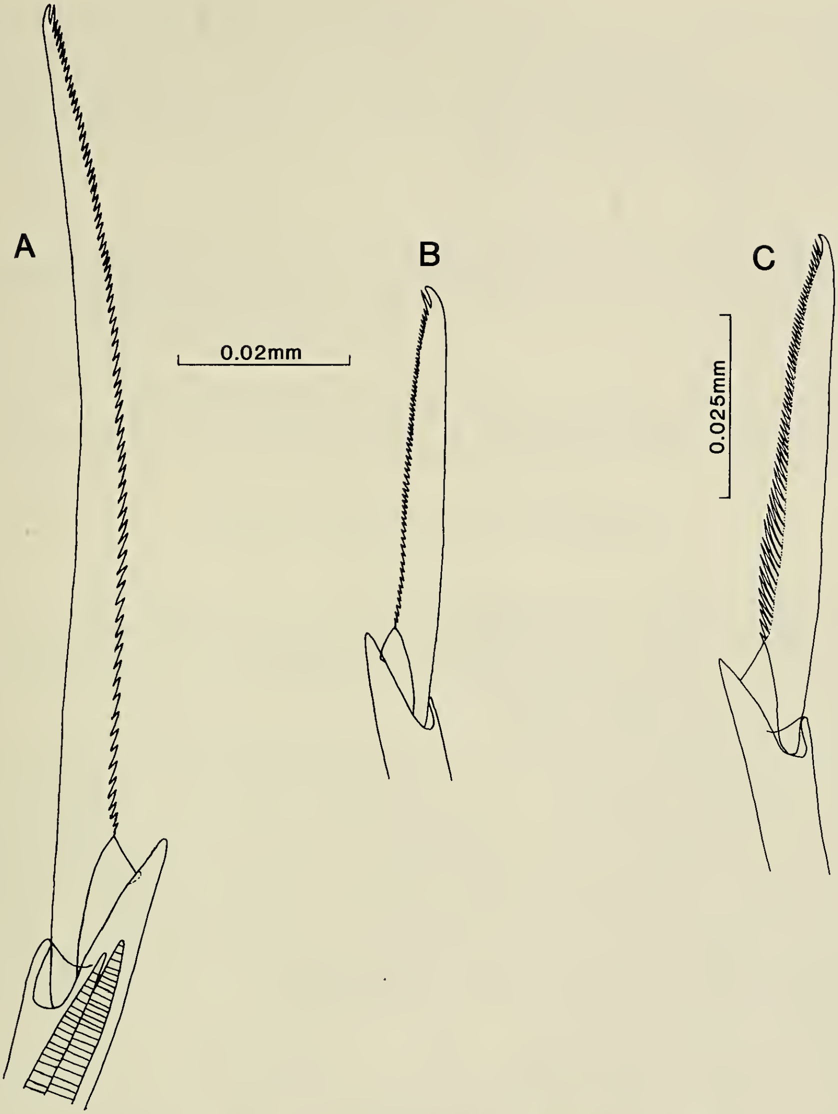

Fig. 13. *Chrysopetalum hernancortezae,* neurosetae, middle segments: A, Upper compound falciger; B, Lower compound falciger; C, Middle compound falciger (A, B, IRCZM 50:993; C, USNM 97354).

segments numbering 20–31; long, symmetrical ones in center of group with obtuse to acute tips; lateral and medial ones with acute tips; midline group paleae numbering about 6, with denticulate surface midrib; lateral group paleae numbering to about 7, all similar, slender, diminishing to spine anteromedially; anterior group setae consisting of few spines scattered across bundle in front of middle group paleae and 1–3 small, biserrate paleae near but usually slightly separated from triserrate ones of midline group. Blades of compound falcigers of middle segments long (Fig. 13A–C), upper few distinctly longer than adjacent ones, gradually shorter below; serrations on upper blades short, coarse, finer on lower blades, long, fine on several blades in middle of bundle; distalmost serration of all blades long, extending about to tips. Interramal regions of middle parapodia (Fig. 11G) without glands containing spindles of fibers; gland in cirrophore of dorsal cirri as figured (Fig. 11H).

*Remarks.*—*Chrysopetalum hernancortezae* is similar to *C. elegans* Bush in having paleae without hoods or hood remnants. Paleae of *C. hernancortezae* are not as slender nor as pointed as those of *C. elegans,* and the large interramal glands containing spindles of fibers present in *C. elegans* do not occur in *C. hernancortezae.*

*Etymology.*—The species is named for the Florida Department of Natural Resources Research Vessel *Hernan Cortez,* used for collecting most of the specimens. The *Hernan Cortez* was retired in 1983 after almost 20 years of reliable service.

### *Chrysopetalum heteropalea,* new species
Figs. 14, 15

*Material examined.*—FLORIDA (Gulf of Mexico): Hourglass Sta K, 51 nmi W of Sanibel Is. Light, 26°24′N, 82°58′W, 37 m, holotype (USNM 97357). FLORIDA (Atlantic): Dade County, S. Biscayne Bay, DERM Sta 16, Ragged Keys, at edge of channel between 2 Keys, 25°32′01″N, 80°10′17″W, 2–3 m, scoured hard bottom, paratype (USNM 97358).

*Description.*—Holotype anterior fragment 1.08 mm long, 0.47 mm wide without setae, 15 segments; paratype anterior and middle fragments, 1.2 mm long, 0.2 mm wide, 16 segments. Prostomium (Fig. 14A, C) wider than long, anterior margin partly turned ventrally and facing anterodorsally; eyes in rectangular arrangement, anterior ones only slightly larger than posterior ones and well separated from each other; median antenna slender, fusiform; lateral antennae attached on anterior margin just above origins of palps; palps about twice longer than wide. Caruncle rounded, cilia on margin not observed. Mouth covering (Fig. 14B) semioval, extending from anterior margin of segment 5. Notosetae only paleae (Figs. 14D, 15A–G), with tips hooded, entire; dorsal surface ornamented with numerous irregular, transverse ridges; ridges about half as numerous as internal cross-ribs; middle group paleae of middle segments about 22, longer symmetrical ones in center of group with obtuse tips, with 8 longitudinal ribs, lateral and medial ones with pointed tips hardly exceeding convex margins; midline group paleae about 5, with denticulate surface midrib; lateral group paleae consisting of 2 longer, broader, symmetrically and acutely tipped ones originating medially (nearest aciculum) and 2 more slender, shorter ones originating laterally. No anterior group notosetae. Blades of compound falcigers relatively short (Fig. 14F–I), upper few not distinctly longer than adjacent ones, gradually shorter below; 1–2 lowest blades very slender; serrations on upper blades short, coarse; long, stout on several blades in middle of bundle; fine, moderately long on blades near lower part of bundle; very fine, short on lowest 1–2 blades. Interramal region of middle parapodia ciliate on anterior side, without glands containing spindles of fibers (Fig. 14E).

*Remarks.*—*Chrysopetalum heteropalea* differs from other species of the genus

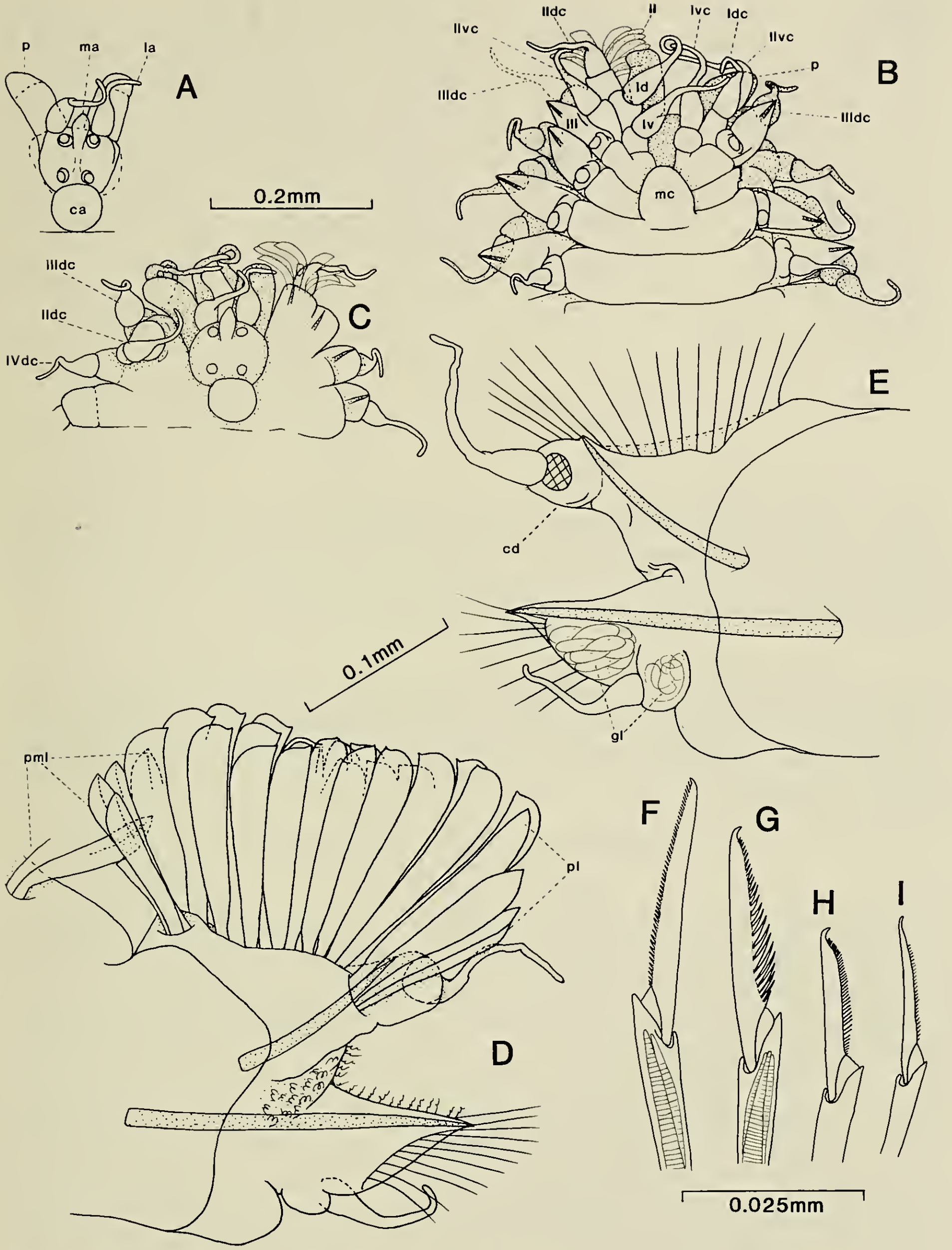

Fig. 14. *Chrysopetalum heteropalea,* holotype: A, Prostomium, dorsal view; B, Anterior end, ventral view; C, Same, dorsal view; D, Right parapodium, middle segment, anterior view; E, Same, posterior view, tips of setae omitted; F, Upper compound falciger; G, Middle compound falciger; H, Lower compound falciger; I, Lowest compound falciger.

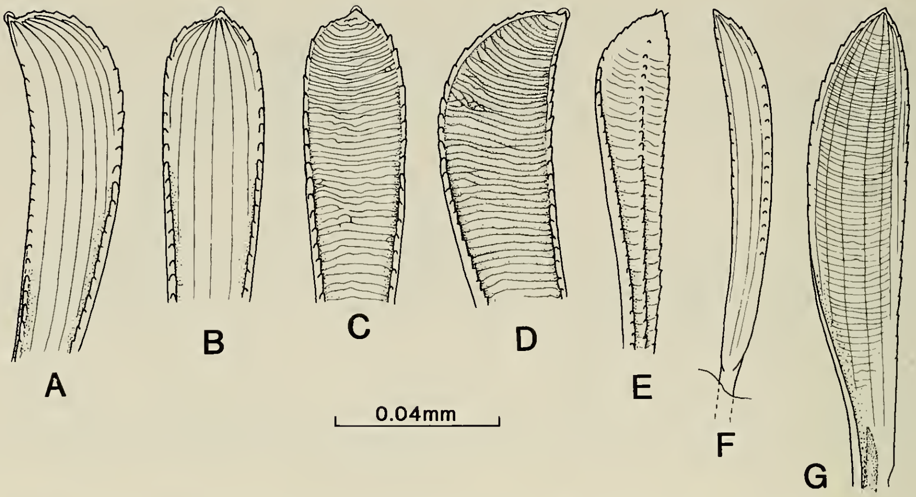

Fig. 15. *Chrysopetalum heteropalea,* notosetae, middle segments, holotype: A, Lateral palea, middle group of right notopodium; B, Same, central palea; C, Same, showing surface ornamentation; D, Same, from near midline; E, Palea, midline group, showing remnants of hood on tip; F, Small palea, lateral group; G, Large palea, lateral group, showing tip of aciculum at base.

by having palea ornamented with transverse ridges rather than knobs and by lacking spines or paleae in an anterior group on notopodia of middle segments.

*Etymology.*—The specific name is derived from the Greek *heteros,* different, and the Latin *palea,* scale, and refers to the unique paleae of the species.

### *Chrysopetalum floridanum,* new species
Figs. 16, 17, 18A–C

*Material examined.*—FLORIDA (Atlantic): Palm Beach-Broward County line S of Boca Raton, on *Phragmatopoma,* 1.3 m, 5 specimens (FSBC I 31377; H. Rudolph).—Dade County, S Biscayne Bay, DERM Sta 16, Ragged Keys, near channel between 2 Keys, 25°32′01″N, 80°10′17″W, scoured hard bottom, 2–3 m, holotype (USNM 97359), 16 paratypes (USNM 97360, 97361; AHF Poly 1433, ZMH P-18227; FSBC I 31378), 8 specimens (DERM).—Same, Sta 20, SW of Soldier Key, attached algae including *Halimeda,* 25°34′13″N, 80°11′27″W, 9 specimens (DERM).—Same, Sta 23, SW of Cape Florida, 25°37′56″N, 80°13′23″W, 3–4 m, *Thalassia,* 1 paratype (YPM), 1 specimen (DERM).—Same, Sta 24, SW of Cape Florida at W edge of shoal in Biscayne Flats-Safety Valve area, 25°38′37″N, 80°11′27″W, 2 paratypes (ZMC).—Same, N Biscayne Bay, Sta 47, middle of Julia Tuttle Causeway-79th Street Causeway Basin, 25°49′32″N, 80°09′25″W, 1 m, thick *Halimeda* with *Syringodium,* 1 paratype (BMNH ZB 1984.59).—Florida Keys (Monroe County): exact location and depth unknown, colls. DER personnel, 1 specimen (FSBC I 31379).—Looe Key National Marine Sanctuary, reef crest, coralline covered rubble, less than 1 m, Sta FLK-2, 1 specimen (USNM 95727).—Same, clumps of *Halimeda,* Sta FLK-6, 2 specimens (USNM 97528).—Same, at base of upper spur and groove buttress, coral rubble, 6+ m, Sta FLK-25, 1

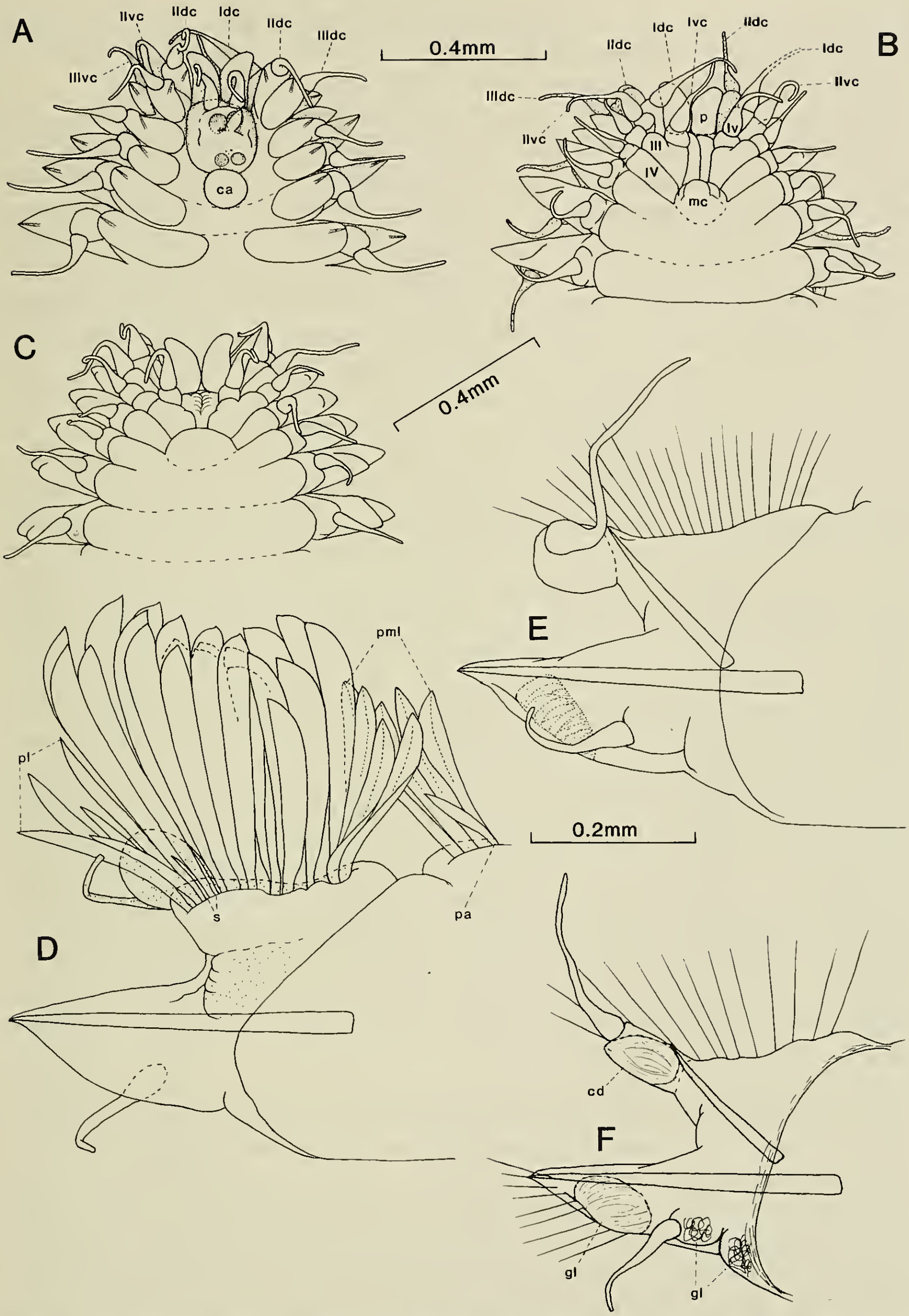

Fig. 16. *Chrysopetalum floridanum*: A, Anterior end, dorsal view; B, C, Same, ventral view; D, Left parapodium, and midline and anterior group paleae of right side middle segment, anterior view; E, F, Same, right side, posterior view, tips of paleae omitted (A, B, holotype; C, USNM 97360; D, E, USNM 97361; F, FSBC I 31377).

specimen (USNM 97529). BAHAMA ISLANDS: Hydro-Lab, 1.2 nmi off Bell Channel, Lucaya, Grand Bahama Is., 26°33'N, 78°34'W, 15–30 m, colls. M. Wells et al., 3–15 Apr 1974, 1 specimen (FSBC I 31380).

*Description.*—Holotype consisting of anterior fragment 7 mm long, 1 mm wide without setae, 35 segments; largest specimen (BMNH ZB 1984.59) consisting of anterior and middle fragments perhaps 10 mm long, 1.3 mm wide, 48 segments; largest complete specimen (FSBC I 31378) immature, 5.5–6 mm long, 40 segments, parallel-sided after first few segments, tapered near posterior end. Prostomium (Fig. 16A) turned anteriorly only slightly or to about 45° angle, anterior eyes at least partly visible near anterior end, facing dorsally or anterodorsally, circular, touching only at middle, appearing separated; surface of prostomium rarely infolded and anterior eyes tending to appear oval and closely appressed; posterior eyes near posterior margin, circular; median antenna originating dorsally or near anterior margin, directed dorsally or anterodorsally; lateral antennae usually completely visible in dorsal view; caruncle covering only small part of posterior end of prostomium; palps originating ventrally near anterior margin of prostomium (Fig. 16B, C). Notosetae consisting of paleae and spines (Figs. 16D, 17A–I, 18A–C). Tips of paleae entire, with remnants of hoods on middle group, dorsal surface moderately to strongly knobbed. Middle group paleae of middle segments (Figs. 16D, 17A–C, 18A–C) 25–33; longer symmetrical ones in middle of group with obtuse tips and 8–10 internal ribs; anterior (older) paleae much shorter than posterior (later formed) paleae. Midline group paleae (Figs. 16D, 17D) about 5, with denticulate surface midrib, without remnant of hood on tip. Lateral group paleae (Fig. 17E, F) about 8, slender, decreasing to spine anteromedially. Full complement of anterior group notosetae (Figs. 16D, 17G–I) consisting of 2 spines equally spaced near lateral group spine and directed somewhat medially with respect to middle paleae, 1 more medial spine directed somewhat laterally, and 1 slender and 1 broader and longer, biserrate palea near midline group paleae; various forms often absent and full complement seldom present. Blades of compound falcigers (Fig. 17J–L) moderately long, upper few distinctly longer than adjacent ones, gradually shorter below, each with distal serration long, extending to near falcate tip. Interramal regions on anterior side of parapodia ciliate, without glands containing spindles of fibers (Fig. 16D); other parapodial glands as figured (Fig. 16E, F).

*Remarks.*—*Chrysopetalum floridanum* is very similar to *C. occidentale* from southern California to Panama. The prostomium of mature *C. occidentale* is turned forward so that the anterior eyes face anteriorly, possibly slightly ventrally, and the median antenna is directed anteriorly. Anterior eyes of *C. occidentale* are oval, closely appressed and visible from the dorsum only through the anterior part of the prostomium. Distal serrations of blades of falcigers of *C. occidentale* do not extend to near falcate tips. On mature specimens of *C. floridanum,* the prostomium is usually dorsally directed with both pairs of eyes visible and with the median antenna directed dorsally or anterodorsally. Anterior eyes are circular, although touching, but not closely appressed, except on a specimen on which the prostomium is infolded dorsomedially. Distal serrations of blades of falcigers of *C. floridanum* are long and extend to near falcate tips. The prostomium seems to be turned more forward on a few small, immature specimens of *C. occidentale,*

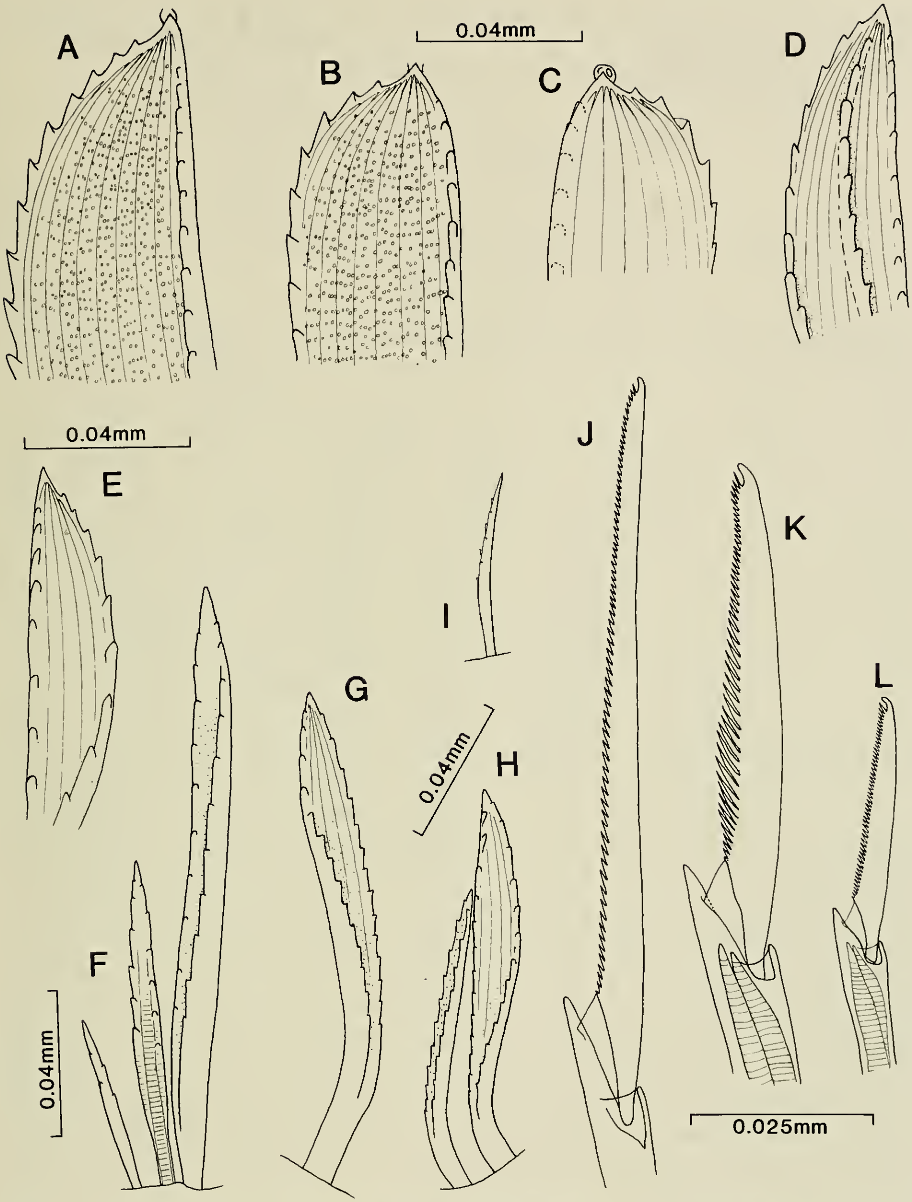

Fig. 17. *Chrysopetalum floridanum,* setae of middle segments: A, Lateral palea of middle group, showing remnants of hood and surface ornamentation; B, Same, central palea; C, Same, newly emerging palea, with entire hood, posterior view; D, Palea, midline group; E, Palea, lateral group; F, Small paleae and spine, lateral group of right notopodium; G. Palea, anterior group, in front of central paleae of middle group; H, Paleae, anterior group, in front of medial paleae of middle group; I, Spine, anterior group; J, Upper compound falciger; K, Middle compound falciger; L, Lower compound falciger (A–C, USNM 97361; D, E, J–L, ZMC; F, G, BMNH ZB 1984.59; H, I, DERM Collection).

so this character should be used with caution. The arrangement of anterior notosetae of middle segments is the same for both species, but various forms of these setae are more often absent on *C. floridanum.*

### *Chrysopetalum eurypalea,* new species

Figs. 18D–I, 19, 20

*Material examined.*—FLORIDA KEYS (Monroe County): Looe Key National Marine Sanctuary, pockets of rubble at base of buttress in spur and groove zone, 6+ m, Sta FLK-15, holotype (USNM 97585).

*Description.*—Holotype mature male, 3.8 mm long, 1.1 mm wide without setae, 27 segments including 4 segments on regenerating posterior end; palea opalescent. Prostomium (Fig. 18D, E) wider than long, anterior margin turned slightly ventrally and facing anterodorsally; eyes in rectangular arrangement, anterior ones larger than posterior ones, circular, touching each other, visible from dorsum below median antenna, directed anterodorsally; posterior eyes at about middle of posterior half of prostomium, separated; median antenna attached dorsally back from anterior margin, directed anterodorsally, pyriform; lateral antennae attached on anterior margin just above origins of palps, completely visible from dorsum; palps about twice longer than wide. Caruncle overlying small part of posterior margin of prostomium. Mouth cover (Fig. 18E) extending from anterior margin of segment 5, semioval. Notosetae consisting of paleae and spines (Figs. 18F–I, 19A, C, D); paleae with tips entire, perhaps with short, persistent hoods, dorsal surface lightly to moderately knobbed. Middle group paleae of middle segments about 24, longer symmetrical ones in center of group relatively broad with almost blunt, obtuse tips, with 12 slender internal longitudinal ribs; long lateral and medial paleae with pointed tips only slightly exceeding convex margins, with 11–12 internal ribs; shorter anterior middle group paleae more slender and pointed, less distinctly ornamented, with fewer internal ribs. Midline group paleae (Fig. 20C) about 6, with surface midribs. Lateral group paleae (Fig. 20D) about 6, slender, decreasing to spine anteromedially, with remnants of hoods. Anterior group notosetae (Figs. 19A, 20E–G) consisting of 2 spines and single slender biserrate palea near medial palea of middle group. Blades of compound falcigers of middle segments (Fig. 20H–K) of moderate length, upper few distinctly longer than adjacent ones, gradually shorter below, each with distal serration extending to near falcate tip; upper few with short, stout serrations; some middle ones with moderately long serrations, others shorter; lower ones with short, fine serrations. Interramal region of middle parapodia (Fig. 19A, B) ciliate, without gland containing spindles of fibers.

*Remarks.*—*Chrysopetalum eurypalea* differs from the other *Chrysopetalum* species with knobbed paleae in having relatively broader and more bluntly-tipped middle group paleae, with the longer, posterior ones having more internal ribs. Internal ribs of longer palea of *C. eurypalea* are relatively narrow and number 11–12 near the tips (Fig. 18F–I). Such paleae on most other species are relatively more slender with usually broader ribs numbering up to 10 near the tips. Long middle group palea of *C. eurypalea* are shaped like those of *C. heteropalea,* but have a different type of surface ornamentation.

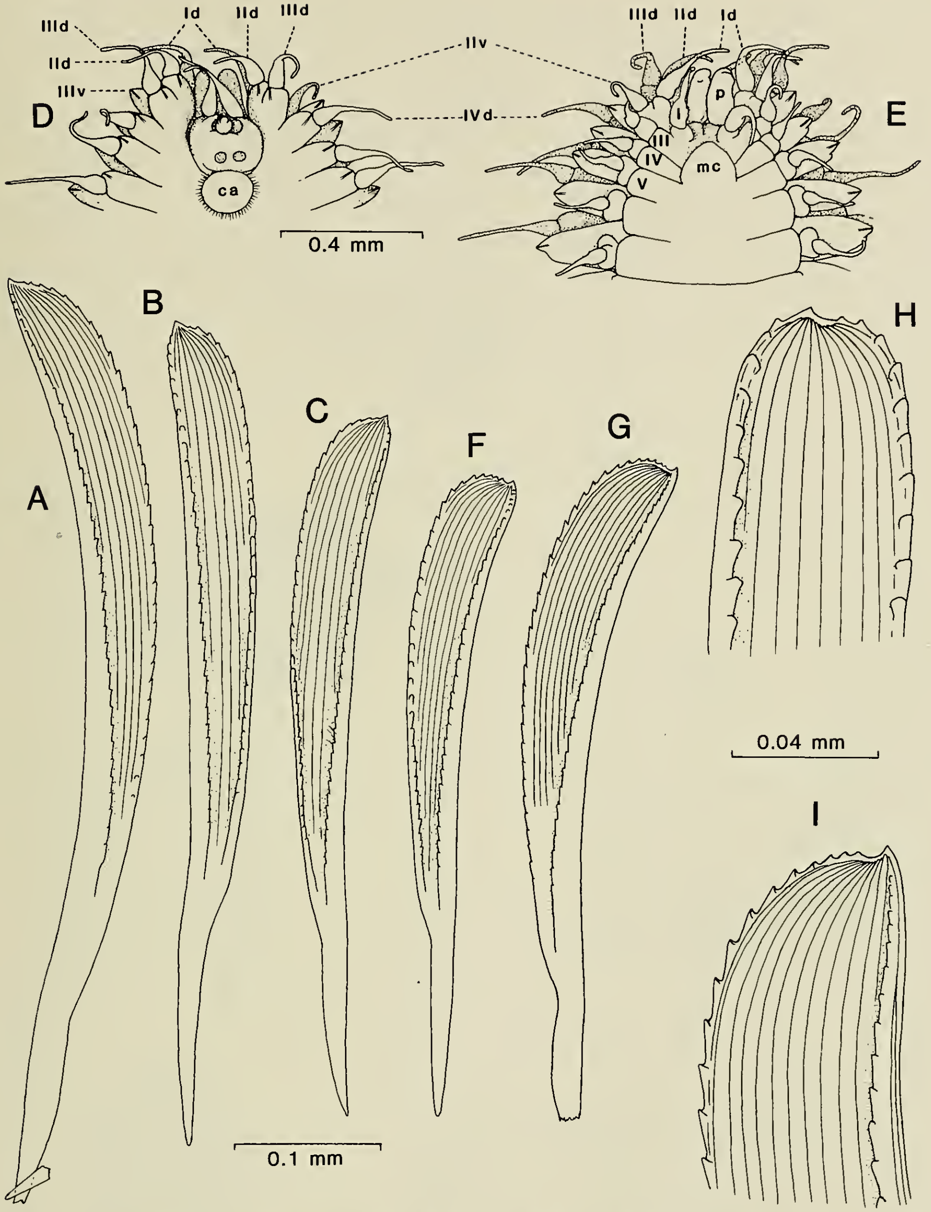

Fig. 18. *Chrysopetalum floridanum,* long, broad middle group paleae of middle segments; A, From lateral part; B, C, From central part (A, B, BMNH ZB 1984.59; C, From holotype lot, USNM 97359–97360). *Chrysopetalum eurypalea,* holotype: D, Anterior end, dorsal view; E, Same, ventral view; F, Central, long, posterior middle group palea, segment 17; G, Same, from lateral part; H, Tip of central, long, broad middle group palea, segment 18; I, Same, from lateral part.

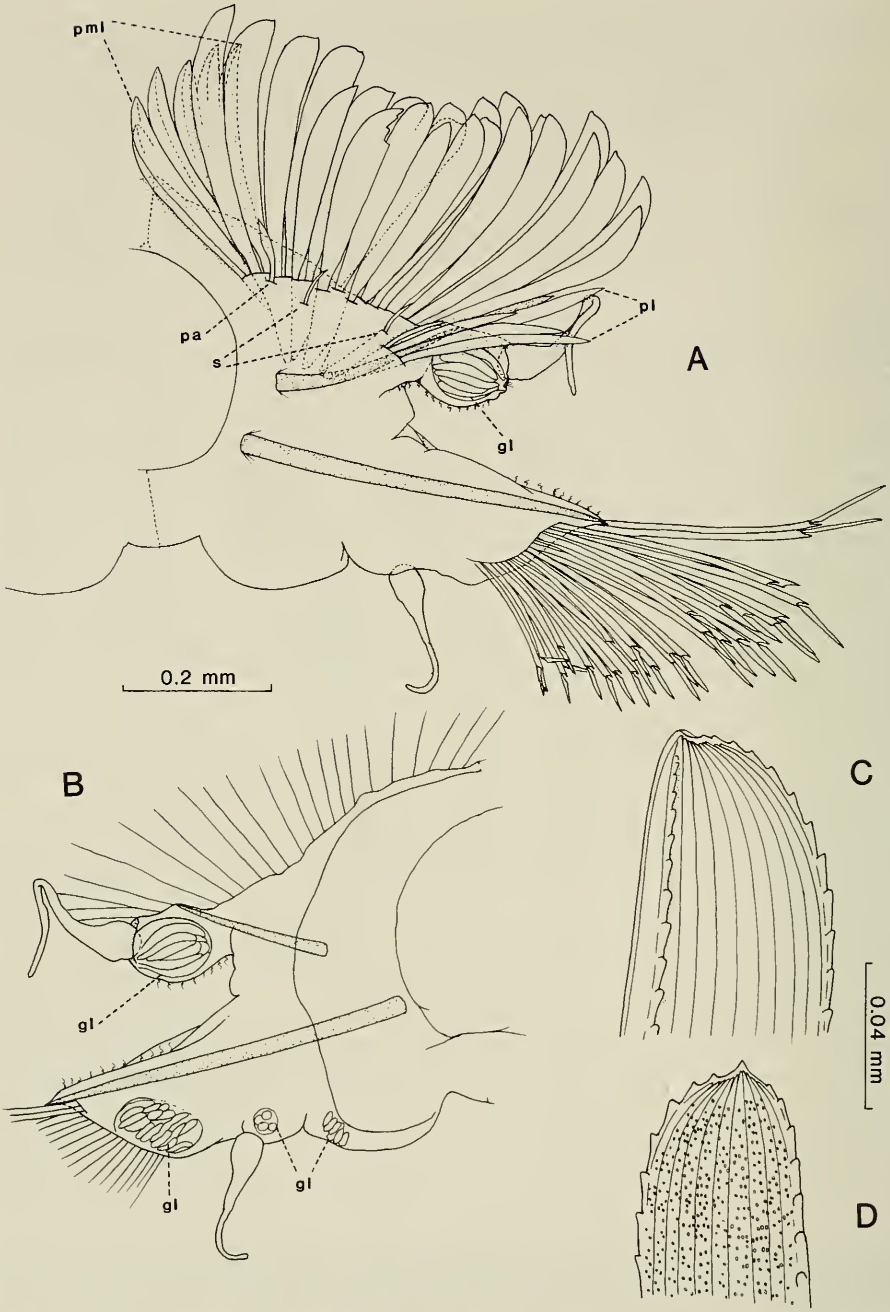

Fig. 19. *Chrysopetalum eurypalea,* segments 17 and 18 of holotype: A, Parapodium, right side, anterior view; B, Same, posterior view, tips of setae omitted; C, Tip of medial, long, broad, middle group palea; D, Tip of central anterior middle group palea.

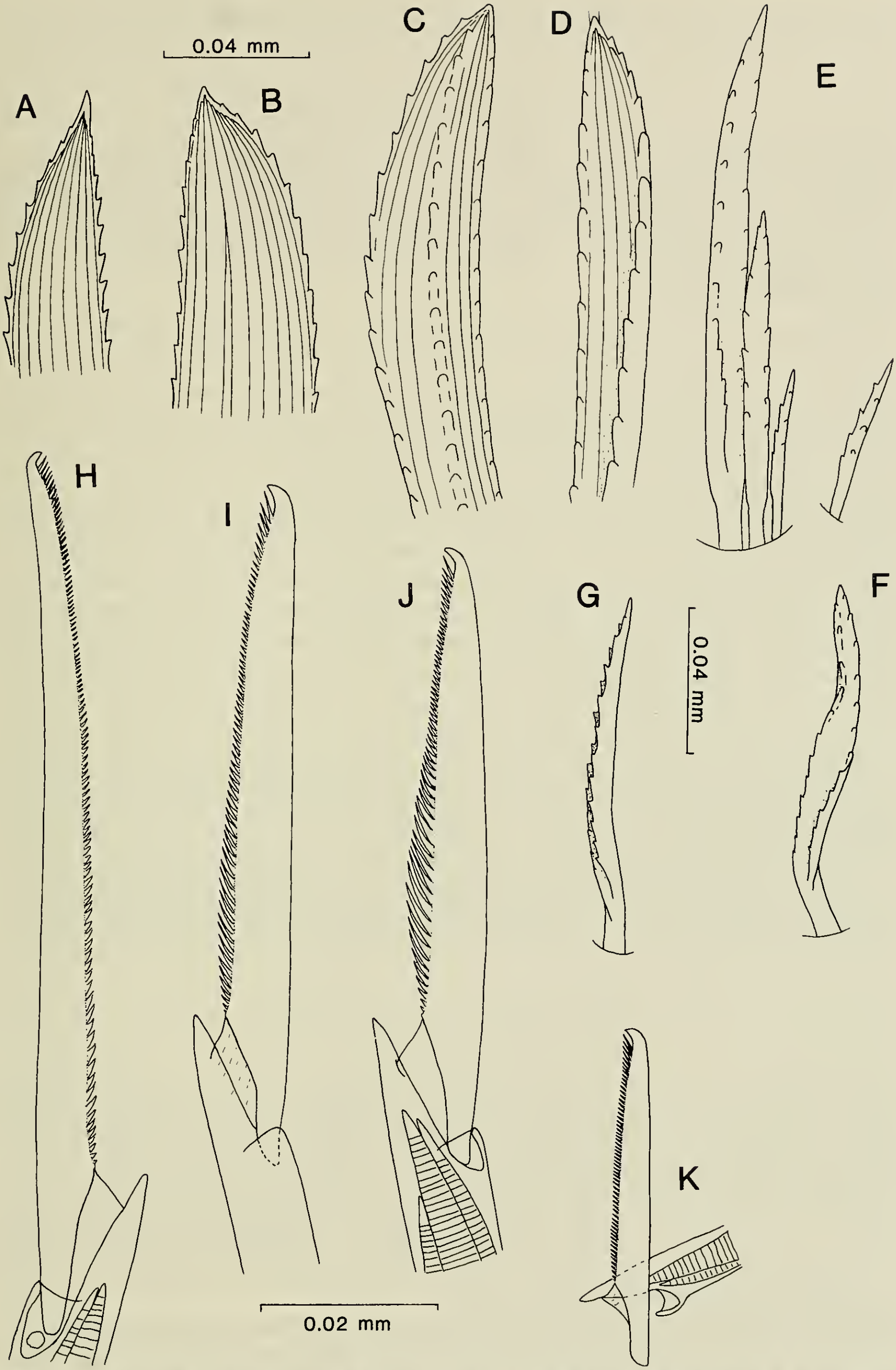

Fig. 20. *Chrysopetalum eurypalea,* segments 17 and 18 of holotype: A, Slender, anterior middle group palea, from extreme lateral part; B, Same, from near medial part; C, Midline group palea; D, Lateral group palea; E, Small lateral group paleae and spine, and adjacent anterior group spine, left notopodium; F, G, Anterior group paleae; H, Upper compound falciger; I, J, Middle compound falciger; K, Lower compound falciger.

*Etymology.*—The specific name is derived from the Greek *eurys,* broad, and the Latin *palea,* scale, and refers to the shape of middle group paleae of the species.

### *Bhawania* Schmarda, 1861

*Bhawania* Schmarda, 1861:164.–Ehlers, 1864:80.—Quatrefages, 1866a:297, 298.—Horst, 1917:136, 137.—Augener, 1918:98–103.—Fauvel, 1932:42; 1936a:16; 1953a:79.—not Jorge, 1953:103.—Rullier, 1964:142.—not Katzmann, Laubier, and Ramos, 1974:313–317.—Day, 1967:117, 118.—Fauchald 1977a:72.
*Psectra* Grube, 1868:51.

*Type-species.—Bhawania myrialepis* Schmarda, 1861; by monotypy.

*Diagnosis.*—Body long, slender. Prostomium retractile within anterior segments, apparently fused laterally with anterior segments; eyes 2 pairs; antennae similar, median antenna originating in front of eyes; caruncle absent; palps oval; mouth opening broad, on anterior margin of segment 3 or 4. Segments 1 and 2 with 3 pairs of cirri. Parapodia biramous, beginning on segment 2; each with very broad notopodial lobe extending laterally about as far as neuropodial lobe, 3 groups of notopodial paleae, compound neuropodial spinigers on anterior few segments, changing to spinigers above and falcigers below on middle and posterior segments. Notopodia with dorsal cirri retractile into cirrophore. Neuropodia with ventral cirri on short cirrophores below setae, similar to dorsal cirri. Paleae slender on segment 2–3, typically beginning on segments 3–5, usually completely covering dorsum, forming smooth surface, extending from bundles occupying greater than ⅔ segmental width. Middle group paleae (pm) of middle segments produced separately, forming single, imbricated row; paleae broad, similar, symmetrically tipped, with 20–25 internal ribs, cross-bars not extending completely to tip, dorsal surface including lateral margins ornamented with 5 or more raised, denticulate ribs. Lateral group paleae (pl) short, slender, thin, pointed. Midline group paleae (pml) thin, paddle-shaped, in longitudinal row diminishing anteriorly, usually overlain by medial paleae of middle group. Pygidium bulbous, with 3 anal cirri.

*Remarks.*—*Chrysopetalum riveti* Gravier, 1908 (Gravier, 1909:638–641, pl. 17, figs. 31–34), from Peru and Panama, referred to *Bhawania* by Augener (1913:79), and *Paleanotus purpurea* Rioja, 1947, from Baja California, may form a different generic group. The two species have notopodia and paleae resembling those of typical *Bhawania* species. However, paleae apparently do not cover the dorsum on the anterior end; there are three types of neurosetae consisting of an upper group of spinigers, a middle group of stout falcigers and a lower group of much more slender falcigers; and the prostomium apparently resembles that of *Paleanotus* (Rioja, 1947). Similar neurosetae have been described on specimens of *Bhawania* from Indo-West Pacific areas (*Bhawania cryptocephala pottsiana* Horst, 1917; *B. cryptocephala.*—Fauvel, 1932, not Gravier, 1901; *B. goodei.*—Imajima and Hartman, 1964, not Webster, 1884).

*Bhawania multisetosa* Hartmann-Schröder, 1981, from Australia, appears to be similar to *Chrysopetalum* Ehlers in most characters; however, Hartmann-Schröder stated that there were only three pairs of cirri on the first two segments and that the median antenna originated in front of the anterior pair of eyes, characters differeing from those of *Chrysopetalum.* Surface ornamentation of paleae consists of irregular longitudinal ridges with humps or bumps aligned with about 12 internal ribs.

*Bhawania brunnea* Morgado and Amaral, 1981, from Brazil, differs from typical *Bhawania* species in apparently having blades of neurosetae which gradually decrease in length from spinigers above to falcigers below. Morgado and Amaral also described subulate palps for *B. brunnea.* Day (1967, fig. 2.1b, b′) illustrated subulate palps for South African specimens he referred to *B. goodei* Webster, but these may actually be cirri. Schmarda's original figure of a ventral view of the anterior end of *B. myrialepis* (Schmarda, 1861, pl. 37, fig. 324) shows two pairs of appendages which appear to be palps and styles of ventral cirri of segment 1. The "palps" of *B. myrialepis* are similar to the broadly oval ones of the two species examined.

Characters of generic importance include the following: specimen size; number, proportions and surface ornamentation (including the number of surface ribs and the type of ornamentation between them) of the paleae of the three groups; types and detail of neurosetae including the character of change between upper ones and lower ones; color of the paleae; and degree of retractility of the prostomium and dorsal cirri. The darkness of the color of the paleae seems to be related to their thickness. This character and that of the degree of retraction of the prostomium and cirri of preserved specimens should be used with caution. Tips of paleae seem to be fragile and easily damaged, so determination of whether a palea of the middle group comes to a small point on some species might not be certain.

### Key to Floridan species of *Bhawania*

1. Paleae of middle group up to 15, thin, with narrow surface ribs and distinct hyaline tips (Fig. 24A–D); slender lateral group paleae up to 5 (Fig. 24A) ............................................ *B. heteroseta* (Hartman)
– Paleae of middle group up to 26, thick, with broad medial and narrow lateral surface ribs and indistinct hyaline tips (Fig. 21E, F, 22A); slender lateral group paleae up to about 20 (Fig. 21E) .......... *B. goodei* Webster

### *Bhawania goodei* Webster, 1884
Figs. 21, 22

*Bhawania goodei* Webster, 1884:308, 309, pl. 7, figs. 10–15.—Treadwell, 1901: 195.—Augener, 1924:51 [list]; 1927:41, 42.—?Monro, 1933:18, 19.—Carpenter, 1956:99.—Fauvel, 1953b:5.—Rioja, 1959:221, 222.—McCloskey, 1970:24, 25.—Day, 1973:14.—Gardiner, 1976:100, fig. 5 a–e.—Fauchald, 1977b:10 [at least Atlantic specimens].
*Palmyra goodei.*—Treadwell, 1939:199, 200, fig. 29.
*Paleanotus heteroseta.*—Taylor, 1961:61, pl. 1, fig. 2 [not Hartman, 1945].

*Material examined.*—BERMUDA: 3 + syntypes (USNM 4783). FLORIDA (Atlantic): Hutchinson Island Sta 2, 27°21.6′N, 80°13.2′W, 11 m, coarse calcareous sand, 2 specimens (USNM 54225; FSBC I 31265).—Same, Sta 5, 27°22.9′N, 80°13.9′W, 11 m, coarse calcareous sand, fragment (FSBC I 31266).—On *Oculina,* Fort Pierce, off Pepper State Park, 27°29.6′N, 80°17.3′W, 5–7 m, 7 specimens

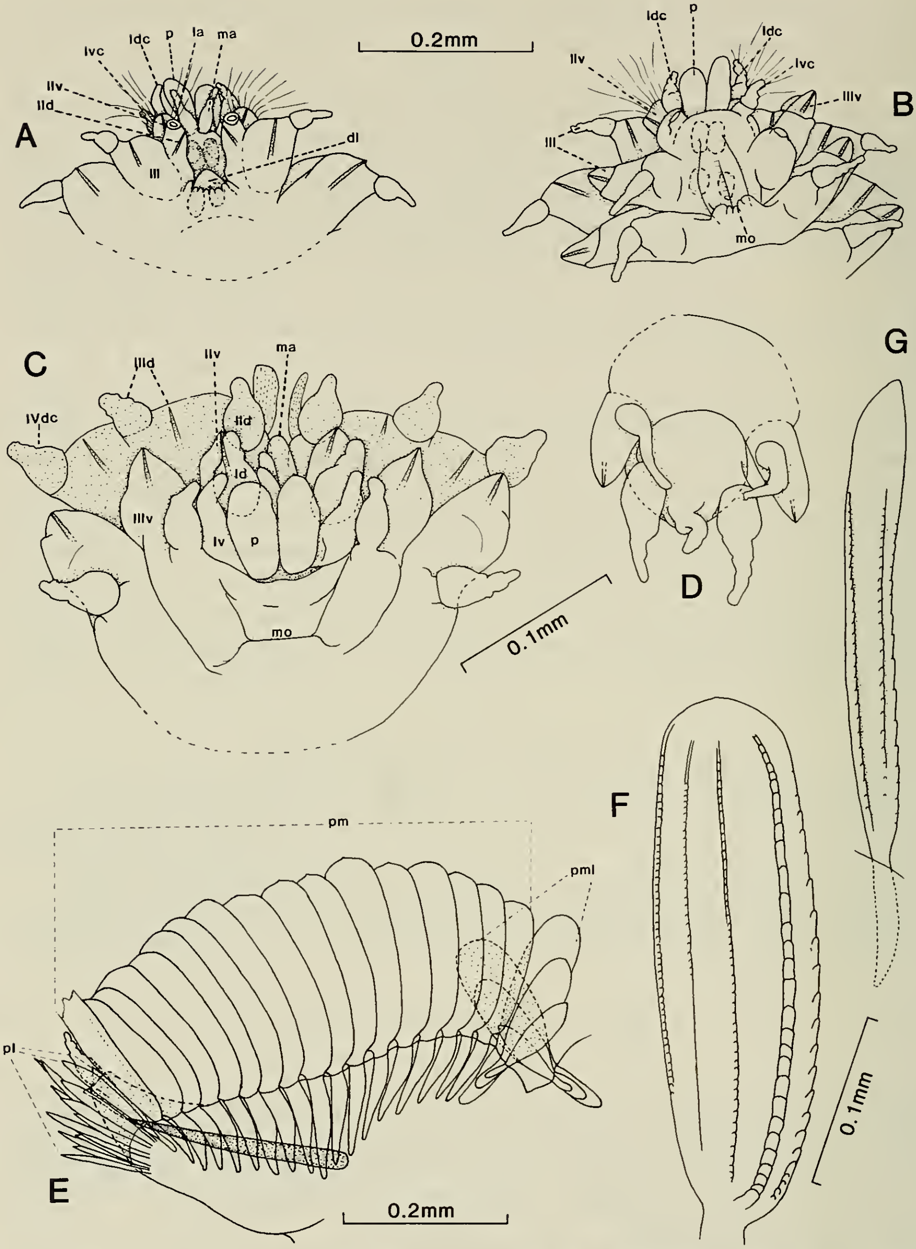

Fig. 21. *Bhawania goodei*: A, Anterior end, dorsal view, large, extended specimen; B, Same, ventral view; C, Anterior end, ventral view, small specimen [ma = ?dl]; D, Pygidium, ventral view; E, Left notopodium of middle segment, anterior view; F, large palea, middle group of left notopodium; G, Slender lateral palea, middle group of same (A, B, D, E, YPM; C, FSBC I 31265; F, G, FSBC I 31271).

(USNM 96363; IRCZM 50:998, 50:999; YPM; AHF).—Same, off St. Lucie Inlet, 42–44 m, 27°10′N, 80°00′W (Area G of Reed, 1980, fig. 1) 2 specimens, 2 fragments (FSBC I 31267; IRCZM 50:997, 1000, 1001).—Same, ENE of Fort Pierce, 27°32.8′N, 79°58.8′W, 77–80 m (Jeffs Reef, Area A, Reed, 1980, fig. 1) 2 specimens (IRCZM 50:1002; USNM 97364).—Off Palm Beach-Broward County Line S of Boca Raton, 1.3 m, on *Phragmatopoma,* 13 specimens (USNM 97362; BMNH ZB 1984.60–62; ZMH P-18230; YPM; FSBC I 31268; H. D. Rudolph).—Biscayne Bay at R. L. Turchin Marina, shell hash, 2.7 m, colls. DER personnel, May 1978, 1 specimen (YPM).—Dade County, DERM collection, N Biscayne Bay, 4 specimens (FSBC I 31269; DERM). Same, S Biscayne Bay, 5 specimens (DERM).—Same, Card Sound, 1 specimen (DERM). FLORIDA (Gulf of Mexico): Hourglass Sta I, 4 nmi W of Sanibel Is. Light, 26°24′N, 82°06′W, 6 m, 1 specimen (FSBC I 31280).—Same, Sta J, 24 nmi W of Sanibel Is. Light, 26°24′N, 82°28′W, 18 m, 9 specimens (FSBC I 31281–31286).—Same, Sta B, 19 nmi W of Egmont Key, 27°37′N, 83°07′W, 18 m, 12 specimens (FSBC I 31270–31279).—Seahorse Key, Levy County, on sponge, coll. T. Hopkins, Sep 1960, 1 specimen (USNM 32383). PUERTO RICO: Arroyo, USFC Str. *Fish Hawk,* 3 Feb 1899, 1 specimen (USNM 15953). PANAMA (ATLANTIC): Galeta Reef, coll. A. Reimer, 2 Oct 1970, 1 specimen (USNM 61629).

*Description.*—Paleae golden-brown on large specimens to golden-yellow on small specimens, iridescent, completely covering dorsum and forming smooth surface. Pigmented glandular areas on lower lateral parts of notopodia and on ventrum between neuropodia and longitudinal muscle bands. Largest specimen 50 mm long, 3 mm wide (Webster 1884); North Carolina specimens up to 30 mm long, 2 mm wide (Gardiner 1976); largest Florida specimen somewhat contracted, 28 mm long, about 2.5 mm wide, 153 segments; smallest specimen 1.3 mm long, broadly oval in outline, 0.7 mm wide, about 20 segments (FSBC I 31269). Body flattened, with short segments much broader than height, broadly convex dorsally, flat ventrally. Prostomium and first 1 or 2 segments usually retracted within anterior segments and under conical lobe (dl) extending from anterior margin of segment 3, with prostomium and antennae seldom visible dorsally or ventrally on large specimens; partly visible on one large specimen (Fig. 21A, B); antennae often visible ventrally on small, contracted specimens (Fig. 21C). Median antenna shorter than lateral antennae, with origin in front of anterior pair of eyes not confirmed; anterior eyes appressed, elongate; posterior ones more rounded; palps oval, twice longer than wide; mouth opening near anterior margin of segment 4 of large extended specimen (Fig. 21B), appearing on segment 3 of small, contracted specimen (Fig. 21C), perhaps changing during development. Cirri of segments 1 and 2 stouter than antennae, shorter than dorsal cirri of middle segments. Notopodia of middle segments (Fig. 21E) each with stout aciculum and slender aciculum (not shown), with 2–3 midline group paleae in longitudinally-arranged group, 10–26 middle group paleae in long, imbricated, transverse row, and up to about 20 slender paleae and 1–2 broader paleae in lateral group. Midline group paleae (Figs. 21E, 22B, C) covered by medial paleae of middle group, thin, with 10–17 internal ribs; anterior one small, but half as long, less than half as wide as adjacent palea of middle group; posterior one about as long and broad as adjacent palea of middle group; anterior dorsal surface convex, with 2–3 surface midribs,

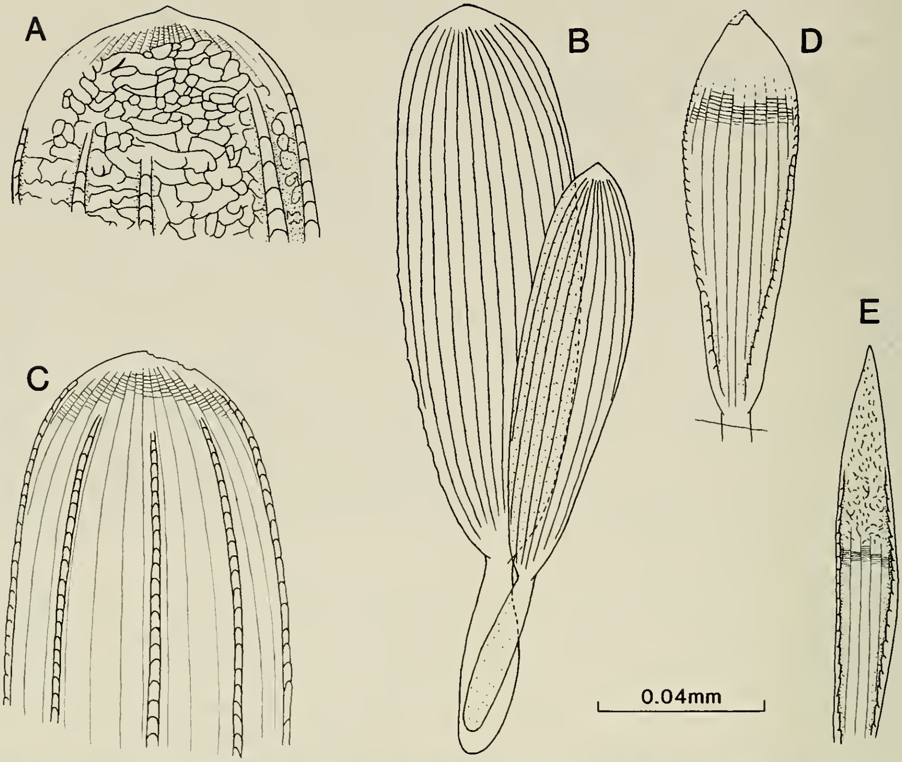

Fig. 22. *Bhawania goodei,* paleae of middle segments: A, Tip of large palea, middle group of left notopodium, showing surface ornamentation and surface ribs; B, Small paleae, midline group; C, Large palea, midline group, showing surface ribs, internal ribs and distal cross-bars; D, Broad palea, lateral group; E, Slender palea, lateral group (A, B, E, YPM; C, FSBC I 31271; D, FSBC I 31272).

with indistinct serrations visible on ribs and lateral margins, with surface ornamentation not as distinct but similar to that of middle group paleae. Middle group paleae, except for lateral one, all similar (Figs. 21F, 22A), each thick, broad, almost straight-sided, blunt-tipped, often with slight point, slightly bent laterally, with about 20 internal ribs having cross-bars extending almost to tip, with pair of lateral and 3 dorsal, surface ribs, with broad serrations on ribs extending to near tip, with ornamentation between surface ribs consisting of prominent, irregular, reticulate ridges; ornamentation extending distally beyond surface ribs but not as far as cross-bars of internal ribs; exposed medial margin and adjacent serrate rib strongly developed, usually visible under dissecting microscope; remaining 2 ribs and lateral margin covered by adjacent, more lateral paleae, with serrations half length and width of those of 2 medial rows. Lateral palea of middle group (Fig. 21G) longer, about half as wide as adjacent middle group palea, with about 11 internal ribs extending to near tip, with tip usually frayed, with pair of marginal and single surface denticulate ribs, latter near medial margin; surface ornamentation of distal part similar to that of lateral paleae; ornamentation similar to that of other middle group paleae proximally. Lateral group paleae up to 20, of 2 types; all serrate only on margins with surface ornamentation consisting of short, irregular, unconnected bars or bumps and with internal ribs ending well back from tips. First type lateral group paleae 1–2, adjacent to lateral, triserrate palea of middle group (Fig. 22D) almost as wide and as stout as latter but shorter, about as long as other lateral group paleae, with obtuse tip, with 10–12 internal ribs extending farther than those of other lateral group paleae. Other type lateral group paleae (Fig. 22E) fragile, easily broken, about half as wide as broad lateral palea, with 5–7 internal ribs extending for about half of emergent length, with acute tips. Neuropodia of middle segments with small group of compound spinigers above and more numerous compound falcigers below; falcigers with stout, unidentate blades; blades of some upper falcigers with very long serrations on margin (Gardiner 1976, fig. 5d). Pygidium (Fig. 21D) rounded, conical, with small midventral cirrus about size of ventral cirri of posterior segments and pair of much larger, ventrolateral cirri.

*Remarks.*—*Bhawania goodei* has been reported from world-wide tropical seas (Imajima and Hartman 1964:47, 386; Day 1967:119). Specimens from West Africa reported as *B. goodei* by Augener (1918:98–103) are apparently another species. The large palea figured by Augener (pl. 2, figs. 1, 2) has gradually rounded lateral margins and an almost semicircular but excavate tip, whereas such palea of typical *B. goodei* are almost parallel-sided and blunt-tipped. Paleae of *B. goodei* often have an indistinct point, but I suspect that Augener's figure shows a palea with a broken tip. *Bhawania cryptocephala* Gravier, 1901, from Djibouti, Gulf of Aden, was referred to *B. goodei* by Day (1953:407). In my opinion, this synonymy is incorrect. Paleae of *B. cryptocephala* have a shape similar to that of the West African specimens of Augener (1918), but have very distinctly pointed tips and a surface ornamentation consisting of knobs, whereas surface ornamentation of paleae of *B. goodei* is very distinctly reticulate and similar but not as pronounced as that on paleae of *B. amboiensis* Horst, 1917. Specimens from Japan referred to *B. goodei* by Imajima and Hartman (1964:47) were apparently based on a report of *B. cryptocephala* of Fauvel (1936b:266) [not Gravier 1901]. The specimens apparently had ventrally originating neurosetae with slender, filiform appendages in addition to an upper group of spinigers and a middle group of short falcigers. Such slender, lower neurosetae are not present on *B. goodei.* The description of paleae of specimens from Pacific Panama and the Galapagos Islands reported as *B. goodei* by Monro (1933) suggests to me that his identification was correct; Fauchald (1977b:10) confirmed Monro's identification.

The species is known in the western Atlantic from Bermuda, the Caribbean area, the Gulf of Mexico, and the east coast of the United States from Florida to North Carolina, mostly on corals and rocky substrates, from intertidal to 80 m depths.

### *Bhawania heteroseta* (Hartman, 1945), new combination
### Figs. 23–25

*Paleanotus heteroseta* Hartman, 1945:12, pl. 1, figs. 1–6.—Pearse and Williams, 1951:138 [identified by O. Hartman].—Wass, 1965:15.—Harper, 1971:20.—Taylor, 1971:119–123.—Day, 1973:14.—Gardiner 1976:100, fig. 5f–i.—Dauer et al., 1984:18.—Gathof, 1984:26-9, 26-10, figs. 26-7, 26-8.

*Material examined.*—FLORIDA (Atlantic): Hutchinson Island Sta 2, 27°21.6′N,

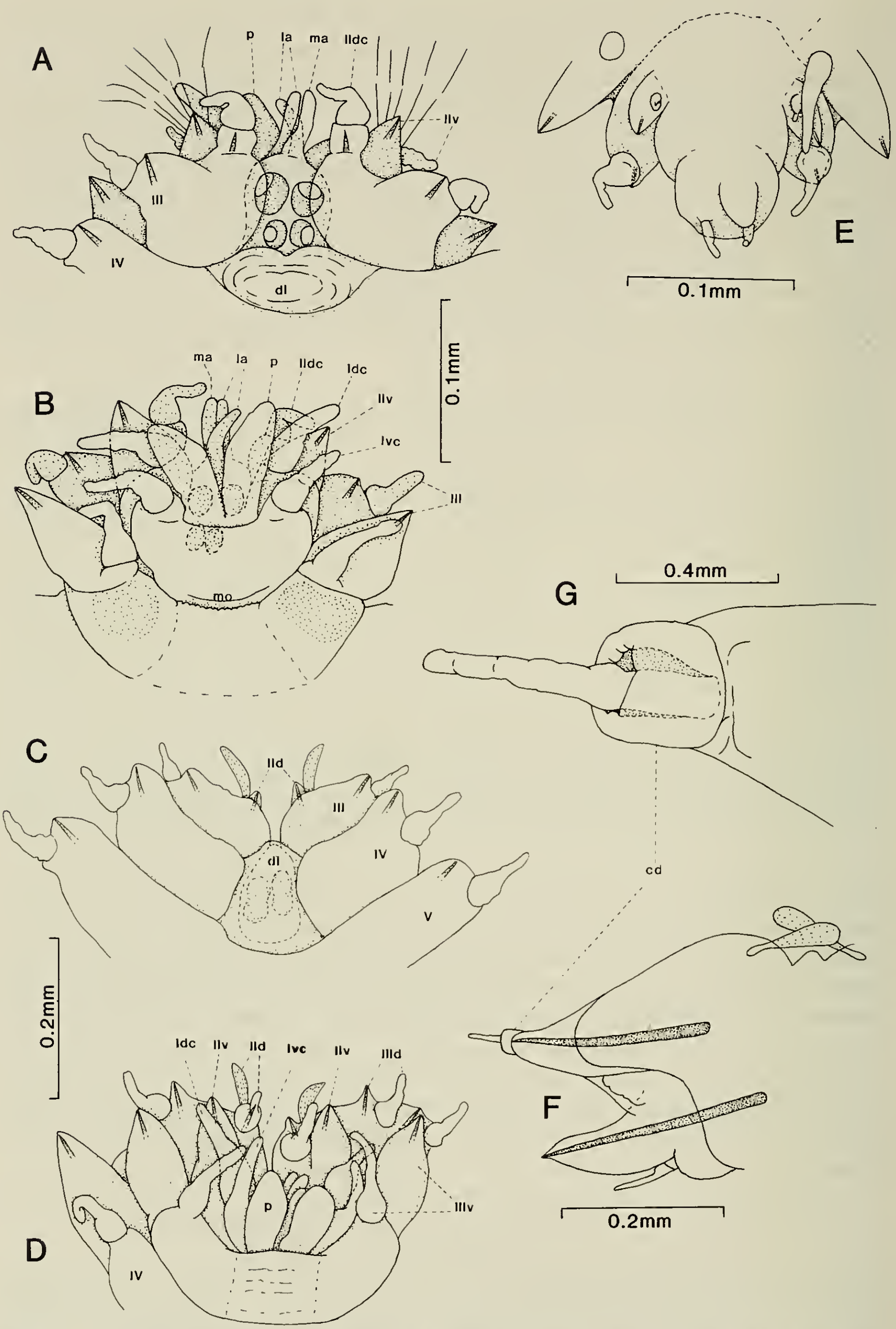

Fig. 23. *Bhawania heteroseta*: A, Anterior end, specimen with prostomium exposed, dorsal view; B, Ventral view of A; C, Same, dorsal view, prostomium covered by dorsal lamella; D, Ventral view of C; E, Pygidium, ventral view; F, Left parapodium, middle segment, anterior view, setae except for small midline paleae omitted; G, Tip of right notopodium, posterior view (A, D, BMNH ZB 1984.63; B, C, FSBC I 31297; E, FSBC I 31308; F, G, FSBC I 31296).

80°13.2′W, 11 m, coarse calcareous sand, 12 specimens (USNM 54226; BMNH ZB 1984.63, 1984.64; IRCZM 50:988, 989; FSBC I 31287–31292).—Same, Sta 4, 27°20.7′N, 80°12.8′W, 11 m, coarse calcareous sand, 2 specimens (FSBC I 31293, 31294).—Same, Sta 5, 27°22.9′N, 80°13.9′W, 11 m, coarse calcareous sand, 12 specimens (USNM 54227; AHF; ZMH P-18228, 18229; FSBC I 31295–31300). FLORIDA (Gulf of Mexico): SOFLA Sta 16, 25°45′42″N, 83°11′04″W, 54 m, 3 specimens (USNM 90636, 90637).—Hourglass Sta I, 4 nmi W of Sanibel Is. Light, 26°24′N, 82°06′W, 6 m, 23 specimens (FSBC I 31318–31321).—Same, Sta J, 24 nmi W of Sanibel Is. Light, 26°24′N, 82°28′W, 18 m, 1 fragment (FSBC I 31322).—Same, Sta K, 51 nmi W of Sanibel Is. Light, 26°24′N, 82°58′W, 37 m, 1 specimen (FSBC I 31322).—Same, Sta L, 73 nmi W of Sanibel Is. Light, 26°24′N, 83°22′W, 55 m, 1 specimen (FSBC I 31324).—Same, Sta A, 4 nmi W of Egmont Key, 27°35′N, 82°50′W, 6 m, 106 specimens (FSBC I 31301–31309).—Same, Sta B, 19 nmi W of Egmont Key, 27°37′N, 83°07′W, 18 m, 3 specimens (FSBC I 31311, 31312).—Same, Sta C, 38 nmi W of Egmont Key, 27°37′N, 83°28′W, 37 m, 3 specimens (FSBC I 31313, 31314).—Same, Sta D, 65 nmi W of Egmont Key, 27°37′N, 83°58′N, 55 m, 4 specimens (FSBC I 31315–31317).—National Marine Fisheries Service, Tampa Bay area estuarine study, 1963–64, upper Tampa Bay, 80 specimens (ZMC; IRCZM 50:699, 50:991; FSBC I 10649, 12107, 12201, 12180, 12213, 12290, 12295, 20646).—Same, Old Tampa Bay, 10 specimens (IRCZM 50:700; FSBC I 10510).—Same, lower Tampa Bay, 166 specimens (YPM; IRCZM 50:698, 50:990; FSBC I 12423, 12635, 12705, 12879, 12977, 13045, 15404).—Same, Terra Ceia Bay, 1 fragment (FSBC I 13466).—Same, Boca Ciega Bay, 5 specimens (FSBC I 12595, 13367, 14552, 14573).—Same, mouth of Tampa Bay, SE tip of Egmont Key, 64 specimens (USNM 97366; MESC 5001-0221; FSBC I 31325; YPM; AHF; IRCZM 50:992).—Off Tampa Bay, Interstate Electronic Corp. Site TB-713, 30 Sep 2–Oct 1979, Sta 3-3, 27°37′06″N, 82°54′06″W, 12 m, 3 + specimens (USNM 97510).—Same, Sta 3-4, 7 specimens (USNM 97511).—Same, Sta 3-7, 8 specimens (USNM 97513).—Same, Sta 3–5, 27°37′12″N, 82°54′06″W, 1 specimen (USNM 97512).—Same, Sta 4-13, 27°37′12″N, 82°55′06″W, 2 specimens (USNM 97514).—Same, Sta 13-8, 27°37′36″N, 82°54′36″W, 13 m, 4 specimens (USNM 97520).—Same, Sta 8-5, 27°38′48″N, 82°55′48″W, 11 m, fragment (USNM 97517).—Same, Sta 8-3, 1 specimen (USNM 97515).—Same, Sta 8-4, 1 specimen (USNM 97516).—Same, Sta 9-7, 27°38′54″N, 82°53′24″W, 9 m, 2 specimens (USNM 97519).—Same, Sta 8-6, 27°38′54″N, 82°55′48″W, 11 m, 1 + specimens (USNM 97518).—NE Gulf of Mexico, EGMEX 70, Sta 22, 28°04′N, 84°41′W, 77 m, R/V *Hernan Cortez,* colls. J. Williams et al., May 1970, 1 specimen (FSBC I 23713).—MAFLA, box core samples, 1977, Transect 3, Sta 16, 28°42′N, 84°20′W, 33 m, coll. N. Blake, 1 fragment (FSBC I 23712).—Same, MAFLA 1975–76 study, Transect 5, Sta 29, Sep 1975, 29°56′N, 86°06′W, 38 m, coarse sand-rubble, 2 specimens (MESC 5001-0220).—Same, Sta 31, Sep 1975, 29°48′N, 86°09.5′W, 45 m, coarse sand-rubble, 1 specimen (FSBC I 31326).—Same, Sta 28, Sep 1975, 29°55′N, 86°05′W, 38 m, coarse sand-rubble, 2 specimens (USNM 97365).—Same, Sta 34, Jan 1976, 29°40′N, 86°17′W, 74 m, coarse sand-rubble, 1 specimen (MESC 5001-0219). TEXAS: STOCS Sta SB3, 27°26′06″N, 96°31′47″W, 82 m, 8 specimens (USNM 90639).—IXTOC Sta S-46, 26°10′00″N, 97°09′48″W, 4.5 m, 3 specimens (USNM 90638). VIRGINIA: York R., Mar 1976, 1 specimen (USNM 56559).—Chesapeake Bay, off Rappahanock R., coll., M. Wass, 1 specimen (USNM 32383).

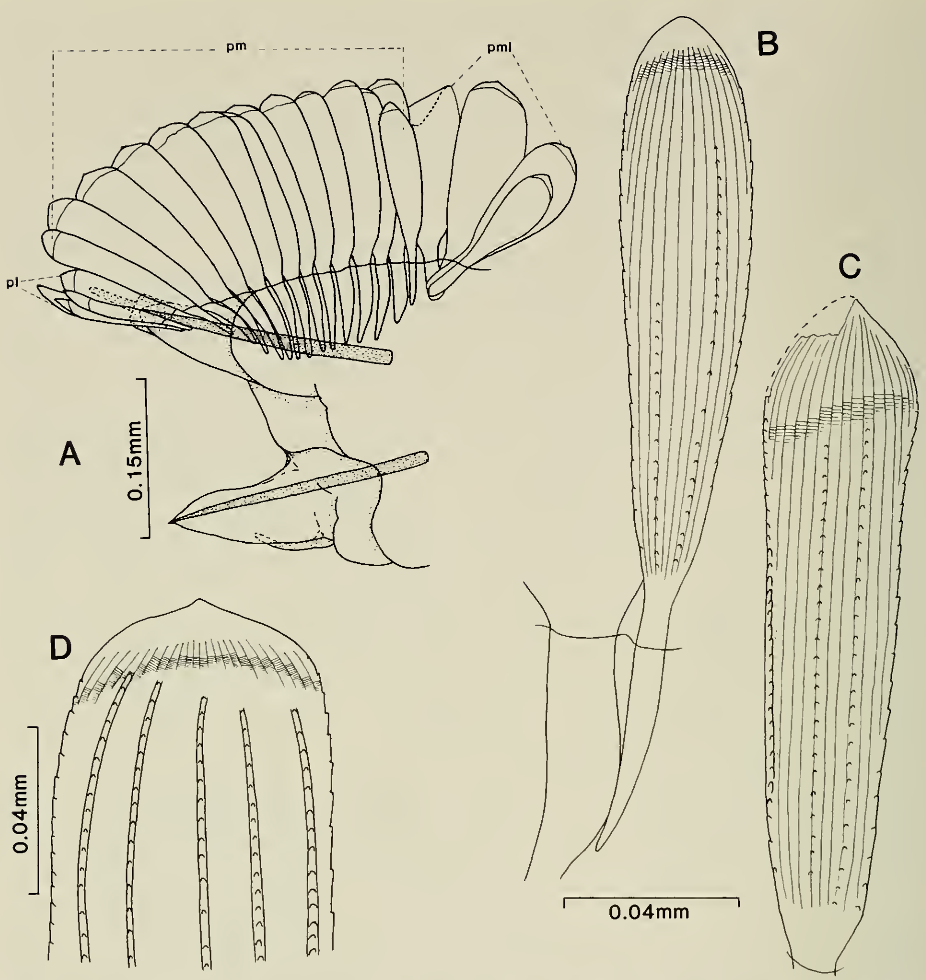

Fig. 24. *Bhawania heteroseta*: A, Left parapodium, anterior view; B–D, Paleae, middle group, showing surface ribs, internal ribs, and distal cross-bars; B, Slender palea near midline paleae; C, Slender palea near lateral paleae; D, Broad middle palea (A, B, FSBC I 31296; C, D, paratype).

*Description.*—Paleae light golden brown, light yellow to pale yellow, iridescent, completely covering dorsum and forming smooth surface on contracted specimens, appearing separated medially on extended specimens. Pigmented glandular areas often present on lower lateral parts of notopodia and on ventrum between neuropodia and longitudinal muscle bands. North Carolina specimens up to 15 mm long, 1 mm wide (Gardiner 1976:100); largest extended specimen examined 12.5 mm long, 0.7 mm wide, 107 segments; most large, sexually mature specimens contracted, 6–8 mm long, 0.7–0.9 mm wide, less than 75 segments; smallest specimens 1.3–1.7 mm long, 0.45–0.5 mm wide, 21–22 segments. Prostomium and first 1 or 2 segments retracted under lamella (dl) at level of segment 4 in about ⅓ of specimens, especially large, mature specimens, but palps and antennae usually visible on ventral side (Fig. 23B, C); prostomium almost completely exposed on perhaps ⅓ of specimens (Fig. 23A, D); contraction intermediate on remainder. Median and lateral antennae similar, slender, extending about as far as palps; palps oval, more than twice longer than wide; eyes rounded, anterior pair larger; mouth opening on anterior margin of segment 3 (Fig. 23C, D). Cirri of segments 1 and 2 stouter than antennae, similar to dorsal cirri of segment 3. Notopodia of middle segments (Fig. 24A) each with single long, stout aciculum, 3–4 midline group paleae in longitudinally arranged group, middle group of up to about 15 paleae in long, imbricated, transverse row, and lateral group consisting of 3–5 moderately slender paleae and single broad palea about as wide as lateral palea of middle group. Midline group paleae (Figs. 24A, 25A–C) usually covered by medial paleae of middle group, very thin, broad, slightly asymmetrically tipped, margins gradually curved; large ones with serrate margins and up to 5 serrate midribs, with up to 25 internal ribs, with cross-bars not extending to tip. Medial palea of middle group (Fig. 24A, B) more slender, shorter than others, with blunt tip, pair of serrate surface midribs and serrate margins, 14–16 internal ribs, with cross-bars not extending to tip. Other middle group paleae, except lateral one, all similar (Fig. 24A, B), each thin, broad, almost straight-sided, slightly bent laterally, with slightly pointed tip, about 24 internal ribs, cross-bars extending about to point where margins turn to form tip, pair of lateral and 4–5 similar, narrow, denticulate surface ribs usually ending well short of internal ribs, surface ornamentation of exposed parts reticulate, similar to that on middle group paleae of *B. goodei* but much less distinct. Lateral palea of middle group (Fig. 24A, C) about half as broad as adjacent middle group palea, with pair of serrate midribs and serrate margins, about 16 internal ribs, cross-bars ending well back from tip but extending farther than surface ribs, tip usually frayed, surface ornamentation back from tip similar to that of paleae of middle group, ornamentation similar to that of lateral group paleae near tip. Lateral group paleae consisting of two types, all about same length, shorter than middle group paleae: single one near lateral palea of middle group (Figs. 24A, 25D) pointed, about as broad as lateral palea of middle group, with serrate lateral margins, about 17 internal ribs ending well back from tip, surface ornamentation consisting of irregular knobs; more lateral paleae (Figs. 24A, 25E, F) about 5 (1–5), very thin, less than half as wide, without serrate margins, with 9–10 internal ribs extending for about ⅔ of emergent length, indistinct surface ornamentation. Neurosetae described by Gardiner (1976, fig. 5g–i), consisting of spinigers and falcigers similar to those of *B. goodei* but with falcigers less numerous and with blades not as stout; blades with long serrations fragile. Pygidium (Fig. 23E) rounded to bluntly conical, with broad, rounded, midventral lamella (cirrus) and pair of very small lateral or ventrolateral cirri.

*Remarks.—Bhawani heteroseta* differs from *B. goodei* in being much smaller, with fewer segments; paleae of the broad middle group are thinner, less numerous, less distinctly but similarly ornamented, with surface ribs all similar and narrow, and with distinct hyaline tips; lateral notosetae are few; and the prostomium is often not retracted within anterior segments (preserved). The prostomium of one specimen of *B. goodei* was found to be almost completely exposed (Fig. 21A, B) and similar to that of many specimens of *B. heteroseta.*

*Bhawania heteroseta* is known in the western Atlantic from Virginia (Wass 1965:15; Dauer et al. 1984:18) to central Florida and the north and central regions of the Gulf of Mexico. The species was reported from the Cape Verde Islands by Rullier (1964:142, 143).

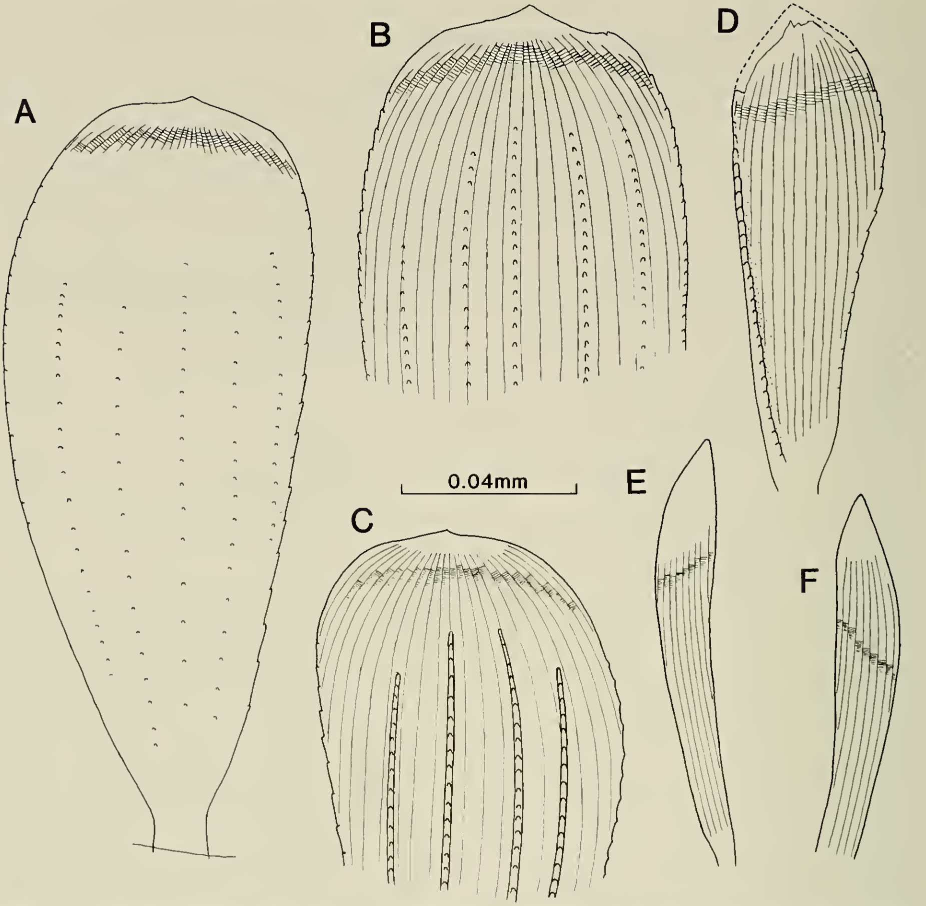

Fig. 25. *Bhawania heteroseta,* paleae of midline and lateral groups, showing surface ribs, internal ribs, and distal cross-bars: A, Second largest palea, midline group; B, Tip of largest palea, midline group; C, Tip of another palea, midline group; D, Broad palea, lateral group; E, F, Slender paleae, lateral group (A–C, F, FSBC I 31296; D, E paratype).

*Bhawania heteroseta* is known from sandy estuarine and offshore areas from shallow water to about 80 m depths; it is not known to inhabit coral reefs or rocky substrates. All of the numerous specimens taken during the Hourglass Cruises were collected by dredge; other collections were made using grabs and dredges, and none of the specimens examined were collected by trawls.

### *Treptopale,* new genus

*Type-species.—Treptopale rudolphi,* n. sp.; gender: feminine.

*Diagnosis.*—Small, slender, more than 50 segments. Prostomium withdrawn, fused laterally with anterior 3 segments; eyes 2 pairs; median antenna originating anteriorly below eyes, cylindrical; caruncle absent; palps spherical; mouth opening on segment 3, without cover; proboscis with small muscular stomach behind stylets (Fig. 26A). Segments 1 and 2 with 3 pairs of dorsal and ventral cirri.

Parapodia biramous, beginning on segment 2, all similar by segment 4; broad notopodial lobes with notopodial paleae in lateral, middle and midline groups; compound neuropodial spinigers on anterior few segments, changing to falcigers on middle and posterior segments; all blades unidentate. Lateral group paleae (pl) few, slender, biserrate with symmetrical tips. Midline group paleae (pml) few, in longitudinal row, bent medially, moderately broad, biserrate, with more or less symmetrical tips. Middle group paleae (pm) completely covering dorsum, extending in fan-shaped bundle from single developmental center, occupying about half of total width of dorsum, forming curved single, imbricated row; paleae broad, paddle-shaped, with symmetrical, short, pointed tips near middle of distal end, about 20 internal ribs. Pygidium not observed.

*Remarks.*—*Treptopale* differs from *Paleanotus* Schmarda in having paleae of the middle group with symmetrical tips. The mouth of *Treptopale* opens on the second apparent ventral segment behind the palps, whereas the mouth opening on *Paleanotus* is on the first apparent ventral segment. This suggests a difference in the proboscis which I cannot confirm. Finally, the possibly immature specimen of *Treptopale* available has more than 50 segments; *Paleanotus* is reported to have about 40 segments.

Both *Paleanotus* and *Treptopale* have paleae of the middle group formed in single bundles. However, those of *Paleanotus* (Fig. 1B) have asymmetrical tips resembling tips of paleae of a lateral bundle of *Chrysopetalum* (Fig. 1A), and it is suggested that *Paleanotus* is descended from a *Chrysopetalum*-like ancestor by a loss of all but one of the lateral bundles of paleae, loss of one pair of ventral cirri, and a broadening of the reduced numbers of paleae so that they cover the dorsum. *Treptopale* can be derived from a *Chrysopetalum*-like ancestor by a similar process. However, it is suggested that *Treptopale* has evolved through loss of all but one middle paleal bundle of each notopodium.

*Etymology.*—The generic name is derived from a combination of the Greek, *treptos,* changed, and *-pale,* the second element of the name of *Heteropale* Johnson, 1897 (=*Paleanotus*), and refers to the principal difference between *Treptopale* and *Paleanotus* Schmarda.

### *Treptopale rudolphi,* new species
Figs. 26, 27

*Material examined.*—FLORIDA (Atlantic): Dade County, S. Biscayne Bay, DERM Sta 16, Ragged Keys, near channel between 2 keys, 25°32′01″N, 80°10′17″W, 2–3 m, scoured hard bottom, holotype (USNM 97370).

*Description.*—Holotype coiled, 5–5.5 mm long, 0.5 mm wide, 60 segments; anterior and middle parts of body similar in width after first few segments, tapered near posterior end. Prostomium (Fig. 26A–C) with posterior eyes dorsal, partly covered by segment 2; anterior eyes larger, not visible from dorsum, apparently on anterior margin above median antenna, directed anterolaterally; palps originating anteroventrally below lateral antennae. Dorsal cirri of segment 1 about in line with median antenna, below dorsal cirri of segment 2; ventral cirri of segment 1 originating lateral to palps; all similar to dorsal cirri of following segments. Notosetae of segment 2 consisting of about 4 short, slender paleae on each side; segment 3 with only middle group paleae; midline and lateral groups of paleae

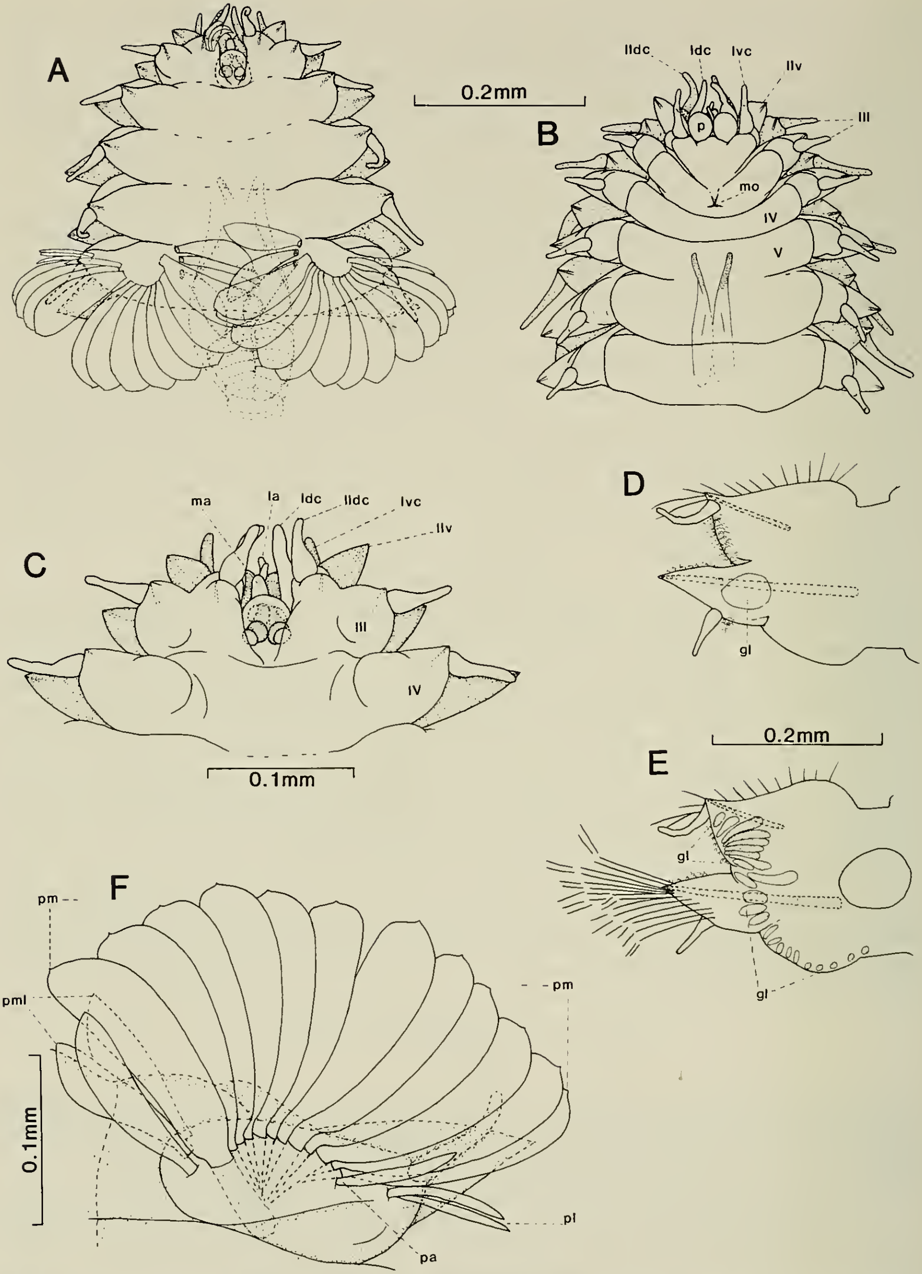

Fig. 26. *Treptopale rudolphi,* holotype: A, Anterior end, dorsal view; B, Same, ventral view; C, Same, dorsal view, enlarged; D, Right parapodium, middle segment, posterior view; E, Left parapodium, middle segment, anterior view; F, Right notopodium, middle segment, dorsal view.

beginning on segment 4. Notopodia of middle segments (Fig. 26D, E) with 1, occasionally 2, relatively short, slender acicula, extending into tip; glands containing opaque granules (Fig. 26E) beginning on anterior side below notopodial aciculum, continuing to near ventral nerve cord, gradually diminishing; dorsal

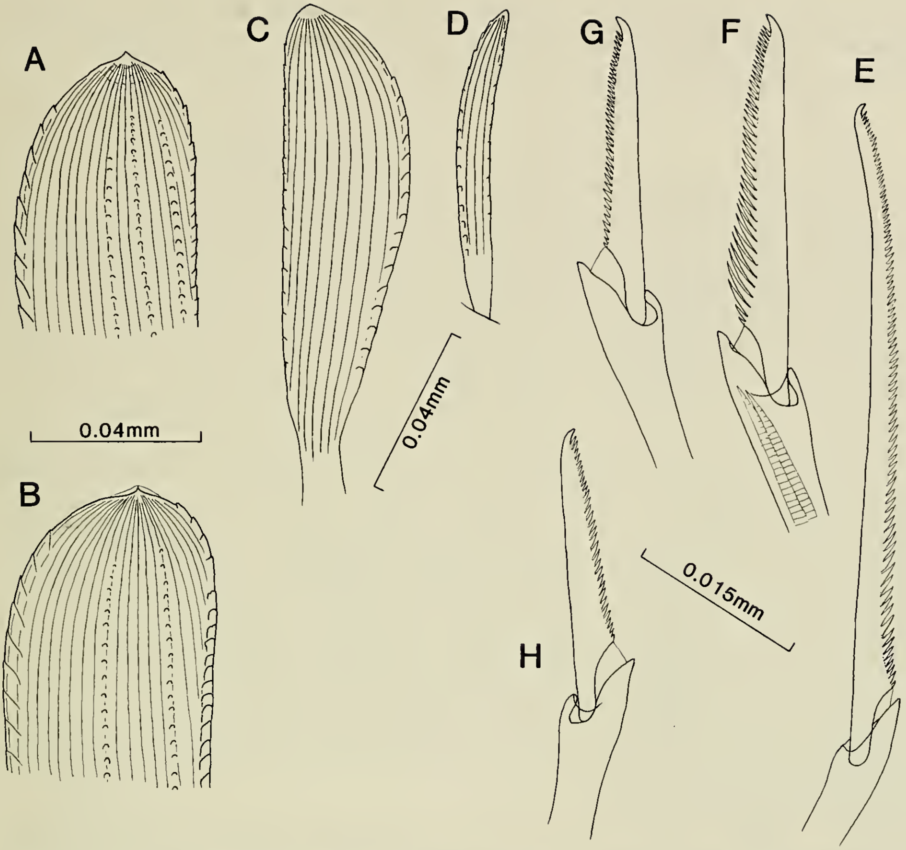

Fig. 27. *Treptopale rudolphi,* setae of middle segments, holotype: A, B, Paleae, middle group, left notopodium; C, Palea, midline group; D, Slender anterior group palea, near lateral paleae of middle group; E, Upper compound falciger; F, Middle compound falciger; G, Same, with short serrations; H, Lower compound falciger.

cirri moderately long, slender, tapered. Neuropodia of middle segments with indistinct postsetal lobe, ventral cirrus with stout base and slender tip; rounded, internal "cavity" containing clear substance, perhaps oil, visible on posterior side of neuropodia (Fig. 26D, g1). Lateral group paleae of middle notopodia (Fig. 26F) 2–3, slender, about ½ length of middle group paleae, serrate on both margins, extending laterally from body anterior to tip of notoaciculum, with about 5 internal ribs. Midline group paleae (Figs. 26F, 27C) 3, all similar, serrate on both margins, shorter than middle group paleae, with about 15 internal ribs. Single anterior group palea (Figs. 26F, 27D) anterior to lateral middle group palea; similar to lateral group paleae. Paleae of broad middle group about 13 (Figs. 26F, 27A, B), all similar, fragile, with hooded tips, equally serrate on both margins, with marginal serrations very broad, with 2 or 3 rows of smaller serrations near medial margins extending to near tips and few more rows ending proximally. Compound falcigers of middle segments (Fig. 27E–H) about 20; blades longer above, gradually shorter below; several blades in middle of bundles with long serrations. Interramal region ciliate (Fig. 26D, E).

*Etymology.*—The species is named in honor of Harvey D. Rudolph, Florida Department of Environmental Regulation, who has provided me with many very interesting specimens from southern Florida.

### *Hyalopale,* new genus

*Type-species.*—*Hyalopale bispinosa,* n. sp.; gender: feminine.

*Diagnosis.*—Body relatively short, about 20 segments. Prostomium withdrawn, fused laterally with anterior 3 segments; eyes 2 pairs; antennae filiform, median antenna originating below eyes; caruncle absent; palps cushion-shaped; mouth opening at posterior margin of first apparent segment behind palps and bisecting segment 3, possibly with small cover extending from segment 4; muscular stomach behind stylets large. Segments 1 and 2 with 3 pairs of dorsal and ventral cirri, with ventral cirri absent from segment 2. Parapodia biramous, beginning on segment 2, all similar by segment 4, each with broad notopodial lobe, only middle group paleae, serrate spines beginning on notopodia of segment 4 near lateral and medial margins of paleae; interramal region ciliate. Compound neuropodial spinigers on anterior few segments, changing to falcigers on middle and posterior segments, all with unidentate blades. Paleae broad, thin, clear, not completely covering dorsum of middle segments, in fan-shaped bundle from single developmental center, occupying ⅓–½ segmental width, forming curved, imbricated row; paleae asymmetrical, similarly oriented, machete-shaped, with short, pointed tips near medial margin, medial margin concave, smooth, partially covered by adjacent paleae, lateral margin exposed, convex, serrate, more than 25 internal ribs; newly forming paleae produced at lateral margin above aciculum. Pygidium small, rounded, with pair of anal cirri.

*Remarks.*—*Hyalopale* differs from *Paleanotus* Schmarda in lacking paleae in lateral and midline groups and in having very thin, clear paleae in the broad middle group with about 25 internal ribs. Lateral and midline group paleae of *Paleanotus* are replaced by spines in *Hyalopale,* and middle group paleae of *Paleanotus* are thicker and have between 15 and 20 internal ribs. The position of the mouth of *Hyalopale* may also differ from that of *Paleanotus,* and antennae of *Hyalopale* are all similar, whereas the median antenna is cylindrical and lateral antennae are cirriform on all specimens of *Paleanotus* that I have examined. The muscular stomachs of *Paleanotus* and *Hyalopale* may differ. The stomach of *Hyalopale,* resembling the proventriculus of Syllidae (Fig. 28B, see Perkins 1980), is much larger than that of any *Paleanotus* that I have observed.

*Etymology.*—The generic name is derived from a combination of the Greek, *hyalos,* glass, and *-pale,* the second element of the name *Heteropale* Johnson, 1897 (=*Paleanotus*), and refers to the clear paleae.

### *Hyalopale bispinosa,* new species
Figs. 28, 29

*Material examined.*—FLORIDA (Atlantic): S Biscayne Bay, DERM Sta 16, Ragged Keys, near channel between 2 keys, 25°32′01″N, 80°10′17″W, 2–3 m, scoured hard bottom, holotype (USNM 97367), paratype (USNM 97368), 2 specimens (DERM).—About 2 mi E of Florida Power and Light Co. Turkey Point power plant, at end of power plant channel, 2.5 m, colls. DER personnel, 15 Feb

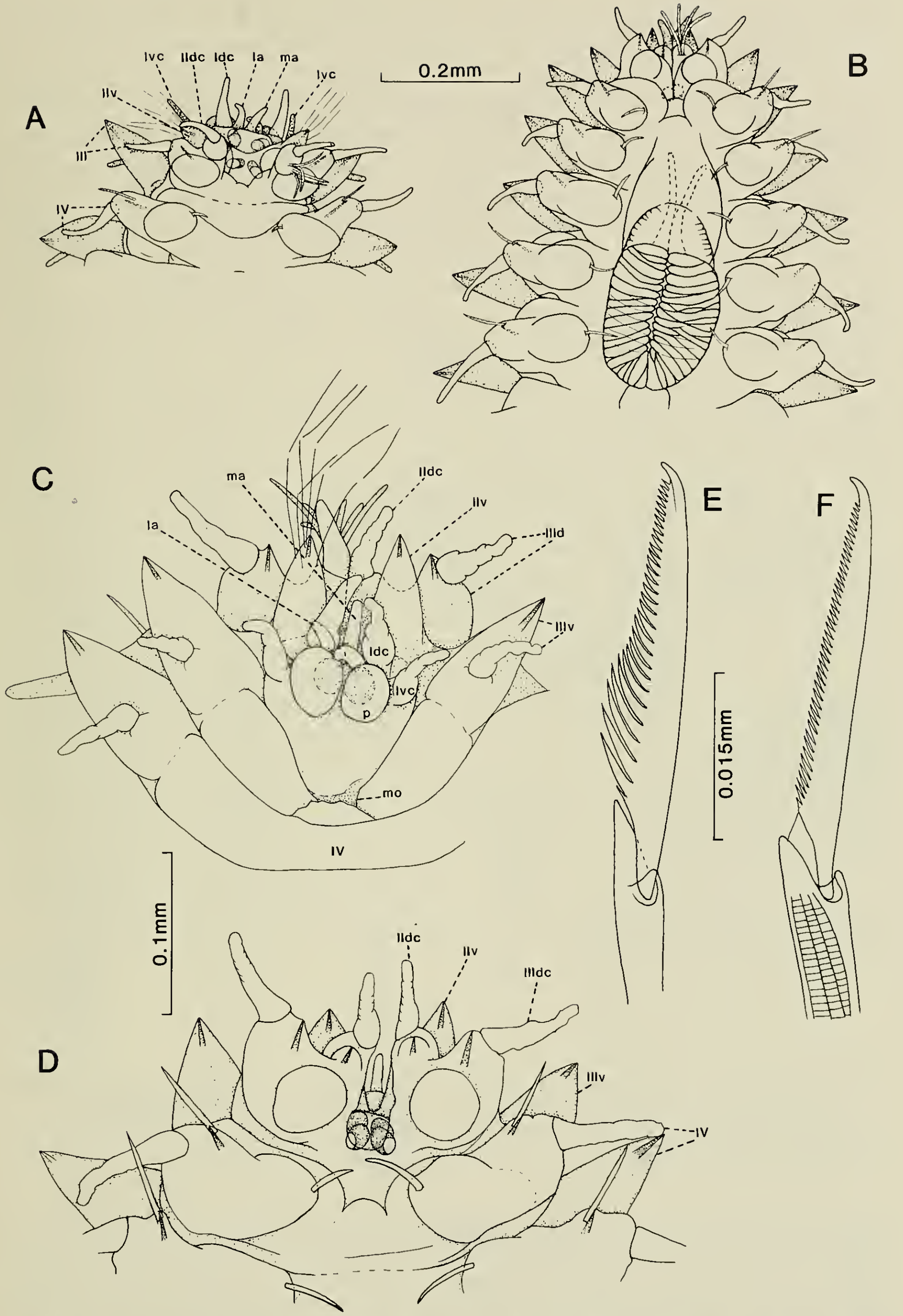

Fig. 28. *Hyalopale bispinosa*: A, Anterior end, dorsal view of specimen with prostomium partly exposed; B, Same, prostomium covered by anterior segments; C, Anterior end, ventral view of B; D, Same, dorsal view, prostomium partly exposed: E, Middle compound falciger; F, Lower compound falciger (A, holotype; B–F, FSBC I 31383-USNM 97369).

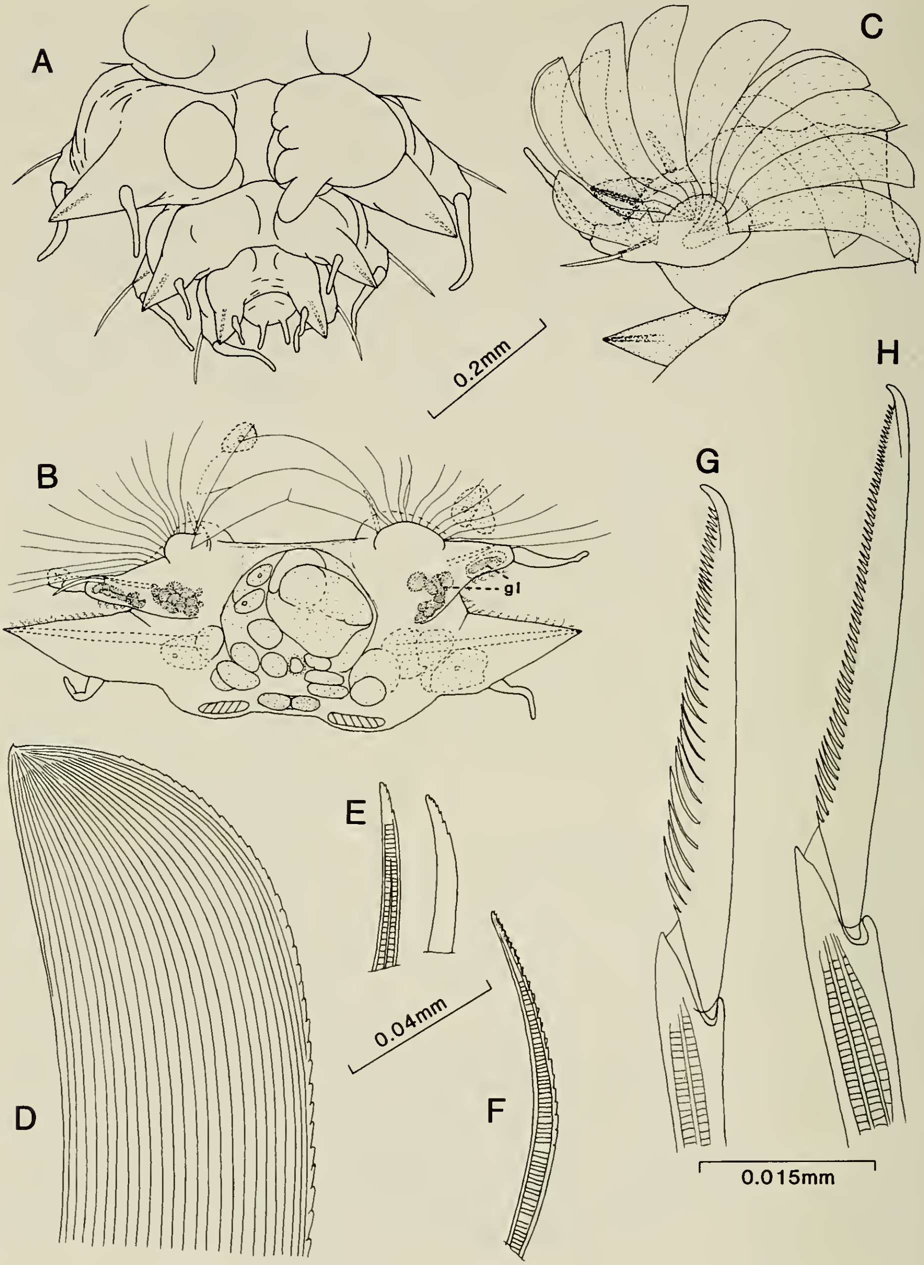

Fig. 29. *Hyalopale bispinosa*: A, Posterior end, ventral view; B, Middle segment, anterior view; C, Left parapodium, middle segment, dorsal view; D, Middle group palea, right parapodium, middle segment, showing internal ribs and serrated lateral margin; E, Spines, midline group, one showing internal structure; F, Spine, lateral group, showing internal structure; G, Middle compound falciger; H, Upper compound falciger (A, holotype; B, DERM Collection; C, USNM 97368; D–H, FSBC I 31383-USNM 97369).

1978, 2 paratypes (USNM 97369; FSBC I 31383).—Florida Keys (Monroe County): Looe Key National Marine Sanctuary, reef crest, coralline covered rubble, less than 1 m, Sta FLK-4, 2 young specimens (USNM 97530).

*Description.*—Holotype, largest complete specimen, 2.8 mm long, 0.7 mm wide, 20 segments; other complete specimen (USNM 97369), also 20 segments; mature female present (Fig. 29B; DERM). Prostomium (Fig. 28A–D) with antennae much smaller than dorsal cirri of segments 1 and 2; anterior eyes directed anteriorly or anterolaterally, on shelf below neuropodia of segment 2, above notopodia of segment 1; posterior eyes directed dorsally or anterodorsally, on shelf below notopodia of segment 2; slightly smaller than anterior eyes. Dorsal cirri of segment 1 attached near level of median antenna, above lateral antennae, similar to dorsal cirri of segment 2; ventral cirri of segment 1 attached lateral to palps, smaller. Notosetae of segment 2 consisting of inverted cone of about 6 spines (Fig. 28B); notosetae of segment 3 only middle group paleae; notosetae of segment 4 and following segments middle group paleae, lateral and midline group spines. Notopodia of middle segments each with aciculum ending well back from tip of moderately long dorsal cirrophore; glands containing opaque granules in cirrophore below aciculum and more proximally (Fig. 29B); dorsal cirrus relatively long, slender. Neuropodia of middle segments with indistinct postsetal lobe, short, slender, ventral cirrus below setae, without apparent neuropodial gland. Lateral and midline group notopodial spines (Fig. 29E, F) usually single, occasionally 2, biserrate; lateral group spine curved, originating anterior to aciculum, directed laterally, usually twice as long as midline group spine; midline group spine originating posteromedial to medial palea of middle group, directed dorsomedially. Middle group paleae of middle segments (Fig. 29C, D) about 13, fragile, easily broken, unornamented except for exposed, convex, serrate, lateral margins, with hooded tips. Compound falcigers of middle segments (Figs. 28E, F, 29G, H) numerous, more than 30, blades longer above, gradually shorter below; several blades in middle of bundles with very long serrations. Anal cirri filiform, originating slightly ventrally (Fig. 29A).

*Etymology.*—The specific name is derived from the Latin prefix *bi,* two, and *spinosa,* thorny, and refers to the two groups of spines on notopodia of middle segments.

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# NEW TROPICAL AMERICAN SPECIES OF *THELYPTERIS* (PTERIDOPHYTA)

Alan R. Smith and David B. Lellinger

*Abstract.*—New species of *Thelypteris* are described from Central America and the Depto. Chocó, Colombia, 9 in subg. *Amauropelta,* 3 in subg. *Goniopteris,* and 1 in subg. *Meniscium.*

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Work on *Thelpyteris* for a flora of Costa Rica–Panama–Chocó by Lellinger, and for the Flora of Mesoamerica by Smith has resulted in the discovery of several new species for the region. Altogether, nearly 125 species of *Thelypteris* are known for Central America and 10 more for the Chocó region. Most have distributions ranging well outside these areas, but about 35 are known thus far only from Mesoamerica. Almost none are endemic to the Chocó region; most of these extend into Panama or Costa Rica, and others range to Ecuador or farther south. The subgenus to which each species belongs is indicated with the name of the species.

### *Thelypteris* (*Goniopteris*) *chocoensis* Smith and Lellinger, sp. nov.
Fig. 1

Rhizoma breviter repens vel suberectum ad apicem paleaceum, paleis ovatis pilosis, pilis 0.1 mm longis stellatis vel furcatis. Frondes monomorphicae 35–90 cm longae. Stipites longitudine ½–1 laminas aequantes 2–4 mm diam. brunneoli adaxialiter glabri aut hirsuti tantum in sulcis. Laminae lanceolato-deltatae acuminatae; rachidibus ad apicem gemmiparis distaliter glabris vel sparse pilosis, pilis usque ad 0.5 mm longis ferrugineis simplicibus aut furcatis; pinnis 14–23 paribus usque ad 15 cm longis 1.2–2 cm latis, ad basin anguste cuneatis, ad apicem acuminatissimis vel caudatis, ⅔–¾ incisis; segmentis valde obliquis (ca. 45–60° ad costam), ad apicem falcatis; costulis venisque abaxialiter glabris, pagina laminae glabris chartaceis non verrucosis. Sori mediali indusiati, indusiis parvis subpersistentibus rufobrunneis ciliolatis; sporangiis glabris.

*Type.*—COLOMBIA: Depto. Chocó: 0.5–2.5 km N of the Inderena Camp on the Río Truando near Caserio La Teresita, 50–100 m, *Lellinger & de la Sota 543* (US; isotypes COL, CR, LP).

*Paratypes.*—COLOMBIA: Depto. Chocó: Corcovada region, Río San Juan, 100 m, *Killip 35363* (COL, US); Truando, *Schott s.n.* (US); Hydro Camp 15 on the Río Curiche, ca. 300 ft, *Duke 15376* (US); Río San Juan 3.5 km SW of Andagoya, just NE of the mouth of the Río Suruco, 60 m, *Lellinger & de la Sota 500* (US). Depto. Antioquia: Vicinity of Planta Providencia, valley of the Río Anorí between Dos Bocas and Anorí ca. 25 km SW of Zaragoza, 400–700 m, *Denslow 2482* (US); Munic. Zaragoza, Río Anorí, Corregimiento de Providencia, 500 m, *Soejarto & Hill 2828* (GH). Depto. Caldas: Santa Cecilia, 800 m, *von Sneidern 5024bis* (US); Carretera La Dorada a Norcasia, km 29, ca. 450 m, *Acosta A. 838* (COL).

This species has been recorded as growing on riverbanks, where it is subject to inundation. Apparently it is most closely related to the plant currently known as

Fig. 1, 2. 1, Holotype of *Thelypteris chocoensis* Smith and Lellinger, *Lellinger & de la Sota 543* (US); 2, Holotype of *Thelypteris cocleana* Smith and Lellinger, *Antonio 2188* (UC).

*Dryopteris magdalenica* Hieron., also from Colombia, which is said to have setose sporangia, less deeply incised pinnae, and fewer (8–10) pairs of pinnae.

### *Thelypteris* (*Meniscium*) *cocleana* Smith and Lellinger, sp. nov.
Fig. 2

Rhizoma repens. Frondes monomorphicae vel subdimorphicae usque ad 135 cm longae, frondibus fertilibus stipitibus comparate longioribus et pinnis comparate contractioribus quam frondibus sterilibus. Stipites glabri. Laminae pinnatae, pinnis 6–12 paribus lateralibus, pinnis distalibus et segmentis apicalis non vel leviter reductis; rachidibus abaxialiter glabris; pinnis plerumque 12–18(24) cm longis, 1.6–3.0(4.2) cm latis, pinnis distalibus sessilibus vel leviter adnatis, gemmis in 1 vel 2 axilis pinnarum, pinnis proximalibus anguste cuneatis petiolulatis (usque ad 1.5 cm) marginibus integris vel parum undulatis; venulis lateralibus fertilibus 7–10 per 3 cm; venulis lateralibus sterilibus 6–7 per 3 cm; venulis secundaribus rectis vel leviter sinuatis, 6–8 paribus fertilibus (10 paribus sterilibus) anastomosantibus et venulam excurrentem liberem producentibus, areolis latioribus quam longioribus; costis venulis paginisque utrinque glabris. Sori oblongi vel lunulati, maturitate subconfluenti; sporangiis non setosis.

*Type.*—PANAMA: Pcia. Coclé: El Copé, along gravel road to right before sawmill, 2400 ft, *Antonio 2188* (UC; isotype MO not seen).

*Paratypes.*—PANAMA: Pcia. Coclé: Above El Potroso sawmill at Continental Divide, 1220–1300 m, *Sytsma 1811* (MO); ca. 1.5 mi N of El Copé, ca. 900 m, *Croat 44555* (UC); N of El Copé at Alto Calvario, 800–900 m, *Folson 7951* (TEX). Pcia. Veraguas: Cerro Tute ridge up from former Escuela Agricola, Sta. Fé, 1100–1400 m, *Hamilton & Krager 3981* (MO, UC), 1000–1300 m, *Hamilton & Dressler 3069* (MO, UC).

The nearest affinities of this species are uncertain. In Maxon and Morton's revision (Bull. Torrey Bot. Club 65:347–376. 1938), it will key to *T. nesiotica* (Maxon and Morton) Morton, the type of which is from Trinidad. It differs from this species in the glabrous lamina below and more cuneate proximal pinnae. *Thelypteris cocleana* is also the only member of subgenus *Meniscium* that bears buds in the axils of the distal pinnae. Of the collections seen, only *Croat 44555* lacks such buds. Other Menisciums sometimes have buds in the axils of proximal pinnae.

### *Thelypteris* (*Amauropelta*) *cocos* Smith and Lellinger, sp. nov.
Fig. 3

Rhizoma suberectum 1.5–2.0 cm diam. Frondes fasciculatae 20–60 cm longae. Stipites usque ad 4 cm longi dense pilosuli, pilis 0.2–0.5 mm longis, ad basin paleacei, paleis castaneis lanceolatis usque ad 4 mm longis 1 mm latis sparse ciliatis vel glabris. Laminae ellipticae; pinnis proximalibus 5–10 paribus sensim reductis, pinnis infimis auriculiformibus, 2–5 mm longis; pinnis usque ad 30 paribus, plerumque oppositis vel suboppositis usque ad 7 cm longis 1.4 cm latis ca. 1 mm ad costam incisis; aerophoris nullis; segmentis ad sinum 2–3 mm latis, ad apicem rotundis vel truncatis; venis 5–9 paribus per segmentum; rachidibus et costis abaxialiter dense pilosis, pilis 0.2–1.0 mm longis; laminis chartaceis utrinque pilosulis, pilis 0.1–0.2 mm longis, abaxialiter glandulosis, glandibus numerosis aurantiacis sessilibus. Sori indusiati, indusiis persistentibus, 0.2–0.4 mm diam.; sporangiis glabris.

*Type.*—COSTA RICA: Cocos Island, *Klawe 1480a* (US).

*Paratype.*—COSTA RICA: Cocos Island, 11 Jun 1929, *Fisher s.n.* (US).

This species is a member of sect. *Amauropelta* and appears to be most closely related to *T. nockiana* (Jenm.) Proctor, which is endemic to Jamaica. This is a most surprising relationship phytogeographically, but the characters of the two species are so similar that we see little reason to doubt the affinity. Primarily, *T. cocos* has smaller indusia, longer hairs of more varied length on the costae below, and more numerous scales at the stipe bases. In their glandularity, rather dense, short hairs on the laminae above and below, numerous gradually reduced lower pinnae, and general habit and dissection of the fronds, there are no important differences.

### *Thelypteris* (*Goniopteris*) *crenata* Smith and Lellinger, sp. nov.

Fig. 4

Rhizoma breviter repens, ad apicem paleaceum, paleis dense stellato-hirsutis, pilis 0.1 mm longis. Frondes 60–90 cm longae monomorphicae. Stipites laminas aequantes vel parum superantes, brunneoli 2–4 mm diam. glabri. Laminae pinnatae, segmentis terminalibus conformibus, pinnis lateralibus 4–7 paribus, 10–18 cm longis 1.4–2.6 cm latis, ad basin cuneatis vel subintegris, ad apicem acuminatis integris, ad medium latissimis late crenatis, crenis 1–2 mm longis ca. 4.5–6 mm latis; venis 3–7 paribus per segmentum, venis infimis ad angulam acutam vel conniventibus ad angulam latiorem et venulam excurrentem producentibus 1 vel 2 paribus proximalibus ad venulam excurrentem conniventibus ad vel infra sinu; rachidibus abaxialiter glabrescentibus vel leviter pilosis, pilis stellatis 0.1 mm longis; costis abaxialiter glabrescentibus vel sparse pilosulis, pilis simplicibus 0.1 mm longis; laminis utrinque glabris. Sori inframediali, exindusiati; sporangiis glabris.

*Type.*—COSTA RICA: Pcia. Guanacaste: Parque Nacional Rincón de la Vieja, SE slopes of Volcan Sta. María above Estación Hacienda Sta. María, *Davidse et al. 23324* (UC; isotype MO, not seen).

*Paratypes.*—COSTA RICA: Pcia. Guanacaste: Lower slopes of Cerro la Giganta ca. 2 km W of the Río Naranjo, 2600 ft, *K. Utley 1901* (DUKE); Hacienda Sta. María, 20 km NE of Liberia, 700–900 m, *Gômez 19821* (UC), *Dodge & Thomas 6302, 7869* (both GH); same locality as type, *Davidse et al. 23317* (MO).

This species differs from *T. obliterata* (Swartz) Proctor, its closest relative, in the fewer pairs of anastomosing veins, the glabrous or glabrescent costae below, and the glabrous sporangia. In addition, the pinnae of *T. obliterata* are in general somewhat more deeply incised and the pinna bases are not so long-cuneate. *Thelypteris obliterata* is known from southern Mexico to Nicaragua and the Greater Antilles.

### *Thelypteris* (*Amauropelta*) *delasotae* Smith and Lellinger, sp. nov.

Fig. 5

Rhizoma erectum, usque ad 10 cm longum, ad apicem paleaceum, paleis lanceolatis usque ad 1 cm longis 1 mm latis castaneis pilosis. Frondes usque ad 75

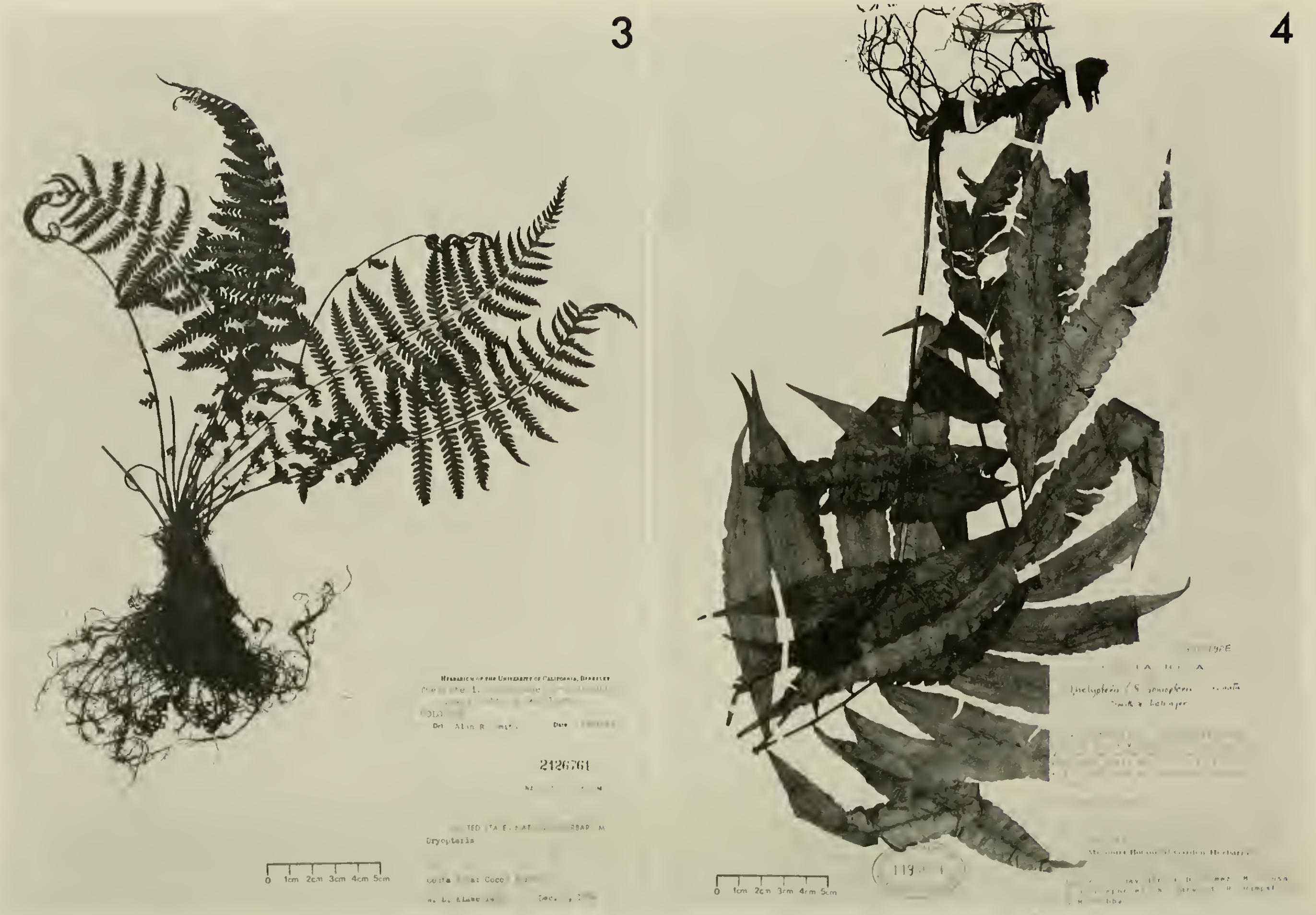

Fig. 3, 4. 3, Holotype of *Thelypteris cocos* Smith and Lellinger, *Klawe 1480a* (US); 4, Holotype of *Thelypteris crenata* Smith and Lellinger, *Davidse et al. 23324* (UC).

cm longae. Stipites 10–35 cm longi 2–4 mm diam., ad basin paleacei, paleis persistentibus eis rhizomatis similibus. Laminae ad basin subabrupte reductae, pinnis deminutis 3–6 paribus; pinnis 20–30 paribus 4–10 cm longis 1.2–2.0 cm latis ca. 1.0–1.5 mm ad costam incisis; aerophoris paxilliformibus aut tuberculiformibus; segmentis ad sinum 3–5 mm latis, ad apicem rotundis vel subacutis; venis plerumque 4–8 paribus per segmentum; rachis costis venis laminisque abaxialiter glabris vel costis interdum pilosulis, pilis antrorsis 0.1–0.2 mm longis; costis abaxialiter leviter paleaceis, paleis lanceolatis vel ovato-lanceolatis usque ad 1.5 mm longis castaneis subclathratis; laminis et costis plerumque leviter dilute caryophyllaceis in sicco. Sori mediali exindusiati, receptaculis non hirsutis; sporangiis glabris.

*Type.*—COSTA RICA: Pcia. Cartago: Hotel Georgina, 2900 m, *de la Sota 5099* (LP; isotype US).

*Paratypes.*—COSTA RICA: Pcia. Cartago: Cerro de la Muerte, 1 km NW of Villa Mills behind Hotel La Georgina, 2900 m, *Mickel 3227* (NY); S slope of Volcán de Turrialba, near the Finca del Volcán de Turrialba, 2000–2400 m, *Standley 35061* (US), *35121* (US). Pcia. Puntarenas: Upper slopes of Cerro Echandi, 2700–3000 m, *Davidse et al. 24000* (MO), *24001* (MO). Pcia. S. José: Near Finca La Cima, above Los Lotes, N of El Copey, 2100–2400 m, *Standley 42745* (US); 15–18 km SE of El Empalme, 2600–2700 m, *Stolze 1372* (F). PANAMA: Pcia. Bocas del Toro: Upper Río Colubre, 2500–3000 m, *Gómez et al. 21902* (MO). Pcia. Chiriquí: 12 mi above Boquete on road to Volcán Barú, 2900–2950 m, *Croat 34883* (MO).

This species is a member of sect. *Lepidoneuron* and is most closely related to *T. euchlora* (Sod.) Reed, known from Colombia to Peru, but differs from that species in the more numerous and persistent rhizome and stipe base scales, the smaller stature, and the costae and rachis above with hairs mostly hyaline, not or only weakly reddish. The two species agree in the general lack of pubescence on the lamina below and a tendency for the lamina to dry pinkish, although this last feature is more pronounced in *T. euchlora.*

### *Thelypteris* (*Amauropelta*) *gomeziana* Smith and Lellinger, sp. nov.

Fig. 6

Rhizoma suberectum vel repens. Frondes 35–105 cm longae. Stipites 7–30 cm longi ad basin paleacei, paleis lineari-lanceolatis, 15 mm longis 1 mm latis brunneis omnino sparse pilosulis. Laminae ellipticae; pinnis proximalibus 3–7 paribus sensim reductis, pinnis abortivis nullis; pinnis 18–30 paribus usque ad 15 cm longis 1.25–2(2.5) cm latis profunde incisis usque ad 0.5–1 mm ad costam; segmentis basalibus saepe productis crenato-lobis, usque ad 5(8) mm latis; aerophoris tuberculiformibus; segmentis ad basin 3–5 mm latis, ad apicem acutis; venis usque ad 9(11) paribus per segmentum adaxialiter prominulis; rachis costis venisque abaxialiter pilosulis, pilis plerumque 0.1–0.3 mm longis erectis; paginis laminarum plusminusve glabris; rachidibus et costis abaxialiter paleaceis, paleis paucis dispersis brunneolis subclathratis; glandulis nullis. Sori rotundati mediali exindusiati; receptaculis setosis; sporangiis glabris.

*Type.*—COSTA RICA: Pcia. Cartago: Páramo de Estaquero, 3200 m, *Gómez 18356* (UC; isotype CR).

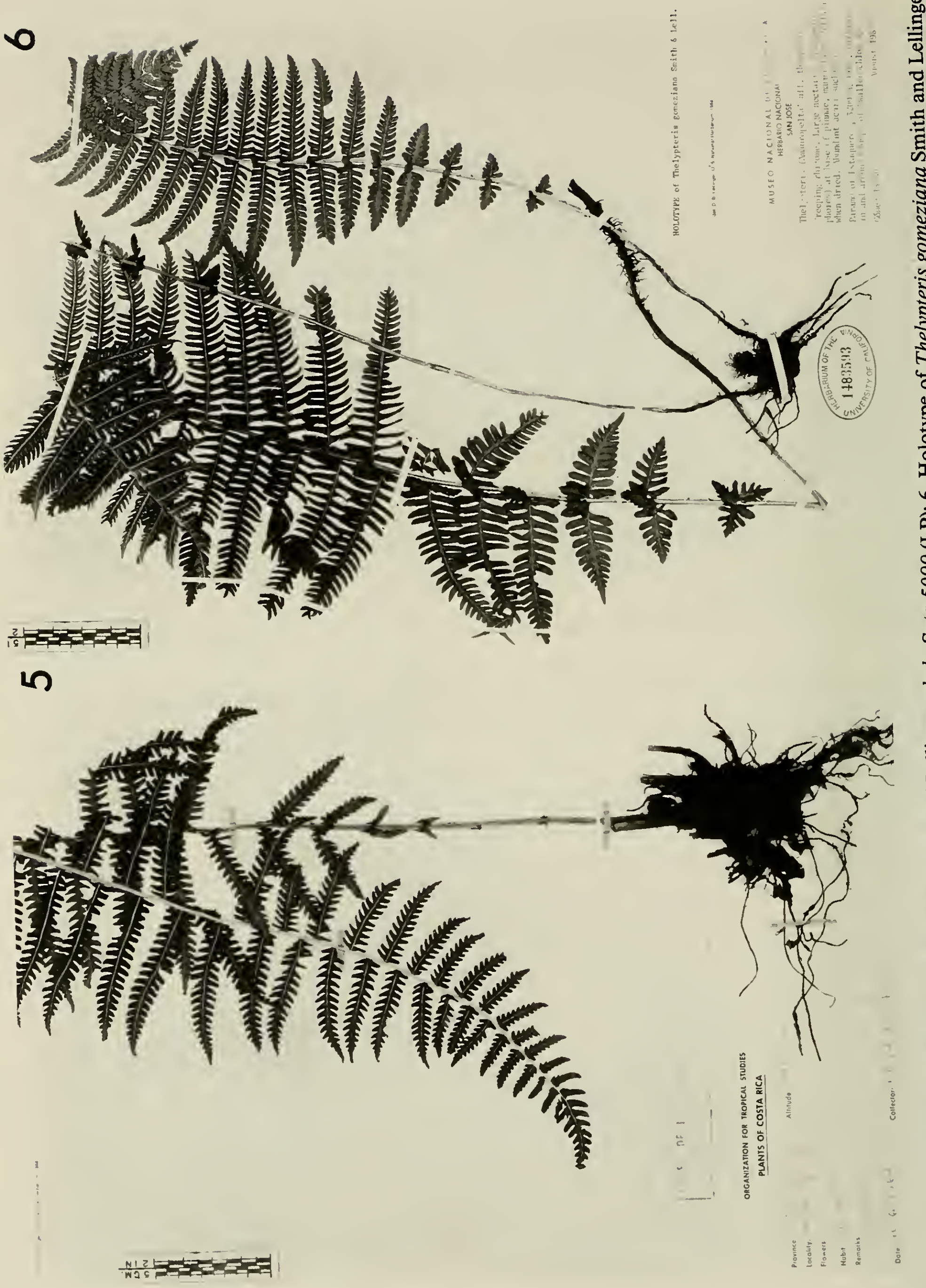

Fig. 5, 6. 5, Holotype of *Thelypteris delasotae* Smith and Lellinger, *de la Sota 5099* (LP); 6, Holotype of *Thelypteris gomeziana* Smith and Lellinger, *Gómez 18356* (UC).

*Paratypes.*—COSTA RICA: Pcia. Cartago: N of Volcán Irazú, 10,000 ft, *Stork 1292* (US); 1 km NW of Villa Mills behind the Hotel La Georgina, 2900 m, *Mickel 3294* (NY, US), *Lellinger 883* (US); 3 km toward Cartago from Millsville, 3000–3300 m, *Holm & Iltis 511* (US). Pcia. S. José: Cerro de las Vueltas, 2700–3000 m, *Standley & Valerio 43885* (US); Near Villa Mills, *Wilbur & Stone 8867* (DUKE, US). Pcia. Limón: Atlantic side of Cerro Chirripó, 10,400–11,000 ft, *Evans & Lellinger 161* (US); Cerro Kámuk, 3350–3550 m, *Davidse et al. 26047* (UC). PANAMA: Pcia. Bocas del Toro: Between Itamut and Bine peaks, Fabrega massif, 3200 m, *Gômez et al. 22523* (UC); 1–2 km WSW of Itamut camp, 3175, *Gômez et al. 22621* (UC). Pcia. Chiriquí: Above El Potrero Camp, Volcán Chiriquí, 2890–3025 m, *Maxon 5336* (US).

This species has been identified in most herbaria as *T. supranitens* (Christ) Reed, but that name has proved to be a synonym of *T. rudis* (Kunze) Proctor. It is closely related to *T. caucaensis* (Hieron.) Alston. A specimen from Volcán Chiriquí (*Killip 5462,* US) also appears to be related, but does not agree in all characters.

### *Thelypteris* (*Goniopteris*) *killipii* Smith and Lellinger, sp. nov.

Fig. 7

Rhizoma erectum usque ad 10 cm longum ca. 5–7 mm in diam. paleaceum, paleis ovatis brunneis pilosulis, pilis stellatis aut furcatis. Frondes monomorphicae 45–80 cm longae. Stipites longitudine ½–⅔ laminas aequantes, 2–4 mm diam. purpureo-brunnei glabrescentes. Laminae anguste lanceolatae, ad apicem acuminatae pinnatifidae; rachidibus egemmiparis dense pilosis et pilosulis, pilis longioribus usque ad 1 mm longis crassis rufobrunneis plerumque simplicibus, pilis brevioribus hyalinis aut rufobrunneis furcatis vel stellatis; pinnis 18–20 paribus usque ad 6 cm longis ad basin 2 cm latis alternis ⅓ incisis, pinnis proximalibus 2 vel 3 paribus leviter brevioribus deflexis anguste ellipticis sessilis; pinnis distalibus lanceolatis ascendentibus falcatis ad basin truncatis; segmentis obliquis plusminusve rectis, ad apicem truncatis aut rotundatis 3–3.5 mm latis, segmentis basalibus (pinnarum distales) paulo elongatis; venis 5–10 paribus per segmentum, 1–2 paribus basalibus ex segmentis contiguis ad sinum conniventibus; costis et venis abaxialiter pilosis et pilosulis, pilis longioribus rufobrunneis plerumque simplicibus, pilis brevioribus hyalinis; paginis laminarum venisque glabris non verrucosis. Sori mediali indusiati, indusiis rufobrunneis setosis persistentibus; sporangiis glabris.

*Type.*—COLOMBIA: Depto. El Valle: Wooded cliffs along the Río Dagua, Dagua Valley, 80–100 m, *Killip 5038* (US; isotypes COL, GH, NY, UC, US).

This species is most closely related to a few others with stout, reddish hairs, especially to *T. curta* (Christ) Reed from Costa Rica and Ecuador, from which it differs in the leaf tissue on the adaxial surface lacking appressed, dense hairs, in the narrow laminae with lanceolate, falcate distal pinnae, and in the almost complete lack of short, hyaline, stellate hairs underlying the long, stout reddish hairs on the costae below. A collection from Bahía Solano, Depto. Chocó, Colombia (*Killip & Garcia 33511,* US) is most like *T. curta,* although in its narrow blades it varies slightly in the direction of *T. killipii.*

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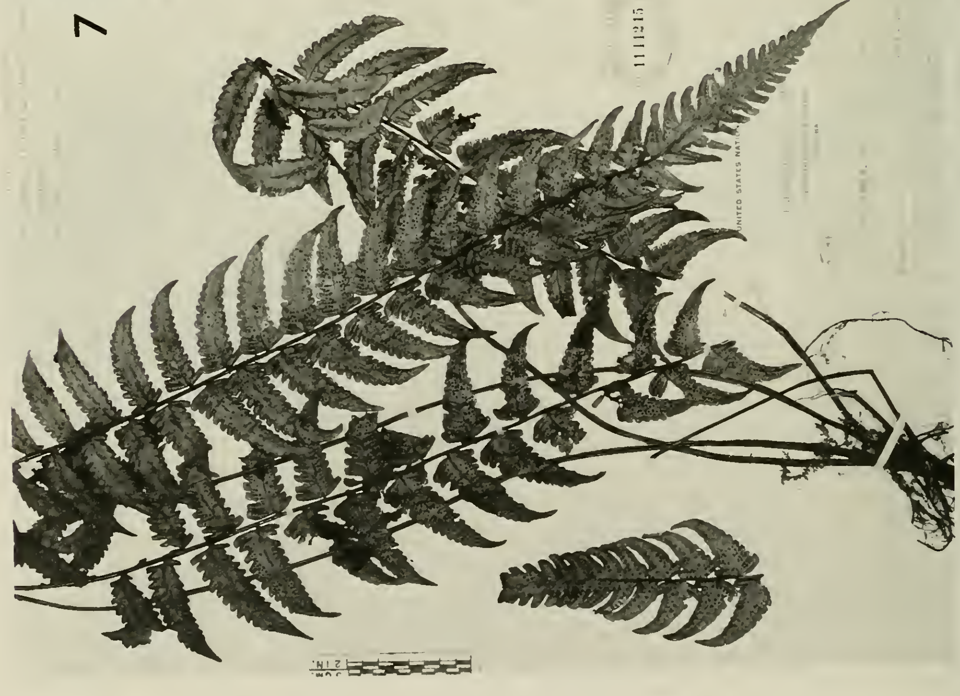

Fig. 7, 8. 7, Holotype of *Thelypteris killipii* Smith and Lellinger, *Killip 5038* (US). 8, Holotype of *Thelypteris ophiorhizoma* Smith and Lellinger, *Lellinger & de la Sota 857* (US).

### *Thelypteris* (*Amauropelta*) *ophiorhizoma* Smith and Lellinger, sp. nov.

Fig. 8

Rhizoma scandens elongatissimum 4–6 mm diam. atrobrunneum paleaceum, paleis ovato-lanceolatis, 4–8 mm longis 0.5–0.75 mm latis brunneis sparse ciliolatis. Frondes 60–75 cm longae. Stipites 2–4 mm diam. remoti ad rhizoma adnati strigosi paleacei, paleis eis rhizomatis similibus. Laminae 45–50 cm longae (praeter pinnas abortivas proximales) 11.5–13 cm latae ad basin acutae ad apicem acuminatae; pinnis abortivis 4–8 paribus oppositis vel suboppositis, paribus infimis ad 8–14 cm supra basin stipitis, pinnis 25–35 paribus lanceolatis aequilateralibus usque ad 7 cm longis 1.1 cm latis sessilibus ad basin truncatis ad apicem acuminatis subfalcatis; costis et costulis strigosulis, costis abaxialiter paleaceis, paleis ovatis brunneolis glabris; pilis valde adpressis; venis simplicibus. Sori rotundati submediali exindusiati.

*Type.*—COLOMBIA: Deptos. Chocó and El Valle: At and on both sides of the principal ridge of the Serranía de Los Paraguas, along the trail from El Cairo to Río Blanco, ca. 8 km SW of El Cairo, 2200–2250 m, *Lellinger & de la Sota 857* (US; isotypes COL, CR, HUA, LP).

*Paratypes.*—COLOMBIA: Depto. Cundinamarca, E side of Quebrada Negra, Muchindote Valley 13 km NE of Gachetá, 2800 m, *Grant 9593* (US; isoparatype COL). Depto. El Valle: Finca La Pradera ca. 6 km SW of El Cairo, 2150–2200 m, *Lellinger & de la Sota 809* (US; isoparatypes COL, CR, LP).

This species is a member of sect. *Lepidoneuron* and is closely related to *T. euchlora* (Sodiro) Reed, with which it shares the character of an exceedingly long, scrambling rhizome with spreading scales and distant, adnate stipe bases, and from which it differs in having smaller fronds, a denser indument of appressed hairs on the costae and costules, and a shorter distance between the lowermost abortive pinnae and the stipe base.

### *Thelypteris* (*Amauropelta*) *proctorii* Smith and Lellinger, sp. nov.

Fig. 9

Rhizoma breviter repens. Frondes 50–85 cm longae. Stipites 5–15 cm lati 2–3 mm diam., ad basin sparsim paleacei, paleis 2–4 mm longis usque ad 1.5 mm latis obscure brunneis, pilis dispersis 0.2 mm longis praeditis. Laminae ad basin pinnis 8–12 paribus lenitissime reductis, pinnis infimis vestigialibus ca. 1 mm longis; pinnis usque ad 40 paribus plerumque oppositis vel suboppositis 4–9 cm longis 1.0–1.8 cm latis ca. 1 mm ad costam incisis leviter inaequilateralibus, segmentis basiscopicis productis; segmentis ad sinum 2–3 mm latis patentibus non falcatis saepe revolutis; venis 8–12 paribus per segmentum; rachis costis venis et interdum laminis abaxialiter pilosis, pilis dispersis vel densis plerumque 0.3–1.0 mm longis; costulis et laminis adaxialiter pilosulis, pilis dispersis plerumque 0.2–0.5 mm longis. Sori exindusiati, receptaculis pilosis, pilis caespitosis, aut indusiati, indusiis minutis pilosis; sporangiis glabris.

*Type.*—GUATEMALA: Depto. El Quiche: Valley of the Río de la Violetas, N of Nebaj, 5800–6000 ft, *Proctor 25305* (US).

*Paratypes.*—HONDURAS: Depto. Morazán: Piedra Herrada, W slope of Cerro de Uyaca, ca. 1500 m, *Standley 23678* (F, US), *23685* (F, US). Depto. Comayagua: El Achote, near Siguatepeque, 1500 m, *Standley 56128* (F, US).

Fig. 9, 10. 9, Holotype of *Thelypteris proctorii* Smith and Lellinger, *Proctor 25305* (US). 10, Holotype of *Thelypteris strigillosa* Smith and Lellinger, *Lellinger & de la Sota 858* (US).

This species is a member of sect. *Adenophyllum* and may be most closely related to *T. pilosula* (Mett.) Tryon, which differs in its relatively large indusia, more prominent stipe base scales, short-creeping or suberect rhizome, and stouter hairs on the lamina above. The fronds of *T. proctorii* have an aspect very similar to those of *T. rivularioides* (Fée) Abbiatti, from southern Brazil and adjacent countries. All four collections of *T. proctorii* have been made from bogs or wet meadows, a habitat not common for *Thelypteris.*

### *Thelypteris* (*Amauropelta*) *strigillosa* Smith and Lellinger, sp. nov.
Fig. 10

Rhizoma erectum curtum ca. 5 mm diam., stipitibus multis congestis absconditum. Frondes 15–65 cm longae. Stipites obsoleti 0.5–1.1 mm diam. 7–15 per rhizoma paleacei dense pilosi, paleis lanceolatis 2–6 mm longis 0.3–1 mm latis integris nitidis brunneis sparse ciliatis. Laminae 10–30 cm longae 2–5 cm latae ad basin et apicem gradatim acuminatae; rachibus atropurpureis vel stramineis dense subvillosis, pilis manifeste septatis, ad basin paleaceis, paleis eis stipitum similibus; pinnis 25–55 paribus lanceatis aequilateralibus usque ad 2.3 cm longis 0.8 cm latis sessilibus ad basin truncatis ad apicem plusminusve acutis, marginibus revolutis; costulis laminis receptaculisque strigillosis, pilis laminarum supra appressis acicularibus infra intervenulis uncinatis; venis fuscis simplicibus. Sori rotundati submediali exindusiati.

*Type.*—COLOMBIA: Deptos. Chocó and El Valle: At and on both sides of the principal ridge of the Serranía de Los Paraguas, along the trail from El Cairo to Río Blanco, ca. 8 km SW of El Cairo, 2200–2250 m, *Lellinger & de la Sota 858* (US; isotypes COL, LP).

*Paratype.*—Same locality as the holotype, *Lellinger & de la Sota 863* (US).

This species is a member of sect. *Uncinella.*

### *Thelypteris* (*Amauropelta*) *tapantensis* Smith and Lellinger, sp. nov.
Fig. 11

Rhizoma apparenter erectum vel subscandens exile 2–3 mm diam., ad apicem paleaceum, paleis ovatis appressis brunneolis glabris. Frondes ca. 12–25 cm longae. Stipites 1–6 cm longi, 1.0–1.5 mm diam. glabri. Laminae ad basin pinnis 5–8 paribus gradatim reductis, pinnis infimis 3–5 mm longis auriculiformibus; pinnis usque ad 20 paribus, usque ad 1.3–3.0 cm longis, 0.6–0.9 cm latis, 1–2 mm ad costam incisis; aerophoris tuberculiformibus vel paxilliformibus; segmentis ad sinum ca. 2 mm latis, ad apicem truncatis vel rotundatis; venis usque ad 4 paribus per segmentum; rachidibus costis venis laminisque epilosis et abaxialiter eglandulosis vel costis distaliter sparse pilosis, pilis appressis 0.2 mm longis; costis abaxialiter sparse paleaceis, paleis amorphis brunneolis. Sori indusiati, indusiis magnis oochlamiformibus ad marginem saepe sparse pilosulis, pilis 0.1–0.2 mm longis; sporangiis glabris.

*Type.*—COSTA RICA: Pcia. Cartago: Ca. 10 km S of Tapantí along new road on E slope above the Río Grande de Orosi, 1400–1600 m, *Burger & Stolze 5678* (NY; isotypes CR, GH).

*Paratypes.*—COSTA RICA: Pcia. Cartago: New road from Tapantí, ca. 7 km S of the bridge, 1500 m, *Hauke 420* (NY); Tapantí, *Gómez 570* (CR).

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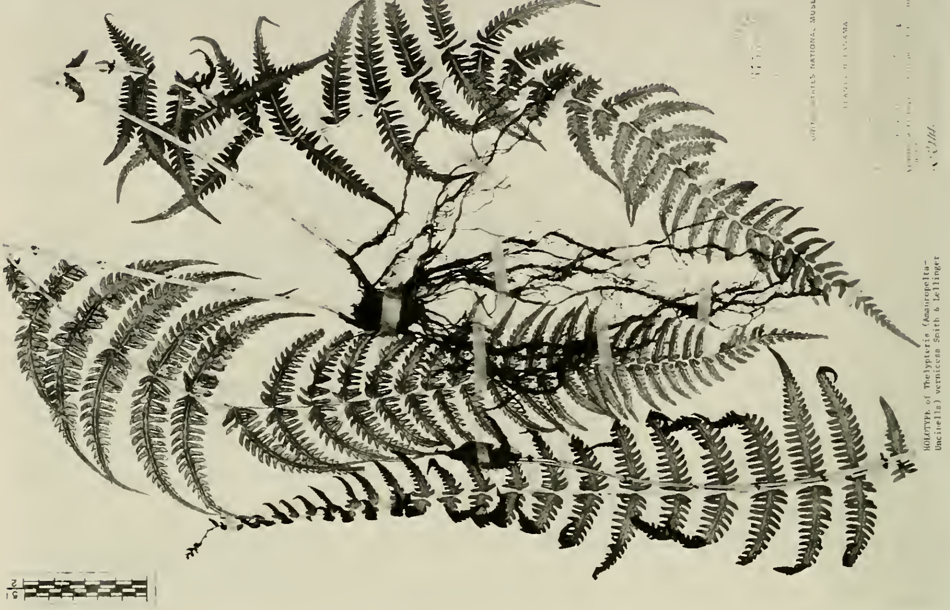

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Fig. 11, 12. 11, Holotype of *Thelypteris tapantensis* Smith and Lellinger, *Burger & Stolze 5678* (NY). 12, Holotype of *Thelypteris vernicosa* Smith and Lellinger, *Maxon 5244* (US).

This diminutive species is a member of sect. *Pachyrhachis* and is most closely related to *T. oaxacana* A. R. Smith and *T. pachyrhachis* (Kunze ex Mett.) Ching. It differs from both by its very small size and filiform rhizome. From *T. pachyrhachis* it also differs in lacking laminar glands. Previous determinations of the type collection include *T. aff. brachypoda* (Baker) Morton and *T. aff. delicatula* (Fée) Proctor, which are similar only in their small stature.

### *Thelypteris* (*Amauropelta*) *vernicosa* Smith and Lellinger, sp. nov.
Fig. 12

Rhizoma suberectum. Frondes usque ad 60 cm longae. Stipites usque ad 5 cm longi, ad basin paleacei, paleis lanceolatis plusminusve patentis ubique pilosis, pilis numerosis hamatis aut acicularibus 0.2–0.3 mm longis. Laminae ad basin pinnis usque ad 8 paribus subgradatim reductis, 5 paribus proximalibus vestigialibus minus quam 2 mm longis; pinnis usque ad 35 paribus distaliter sensim reductis usque ad 7 cm longis 1.6 cm latis, ad costam 1.0–1.5 mm incisis subinaequilateralibus, segmentis basiscopicis brevioribus obliquioribus quam segmentis acroscopicis; aerophoris parvis et tuberculiformibus vel nullis; segmentis ad sinum 2–3 mm latis subobliquis ad apicem falcatis acutis; venis 10 paribus per segmentum; rachis costis laminisque abaxialiter sparse pilosis, pilis hamatis 0.2–0.3 mm longis; laminis adaxialiter glabrescentibus nitidis vel venis pilosis, pilis paucis dispersis acicularibus 0.2 mm longis. Sori exindusiati leviter oblongi mediali; sporangiis glabris.

*Type.*—PANAMA: Pcia. Chiriquí: Vicinity of El Boquete, on dripping, partially shaded cliffs, 1000–1300 m, *Maxon 5244* (US).

*Paratype.*—Same locality, *Maxon 5243a* (US).

This species is a member of sect. *Uncinella* and is closely related to *T. scalaris* (Christ) Alston, which differs in having small but distinct indusia, the laminae above dull and with numerous, minute, acicular hairs, equilateral pinnae, and less oblique pinna segments. The specimen designated as holotype of *T. vernicosa* was determined by Christensen as *Dryoptreris supranitens* Christ, which is not closely related. The paratype cited appears to be a juvenile specimen and was determined by Christensen as a variety of *Dryopteris consanguinea* (Fée) C. Chr., a member of sect. *Amauropelta* confined to the Lesser Antilles.

### *Thelypteris* (*Amauropelta*) *zurquiana* Smith and Lellinger, sp. nov.
Fig. 13

Rhizoma suberectum. Frondes 65–125 cm longae. Stipites ad basin dense paleacei, paleis ovatis 5 mm longis 3 mm latis brunneis glabris. Laminae lanceolatae, pinnis proximalibus 3 paribus reductis et subter 7–10 paribus abortivis, ad 5–15 cm supra basin stipitis extensis; pinnis distalibus ca. 25 paribus, usque ad 13 cm longis 2 cm latis, ad apicem caudatis, ad basin acutis, inaequilateralibus, latere basiscopicis angustiore, ad costam 1–2 mm incisis; aerophoris nullis aut tuberculiformibus usque ad 0.2 mm longis; segmentis ad basin 2–3.5 mm latis, acutis patentibus vel eis latere basiscopicis obliquis; venulis usque ad 10-jugis per segmentum; rachidibus costis venulis et paginis superiore necnon inferiore laminae puberulis (pilis usque ad 0.1 mm longis), glandibus nullis. Sori indusiati, indusiis parvis spathulatis brunneis, marginibus minute pilosulis; sporangiis glabris.

Fig. 13. Holotype of *Thelypteris zurquiana* Smith and Lellinger, *Stolze 1522* (UC).

*Type.*—COSTA RICA: Pcia. S. José: Southern slopes of Cerro Zurquí, 5 km N of S. Luis Norte, 1800 m, *Stolze 1522* (UC; isotype F not seen).

*Paratype.*—COSTA RICA: Pcia. S. José: La Palma area NE of S. Jerónimo above the La Hondura valley, 1500 m, *Burger & Stolze 5277* (F not seen; isoparatype US).

This species is a member of sect. *Blepharotheca* and is most closely related to *T. christensenii* (Christ) Reed, from which it differs in having pinnae with caudate apices and acute bases, more scaly stipe bases, and with more obvious, dark, spathulate indusia.

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# A NEW SPECIES OF *AULODRILUS* BRETSCHER (OLIGOCHAETA: TUBIFICIDAE) FROM NORTH AMERICA

Ralph O. Brinkhurst and Michael T. Barbour

*Abstract.*—*Aulodrilus paucichaeta,* new species, differs from other members of the genus in having no hair or palmate chaetae and no lateral expansions on the bifid chaetae. The chaetae of this species are fewer in number and more robust than those of other species. It is larger in size than the other members of the genus but the reproductive system is clearly that of an *Aulodrilus.* Somatic characters of *A. paucichaeta* superficially resemble those of *Isochaetides curvisetosus,* and it is regarded as distinct from *I. hamata,* which was inadequately described and is best retained as a species inquirenda.

Some years ago the second author collected some unusual tubificid specimens from freshwater tidal marshes in Piscataway Creek, Maryland, a tributary of the Potomac River, downriver of Washington, D.C. These worms resembled members of the genus *Aulodrilus,* but as the reproductive systems of species in that genus badly needed redescription, it was impossible to be sure of the generic status of the material. Since that time, the male ducts of *Aulodrilus* species have been described by Giani et al. (1984), and it is clear that the new material does, in fact, belong in that genus despite its unusually large size and the robust form of the chaetae. Additional material collected in North Carolina has also been examined which, while immature, closely resembles this species.

## Methods and Materials

Specimens were whole mounted in Canada balsam apart from two that were serially sectioned, stained, and mounted in Canada balsam. Two of the whole mounted worms were dissected; the head and tail of a third was preserved in alcohol, but is now missing. Four specimens remain in alcohol.

## *Aulodrilus paucichaeta,* new species
Fig. 1

*Holotype.*—USNM 098228, a slide-mounted specimen.

*Type-locality.*—Freshwater marshes near the confluence of Piscataway Creek and the Potomac River, Maryland, downriver of Washington, D.C. Substrate of sand and detritus, with varying amounts of silt and clay, 3 Oct 1979.

*Paratypes.*—USNM 098229-36, 12 mature and 1 immature specimens, 4 mounted whole on separate slides, 3 dissected and mounted on separate slides, 2 specimens sectioned and mounted on 2 slides each (one of which was destroyed in the mail), 4 preserved whole in alcohol.—Barbour collection, 2 mature and 1 immature specimens on 1 slide, from the type-locality, 18 Jun 1984.—Brinkhurst collection, 1 mature whole mounted specimen from the type-locality, 4 Sep 1984.

*Other material.*—6 whole mounted immature specimens probably attributable to this species, State of North Carolina Department of Natural Resources and Community Development, D. Lenat collection, Mill Creek near Sneads Ferry, Onslow Co., Feb 1984;—Reedy Branch, Faison, Duplin Co., Mar 1982;—Chowan River, Riddicksville, Herford Co., Aug 1982;—Swift Creek, Hilliardston, Nash Co., Aug 1982;—Sandy Creek, Stedman, Cumberland Co., May 1981. All from coastal plains streams, most with a low pH.

*Etymology.*—Worm with few chaetae; the specific epithet being used as a noun in apposition.

*Description.*—Large worms, more than 50 mm long by 1 mm broad even with tail missing (preserved, mounted and flattened specimens), more than 100 segments. Anterior chaetal bundles with 2–3 chaetae each, upper teeth shorter and thinner than lower; chaetae progressively increasing in size from II to IX, usually only 2 per bundle from VI to IX, ventral chaetae missing on mature specimens on IX–X, postclitellar chaetae single (4 per segment) with thick recurved lower teeth. Spermathecal pores lateral in position and one-third back from anterior edge of X, male pores prominant in chaetal line ventrally on XI. Spermathecae spherical, largely filling X, with no detectable ducts; filled with sperm in bundles on mated specimens. Male ducts with large funnels, vasa deferentia at least 2.4 mm long by 0.3 mm wide (dissected specimen) from atrium to ovary, close to (broken off) sperm funnel. Vasa deferentia enter atria apically, close to moderate-sized prostates. Atria small, intimately associated with large, spherical, muscular penial bulbs. Penes wedge-shaped, or almost spherical in whole mounts, enclosed in voluminous penis sacs opening to exterior via broad pores with raised medial edges. Sperm sacs and egg sacs to XIII or XIV. Blood vessels closely coiled in III–V, enlarged blood vessels in VII–IX and especially VIII, closely coiled to XI.

*Habitat.*—Freshwater marsh but tidally influenced; wetland vegetation diverse but dominated by spatterdock (*Nuphar luteum*) and wild rice (*Zizania aquatica*). Substrate sandy, but with varying amounts of silt and clay and detritus. Perhaps also found in coastal plains sandy streams, mostly with low pH.

*Distribution.*—Known from the type-locality near Washington, D.C. and probably from North Carolina.

*Remarks.*—The chaetae of *A. paucichaeta* differ from those of all other species in the genus. This species of *Aulodrilus* lacks hair chaetae as do *A. limnobius* and *A. americanus.* However, *A. limnobius* has up to 10 chaetae per bundle anteriorly, and all the chaetae are small, bifid with reduced upper teeth and bear lateral flanges; *A. americanus* also has up to 10 chaetae per bundle, and has simple pointed chaetae anteriorly and palmate chaetae posterior to VI.

Members of the genus *Aulodrilus* are known to reproduce asexually by fragmentation. Fragmentation appears to be more common in *Aulodrilus* found in temperate regions than in those found in warmer or more tropical climates. Fragmentation may be a compensatory mechanism for less favorable conditions and therefore be influenced by temperature. Sexual maturity in *Aulodrilus* would occur in optimal conditions. It is not known whether *A. paucichaeta* is able to reproduce via fragmentation. Mature individuals of *A. paucichaeta* were not numerous but were found in the months of May, June, and September.

The male ducts of *A. paucichaeta* are similar to those described for all the other species in the genus by Giani et al. (1984). The atria are small, the penis sacs

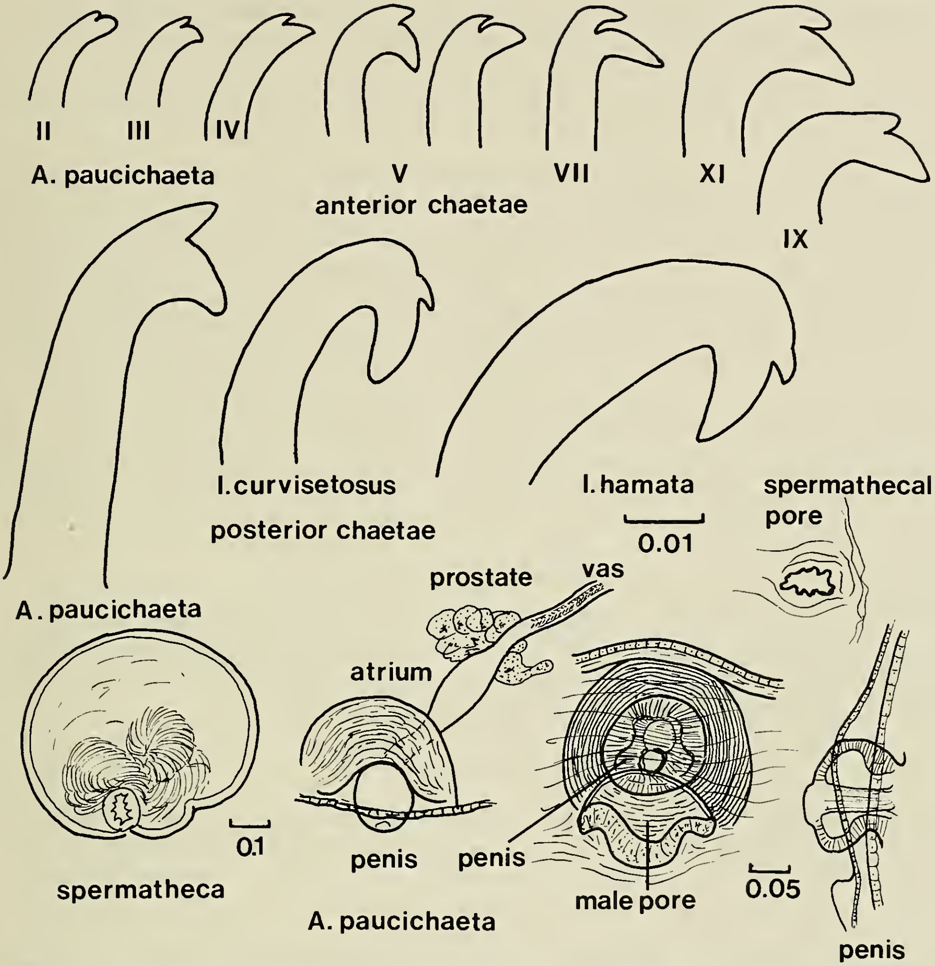

Fig. 1. *Aulodrilus paucichaeta* chaetae and reproductive organs, with posterior chaetae of *Isochaetides curvisetosus* and *I. hamata.*

are large and muscular, and the penes lack cuticular sheaths. The prostate glands are lobed and attached to the atria at one point, and the prostates are not obviously stalked as in most other members of the subfamily Tubificinae. The sperm in the spermathecae of both this species and the other members of the genus *Aulodrilus* are in bundles rather than in spermatozeugmata, which again indicates a degree of separation of this genus from the other tubificines. This characteristic, along with the lack of a cuticular penis sheath and the less clearly stalked prostates may all be taken to be plesiomorphic conditions of these characters, and may suggest that *Aulodrilus* represents a very early descendent of the ancestral tubificine. Giani et al. (1984) discuss these characters in more detail and contend that these characters are not sufficiently different to prevent the merging of the subfamily Aulodrilinae within the Tubificinae.

The only species that could cause any confusion to biologists attempting to identify this species with dichotomous keys would be *Isochaetides curvisetosus*

(Brinkhurst and Cook, 1966). Mature specimens of *I. curvisetosus* differ in having spermathecal chaetae in the ventral bundles of X, and while the ventral chaetae behind approximately XXV are solitary with large lower teeth, they are more strongly recurved than those of the new species, and are accompanied by smaller dorsal chaetae. The description of *I. curvisetosus* in Brinkhurst and Jamieson (1971) is confused by a typographical error that resulted in a line of text being omitted from the manuscript. The chaetae of the species inquirenda *I. hamata* (Moore, 1905) are identical to those of *I. curvisetosus,* and the possibility that these are synonymous has been discussed in the past literature (Brinkhurst and Wetzel 1984). M. S. Loden and W. T. Wassell (pers. comm.) have indicated that the drawings of the male ducts of the type-specimen of *I. curvisetosus* are accurate, but the ejaculatory ducts may have been stretched during dissection, as they appear narrow relative to the atria in a way that differs in other material Loden and Wassell have examined. *Aulodrilus paucichaeta* has male ducts in which the atria taper imperceptibly into the ejaculatory ducts, and the penis sacs are small globular structures at the termination of the ducts. The original description of the penes in *I. hamata* suggests exceedingly long penes but the drawings were said to be diagrammatic and based on partially mature worms (Moore 1905). However, even if there was an error in the description of the penes in *I. hamata,* M. S. Loden has pointed to other significant differences in the blood vascular and digestive system that would prevent him from accepting this synonymy. It seems preferable therefore, to leave *I. hamata* as an inadequately known species unless it is rediscovered, the remaining types all being immature.

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# LARVAL BIOLOGY OF *BRIAROSACCUS CALLOSUS* BOSCHMA (CIRRIPEDIA: RHIZOCEPHALA)

Clayton R. Hawkes, Theodore R. Meyers, and Thomas C. Shirley

*Abstract.*—*Briarosaccus callosus,* a rhizocephalan barnacle hosted by three species of king crabs (*Paralithodes camtschatica, P. platypus, Lithodes aequispina*) in southeastern Alaska, was reared through four naupliar stages and a cyprid stage in the laboratory. The second to fourth naupliar stages have a characteristic dorsal shield and the third and fourth stages have a broader antennule with one less seta than the first and second stages. No other differences were observed in the appendages and setation among the four stages. The cyprid stage developed within 20–29 days at 6 to 8°C. A wide variation in size of cyprids from *P. platypus* and *L. aequispina* hosts may be attributed to sexual dimorphism, with males larger as reported in other Rhizocephala. Based on larval morphology the rhizocephalans hosted by *P. platypus* and *L. aequispina* are considered to be conspecific.

The rhizocephalan *Briarosaccus callosus* Boschma is a widely distributed parasite of many lithodid species (Boschma 1962, 1970; Arnaud and Do-Chi 1977; Somerton 1981; Hawkes et al. 1985). Rhizocephalans are recognizable as Cirripedia only during their larval stages, and the lack of hard parts in adults renders rhizocephalan taxonomy difficult. *Briarosaccus callosus* was assigned to a new genus and species based on the large size of its externa, robust appearance, and cuticular retinacula and thickness of the mantle (Boschma 1930, 1970).

Detailed descriptions of the adult externae of *B. callosus* have been given previously by Boschma (1930, 1962), Boschma and Haynes (1969) and Bower and Sloan (in press). However, the larval stages and the life history of this and many other rhizocephalans have not been described. Boschma (1927) noted that the larval forms of Rhizocephala were of special interest from a taxonomic point of view because of the paucity of useful taxonomic characters in adults. Boschma (1927) reported only a few rhizocephalans in which the larval stages are known, but stated that the different larval morphologies provided sufficient evidence to distinguish species. However, few of Boschma's subsequent taxonomic works included larval descriptions.

Histological examinations of Alaskan king crab parasitized by *B. callosus* have raised dbouts as to whether the parasite is conspecific in all species of lithodid crabs (Sparks and Morado, in press). The barnacle rootlets in parasitized red and golden king crabs, *Paralithodes camtschatica* and *Lithodes aequispina,* are different, perhaps due to the difference in hosts or possibly because they represent two different species of parasites. Blue king crabs, *P. platypus,* have different histological and physiological responses to the parasite than golden king crabs. Golden king crabs also have a much lower rate of multiple infection than blue king crabs (Shirley et al. in press). Whether one or more species of *Briarosaccus* occurs in Alaskan king crabs is potentially important for management strategy of crab populations. Life history information may also help explain why, in southeastern

Alaska, certain populations of *P. platypus* and *L. aequispina* are heavily parasitized while populations of *P. camtschatica,* the red king crab, are not (Hawkes et al. in press).

This report describes the naupliar and cyprid stages of *B. callosus,* other details of the parasite's life history, and addresses the question of conspecificity of specimens from red, blue, and golden king crab hosts.

## Materials and Methods

Parasitized *L. aequispina* (n = 19) from Lynn Canal near Haines, Alaska (59°20'N, 135°20'W), *P. platypus* (n = 19) from Glacier Bay (58°50'N, 135°50'W), and *P. camtschatica* (n = 3) from the Juneau area (58°20'N, 134°30'W) were maintained in separate-flowing sea water tanks. Crabs were tagged for individual identification with a numbered plastic disc (fry tags) glued to the middle of each carapace. Crabs were fed mussels and fish diet, ad libitum.

The maturity of *B. callosus* eggs within externae was monitored every 2–3 weeks by microscopic examination. Eggs were extracted from the outer mantle cavity with a Pasteur pipette inserted through the papilla. When ova contained completely formed nauplii, spawning of the externa was imminent. Crab hosts with prespawning externae were placed in a closed vessel of filtered sea water until the natural extrusion of barnacle larvae occurred. After extrusion, fractional aliquots of larvae from an entire brood were counted to provide an estimate of the number of nauplii in a single spawning. Immediately after spawning, each externa became flaccid from the emptying of the outer mantle chamber. By monitoring ovarian maturity in barnacle externae, estimates were made of brood development and periodicity of release.

During March through July, 1984, *Briarosaccus* larvae from all three host species of king crab were reared in 5 liter glass containers and in petri dishes at ambient sea water temperatures. Water temperature increased from 6 to 8°C during that period of time. Like other rhizocephalans, *B. callosus* larvae are nonfeeding (Yanagimachi 1961b; Ritchie and Hoeg 1981). Specimens of reared larvae were periodically preserved in 10% buffered formalin. Drawings were made of larvae with the aid of a camera lucida mounted on a compound microscope. Measurements were made with an ocular micrometer. At least five nauplii of each stage were dissected and examined to determine the setation formula and possible morphological differences among broods from different host species (Bassindale 1936). The lengths of the dorsal shield and the body, measured from the anterior border to the end of the caudal spine, were determined from a minimum of 30 nauplii of each stage. Mean body lengths of cyprids from each brood were determined from a minimum of 17 larvae. Student's t tests were used to compare mean values ($\bar{x}$) which were given ± one standard deviation. Probabilities less than 0.05 are considered significant and those less than 0.01 are considered highly significant.

## Results

Larvae of *B. callosus* were released from externae as stage I nauplii. Broods of larvae varied in number from $312 \pm 96 \times 10^3$ to $388 \pm 127 \times 10^3$. The time interval between broods was not significantly different ($P = 0.81$) for *B. callosus*

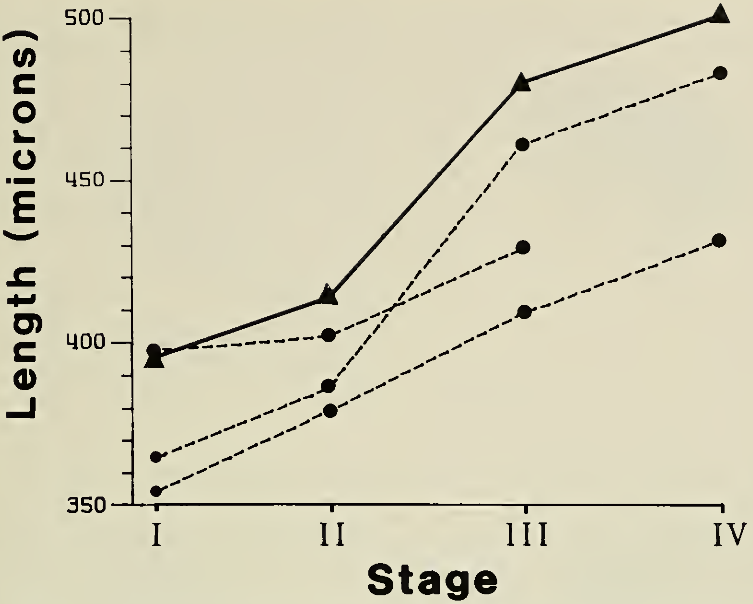

Fig. 1. Mean body lengths of naupliar stage larvae of *Briarosaccus callosus* from broods hosted by one golden (triangles) and three blue king crabs (circles).

infecting blue king crabs (n = 4, 45 ± 5.3 days) and golden king crabs (n = 8, 48 ± 6.2 days) during June to August. Seven different broods were obtained for larval rearing of *B. callosus,* but only three of these were successfully cultured to cyprids. The most successful rearing technique was maintaining small numbers of larvae in petri dishes of sea water.

*Briarosaccus callosus* has four naupliar stages (Fig. 1) before metamorphosis to a cyprid. The nauplii have three pairs of jointed appendages (Fig. 2) and are similar in shape to other rhizocephalans described by Boschma (1927), Reinhard (1946) and Schram (1972). The appearance of the appendages and the numbers of setae on them did not vary in nauplii from the different crab hosts.

The first stage nauplius (Fig. 3*a*) is triangular, with frontal horns directed outward and slightly posteriorly, and has a setation formula of 0.1.1.2.1; 0.5.–0.3.1.G; 0.2.–0.4.0.G. It is nearly colorless, contains numerous fat droplets, has no eye spot, and is similar to the specimens that Boschma (1927) found within the mantle cavity of preserved externae of *Sacculina carcini, S. exarcuata, S. neglecta,* and *Peltogaster gracilis.*

Metamorphosis to the second naupliar stage is usually complete within 24 hours after extrusion from the externa. This stage is slightly larger (Fig. 1), and the horns are directed anteriorly. The larva has an oval-shaped dorsal shield (Fig. 3*b*–*c*), which is easily lost in fixed specimens. This complex structure is marked with ribs forming small diamond-shaped patterns similar to markings reported for other rhizocephalan larvae (Reinhard 1946; Schram 1972). The setation formula for stage II nauplii is the same as for stage I.

Stage III nauplii developed in seven to eight days followed by stage IV in eight to 10 days. Though similar to the second stage these last two naupliar stages are

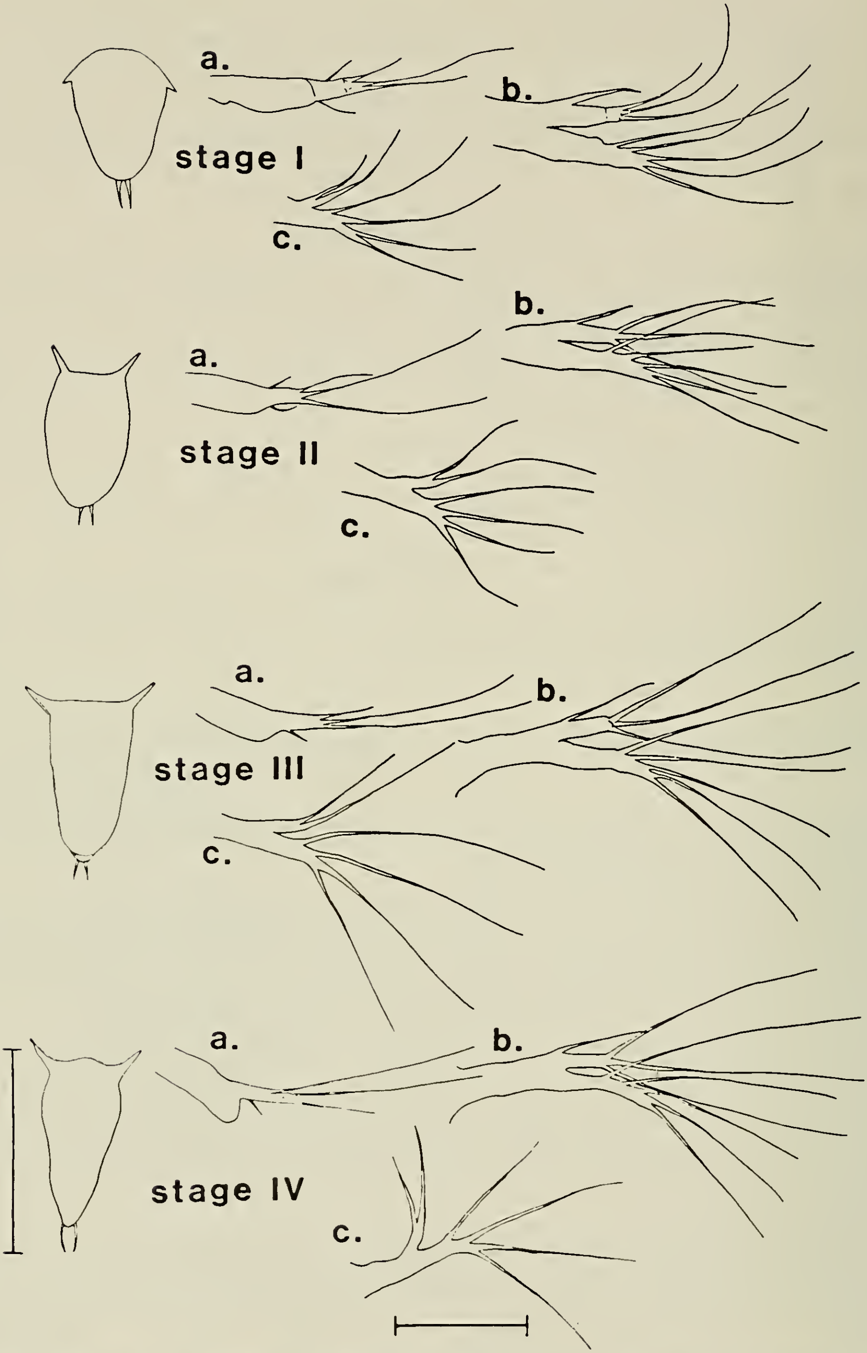

Fig. 2. Body (scale = 500 $\mu$m) and appendages (scale = 100 $\mu$m) of the 4 naupliar stages of *Briarosaccus callosus*; (a) antennule, (b) antenna, (c) mandible.

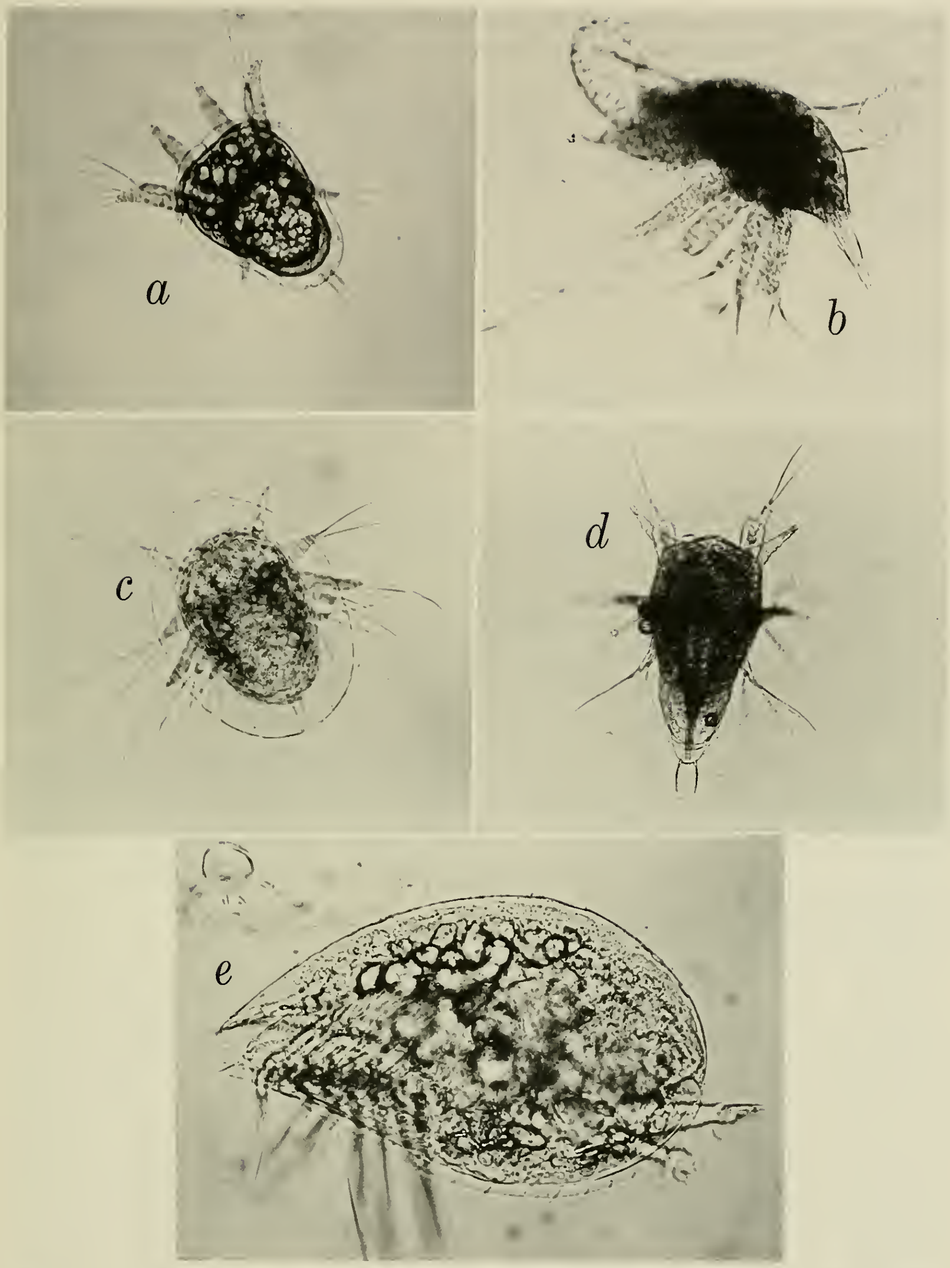

Fig. 3. *Briarosaccus callosus* larvae: *a,* First naupliar stage from a blue king crab host; *b,* Lateral view of second naupliar stage from a golden king crab host; *c,* Ventral view of second naupliar stage from a golden king crab host; *d,* Fourth naupliar stage from a golden king crab host. A developing cyprid is visible in the abdomen; *e,* Cyprid from a blue king crab host.

Table 1.—Naupliar stages of *Briarosaccus callosus*; total lengths for bodies and dorsal shields (carapace) of one brood from a golden king crab and broods from 3 different blue king crabs. Sample size is in parentheses if less than 30.

| | Length (μm) | |
|---|---|---|
| | Body | Carapace |
| Golden king crab | | |
| I | 393 ± 15.5 | |
| II | 413 ± 14.1 | 546 ± 20.0 (16) |
| III | 478 ± 22.7 | 657 ± 16.4 |
| IV | 500 ± 11.1 | 615 ± 11.9 (26) |
| Blue king crab | | |
| I | 351 ± 10.5 | |
| II | 379 ± 7.7 | 476 ± 5.41 (24) |
| III | 410 ± 13.0 | 559 ± 13.1 (9) |
| IV | 437 ± 8.61 | 538 ± 10.6 (22) |
| I | 362 ± 10.2 | |
| II | 386 ± 8.4 | 504 ± 20.7 |
| III | 461 ± 3.05 | |
| IV | 483 ± 9.1 (27) | |
| I | 397 ± 16.8 (21) | |
| II | 400 ± 13.9 | 489 ± 12.5 |
| III | 420 ± 14.6 | |

larger; the antennule is broadened at the base and has one less seta. Consequently, the setation formula for both stages III and IV is 0.1.2.1; 0.5.–0.3.1.G.: 0.2.–0.4.0.G. The dorsal shield becomes slightly smaller between stages III and IV (Table 1). In stage IV the abdomen is more slender and elongate, and the cyprid is visible internally (Fig. 3*d*).

No morphological differences could be found among the larvae of *B. callosus* hosted by the three species of king crab.

Cyprids of *B. callosus* (Fig. 3*e*) were enclosed in a bivalve shell with the antennules projecting beyond the anterior edge. A similar morphology has been reported for other rhizocephalan cyprids (Reinhard 1946; Yanagimachi 1961a). Two of the successful broods were from *P. platypus* hosts (Table 2). Cyprid larvae ($\bar{x}$ = 374 ± 8 μm in length) from one of these broods developed in 29 days at 6 to 7°C while those from the other blue king crab ($\bar{x}$ = 321 ± 12 μm in length) developed in 20 days. This second brood of cyprids remained alive for an additional 16 days at 7 to 8°C. When reared at 4°C, nauplii from this brood only developed to the fourth naupliar stage but survived for 57 days. A third culture of cyprids ($\bar{x}$ = 399 ± 16 μm in length), originating from *L. aequispina*, developed within 25 days at 7–8°C. Cyprid body lengths of all three broods were highly significantly different (Table 2). *Briarosaccus callosus* larvae from a *P. camtschatica* host were successfully reared only to the first naupliar stage ($\bar{x}$ = 387 ± 12.0 μm in length).

## Discussion

Very few reports of larval biology of Rhizocephala exist. Newly hatched nauplii were measured by Yanagimachi (1961a) in *Peltogasterella gracilis* and their sex

Table 2.—Measurements of cyprids, parent externae of *Briarosaccus callosus,* and the respective king crab host.

| | Host | | | Parent externa | | |
|---|---|---|---|---|---|---|
| King crab host | Length (mm) | Weight (g) | Cyprid length ($\mu$m ± SD) | Diameter (mm) | Length (mm) | Weight (g) |
| Golden | 127 | 1110 | 399 ± 15 | 22 | 48 | 21.3 |
| Blue | 115 | 1065 | 374 ± 8 | 26 | 44 | 13.2 |
| Blue | 99 | 556 | 321 ± 12 | 38 | 54 | 17.8 |

determined according to size, with males (250–290 $\mu$m) being larger than females (207–243 $\mu$m). Newly emerged *B. callosus* larvae also varied greatly in size but were larger than larvae of *P. gracilis.* The second to fourth stages of *B. callosus* were similar, having a characteristic dorsal shield similar to *P. paguri* (Reinhard 1946; Schram 1972). However, the stages were not easily differentiated since the size ranges of the body and dorsal shield overlapped slightly. The size difference between male and female was pronounced in all stages. Schram (1970) suggested that the naupliar stages might be recognized by differences in the setation of the appendages. This is certainly true among different species. For example, the setation formulae for the metanauplius of *Peltogaster paguri* (Schram 1972) is different than that for *B. callosus* in the second antenna and mandible. Since setation of the appendages is similar among the naupliar stages of *B. callosus,* it could not be used as a diagnostic character for each instar.

The difference in sizes between the three broods of *B. callosus* cyprid larvae may best be explained by sexual dimorphism (Yanagimachi 1961a; Ritchie and Hoeg 1981; Hoeg 1984) rather than species differentiation, since no morphological distinctions between the nauplii or cyprids were present among broods. Thus, barnacle parasites of blue, golden, and probably red king crabs are considered conspecific. In addition, the periodicity of parasite brood release and seasonality of spawning did not differ between externae on blue or golden king crab hosts, again suggesting that they most likely represent the same species.

The two largest-sized cyprids probably represented male broods while the small-sized brood was probably female. The wide range in sizes may be explained by mixed sex broods as described for *Lernaeodiscus porcellanae* (Ritchie and Hoeg 1981). In *L. porcellanae* a predominance of male cyprids occurred during the winter with females occurring in the summer. Broods of *Sacculina carcini* cyprids have also displayed bimodal size distributions, some broods (< 10%) having mostly one sex with a very small proportion of the other sex (Hoeg 1984). Hoeg (1984) concluded that sex determination of *Sacculina carcini* cyprids is difficult for intermediate-sized larvae because of the small size difference between males and females and because the size of both sexes varied between his two sampling periods (May–June and August).

*Briarosaccus callosus* is the first large cold-water rhizocephalan to have been reared successfully through its free-living larval stages in the laboratory. It is considerably different from other rhizocephalans in its very large externa, larger brood size and larvae, long brood periodicity, and slow larval development rate. *Sylon hippolytes,* a parasite of the prawn, *Spirontocaris lilljeborgi,* in southern Norway, has a much smaller externa with two mantle openings that releases only one brood averaging 100,000 larvae during its life cycle (Lützen 1981). These larvae are in the cyprid stage at emergence and all are approximately equal in length (170 μm) (Lützen 1981). *Clistosaccus paguri,* a rhizocephalan on the hermit crab, *Pagurus bernhardus,* releases cyprids monthly which are similar to those of *S. hippolytes* in size and appearance (Hoeg 1982). *Peltogasterella gracilis* releases broods of nauplii every two weeks, that become cyprids in about five days at 20°C (Yanagimachi 1961a). These cyprids have longer body lengths and may be sexed according to size (males = 295–336 μm, females = 235–275 μm). This is also true for *L. porcellanae* from California which every 10–14 days releases a brood of a few hundred to approximately 20,000 nauplii which complete development to cyprids in three to five days (Ritchie and Hoeg 1981). Cyprids of *Sacculina carcini* are also similar in size (239–268 μm) and life history (Hoeg 1984). *Peltogaster paguri* produces broods every 30 to 40 days that range in number from 9,800 to 28,000 nauplii (Reinhard 1942b).

The longer larval devleopment in *B. callosus* has implications for its life history. A longer planktonic existence decreases chances for larval survival. The larger brood partly compensates for this and also affords a greater potential for dispersal of larvae to new areas. The latter point may help explain the widespread distribution of this parasite (Boschma 1962).

Although the complete life history of *B. callosus* is still not known, analogies with other rhizocephalans are useful. Ritchie and Hoeg (1981) determined that the smaller female *L. porcellanae* cyprids entered the branchial chambers of the crab host and attached to a gill lamella where metamorphosis from cyprid to kentrogon began immediately. The kentrogon developed a hollow stylet on its ventral side which punctured the host tissues and injected a small mass of cells. These cells proliferated, becoming the female interna and its external reproductive system, the externa. Newly emerged virginal externae do not reach sexual maturity unless hyperparasitized or fertilized by the larger male cyprids (Reinhard 1942a; Yanagimachi 1961a; Ritchie and Hoeg 1981; Hoeg 1984). Yanagimachi (1961a) demonstrated that the sex of larvae is genetically determined in *Peltogasterella gracilis,* since eggs as well as newly hatched nauplii occurred in two sizes which differed in their sex chromosomes. He also provided evidence of the settling sites for large and small cyprids. It is very probable that *B. callosus* has the same reproductive pattern. Two blue king crabs which had no external indication of parasitism were discovered to be parasitized only after necropsy. The rudimentary development of the interna near the gills supports the contention that the gill is the site of invasion. A virginal externa (11 mm total length) on a *P. platypus* did not increase in size over a 5 month period. The larvae of *B. callosus* were also of different sizes, indicating sexual dimorphism. The life history of *B. callosus* is still speculative until infection experiments can be conducted with host crabs.

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# *HETEROMYSOIDES DENNISI,* A NEW MYSIDACEAN CRUSTACEAN FROM CEMETERY CAVE, GRAND BAHAMA ISLAND

Thomas E. Bowman

*Abstract.—Heteromysoides dennisi,* the fifth species of the genus, is described from Cemetery Cave, a blue hole on Grand Bahama Island. It is characterized by having a spiniform process on the eyestalk and lacking a telsonic fissure.

The genus *Heteromysoides* was established by Băcescu for species of Heteromysini that differed from *Heteromysis* in having the cornea reduced and restricted to the distolateral part of the eyestalk, male lobe of antenna 1 represented by a pustulate knob armed with few or no setae, and pleopods not sexually dimorphic. The genus originally contained *H. cotti* (Calman, 1932) from a marine cave on Lanzarote, Canary Islands, and *H. spongicola* Băcescu, 1968, from the north coast of Cuba. Two species were recently added: *H. longiseta* Băcescu, 1983, from Heron Island, Australia, and *H. berberae* Băcescu and Müller (1985) from Somalia. A fifth species, the second from a marine cave, is described below.

### *Heteromysoides dennisi,* new species
Figs. 1, 2

*Material.*—Bahamas, Grand Bahama Is., Cemetery Cave, a blue hole located 100 m off the S coast of the island, entrance depth 3–4 m. Specimens collected 330 m in from entrance at a depth of 17 m by Dennis Williams, 15 Sep 1984: ♂ holotype (USNM 222426) and 14 paratypes (USNM 222427).

*Etymology.*—Named for Dennis Williams, in recognition of his leadership in exploring marine caves.

*Description.*—Length up to 2.6 mm. Rostrum evenly rounded; posterior margin of carapace emarginate dorsally, exposing last pereonite. Eyestalk subquadrate; distolateral corner produced into acute process; cornea occupying central half of lateral surface. Telson entire, lacking apical cleft, slightly longer than width at base; distal third with 3 small and 1 large lateral spines, and 2 pairs of apical spines, outer pair twice length of inner pair.

Antenna 1 peduncle, segment 1 longer than segment 3, distolateral process with 3 apical setae; segment 2 short, triangular, with dorsal lobe bearing 2 setae, anterodistal corner with single seta; segment 3 with 3 setae at distolateral corner, 1 dorsal seta near base of outer flagellum, and round lobe between flagella bearing 3 setae. Male lobe pustulate, with 1 long seta.

Antenna 2, length of scale nearly 3.5 × greatest width, without suture separating distal segment; lateral margin slightly concave, medial margin slightly convex. Peduncle composed of 2 broad proximal segments and 3 narrower distal segments; distolateral corner of segment 2 produced into acute spine.

Right mandible incisor 3-cuspate; lacinia subcylindrical, apex produced into 5 cusps; spine-row with 2 spines, 1st simple, second representing 4 spines fused

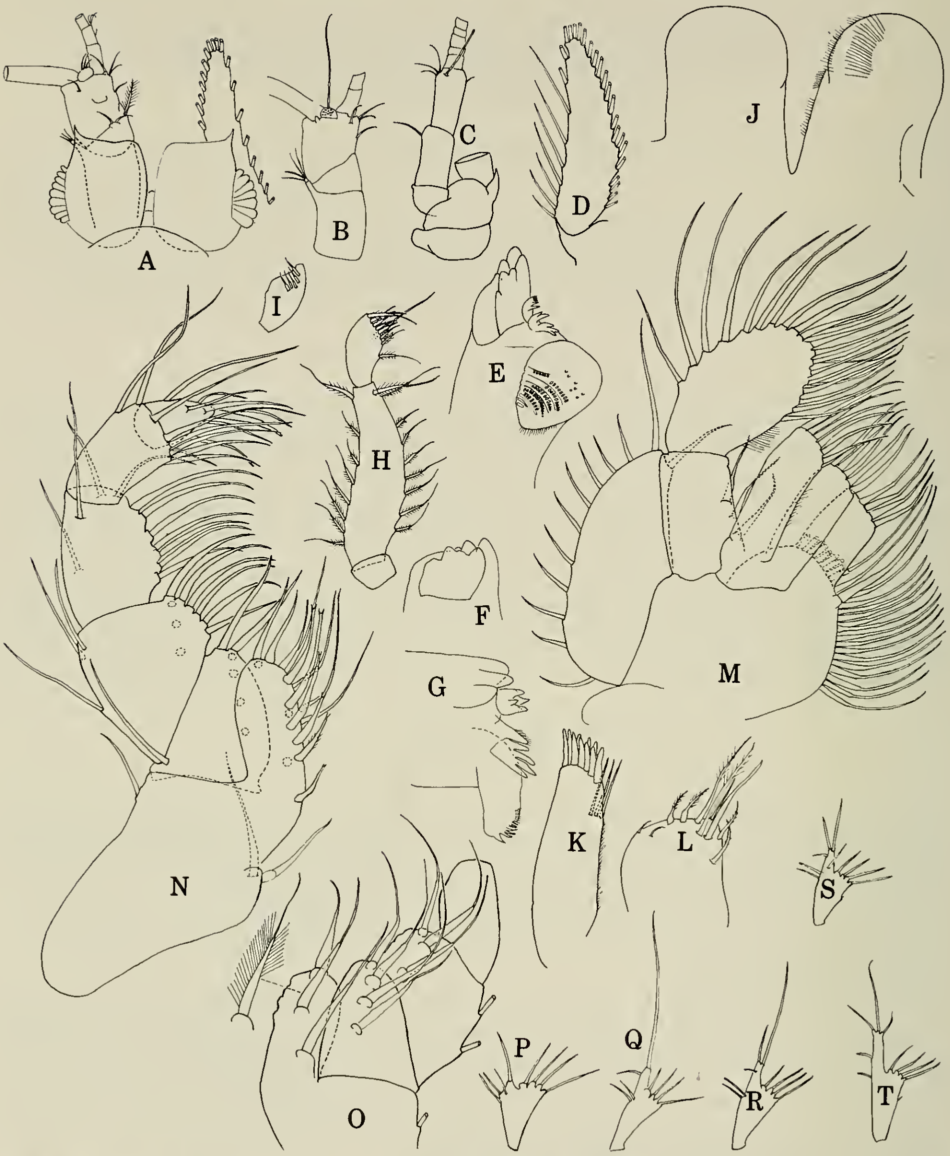

Fig. 1. *Heteromysoides dennisi*: A, Anterior end, dorsal; B, Antenna 1 peduncle, ventral; C, Antenna 2 peduncle, dorsal; D, Scale of antenna 2; E, Left mandible; F, Incisor and lacinia of left mandible; G, Right mandible; H, Mandibular palp; I, 3rd segment of mandibular palp from reverse side, showing surface setae; J, Labrum; K, L, Outer and inner lobes of maxilla 1; M, Maxilla 2; N, Maxilliped; O, Part of maxilliped from reverse side, showing setae with insertions indicated by dotted circles in N; P–T, Pleopods 1–5.

proximally and free apically; molar elongate with marginal hairs and denticles. Left mandible incisor 3-cuspate; lacinia 4-cuspate; spine-row with 3 spines, 1st with denticulate apex, 2nd and 3rd with 2 and 3 apical teeth respectively; molar shorter than in right mandible, grinding surface with rows of nodules. Palp with

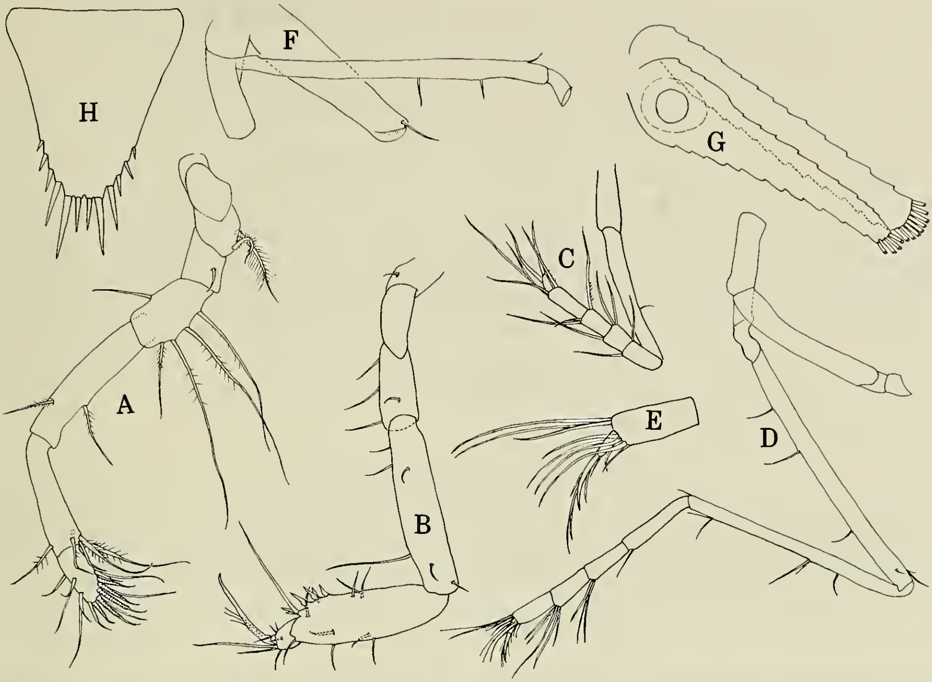

Fig. 2. *Heteromysoides dennisi*: A, Pereopod 1; B, Pereopod 2; C, Pereopod 4; D, Pereopod 6; E, Pereopod 7, dactyl and last "tarsal" segment; F, Penis and proximal segments of pereopod 7; G, Uropod; H, Telson.

very short 1st segment; 2nd segment about 2.5× length of 3rd segment, with row of basally plumose setae on both margins, distal setae much longer than others; 3rd segment widening distally, oblique apex with row of close-set marginal setae, long seta inserted subapically.

Paragnaths short, apically rounded, setation sparse (Fig. 1J).

Maxilla 1 outer lobe with 3 surface setae and about 10 apical spines; inner lobe with 3 long setae and about 7 short setae. Maxilla 2 with well developed heavily setose endites; segments of endopod subequal in length, distal segment broadly oval, heavily setose; exopod reaching distal margin of proximal segment of endopod.

Maxilliped (endopod of thoracopod 1) with well developed endite of basis reaching nearly to distal margin of ischium; medial margins of segments densely setose. Pereopod 1 (endopod of thoracopod 2), merus with 4 long setae on anterior margin; propus with 4 long setae at anterodistal corner; dactyl with marginal plumose setae and longer naked setae. Pereopod 2 propus wider than other segments, nearly ⅓ as wide as long; distal ⅓ of flexor margin with several spines with swollen bases and setae at distal corner about ⅔ as long as propus; claw slender, more than 3× length of rest of dactyl. Pereopods 3–7 long, slender, "tarsus" of 3–5 segments, each with distal cluster of long setae. Penis cylindrical, more than ½ length of merus of pereopod 7, apex with groove and single seta.

Pleopods with 4 setae on pseudobranchial lobes and 2 setae on medial margin. One apical seta on pleopods 1–2, 2 on pleopods 3–4, 3 on pleopod 5. Pleopod 1 apex not reaching beyond pseudobranchial lobe. Apical seta of pleopod 2 about 1.8 × length of pleopod body.

Rami of uropod subequal in length. Exopod subrectangular, almost 7 × as long as wide. Endopod tapering distally, nearly 4 × as long as greatest width (across statocyst); without spines in region of statocyst.

*Comparisons.—Heteromysoides dennisi* can be readily distinguished from the four other species of *Heteromysoides* by two easily seen features, a spiniform process at the distolateral corner of the eyestalk, and the absence of an apical fissure in the telson. The other species of *Heteromysoides* have well developed apical fissures armed with marginal denticles. Other distinctive characters of *H. dennisi* are the absence of spines on the uropodal endopod and the well developed endite on the maxilliped. The significance of the latter cannot be properly evaluated, since the structure of the maxilliped is unknown in *Heteromysoides,* except in *H. spongicola,* which lacks an endite.

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# *ISOCHAETIDES COLUMBIENSIS,* NEW SPECIES (OLIGOCHAETA: TUBIFICIDAE) FROM THE COLUMBIA RIVER, OREGON

Ralph O. Brinkhurst and Robert J. Diaz

*Abstract.*—*Isochaetides columbiensis,* new species, is unique in the possession of highly modified chaetae in segment II but otherwise resembles other members of the genus in terms of the form of the male ducts and the possession of modified spermathecal chaetae.

In July 1976 a plant propagation program was begun at the Miller Sands habitat development site in the Columbia River Estuary (Clairain et al. 1978). A benthic biological study was undertaken in August 1980 to monitor the development of the benthic community at this site. The taxonomy of the oligochaetes obtained during the study was determined. The collection from one of the natural reference marshes studied contained a number of interesting species, and among them was a new species of the genus *Isochaetides,* described here.

## Materials and Methods

Samples were obtained in the field by hand digging a 0.05 $m^2$ by 10 cm deep area and screening the sediment through a 500 $\mu$m sieve. Worms were preserved in formalin with rose bengal stain and were subsequently whole-mounted in Canada Balsam. All of the specimens of the new species were found in samples from Snag Island in the Lewis and Clark National Wildlife Refuge.

The type-series of the new species is deposited at the U.S. National Museum (USNM), Smithsonian Institution, Washington, D.C.

## *Isochaetides columbiensis,* new species
Figs. 1, 2

*Holotype.*—USNM 097961, whole-mounted specimen in Canada Balsam.

*Type-locality.*—Snag Island, Columbia River Estuary, Oregon, mid-tide level, Aug 1980, coll. U.S. Army Corps of Engineers staff; 123°37′30″W, 48°15′00″N.

*Paratypes.*—USNM 097962–097969, 8 specimens whole-mounted on 8 slides, 1 specimen with head and tail whole-mounted on one slide, genital region sectioned on another; ROB collection, 4 specimens whole-mounted on one slide and one dissected specimen; RJD collection, 3 specimens whole-mounted on one slide.

*Etymology.*—*Columbiensis* refers to the Columbia River system from which the new species was found.

*Description.*—Worms fragmented, longest fragment 10 × 0.25 mm, 38 segments. Anterior end bluntly rounded with small prostomium; eversible pharynx large, apparently with a spherical diverticulum when inverted, which forms the external mouth when pharynx everted (Fig. 1). All chaetae bifid, no hair chaetae present.

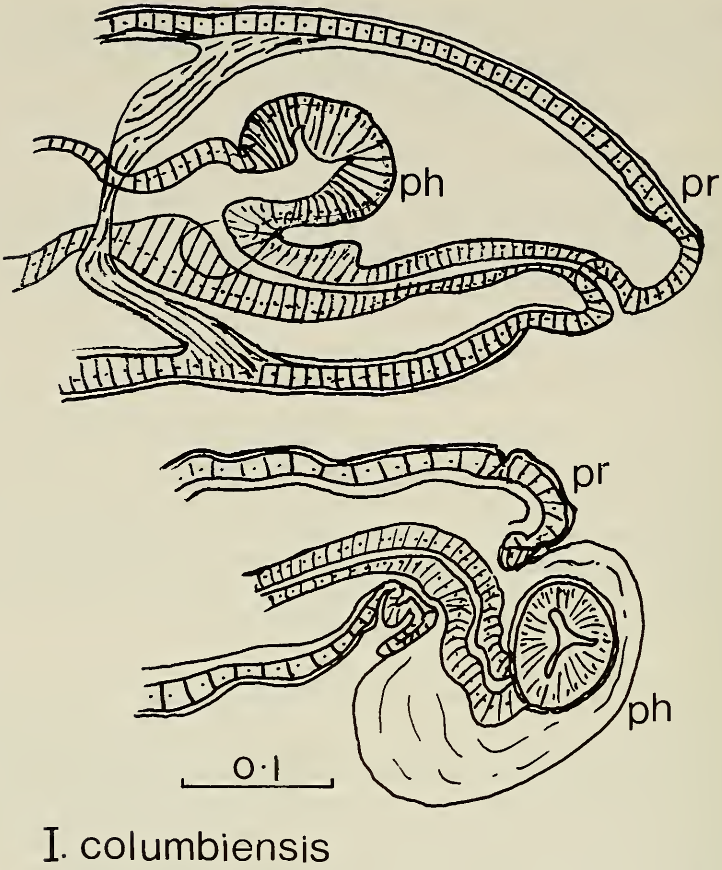

Fig. 1. *Isochaetides columbiensis,* pharynx, everted and retracted condition. ph = pharynx, pr = prostomium.

Chaetae of II, 2–4 per bundle with reduced upper teeth and strongly recurved, thick lower teeth (Fig. 2). In other anterior segments, at first 2 but increasing to mostly 4 and up to 6 chaetae per bundle with upper teeth as thick as but much longer than lower, by VII, teeth approach equal length, but in VIII–IX upper tooth shorter than lower. Ventral bundles of X with single large spermathecal chaetae with large glands.

Postclitellar bundles with 3 chaetae with short upper teeth and recurved lower teeth, these not reaching extreme form of those in II. All somatic chaetal bundles accompanied by small chaetal glands. Spermathecae spherical with short, narrow ducts, spermatozeugmata short and broad. Spermathecal pores beside spermathecal chaetae. Length of vas deferens not observed. Atria appear to be simple widenings of vasa deferentia, with prostates attached near midpoints, ejaculatory ducts quite short and entering small penial bulbs apically (Fig. 2). Penes bearing small penis sheaths.

*Habitat.*—Tidal freshwater marsh, with oligochaetes 93% of the fauna, sediments 56% mud, volatile solids 4.3%, tidal range 1.9 m.

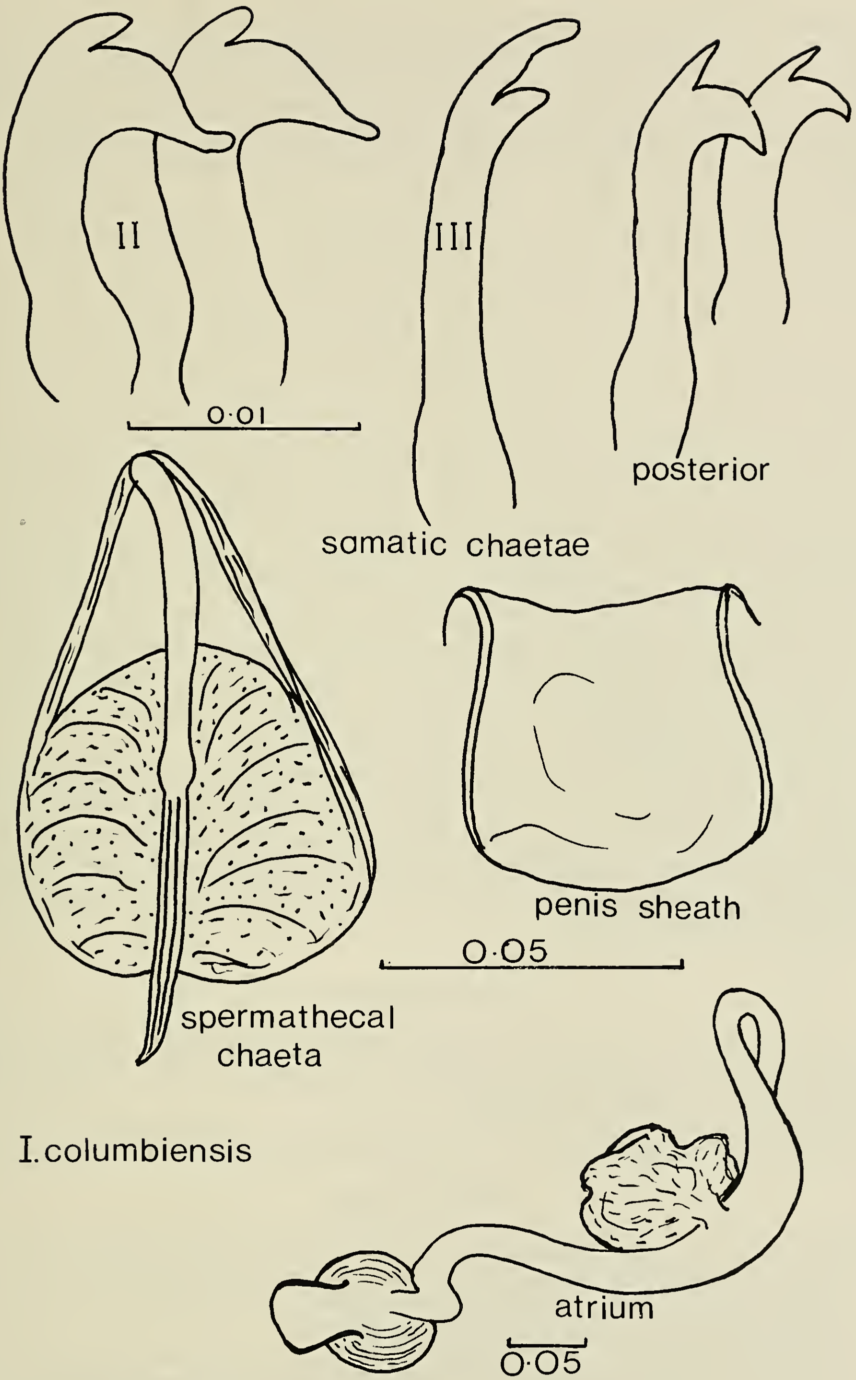

Fig. 2. *Isochaetides columbiensis,* chaetae, male duct and penis sheath.

*Distribution.*—Known only from the type-locality.

*Remarks.*—The genus *Isochaetides* was emended by Brinkhurst (1981) and now contains a number of taxa, mostly poorly known, that have modified spermathecal chaetae, bifid somatic chaetae, and penis sheaths that are thin if present. The type-species occurs in Lake Baikal, and a recent redescription (Brinkhurst 1984) suggests that the atria more strongly resemble those of *Tubifex* than had been considered previously, as the vas deferens can now be seen as much narrower than the atrium at the point of union between the two. A similar situation may exist in the holotype of this species, but it is difficult to observe the vas deferens and in the paratype (Fig. 2) the vas deferens appears to taper slowly into the atrium. It is possible that the amount of prostatic secretion present in the upper atrial lining could account for the apparent difference, but as all the material in question consists of mated specimens this seems unlikely. The genus as now constituted is widespread, with another Lake Baikal species and others from Asia, South America and North America and Europe. This new species approaches *I. curvisetosus* and *Aulodrilus paucichaeta* (recently described by Brinkhurst and Barbour 1985), but the modified chaetae of II in the new species and the form of the penis sheath are both diagnostic. The atria of *I. curvisetosus* are probably more like those illustrated here for the new species than they are like the illustration in the original and revised descriptions of *I. curvisetosus* (see Loden 1978). The latter are accurate renditions of what can be seen on the dissected holotype of *I. curvisetosus,* but the ejaculatory duct appears to have been stretched in the process of the dissection and appears too narrow according to new evidence from fresh material (M. S. Loden and W. T. Wassel, pers. comm.).

The fauna at this site is interesting in that three unusual western tubificid species were found (*Limnodrilus silvani, Telmatodrilus vejdovskyi,* and *Varichaetadrilus pacificus*) together with other usual forms (*Bothrioneurum vejdovskyanum, Limnodrilus udekemianus, L. hoffmeisteri,* a *Rhyacodrilus* and a *Spirosperma* species). Non-oligochaete community dominants were chironomid larvae, *Corbicula fluminea,* and saphaerid larvae.

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# CRYPTOCHIRIDAE, THE CORRECT NAME FOR THE FAMILY CONTAINING THE GALL CRABS (CRUSTACEA: DECAPODA: BRACHYURA)

Roy K. Kropp and Raymond B. Manning

*Abstract.*—Cryptochiridae Paulson, 1875, is shown to be a senior synonym of Hapalocarcinidae Calman, 1900.

Until now, most authors have assigned the gall crabs, members of the genera *Cryptochirus* Heller, 1861, *Hapalocarcinus* Stimpson, 1859, *Troglocarcinus* Verrill, 1908, and several others, to the family Hapalocarcinidae Calman, 1900. Manning and Holthuis (1981:250), who summarized the names applied to families of marine brachyuran crabs, cited Calman as author of the family name.

However, a different family group name was used by at least three different authors prior to 1900. O. Paulson (1875:78) introduced the subfamily Cryptochirinae within the family Pinnotheridae for the genus *Lithoscaptus* A. Milne-Edwards, 1862, now a synonym of *Cryptochirus* Heller, 1861. Paulson, who may not have been aware that Heller's account was published before that of Milne-Edwards, actually considered *Cryptochirus coralliodytes* Heller to be a junior synonym of *Lithoscaptus paradoxus,* whereas the reverse is true. Later, F. Richters (1880:159) cited the family Cryptochiridae. He recognized that *Lithoscaptus paradoxus* A. Milne-Edwards, 1862, was a synonym of *Cryptochirus coralliodytes* Heller, 1861, and synonymized the former. He erroneously attributed the family name Lithoscaptidae to A. Milne-Edwards. As pointed out by Manning and Holthius (1981:250), Milne-Edwards used a name in the French vernacular for the family.

E. von Martens, in the *Zoological Record* for 1880, cited the "Cryptochiridae" on p. 30, and noted that Richters had proposed the family but had not characterized it.

Calman (1900:48) recognized that Paulson had used the family group name Cryptochirinae, and, on p. 49, noted "we can only regard these two genera [*Cryptochirus* and *Hapalocarcinus*] as forming a family for the present *incertae sedis,* for which the name Hapalocarcinidae will have to replace Milne-Edwards's "Lithoscaptes," the latter being based on a synonym of *Cryptochirus.*"

The synonymy for the family Cryptochiridae Paulson, 1875, is as follows:

Lithoscaptes A. Milne-Edwards, 1862:F10 [vernacular name; type-genus *Lithoscaptus* A. Milne-Edwards, 1862].
Cryptochirinae Paulson, 1875:77 [type-genus *Cryptochirus* Heller, 1861].
Hapalocarcinidae Calman, 1900:49 [type-genus *Hapalocarcinus* Stimpson, 1859].

The superfamily name (see Bowman and Abele 1982, for a summary of crustacean classification to the family level) becomes Cryptochiroidea Paulson, 1875.

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# ON THE STATUS AND AFFINITIES OF *HYBOMYS PLANIFRONS* (MILLER, 1900) (RODENTIA: MURIDAE)

Michael D. Carleton and C. Brian Robbins

*Abstract.*—The taxonomic status and phylogenetic affinity of *Hybomys planifrons* are reviewed and reassessed. This form, which Miller (1900) named from Mt. Coffee, Liberia, has been treated either as a subspecies of the Central African *H. univittatus,* as a subspecies of the West African *H. trivirgatus,* or as a species as originally described. Based upon principal component analyses of cranial variables, a cladistic evaluation of cranial and dental attributes, standard chromosomal preparations, and distributional information, we conclude that *planifrons* is a distinct biological species. *Hybomys planifrons* inhabits that portion of the West African high forest generally identified as the Liberian forest refuge. It bears closest relationship to *H. trivirgatus,* another West African species whose broader distribution covers high forest west of the Niger River; *H. planifrons* and *trivirgatus* are more distantly related to *H. univittatus,* found only east of the Cross River in Nigeria but extending over much of the great rainforest of Central Africa. New karyotypic information is presented for populations of *univittatus.* The karyotypic and morphological heterogeneity observed among our samples suggests that *univittatus* is a composite of two or more species.

In 1900, Gerrit S. Miller described the murid rodent *Arvicanthis planifrons* from "a damp, densely forested region" on the slopes of Mount Coffee, Liberia, elevation about 400 to 500 feet. He compared the new species, based upon two specimens, to the Central African *univittatus,* a form then placed either in *Mus* or *Arvicanthis.* In his description, Miller remarked upon the external resemblance of *planifrons* to *univittatus,* notably the presence of a black, mid-dorsal line without lateral stripes. However, he detailed numerous cranial differences, including the dorsal profile of the cranium, the depth of the rostrum, size and shape of the zygomatic plate, and robustness of the mandible, and concluded that (1900:642) "The external similarity of this animal to *Arvicanthis univittatus* forms a striking contrast to the distinctness of its cranial characters." Miller indicated that his comparisons to *univittatus* were based upon three specimens from Benito River, Cameroon, but nowhere mentioned *trivirgatus* (Temminck, 1853), another similar species described earlier from the Gold Coast of West Africa and one subsequently linked to the taxonomy of *planifrons.* In all likelihood, specimens of *trivirgatus* were not represented in the USNM collection at the time Miller named *planifrons.*

In the several decades following its description, Miller's *planifrons* seems to have drawn little notice in matters concerning the taxonomy of *univittatus* and *trivirgatus.* Instead attention focussed around the generic distinctiveness of *trivirgatus* and *univittatus* and the level of their interrelationship. Thomas (1910) erected the genus *Hybomys,* type-species *Mus univittatus* Peters, primarily because the arched cranial vault of *univittatus* was quite different from either *Mus* or *Arvicanthis* as he understood them. His diagnosis of *Hybomys* failed to mention *trivirgatus* or *planifrons* or otherwise designate the contents of the new genus. The next year, Thomas (1911) diagnosed *Typomys*, type-species *Mus trivirgatus* Temminck, for the three-striped mice of West Africa then conventionally placed in *Arvicanthis* (Trouessart, 1898). Thomas' frequent contrasts to *Hybomys univittatus* reveal that he considered it and *Typomys trivirgatus* related to some degree, but in the same paper, he also emphasized what he saw as the strong dental similarity of *Typomys* to *Mylomys*. No reference was made to *planifrons*. Ingoldby (1929) questioned the generic separation of *univittatus* and *trivirgatus*, noting the intergradation of characters purportedly differentiating the two as observed in a population from Lagos, Nigeria; his description of these mice as *Hybomys trivirgatus pearsei* formalized that conviction. Hayman (1935) provided exceptions to Ingoldby's assertion about the absence of constant cranial characters distinguishing the three-striped and single-striped mice. Still he acknowledged Ingoldby's arguments for their generic association and listed two series from the Gold Coast as *Hybomys trivirgatus*.

Allen's (1939) checklist of African mammals stabilized the generic contents of *Hybomys* as its morphological limits are perceived today, but the affinity of *planifrons* has since fluctuated in interpretation. Allen (1939) placed *planifrons* as a subspecies of *univittatus*, together with the nominate subspecies and two others, *lunaris* Thomas, 1906, from Mt. Ruwenzori and *badius* Osgood, 1936, from Mt. Cameroon. *Hybomys trivirgatus* contained the nominate subspecies and Ingoldby's (1929) *pearsei*. Allen did not advance his reasons for listing *planifrons* under *univittatus*, but presumably the species' alignments reflected the pattern of striping of the dorsal pelage. Ellerman (1941), too, included *planifrons* as a race of *univittatus* but stated that skulls of *planifrons* were not examined, his arrangement primarily observing Allen's (1939) listing.

Rosevear's (1969) cogent analysis of the *Hybomys* situation in West Africa resulted in the transferral of *planifrons* to subspecific status under *trivirgatus*. Although recognizing the obvious difference in number of dorsal stripes, Rosevear emphasized the many cranial details shared by *planifrons* and *trivirgatus* and concluded (1969:372) that ". . . the skull [of *planifrons*], in size as well as form, is so extremely close to that of typical *trivirgatus* that there seems to be no reasonable probability of two different species being involved." Consequently, Rosevear maintained *planifrons* as a single-striped race of *trivirgatus*, considering it to be "not truly sympatric" with three-striped populations but rather "kept apart by ecological or other factors," and placed *pearsei* in synonomy under *t. trivirgatus*. In his key to African Rodentia, Misonne (1974) distinguished *trivirgatus* and *univittatus* on the configuration of their incisive foramina and remarked that lateral lines may be absent in some specimens of *trivirgatus*, diminishing the value of this pelage character for identification. Thus, Misonne, like Rosevear, aligned *planifrons* as a subspecies of *trivirgatus*, but curiously still listed *univittatus* as occurring in parts of West Africa. As a result of recent field work in West Africa, biologists have again questioned the synonomy of *planifrons* under *trivirgatus* because they have discovered the two forms living close together with little evidence of intergradation (Roche 1971; Coe 1975; Dosso 1975). In his analysis of the Dahomey Gap as a faunal barrier, Robbins (1978) (following Misonne 1974) continued to recognize the single-striped mice of West Africa as *Hybomys univittatus.*

The last paper underscores the zoogeographic importance of reevaluating the affinity of taxa such as Miller's *planifrons* as a basis for understanding patterns of speciation of mammals inhabiting the high forest tracts of West Africa and the Congo Basin. Accordingly, we here review the status and relationship of *Hybomys planifrons* (Miller) and present new information on its morphology, karyotype, and distribution.

*Materials and methods.*—Study specimens consisted mainly of conventional study skins with associated skulls, and to a lesser extent, fluid-preserved whole carcasses, housed in the following museum collections, their acronyms listed in parentheses: American Museum of Natural History (AMNH); British Museum of Natural History (BMNH); Carnegie Museum of Natural History (CM); Field Museum of Natural History (FMNH); Harvard University, Museum of Comparative Zoology (MCZ); and the Smithsonian Institution, National Museum of Natural History (USNM).

In descriptions of the dentition, we have followed Miller's (1912) familiar t-system for the upper molars and Musser's (1981) terminology for the lower molars. Identification of the topographic features of the murid skull generally observes the terminology used in Musser (1981) and Carleton and Musser (1984).

To evaluate size and shape changes of the skull with increasing age and to improve comparability of the population samples, each specimen was assigned to one of five stages of dental wear. Comparative exemplars for the five wear stages were identified for a series of *H. trivirgatus* from Ghana, whose museum numbers are given below.

Stage I: $M^3$ unerupted or, if erupted, then scarcely worn, cusps of $M^1$ and $M^2$ prominent in relief, conical and acute; dentinal lakes of primary cusps isolated by inflexed enamel borders, which are in contact or nearly so (USNM 414482).

Stage II: $M^3$ wholly erupted and exhibiting moderate wear, that is, cusps still elevated with dentine of t8 confluent with t6 but not t4; dentine of chevrons of $M^1$ and $M^2$ confluent yet shape of cusps distinctly outlined by enamel constrictions; t8 of $M^1$ and $M^2$ not united with t6 or t4 (USNM 412823).

Stage III: $M^3$ heavily worn, that is, cusps nearly flat and enamel of t8 and t4 united but their dentinal basins still separated; cusps of $M^1$ and $M^2$ moderately worn and bluntly rounded, their dentine more broadly connected; t8 of $M^1$ and/or $M^2$ continuous with dentine of t6, either through annectant ridge or diminuitive t9, but not t4 (USNM 412813).

Stage IV: Central enamel island present on $M^3$, formed by union of dentine of t4-t5-t6-t8; cusps of $M^1$ and $M^2$ blunt and low but their definition still apparent; dentine of t8 continuous with t6 on both $M^1$ and $M^2$ and with t4 on $M^1$ and sometimes $M^2$ (USNM 412801).

Stage V: $M^3$ "dished out," central enamel lake obliterated; cusp definition of $M^1$ and $M^2$ poorly discernable, coronal surface almost flat (USNM 412822).
Having defined the wear classes based on examples of *H. trivirgatus,* it was discovered that recognition of wear classes (especially discriminating individuals in Stage II versus III) in samples of *univittatus* was sometimes ambiguous because of the stronger development and usual presence of t9. As a result, more attention

was placed on the wear sequence of $M^3$ and the prominence of cusps on $M^1$ and $M^2$ in assigning wear stages to individuals of *univittatus.*

Several measurements of the skin and skull were taken to characterize the morphology of the samples. Total length, tail length, and hindfoot length were extracted to the nearest whole mm from the skin tag. Twelve dimensions of the skull were measured to the nearest 0.1 mm by means of hand-held dial calipers accurate to 0.05 mm. These measurements, their abbreviations as used herein, and their definitions where necessary are as follows: (1) occipitonasal length, OcNL; (2) rostral length, LRos; (3) greatest zygomatic breadth, ZyB; (4) width of zygomatic plate, WZyP; (5) least interorbital width, IoC; (6) postpalatal length, PpL (from the posteromedial border of the basioccipital to the anterior margin of the mesopterygoid fossa); (7) length of hard palate, HPL (from the anterior border of the mesopterygoid fossa to the posterior edge of the incisive foramina); (8) length of incisive foramen, LIF; (9) diastemal length, LDia; (10) alveolar length of maxillary toothrow, LMax; (11) greatest breadth across upper molars, BMls (caliper jaws placed at labial margin of first molars); (12) depth of mandible, DMan (from ventralmost level of the angular process to the top of the condylar process).

In addition to the mensural variables, ten qualitative characters of the dentition and cranium were reviewed and tabulated for the specimen samples. The definition and abbreviation labels of these discrete variables are: (1) presence of a lateral bony strut at the base of the alisphenoid bone (A1St); (2) presence of a t9 on the first upper molar ($t9M^1$); (3) presence of a t9 on the second upper molar ($t9M^2$); (4) presence of an anteromedian cusplet ($AMCM_1$), (5) an anterolabial cusplet ($ALCM_1$), and (6) posterlabial cusplet ($PLCM_1$) on the lower first molar; (7) occurrence of two medial rootlets on the lingual border ($DLnRM^1$) and (8) a single medial rootlet on the labial border ($LbRM^1$) of the first upper molar; (9) occurrence of accessory rootlets on the labial border ($LbRM_1$) and (10) lingual border ($LnRM_1$) of the first lower molar. Tabulation of dental structures was mainly restricted to specimens assigned to wear classes I–IV, while detection of molar roots was mostly confined to individuals in wear classes III–V.

Due to the high incidence of broken skulls and the small number of specimens generally available from a collecting site, localities were combined to achieve sample sizes suitable for statistical analyses. Twelve composite OTUs were so identified and are listed below, together with their sample size and identification code used in figures.

*Hybomys planifrons,* p: Ivory Coast, Liberia, and Sierra Leone, N = 14.
*Hybomys trivirgatus,* t1: Ghana, N = 16; t2: Ivory Coast, N = 22; t3: Liberia, N = 7; t4: Nigeria, N = 10; t5: Sierra Leone, N = 3.
*Hybomys univittatus,* u1: Cameroon, Batanga, N = 17; u2: Cameroon, Eseka and vicinity, N = 15; u3: Cameroon, Lolodorf, N = 23; u4: Gabon, Cap Esterias, N = 9; u5: Zaire, Upper Congo area, N = 17; u6: Zaire, Kivu Prov., N = 21.

Standard descriptive statistics (mean, range, standard deviation, variance, standard error) were derived for the twelve OTUs. One-and two-way analyses of variance were performed to assess the effects of sex and age on nongeographic population variation. In evaluating the age factor, we excluded the youngest and oldest cohorts, the analyses being restricted to specimens in wear classes II–IV. Similarly, we restricted our multivariate analyses to individuals in the same three wear-classes, although this range of classes still introduced significant age variation that might complicate a comparison of samples with dissimilar age profiles. However, we did not feel constrained to correct statistically for possible age differences among our OTUs, since the magnitude of inferred species differences exceeded the intraspecific geographic and nongeographic variation apparent. Principal components were extracted from a variance-covariance matrix and computed using only the 12 cranial variables transformed to natural logarithms. A principal component program was preferred over canonical variate and discriminant function analyses because no a priori designation of groups is required nor assumptions about multivariate normality. In view of some of our small samples sizes, occurrence of multivariate normality is highly suspect. All analytic procedures were carried out using Systat, a series of statistical routines on diskette programmed for microcomputers.

Preparation of chromosomal material, and descriptive terminology for chromosomal morphology follow Patton (1967), except that we include the sex chromosomes in our calculation of fundamental number (FN), given their ambiguous identification in *Hybomys.* Karyotypes of specimens from the following localities were examined.

*Hybomys planifrons.*—Sierra Leone: Meema (USNM 463386 ♀); 10.1 km E Fintonia (USNM 546938 ♀).

*Hybomys trivirgatus.*—Sierra Leone: Belebu, (USNM 463170 ♀).

*Hybomys univittatus.*—Cameroon: 11 km S, 1 km E Bamenda (CM 58832 ♂, 58833 ♀); 6 km S, 5 km E Eseka (CM 58834 ♀). Gabon: Estuaire Prov., 1 km SE Cap Esterias (CM 90809 ♂, 90812 ♂, 90813 ♂). Zaire: Yalosemba (USNM 537813 ♂, CM 86727 ♀).

## Qualitative Character Variation

*External.*—As suggested by the specific epithets *trivirgatus* and *univittatus,* the striping pattern of the dorsal pelage has historically received important attention in the diagnosis and recognition of mice now placed in the genus *Hybomys.* Thomas (1911) emphasized the tri-striped pattern in examples of *trivirgatus* in erecting his genus *Typomys.* And the single, black dorsal line evident in *planifrons* persuaded earlier workers to align it as a West African subspecies of the Congo Basin form *univittatus,* which also possesses but a single mid-dorsal stripe (Allen and Coolidge 1930; Allen 1939; Ellerman 1941). This taxonomic placement was later reversed when investigators attributed greater significance to the cranial similarities of *trivirgatus* and *planifrons* (see below), and consequently viewed *planifrons* as a single-striped race of *trivirgatus* (Rosevear 1969; Misonne 1974). From this perspective, the pattern of dorsal striping was interpreted as variable at the population level and hence unsuitable as a character for species diagnosis and identification. For instance, Misonne (1974:19), who included *planifrons* under *trivirgatus,* stated that "These lines [i.e., lateral lines of *trivirgatus*] may disappear so that they are of little use for identification."

Although some variation obtains, the pelage patterns observed in our West African samples assignable to *planifrons* or *trivirgatus* suggest a greater constancy than previously supposed. Compared to the medial stripe, the lateral ones are paler, sometimes very faint, in specimens of *trivirgatus*; the weakest definition of lateral lines occurs among our Nigerian samples. Nevertheless, a trilinear arrangement of stripes is discernable even in the faintest examples, unlike the complete lack of lateral stripes as observed in true *planifrons.* In addition to the consistency of stripe definition, the medial stripe in *trivirgatus* extends onto the animal's forehead, reaching between the eyes and less commonly onto the rostrum; whereas the mid-dorsal stripe possessed by specimens of *planifrons* usually terminates at the level of their pinnae (Fig. 1), a distinction noted by Rosevear (1969). Aside from the pronouncement of dorsal stripes the ground color of the fur appreciably differs too. In *trivirgatus,* the general appearance of the dorsum is paler, more speckled, and harsher, qualities imparted by the greater predominance of yellow-tipped hairs. In contrast, specimens of *planifrons* contain more reddish-tipped hairs in the dorsal coat, giving them a richer and more uniform dark brown tone. The venters of both forms are more variable, but examples of *planifrons* typically exhibit a stronger suffusion of reddish overlaying dark gray bases, while those of *trivirgatus* have a more yellowish wash with bases of a paler gray. These tonal contrasts are subtler than the stripe differences, yet they reinforce the impression that *planifrons* is something more biologically distinct than a variant of *trivirgatus* that lacks lateral stripes.

In certain respects, populations assigned to *univittatus* display more striking chromatic variations of the fur. The black dorsal stripe (which, in contrast to *planifrons,* usually ends on the nape) may be very faint and virtually undetectable in some individuals. The indistinctness of the stripe seemingly arises in two ways. In one, hairs constituting the stripe itself are paler such that the stripe fades into the dorsum ground color. The two USNM specimens from Uganda, for example, exhibit this condition, but we observed it in individuals from other parts of the range of *univittatus* as well. In the other, the overall darker saturation of the pelage almost matches the black tone of the dorsal line and obscures it. This appearance characterizes the holotype of *H. univittatus badius* Osgood, which possesses a rich dark brown dorsum with a reddish tinge and a similarly colored venter. The underparts of most *univittatus* are some shade of grayish.

Thomas (1910, 1911) reported the number of mammae as 0-2 = 4 or 1-2 = 6 for *univittatus* and 0-2 = 4 for *trivirgatus,* but Rosevear (1969) noted that all female *univittatus* in BMNH have the 1-2 = 6 mammary distribution, and that 0-2 = 4 is characteristic only of *trivirgatus.* Females of *planifrons* also apparently lack anterior pairs; no axillary or pectoral teats were detected on dried skins, and one live-trapped, lactating female from Sierra Leone possessed only two inguinal pairs.

The fifth digit of the hindfoot of *Hybomys* barely exceeds the first in length and extends only to the bases of digits two to four. *Hybomys* possess only five metatarsal pads on the bare plantar surface, a number substantiated in fluid-preserved examples of *planifrons, trivirgatus,* and *univittatus.* The pad missing from the usual muroid complement of six is the lateral one (=hypothenar pad) of the posteriorly placed metatarsal pair. Both Tullberg (1893) and Sanderson (1940) illustrate the hindfoot conformation of *Hybomys univittatus* and accurately depict the number and position of the metatarsal pads.

*Cranial.*—As remarked by Rosevear (1969), the subgeneric archetypes *H.* (*Hy-*

Fig. 1. Dorsal view of skins of: Left, *Hybomys trivirgatus,* adult female (USNM 545624) from Lalehun, Sierra Leone; Right, *Hybomys planifrons,* young adult female (USNM 466767) from Niebe, Ivory Coast.

*bomys*) *univittatus* and *H.* (*Typomys*) *trivirgatus* exhibit such striking conformational differences of their skulls that characterization of the cranium for the genus proves difficult. With this obstacle in mind, the following description of cranial morphology treats first those characters general for the genus, next those that separate *univittatus* from both *planifrons* and *trivirgatus*, and last, traits that provide discrimination of *planifrons* from *trivirgatus*.

The skull in *Hybomys* is medium-sized (occipitonasal length = 31–36 mm) with a rounded, smoothly contoured braincase (Fig. 2). Temporal and lambdoidal ridges are scarcely evident even in old animals. The interparietal is relatively long but narrow, its lateral apices terminating far short of the squamosal-parietal suture. A narrow but distinct bead extends from the frontal-parietal junction just past the narrowest portion of the interorbital constriction and delineates the arcuate supraorbital edges. The zygomatic arches are not bowed laterally but appear parallel over their midsection. The squamosal part of the arches seems to be slung unusually low on the side of the skull, dipping to the plane of the maxillary alveoli (Fig. 3). A weak short ridge extends caudad from the squamosal root of the zygoma. The area covered by the squamosal bone posterior to the root of the zygomatic arch is diminuitive, a condition which suggests a small surface of origin for the temporalis muscle. The rostrum appears relatively long and broad, the anterior nasal tips normally tapering, not broadly expanded. The bullae are medium-sized and otherwise unremarkable; a groove indicating passage of the internal carotid artery scores their anteromedial surface. A large stapedial foramen penetrates the posteromedial wall of the bullae at the petrotympanic junction, but no squamosal-alisphenoid groove exists, nor does a sphenofrontal foramen. This combination of features suggests a carotid circulatory pattern like that typical of other murines, in which the supraorbital branch is lacking and supply of the orbit instead arises from the infraorbital vessel (Bugge 1970; Musser 1982). The triangular-shaped pterygoid fossae are little recessed and border the moderately long mesopterygoid fossa, the palatal end of which is bluntly u-shaped or sometimes bears a medial promontory. Well-defined sphenopalatine vacuities perforate the dorsal walls of the mesopterygoid fossa at the level of the basisphenoid-presphenoid suture. The hard palate is relatively flat and unmarked by ridges and corrugations. The posterior-palatine foramina are usually located in the palatine-maxillary suture and emerge at a point even with the middle of the second molar. The incisive foramina are notably wider at their midsection and strongly convergent anteriorly. The spacious postglenoid foramen is crescentic and sometimes confluent with the middle lacerate foramen or separated from it by a flange of the periotic bone. No squamosomastoid (=subsquamosal) foramen occurs in *Hybomys*. A conspicuously large optic foramen penetrates the orbitosphenoid bone in *Hybomys*, perhaps reflecting their diurnal habits; the opening of the optic foramen is two-thirds to subequal the size of the sphenoidal fissure. The dentary bone lacks a capsular projection on its lateral face, the incisive alveolus terminating about the level of the front edge of the coronoid process.

Rosevear (1969) thoroughly enumerated the trenchant points of contrast distinguishing the "*Hybomys*-type" of skull from that of the "*Typomys*-type," the latter designation applying both to *trivirgatus* and *planifrons*. The dorsal cranial profile is notably arched in *univittatus*, its outline curved symmetrically both

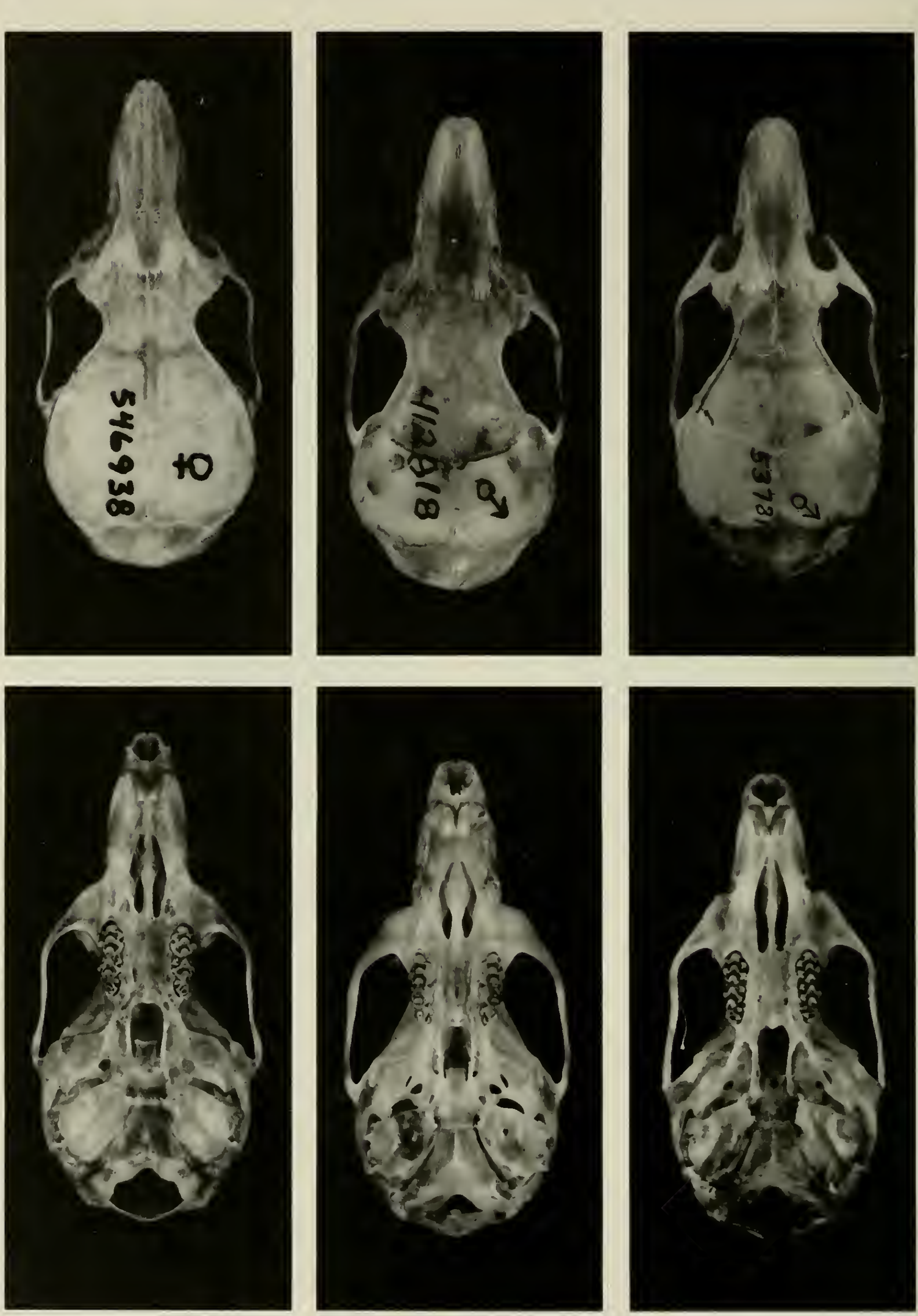
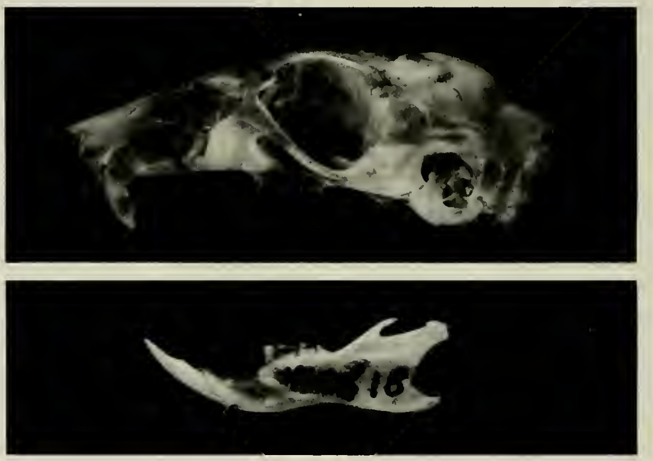


Fig. 2. Dorsal (upper) and ventral (lower) view of skulls of: Left, *Hybomys planifrons,* adult female (USNM 546938) from 10.1 km E Fintonia, Sierra Leone; Middle, *Hybomys trivirgatus,* adult female (USNM 412818) from 1 mi N Berekuso, Ghana; Right, *Hybomys univittatus,* adult male (USNM 537814) from Tandala, Zaire. Approximately 2×.

anteriorly and posteriorly from the apex of the cranial vault located approximately at the midpoint of the orbit (Fig. 3). In *planifrons* and *trivirgatus,* the highest point of the cranial vault is displaced more posteriad, near the rear of the orbit, which imparts a flatter, longer slope to the facial region in contrast to the arcuate curve of the braincase. The rostrum in examples of *trivirgatus-planifrons* is relatively longer but not as deep as that seen in *univittatus.* Moreover, the nasal tips are more attenuate in *trivirgatus-planifrons* compared to rounded in *univittatus.* The anterior ends of the supraorbital ridges recurve laterad in *trivirgatus-planifrons* but terminate parallel to one another in *univittatus,* giving a more hourglass-shape to the interorbital region of the former and cuneate appearance to the latter (Fig. 2). The maxillary portion of the zygomatic arch features several points of dissimilarity. In *univittatus,* the zygomatic plate is broader with a vertical leading edge and deeper zygomatic notch; whereas in *trivirgatus-planifrons,* the zygomatic plate is narrower, its leading edge inclined and the zygomatic notch shallow. In addition, the zygomatic plate seems shifted forward on the skull of *univittatus,* the posterior edge of the plate aligned with the anterior root of the first molar. A line projected along the rear edge of the plate in *trivirgatus-planifrons* intercepts the first lamina of the first molar. The length of the incisive foramen in *univittatus* surpasses that in *trivirgatus-planifrons,* but the difference is more striking in comparisons of *univittatus* and *trivirgatus* skulls (Fig. 2; Appendix 2). The incisive foramina of *trivirgatus-planifrons* appear broader and their ends noticeably converge both anteriorly and posteriorly. *Hybomys univittatus* possess a significantly deeper, more robust mandible, the greater depth especially evident between the condyloid and angular processes (Fig. 3). The more deeply excavated notch above the angular process accentuates the gracile appearance of the mandible in *trivirgatus-planifrons.*

Other authors had previously emphasized the diagnostic value of many of the cranial traits discussed above, particularly the dorsal contour of the skull (Miller 1900; St. Leger 1931), the morphology of the zygomatic plate (Miller 1900; Thomas 1911; Ingoldby 1929), and the size and shape of the incisive foramina (Miller 1900; Thomas 1911; St. Leger 1931; Hayman 1935). In a morphometric study comparing large samples of *univittatus* and *trivirgatus,* Van der Straeten and Verheyen (1982) quantitatively verified the discriminatory power of several of the same variables identified through visual inspection of skulls by earlier systematists.

Still other cranial attributes differentiate *univittatus* from *trivirgatus* and *planifrons.* The cross-sectional area of the optic foramen appears approximately equal to that of the sphenoidal fissure in examples of *trivirgatus-planifrons*; whereas in *univittatus,* the optic foramen is smaller, about two-thirds the size of the sphenoidal fissure. Comparison of the basal portion of the alisphenoid bone discloses another reliable means of separation. Specimens of *univittatus* possess a strut of bone that partitions the combined masticatory-buccinator foramen from the foramen ovale accessorius (Fig. 4). Examples of *trivirgatus-planifrons* usually lack this strut of the alisphenoid. Instead, the spacious opening found represents a coalescence of the masticatory-buccinator foramen and the foramen ovale accessorius. In this condition, the anterior end of the alisphenoid canal and the foramen ovale are visible laterally, their position no longer obscured by the alisphenoid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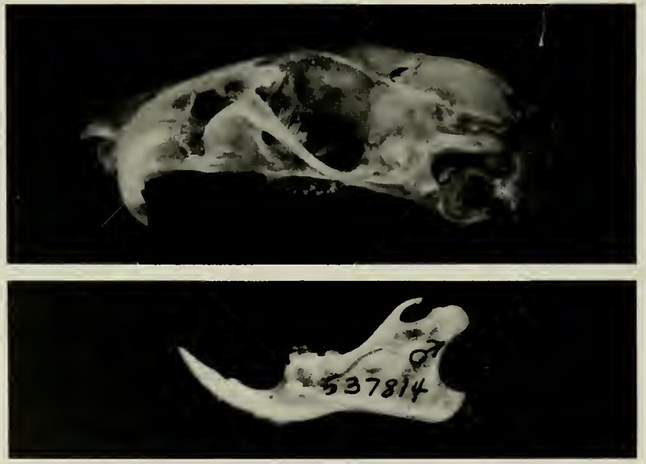
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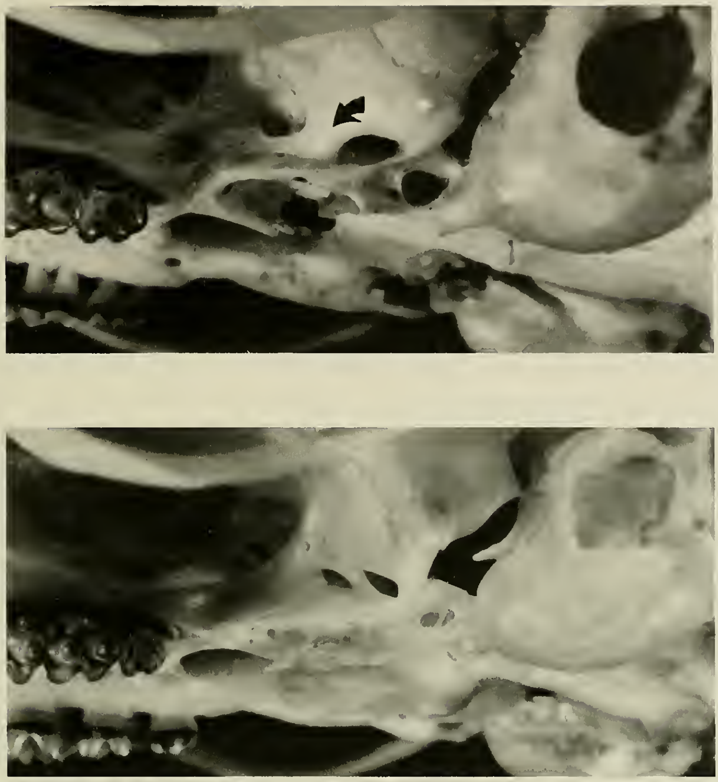

Fig. 4. Ventrolateral view of alisphenoid region of: Top, *Hybomys univittatus* (USNM 101982) from Gabon; Bottom, *Hybomys trivirgatus* (USNM 420628) from 6 mi N Kade, Ghana. Arrow denotes the alisphenoid strut characteristic of *univittatus*. Approximately 5 ×.

strut. The alisphenoid strut was observed in 94% of the specimens of *univittatus* examined, but in only 6.4% of *trivirgatus* and none of *planifrons* (Table 1).

Compared to the suite of cranial features that separate *univittatus* and *trivirgatus-planifrons*, those that discriminate *trivirgatus* from *planifrons* are few and subtler. The interorbital region in *planifrons* appears more constricted and does average smaller than *trivirgatus*, but their ranges overlap substantially (Appendix 2; Fig. 1). The incisive foramina of *planifrons* are broad like those of *trivirgatus*, but unlike *trivirgatus*, the posterior ends of the incisive foramina usually reach the level of the front edge of the first molars and hence are longer (Appendix 2; Fig. 1). This characteristic of *planifrons* illuminates the ambiguities Rosevear (1969) encountered in identifying specimens from certain localities in West Africa (for example, Mt. Bintamane, Sierra Leone), where mice exhibited a *trivirgatus*-

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Fig. 3. Lateral view of skull and mandible of: Top, *Hybomys planifrons*, adult female (USNM 546938) from 10.1 km E Fintonia, Sierra Leone; Middle, *Hybomys trivirgatus*, adult female (USNM 412818) from 1 mi N Berekuso, Ghana; Bottom, *Hybomys univittatus*, adult male (USNM 537814) from Tandala, Zaire. Approximately 2 ×.

Table 1.—Percent occurrence of certain cranial and dental traits in samples of *Hybomys* (sample sizes in parentheses).*

| Species and country | AlSt | T9M$^1$ | T9M$^2$ | AMCM1 | ALCM1 | PLCM1 | LbRM$^1$ | DLnRM$^1$ | LbRM1 | LnRM1 |
|---|---|---|---|---|---|---|---|---|---|---|
| *H. planifrons* | | | | | | | | | | |
| All localities | 0.0 | 5.5 | 0.0 | 0.0 | 0.0 | 25.0 | 0.0 | 15.1 | 0.0 | 9.0 |
| | (34) | (36) | (36) | (36) | (36) | (36) | (33) | (33) | (33) | (33) |
| *H. trivirgatus* | | | | | | | | | | |
| Ghana | 2.8 | 96.7 | 32.2 | 0.0 | 0.0 | 35.2 | 0.0 | 0.0 | 0.0 | 3.6 |
| | (35) | (31) | (31) | (34) | (34) | (34) | (27) | (27) | (28) | (28) |
| Ivory Coast | 2.7 | 85.2 | 23.5 | 0.0 | 0.0 | 23.5 | 6.2 | 3.1 | 0.0 | 0.0 |
| | (36) | (34) | (34) | (34) | (34) | (34) | (32) | (32) | (32) | (32) |
| Liberia | 0.0 | 84.6 | 15.3 | 0.0 | 0.0 | 30.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| | (12) | (13) | (13) | (13) | (13) | (13) | (11) | (11) | (11) | (11) |
| Nigeria | 0.0 | 75.0 | 0.0 | 0.0 | 0.0 | 18.7 | 0.0 | 9.0 | 0.0 | 0.0 |
| | (17) | (16) | (16) | (16) | (16) | (16) | (11) | (11) | (11) | (11) |
| All localities | 6.4 | 86.4 | 22.5 | 0.0 | 0.0 | 26.6 | 2.2 | 2.2 | 0.0 | 1.0 |
| | (108) | (103) | (102) | (105) | (105) | (105) | (90) | (90) | (91) | (91) |
| *H. univittatus* | | | | | | | | | | |
| Gabon | 86.6 | 100.0 | 90.0 | 92.3 | 27.5 | 100.0 | 100.0 | 24.2 | 100.0 | 100.0 |
| | (30) | (41) | (40) | (39) | (40) | (40) | (33) | (33) | (31) | (31) |
| Cameroon | 94.1 | 100.0 | 97.3 | 90.9 | 50.0 | 99.0 | 96.8 | 28.7 | 100.0 | 93.5 |
| | (120) | (114) | (114) | (110) | (110) | (110) | (95) | (94) | (92) | (93) |
| Zaire | 96.3 | 100.0 | 98.9 | 96.6 | 55.0 | 98.8 | 98.8 | 23.8 | 100.0 | 100.0 |
| | (82) | (92) | (92) | (89) | (89) | (89) | (84) | (84) | (85) | (86) |
| All localities | 94.1 | 100.0 | 96.8 | 93.4 | 48.1 | 99.1 | 98.1 | 25.3 | 100.0 | 97.2 |
| | (239) | (253) | (250) | (244) | (245) | (245) | (218) | (217) | (213) | (215) |

* Grand totals for "All localities" include all specimens examined of a species.

like skull but possessed long incisive foramina as seen in *univittatus.* The greater length of the incisive foramina in *planifrons* is reflected in its concomitantly shorter hard palate compared to the longer one recorded for specimens of *trivirgatus.*

*Dental.*—The molars of *Hybomys* are strongly cuspidate, the triserial arrangement of the major cones well-marked even in worn teeth (Fig. 5). The central row of cusps (t2, t5, and t8) in the upper molars of young animals are inclined posteriorly, but this orientation is obscured in older specimens. The cusps of each chevron are united transversely but retain their distinctiveness until extremely worn. The anterior chevron (consisting of t1, t2, and t3) of the first upper molar is isolated from the second (t4, t5, and t6); however, cusps of the second and third (t8 and usually a t9) chevrons are interconnected at their margins. A low lingual ridge joins the t4 to the t8, and the t6 and t8 are united either by a small intermediate t9 or by a thin enamel crest. The cusps composing the first and second chevrons are arrayed almost symmetrically, the t1 and t4 set only slightly posterior to and being slightly larger than their buccal counterparts, the t3 and t6. The second upper molar contains a t1 and diminuitive t3 representing the first chevron, the full complement of t4-t5-t6 of the second, and a large t8 comprising the third (a small t9 is consistently found in some forms). The connections of the t8 to the second chevron are the same as described for the first molar. The third upper molar is approximately one-half the size of the second and exhibits lower cusp height and cusp definition relative to the anterior cheekteeth. A conspicuous t1 is present but unites with the anterolingual border of the t5 after little wear. A definitive t3 is absent but may be represented by an enamel spur extending from the anterobuccal margin of the t5. The second chevron is apparently complete but the individual cusps are broadly connected. The t8 consists of a round to oval heel, which eventually unites with the second chevron to enclose a central enamel island. Posterior cingula are usually absent, but where found, they resemble a minute posterolabial spur off of the t8 and become indiscernible after little wear. A t7 does not occur in the upper molars of the genus *Hybomys.*

The lower molars present a biserial arrangement of cusps that are more confidently homologized to those of a cricetid molar. In the first and second molars, the protoconid-metaconid and hypoconid-entoconid form opposite pairs; the primary cusps comprising each pair unite at their anteromedial borders (Fig. 5). The anteroconid of the first molar is deeply bifurcate, the anterolingual and anterolabial cusps so well defined that they almost match the major cones in prominence. The anterolabial-anterolingual cusps and protoconid-metaconid join medially in an x-shaped configuration, but a deep trough separates the hypoconid-entoconid and protoconid-metaconid. Both first and second molars possess a posterior cingulum, situated at their posteromedial margin. This structure is lower in relief compared to the major cusps; it is conically shaped in younger animals and assumes an oval appearance with wear. As in its upper homolog, the lower third molar displays lower cusp relief and definition. The broad talonid heel of the third molar presumably consists of a fused hypoconid-entoconid; no posterior cingulum is present.

The above description generally characterizes the molar dentition of *Hybomys,* but differences do occur between the named forms with respect to the presence and development of certain minor coronal features. These variations include the

Fig. 5. Upper left (top) and lower right (bottom) molar toothrows of: Left, *Hybomys planifrons* (USNM 546936) from 10.3 km SE Fintonia, Sierra Leone; Middle, *Hybomys trivirgatus* (USNM 481859) from 25 km N Zwedru, Liberia; Right, *Hybomys univittatus* (USNM 535545) from Irangi, Zaire. Arrows indicate the presence of a t9 in the $M^1$ of *trivirgatus* and $M^1$ and $M^2$ of *univittatus*. Approximately 15×.

occurrence and size of the t9 on the first and second upper molars, and the presence of an anteromedial cusplet (AMC), anterolabial cusplet (ALC), and posterolabial cusplet (PLC) on the lower first molar.

A conspicuous, well-defined t9 exists on the first and second molars of all sampled populations of *univittatus* (Figs. 5, 6; Table 1). This cusp is more closely apposed to the t6 than to the t8 and unites with the posterobuccal border of the t6 in early wear stages. Rosevear (1969:371) recognized this condition in *univittatus* and contrasted it with the morphology of West African forms ("*Typomys*-type") as follows: "In $M^1$ and $M^2$ t9 is often (but not always) reduced to little more than a ridge, especially in $M^2$ where the reduction is sometimes so great that the cusp appears to be lacking." This description is adequate, but collation of the occurrence of the t9 among West African populations reveals sharp discontinuity along taxonomic lines. A t9 was observed on the first molar of most individuals (average = 86.4%) of *trivirgatus* examined (Figs. 5 and 6; Table 1). The t9 evident in *trivirgatus* usually does not equal in size and discreteness that found in specimens of *univittatus*; still a noticeable enamel indentation of the labial border of the first molar marks its usual presence. In contrast, a t9 was documented in few individuals of *planifrons* (average = 5.5%), and its development, if present, resembles little more than a bulge of the crest connecting t6 and t8. In such instances, identification of a t9 as present or absent was subjective for examples of both *planifrons* and *trivirgatus.* Whereas a t9 occurs on the second molar of most *univittatus* (96.8% of all samples), its presence is infrequent in *trivirgatus* (22.5%) and unknown in *planifrons.* Among the population samples of *trivirgatus,* the lowest frequency occurrence of the t9 was recorded for the Nigerian series (Table 1).

No distinction between *planifrons* and *trivirgatus* was discovered for the occurrence of the supplemental conulids of the lower first molar, but both differed substantially from *univittatus* (Figs. 5, 6; Table 1). An anteromedian cusplet (AMC) projects from the junction of the anterolabial and anterolingual cusps in over 90 percent of the specimens of *univittatus*; whereas, this trait was not detected in any *planifrons* and *trivirgatus.* The presence of an anterolingual cusplet (ALC) and posterolingual cusplet (PLC) on the buccal cingulum of the lower first molar was frequently tabulated for *univittatus* but never (ALC) or infrequently (PLC) recorded for *planifrons* and *trivirgatus.*

The number of molar roots also provides a reliable criterion for distinguishing *univittatus* from *planifrons* and *trivirgatus.* The typical root formulae observed on the upper and lower molars are as follows (less frequent character state in parentheses): *univittatus*—4(5)/4, 3(4)/4, 3/3; *planifrons* and *trivirgatus*—3(4)/2, 3/3, 3/3.

The disparities in root number arise in a different manner according to the molar and/or species in question, and these variations were scored for the upper and lower first molars only (Fig. 7; Table 1). A small labial rootlet, situated midway to the large anterior and posterior roots, is visible in virtually every suitable specimen of *univittatus* but seldom detectable in *planifrons* and *trivirgatus.* St. Leger (1931) earlier drew attention to this dissimilarity and noted that when a labial rootlet is present in *trivirgatus,* it is located more medially compared to *univittatus.* The five-rooted condition of the upper first molar of *univittatus* and four-rooted variant of *planifrons*/*trivirgatus* occur when the large medial root is subdivided, a trait observed infrequently in all forms. In addition to the large

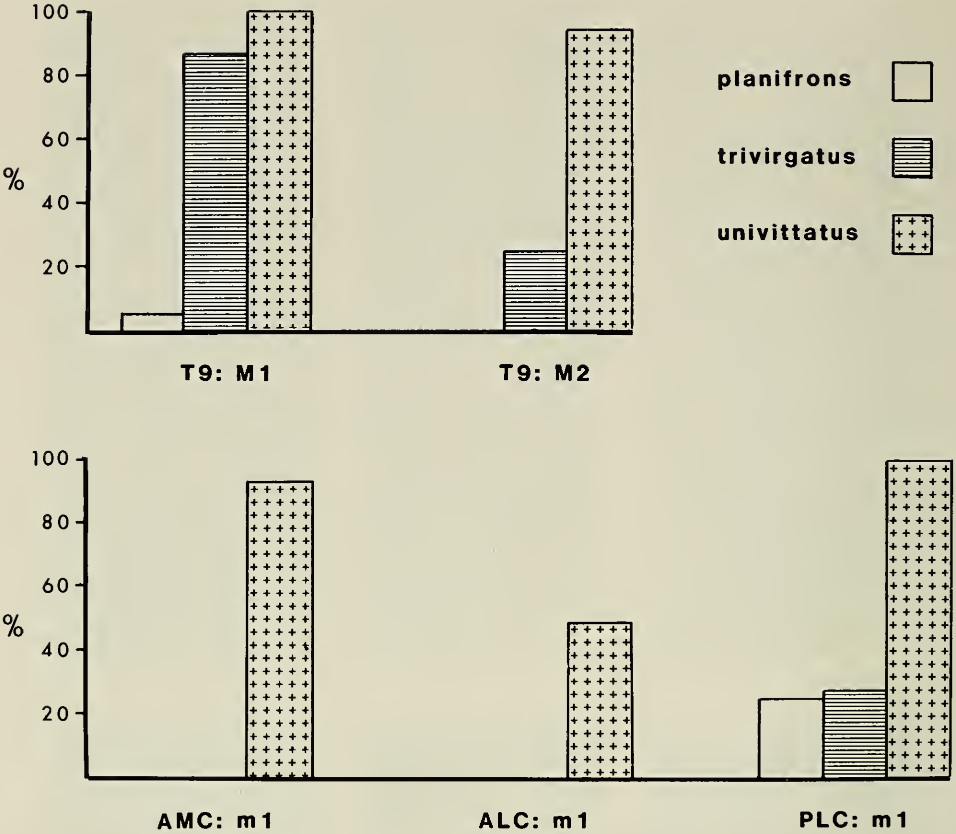

Fig. 6. Histograms illustrating percent occurrence of certain dental traits within three species of *Hybomys* for all specimens examined (see Table 1 for sample sizes and Materials and Methods for identification of character abbreviations).

anterior and posterior roots, satellite rootlets typically anchor the labial and lingual margins of the lower first molars of *univittatus* (hence $M_1$ four-rooted), but not *planifrons* and *trivirgatus* ($M_1$ two-rooted).

## Numerical Analyses

Mice of the genus *Hybomys* display little sexual dimorphism in size, a conclusion supporting the previous finding of Van der Straeten and Verheyen (1982), who critically analysed large homogeneous population samples of *trivirgatus* and *univittatus.* Males did average 0.5 to 1.0 percent larger than females in the majority of cranial dimensions, but the slight disparity did not contribute significantly to deviations from the population mean (Table 2). Only the results for six cranial variables, several of which (for example, OcNL, LRos, ZyB) might be expected to exhibit sexual dimorphism, are given here, but the pattern is typical. We interpret the sole exception of statistical significance, BMls in *planifrons,* as a Type I sampling error, in view of the absence of appreciable sex effects documented for all other dimensions recorded for *planifrons, trivirgatus,* or *univittatus* and in

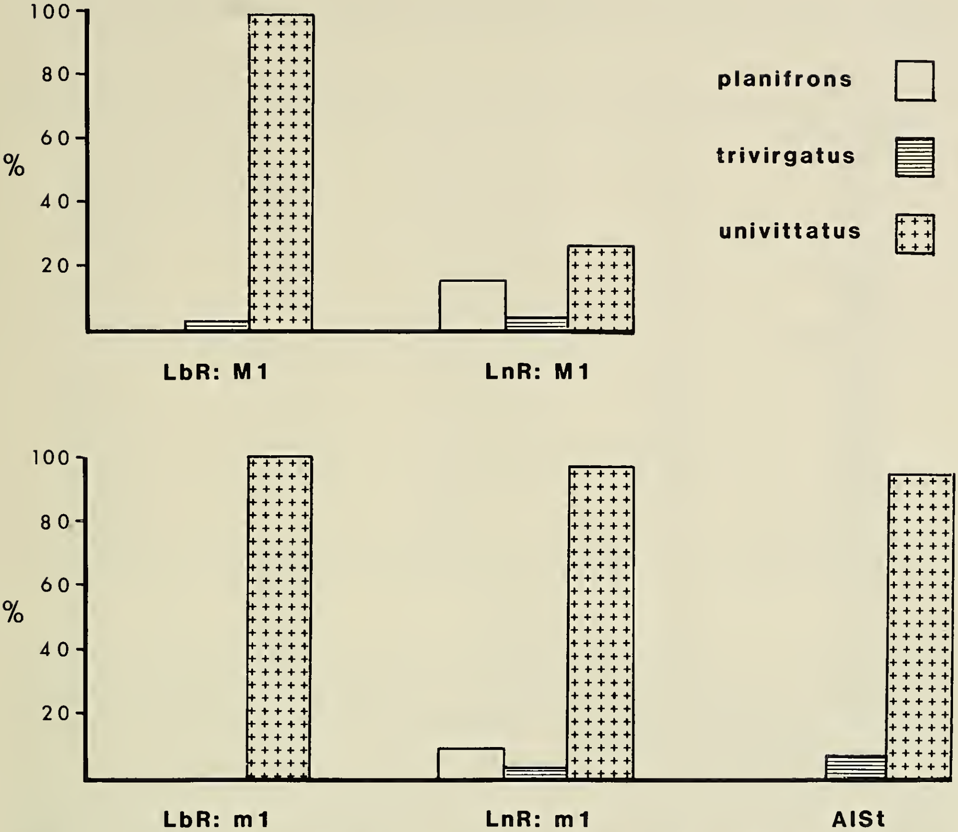

Fig. 7. Histograms illustrating percent occurrence of certain molar roots and one cranial trait within three species of *Hybomys* for all specimens examined (see Table 1 for sample sizes and Materials and Methods for identification of character abbreviations).

view of the small number of *planifrons* available. Sexes were pooled in the subsequent multivariate programs.

Age, in contrast, contributed substantially to nongeographic variation, despite our elimination of individuals from the youngest and oldest wear-classes in the two-way ANOVA (Table 2). The influence of sample sizes on the significance levels realized is apparent in the comparison of results for *planifrons* and *univittatus.* With large samples, even variables known to be relatively age-invariant, such as LMax and IoC, attained significant F-ratios. Our measurement of the maxillary toothrow was an alveolar length, and individuals in older wear-classes seemed to undergo some erosion of bone away from the dental roots so that alveolar length increased with age. In their discriminant function analysis of *trivirgatus* and *univittatus,* Van der Straeten and Verheyen (1982) too remarked upon the positive association of overall cranial size and age (they recognized two age groups), but the within-group, age-class differences did not approach the dispersion observed between the centroids of the two species.

We initially applied principle component analysis to all specimens of *Hybomys* with complete cranial measurements (variables = 12; n = 162), although only the

Table 2.—Results of two-way anova for nongeographic variation in combined species samples of *Hybomys.*

| Species and variables | Error df | F (sex) | F (age) | F (interaction) |
|---|---|---|---|---|
| *H. planifrons* | | | | |
| OcNL | 8 | 0.08 | 2.54 | 0.06 |
| LRos | 8 | 0.00 | 2.03 | 0.05 |
| ZyB | 8 | 0.00 | 2.39 | 0.20 |
| IoC | 8 | 0.37 | 1.75 | 0.07 |
| LMax | 8 | 0.76 | 0.79 | 0.72 |
| BMls | 8 | 8.12* | 0.91 | 0.16 |
| *H. trivirgatus* | | | | |
| OcNL | 49 | 0.07 | 4.77* | 0.01 |
| LRos | 49 | 0.15 | 6.20** | 0.07 |
| ZyB | 49 | 0.04 | 4.90* | 0.01 |
| IoC | 49 | 0.88 | 1.16 | 0.25 |
| LMax | 49 | 0.19 | 2.35 | 0.70 |
| BMls | 49 | 0.09 | 2.42 | 0.16 |
| *H. univittatus* | | | | |
| OcNL | 87 | 0.69 | 16.95*** | 0.88 |
| LRos | 87 | 0.84 | 7.61** | 1.17 |
| ZyB | 87 | 0.61 | 15.57*** | 0.60 |
| IoC | 87 | 0.14 | 4.00* | 0.39 |
| LMax | 87 | 0.61 | 3.87* | 0.10 |
| BMls | 87 | 0.25 | 14.99*** | 0.64 |

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

centroids of our 12 OTUs are portrayed. The results of this analysis disclosed three aggregations of OTUs that correspond to the named taxa represented. Samples of *univittatus* were separated from those of *planifrons* and *trivirgatus* on the first principal component (Fig. 8); no discrimination between *planifrons* and *trivirgatus* was apparent on this component. Only three variables—WZyP, LIF, and DMan—conspicuously contributed to the sharply defined hiatus between *univittatus* and *planifrons-trivirgatus* (Table 3), a separation which underscores the pronounced contrasts in shape of the "*Hybomys*-type" versus "*Typomys*-type" cranium. Two of these variables (WZyP and LIF) are among the several identified by Van der Straeten and Verheyen (1982) as providing the best discrimination of *trivirgatus* and *univittatus.* Interestingly, the magnitude of these shape contrasts overshadows size as the principal source of variation on principal component one. Instead, the grading of OTUs, particularly those of *univittatus,* along principal component two conforms to one's expectation of a general size factor. The several length variables (OcNL, LRos, PPL, HPL, LDia) that load most heavily on this component support this interpretation (Table 3). Principal component three emphasizes the distinctiveness of specimens representing *planifrons,* a segregation principally due to their possession of relatively long incisive foramina and a short hard palate. The discontinuity of *planifrons* surpasses that evident among the geographic representatives of *trivirgatus.*

Because of the predominant influence of those variables that accounted for the segregation of *univittatus* on principal component one, the analysis was next

Table 3.—Results of principal component analysis using 12 cranial variables of all specimens (n = 162) of *Hybomys*.

| | I | II | III |
|---|---|---|---|
| Eigenvalue | 0.067 | 0.013 | 0.005 |
| % variance explained | 69.8 | 13.5 | 5.2 |
| Cumulative % variance | 69.8 | 83.3 | 88.5 |
| Variables | | | |
| OcNL | 0.28 | 0.91 | 0.07 |
| LRos | −0.27 | 0.84 | 0.05 |
| ZyB | 0.60 | 0.57 | 0.14 |
| WZyP | 0.98 | 0.02 | −0.20 |
| IoC | −0.42 | 0.59 | −0.07 |
| PpL | 0.09 | 0.82 | 0.11 |
| HPL | −0.33 | 0.70 | −0.41 |
| LIF | 0.92 | −0.05 | 0.28 |
| LDia | 0.35 | 0.72 | 0.12 |
| LMax | 0.52 | 0.28 | 0.16 |
| BMIs | 0.37 | 0.60 | 0.19 |
| DMan | 0.91 | 0.13 | 0.25 |

restricted to individuals of *planifrons* (n = 14) and *trivirgatus* (n = 55) with intact skulls. In this iteration, the large positive loadings derived for most variables on the first principal component suggest a general size factor (Table 4). Examples of *planifrons* are differentiated along the second principal component, their separation again reflecting their longer incisive foramina and shorter palate and to a lesser degree the greater length of their toothrows and narrower interorbital region. Although some overlap of individual scores occurs on this component, the mor-

Table 4.—Results of principal component analysis using 12 cranial variables of specimens of *H. trivirgatus* (n = 55) and *H. planifrons* (n = 14).

| | I | II |
|---|---|---|
| Eigenvalue | 0.017 | 0.007 |
| % variance explained | 43.6 | 17.1 |
| Cumulative % variance | 43.6 | 60.7 |
| Variables | | |
| OcNL | 0.77 | −0.02 |
| LRos | 0.74 | 0.04 |
| ZyB | 0.68 | 0.09 |
| WZyP | 0.84 | −0.36 |
| IoC | 0.40 | −0.44 |
| PpL | 0.67 | 0.02 |
| HPL | −0.01 | −0.66 |
| LIF | 0.59 | 0.63 |
| LDia | 0.75 | 0.15 |
| LMax | 0.26 | 0.44 |
| BMIs | 0.56 | 0.22 |
| DMan | 0.61 | 0.38 |

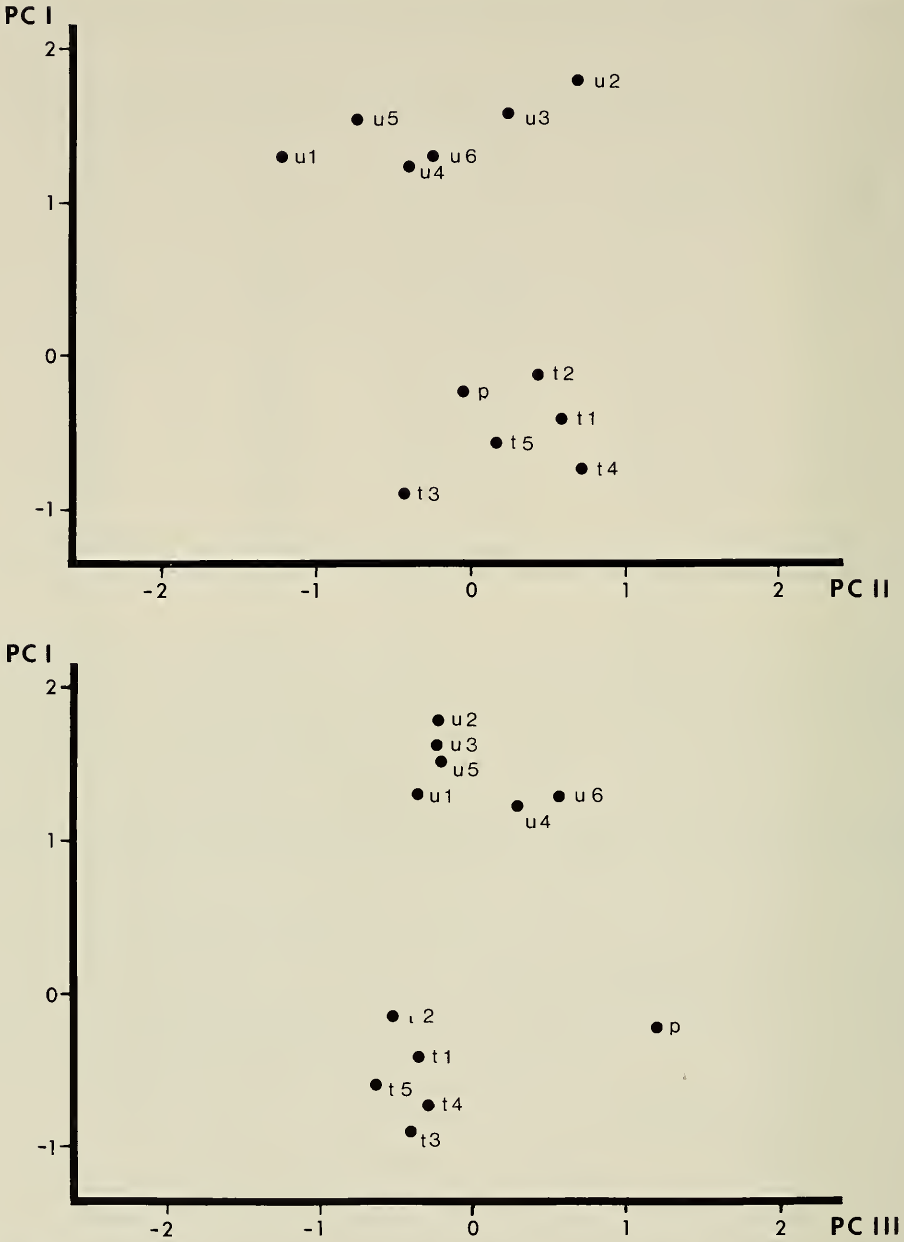

Fig. 8. Scatter plots of principal components using all intact specimens representing 12 samples of *Hybomys: Top,* PC I versus PC II; and *Bottom,* PC I versus PC III (see Table 3; identification of sample codes given in Materials and Methods).

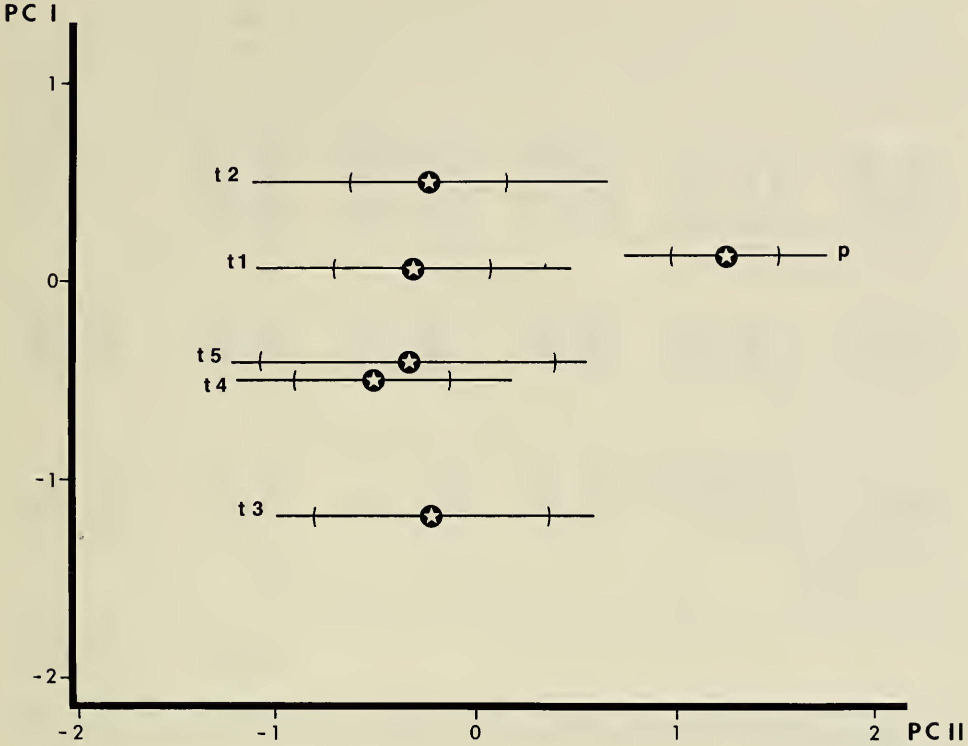

Fig. 9. Scatter Plot of principal component I versus II using all intact specimens representing *Hybomys planifrons* and five samples of *Hybomys trivirgatus* (see Table 4; identification of sample codes given in Materials and Methods). Horizontal lines delimit ±1 SD of individual scores around a group's centroid on Pc II, and parentheses indicate ±2 SE of the mean. To avoid visual congestion, dispersion statistics are not depicted for PC I.

phological singularity of *planifrons* readily contrasts with the five samples of *trivirgatus* (Fig. 9).

## Karyology

Our knowledge of chromosomal variation for the genus *Hybomys* includes information on the forms *planifrons, trivirgatus, univittatus,* and *lunaris,* as contributed by the studies of Matthey (1959), Tranier and Dosso (1979), and Verheyen and Van der Straeten (1985) (see Table 5). We shall report and compare our findings in light of those previous works.

Our two Sierra Leonean specimens of *planifrons,* both females, possess odd-numbered diploid counts that differ from one another yet exhibit the same total number of chromosomal arms. The one from 10.1 km E Fintonia has a 2N of 39, which consists of one large submetacentric and 19 pairs of acrocentric chromosomes graded evenly in size from small to large (Fig. 10a). The other female, from Meema, has 35 chromosomes, including the unpaired large submetacentric, two pairs of large submetacentrics, and 15 small to large pairs of acrocentrics

Table 5.—Diploid number (2n), fundamental number (FN, including sex chromosomes), and number of large biarmed chromosomes (LBA) in samples of *Hybomys* (References: 1 = Matthey, 1959; 2 = Trainer and Dosso, 1979; 3 = Verheyen and Van der Straeten, 1985; 4 = this study).

| Taxa and locality | 2n | FN | LBA | References |
|---|---|---|---|---|
| *H. planifrons* | | | | |
| Ivory Coast: Tai, Grabo, Soubre | 38 | 42 | 4 | 2 |
| Sierra Leone: E Fintonia | 39 | 40 | 1 | 4 |
| Sierra Leone: Meema | 35 | 40 | 5 | 4 |
| *H. trivirgatus* | | | | |
| Ivory Coast: Adiopodoume | 40 | 40 | 0 | 3 |
| Ivory Coast: Adiopodoume, Soubre | 40, 42, 43 | 40, 42, 43 | 0 | 2 |
| Sierra Leone: Belebu | 40 | 40 | 0 | 4 |
| *H. univittatus* complex | | | | |
| Cameroon: between Bimba and Mieri | 44 | 46 | 0 | 3 |
| Cameroon: SE Bamenda, SE Eseka | 46 | 46 | 0 | 4 |
| Gabon: SE Cap Esterias | 48 | 48 | 0 | 4 |
| Rwanda: Uwinka | 48 | 48 | 0 | 3 |
| Zaire: Yalosemba | 48 | 48 | 0 | 4 |
| Locality not given | 48 | 48 | 0 | 1 |

(Fig. 10b). These counts were consistently obtained from different spreads of the same individual.

Trainer and Dosso (1979) first reported a karyotype for *planifrons* for specimens collected from southwestern Ivory Coast. (Since the karyotype was not figured, Tranier kindly lent us the original negatives; however, due to their age, we could not critically compare the chromosomal morphologies of the Sierra Leone and Ivory Coast specimens. Therefore, our comments are based upon their published description.) These exhibited a 2N of 38 with 2 pairs of metacentric-submetacentric chromosomes and 17 pairs of acrocentric elements. This condition falls between that observed in our two specimens, both in diploid number and in number of biarmed elements. Tranier and Dosso (1979) identified the X as a large metacentric and the Y as a medium-sized submetacentric; however, this configuration seems highly unlikely given the chromosomal assortment observed in our 2N = 39 female. Based on the studies to date, a karyotype having at least one large biarmed chromosome is unique within the genus but the disparity in diploid numbers recorded from just three localities suggests remarkable polymorphism within *planifrons* that deserves further investigation.

Our one example of *trivirgatus,* a female from Belebu, Sierra Leone, has a 2N of 40, all pairs consisting of small to large acrocentrics (Fig. 11). This diploid complement agrees with the typical condition Verheyen and Van der Straeten (1985) reported for a series of *trivirgatus* from Adiopodoume, Ivory Coast, although one of their specimens had 2N = 42 as the modal count. Tranier and Dosso (1979) also recorded a diploid number of 40 for a specimen of *trivirgatus* from Soubre, Ivory Coast, but in two others, a male and female, they found 2N = 43 and 2N = 42, respectively. All of the diploid variants thus far documented for *trivirgatus* retain an entirely acrocentric chromosomal complement. The mech-

Fig. 10. Karyotypes of *Hybomys planifrons*: a, female (USNM 546938) from 10.1 km E Fintonia, Sierra Leone, with 2N = 39; b, four additional large biarmed chromosomes found in female (USNM 463386) from Meema, Sierra Leone, with 2N = 35.

anism of sex determination warrants clarification for *trivirgatus*. Tranier and Dosso (1979) suggested an XY1Y2 system to account for the 2N = 43 male, but Verheyen and Van der Straeten (1985) postulated an XX′Y system and assumed that the largest pair of acrocentrics represent the sex chromosomes. These are heteromorphic in arm length in their female specimens, a condition observed in our single example (Fig. 11).

Two chromosomal morphologies were observed among our samples of *univittatus*. The Cameroon specimens (from the vicinity of Bamenda and Eseka) have a total of 46 chromosomes, all acrocentric ranging in size from small to large (Fig. 12a). In contrast, the Gabon (Cap Esterias) and Zaire (Yalosemba) mice possess a diploid count of 48, again all acrocentric elements sorted from small to large in size (Fig. 12b). The almost identical male and female karyotypes from both lo-

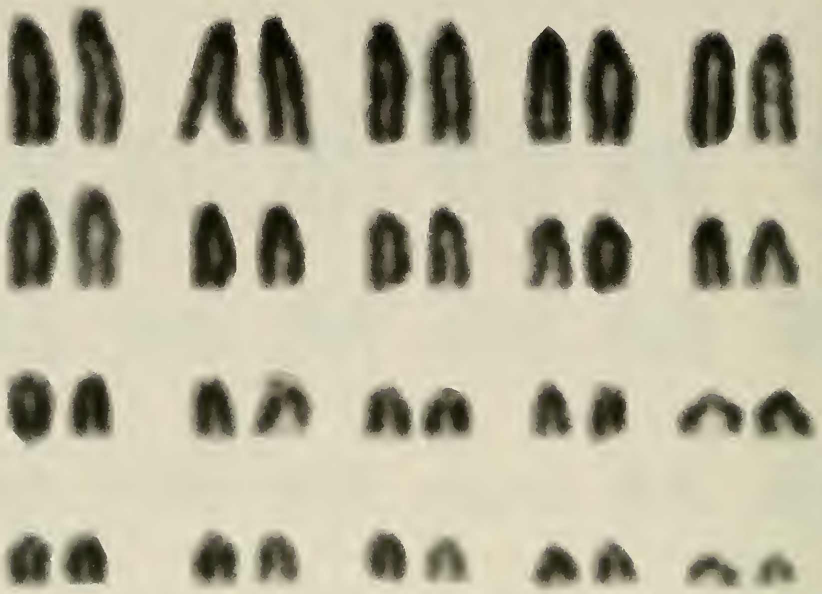

Fig. 11. Karyotype of female *Hybomys trivirgatus* (USNM 463170) from Belebu, Sierra Leone.

calities preclude determination of the sex chromosomes from standard preparations.

Matthey (1959) first published on the karyotype of *univittatus* and described a diploid morphology (2N = 48; all acrocentric) that matches our samples from Gabon and Zaire. Verheyen and Van der Straeten (1985) recently contributed additional chromosomal information for Central and East African *Hybomys* that resembles the variation we encountered, but they attributed their chromosomal variants to different taxa. They identified specimens from Uwinka, Rwanda, having a 2N of 48, as *H. lunaris*; whereas they considered those from between Bimba and Mieri, Cameroon, having a 2N of 44, as *H. univittatus* proper. The latter sample is the only known instance of biarmed chromosomes in the *univittatus* complex, for Verheyen and Van der Straeten (1985) documented a very small pair of metacentrics in their spreads. We shall attempt to reconcile the chromosomal morphologies with the nomenclatural discrepancies apparent in their data and ours in the discussion below.

## Discussion

*Taxonomy.*—The variety of taxonomic opinions advanced for *planifrons* since Miller (1900) diagnosed it have largely reflected the characters emphasized by the systematists who have addressed the question of its status and affinities. Miller himself, who in all probability lacked comparative examples of *trivirgatus,* drew attention to numerous cranial details in recognizing *planifrons* as a species distinct from *univittatus.* His description forcefully asserted the fundamental contrasts in cranial shape exhibited by the two kinds. Yet later authors seemingly attached greater importance to the dorsal striping pattern of the pelage and considered

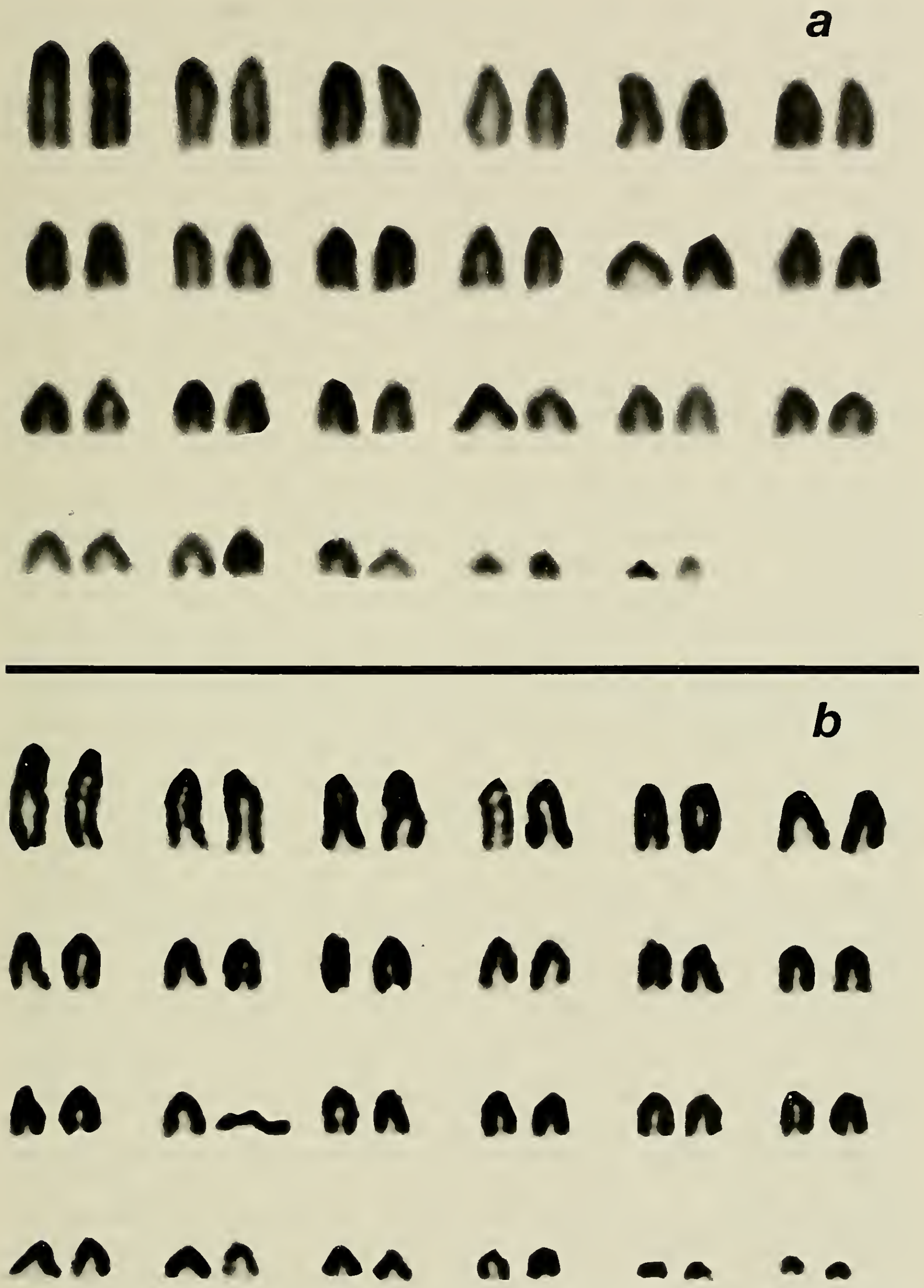

Fig. 12. Karyotypes of *Hybomys univittatus*: a, female (CM 58834) from the vicinity of Eseka, Cameroon; b, male (USNM 537813) from Yalosemba, Zaire.

*planifrons* as a disjunct West African representative of *univittatus* (Allen and Coolidge 1930; Allen 1939; Ellerman 1941). Rosevear's (1969) analysis resubstantiated the magnitude of cranial dissimilarities observed between *univittatus* and the two forms of West African *Hybomys,* and, indeed, the very fineness of the cranial resemblance shared by *planifrons* and *trivirgatus* persuaded him to include *planifrons* as a distinctive ecological race of *trivirgatus.* Nevertheless, Rosevear did acknowledge the contradictory evidence (for example, Heim de Balsac and Lamotte 1958) provided by the two forms being collected at nearby localities in parts of West Africa and apparently maintaining their morphological identities in such places. Such distributional evidence has continued to accumulate (such as Roche 1971; Coe 1975; Dosso 1975; Tranier and Dosso 1979), along with the discovery of a different karyotype in specimens of *planifrons* (Tranier and Dosso 1979). As a consequence, the latter authors have returned *planifrons* to its former status as species.

Of the systematic treatments variously accorded Miller's *planifrons,* we believe the evidence for its specific distinction is most compelling. *Hybomys planifrons,* in concert with *H. trivirgatus,* differs from *univittatus* in a host of features as recounted above. The differentiation of *planifrons* from *trivirgatus* is less pronounced but nonetheless definable on the basis of: the consistent presence of a single dorsal stripe without faint lateral ones; the rare occurrence of a t9 on $M^1$ and its absence on $M^2$; a cranial conformation that features long incisive foramina, a short hard palate, and narrow interorbital constriction; and a chromosomal complement having a lower 2N (35 to 39) and containing at least one large biarmed autosome. In addition, hemoglobin band patterns are quite distinct (see Robbins et al. 1983, for techniques), based upon 12 specimens of *planifrons* and 16 of *trivirgatus* from six localities in Sierra Leone. Both species were collected at one locality (10 mi W Panguma), but unfortunately, only one example of *planifrons* was preserved as a voucher specimen. The persistence of these morphological and chromosomal traits in specimens of *planifrons* collected close to populations exhibiting the typical *trivirgatus* phenotype (for example, localities in Sierra Leone, Liberia, and southwestern Ivory Coast—Appendix 1) argues strongly that *planifrons* is reproductively isolated from *trivirgatus.*

Of the species currently recognized in *Hybomys,* the relationship of *planifrons* undoubtedly lies closer to *trivirgatus.* The basic resemblance of their skull configuration, which presents a sharp contrast to the skull-type seen in *univittatus,* suggests this affinity, as Rosevear (1969) had already perceived although he expressed this relationship at a different taxonomic level.

In addition to their phenetic similarity, a cladistic assessment of several external, cranial, and dental characters supports the same pattern of relationship among the three species. For one, females of *trivirgatus* and *planifrons* possess only two inguinal pairs of mammary glands, both species lacking the anterior pectoral pair found in *univittatus.* Trends of mammary gland reduction have been identified in other groups of Muroidea, probably from an ancestral condition of eight mammae (Arvy 1974; Carleton 1980; Neithammer 1972). The presence of a bridge of the alisphenoid bone dividing the masticatory-buccinator foramen from the foramen ovale accessorius is believed to represent a primitive feature of the muroid skull, and its loss, resulting in the formation of a single spacious opening, has been interpreted as a derived condition (Carleton and Musser 1984; Musser 1982;

Musser and Newcomb 1983). The occurrence of this bony strut is a rare trait ($<$7%) in samples of both *trivirgatus* and *planifrons,* but is a standard feature ($>$90%) among populations of *univittatus.* We interpret the reduction in size and frequency occurrence of the t9 on the $M^1$ and $M^2$ of *trivirgatus* and its virtual absence in *planifrons* as apomorphic states. Jacobs (1978) proposed that the t9 of a murid molar is homologous to the metacone in the standard Cope-Osbornian system of dental terminology. If his homology proves correct, then reduction and loss of the metacone, a constituitive cusp of muroid molar teeth, are clearly evolutionarily derived conditions. Musser and Newcomb (1983:537) also viewed the absence of a t9 as a derived trait among Malaysian murids, although they considered its disappearance to result from amalgamation with the t8. In the case of *Hybomys,* the loss of t9 seems to reflect a progressive narrowing until only a simple enamel crest remains connecting the t6 and t8. The presence of supplemental cusps (AMC, ALC, PLC) on the anterior and labial cingula of the lower molars was thought to be primitive in the Malaysian murids studied by Musser and Newcomb (1983). However, in view of the simple lower molar topography demonstrated in early murids and the probable derivation of murids from a cricetid ancestor (Jacobs 1978), the secondary development of such conulids from hypertrophied cingula seems equally probable. Accordingly, we consider their presence as derived in *univittatus.* If we err in this interpretation, and Musser and Newcomb's (1983) polarity is the true one, then the sister-group relationship of *planifrons* and *trivirgatus* is even more convincingly supported. The possession of additional molar roots, such as observed in *univittatus,* represents an advanced condition over the primitive three-rooted upper and two-rooted lower molars characteristic of early murids and muroids (Carleton and Musser 1984; Jacobs 1978; Musser and Newcomb 1983). Other traits, such as the enlarged optic foramen and the many proportional differences that define the "*Typomys*-type" skull, associate *planifrons* and *trivirgatus* as a pair-group contrasted to *univittatus,* but the polarities of such characters are not easily interpretable.

Still, the brunt of the evidence indicates that *planifrons* and *trivirgatus* share a more recent common ancestor, their kinship to *univittatus* being more distant (Fig. 13). This conclusion adds weight to Van der Straeten and Verheyen's (1982) suggestion that the subgenera *Typomys* and *Hybomys* should be reinstituted. Those authors based their nomenclatural recommendation on the morphological hiatus revealed in their multivariate analyses of *trivirgatus* and *univittatus.* Our study not only corroborates their morphometric results but also divulges a suite of qualitative features that underscore the divergence of *planifrons-trivirgatus* from *univittatus.* Moreover, the karyotypic data portray two distinct arrays of chromosomal arm variation, one high (FN = 46–48) characterizing the *univittatus* complex and one low (FN = 40–42) typifying *planifrons* and *trivirgatus.* Standard chromosomal preparations suggest plausible mechanisms for derivation of the several chromosomal variants within each group, but transformation from one FN level to the other is more complicated and cannot be resolved without banding information and some idea of the distribution of euchromatin and heterochromatin. Whether *Typomys* and *Hybomys* merit generic segregation must await an evaluation of character variation among *Hybomys* and its near relatives.

Although our study principally focusses on the status and relationships of *planifrons,* some comment is warranted concerning the specific integrity of *univittatus.*

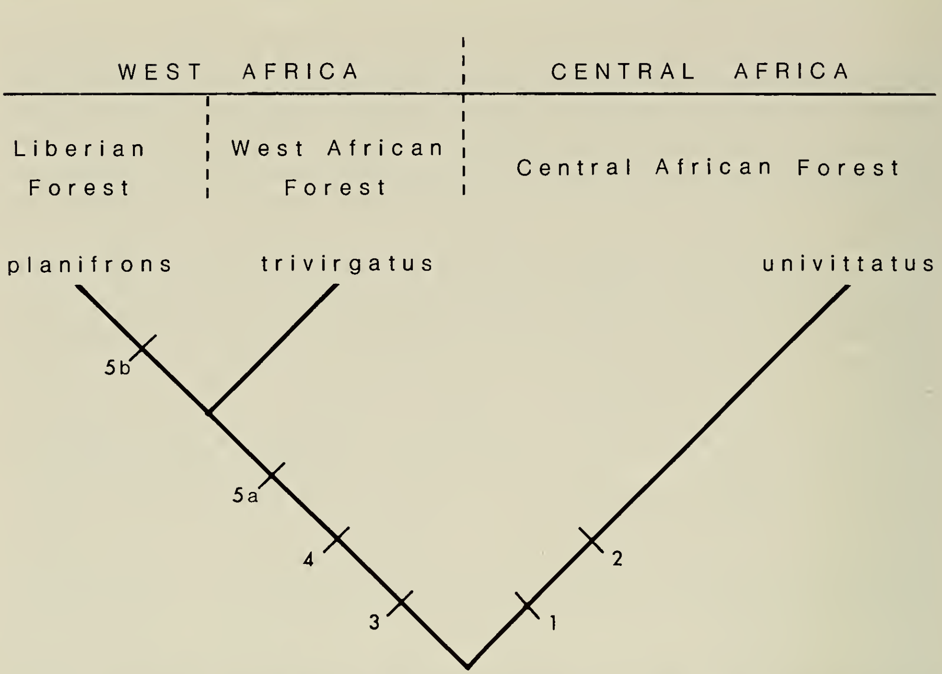

Fig. 13. Hierarchy of proposed relationship among three species of *Hybomys* and their geographical distribution with regard to major forest zones. Apomorphic character state transformations are: 1) acquisition of accessory molar roots; 2) acquisition of supplemental molar cusps; 3) loss of the pectoral pair of mammae; 4) loss of the alisphenoid strut; 5a) reduction in size of t9; 5b) loss of t9.

The morphological and chromosomal heterogeneity uncovered here and in other recent studies intimates that more than one species is represented among our samples. Several forms have been described, all of them treated as subspecies of *univittatus* until very recently: *Mus univittatus* Peters, 1876, from Dongila, Gabon; *Mus rufocanus* Tullberg, 1893, from Vevaka, Cameroon, considered a synonym of the nominate race; *Mus univittatus lunaris* Thomas, 1906, from Ruwenzori east, Uganda, elevated to species by Verheyen and Van der Straeten (1985); *Hybomys univittatus badius* Osgood, 1936, from Mt. Cameroon; and *Hybomys univittatus basilii* Eisentraut, 1965, from Mocatal, Fernando Poo, raised to a species by Van der Straeten (1985). The evidence for the specific status of *lunaris* derives from chromosomal and morphometric analyses (Van der Straeten 1985; Verheyen and Van der Straeten 1985); that for the recognition of *basilii* on morphological divergence from mainland *univittatus* (Van der Straeten 1985).

Basically two kinds of karyotypes (2N = 44, 46; FN = 46 and 2N = 48; FN = 48) have now been reported for populations of *univittatus*-like forms (Table 5). Verheyen and Van der Straeten (1985) documented such a chromosomal difference between examples from Rwanda (2N = 48) and Cameroon (2N = 44) and considered the former to represent *H. lunaris* and the latter true *H. univittatus*. The 2N = 48 karyotype exactly matches that which we discovered in our specimens from Gabon and Zaire. Since our Gabon sample from Cap Esterias originated from a place just northwest of Dongila, the type locality of *Mus univittatus* Peters, we regard the all-acrocentric, 2N = 48 chromosomal formula as characteristic of *univittatus,* not *lunaris.* Verheyen and Van der Straeten (1985) assumed that *lunaris* applied to their Rwandan locality because it was the geographically closest epithet available for easternmost populations of *Hybomys.* Thomas (1906) described *lunaris* from an intermediate elevation on the northeastern slope of Mt. Ruwenzori, the Mubuku Valley, Uganda, and his diagnosis clearly depicts a small, delicate form of *Hybomys.* In fact, our two Ugandan examples (both in age class IV) from Kanyawara, a place near the type-locality, precisely fit Thomas' description in their coloration, delicate skull, and small size (OcNL = 31.6, 31.8; LMax = 5.2, 5.3; IoC = 5.1, 5.3; HFL = 25, 25). These two specimens contrast sharply with the larger robust skulls seen in our examples from Uwinka, Rwanda, the same locality where Verheyen and Van der Straeten obtained karyotypic preparations. Morphologically and chromosomally, the karyotyped *Hybomys* from Gabon, Rwanda, and Zaire, reported herein and by Verheyen and Van der Straeten (1985), conform closely and appear to represent but one species, *univittatus.*

Chromosomal morphologies that depart from the 2N = 48 condition have been described for *univittatus*-like populations inhabiting the forests of Cameroon. Great significance cannot be ascribed to the karyotypic differences we obtained for specimens from Bamenda and Eseka (2N = 46; FN = 46) as compared to that reported by Verheyen and Van der Straeten (1985) for samples from Mieri-Bimba (2N = 44; FN = 46), because a simple Robertsonian-type polymorphism could explain the presence/absence of the small metacentric pair and consequent difference in diploid number. Verheyen and Van der Straeten (1985) considered the chromosomal formula found in the Mieri-Bimba specimens to be characteristic of *univittatus,* but as argued above, we believe that the 2N = 48, all-acrocentric complement applies to true *univittatus.* In addition to the chromosomal difference, Van der Straeten (1985) demonstrated an appreciably larger size for the Cameroon series as compared to specimens from Rwanda. In like manner, considerable morphological heterogeneity, not all of it consonant with a simple interpretation of intraspecific geographic variation, occurs among our OTUs of "*univittatus,*" particularly the three from Cameroon. Specimens from Lolodorf and the vicinity of Eseka, for example, are larger in most cranial dimensions than those from Batanga (Fig. 8, Appendix 2); the latter are phenetically closer to the animals from Gabon that have the 2N = 48 karyotype.

In summary, we see evidence of at least three moieties comprising the population samples traditionally called "*univittatus.*" All of these possess the "*Hybomys*-type" cranial architecture, supplemental molar cusps, accessory roots, and an alisphenoid strut, yet they also exhibit slight but consistent differences in size, proportion, and karyotype that suggest separate biological species. A medium-sized form having a diploid number of 48 seems to range most broadly in Central Africa and, of the three, probably deserves the appellation *univittatus* Peters, 1876. The other two moieties, one smaller and one larger than *univittatus,* are apparently more restricted geographically. The small and delicate form *lunaris* may qualify for species recognition to judge from the distinctive morphology seen in our two Ugandan specimens and their concurrence with Thomas' (1906) description. However, the karyotypic divergence attributed to "*lunaris*" by Verheyen and Van der Straeten (1985) is questionable; in our opinion, *univittatus lunaris* Thomas, 1906, has yet to be examined karyotypically. The larger-bodied animals are represented by series from Cameroon with lower diploid numbers (44, 46), but the level of their differentiation and what names should be properly attached are presently unclear. Three possibilities are Tullberg's (1893) *rufocanus* from Vevaka, Cameroon, Osgood's (1936) *badius* from Mt. Cameroon, and Eisentraut's (1965) *basilii* from Fernando Poo (recently elevated to species by Van der Straeten, 1985), any of which could prove applicable. Indeed, detailed study of population samples from Cameroon may provide a key to understanding differentiation within the subgenus *Hybomys*. Eisentraut's (1973) analysis of vertebrate distribution in Cameroon and on nearby Fernando Poo pictures a very complex evolution and intermixture of lowland and montane faunal elements, and certainly the number of species uncovered in the few thoroughly reviewed rodent genera in Cameroon corroborates this pattern of complexity (Robbins et al. 1980; Robbins and Schlitter 1981). Whether populations of *Hybomys* experienced similar fragmentation and differentiation in west–central Africa will require additional studies of variation over broader segments of their range and critical association of distinctive morphologies to type-specimens.

*Ecology and zoogeography.*—Our knowledge of the ecology and behavior of *Hybomys* has been derived primarily from investigations of the Central African form *univittatus.* Such studies have disclosed that these mice are solitary and terrestrial, are generally diurnal in their activity rhythms, and consume mostly insects and fruits and less often seeds (Duplantier 1982; Genest-Villard 1978, 1980; Rosevear 1969). Ecological descriptions of collecting sites consistently associate *univittatus* with the great equatorial rainforest of Central Africa, in both primary and secondary stands with dense understory and lush ground cover (Duplantier 1982; Genest-Villard 1980; Misonne 1963). When available for comparison, information on West African *Hybomys* basically resembles the life history and habitat requirements sketched for *univittatus* (Cole 1975; Rosevear 1969). Still it would be worthwhile to explore whether the apparent contrast in size of the optic foramen (which should first be confirmed quantitatively) noted between *univittatus* and *trivirgatus-planifrons* relates to any behavioral differences. Hooper and Carleton (1976), for instance, demonstrated a contrasting reliance upon olfactory versus visual cues in prey detection and capture corresponding to dietary contrasts in life stages of invertebrates consumed, for a congeneric pair of Middle American insectivorous murids that possess different-sized eyeballs and optic foramina.

Since the distinctiveness of *planifrons* has been obscured by its synonomy under *trivirgatus* or *univittatus,* little attention has been devoted to understanding its specific habitat associations and possible interactions where it seems to coexist with *trivirgatus.* One can conclude that the two species occur sympatrically as indicated by general locality designations (Dosso 1975; Heim de Balsac and Lamotte 1958; Roche 1971; Tranier and Dosso 1979), but it is not readily clear from reading such accounts whether the two kinds inhabit the same microenvironment (that is, were actually taken in the same trap line). Coe (1975) did observe that his examples of *trivirgatus* were restricted to the upper regions of the Nimba range; whereas, specimens of *planifrons* were (p. 537) ". . . limited to high forest and its fringes at low altitude . . ." and (p. 556) were ". . . all trapped in secondary forest and along track sides in dense vegetation."

During a survey of small mammals in northern Sierra Leone, we had the opportunity to collect five specimens of *H. planifrons* and to observe firsthand the character of their habitat. This area, between 9°35′ and 9°55′N, receives a moderately high amount of rainfall (about 2000 mm annually) and supports a mosaic of habitats, including low and high-grass savannahs, seasonally flooded grasslands (bolilands), and invasive forest. Although the dominant vegetation type covering this region is Guinea Savannah, all specimens of *planifrons* were collected at three localities in the high-canopied, semi-deciduous forest, distributed either as a narrow corridor of riverine forest, as forest fringing a small shallow lake, or as an isolated hillside patch enclosing a moist ravine (Fig. 14). No *Hybomys* were collected in forested areas where the understory was sparse and the ground open; instead, each of the three sites contained a luxuriant understory and dense ground cover. A profusion of vines and creepers, the lush growth of ferns and other herbaceous plants, and the presence of some sedges and mosses suggested the wetter character of such microenvironments within the forest. In fact, we came to anticipate the presence of *H. planifrons* where dense stands of one particular herbaceous plant, *Marantachloa* sp. (Marantaceae), grew (Fig. 15). Presumably the association of *planifrons* with *Marantachloa* was only indicative of the existence of a moister, cooler microclimate preferred by the mice. Of the five specimens, three were taken at trap stations on the ground beneath such dense vegetation, and two were collected in the hollow of a rotting log covered with moss and mushrooms. The capture of two animals was between 7:00 and 7:30 and between 8:00 and 10:00 in the morning, suggesting that *planifrons* too is diurnal.

The known distributional limits of *Hybomys* mirror its association with primary or secondary tropical forest, as the range of the genus tightly conforms to the reaches of the great lowland rainforests in Africa (Fig. 16). Collecting sites beyond the perimeter of the major rainforest zone underscore the fidelity of *Hybomys* to high forest habitats, for they include gallery forest (for example, *planifrons* in northern Sierra Leone) or montane forest at intermediate elevations (for example, *univittatus* in Uganda). Populations of the *univittatus* complex occupy the evergreen rainforests of Central Africa and are not known to occur west of the Cross River in eastern Nigeria, a range approximately equivalent to the Congo Forest Block of Booth (1958b) or the Lower Guinea Forest of Moreau (1966, 1969). *Hybomys trivirgatus* is a species of the West African rainforest belt, its eastern frontier terminating at the Niger River and extending westerly to southeastern Sierra Leone. This distribution encompasses all of the Upper Guinea Forest of Moreau (1969), as well as the Western Nigerian Forest, which some have considered a subregion of the Lower Guinea Forest (Booth 1958b; Moreau 1969). The occurrence of *planifrons* is evidently more geographically restricted, our samples only representing Sierra Leone and Liberia, southeastern Guinea around Mt. Nimba, and southwestern Ivory Coast west of the Sassandra River. This distributional pattern approximately corresponds to the Liberian Forest, generally viewed as a discrete subdivision of the West African tropical forest (Booth 1958b; Delany and Happold 1979).

The several forest provinces mentioned above have been distilled from zoogeographic studies of a variety of forest-inhabiting vertebrates, including mammals (Booth 1954, 1958a, b; Grubb 1978, 1982), birds (Marchant 1954; Moreau 1966, 1969; Diamond and Hamilton 1980), rhacophorid tree frogs (Schiotz 1967), and cyprinodont fishes (Clausen 1964). In view of the breadth of these zoogeographic syntheses, the distributional congruence of species of *Hybomys* to pre-

Fig. 14. Hillside patch of high forest with lush growth of herbaceous ground cover in Outamba-Kilimi National Park, northern Sierra Leone. Specimens of *Hybomys planifrons* were collected on the ground beneath the dense plant cover.

Fig. 15. Dense stand of *Marantachloa* sp. (Marantaceae) underneath riverine forest in Outamba-Kilimi National Park, northern Sierra Leone. *Hybomys planifrons* were trapped in forested areas where this plant grew in profusion.

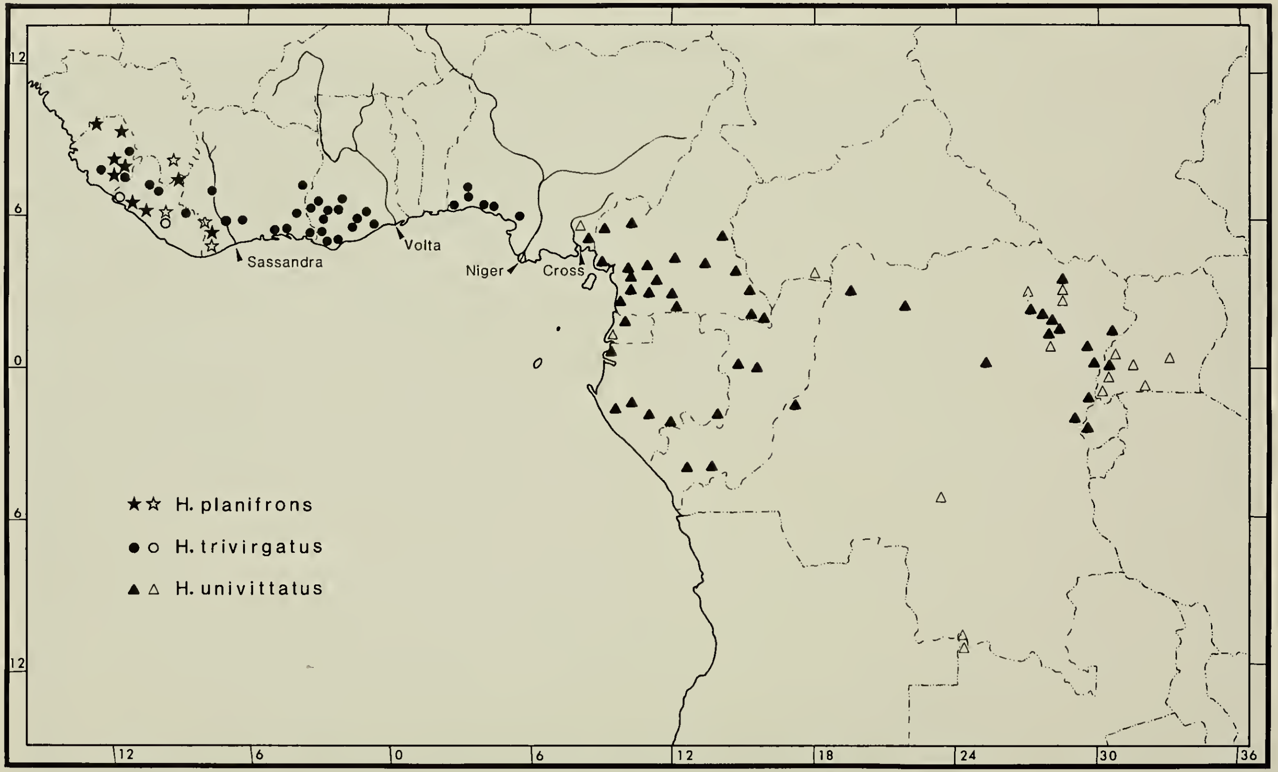

Fig. 16. Distribution map of western and central Africa illustrating collection localities of mice of the genus *Hybomys.* Closed symbols represent specimens examined by one of us; open symbols signify literature records. The mouths of four West African rivers mentioned in the discussion are indicated by arrows.

viously recognized forest zones, is not unexpected. Numerous workers have cited the Niger River as the probable boundary line or "natural barrier" separating populations of *trivirgatus* and *univittatus,* or *Typomys* and *Hybomys,* those names employed either as subgenera or genera by the various authors (St. Leger 1931; Hayman 1935; Rosevear 1953, 1969; Van der Straeten and Verheyen 1982). However, as remarked by Rosevear (1969), what species inhabits (or inhabited) the interfluvial region between the Niger and Cross remains unknown: localities of *trivirgatus* occur only west of the Niger River and those of *univittatus* only east of the Cross (Fig. 16). Whatever the case, the differentiation of these mice across the Niger-Cross catchment is at least recognizable at the subgeneric level. Other authors have emphasized the pronounced discontinuity in faunal affinities of forest-dwelling vertebrates at the Niger River (Booth 1958b; Diamond and Hamilton 1980; Robbins 1978).

The hiatus in distribution of *trivirgatus* in southern Benin and Togo (Dahomey Gap) and in southeastern Ghana (Accra Plains) corresponds to southern projections of Guinea Savannah, areas whose increased aridity and lack of high forest have been convincingly attributed to recent modifications through human agency (Booth 1958b, 1959; Robbins 1978). Thus, the conspecificity of populations in western Nigeria with those west of the Dahomey Gap suggests a recent distribution of *trivirgatus* across a continuous West African forest belt, a geographic pattern which supports those who have questioned the significance of the gap as an isolating factor (Booth 1958b; Diamond and Hamilton 1980; Robbins 1978).

We have no records of *planifrons* from east of the Sassandra River in southwestern Ivory Coast (Fig. 16). In view of the collecting activity in southern Ivory Coast and Ghana, this distributional terminus does not appear to be an artifact of inadequate sampling, but the presence of *planifrons* should still be sought among samples of *Hybomys* east of the Sassandra. As presently known, the range of *planifrons* conforms to an hypothesized Liberian forest refuge. The past formation of such a refuge has been interpolated from the relatively high endemicity of vertebrate faunas inhabiting this westernmost high forest tract (Diamond and Hamilton 1980; Grubb 1982), from otherwise anomalous breaks in distribution in the vicinity of southwestern Ivory Coast (Booth 1958b; Schiotz 1967), and from the sharp convergence of isohyets (the "Baoule V") toward the coastline and related constriction of the rainforest in this region (Moreau 1969).

The distributional pattern observed in *Hybomys* concords with our interpretation of kinship among the species. That is, the two forms occupying the West African forest belt, or parts thereof, bear closer phylogenetic relationship to one another than to the species (or species complex) inhabiting the Central African forest block.

Moreover, a similar pattern of relationship and geographical distribution reappears in certain other murines restricted to tropical rainforest (Fig. 17). In particular, the taxonomic history and distribution of *Malacomys* species recall the situation documented for *Hybomys,* in consisting of a broadly distributed Congo forest form, *longipes* (plus the little-known *verschureni*), and two West African species, *edwardsi* and *cansdalei.* Like *Hybomys planifrons, Malacomys cansdalei* had been considered a disjunct race of the Central African species (Rosevear 1969; Rautenbach and Schlitter 1978), but additional study disclosed its distinctiveness and probable cognate affinity to *edwardsi,* another species of the West African

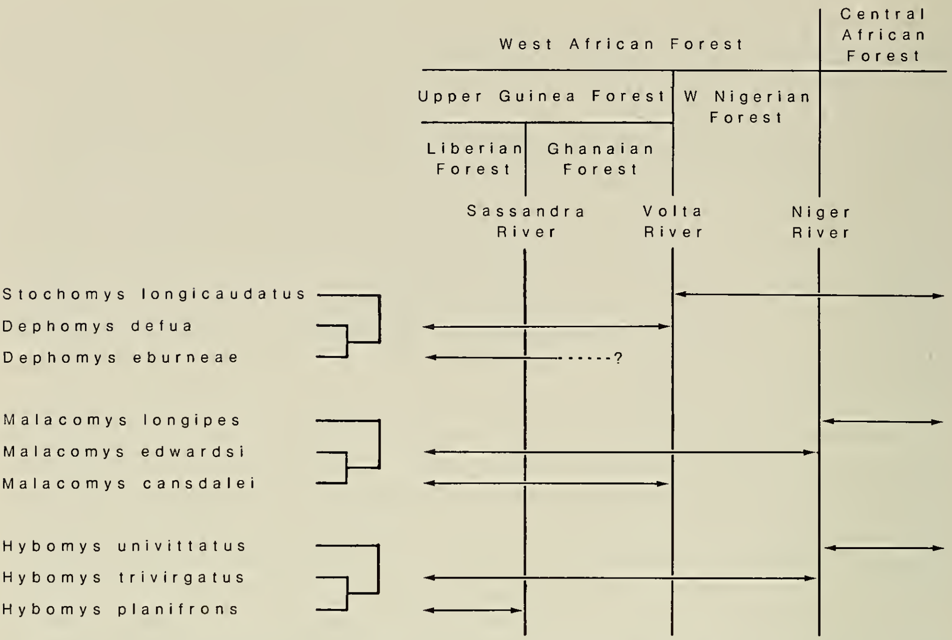

Fig. 17. Limits of distribution of three vicariant examples of high forest rats in relation to major forest blocks and rivers. Cladograms to the right of the scientific names represent hypothesized relationship within each three-taxon example.

high forest (Van der Straeten and Verheyen 1979). In the case of *Malacomys,* however, the more geographically restricted of the two West African species, *cansdalei,* ranges more widely than *Hybomys planifrons. Dephomys defua, D. eubrneae,* and *Stochomys longicaudatus* are also rats that live primarily in tropical rainforests. Although some systematists have maintained *Dephomys* as a subgenus of *Stochomys* (Heim de Balsac and Bellier 1967; Misonne 1971), others have not (Rosevear 1969; Carleton and Musser 1984). Despite the disagreement over their nomenclatural rank, their near relationship is reasonably established. Based on USNM material, the contiguous pattern of differentiation of *Stochomys* and *Dephomys* resembles that evident in *Hybomys* and *Malacomys,* except that the Central African *Stochomys longicaudatus* penetrates further into West Africa (Fig. 17), having been collected at Agou, Togo.

Assuming an allopatric speciation model for the three examples of high forest rats, the occurrence within each triad of the closest related species pairs in West African forest suggests: 1) the past fragmentation of this forest into at least two West African refugia during dryer climatic periods; 2) the differentiation and genetic divergence of these allopatric stocks during such isolation, and 3) the subsequent range expansion and overlap of the derivative species following climatic amelioration and reunion of the forests. Such a speciation history seems to account more plausibly for the congruent phylogenetic and geographic patterns observed, rather than a speciation history involving multiple dispersals into West Africa from a Central African place of origin. The occurrence of two refugia in West Africa has been postulated in some zoogeographic interpretations (Booth

1958b; Diamond and Hamilton 1980; Schiotz 1967), but firm stratigraphic or palynological evidence demonstrating the existence or location of such refugia remains disturbingly elusive (Livingstone 1975, 1982).

Whether other kinds of forest rats adhere to this pattern, or exhibit yet others, will require further study to refine the number of biological species, the basis of their recognition, and the limits of their distribution. Too few forest-dwelling genera are thusly documented. Fewer still is the number of those genera for which we have reasonably corroborated hypotheses of relationship, either between them or among their constituent species. Nevertheless, the systematic complexity and cosmopolitan forest distribution of genera such as *Praomys* and *Hylomyscus* promise further insight. For instance, Verheyen and Van der Straeten (1981) recently resurrected *Praomys rostratus,* another species Miller (1900) described from Mt. Coffee, from synonomy under *P. tullbergi,* a species having a broader distribution throughout western and westcentral forests.

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# Appendix I

The preparation of the distributional map (Fig. 16) relied primarily upon specimens examined by us and to a lesser extent locality records gleaned from the literature. Both kinds of distributional sources are documented below under the headings of Specimens Examined and Additional Records. The locality information appears essentially as stated on specimen tags or as given by authors. To aid verification where necessary and to assist location of obscure collecting sites, we generally consulted the gazetteers provided by Davis and Misonne (1964), Rautenbach and Schlitter (1978), and Rosevear (1965).

## Specimens Examined

*Hybomys planifrons.* IVORY COAST: Niebe, 5°21′N, 7°22′W, 3 (USNM). LIBERIA: Du River, 4 (MCZ); Duside, 2 (AMNH); Gunyon Bassa, 5 (BMNH); Mount Coffee, 2 (USNM, holotype and paratype); Mount Nimba, near Granfield, 1 (BMNH); Nimba Ridge, Mt. Alpha, 1 (BMNH); S Nimba Ridge, 7°44′N, 8°28′W, 5 (BMNH); Parinari Forest, Nimba, 1 (BMNH). SIERRA LEONE: Bintamane Mountain, 13 (BMNH); 10.3 km SE Fintonia, 9°38′N, 12°9′W, 2 (USNM); 10.1 km E Fintonia, 9°45′N, 12°10′W, 2 (USNM); Kenema, 1 (BMNH); Konia 8°07′N, 11°01′W, 1 (USNM); Meema, 8°07′N, 11°00′W, 2 (USNM); Niahun, 8°01′N, 11°02′W, 1 (USNM); 10 mi N Panguma, 8°17′N, 11°16′W, 1 (USNM); 5.2 mi W Sainya, 9°48′N, 12°27′W, 1 (USNM). Total = 48.

*Hybomys trivirgatus.* GHANA: Adamso, 6°05′N, 1°45′W, 1 (USNM) Ankasa, 40 mi W Axim, 3 (BMNH); Axim, 1 (BMNH); 1 mi N Berekuso, 5°46′N, 0°13′W, 15 (USNM) Bibianaha, 1 (BMNH); Bunsu, 6°19′N, 0°27′W, 2 (BMNH); Goaso, Ashanti District, 4 (BMNH); 6 mi NW Kade, 6°06′N, 0°51′W, 11 (USMN); Kumasi, 9 (BMNH); Mapong, Ashanti District, 7 (BMNH); Oda, 4 (FMNH), 1 (MCZ); Pampramase, 6°40′N, 2°55′W, 2 (BMNH); 32 mi W Prestea, 5°23′N, 2°28′W, 8 (USNM); Tano River, Tano Lodge, 5 (BMNH); W of Sefwi Wiawso, 4 (BMNH). IVORY COAST: 17 km W Abidjan, 5°19′N, 4°08′W, 8 (CM); Adiopodoume, 5°19′N, 4°08′W, 8 (AMNH), 1 (CM), 2 (USNM); Blekoum, 6°23′N, 3°31′W, 3 (USNM); Ehania, 5°17′N, 3°04′W, 5, (USNM); Jacqueville, 5°12′N, 4°24′W, 1 (USNM); 15 km N Lakota, 6°00′N, 5°43′W, 5 (AMNH); Sassandra River, 7°00′N, 7°03′W, 2 (USNM); Soubre, 5°49′N, 6°45′W, 2 (USNM); Yabrasso, 7°26′N, 3°28′W, 3 (USNM). LIBERIA: Banga, 1 (MCZ); Peahtah, 1 (MCZ); Wiersn, 1 (AMNH); Tars Town, 25 km N Zwedru, 6°13′N, 8°08′W, 12 (USNM). NIGERIA: 6 mi N Ago Shasha, 4 mi S Ilashe, 1 (USNM); 30 mi W Benin, 6 (USMN); Gambari, S of Ibadan, 2 (BMNH); Ibadan, 1 (USNM); Ijii Waterworks, near Lagos, 1 (BMNH); Lagos, 5 (BMNH, inc. holotype of *T. t. pearsei*); Federal District, University of Lagos, 10 (USNM); Mamu Forest Reserve, near Ibadan, 1 (BMNH); Nikrowa, W of Benin, 1 (BMNH); Sapoba, 1 (USNM). SIERRA LEONE: Bambawo Forest Reserve, 5 (BMNH); Belebu, 7°47′N, 12°00′W, 1 (USNM); 4 mi S Lalehun, Gola Forest Camp, 7°54′N, 10°58′W, 2 (USNM); Sandaru, 1 (BMNH). Total = 171.

*Hybomys univittatus.* CAMEROON: Alum, 20 mi E Efulan, 1 (CM); 11 km S, 1 km E Bamenda, 5°51′N, 10°10′E, 1900 m, 2 (CM); Batanga, 26 (CM); Boumba Ngoko, vicinity of Bateka Malen, 2°09′N, 15°11′E, 2 (USNM); 30 km W Bertoua, 8 (AMNH); Bipindi, 13 (AMNH); 4 km N Buba-Bokwai Rd., 1 (FMNH); Mount Cameroon, 5800 ft, 1 (FMNH, holotype of *H. u. badius*); Campo, 1 (CM); Ebolowa, 4 (CM), 1 (FMNH); Efulan, 2 (CM), 4 (USNM); Efulan-Kribi, 1 (AMNH); Eseka, 3°38′N, 10°47′E, 1 (AMNH); 5 km SW Eseka, 3°37′N, 10°45′E, 2 (AMNH); 6 km SE Eseka, 3°35′N, 10°48′E, 2 (AMNH), 1 (CM); 8 km SW Eseka, 3°35′N, 10°44′E, 1 (AMNH), 2 (CM); Kribi, 2 (CM); Lolodorf, 39 (CM), 5 (MCZ); 12 km SE Mamfe, 2 (AMNH); Mengama, 80 mi SE Ebolowa, 1 (CM); Metet, 7 (CM), 6 (MCZ); 20 km E Minta, 3 (AMNH); Moloudou, 2 (CM); 30 km E Nanga-Eboko, 3 (AMNH); 5 km E Ndokayo, 2 (AMNH); Sakbayeme, 3 (FMNH); Sangmelima, 12 (CM); Sonsak, 1 (MCZ); Tisongo, 1 (USNM); Yaounde, 1 (CM); Yokadouma, 5 (CM). CONGO: Dolisie, 4 (AMNH); Etoumbi, 66 (AMNH); Makoua, 1 (AMNH); Mouyondzi, 3 (AMNH). EQUATORIAL GUINEA: Benito River, 15 mi from mouth, 3 (USNM). GABON: Anguanamo Ngovi, 22 (USNM); Estuaire Prov., 1 km SE Cap Esterias, 9 (CM); Mperi, Fernan Vaz, 2 (USNM); Fougamou, 4 (AMNH); Labamba, 1 (FMNH); Mount Tandou, Mouila, 1 (FMNH); Ogouma, Reni Nkami, 4 (USNM); Yombi, 5 (FMNH). NIGERIA: 14 mi S Oban, 2 (USNM). RWANDA: Uinka (=Shangugu), 5 (USNM). UGANDA: Kanyawara, 0°34′N, 30°21′E, 2 (USNM). ZAIRE: Avakubi, 12 (AMNH); Bafwasende, 4 (AMNH); Bogomanda, Lemera, 9 (USNM); Gamangui, 1 (AMNH); Irangi, 30 (USNM); Irumu, 2 (FMNH); Ituri Forest, 3 (FMNH); Kisiki, 36 km N Beni, 2500 ft, 2 (MCZ); Lukolela, 8 (AMNH); Kivu, Tshibati, near Lwiro, 6400 ft, 9 (AMNH); SW Lake Kivu, Falls of Lwiro River, 6800 ft, 6 (AMNH); Medje, 5 (AMNH); Ngayu, 1 (AMNH); Niangara, 4 (AMNH); Niapu, 3 (AMNH); Stanleyville, 1 (AMNH); Equatorial Region, Gemena Zone, Tandala, 3°02′N, 19°21′E, 1 (USNM); Bumba Zone, Yalosemba, 2°35′N, 21°51′E, 1 (CM), 1 (USNM). TOTAL = 398.

### Additional Records

*Hybomys planifrons.* GUINEA: Boola (Heim de Balsac and Lamotte 1958); Ziela, Mt. Nimba (Rosevear 1969). IVORY COAST: Grabo; Soubre; Tai (Dosso 1975; Tranier and Dosso 1979). LIBERIA: Mount Barclay; Deaple; Freemantown; Harbel (Rosevear 1969).

*Hybomys trivirgatus.* IVORY COAST: Lamto (Heim de Balsac and Bellier 1967); Tai (Dosso, 1975). LIBERIA: Grand Cape Mount (Jentink 1888); Gonyon (Rosevear 1969); S Nimba Ridge (Coe 1975).

*Hybomys univittatus.* CAMEROON: Foulassi, 6 km NNW Sangmelima (Perret and Aellen 1956); Mamfe, 400 ft; Fineschang, 650 ft; Tinta Assumbo Mts., 2300 ft (Sanderson 1940); CENTRAL AFRICAN REPUBLIC: la Maboke (Petter and Genest 1970). EQUATORIAL GUINEA: Cabo San Juan (Cabrera 1929). NIGERIA: Nko, 450 ft; Okoiyong, 450 ft (Sanderson 1940); Oban (Rosevear 1969). UGANDA: Kalinzu Forest, Ankole; Maramagambo Forest, Ankole; Bugoma Forest, Bunyoro; Impenetrable Forest, Kigezi; Malabigambo Forest, Masaka; Mbanga Forest, Mubuku Valley, Toro; Mayanja Forest, West Mengo; Mpanga Forest, West Mengo (Delaney 1975). ZAIRE: Fundi Mambaka; Philipili (Dollman 1914); Tingasi; Stat. Gadda; Poko, 20–30 mi NW Medje; Inkongo, Sankuru River (Thomas 1888, 1915, 1916). ZAMBIA: Mwinilunga District, Harr (Ansell 1974, 1978).

## Appendix 2

Cranial and External Measurements (in mm) of Selected Samples of *Hybomys*

| Species and locality | n | $\bar{x}$ | 1 SD | Range |
|---|---|---|---|---|
| Occipitonasal length | | | | |
| *H. planifrons* | | | | |
| All | 14 | 32.9 | 0.71 | 31.9–34.2 |
| *H. trivirgatus* | | | | |
| Ghana | 16 | 33.6 | 0.90 | 32.3–35.1 |
| Ivory Coast | 22 | 33.6 | 1.23 | 31.0–36.0 |
| Nigeria | 10 | 33.4 | 0.62 | 32.5–34.4 |
| *H. univittatus* | | | | |
| Cameroon: Eseka and vic. | 15 | 34.7 | 0.96 | 32.7–36.5 |
| Cameroon: Lolodorf | 23 | 33.6 | 1.21 | 31.3–36.1 |
| Gabon: Cap Esterias | 9 | 32.6 | 0.81 | 31.7–34.0 |
| Zaire: Kivu Prov. | 21 | 33.6 | 1.30 | 31.5–35.6 |
| Rostral length | | | | |
| *H. planifrons* | | | | |
| All | 14 | 12.3 | 0.44 | 11.5–13.0 |
| *H. trivirgatus* | | | | |
| Ghana | 16 | 12.6 | 0.52 | 11.6–13.5 |
| Ivory Coast | 22 | 12.6 | 0.70 | 11.0–13.5 |
| Nigeria | 10 | 12.5 | 0.24 | 12.2–12.9 |
| *H. univittatus* | | | | |
| Cameroon: Eseka and vic. | 15 | 12.0 | 0.41 | 11.3–12.7 |
| Cameroon: Lolodorf | 23 | 12.0 | 0.55 | 11.2–13.2 |
| Gabon: Cap Esterias | 9 | 11.6 | 0.53 | 10.9–12.4 |
| Zaire: Kivu Prov. | 21 | 11.7 | 0.61 | 10.5–12.6 |
| Greatest zygomatic breadth | | | | |
| *H. planifrons* | | | | |
| All | 14 | 15.3 | 0.47 | 14.7–16.4 |
| *H. trivirgatus* | | | | |
| Ghana | 16 | 15.6 | 0.66 | 14.6–16.8 |
| Ivory Coast | 21 | 15.3 | 0.77 | 13.7–16.4 |
| Nigeria | 10 | 15.2 | 0.32 | 14.7–15.8 |
| *H. univittatus* | | | | |
| Cameroon: Eseka and vic. | 15 | 16.6 | 0.45 | 15.9–17.2 |
| Cameroon: Lolodorf | 23 | 16.0 | 0.57 | 14.8–17.0 |
| Gabon: Cap Esterias | 9 | 15.8 | 0.58 | 15.1–16.8 |
| Zaire: Kivu Prov. | 18 | 16.0 | 0.60 | 14.9–17.0 |
| Width of zygomatic plate | | | | |
| *H. planifrons* | | | | |
| All | 14 | 2.6 | 0.17 | 2.3–2.8 |
| *H. trivirgatus* | | | | |
| Ghana | 16 | 2.6 | 0.24 | 2.2–3.2 |
| Ivory Coast | 22 | 2.8 | 0.28 | 2.1–3.3 |
| Nigeria | 10 | 2.4 | 0.18 | 2.1–2.7 |

Appendix 2

Continued

| Species and locality | n | $\bar{x}$ | 1 SD | Range |
|---|---|---|---|---|
| *H. univittatus* | | | | |
| Cameroon: Eseka and vic. | 15 | 4.0 | 0.33 | 3.3–4.7 |
| Cameroon: Lolodorf | 23 | 3.9 | 0.29 | 3.4–4.4 |
| Gabon: Cap Esterias | 9 | 3.5 | 0.25 | 3.3–4.0 |
| Zaire: Kivu Prov. | 21 | 3.5 | 0.29 | 3.1–4.4 |
| | | Least interorbital width | | |
| *H. planifrons* | | | | |
| All | 14 | 6.0 | 0.25 | 5.5–6.4 |
| *H. trivirgatus* | | | | |
| Ghana | 16 | 6.4 | 0.33 | 5.7–6.9 |
| Ivory Coast | 22 | 6.3 | 0.36 | 5.9–7.1 |
| Nigeria | 10 | 6.4 | 0.26 | 6.0–6.7 |
| *H. univittatus* | | | | |
| Cameroon: Eseka and vic. | 15 | 5.9 | 0.29 | 5.3–6.2 |
| Cameroon: Lolodorf | 23 | 5.8 | 0.57 | 5.3–6.7 |
| Gabon: Cap Esterias | 9 | 6.1 | 0.22 | 5.8–6.4 |
| Zaire: Kivu Prov. | 21 | 5.8 | 0.31 | 5.1–6.5 |
| | | Postpalatal length | | |
| *H. planifrons* | | | | |
| All | 14 | 11.1 | 0.41 | 10.4–11.8 |
| *H. trivirgatus* | | | | |
| Ghana | 16 | 11.3 | 0.36 | 10.7–11.9 |
| Ivory Coast | 22 | 11.2 | 0.50 | 10.1–12.1 |
| Nigeria | 10 | 11.4 | 0.39 | 10.7–12.1 |
| *H. univittatus* | | | | |
| Cameroon: Eseka and vic. | 15 | 11.6 | 0.59 | 10.7–12.9 |
| Cameroon: Lolodorf | 23 | 11.0 | 0.62 | 9.9–12.2 |
| Gabon: Cap Esterias | 9 | 10.4 | 0.60 | 10.0–11.7 |
| Zaire: Kivu Prov. | 21 | 11.1 | 0.53 | 10.1–12.0 |
| | | Length of hard palate | | |
| *H. planifrons* | | | | |
| All | 14 | 5.6 | 0.29 | 5.0–6.1 |
| *H. trivirgatus* | | | | |
| Ghana | 16 | 6.2 | 0.39 | 5.5–6.9 |
| Ivory Coast | 22 | 6.1 | 0.33 | 5.6–6.9 |
| Nigeria | 10 | 6.4 | 0.29 | 5.9–6.7 |
| *H. univittatus* | | | | |
| Cameroon: Eseka and vic. | 15 | 6.0 | 0.29 | 5.5–6.5 |
| Cameroon: Lolodorf | 23 | 5.8 | 0.33 | 5.2–6.6 |
| Gabon: Cap Esterias | 9 | 5.6 | 0.20 | 5.2–5.8 |
| Zaire: Kivu Prov. | 21 | 5.7 | 0.38 | 5.0–6.5 |
| | | Length of incisive foramen | | |
| *H. planifrons* | | | | |
| All | 14 | 5.7 | 0.33 | 5.0–6.3 |

Appendix 2

Continued

| Species and locality | n | $\bar{x}$ | 1 SD | Range |
|---|---|---|---|---|
| *H. trivirgatus* | | | | |
| Ghana | 16 | 5.3 | 0.36 | 4.8–5.9 |
| Ivory Coast | 22 | 5.5 | 0.37 | 4.9–6.3 |
| Nigeria | 10 | 5.0 | 0.19 | 4.5–5.2 |
| *H. univittatus* | | | | |
| Cameroon: Eseka and vic. | 15 | 6.8 | 0.35 | 6.3–7.7 |
| Cameroon: Lolodorf | 23 | 6.8 | 0.43 | 6.1–7.6 |
| Gabon: Cap Esterias | 9 | 6.6 | 0.25 | 6.1–7.0 |
| Zaire: Kivu Prov. | 21 | 6.8 | 0.34 | 6.1–7.6 |
| | | Diastemal length | | |
| *H. planifrons* | | | | |
| All | 14 | 8.2 | 0.38 | 7.7–8.7 |
| *H. trivirgatus* | | | | |
| Ghana | 16 | 7.9 | 0.28 | 7.4–8.4 |
| Ivory Coast | 22 | 8.1 | 0.55 | 7.1–9.1 |
| Nigeria | 10 | 8.0 | 0.27 | 7.7–8.5 |
| *H. univittatus* | | | | |
| Cameroon: Eseka and vic. | 15 | 8.2 | 0.28 | 7.7–8.8 |
| Cameroon: Lolodorf | 23 | 8.5 | 0.49 | 7.5–9.2 |
| Gabon: Cap Esterias | 9 | 8.3 | 0.26 | 7.9–8.6 |
| Zaire: Kivu Prov. | 21 | 8.1 | 0.51 | 7.4–9.1 |
| | | Alveolar length of maxillary toothrow | | |
| *H. planifrons* | | | | |
| All | 14 | 5.6 | 0.17 | 5.3–5.9 |
| *H. trivirgatus* | | | | |
| Ghana | 16 | 5.4 | 0.24 | 5.0–5.9 |
| Ivory Coast | 22 | 5.4 | 0.28 | 4.8–5.8 |
| Nigeria | 10 | 5.3 | 0.17 | 5.1–5.6 |
| *H. univittatus* | | | | |
| Cameroon: Eseka and vic. | 15 | 6.1 | 0.17 | 5.7–6.4 |
| Cameroon: Lolodorf | 23 | 5.7 | 0.20 | 5.2–6.0 |
| Gabon: Cap Esterias | 9 | 5.4 | 0.16 | 5.2–5.7 |
| Zaire: Kivu Prov. | 21 | 5.6 | 0.14 | 5.3–5.9 |
| | | Breadth across upper molars | | |
| *H. planifrons* | | | | |
| All | 14 | 6.8 | 0.22 | 6.5–7.2 |
| *H. trivirgatus* | | | | |
| Ghana | 15 | 6.8 | 0.32 | 6.1–7.2 |
| Ivory Coast | 22 | 6.7 | 0.31 | 6.2–7.4 |
| Nigeria | 9 | 6.7 | 0.16 | 6.6–7.1 |
| *H. univittatus* | | | | |
| Cameroon: Eseka and vic. | 15 | 7.1 | 0.27 | 6.7–7.5 |
| Cameroon: Lolodorf | 23 | 6.9 | 0.25 | 6.5–7.3 |
| Gabon: Cap Esterias | 9 | 6.9 | 0.23 | 6.5–7.3 |
| Zaire: Kivu Prov. | 21 | 6.7 | 0.19 | 6.2–7.1 |

Appendix 2

Continued

| Species and locality | n | $\bar{x}$ | 1 SD | Range |
|---|---|---|---|---|
| | | Depth of mandible | | |
| *H. planifrons* | | | | |
| All | 14 | 7.2 | 0.38 | 6.7–8.0 |
| *H. trivirgatus* | | | | |
| Ghana | 16 | 7.0 | 0.36 | 6.6–7.6 |
| Ivory Coast | 22 | 6.9 | 0.43 | 5.9–7.7 |
| Nigeria | 10 | 7.1 | 0.27 | 6.7–7.5 |
| *H. univittatus* | | | | |
| Cameroon: Eseka and vic. | 15 | 8.8 | 0.46 | 7.9–9.4 |
| Cameroon: Lolodorf | 22 | 8.4 | 0.54 | 7.0–9.6 |
| Gabon: Cap Esterias | 9 | 8.3 | 0.29 | 7.9–8.8 |
| Zaire: Kivu Prov. | 20 | 8.5 | 0.44 | 7.4–9.4 |
| | | Total length | | |
| *H. planifrons* | | | | |
| All | 14 | 219.4 | 9.35 | 201–234 |
| *H. trivirgatus* | | | | |
| Ghana | 15 | 222.4 | 12.30 | 200–248 |
| Ivory Coast | 20 | 224.0 | 10.11 | 199–243 |
| Nigeria | 10 | 218.8 | 6.05 | 210–226 |
| *H. univittatus* | | | | |
| Cameroon: Eseka and vic. | 14 | 254.5 | 13.36 | 233–280 |
| Cameroon: Lolodorf | 3 | 243.7 | — | 237–254 |
| Gabon: Cap Esterias | 5 | 236.2 | 5.76 | 228–243 |
| Zaire: Kivu Prov. | 12 | 238.7 | 13.68 | 214–259 |
| | | Tail length | | |
| *H. planifrons* | | | | |
| All | 14 | 96.3 | 6.39 | 85–107 |
| *H. trivirgatus* | | | | |
| Ghana | 15 | 98.7 | 9.05 | 82–120 |
| Ivory Coast | 20 | 101.2 | 5.71 | 90–111 |
| Nigeria | 10 | 99.1 | 6.49 | 90–115 |
| *H. univittatus* | | | | |
| Cameroon: Eseka and vic. | 14 | 121.3 | 8.21 | 107–135 |
| Cameroon: Lolodorf | 4 | 119.5 | — | 109–136 |
| Gabon: Cap Esterias | 5 | 113.8 | 5.07 | 106–120 |
| Zaire: Kivu Prov. | 12 | 118.1 | 7.22 | 103–126 |
| | | Hindfoot length | | |
| *H. planifrons* | | | | |
| All | 14 | 30.7 | 1.07 | 28–32 |
| *H. trivirgatus* | | | | |
| Ghana | 16 | 31.6 | 1.36 | 30–34 |
| Ivory Coast | 22 | 32.7 | 1.16 | 30–35 |
| Nigeria | 10 | 33.2 | 1.23 | 31–35 |

Appendix 2

Continued

| Species and locality | n | $\bar{x}$ | 1 SD | Range |
|---|---|---|---|---|
| *H. univittatus* | | | | |
| Cameroon: Eseka and vic. | 15 | 32.3 | 1.35 | 30–35 |
| Cameroon: Lolodorf | 4 | 32.5 | — | 31–34 |
| Gabon: Cap Esterias | 5 | 30.0 | 1.00 | 29–31 |
| Zaire: Kivu Prov. | 13 | 30.9 | 0.76 | 30–32 |

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# *CAECIDOTEA PHREATICA,* A NEW PHREATOBITIC ISOPOD CRUSTACEAN (ASELLIDAE) FROM SOUTHEASTERN VIRGINIA

Julian J. Lewis and John R. Holsinger

*Abstract.* — *Caecidotea phreatica* is described from groundwater outlets (drains, wells, and a seep) on the Coastal Plain of southeastern Virginia. It is assigned to the Hobbsi Group and is the first stygobiont isopod found in Virginia outside of karst areas in the western part of the state. The natural habitat of this species is believed to be interstitial.

The species described below is the first subterranean isopod to be found in Virginia distant from karst areas in the Appalachian Valley and Ridge Province in the western part of the state. Virginia has the distinction of containing more species of subterranean asellid isopods than any other state due to the presence of the diverse fauna of the Cannulus Group (Steeves 1963; Lewis 1980), and to a lesser extent, the Stygia Group (Steeves 1963). In addition to the species of *Caecidotea,* the only known troglobitic species of *Lirceus* are endemic to caves in Virginia (Holsinger and Bowman 1973; Estes and Holsinger 1976). Of this assemblage of subterranean species, it is difficult to differentiate between obligate troglobites and phreatobites, inasmuch as some species [e.g., *C. bowmani* (Lewis 1980)] are found in seeps or drain tiles where phreatobites would be expected, but caves are also found nearby. In contrast, *Caecidotea phreatica* is clearly an obligate phreatobite, known only from the Coastal plain near the mouth of Chesapeake Bay. Although most of the known phreatobitic *Caecidotea* occur in glacial deposits in the central United States (see Lewis and Bowman 1981; Lewis 1982), a few species are also known from Coastal Plain habitats similar to that of *C. phreatica*: *C. hobbsi* from crayfish burrows in Florida (Steeves 1966); *C. paurotrigonus* from a drain tile in Mississippi (Fleming 1972); and *C. beattyi* from a drain tile in southern Illinois (Lewis and Bowman 1981).

As pointed out previously (Lewis 1982), the ecological forte of the species of the Hobbsi Group (to which the new species is assigned) has been their colonization of phreatic habitats. The majority of phreatobites that occur outside of cave areas belong to the Hobbsi Group, although within the Stygia Group, *C. beattyi* is clearly a phreatobitic offshoot of the closely related troglobite *C. antricola* that occurs in the Ozarks adjacent to the range of this species.

The troglobitic fauna of the eastern United States is probably relatively well known at this point due to the intensive biological exploration of caves during the past two decades. However, the phreatobitic fauna probably remains poorly known, due both to the lag in collecting from subterranean habitats other than caves and the difficulty in finding ways of collecting from phreatic habitats. Whereas caves offer relatively easy access to troglobitic species, collecting phreatobites is contingent on the often ephemeral presence of isopods in drain tiles and adjacent ditches, seepage areas, wells, or cisterns. Additional undescribed species probably remain to be found in habitats on the Coastal Plain as well as elsewhere.

### *Caecidotea phreatica*, new species
Figs. 1–3

*Material examined.*—VIRGINIA. Isle of Wight Co.: basin fed by drain pipe (#1) on Taylor farm, 5.6 km N of Chuckatuck, 3 ♂♂, 5 ♀♀, J. R. Holsinger, 27 Mar 1983; basin fed by drain pipe (#2) on Taylor farm, 18 ♂♂, 34 ♀♀, J. R. Holsinger, 24 Apr 1983.—Nansemond Co.: outlet of drain tile at bottom of access well on Barlow farm, 3.2 km NNE of Chuckatuck, 2 ♂♂, 2 ♀♀, J. R. Holsinger and R. B. Godfrey, 26–27 Mar 1983; shallow well (#1) on Barlow farm, 5 ♂♂, 8 ♀♀, J. R. Holsinger and R. B. Godfrey, 26 Mar 1983; shallow well (#2) on Barlow farm, 1 fragment, J. R. Holsinger, 27 Mar 1983; outlet of drain, 4.8 km NW of Suffolk, 20 ♂♂, 33 ♀♀, Leslie Hubricht, 25 Feb 1945; seep-fed pool in woods, 4.8 km NW of Suffolk and 0.5 km W of Murphy's Pond, 10 ♂♂, 7 ♀♀, J. R. Holsinger, 25 Mar 1984.

A 9.5 mm ♂ from the Holsinger collection of 25 March 1984 is designated as the holotype (USNM 227038); the remaining specimens are paratypes. All of the material examined has been deposited in the National Museum of Natural History (Smithsonian Institution) under catalog numbers of the former United States National Museum (USNM).

*Description.*—Eyeless, unpigmented. Longest ♂ about 9.5 mm, ♀ 7.5 mm; body slender, about 7× as long as wide. Head about 1.4× as wide as long, anterior margin concave, postmandibular lobes slightly pronounced. Pleotelson about twice as long as wide, sides subparallel, caudomedial lobe slightly pronounced.

Antenna 1 reaching about midlength of last segment of peduncle of antenna 2, flagellum with up to about 7 segments, esthete formula 3–0. Mandibles with 4-cuspate incisors and lacinia mobilis; palp with plumose setae in rows on distal segments. Maxilla 1, outer lobe with 13 robust spines, inner lobe with 5 plumose setae.

♂ Pereopod 1, propodus about 1.7× as long as wide, palmar margin elongate, with proximal spine, medial bicuspid process separated by U-shaped cleft from lower, bicuspid distal process; dactyl flexor margin without process, undulating, with small spines. ♀ Pereopod 1, about 2.5× as long as wide, propodus without processes. Pereopod 4 sexual dimorphism apparent, carpus of ♂ about 2.1× as long as wide, ♀ about 2.6×.

♂ Pleopod 1 longer than pleopod 2, protopod very elongate, about equal in length to exopod, with 6–7 retinacula; exopod about 2.3× as long as wide, rounded distal margin with plumose setae, concave lateral margin with short non-plumose setae. Pleopod 2 exopod, proximal segment with 3 lateral setae, distal segment with about 11 long plumose setae along lateral and distal margins, 4 non-plumose setae along mesial margin. Endopod with distinct basal apophysis; tip with 4 processes: (1) caudal process broadly rounded, heavily sclerotized, (2) mesial process broad, subovate, (3) lateral process higher, digitiform, slightly recurved, and (4) cannula obscured by surrounding processes, low, conical. Pleopod 3 exopod distal and distolateral margins with short plumose setae. Pleopod 4 with

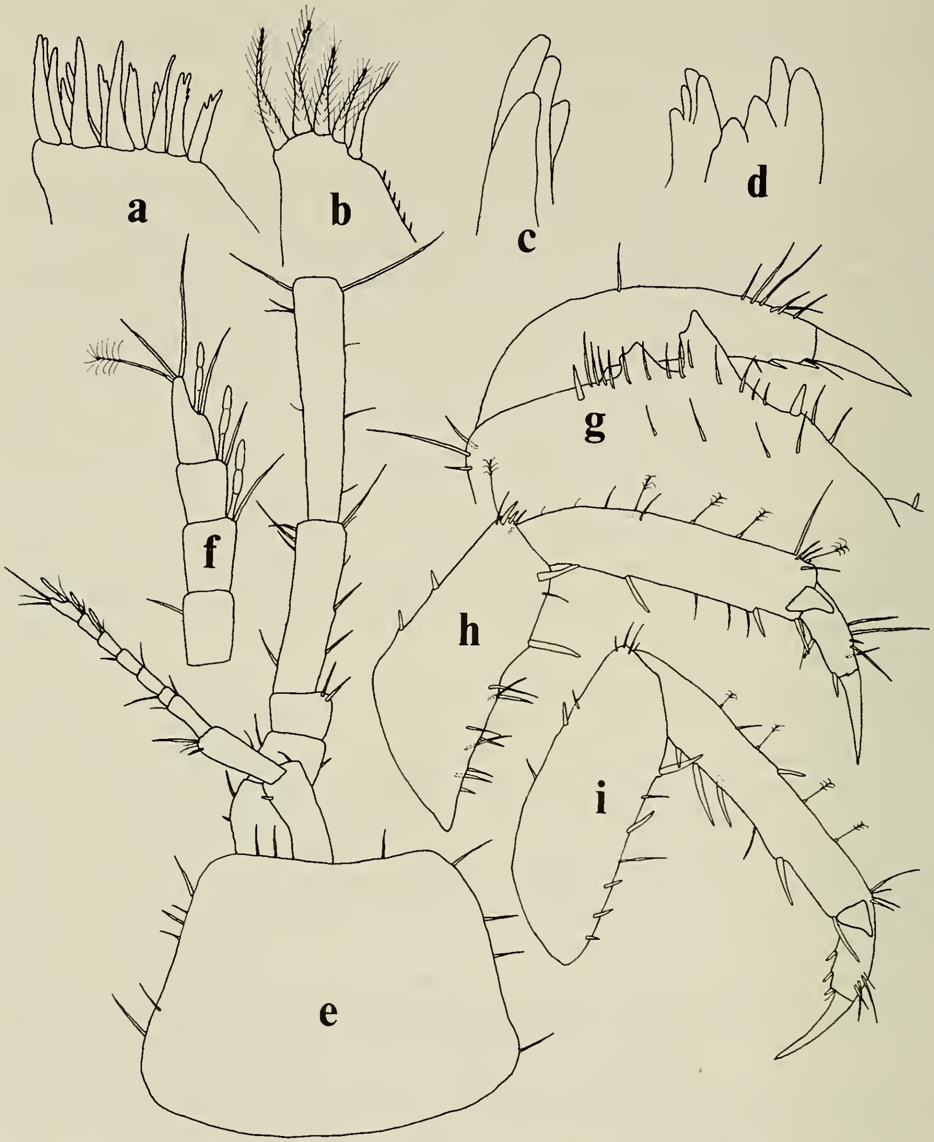

Fig. 1. *Caecidotea phreatica,* ♂ paratype a–h, ♀ paratype i: a, Maxilla 1, outer lobe; b, Same, inner lobe; c, Right mandible, incisor; d, Left mandible, incisor and lacinia; e, Head and antennae; f, Antenna 1, distal segments; g, Pereopod 1, palmar margin of propodus; h,i, Pereopod 4, distal segments.

single sigmoid suture, proximolateral setae present. Pleopod 5 with 2 sutures. Uropods about equal in length to pleotelson in ♂, slightly shorter in ♀.

*Etymology.*—The name is derived from the Green word *phreatos,* meaning "well" or "reservoir."

*Relationships.*—*Caecidotea phreatica* shares the general morphology of other members of the Hobbsi Group (Lewis 1982): gnathopod propod armed with well developed processes, first pleopod exopod with plumose setae along distal margin,

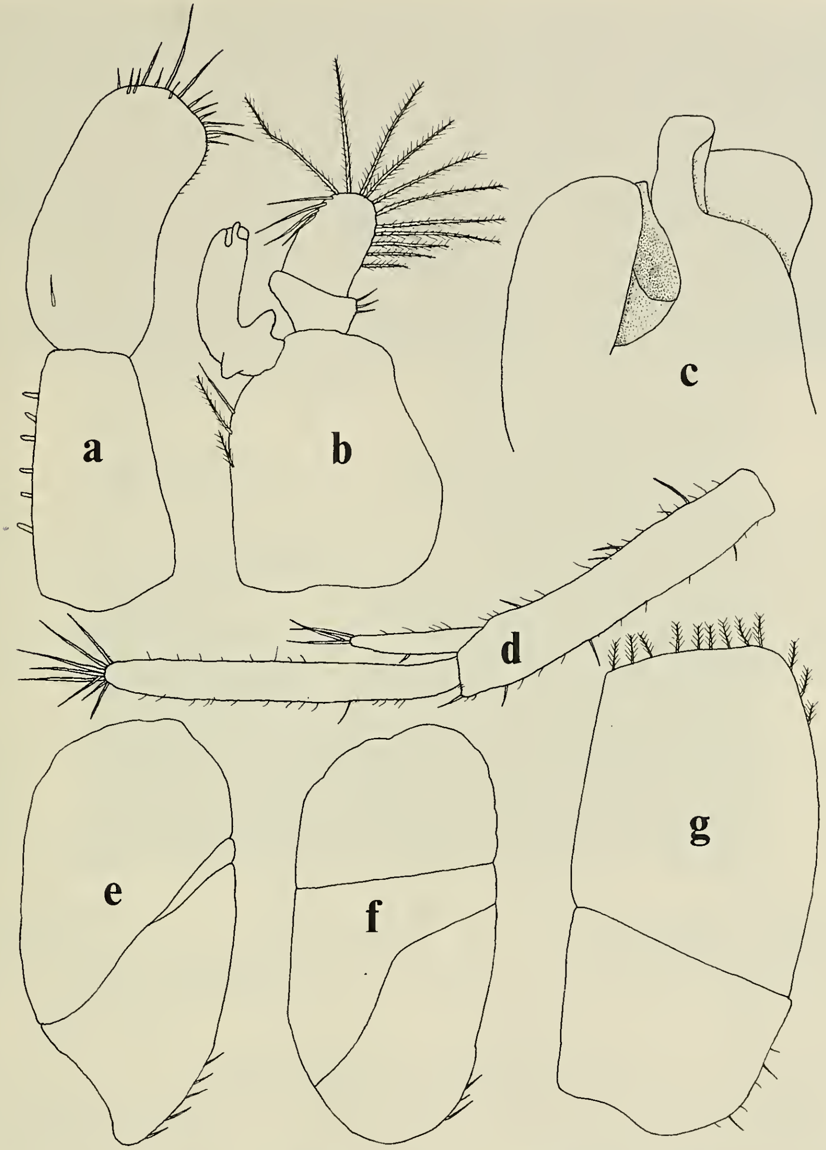

Fig. 2. *Caecidotea phreatica,* ♂ paratype: a, Pleopod 1; b, Pleopod 2; c, Same, endopod tip; d, Uropod; e, Pleopod 4; f, Pleopod 5; g, Pleopod 3.

and second pleopod endopod tip with cannula extending parallel to axis of the endopod, largely obscured by other processes. Otherwise, this species is not geographically or morphologically near other members of the Hobbsi Group.

*Distribution and ecology.*—To date, *Caecidotea phreatica* has been collected at seven localities in southeastern Virginia (Fig. 4). This species has been collected from a variety of groundwater outlets, including drains (Fig. 4, sites 1, 5, 6, and 7), shallow wells (sites 3 and 4), and a seep-fed pool (site 2). Sites 3–7 occur on the Churchland Flat just east of the Suffolk Scarp and are in the Sedgefield Member

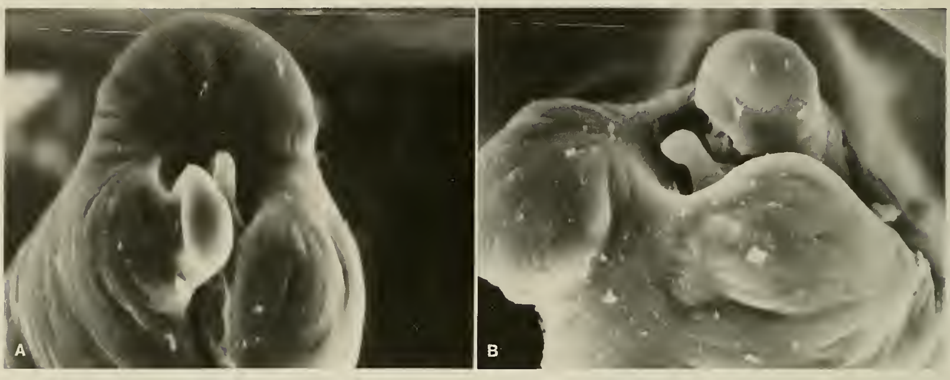

Fig. 3. Scanning electron micrographs of the tip of the endopod of the ♂ second pleopod: A, Anterior aspect; B, Distal aspect. ×1750.

of the Tabb Formation of late Pleistocene age (see Peebles et al. 1984). According to a geological study of this area by Coch (1968), this formation, which was called Sand Bridge in that paper, is composed of marsh and lagoon silty clay, tidal channel clayey sand, and fluvial and lagoon silty sand. Sites 1 and 2 occur on the Isle of Wight Plain just west of the Suffolk Scarp and are in the Windsor Formation of early Pleistocene age. This formation is composed of marine and estuarine

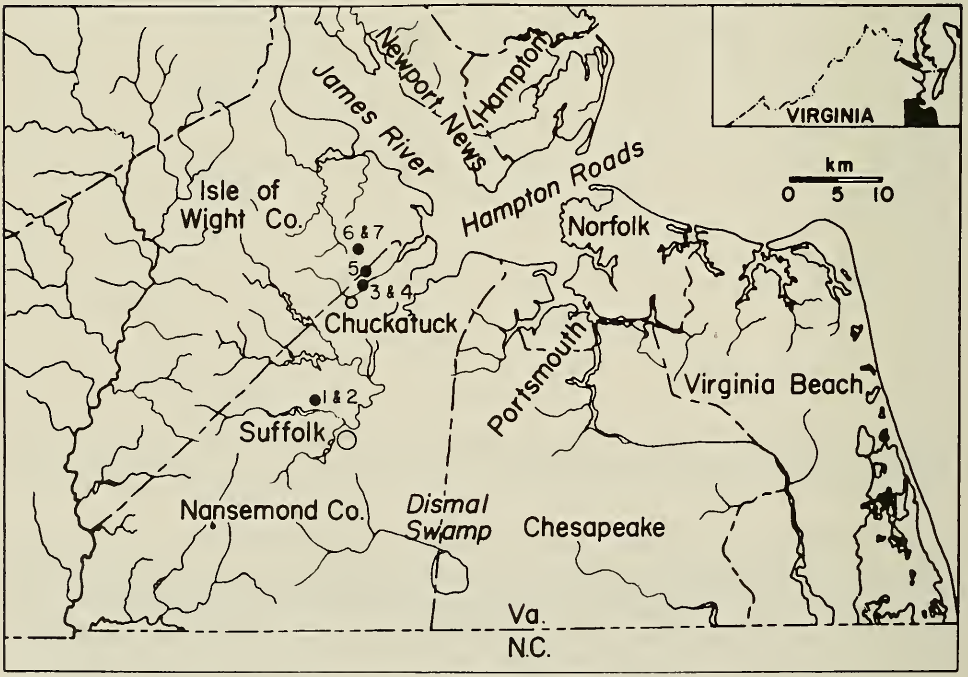

Fig. 4. Distribution of *Caecidotea phreatica* in southeastern Virginia: 1 and 2, Outlet of drain and seep-fed pool, Nansemond Co.; 3 and 4, Shallow wells on Barlow farm, Nansemond Co.; 5, Access well to drain tile on Barlow farm, Nansemond Co.; 6 and 7, Drain pipe outlets on Taylor farm, Isle of Wight Co.

Fig. 5. Outlet of drain pipe (#1) on Taylor farm in Isle of Wight Co., Virginia. Isopods were collected from the basin immediately below the end of the pipe in foreground. The pipe is an outlet for an underground drain tile system beneath the field seen in the background. Photograph from a kodachrome color slide by Holsinger.

sand and silt (Coch 1968). Although the drain outlet visited by Leslie Hubricht in 1945 (Fig. 4, site 1) could not be precisely located during recent fieldwork, it would be near Murphy's Pond and in the Windsor Formation according to the location given on the collection label.

Because *C. phreatica* has been collected from drain outlets, shallow wells, and a seep, we can only speculate on the nature of its natural habitat which is presumably subterranean. All collections have been made from groundwaters that drain areas of unconsolidated sediments of Pleistocene age. In addition, all collections have been made in late winter or early spring at a time when the resurgence of shallow groundwater is usually at a peak. The isopods, as well as the phreatobitic amphipods and flatworms that are sometimes found together with the former (see below), are probably flushed out of their underground habitat by increased flow at this time of year. The subterranean habitat of these phreatobites is believed to be an interstitial medium formed in coarser sediments just beneath the ground water table.

Of particular interest in our observations of *C. phreatica* are the two drain pipe outlets on the Taylor farm (Fig. 4, sites 6 and 7) which open along the bank of a small creek. Groundwater from the pipes flows into ceramic tile, catch basins, which are partly submerged in the creek bed and contain small amounts of organic detritus (Fig. 5). These pipes are the outlets of drain tile systems buried approximately 1.5 m below the surface of adjacent fields. Drain tiles are placed under cultivated fields in agricultural areas with poor natural drainage and are fairly common in certain places on the Coastal Plain in southeastern Virginia.

Collections of isopods were made from the catch basins in March and April 1983, but on a subsequent visit in December 1983, isopods were not found. However, in March 1984, isopods were again observed in the basins. In addition to *C. phreatica,* phreatobitic flatworms, *Sphalloplana hypogea* (Kenk, 1984), and amphipods, *Stygobromus indentatus* (Holsinger, 1967), were collected from the basins. A few epigean invertebrates were also found in small numbers and included oligochaetes, fingernail clams (Sphaeriidae), the amphipods *Crangonyx* spp. (both the *gracilis* and *richmondensis* groups) and *Synurella chamberlaini* (Ellis), and the isopod *Caecidotea forbesi* (Williams).

At other localities, *C. phreatica* was collected with a plankton net from shallow wells on the Barlow farm, and by hand from a woodland pool fed by the seepage of groundwater. Two of these wells are approximately 1.8 m and 4.5 m deep, respectively, and serve as sources of water. The other well provides access to drain tiles and is 1.5 m deep. In the seep-fed pool, *C. phreatica* was found on leaf litter in association with epigean flatworms (*Procotyla* cf. *fluviatilis*) and amphipods (*Crangonyx* sp.—*gracilis* group). The 1945 Hubricht collection of *C. phreatica* from a drain outlet 4.8 km northwest of Suffolk also contained 82 specimens of the phreatobitic amphipod *Stygobromus indentatus* (see Holsinger 1967).

## Acknowledgments

We are grateful to Joseph H. Barlow, Sr., and Robert P. Taylor for allowing us free access to their properties to collect specimens and make observations, and to George D. Corbett and Rustin B. Godfrey for their assistance with some of the fieldwork. David A. Hubbard (Virginia Division of Mineral Resources) called our attention to the paper by N. K. Coch, and Dr. Roman Kenk (Smithsonian Institution) identified the flatworms. We also thank Katharine M. Speiden and Deborah Miller Carson of Old Dominion University for preparing the distribution map. The Hubricht collection was provided to us on loan from the Smithsonian Institution by Dr. Thomas E. Bowman. This work was supported in part by a grant from the National Science Foundation (DEB-8206716) to J. R. Holsinger. Funds to J. J. Lewis from the Department of Biology, University of Louisville, provided for SEM beam time and materials.

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# *THAUMATOCONCHA POROSA,* A NEW SPECIES OF ABYSSAL OSTRACODE FROM THE INDIAN OCEAN (HALOCYPRIDA: THAUMATOCYPRIDIDAE)

Louis S. Kornicker

*Abstract.*—*Thaumatoconcha porosa* is described and illustrated from an adult male collected at abyssal depths (3716 m) in the Indian Ocean west of Madagascar (Mozambique Channel). The copulatory organ of the new species differs from that of other species of *Thaumatoconcha* in being more slender. *Thaumatoconcha* has not been reported previously from the Indian Ocean. A second specimen, an A-1 male collected at abyssal depths (4560 m) in the Atlantic Ocean west off South Africa (Cape Basin), is briefly described and illustrated, but is left in open nomenclature, as *Thaumatoconcha* species.

Kornicker and Sohn (1976) proposed the genus *Thaumatoconcha* for nine species (one left in open nomenclature) collected at bathyal and abyssal depths in the Atlantic and Pacific Oceans. Extensive collections from the vicinity of Africa made available to me by the Centre National de Tri d'Océanographie Biologique, Brest, France, provided only two specimens of *Thaumatoconcha*: one from 4560 m in Cape Basin, Atlantic Ocean, the other from 3716 m in Mozambique Channel, Indian Ocean; the latter is the first record of the genus in the Indian Ocean. Both specimens are described herein.

## *Thaumatoconcha* Kornicker and Sohn, 1976

*Type-species.*—*Thaumatoconcha radiata* Kornicker and Sohn, 1976:35.

*Distribution.*—Atlantic Ocean, 32°N–73°S; Pacific Ocean, 7°S–70°S; Indian Ocean, 11°44′S, 47°35′E. Known depth range 587–4758 m.

*Discussion.*—A crescent-shaped scar is clearly visible on the carapace of the new species described herein and, also, on the species left in open nomenclature. The scar is anteroventral to the central adductor muscle attachments (Figs. 1a, b, 4a). On reexamining shells of several species of *Thaumatoconcha* described by Kornicker and Sohn (1976) (*T. hessleri, T.* species E, and *T. radiata*) a similar scar was noted, although sometimes poorly developed and indistinct, especially on strongly calcified shells of *T. radiata.* The scar is also visible on the illustration of *T. elongata* presented by Kornicker and Sohn (1976:fig. 41e). The scar is termed *mandibular scar* herein, because I believe it marks the place of attachment of a tendon whose opposite end is attached to the dorsal apex of the mandibular basale. The tendon is similar to that illustrated by Harding (1965:11, fig. 2) on an unidentified ostracode. The mandibular scar was overlooked by Kornicker and Sohn (1976), and probably occurs on all members of *Thaumatoconcha.*

I would like to take this opportunity to correct the legend of figure 48 in Kornicker and Sohn (1976:71) which illustrates the valve of *T. hessleri* USNM 143744, not USNM 143862.

### *Thaumatoconcha porosa*, new species
Figs. 1–3

*Etymology.*—From the Greek *porosus* (full of holes), in reference to marginal pore canals concentrated in a short zone at midlength of the ventral margin of the carapace.

*Holotype.*—Adult male on slide and in alcohol, deposited in the Muséum National d'Histoire Naturelle, Paris, France, MNHN Os 78; unique specimen.

*Type-locality.*—Benthedi cruise, R. V. *Suroit,* station 87-CH, Mozambique Channel, SE of Glorioso Islands, 4 Apr 1977, 11°44′S, 47°35′E, depth 3716 m, bottom trawl.

*Description of adult male* (Figs. 1–3).—Valves circular, with greatest height near midlength (Fig. 1a, b); straight anteroventral margin with small conical projections at each end lateral to valve edge (Fig. 1d); minute pore present at tip of each protuberance; middle of ventral margin with concentration of 25–30 pore canals (Fig. 1e); shell thickness slightly less in vicinity of pore canals than thickness anterior and posterior to canals (visible when viewed laterally in transmitted light); pores open on outer surface of valve; outer surface of carapace appearing smooth but thin outer layer with faint punctae (especially visible in fragment of shell viewed under cover slip (Fig. 1c).

Central adductor muscle attachments (Fig. 1a, b): consisting of 8–10 wedged-shaped segments radially arranged.

Mandibular scar (Fig. 1a, b): crescent-shaped, concave towards central adductor muscle bundle, located anteroventral to the muscle bundle.

Size: holotype length 1.39 mm, height 1.00 mm.

First antenna (Fig. 2a–c): limb with 8 distinct joints. 1st joint with small lateral bulge bearing bristle with short marginal spines, and dorsal bristle with short marginal spines; medial surface of joint with long hairs. 2nd joint with long spines forming rows on medial surface, short spines on lateral surface, and 2 bristles (1 ventral, 1 dorsal), both with short marginal spines. 3rd joint with hairs along ventral and dorsal margins; 3rd and 4th joints distinctly separated in sclerotized areas of ventral and dorsal margins; 3rd and 4th joints separated by medial and lateral suture on left limb but fused on right limb; length of 3rd joint 63 percent length of 4th joint. 4th joint with 2 long, bare, terminal bristles with stout bases; dorsal margin of joint with few small indistinct spines. 5th joint with 1 long bristle with long, curved, distal hairs on ventral margin (hairs absent near tip), 1 medium length bristle with minute widely spaced marginal spines, and 1 shorter bare bristle with base on medial surface of joint. 6th joint with few minute spines along dorsal margin. 7th joint with 1 short dorsal bristle and 2 long ventral bristles with short, widely separated, marginal spines. 8th joint with 3 bristles (1 short, 1 medium, 1 long), all with widely spaced, minute, marginal spines.

Second antenna (Fig. 2d): protopodite with long hairs along ventral margin. Endopodite 3-jointed (Fig. 2d): 1st joint with long medial hairs near ventral margin and 3 bristles (1 ventral, 2 dorsal); 2nd joint narrower and longer than 1st, with long hairs on ventral margin and on medial surface near ventral margin, and with 4 bristles (1 short, lateral; 4 terminal), all with short marginal spines; 3rd joint with stout, sclerotized, curved, hook-like process with 2 spines at tip; surface pustulose, near tip. Exopodite with 8 joints; joint 1 divided by suture into long

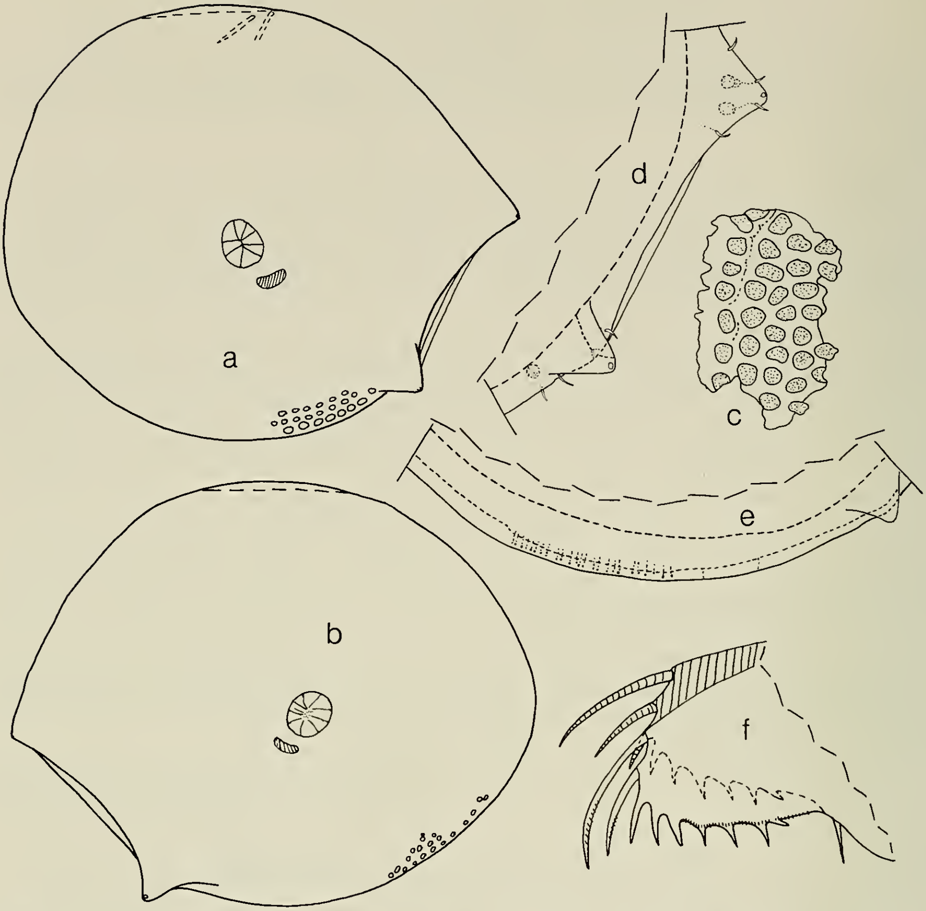

Fig. 1. *Thaumatoconcha porosa,* adult male, holotype, MNHN Os 78, length 1.39 mm: a, Lateral view of complete specimen from right side showing central muscle attachments, mandibular scar (lined pattern), some punctae at lower right, and dashed lines near dorsal margin representing the linear hinge and distal ends of 2 dorsal muscles; b, Lateral view of left valve somewhat flattened; c, Fragment of shell under cover slip showing punctae; d, Lateral view of anteroventral part of right valve showing pores at tip of conical protuberances and short marginal hairs; e, Lateral view of ventral margin of right valve showing concentration of pores near midlength; f, Caudal lamellae of furca (anterior of right lamella with pattern), and the individual process on posterior of body following laminae.

proximal and short distal parts; bristle of 2nd joint with narrow spines and distal natatory hairs (spines on proximal half of bristle on 1 limb, and on distal half on other limb); bristles of joints 3–8 with natatory hairs, no spines; 9th joint with 1 long bristle with small spines near middle and distal natatory hairs, and 1 shorter bristle (less than ½ length of long bristle) with slender widely spaced spines, no natatory hairs; some joints with minute distal spines forming short row.

Mandible (Figs. 2e, f, 3b): Coxale endite with proximal and distal sets of teeth separated by small space (Fig. 2e). Proximal set of teeth comprising 4 teeth (proximal of these with 1 pointed cusp; distal 3 with 4 cusps); densely arranged spines between teeth and extending onto medial surface of endite; lateral surface proximal to teeth with long spines forming rows. Distal set of teeth consisting of 2 stout

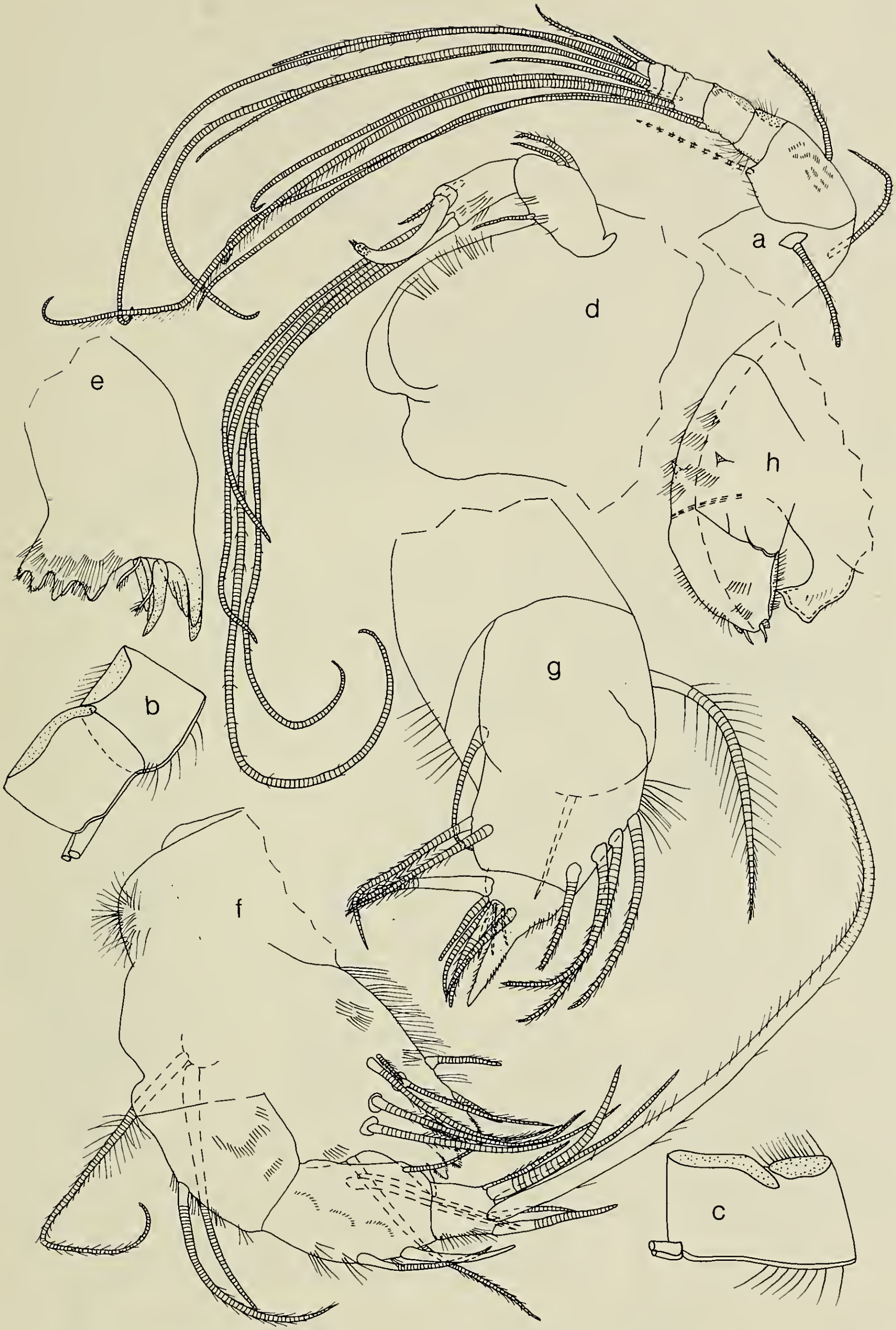

Fig. 2. *Thaumatoconcha porosa,* adult male, holotype, MNHN Os 78: a, Lateral view of left 1st antenna; b, Lateral view of 3rd and 4th joints of left 1st antenna; c, Medial view of 3rd and 4th joints of right 1st antenna; d, Medial view of protopodite and endopodite of right 2nd antenna; e, Medial view of distal end of coxale endite of left mandible; f, Lateral view of basale and endopodite of left mandible; g, Maxilla (endites not shown); h, Upper and lower lips, anterior to left.

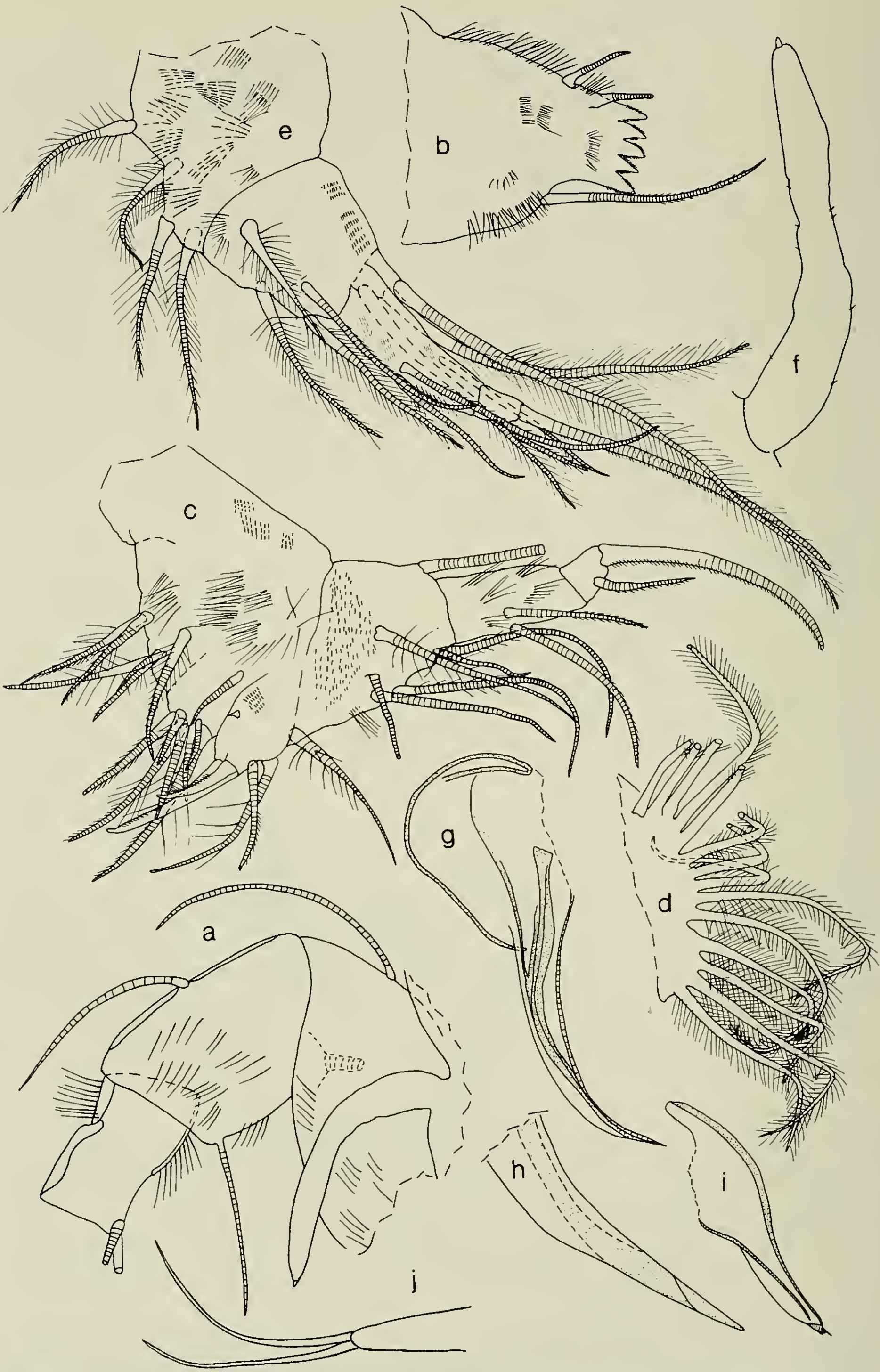

Fig. 3. *Thaumatoconcha porosa,* adult male, holotype, MNHN Os 78: a, Medial view of joints 1–4 of right 1st antenna, and Bellonci organ; b, medial side of distal part of basale of right mandible; c,

teeth; inner tooth comprising 1 stout and 5 or 6 smaller pointed teeth; outer tooth with 6 cusps; 2 bristles with spinous tips present at base of distal set of teeth. Basale (Figs. 2f, 3b): teeth of endite with 5 triangular cusps with minute serrations along margins; posterior margin of endite with 1 proximal bristle with marginal spines and 1 bare distal bristle with blunt tip; anterior margin of endite with 1 long spinous bristle; lateral side of endite with long hairs; 5 spinous bristles, and short, stout, distal, triangular process with minute teeth along anterior edge and curved tip (this process somewhat hidden behind bristles of illustrated limb, Fig. 2f); medial side of basale with mound bearing 2 long bristles (outer with long proximal and short distal spines, inner bare). Endopodite 3-jointed (1st and 2nd joints about same length, 3rd joint narrower and about ½ length of other joints) (Fig. 2f); 1st joint with 1 spinous dorsal bristle, and spines on lateral and medial surface and along dorsal margin; ventral margin of 2nd joint with 2 long bristles near midlength and 1 shorter distal bristle; dorsal margin of 2nd joint with 1 annulate proximal bristle and 1 non-annulate, distal, claw-like bristle; terminal end of 3rd joint with 3 lateral bristles (middle of these claw-like and about 3 times length of longer other bristles), and 3 slender ventral bristles.

Maxilla (Fig. 2g): endite I with 12 bristles, endites II and III obscure but each with about 9–11 bristles, some bristles flat, pectinate. Boundary between coxale and basale not well defined; basale with 3 bristles (some of these could be on coxale; dorsal bristle with long proximal and short distal spines). Endopodite: 1st joint hirsute, with 4 spinous bristles on anterior (dorsal) margin, and 2 spinous distal bristle on posterior (ventral) margin; anterior margin of end joint spinous; terminal end of end joint with total of 8 or 9 bristles (anterior bristle linear, claw-like, with minute teeth along edges; posterior bristle curving anteriorly, with marginal spines, remaining bristles spinous).

Fifth limb (Fig. 3c, d): epipodial appendage with bristles in 3 groups, each with 5, 5, and 4 (distal group) plumose bristles. Protopodite, basale, and endopodite with total of 19–21 bristles; endopodite with short, triangular, tooth-like process. Exopodite 3-jointed: 1st joint with long, spinous, dorsal bristle, and 6 bristles closer to ventral margin; 2nd joint hirsute, slender, longer than 1st, with 2 bristles on or near ventral margin at mid-length; end joint with 1 short spinous bristle and 1 long claw-like bristle with spines along ventral margin (short bristle 35–37 percent length of long bristle).

Sixth limb (Fig. 3e): epipodial appendage with bristle in 3 groups, each with 6, 4, and 5 (distal group) plumose bristles. Protopodite hirsute, with 4 bristles on or near ventral margin. Exopodite 4-jointed: 1st joint divided by weak suture into proximal part with 2 ventral bristles, and distal part with 2 ventral bristles and small dorsal process with 3 plumose bristles; 2nd and 3rd joints fused, hirsute, with 3 spinous bristles (2 midventral, 1 dorsal); end joint with 1 short spinous bristle and 1 long claw-like bristle with short spines along ventral margin (short bristle 26–31 percent length of long bristle).

Seventh limb (Fig. 3j): small with 2 long bristles.

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←

5th limb, epipodial appendage not shown; d, Epipodial appendage of 5th limb; e, 6th limb, epipodial appendage not shown; f, Organ of Bellonci; g, Anterior part of copulatory organ; h, Tip of organ shown in g; i, Posterior part of copulatory organ, j, 7th limb.

Furca (Fig. 1f): each lamella with 2 long anterior claws separated from lamella by suture, followed by 6 short claws and 1 short backward pointing process (claws and process not separated from lamella by suture); all claws with minute teeth; ventral part of lamella with minute spines; right lamella anterior to left.

Bellonci organ (Fig. 3a, f): elongate, reaching just past distal end of 2nd joint of 1st antenna; with few marginal hairs, and minute process on rounded tip.

Posterior of body (Fig. 1f): single slender process present proximal to furcal lamella; posterior margin of body divided into narrow segments (segments without sclerotized substructures).

Lips (Fig. 2h): ventral end of upper lip projecting posteriorly, with 2 short outer processes and 2 narrower inner pointed processes; small triangular process on each side of body proximal to upper lip. Lower lip consisting of 2 triangular flaps, each with sclerotized pointed process at tip.

Copulatory organ (Fig. 3g–i): single organ on left side of body consisting of 2 parts: anterior part elongate, curved, tapering to acuminate tip (Fig. 3g, h); posterior part shorter than anterior part, with 2 or 3 spines on sclerotized tip (Fig. 3i).

*Comparisons.*—The narrow copulatory organ of the male *T. porosa* separates the species from other species of *Thaumatoconcha* of which the male is known. The 1st endopodial joint of the maxilla of *T. porosa* bears fewer bristles (6) than other *Thaumatoconcha* (7–10) (Kornicker and Sohn 1976: tab. 13). Only three *Thaumatoconcha* have 1st antennae with the 3rd joint not longer than the 4th (*T. porosa, T. hessleri* Kornicker and Sohn, 1976:71, and *Thaumatoconcha* species A. Kornicker and Sohn, 1976:91). Only females are known for the last two species. The carapace of *T. porosa* differs from that of *T. hessleri* and *Thaumatoconcha* species A in having 25–30 marginal pore canals concentrated in a short zone near midlength of the ventral margin; wall thickness of the shell is thinner in the pore-zone (Fig. 1e). Because marginal pore canals were not described by Kornicker and Sohn (1976), I examined two paratypes of *T. hessleri* (USMN 143755, 144006) and the unique specimen of *Thaumatoconcha* species A (USMN 143862); pore canals along the ventral margin of the carapace of both species are more or less evenly distributed, and wall thickness of the shell along the ventral margin is constant. The length of the carapace of the unique male *T. porosa* (1.39 mm) is smaller than that of previously described males of other species (1.59–1.99 mm).

### *Thaumatoconcha* species
### Fig. 4

*Material.*—1 A-1 male, Walvis 1 cruise, R. V. *Jean Charcot,* station B, sample DS-05, Cape Basin, 30 Dec 1978, 33°20′05″S, 2°34′09″E, depth 4560 m, epibenthic dredge. Specimen deposited in the Muséum National d'Histoire Naturelle, Paris, France, MNHN Os 79.

*Description* (Fig. 4).—Carapace decalcified; anteroventral margin between ventral and dorsal processes slightly concave on right valve (Fig. 4a) but linear on left; surface with shallow punctae and without posterodorsal processes; ridges paralleling anteroventral margin indistinct (probably because of carapace being decalcified); marginal pores more or less equally distributed along ventral margin.

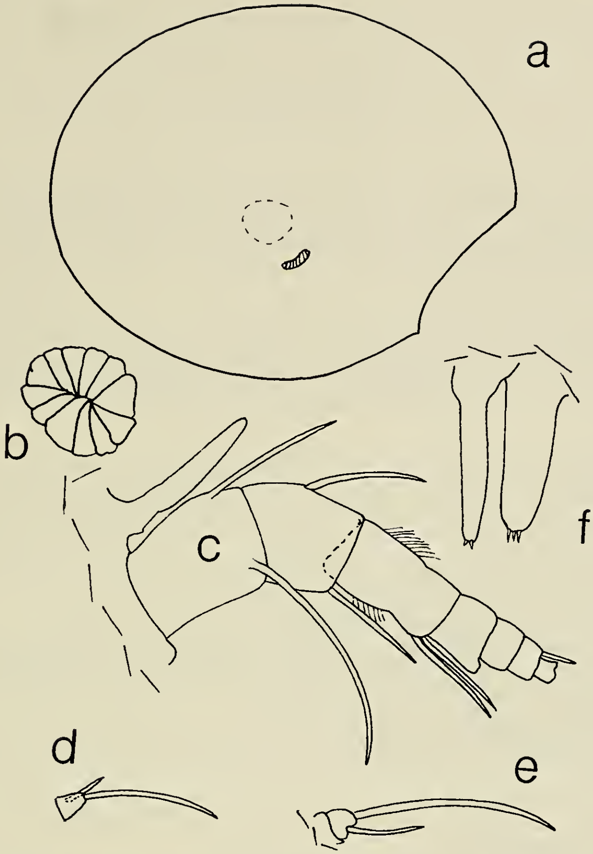

Fig. 4. *Thaumatoconcha* species, juvenile male (A-1 instar), MNHN Os 79, length 1.32 mm: a, Lateral view of complete specimen from right (dashed circle represents position of central adductor muscle attachments, crescent with lined pattern represents mandibular scar; b, Lateral view of central adductor muscle attachments of right valve; c, Medial view of left 1st antenna (not all bristles shown), and Bellonci organ; d, End joint of 5th limb; e, End joint of 6th limb; f, Copulatory organ, anterior to left.

Central adductor muscle attachments (Fig. 4b): consisting of about 12 radial scars.

Mandibular scar (Fig. 4a): consisting of small crescent-shaped scar anteroventral to central adductor bundle.

Size: length 1.32 mm, height 1.13 mm, length to height ratio 1.17.

First antenna (Fig. 4c): 1st joint with 2 bristles (1 lateral, 1 dorsal). 2nd joint with 1 dorsal midbristle and 1 ventral terminal bristle. 3rd and 4th joints fused; 3rd joint longer than 4th (Fig. 4c), with dorsal and ventral spines; 4th joint with 2 terminal ventral bristles reaching middle of 7th joint. 5th joint with 3 terminal ventral bristles (1 short, 2 long). 6th joint bare. 7th joint with 1 short dorsal bristle and 2 long ventral bristles. 8th joint with 3 terminal bristles (shortest of these dorsal).

Second antenna: protopodite bare. Endopodite 3-jointed: 1st joint with 3 bristles

(1 ventral, 2 dorsal); 2nd joint with 5 bristles (1 lateral, 4 ventral); 3rd joint, short, thumb-shaped, with 5 short terminal bristles. Expodite with 9 joints; 1st joint divided into 2 parts (proximal of these longer than other); joints 2–8 each with 1 long bristle with distal natatory hairs; 9th joint with 2 long bristles with natatory hairs.

Mandible: basale with 3 bristles (1 anterior, 2 posterior); lateral side with 5 bristles and short triangular process with curved tip; medial side with 2 bristles. Endopodite: 1st joint with 1 dorsal bristle; 2nd joint with 3 ventral and 2 dorsal bristles; 3rd joint with 6 bristles.

Maxilla: 1st endopodial joint with 6 anterior and 2 posterior bristles.

Fifth limb: epipodial appendage with bristles forming 3 groups of 5, 5, and 4 (distal group) bristles. 2nd exopodial joint with 2 midbristles (1 ventral, 1 medial). 3rd exopodial joint with 2 unequal bristles (short bristle 31 percent length of long bristle) (Fig. 4d).

Sixth limb: epipodial appendage with bristles forming 3 groups of 4 or 5, 4, and 5 (distal) bristles. Exopodite: 1st joint with 4 bristles, and process on dorsal corner bearing 3 plumose bristles; 2nd joint with 3 bristles (2 midventral, 1 dorsal); 4th joint with 2 bristles (shorter of 2 missing on right limb); short bristle of 4th joint 42 percent length of long bristle (Fig. 4e).

Seventh limb: with 2 long bristles (shorter ¾ length of other).

Furca: each lamella with 2 anterior claws separated from lamella by suture, followed by 5 shorter claws fused to lamella, and then short backward pointing process. Right lamella slightly anterior to left.

Bellonci organ: elongate, reaching past 1st joint of 1st antenna, with rounded tip (Fig. 4c).

Posterior of body: 1 slender process posterior to furcal lamellae; body dorsal to slender process segmented.

Copulatory organ (Fig. 4f): consisting of long slender anterior part with minute spines at tip, and shorter sausage-shaped posterior part with 3 small bristles at tip.

*Remarks.*—Juveniles of this genus are difficult to identify with a high degree of certainty. The present specimen has a copulatory organ that conceivably could develop in the adult to be like that of *C. porosa,* but the specimen differs from the latter species in having the 3rd joint of the 1st antenna longer than the 4th. It also differs in that respect from two other species, *T. hessleri* and *Thaumatoconcha* species A. The great difference in lengths of the bristles of the end joint of the 6th limb indicates that the present specimen is not *T. radiata.* The rounded tip of the Bellonci organ indicates that it is not *T. punctata.* The slender anterior lobe of the copulatory organ makes it unlikely that it is any of the species that have a broad anterior lobe on the adult copulatory organ (*T. caraionae, T. elongata, T. polythrix, T. radiata, T. sandersi, T. tuberculata*).

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# SYNONYMY OF *PRISTINELLA JENKINAE* (OLIGOCHAETA: NAIDIDAE)

R. D. Kathman

*Abstract.*—The naidid oligochaetes *Pristinella jenkinae* (Stephenson, 1931), *P. idrensis* (Sperber, 1948), *Pristina taita* Stout, 1956, and *Pristina nothofagi* Stout, 1957, are considered to be synonymous based on overlapping characteristics. The high degree of variability both within a single specimen and among different specimens negates any justification for separating these four species.

During a recent investigation into the effects of a pentachlorophenol spill on benthic invertebrates in Hyland Creek, Cloverdale, British Columbia, 11 specimens of a naidid oligochaete resembling both *Pristinella idrensis* (Sperber, 1948) and *P. jenkinae* (Stephenson, 1931) were collected. Examination and comparison of these with specimens identified as *P. idrensis* from the United States by J. Hiltunen, and with specimens identified as *P. jenkinae* from Africa by R. O. Brinkhurst and R. Grimm (pers. comm.) indicate that the variability and overlap of almost all chaetal characteristics makes it impossible to distinguish the two species. Furthermore, *Pristina taita* Stout, 1956, and *P. nothofagi* Stout, 1957, considered as possible synonyms of *P. idrensis* by Brinkhurst (1971), are also placed into synonymy with *P. jenkinae.*

### *Pristinella jenkinae* (Stephenson, 1931)
Fig. 1

(?)*Naidium luteum* Schmidt.—Michaelsen, 1905:306.
*Naidium jenkinae* Stephenson, 1931:39–41, fig. 1.
*Naidium jenkinae* Stephenson.—Stephenson, 1932:327.
(?)*Pristina rosea* (Piguet).—Michaelsen and Boldt, 1932:596–597.—Kondo, 1936: 386–387, pl. XXIV, fig. 16.
*Naidium roseum* Piguet.—Marcus, 1943:130–131, pl. XXV, fig. 105, pl. XXVI, fig. 106.
*Pristina jenkinae* (Stephenson).—Sperber, 1948:224–225.—Brinkhurst 1971:396–397, fig. 7.23A, B.
*Pristina taita* Stout, 1956:99–101, figs. 2–5.
*Pristina nothofagi* Stout, 1957:289–292, figs. 1–6.
*Pristina idrensis* Sperber, 1948:220, fig. 23d–e, pl. XX, XXI, fig. 1.

*Holotype.*—Typus ammissus (Reynolds and Cook, 1976).

*Material examined.*—Kathman collection: 11 specimens, Hyland Creek, Cloverdale, British Columbia, coll. G. Derksen, 2 Nov 1984. Hiltunen collection: 1 specimen, Lake George Channel of St. Mary's River, Michigan, 17 Aug 1968; 1 specimen, Station 19 on Lake Huron, 29 Sep 1968; 1 specimen, Buckhorn Creek, a tributary of Cape Fear River, North Carolina, Apr 1974; 1 specimen, Cedar River, Kings County, Washington, coll. S. White. Brinkhurst collection: 9 specimens, Crocodile River, Republic of South Africa.

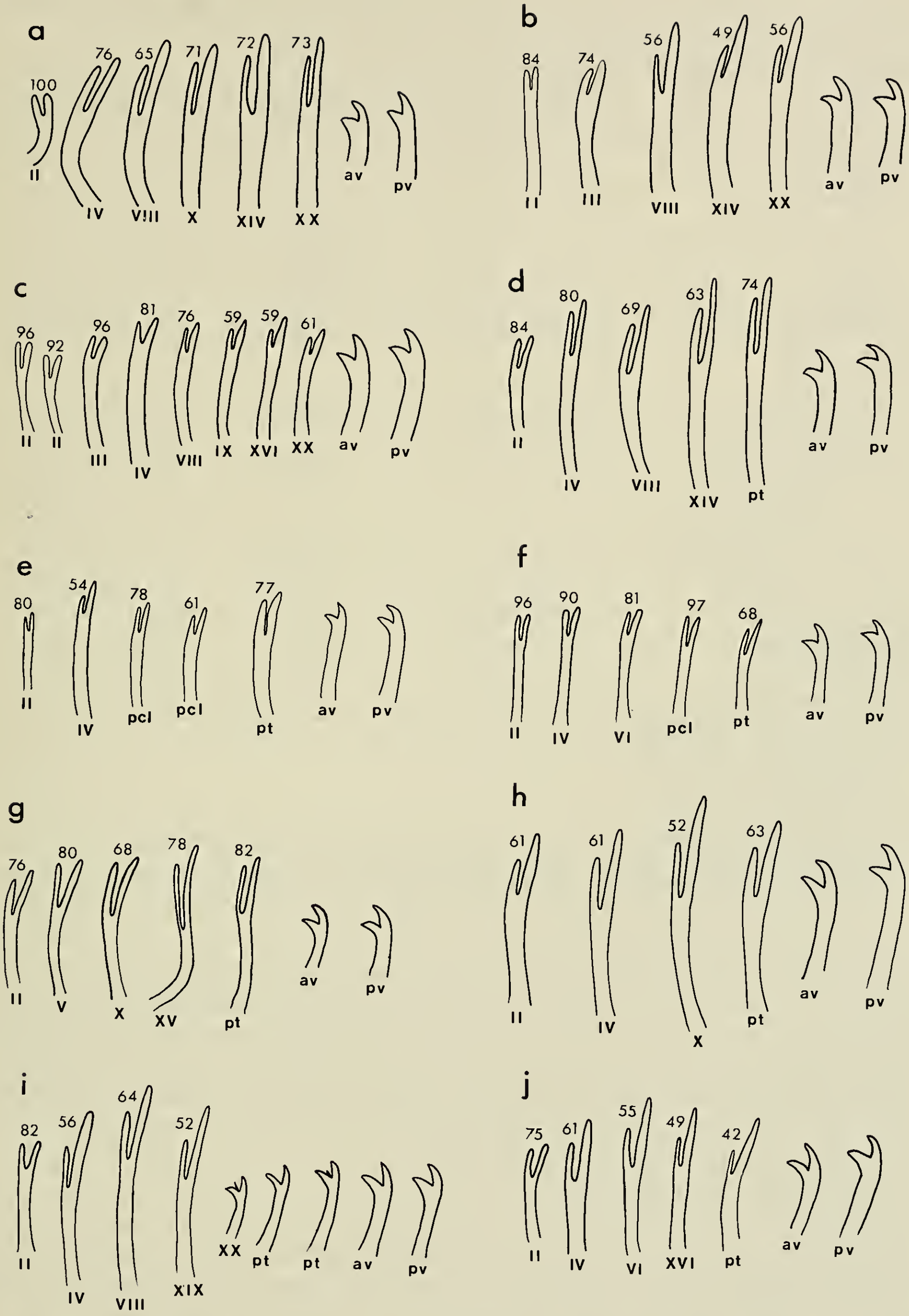

Fig. 1. Size and shape of ventral and needle chaetae of 10 specimens from Canada, U.S.A. and Africa. a–c, Hyland Creek, BC; d, Cedar River, WA; e, Lake Huron, MI; f, St. Mary's River, MI; g, Buckhorn Creek, NC; h–j, Crocodile River, S. Africa. Roman numeral = segment number; Arabic numeral = ratio of length of distal tooth to proximal tooth expressed as a percentage; av = anterior ventral; pcl = post clitellar; pt = posterior; pv = posterior ventral.

Table 1.—Characteristics derived from published descriptions of four species of *Pristina* and from new material of *Pristinella jenkinae* from North America and Africa.

| | *Pristina idrensis*[a] | *Pristina jenkinae*[a] | *Pristina taita*[b] | *Pristina nothofagi*[b] |
|---|---|---|---|---|
| Ventral chaetae | | | | |
| Number: anterior | 3–7 | 2–7[c] | 2–7 | 2–6 |
| posterior | ? | 2–3 | 2–3 | ? |
| Nodulus | D[d] | M-ant.<br>D-post. | M | D |
| Length (μm) | 32–45 | 50–55 | 30–64 | 30–40 |
| Relative length of teeth | Equal | Equal | ? | Equal |
| Dorsal chaetae | | | | |
| Hairs: number | 1–2 | 1 | 1 (2) | 1 |
| length (μm) | 110–200 | 165–234 | 60–360 | 110–200 |
| Needles: number | 1–2 | 1 | 1 (2) | 1 |
| length (μm) | 29–57 | 62–65 | 35–72 | 35–50 |
| nodulus | D | D | ? | None |
| length of teeth (μm): | | | | |
| distal | 3–3.7 | ≈½ proximal[e] | 4–5 | 6[f] |
| proximal | 3.7–4.5 | 5–9 | 7–8 | 6 |
| Stomach beginning | ½VI–½VII | VII | VI–VII | VII |
| Total length (mm) | 3–4 | 2.5–3 | 1.5–5 | 1 |
| Number of segments | 14–18 | ? | 22–25 | to 22 |
| Number of specimens | 26 | 0[g] | ? | ? |

[a] According to Sperber, 1948.
[b] According to Stout, 1956, 1957, respectively.
[c] According to Pop, 1973.
[d] D = distal; M = median.
[e] Actual length not available, although considered to be ≈½ as long as proximal.
[f] Described as "slightly larger."
[g] Data from literature; no specimens personally examined by Sperber.

*Description.*—No proboscis. Dorsal bundles with 1, sometimes 2, non-serrated hair and 1, sometimes 2, needle chaetae, with distal nodulus, and distal tooth often thinner than, and from half as long to nearly as long as proximal, usually subequal in II; ventral chaetae 2–9 anteriorly (usually 4–6), 2–3 (rarely 4–5) posteriorly, nodulus slightly distal to distal, all teeth equally long; chaetal size variable (see Table 1); penial chaetae in VII; number of segments variable, to 28; length 1–4 mm; other characters as in the genus.

*Distribution.*—Cosmopolitan.

*Remarks.*—Although Sperber (1948) suggested that the *Pristina* species could be separated into groups based partly on the presence or absence of a proboscis, it was not until recently (Brinkhurst 1985) that the genus *Pristinella* was erected for those species without a distinct proboscis plus other associated characters.

Within this genus, the species *P. idrensis* is traditionally separable on the basis of differences in the size and shape of the chaetae. When the species was initially erected Sperber (1948) emphasized the "size and form" of the animal and the form of the stomach, septal glands and nephridia in separating *P. idrensis* from *P. amphibiotica,* although she admitted that *P. idrensis* might represent a subspecific form or ecomorph of *P. amphibiotica.* Nowhere did she compare *P.*

Table 1.—Extended.

| Hyland Creek, BC Canada | Cedar River, WA USA | Lake Huron, MI USA | St. Mary's River, MI USA | Buckhorn Creek, NC USA | Crocodile River, RSA Africa |
|---|---|---|---|---|---|
| 4–9 | 6–7 | 6–7 | 5–6 | 4–5 | 2–5 |
| 2–3 (4) | 3–4 | 5 | 3 | 2 | 2–3 |
| D | D | D | D | D | D |
| 39–60 | 46–54 | 27–36 | 35–39 | 36–44 | 36–52 |
| Equal | Equal | Equal | Equal | Equal | Equal |
| 1 (2) | 1 (2) | 1 (2) | 1 | 1 | 1–2 |
| 40–325 | 95–318 | 130–143 | 88–125 | 113–163 | 55–218 |
| 1 (2) | 1 | 1 | 1 (2) | 1 | 1–2 |
| 31–68 | 40–65 | 31–39 | 33–41 | 30–41 | 39–55 |
| D | D | D | D | D | D |
| 1.9–6.3 | 3.1–6.2 | 1.5–3.6 | 2.5–3.0 | 3.8–6.9 | 2.8–5.7 |
| 1.9–8.7 | 3.7–9.4 | 2.0–4.7 | 2.8–4.1 | 5.0–8.8 | 3.4–10.9 |
| ? | ? | ? | ? | ? | ? |
| 1.1–2.3 | 1.8 | 1.5 | 1.3 | 1.4 | 1.6–4 |
| (14?) 24–28 | 25 | 19 | 22 | 18 | 24–28 |
| 11 | 1 | 1 | 1 | 1 | 9 |

*idrensis* to *P. jenkinae,* a species which appears to more closely resemble *P. idrensis* than does *P. amphibiotica* in terms of the chaetae. Any comparison between *P. idrensis* and *P. jenkinae* must be limited largely to the chaetal characteristics as little else was covered in the original description, and the types are missing. In her account of *P. jenkinae,* Sperber paid close attention to specimens of *P. jenkinae* apparently misidentified as *P. rosea* Piguet but seems never to have considered the potential relationship with *P. idrensis.*

The characteristic used most often to distinguish *P. idrensis* from *P. jenkinae* is the relative length of the distal to the proximal tooth in needle chaetae. Brinkhurst (1971:391) states that the needle teeth are long and parallel, with the distal tooth slightly longer than the proximal (Sperber says 80%) in *P. idrensis,* and that the needle teeth diverge with the distal about half the length (50%) of the proximal in *P. jenkinae.* This wording was based on an examination of the original illustrations in both instances. His drawings (redrawn from the originals) show the distal tooth of each species to be approximately three-quarters (75%) as long as the proximal, but it is clear that the proximal tooth in *P. jenkinae* has been accidentally shortened by the artist (confirmed by R. O. Brinkhurst, per. comm.).

Examination of chaetal characteristics of all my material shows a great deal of variability not only among specimens from the same or different geographic locations, but within single specimens in this set. This can be seen in Fig. 1, in which the needle teeth change in both total and relative lengths. The distal/proximal ratios, expressed as percentages, show that the lengths can vary as much as 35 percentage points within a single individual, and as much as 51 percentage points among different worms. There is no consistent pattern to these changes, except that the chaetae of segment II are usually shorter than the others and have subequal teeth. Many investigators (for example, Barbour et al. 1980; Loden and Harman 1980; Smith 1985; Stout 1956) have shown that chaetae of a particular species vary with environmental conditions, among different geographic locations, and within single specimens. There is no reason, therefore, to believe that *P. jenkinae* is unique among the group in showing the wide variations of chaetal size and shape. Indeed, two of the nine individuals examined from Africa showed an abrupt change from the long parallel needle teeth to short bifid or pectinate needles posteriorly (Fig. 1i). Other data presented in Table 1 provide further evidence for synonymizing these four species, as there appears to be some degree of overlap in every characteristic among the specimens and descriptions.

Stout (1956), in his description of *P. taita,* emphasized the variation in chaetal size for single worms and between worms several times, and even stated that his values for *P. taita* cover the range of six other species (including *P. idrensis* and *P. jenkinae*). Despite this, he erected a new species partly based on the length of the hairs in segments VIII and IX. He defends erection of another species, *P. nothofagi,* a year later (Stout 1957) by stating that although it has the same chaetal characteristics as *P. jenkinae* (and two others), it is much smaller. The data in Table 1 show that it otherwise fits well within the range of *P. taita* (which he does not discuss in his 1975 paper) as well as within the *P. idrensis-P. jenkinae* limits.

Prior to synonymizing these four species the distributions were also highly unusual in this generally cosmopolitan family. *Pristinella idrensis* was common, but only in North America, Europe, and Asia (Israel), while *P. jenkinae* was only found in South America, Africa, and Asia (Japan), and *P. taita* and *P. nothofagi* had only been reported once from New Zealand. As is typical of many species of *Pristina* and *Pristinella, P. jenkinae* can now be considered cosmopolitan.

Sperber (1948) considered *P. idrensis* a possible synonym of *P. amphibiotica* and also showed historic confusion between *P. jenkinae* and *P. rosea* (see synonymy listed above). Until specimens of *P. amphibiotica* and *P. rosea* can be examined, they will have to remain as valid species, although the chaetal characteristics, including the presence of penial chaetae, would suggest that either or both of these species could be considered as potentially synonymous with *P. jenkinae.*

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# *MICROPHIOPHOLIS,* REPLACEMENT NAME FOR *MICROPHOLIS* THOMAS, 1966 (OPHIUROIDEA: AMPHIURIDAE), *NON* HUXLEY, 1859 (AMPHIBIA: DISSOROPHIDAE)

Richard L. Turner

*Abstract.*—The extant ophiuroid genus *Micropholis* Thomas, 1966, is a junior homonym of the fossil amphibian genus *Micropholis* Huxley, 1859. The replacement name *Microphiopholis* is herein proposed for the six species of brittle star formerly assigned to *Micropholis* Thomas, 1966.

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In his revision of the amphiurid genus *Amphipholis* Ljungman, 1867, Thomas (1966) established the new genus *Micropholis* for the type-species *Ophiolepis atra* Stimpson, 1852, and five other species of brittle star formerly assigned to *Amphipholis. Micropholis* was distinguished from *Amphipholis* (restricted) and *Axiognathus* Thomas, 1966 (ex *Amphipholis*), by the presence of much finer scales on its disc and by having perforated arm vertebrae. *Micropholis* has since been accepted by several authors (Tommasi 1970, 1971; Singletary 1971, 1980; Singletary and Moore 1974; Wardle et al. 1975; Camargo 1982; Clements and Stancyk 1984).

More than a century earlier, the generic name *Micropholis* was used by Huxley (1859) for a labyrinthodont amphibian (*M. stowii* Huxley, 1859) from the Lower Triassic of South Africa. The genus was named for the presence of small, polygonal, dermal, gular scutes.

*Micropholis* Thomas, 1966, is a junior homonym of *Micropholis* Huxley, 1859. In accordance with ICZN Art. 60, a replacement name for the ophiuroid is herein proposed.

### Class Ophiuroidea Gray, 1840
### Order Ophiurida Müller and Troschel, 1840
### Family Amphiuridae Ljungman, 1867
### *Microphiopholis* nom. nov. pro *Micropholis* Thomas, 1966 (preoccupied)

*Type-species.*—*Ophiolepis atra* Stimpson, 1852, by original designation of Thomas (1966). A presumed syntype (MCZ 1438) consists of arm fragments and the disc integument; the oral frame is missing.

*Etymology.*—*Microphiopholis* is of feminine gender, derived from the original name.

*Distribution.*—*Microphiopholis* presently includes six species, of which three are western Atlantic and three eastern Pacific. Based on synonymies, collection data, and notes in Clark (1915), Nielsen (1932), Parslow and Clark (1963), Thomas (1965), Tommasi (1970), and Camargo (1982), the species have the following distribution: *M. atra,* Virginia to São Paulo, Gulf of Mexico, and Caribbean Sea; *M. gracillima* (Stimpson, 1852), as for *M. atra* and including Bermuda; *M. subtilis*

(Ljungman, 1867), Puerto Rico (?), São Paulo, and Rio de Janeiro; *M. geminata* (Le Conte, 1851) and *M. platydisca* (Nielsen, 1932), Gulf of Panama; *M. puntarenae* (Lütken, 1856), Puntarenas, Costa Rica.

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# A NEW CURIMATID FISH (CHARACIFORMES: CURIMATIDAE) FROM THE AMAZON BASIN

Richard P. Vari and Jacques Géry

*Abstract.*—*Curimata fasciata* is described from several localities in the upper Rio Madeira system of the southwestern portion of the Amazon basin. The presence of irregular longitudinal stripes centered along the middle of the lateral and dorsal rows of body scales distinguishes the species from all other curimatids.

The ichthyofauna of the upper portions of the eastern tributaries of the Rio Madeira in the Brazilian states of Rondônia and Mato Grosso is poorly known, with relatively sparse samples of the fishes of the region presently available. Recent collecting activities associated with the Projecto Aripuanã (see Arnaud and Cortez 1976 for an overview) and by researchers at the Museu Nacional, Rio de Janeiro have resulted in the first major collections of fishes from that portion of the Rio Madeira system. Included within that material was a distinctive undescribed species of curimatid characiform fish described herein.

Counts and measurements in the description follow the methods outlined in Vari (1982, 1984). Values in square brackets are those of the holotype. Specimens examined for this study are deposited in the following institutions: British Museum (Natural History), London, BMNH; Géry collection; Instituto Nacional de Pesquisas da Amazônia, Manaus, INPA; Museu Nacional, Rio de Janeiro, MNRJ; Museu de Zoologia da Universidade de São Paulo, MZUSP; and National Museum of Natural History, Smithsonian Institution, Washington, D.C., USNM.

## *Curimata fasciata,* new species
Fig. 1

*Holotype.*—MNRJ 11208, 89.6 mm standard length (SL), collected by Gustavo W. Nunan, Decio F. Moraes, Jr., and Wagner D. Bandeira, in the Rio Romari (or São Domingo) near Nova União, Municipality of Ouro Preto do Oeste, Território de Rondônia, Brazil (10°53′17″S, 62°33′35″W); Nov 1983.

*Paratypes.*—27 specimens. 8 specimens: USNM 270377, 4 specimens (1 cleared and counterstained for cartilage and bone), 72.3–92.3 mm SL; MNRJ 11,271, 4 specimens, 74.3–90.4 mm SL; collected with holotype. 5 specimens: USNM 270375, 2 specimens, 90.1–96.0 mm SL; INPA, 3 specimens, 64.0–86.8 mm SL; Rio Aripuanã, above cachoeira de Dardenelos, Mato Grosso, Brazil (approx. 10°19′42″S, 59°12′30″W). 8 specimens: USNM 270376, 2 specimens, 78.0–83.3 mm SL; INPA, 2 specimens, 77.8–79.1 mm SL; BMNH 1985.2.5:1–2, 2 specimens, 79.4–80.1 mm SL; MZUSP 28724, 2 specimens, 86.1–87.1 mm SL; Rio Aripuanã, approximately 10 km above cachoeira de Dardenelos, Cidade de Humboldt, Mato Grosso, Brazil. 6 specimens, Gêry collection, 55.3–83.9 mm SL; Rio Aripuanã, above cachoeira do Andorinhas, Mato Grosso, Brazil.

*Diagnosis.*—The possession of a series of distinct irregular longitudinal stripes

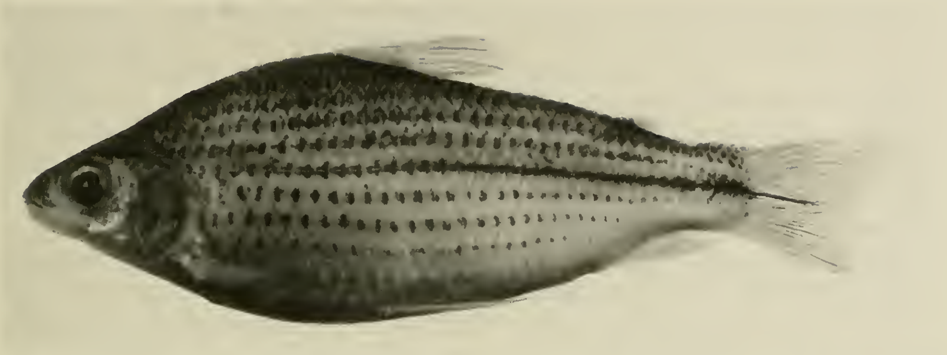

Fig. 1. *Curimata fasciata,* holotype, MNRJ 11208, 89.6 mm SL; Rio Aripuanã, Mato Grosso, Brazil.

along the lateral and dorsal surfaces of the body wall distinguishes *Curimata fasciata* from all other curimatid species with the exception of *Curimatus multilineatus* (=*Curimata multilineata*). The latter species, described by Myers (1927: 109) from the upper portions of the Rio Negro basin, also has a pattern of dark longitudinal body stripes, but can nonetheless be readily separated from *C. fasciata* by the relative position of the pigment bands. In *Curimata fasciata* the stripes are formed by spots centered along the middle of the dorsal and lateral rows of body scales, whereas in *C. multilineata* the dark pigmentation lies along the point of overlap of vertically adjoining rows of horizontal scales. *Curimata fasciata* is also characterized by a dark band outlining the posterior portion of the lateral line and by a dark band along the middle rays of the caudal fin, pigmentation patterns lacking in *C. multilineata. Curimata multilineata,* in turn, has a horizontal stripe running from the tip of the snout to the orbit and from the rear of the orbit across the opercle, a band which is not present in *C. fasciata.*

*Description.*—Body moderately elongate, deeper in ripe females; compressed. Dorsal profile of head concave above snout, straight or very slightly concave above orbit. Dorsal profile of body smoothly curved from rear of head to origin of rayed dorsal fin; straight and posteroventrally slanted at base of dorsal fin, gently convex from base of last dorsal ray to caudal peduncle. Dorsal body surface with indistinct median keel immediately anterior to rayed dorsal fin, smoothly rounded transversely posterior to fin. Ventral profile of head nearly straight; ventral profile of body straight or gently concave to origin of pelvic fin, gently curved from that point to caudal peduncle. Prepelvic region indistinctly flattened, flattening more pronounced posteriorly, with obtuse angle in body wall proximate to pelvic fin origin. Prepelvic region with median series of 3 or 4 somewhat enlarged scales immediately anterior to pelvic fin origin. Indistinct median postpelvic keel extending from slightly behind origin of pelvic fin posteriorly to anus. Secondary obtuse keel on each side of postventral portion of body about two scale rows dorsal of ventral midline.

Greatest body depth at origin of rayed dorsal fin, depth 0.36–0.42 [0.39]; snout tip to origin of rayed dorsal fin 0.47–0.52 [0.50]; snout tip to origin of anal fin 0.84–0.89 [0.86]; snout tip to origin of pelvic fin 0.53–0.58 [0.55]; snout tip to anus 0.79–0.84 [0.82]; origin of rayed dorsal fin to hypural joint 0.54–0.59 [0.56].

Rayed dorsal fin obtusely pointed, first branched fin ray longest, longest ray approximately 2.3–2.6 times length of ultimate ray. Pectoral fin pointed; length of pectoral fin 0.19–0.22 [0.20], extending approximately two-thirds of distance to origin of pelvic fin. Pelvic fin pointed, length of pelvic fin 0.23–0.25 [0.24], reaching three-quarters of distance to origin of anal fin. Caudal fin forked. Adipose dorsal fin well developed, unscaled. Anal fin emarginate, first branched ray longest, anteriormost branched rays approximately two and one-half times length of ultimate ray. Caudal peduncle depth 0.13–0.14 [0.13].

Head obtusely pointed in profile, head length 0.28–0.30 [0.28]; upper jaw longer, mouth inferior; snout length 0.29–0.32 [0.30]; nostrils very close, anterior circular, posterior crescent-shaped with aperture closed by thin flap of skin separating nares; orbital diameter 0.28–0.31 [0.30]; adipose eyelid moderately developed, with vertically ovoid opening over center of eye; length of postorbital portion of head 0.40–0.44 [0.43]; gape width 0.28–0.32 [0.31]; interorbital width 0.39–0.45 [0.43].

Pored lateral line scales from supracleithrum to hypural joint 32 to 37 [34]; all scales of lateral line pored, canals in scales straight; 4 or 5 series of scales extending beyond hypural joint onto caudal fin base; 5½ or 6½ [5½] scales in transverse series from origin of rayed dorsal fin to lateral line; 4½ or 5½ [4½] scales in transverse series from lateral line to origin of anal fin.

Dorsal-fin rays ii,9 or iii,9 (when three unbranched rays present, first very short) [ii,9]; anal-fin rays ii,7 or iii,7 (when three unbranched rays present, first very short) [iii,7]; pectoral-fin rays 14 to 16 [15]; pelvic-fin rays i,8 [i,8].

Total vertebrae 32 (4), 33 (20), 34 (1).

*Color in alcohol.*—Specimens lacking guanine in scales with overall tan ground coloration, darker on dorsal portions of head and body. Head with field of dark small chromatophores on upper lip, snout, interorbital and supraoccipital regions. Patch of dark pigmentation over sixth infraorbital (dermosphenotic) and above anterodorsal margin of opercle. Dorsal half of opercle with scattered small chromatophores, more so in larger specimens.

Distinct spots of pigmentation centered at junction of scales along middle of dorsal and lateral rows of body scales. Individual spots of scale rows form irregular longitudinal stripes of differing degrees of intensity. Longitudinal stripe on third scale row ventral of lateral line with pigmentation poorly developed on anterior and posterior portions, particularly in smaller individuals. Spots of first and second scale rows ventral of lateral line diminishing in size posteriorly, not reaching to hypural joint and ventral margin of caudal peduncle respectively. Spots of lateral line scales well developed, outlining lateral line canals; spots contiguous on posterior half of body, forming continuous line. Spots of scale series dorsal of lateral line well developed, forming irregularly continuous horizontal stripes. Spots merging into overall darker chromatophore field present on dorsal portion of body, particularly approximate to middorsal region of body between rayed and adipose dorsal fins, and along dorsal surface of caudal peduncle. Longitudinal series of spots somewhat masked in specimens retaining guanine in scales. Overall coloration of specimens retaining guanine silvery, but with spots of pigmentation on scales readily apparent.

Irregular field of dark scattered chromatophores on midlateral surface of caudal peduncle. Chromatophore field extending anteriorly one or two scales anterior of hypural joint and continuing posteriorly to limit of scales on base of caudal fin; peduncle pigmentation continuous posteriorly with horizontal band of middle rays of caudal fin.

Rayed dorsal fin with series of small chromatophores along anterior margin of fin and on distal portion of rays, giving distal half of fin a dusky appearance. Obscure spot of pigmentation sometimes present between third and fifth branched rays near their bases; spot more apparent in smaller individuals. Caudal fin rays outlined by series of chromatophores. Median rays of caudal fin with distinctly dusky to black band of pigmentation continuous with dark stripe along lateral line. Adipose dorsal and pelvic fins dusky. Pectoral fin with chromatophore series along margins of dorsalmost fin rays.

*Distribution.*—*Curimata fasciata* is known from the upper portions of the eastern drainages of the Rio Madeira system.

*Relationships.*—Although *Curimata fasciata* has a pigmentation pattern seemingly very similar to that of *C. multilineata* Myers, the two species are not each other's closest relatives. As noted in the "Diagnosis" the longitudinal stripes of the two forms differ in position and are apparently non-homologous. The relationships of *C. fasciata* lie rather with a group of species including *C. elegans* Steindachner (1874), *C. metae* Eigenmann (1922) and *C. robustula* Allen (in Eigenmann and Allen 1942) which share with *C. fasciata* a series of derived characters including an elaborate pattern of papillose lobes in the roof of the mouth, dark pigmentation outlining the terminal portion of the lateral line, and an obscure midlateral spot on the caudal peduncle.

*Remarks.*—A variety of very different classificatory schemes have been utilized within the family Curimatidae. The number of recognized genera under different systems has fluctuated from seven (Eigenmann 1910) to 29 (Fernández-Yépez 1948). Research completed (Vari 1982, 1984) or in progress attempts to redefine subunits of the family along natural lines, and has or will result in the synonymization of numerous genera and the redefinition of recognized taxa. Pending completion of those studies, the species described herein is retained in the broadly encompassing genus *Curimata* which has included the bulk of the species of the family in the more widely utilized classificatory schemes.

*Etymology.*—*fasciata,* the specific epithet from the Latin for striped, is in reference to the longitudinal body stripes of the species.

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The specimens that served as the basis for this paper were made available by Dr. Gustavo W. Nunan (MNRJ) and Dr. Michel Jeǵu (INPA). Those individuals and their colleagues also provided the senior author with considerable assistance during visits to their respective institutions. Technical assistance in this study was provided by Mr. Andrew G. Gerberich. Figure 1 was prepared by Mr. Theophilus Britt Griswald. This paper benefitted from the comments and criticisms of Dr. Stanley H. Weitzman and Dr. Wayne C. Starnes. We thank all of those individuals for their assistance and interest. Research associated with this study and travel expenses were partially supported by the I.E.S.P. Neotropical Lowland Research program of the Smithsonian Institution.

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Note added in proof.—Since this paper went to press, the four paratypes originally in the Géry collection have been deposited in the Muséum d'Histoire Naturelle, Geneva (MNHG 2226.24).

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# A NEW BURROWING CRAYFISH (DECAPODA: CAMBARIDAE) FROM SOUTHWESTERN ARKANSAS

Horton H. Hobbs, Jr. and Henry W. Robison

*Abstract.*—*Fallicambarus* (*F.*) *harpi*, a burrowing crayfish, is described from two localities in the Caddo River (a tributary of the Ouachita River) basin of Pike County, Arkansas. It differs conspicuously from its closest relatives, *F.* (*F.*) *strawni* (Reimer, 1966) and *F.* (*F.*) *jeanae* Hobbs (1973), in possessing a free (never adnate) cephalic process on the first pleopod of the first form male.

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The new crayfish described here is the fourth member of the nominate subgenus of *Fallicambarus* to be reported from Pike County, Arkansas: *F.* (*F.*) *strawni* (Reimer, 1966) occurs in the extreme western part of the county, *F.* (*F. spectrum* Hobbs (1973) in the north-central part (both in the Little Missouri River basin), and *F.* (*F.*) *jeanae* Hobbs (1973) and *F.* (*F.*) *harpi*, new species, in the northeastern part of the county in the Antoine River basin and the Caddo River basin, respectively. Only two other crayfishes, *F.* (*F.*) *macneesei* (Black, 1967) and *F.* (*F.*) *dissitus* (Penn, 1955), which range to the south and southeast, exhibit characteristics ascribed to the typical subgenus (see Hobbs 1973:463).

### *Fallicambarus* (*Fallicambarus*) *harpi*, new species
Fig. 1

*Diagnosis.*—Antennal scale reduced; ventral surface of propodus of chela lacking row of stiff setae along lateral margin, tubercles of 2 ventral rows on merus of cheliped small but distinct; mesial ramus of uropod lacking distolateral spine. First pleopod of first form male almost straight and bearing small or well developed caudodistally directed cephalic process; mesial process little curved and directed caudally, and central projection strongly arched with apex directed proximally. Telson with transverse suture. Coxa of fourth pereiopod of male with very strong, compressed boss with rounded ventral margin. Chela slightly more than half as wide as long, and length of mesial margin of palm less than half width of palm. Annulus ventralis as figured: not broadly excavate anteriorly and not obscuring sclerite immediately caudal to annulus.

*Holotypic male, form I.*—Body subovate, somewhat compressed although branchiostegites somewhat inflated (Fig. 1a, k). Abdomen much narrower than cephalothorax (10.5 and 16.8 mm). Greatest width of carapace distinctly posterior to caudodorsal extremity of cervical groove and greater than height (16.8 and 15.1 mm). Aerola linear over much of its length which comprising 40.8 percent of entire length of carapace (45.6 percent of postorbital length). Rostrum with convergent, moderately thickened margins, contracting anteriorly forming short triangular acumen, apex of which corneous, slightly upturned, and extending just beyond base of penultimate podomere of antennular peduncle. Dorsal surface of rostrum concave with submarginal row of setiferous punctations and few scattered ones between. Subrostral ridges well developed and evident in dorsal aspect along basal third of rostrum. Postorbital ridge strong, grooved dorsolaterally, merging imperceptibly with carapace anteriorly and somewhat swollen posteriorly. Suborbital angle obsolete. Branchiostegal spine represented by slight obtuse prominence at lower anterior extremity of cervical groove. Cervical spine lacking. Carapace punctate dorsally and laterally, with few weak tubercles in anteroventral branchiostegal region which conspicuously inflated.

Abdomen shorter than carapace (29.7 and 34.1 mm); pleura very short and rounded, only that of sixth segment with angular caudoventral margin; pleuron of first abdominal segment slightly overlapped by cephalic lobe of that of second. Cephalic section of telson (Fig. 1h) without spines; much of telson and uropods setose dorsally. Proximal podomere of uropod without spines. Both rami comparatively slender and bearing conspicuous median rib, that on mesial ramus extending almost to distal margin but lacking distal spine; mesial ramus also lacking distolateral spine, rib on proximal segment of lateral ramus terminating in spine, that on distal segment lacking spine and not reaching distal margin.

Cephalomedian lobe of epistome (Fig. 1g) subovate with marginal anterior and anterolateral areas elevated ventrally; main body comparatively long and lacking fovea. Ventral surface of proximal podomere of antennule lacking spine. Antennal peduncle without spines, flagellum broken but remainder reaching first abdominal tergum; antennal scale (Fig. 1l) almost 3 times as long as broad and widest at about midlength; mesiodistal margin of lamellar area sloping distolaterally from just beyond midlength to base of distolateral spine which reaching end of proximal third of penultimate podomere of antennular peduncle. Ventral surface of ischium of third maxilliped with lateral row of short plumose setae, mesial sector studded with clusters of stiff setae.

Right chela (Fig. 1m) about 1.7 times as long as broad, strongly depressed; mesial margin of palm little less than half width of palm and bearing row of 7 tubercles subtended laterally by row of 5 smaller ones (left with 6 and 5, respectively); dorsal surface of palm with widely scattered squamous tubercles and few punctations; lateral margin of chela with serrate row of tubercles extending from near base almost to midlength of fixed finger; ventral surface of palm with few scattered tubercles, 3 or 4 flanking mesial margin of ridge extending onto fixed finger, large tubercle present opposite base of dactyl. Opposable margin of fixed finger with row of 6, second from base largest, tubercles along proximal three-fifths; single large tubercle on lower level short distance beyond distalmost member of row; dorsal surface of finger with prominent submedian longitudinal ridge flanked by conspicuous punctations; distal half of lateral margin bearing row of 5 setiferous punctations. Opposable margin of dactyl with prominent tubercle in proximal excavation and with 5 tubercles between distal margin of excavation and base of distal fourth of finger, only proximalmost large, sizes of remaining four variable although not graduated; dorsal surface of finger with strong submedian longitudinal ridge flanked along proximal fourth of finger by tubercles and distally by large, deep punctations; mesial surface with subserrate row of tubercles decreasing in size distally; ventral surface like that of fixed finger, bearing submedian longitudinal ridge flanked by few small tubercles proximally and punctations along most of ridge.

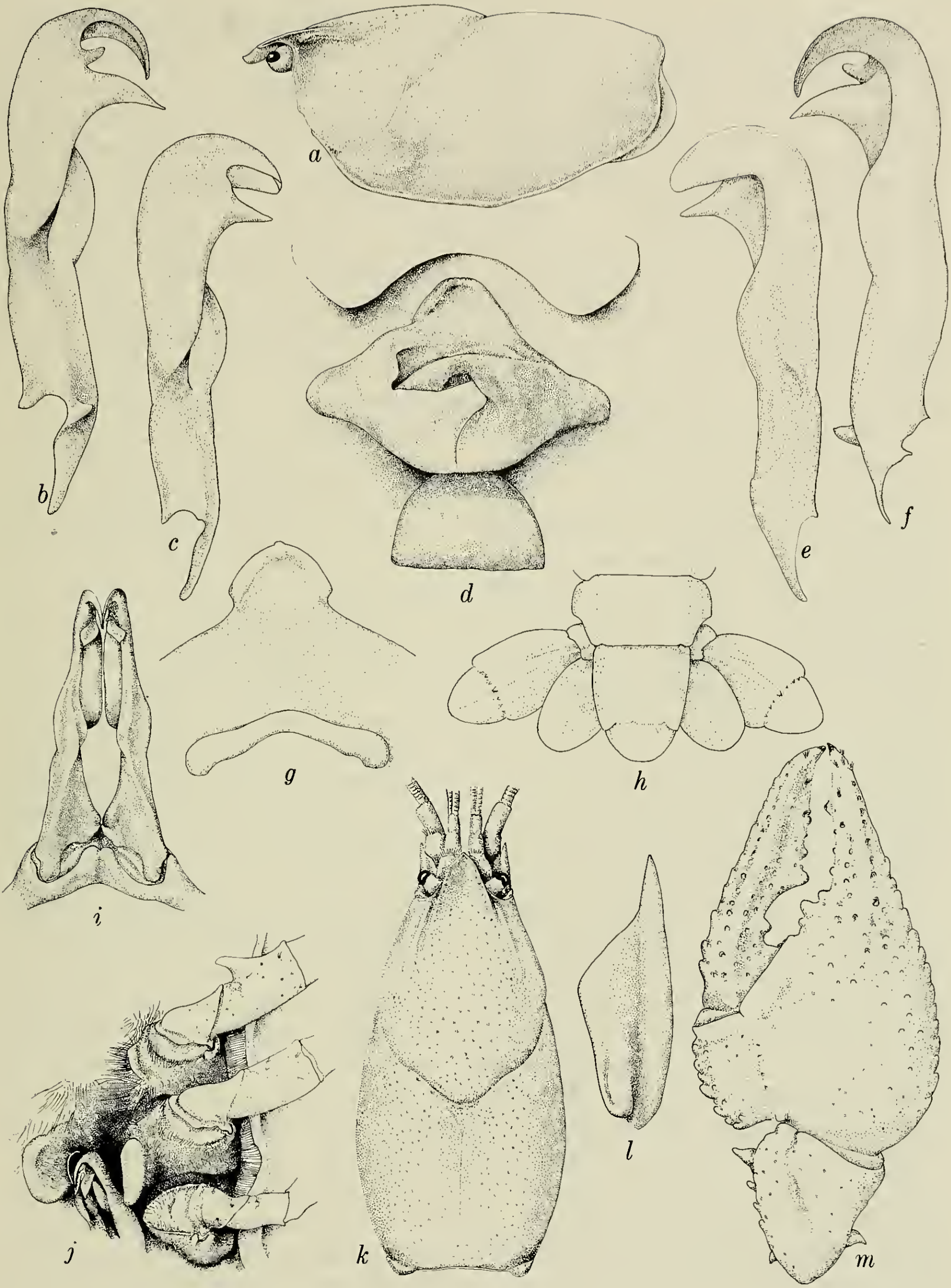

Fig. 1. *Fallicambarus* (*F.*) *harpi* (a, b, f, i, g, h, j, k, l, and m from holotype; c and e from morphotype, d from allotype): a, Lateral view of carapace; b, c, Mesial view of first pleopod; d, Annulus ventralis and adjacent sternal features; e, f, Lateral view of first pleopod; g, Epistome; h, Dorsal view of telson and uropods; i, Caudal view of first pleopods; j, Ventrolateral view of basal podomeres of third, fourth, and fifth pereiopods and first pleopods; k, Dorsal view of carapace; l, Right antennal scale; m, Dorsal view of distal podomeres of first pereiopod.

Carpus of cheliped with sinuous furrow and scattered punctations dorsally; dorsomesial surface tuberculate, mesial surface with row of 3 tubercles increasing in size distally, distalmost spinelike and directed mesiodistally; ventromesial surface with several small tubercles, some sublinearly arranged; distoventral margin with large tubercle on lateral condyle and another near median line; lateral surface punctate. Merus with dorsal surface tuberculate, tubercles of approximately same size and forming subserrate row along most of length of podomere, none conspicuously acute; mesial and lateral surfaces punctate; ventral surface with lateral row of 7 small tubercles and mesial one of 14, only distalmost conspicuously larger than others. Mesioventral margin of basioischial podomere with 1 or 2 very small tubercles distal to fracture suture. Chela of second pereiopod with marginal rows of setae on palm, and carpus with dorsal row of long setae; mesial surfaces of propodus and carpus lacking tufts of plumose setae.

Ischium of third pereiopod with simple hook extending proximally over basioischial articulation (Fig. 1j), not opposed by tubercle on basis. Coxa of fourth pereiopod with massive caudomesial boss, latter compressed laterally, rounded ventrally and disposed in longitudinal axis of body but tilted laterally; mesial and lateral surfaces of boss with setiferous punctations. Coxa of fifth pereiopod lacking boss but with setiferous ventral membrane.

First pleopods (Fig. 1b, f, i) reaching coxae of third pereiopods, lying deep within sternum and largely hidden by setae extending caudally and mesially from ventral margins of sternum and mesial borders of coxae of pereiopods. Proximomesial spur well developed. Appendages almost straight, not caudally inclined; terminal elements acute to subacute; tapering mesial process extending almost directly caudally; compressed, corneous, cephalic process, smallest of 3, projecting caudally and slightly distally from between mesial process and corneous scythelike central projection, tip of latter directed proximally (see Table 1).

*Allotypic female.*—Differing from holotype in other than secondary sexual features as follows: branchiostegal regions less inflated; rostrum with distinct, although short median carina near apex; tubercles absent in anteroventral branchiostegal region; epistome with shallow median fovea; chela markedly similar to that of male but only 3 tubercles in lateral row on mesial margin of chela, and opposable margin of dactyl with only 4 tubercles distal to excavation; distalmost tubercle of dorsal row on merus of cheliped subacute and ventral rows of tubercles consisting of 8 and 11 (8 and 10 on left member).

Annulus ventralis (Fig. 1d) capable of slight hingelike motion, somewhat spindle shaped, much broader than long, strongly sculptured with anteromedian furrow and tongue extending posterodextrally, fossa disappearing near midlength dextral to median line. Sinus originating in median depression and following tilted sinistral S-shaped course across median line terminating on caudal wall of annulus. Postannular sclerite half as wide as annulus and almost two-thirds as long as broad, obliquely truncate anteriorly and longitudinally ribbed in median elevated area. First pleopod although uniramous moderately well developed (see Table 1).

*Morphotypic male, form II.*—Differing from holotype in following respects: branchiostegites less inflated, resembling allotype; rostrum almost reaching end of penultimate podomere of antennular peduncle; telson not clearly divided by suture although caudal section distinctly set off by lateral emarginations; chela lacking row of tubercles on ventral surface of palm flanking base of ridge extending

Table 1.—Measurements (mm) of *Fallicambarus* (*F.*) *harpi.*

| | Holotype | Allotype | Morphotype |
|---|---|---|---|
| Carapace: | | | |
| Entire length | 34.1 | 36.0 | 29.3 |
| Postorbital length | 30.5 | 32.4 | 26.2 |
| Width | 16.8 | 16.7 | 13.7 |
| Height | 15.1 | 16.4 | 13.1 |
| Areola: | | | |
| Width | 0 | 0 | 0 |
| Length | 13.9 | 14.5 | 12.1 |
| Rostrum: | | | |
| Width | 4.6 | 5.2 | 4.1 |
| Length | 4.7 | 4.7 | 4.4 |
| Chela: | | | |
| Length, palm mesial margin | 6.9 | 5.3 | 4.3 |
| Palm width | 15.2 | 11.6 | 8.7 |
| Length, lateral margin | 26.1 | 20.8 | 15.6 |
| Dactyl length | 20.7 | 14.7 | 10.1 |
| Abdomen: | | | |
| Width | 10.5 | 11.2 | 8.8 |
| Length | 29.7 | 32.3 | 24.9 |

onto fixed finger; distal tubercle on dorsal surface of merus of cheliped acute; truncate hook on ischium of third pereiopod not reaching basioischial articulation. First pleopod (Fig. 1c, e) with mesial process much like that in first form male but cephalic process exceedingly reduced, hardly recognizable, and central projection much heavier, non-corneous, and not nearly so strongly recurved, its apex directed caudally and only slightly proximally (see Table 1).

*Color notes.*—Dorsum of cephalic region of carapace, including rostrum very dark, almost black, that of thoracic region greenish tan except for small black triangular spot in open anterior section of areola, narrow band bordering cervical groove, and another band adjacent to posterior margin of carapace; hepatic and mandibular adductor regions also black; orbital, antennal, mandibular, and branchiostegal regions greenish tan. Abdomen with broad median longitudinal, dark red stripe extending from second through fifth segment, becoming pale and disappearing before reaching caudal margin of sixth; lateral part of latter segment, telson, and uropods greenish tan with dark markings; mesial ramus of uropods with black median longitudinal rib. Dorsal surface of cheliped dark green with black suffusion becoming intense mesially so that dorsodistal border of merus, mesial part of carpus, tubercular area of palm, all of dorsum except tips of fingers and proximomesial part of fixed finger almost black; tips of fingers and lateral and ventral surfaces of entire cheliped pinkish to yellowish cream. Remaining pereiopods cream with greenish suffusion marking dorsal parts of podomeres from ischium through propodus, more intense on merus and propodus. Sternal elements and ventral surfaces of pereiopods cream to pinkish cream.

*Size.*—The largest specimen examined is a female having a carapace length of

39.6 (postorbital carapace length 35.8) mm. The smallest and largest first form males have corresponding lengths of 29.0 (25.8) mm, and 35.4 (31.5) mm, respectively.

*Type-locality.*—A seepage area located 0.2 mile east of Glenwood, Pike County, Arkansas (Sec. 1, R. 24W, T. 5S) on U.S. Highway 70, on the property of Milburn Dillard. This seep is located in a pasture in front of Mr. Dillard's house just north of the highway and is situated between a stock pond and the south end of a private airplane runway. All specimens found there were collected in the early evening as they crawled about in the wet grassy areas. Soil consisted of a sandy clay with some organic material. Grasses and sedges were abundant, and members of the genera *Pinus* and *Quercus,* and *Cornus florida* were growing in a wooded area to the north of the runway. Most of the crayfish were located by a Doberman Pinscher.

*Range and specimens examined.*—All of the specimens available came from two localities in the Ouachita River basin in Pike County, Arkansas: type-locality, 16 Apr 1982, 36 ♂ I, 13 ♂ II, 8 ♀, and 1 j ♂; 21 Apr 1982, 2 ♂ I, 4 ♀, Kyla Dillard, collector; and approximately 0.3 mile E of Glenwood on U.S. Highway 70, 18 Mar 1982, 6 ♂ I, 3 ♀, K.D., collector.

*Disposition of types.*—The holotype, allotype, and morphotype (USNM 217946, 217947, 217948, respectively), are deposited in the National Museum of Natural History, Smithsonian Institution as are the following paratypes: 41 ♂ I, 10 ♂ II, 12 ♀, and 1 j ♂. Also, paratypic series consisting of 1 ♂ I, 1 ♂ II, and 1 ♀, are deposited in the Museum National d'Histoire Naturelle, Paris, and in the Rijksmuseum van Naturlijke Historie, Leiden, The Netherlands.

*Variations.*—The shape of the rostrum is quite variable, ranging from that depicted in Fig. 1k to one in which the margins converge from the base, obliterating the basal limit of the acumen; also the upper surface may be deeply or shallowly concave and may or may not support a short anteriorly situated median carina. The branchiostegal region may or may not be conspicuously inflated, and the anteroventral branchiostegal region, always inflated, may appear bilobed. For the most part, the distribution of tubercles on the chelipeds is consistent, but the numbers vary slightly, and their sizes, particularly on the distal part of the merus, are often quite different, sometimes distinctly spiniform. Except for the degree of development of the cephalic process, which sometimes is quite small but always projecting caudodistally, the first pleopod exhibits only slight variations. The annulus ventralis may be almost fixed or may be movable through an arc of about 20 degrees.

*Relationships.*—*Fallicambarus* (*F.*) *harpi* has its closest affinities with *F.* (*F.*) *strawni* (Reimer, 1966) and *F.* (*F.*) *jeanae* Hobbs (1973), and, except for possessing a cephalic process on the first pleopod of the male, appears to share more in common with the latter than with the former. This is evident in the broad chela, features of the telson and uropod, the similar annulus ventralis, and the form of the boss of the coxa of the fourth pereiopods. It may be distinguished from *F.* (*F.*) *strawni* by possessing a proportionately broader chela, a cephalic process on the first pleopod that projects freely rather than being subadnate to the mesial process, and exhibiting a telson that is either divided by a transverse suture or possesses lateral emarginations that set off the posterior section. It differs from *F.* (*F.*) *jeanae* most conspicuously in possessing a cephalic process on the first pleopod of the male and less obvious differences in the bosses on the coxae of the fourth pereiopods and in the annulus ventralis of the female.

*Life history notes.*—First form males were collected on March 18, April 16, and April 21, 1982. Ovigerous females or those carrying young have not been observed.

*Etymology.*—This crayfish is named in honor of George L. Harp, a friend and colleague of one of us (HWR), who has contributed greatly to our knowledge of the aquatic invertebrates of Arkansas.

## Acknowledgments

We are grateful to Kyla Dillard for donating the specimens to us and extend our thanks to H. H. Hobbs III of Wittenberg University and C. W. Hart, Jr., of the Smithsonian Institution for their criticisms of the manuscript.

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# *THERMOSPHAEROMA CAVICAUDA* AND *T. MACRURA*, NEW SPHAEROMATID ISOPODS FROM MEXICAN HOT SPRINGS

Thomas E. Bowman

*Abstract.*—*Thermosphaeroma cavicauda* n. sp. is described from a hot spring (29°C) in Durango, Mexico. It is unique within the genus in having a terminal notch in the telson and well developed branchial folds. *Thermosphaeroma macrura* n. sp., described from a hot spring (32°) in central Chihuahua, Mexico, is characterized by an unusually long pleotelson. The two new species bring the number of known species of *Thermosphaeroma* to seven.

The five known species of *Thermosphaeroma,* reviewed by Bowman (1981), inhabit hot springs in the southwestern United States and Mexico. The isolated nature of these springs has produced a high degree of endemism in their faunas, and we may expect that as more springs are explored additional species of *Thermosphaeroma* will be found. Two such species are described herein.

## *Thermosphaeroma cavicauda,* new species
Figs. 1–3

*Material.*—Mexico, Durango State, spring-fed ditch about 0.6 km W of La Laguna, 5–6 km ESE of highway 45, 24°10′25″N, 104°38′19″W, leg. R. R. Miller and D. L. Soltz, 13 Apr 1983: ♂ holotype, USNM 227044, and 39 paratypes, USNM 227045.

*Etymology.*—From the Latin "cavus," hollow, hole, plus "cauda," tail, referring to the terminal notch in the telson, lacking in other known species of *Thermosphaeroma.* Proposed as a noun in apposition.

*Description.*—Length up to 10.2 mm. Body about 0.58 × as wide as long, pereon lateral margins nearly parallel. Pereopods hirsute; pereonites only sparsely hirsute. Pleotelson almost ⅔ as long as basal width, triangular, lateral margins weakly convex, becoming slightly concave near apex; apex with shallow U-shaped notch. Clypeus ⅔ as long as wide, anterior margin rounded. Antenna 1 flagellum 6–8-merous; antenna 2 flagellum up to 12-merous. Mandible incisors 4-cuspate; lacinia 3-cuspate; right spine-row with 7 spines (1st 3 with common base), left spine-row with 4 spines. Maxilla 1 outer ramus with 2 short dentiform spines, outer spine with bifid apex. Flexor margin of dactyl of pereopod 1 armed with cylindrical spinules. Appendix masculina of pleopod 2 sinuous, much longer than endopod. Branchial folds well developed on both surfaces of rami of pleopods 4 and 5. Pleopod 5 endopod with only slight indication of incision on lateral margin proximal to reniform swelling. Exopod of uropod subequal in length to endopod or slightly longer in smaller specimens, apex pointed and curved slightly laterad; endopod with medial margin curving rather abruptly laterad distally, ending in angular distolateral corner.

*Comparisons.*—*Thermosphaeroma cavicauda* can be distinguished immediately

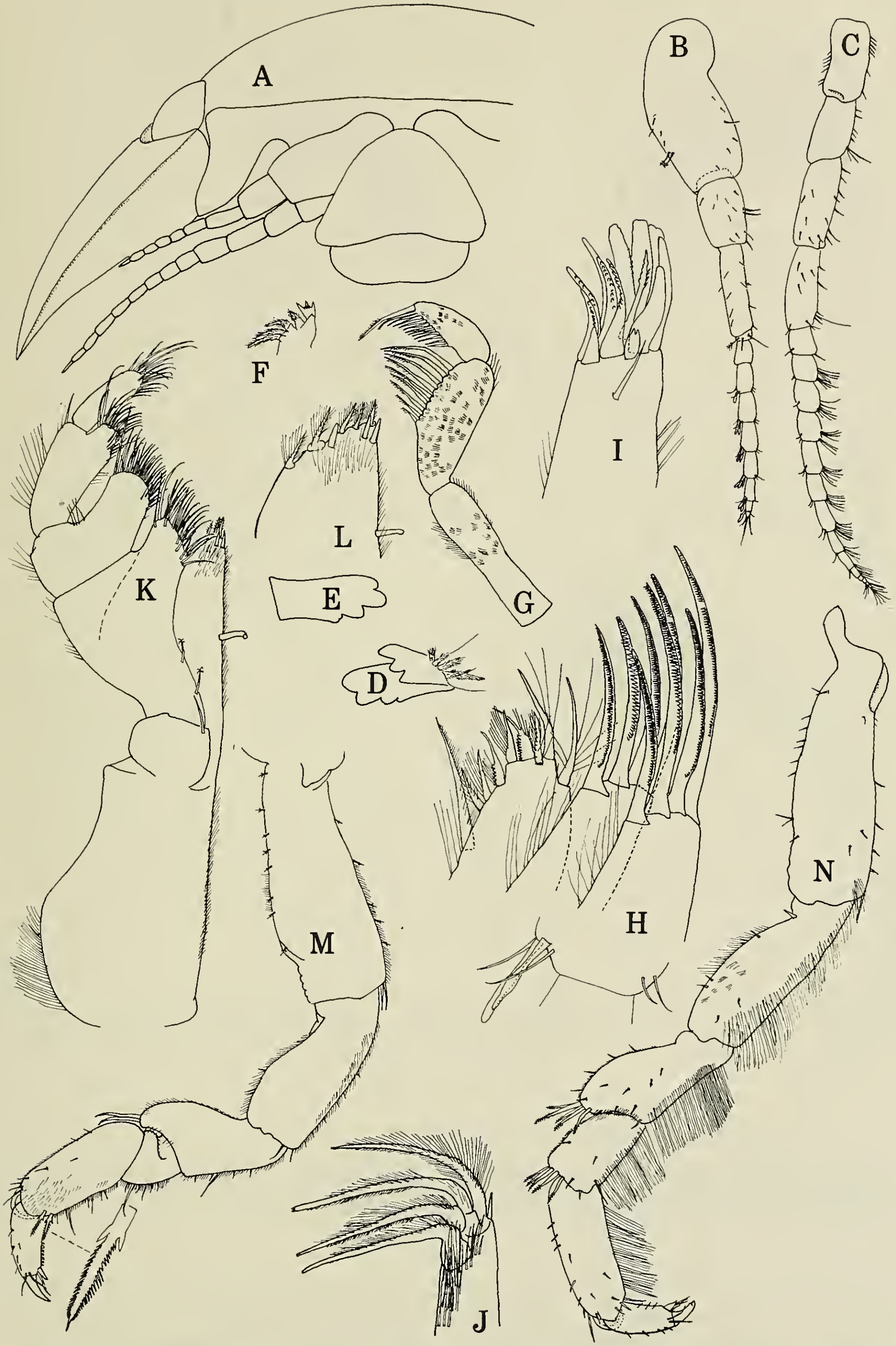

Fig. 1. *Thermosphaeroma cavicauda*: A, Head, ventral; B, Antenna 1; C, Antenna 2; D, Incisor, lacinia, and spine row of left mandible; E, Incisor of right mandible; F, Spine row of right mandible; G, Mandibular palp; H, Maxilla 2; I, J, Outer and inner rami of maxilla 1; K, Maxilliped; L, Maxilliped, detail of endite; M, Pereopod 1.

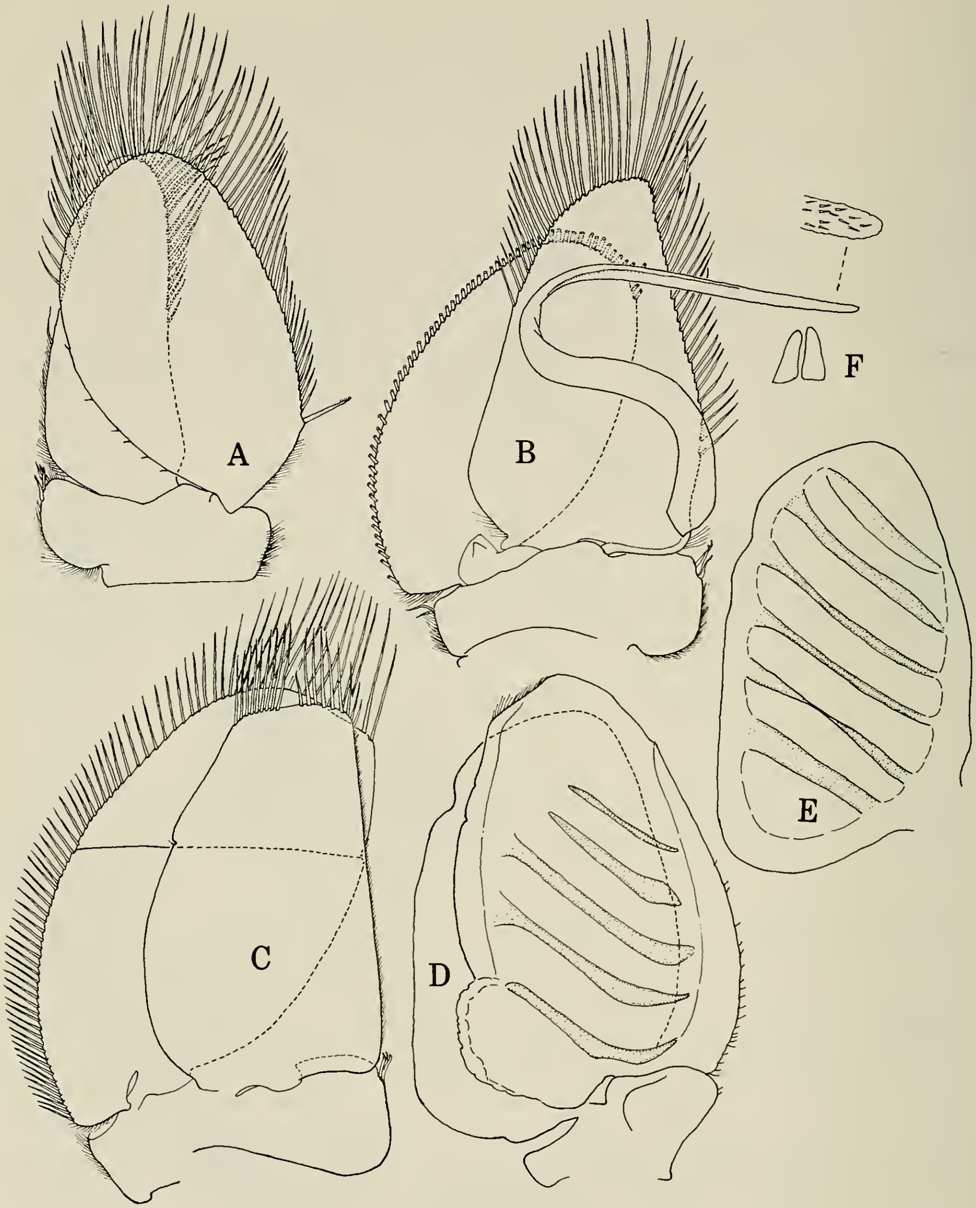

Fig. 2. *Thermosphaeroma cavicauda*, ♂: A, Pleopod 1; B, Pleopod 2; C, Pleopod 3; D, Pleopod 4 (folds of endopod not shown); E, Pleopod 4 endopod; F, Penes.

from all known species of *Thermosphaeroma* by the terminal notch in the telson, lacking in all other species of the genus. Except for the notch, the pleotelson is similar in shape to that of *T. milleri.* The uropods are similar in shape and proportions to those of *T. smithi,* although the exopod is proportionally longer in the latter species. The branchial folds are better developed in *T. cavicauda* than in other species of *Thermosphaeroma.*

*Habitat.*—The spring-fed ditch from which *T. cavicauda* was collected was 0.3–

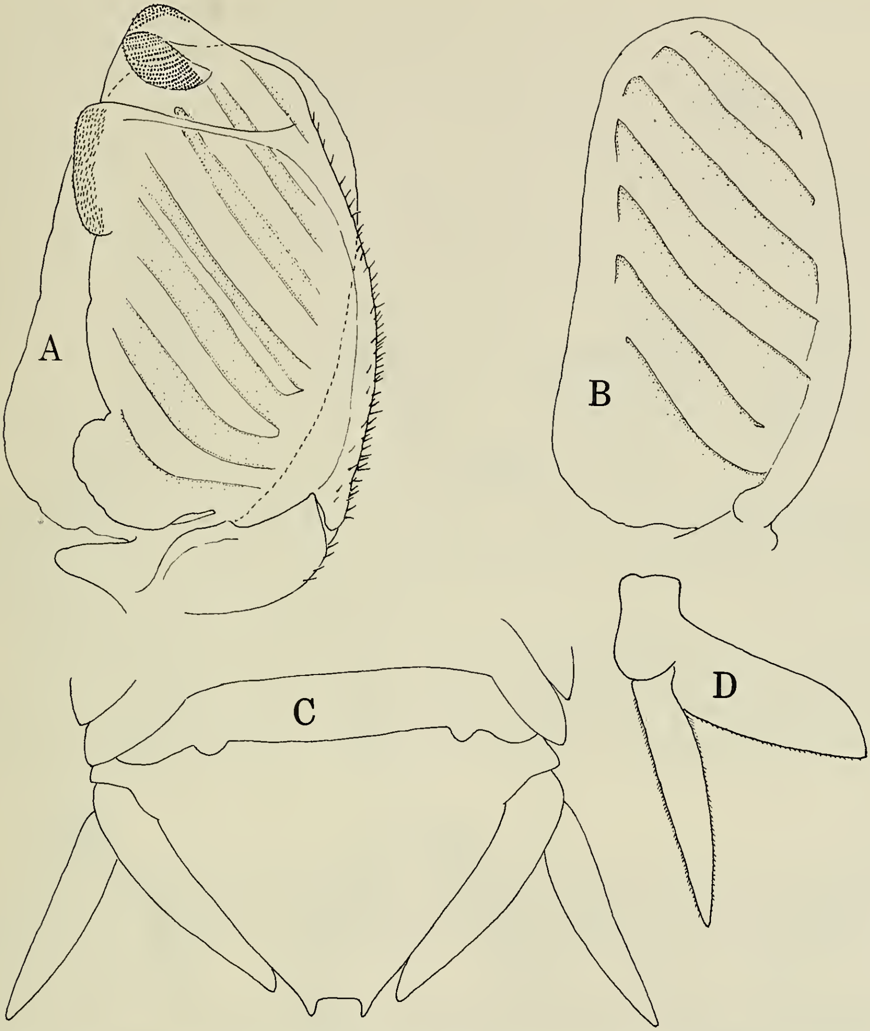

Fig. 3. *Thermosphaeroma cavicauda*: A, Pleopod 5 (folds of endopod not shown); B, Pleopod 5 endopod; C, Pleon and pleotelson; D, Right uropod, ventral.

1.0 m wide with pools 5–7 m in diameter. Depth was generally about 0.3 m. The bottom sediment was fine silt and mud. The water was clear, but quickly became muddied when disturbed. The temperature of the water was 29°C, of the air 25°C. Dissolved $O_2$ measured 8.0 ml/liter. Specific conductance was 315 micromhos/cm.

### *Thermosphaeroma macrura*, new species
Fig. 4

*Material.*—Mexico, Chihuahua State, stream tributary to Río Conchos, about 0.5 km S of Julimes, leg. R. R. Miller and D. L. Soltz, 17 Apr 1983; ♂ holotype, USNM 227046, and juvenile paratype, USNM 227047.

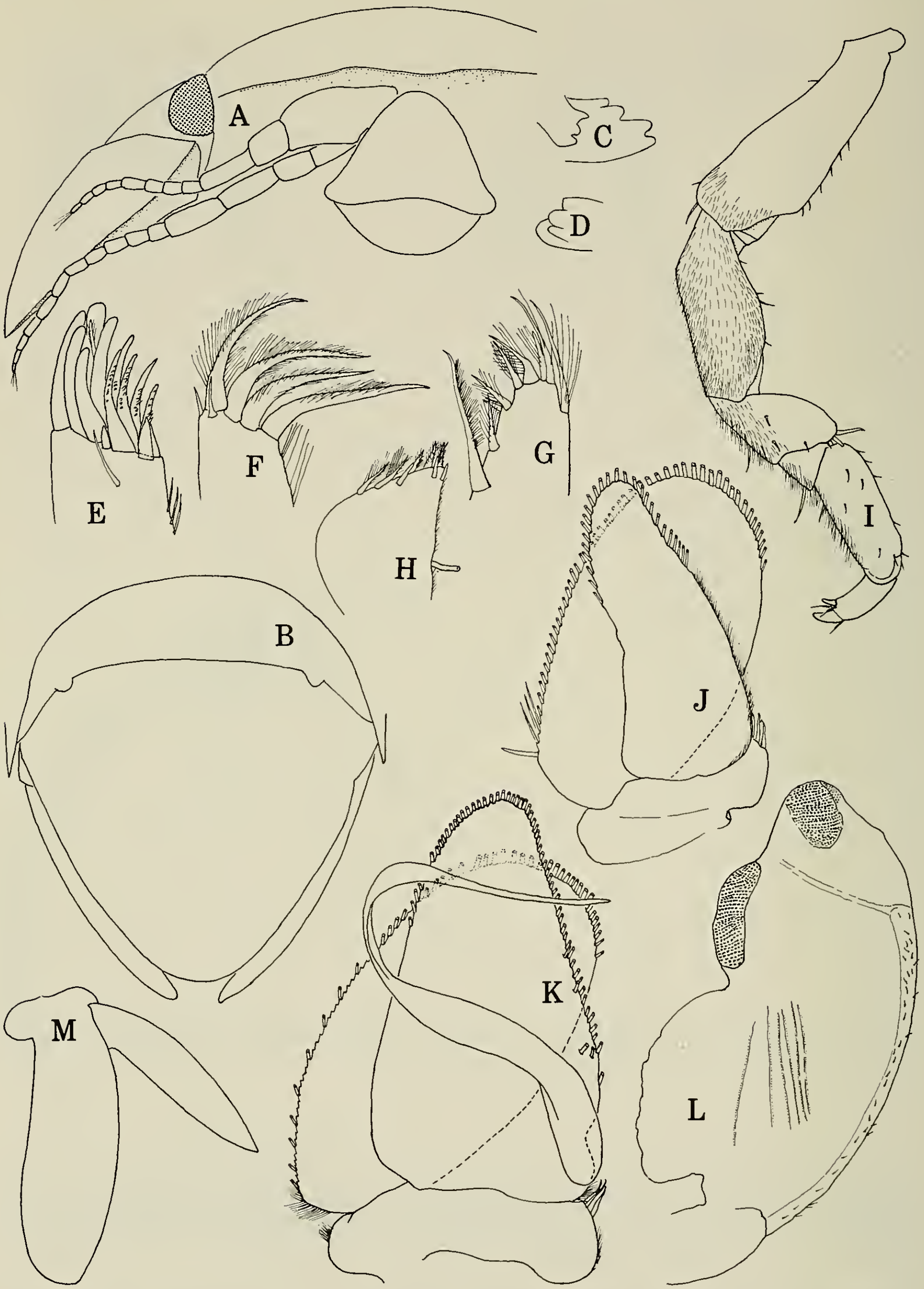

Fig. 4. *Thermosphaeroma macrura,* ♂ holotype: A, Head, ventral; B, Pleon and pleotelson, dorsal; C, Incisor and lacinia of left mandible; D, Incisor of right mandible; E, F, Outer and inner rami of maxilla 1; G, Inner ramus of maxilla 2; H, Endite of maxilliped; J, Pleopod 1; K, Pleopod 2; L, Pleopod 5 exopod; M, Right uropod, dorsal.

*Etymology.*—From the Greek "makros," long, plus "oura," tail, referring to the unusually long pleotelson. Proposed as a noun in apposition.

*Description.*—Length of holotype 10.8 mm, of paratype 7.0 mm. Body about 0.54× as wide as long; pereon gradually widening through pereonite 5, then gradually narrowing. Pereopods hirsute; pereonites sparsely hirsute. Pleotelson about 0.9× as long as basal width, lateral margins evenly convex, apex rounded. Clypeus nearly ⅔ as long as wide, anterior margin rounded. Antenna 1 flagellum 9-merous; antenna 2 flagellum 14-merous. Mandible incisors 4-cuspate, lacinia 3-cuspate. Maxilla 1 outer ramus with 2 dentiform spines, inner spine nearly twice length of outer. Flexor margin of dactyl of pereopod 1 unarmed except for accessory claw. Appendix masculina of pleopod 2 sinuous, much longer than endopod. Branchial folds not strongly developed on pleopods 4 and 5. Pleopod 5 exopod with shallow U-shaped incision on lateral margin proximal to reniform swelling. Exopod of uropod about 0.7× as long as endopod, apex pointed; endopod with broadly rounded apex with a slight lateral shoulder.

*Comparisons.*—*Thermosphaeroma macrura* has a markedly more elongate pleotelson than other species of the genus. The uropods of *T. subequalum* are most similar in shape, but are subequal in length. The endopod of pleopod 5 resembles that of *T. smithi,* but the latter has quite differently shaped uropods and pleotelson, and 2-cuspate incisors.

*Habitat.*—The stream from which *T. macrura* was collected was 5–10 m wide and probably up to 1 m deep. The bottom consisted of mud, silt, rocks, and boulders. The water was clear, but murky, and easily roiled. It was badly polluted. The temperature of the water was 32°C, of the air 34°C. Specific conductance was 1790 micromhos/cm.

## Remarks

The new localities extend the known range for *Thermosphaeroma.* The type-locality for *T. macrura* is near that of *T. smithi,* but that of *T. cavicauda* is the first record of the genus from Durango, and represents a western expansion of the generic range.

The modified diagnosis of *Thermosphaeroma* (Bowman 1981) requires further modification to accommodate *T. cavicauda.* The modified sentences are (additions italicized): (1) Branchial folds *usually* weak or absent on pleopod 4 exopod, *sometimes well developed*; (2) Pleotelson similar in both sexes, rounded posteriorly, *usually* without, *sometimes with* terminal notch or slit.

## Acknowledgments

I am grateful to Dr. Robert R. Miller for sending me the specimens of the two new species and for providing detailed information on the collection localities.

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# A NEW SEA-CAVE AMPHIPOD FROM BERMUDA (DULICHIIDAE)

J. L. Barnard and Janice Clark

*Abstract.*—*Podobothrus bermudensis* is described from a sea-cave in Bermuda. It lacks body pigment but retains well developed eyes; its principal anomaly within the Dulichiidae is the immensity of the antennae. The new genus differs from its closest congener, *Podocerus,* in the smaller disjunct coxae 3–7, feeble gnathopods, much more elongate apical spination on the rami of uropods 1–2, thin mandibular palp, and the poorly setose immense antennae.

The new genus and new species, *Podobothrus bermudensis,* described herein, occurs in Green Bay Cave, Bermuda. It has close resemblance to *Podocerus,* a genus with many species that occurs in shallow tropical and temperate waters. It was apparently collected from hydroids infesting a derelict rope found inside the unlighted cave. The eyes of the new genus are as well developed as in *Podocerus,* but the body and eyes lack pigment. In contrast to *Podocerus,* the coxae of segments 3–7 on the new genus are especially small, the gnathopods are feeble, the antennae are immense and sparsely setose, the apical spines on the rami of uropods 1–2 are elongate, and the mandibular palp is very thin.

References assisting in the identification of this amphipod are as follows: J. L. Barnard (1969), Laubitz (1977, 1979, 1983).

## Master Legend

Capital letters as follows refer to parts; lower case letters to left of capital letters refer to specimens noted in legends; lower case letters to right of capitals refer to adjectival modifications in list below:

> A, antenna; B, body; D, dactyl; E, epimera; F, accessory flagellum; G, gnathopod; I, inner plate or ramus; K, prebuccal, lateral; L, labium; M, mandible; P, pereopod; R, uropod; S, maxilliped; U, labrum; V, palp; W, urosome; X, maxilla; d, dorsal; r, right; s, setae removed; t, left; v, ventral.

## Family Dulichiidae Dana, 1849

### *Podobothrus,* new genus

*Diagnosis.*—Dulichiidae with body depressed (versus cylindrical), rostrum absent, head cuboidal, lateral nacelles with bulging eyes; antennae much longer than body, sparsely setose, antenna 1 shorter than 2, accessory flagellum present, 1-articulate; gnathopods feeble; pleonites 6–7 fused dorsally; all coxae strongly disjunct; urosomites 1–3 strongly developed and separate, telson partly fused dorsally to urosomite 3; uropods 1–2 well developed, both strongly biramous, uropod 3 composed of vestigial peduncle lacking rami; gills present only on coxae 3–6.

*Type-species.*—*Podobothrus bermudensis,* new species.

*Etymology.*—'Podo' from the Greek *pous* as, in Podoceridae, and 'bothrus' from the Greek *bothros,* a pit.

*Relationship.*—Probably closest to *Podocerus* but differing in the immense antennae, strongly disjunct coxae 2–7, and elongate apical spination of uropods 1–2.

According to Dr. Laubitz this genus does not fit the subfamily Podocerinae as described in Laubitz (1983). It is so strongly distinct from any of the other subfamilies, however, that we believe Podocerinae simply has to be emended to accept *Podobothrus.* Exceptions to the subfamilial diagnosis are gills absent on coxa 2; mandibular palp slender; coxae shorter than pereonites.

Differing from the *Dulichia* group (see Laubitz 1979) in the *Podocerus*-like head shape in contrast to the large and projecting keel-like condition of *Dulichia* and its congeners, and the presence of a third uropod.

Differing from *Cyrtophium* in the presence of an accessory flagellum and short antenna 1; from *Laetmatophilus* in the immense antennae, presence of an accessory flagellum, disjunct coxae 2–7, fully developed uropod 2 and presence of uropod 3; from *Leipsuropus* in the disjunct coxae and presence of uropods 2 and 3; from *Xenodice* (and Xenodicinae) in the short antenna 1, depressed body, lateral ocular bulges and more strongly disjunct coxae; and from *Neoxenodice* in the short antenna 1, much less disjunct coxae, long pereopods 3–4 and fused pereonites 6–7.

*Podobothrus* is not assignable to the Iciliidae which Laubitz (1983) places in the superfamily Eusiroidea because the gnathopods of that family are simple and elongate, the coxae are medium sized, acuminate, and coxae 3–4 are much larger than coxae 1–2.

### *Podobothrus bermudensis,* new species
Figs. 1–3

*Diagnosis.*—Having the generic characters.

*Description of holotype,* male, 1.76 mm.—Length of antenna 1; 2.37 mm, of antenna 2: 3.20 mm; articles 2 and 3 of antenna 1 immensely longer than article 1, ratio of articles 1–3 and flagellum = 5:19:22:29, primary flagellum 5-articulate (apical article vestigial), accessory flagellum 1-articulate. Ratio of articles 3, 4, 5 and flagellum of antenna 2 = 7:22:36:36, flagellum 4-articulate (apical article vestigial).

Epistome rounded anteriorly, upper lip evenly incised below. Right and left incisors with 5 and 4 teeth, right lacinia mobilis principally bifid but with accessory teeth, left with 4 teeth, rakers 2 plus accessory minor raker and accessory setules, molar triturative, with facial flake and seta; palp immense, slender, article 2 poorly setose, article 3 shorter than 2, slender, setal formula = A, 2D, 6E. Mandibular lobes of lower lip sharp. Inner plate of maxilla 1 vestigial, outer plate with 9 spines, palps symmetrical, with 5 apical spines and 2 facial setae. Inner plate of maxilla 2 narrower and shorter than outer, medial margin with 3 weak setae. Inner plate of maxilliped with 2 thick apical spines, one ventral coupling spine and 4 apical setae, 3 mediofacial setae, outer plate with 2 medial spines and 3 apicomedial spine-setae (plumose), palp slender, dactyl stubby, with 3 apical setae.

Gnathopod 1 slender, feeble, barely subchelate, carpus scarcely lobed, dactyl

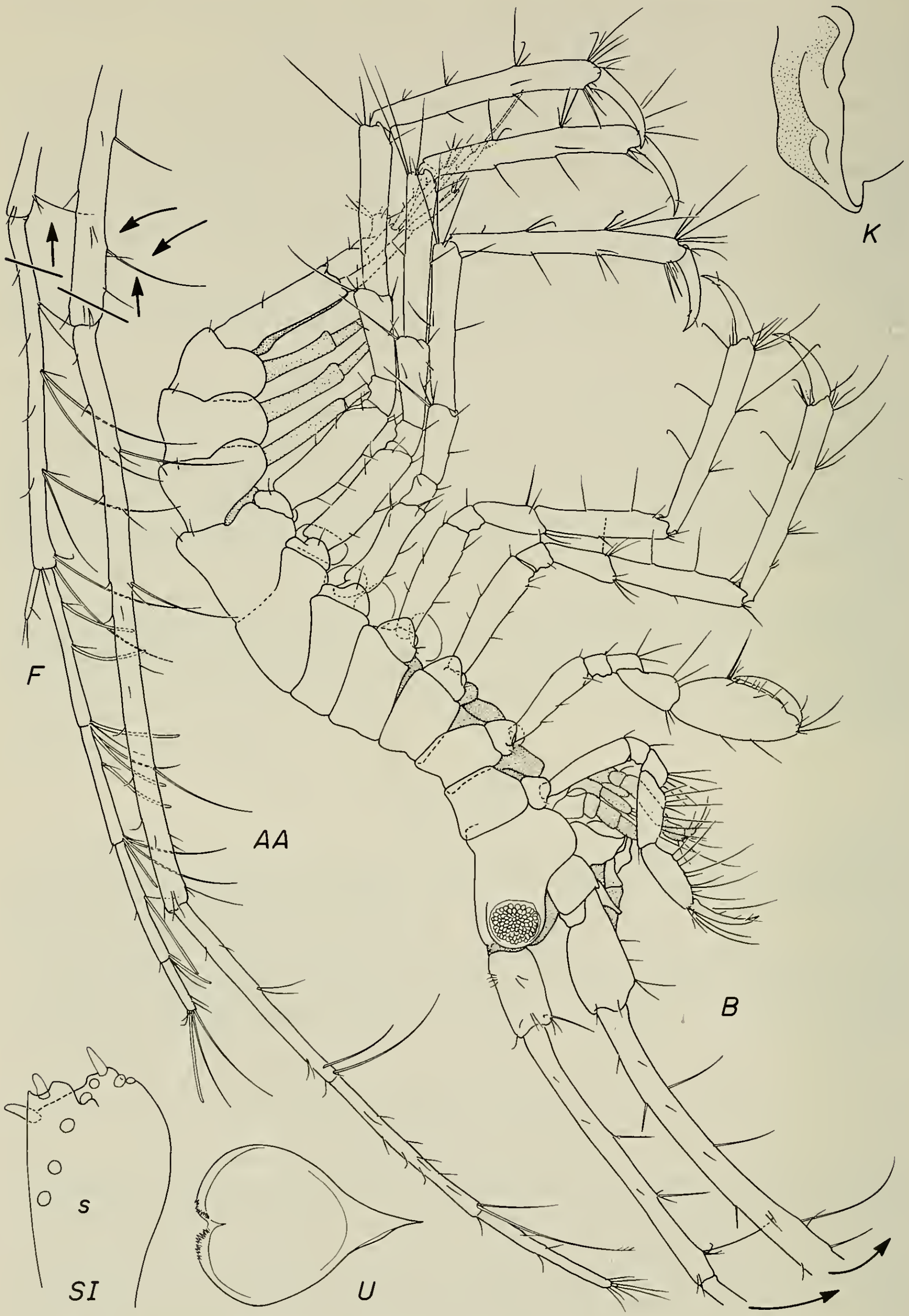

Fig. 1. *Podobothrus bermudensis,* holotype male 1.76 mm.

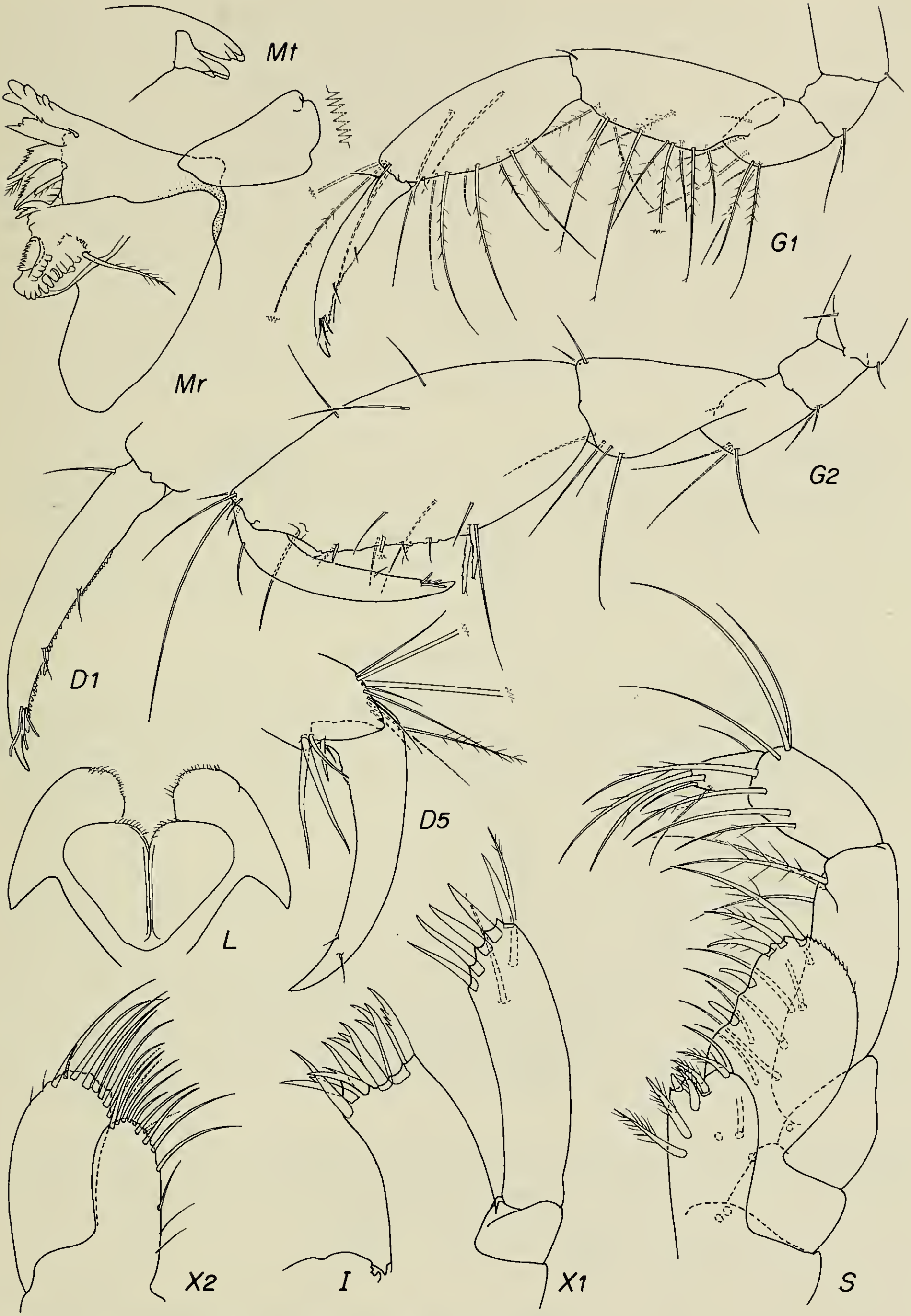

Fig. 2. *Podobothrus bermudensis,* holotype male 1.76 mm.

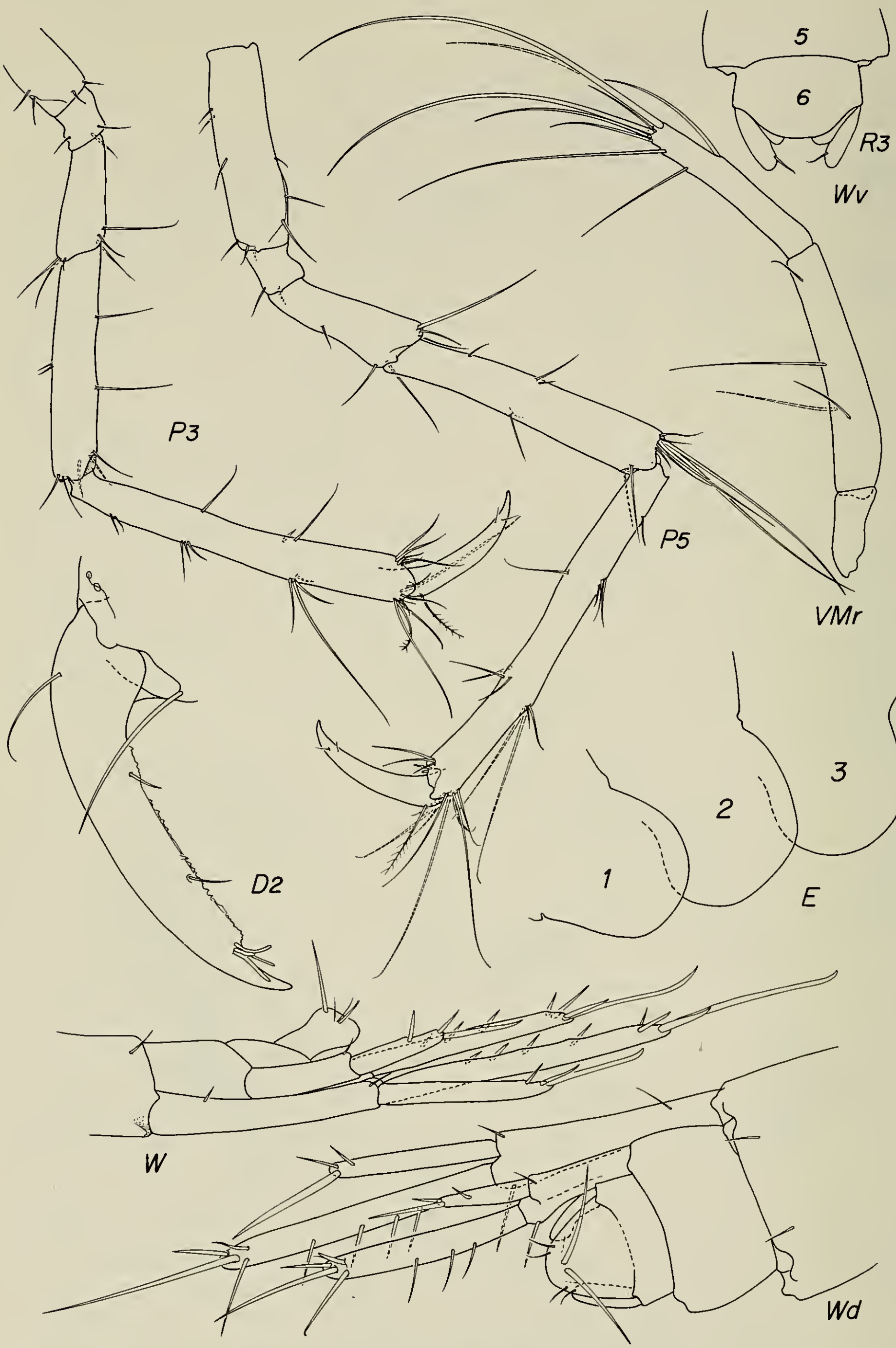

Fig. 3. *Podobothrus bermudensis,* holotype male 1.76 mm.

elongate, palm lacking definition by armaments. Gnathopod 2 scarcely enlarged (for a podocerid), barely subchelate, carpus weakly lobate, propodus slender, palm defined by 2 spines, weakly crenulate, dactyl fitting palm.

Pereopods 3–7 elongate, all similar, article 2 of only 6–7 weakly expanded, article 6 longer than 5, locking armament with 5 elements, dactyls with inner marginal and outer facial setule each. Gills 4, attached to coxae 3, 4, 5, 6. Epimera rounded and unarmed. Peduncles of pleopods with 3 coupling hooks each, otherwise unarmed, pleopods 2–3 with stronger apicolateral cusp than pleopod 1, all rami with 4 articles except outer ramus of pleopod 3 with 5 articles.

Outer rami of uropods 1–2 shortened, longest apical spine on any ramus about as long as outer ramus of uropod 1 or 65% as long as inner ramus of uropod 1. Uropod 3 forming flap attached lateral to anal extensions, with one inner setule. Telson with dorsal hump bearing 2 long spines and 2–3 lateral setules on each side.

*Illustrations.*—Antennae 1–2 cut off from body but marked by perpendicular lines to show attachment to bases on body drawing; scale of palp of mandible strongly reduced from scale of body of mandible; gills drawn attached to body.

*Holotype.*—USNM 195144, male, 1.76 mm. Unique.

*Type-locality.*—Bermuda, Green Bay Cave, 8 Jul 1982, coll. Dr. T. Iliffe, apparently from hydroids on derelict rope.

## Acknowledgments

We thank Dr. Iliffe for the many specimens of cave amphipods he has given us, and Patricia B. Crowe for her assistance in the laboratory. We thank Diana R. Laubitz of National Museums of Canada for reviewing our work. Our figures were inked by Linda B. Lutz of Mobile, Alabama.

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# A NEW SPECIES OF *BIVIBRANCHIA* (PISCES: CHARACIFORMES) FROM THE AMAZON RIVER BASIN

Richard P. Vari and Michael Goulding

*Abstract.*—*Bivibranchia notata* is described as new from the lower Rio Tapajós, Brazil. The species is distinguished from *B. protractila* Eigenmann, *B. velox* (Eigenmann and Myers), and *B. bimaculata* Vari by a variety of meristic and morphometric characters. The possession of a distinct midlateral body spot centered posterior of the vertical through the insertion of the posteriormost dorsal fin rays further distinguishes *B. notata* from *B. bimaculata* in which the spot is located more anteriorly, and from *B. velox* which has a plain body. A key is provided to the species of *Bivibranchia.*

*Bivibranchia velox* is reported from the lower Rio Xingu, the first citation of the species from the main portion of the Amazon basin. The distribution of *B. protractila* in the Amazon and variation in the pigmentation of the species in that river system is discussed.

The genus *Bivibranchia* Eigenmann (1912:258) is a small group of unusual hemiodontid characiforms readily distinguished externally by their highly protractile upper jaws; a system unique within the Characiformes and only approximated, although to a much lesser degree, in *Argonectes* the sister group to *Bivibranchia* (Roberts 1974:432). The alterations of the jaws and suspensorium permitting such pronounced jaw protractility along with various modifications of the branchial arches were discussed by Roberts (1974). More recently Vari (1985) has described a number of other apomorphous alterations of the anteriormost full pleural ribs, their associated vertebrae, parapophyses, and intercostal ligaments that distinguish *Bivibranchia* (including *Atomaster* Eigenmann and Myers, 1927) within the Hemiodontidae, and indeed within the entire Characiformes. That author also described a unique hypertrophy of the portions of the glossopharyngeal and vagus (ninth and tenth cranial) nerves innervating the branchial arches. Associated with the pronounced expansion of these nerves is a dramatic increase in the degree of development of the vagal lobe of the medulla oblongata, and the presence of a series of elaborate folds on the lateral surface of the enlarged vagal lobes. These modifications are all unique to *Bivibranchia* among examined characiforms and congruent with the hypothesis of the monophyly of the genus. In that same paper Vari described a new hemiodontid, *Bivibranchia bimaculata,* which was the third characiform species with a markedly protractile mouth. Recent collecting activities in the Amazon River basin have revealed the existence of a new *Bivibranchia* species described herein, and provide additional data on the variation in pigmentation of *B. protractila,* and on the geographic distribution of that species and *B. velox* within that drainage system.

*Methods and materials.*—Counts of total vertebrae were taken from radiographs and cleared and stained specimens, and include the four vertebrae of the Weberian apparatus, with the fused $PU_1 + U_1$ of the caudal skeleton counted as a single element. Numbers in parentheses after a vertebral count are the number of specimens with that particular count. In counts of the pelvic and median rays, unbranched rays are indicated by Roman numerals and branched rays by Arabic numerals. The ranges for meristic counts are based on the holotype and paratypes, with the value for the holotype indicated in square brackets.

Specimens examined for this study are deposited in the following institutions: Museu de Zoologia da Universidade de São Paulo, MZUSP; and National Museum of Natural History, Smithsonian Institution, USNM.

## Key to the species of *Bivibranchia,* Eigenmann

1. 81 to 90 pored lateral line scales to hypural joint. Scales of adults with distinct ctenni .......................... *B. velox* (Eigenmann and Myers)

– 49 to 73 pored lateral line scales to hypural joint. Scales of adults cycloid ........................................................................ 2

2. 63 to 73 pored lateral line scales to hypural joint. 11 or 12 scale rows in transverse series from lateral line to origin of rayed dorsal fin. ........ ............................................. *B. notata,* new species

– 49 to 55 pored lateral line scales to hypural joint. 7½ to 9½ scale rows in transverse series from lateral line to origin of rayed dorsal fin. ........ 3

3. Distinct large, dark midlateral spot on body centered along or slightly posterior of vertical through insertion of posteriormost dorsal-fin ray. Smaller spot of dark pigmentation typically present on midlateral surface of caudal peduncle. 8 branched anal-fin rays. Pelvic fin length 0.18–0.20 of SL. ........................................ *B. bimaculata* Vari

– Body plain or with faint or discrete midlateral spot on body. When midlateral pigmentation patch present, centered distinctly posterior of vertical through insertion of posteriormost dorsal-fin ray. 7 branched anal-fin rays. Pelvic fin length 0.14–0.17 of SL. ............... *B. protractila* Eigenmann

## *Bivibranchia notata,* new species

Fig. 1, Table 1

*Holotype.*—MZUSP 28657, 68.3 mm standard length (SL), coll. Michael Goulding, 25 Nov 1983, Rio Tapajós, beach at Alter do Chão, Pará, Brazil (approx. 2°31′S, 54°57′W).

*Paratypes.*—1 specimen, taken with holotype, USNM 268049, 66.6 mm SL. 6 specimens: MZUSP 23712, 3 specimens, 26.5–30.7 mm SL; USNM 268562, 3 specimens 28.4–35.1 mm SL, coll. Expediçao Permanente de Amazônia, under direction of Paulo E. Vanzolini, 25 Nov 1970, pool in Rio Tapajós at Barreirinha near São Luís, Pará, Brazil (approx. 4°26′S, 56°14′W).

*Diagnosis.*—*Bivibranchia notata* shares with the other species of the genus numerous derived modifications of the upper jaw, suspensorium, branchial arches, anterior ribs and vertebral column that distinguish *Bivibranchia* within the Hemiodontidae (see Vari 1985). The limited available material of the new species has prevented the dissections necessary to confirm the presence of the hypertrophy of the glossopharyngeal and vagus nerves described by Vari as synapomorphous

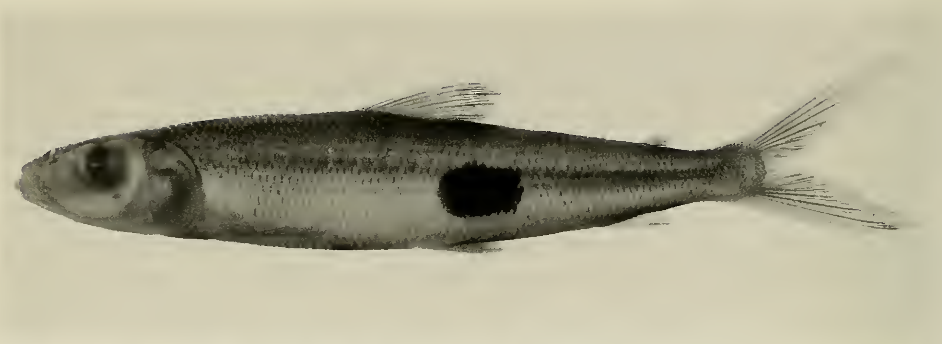

Fig. 1. *Bivibranchia notata,* new species, holotype, MZUSP 28657, 68.3 mm SL; Rio Tapajós, Alter do Chão, Pará, Brazil.

for other *Bivibranchia* species. Neither was it possible to determine whether this species has the hypertrophy of the vagal lobes of the medulla oblongata, and the elaboration of the surface of those lobes that are common to its congenerics. *Bivibranchia notata* does, however, have the distinctive vertical expansion of the epibranchials and ceratobranchials, and the elaboration of the soft tissues overlying these elements that are characteristic of *Bivibranchia.* If the cranial nerve and medulla oblongata hypertrophies of other *Bivibranchia* species are indeed correlated with the unique soft tissue and osteological modifications of the branchial apparatus, then we would expect that *B. notata* shares the neurological apomorphies for the genus. Similarly, it is assumed that the hard tissue modifications of the third and fourth full pleural ribs and associated vertebrae obvious in the radiographs of *B. notata* are paralleled by the system of intercostal ligaments typical for *Bivibranchia* (see Vari 1985 for a fuller description of the system).

The presence on the midlateral body surface of *Bivibranchia notata* of a large spot of dark pigmentation centered distinctly posterior of the vertical through the insertion of the posteriormost dorsal-fin ray separates that species from *B. velox* which has a plain body and from *B. bimaculata* in which the midlateral body spot is approximately centered along the vertical through the insertion of the posteriormost dorsal-fin ray. The 63 to 73 pored lateral line scales to the hypural joint distinguish *Bivibranchia notata* from *B. bimaculata* which has 49 to 55 scales in that series, *B. protractila* which has 50 to 54 scales, and *B. velox* which has 81 to 90 scales (originally listed by Eigenmann and Myers 1927 as having 89 to 98 scales, a count including 8 or 9 scales on the caudal fin base beyond the hypural joint). The 11 or 12 scale rows above the lateral line in a transverse series to the origin of the rayed dorsal fin further differentiates *B. notata* from *B. bimaculata* and *B. protractila* which have 8½–9½ and 7½–8½ scale rows respectively in that series.

*Description.*—Morphometrics of the holotype and paratypes are given in Table 1. Body slender, slightly compressed laterally. Greatest body depth at origin of rayed dorsal fin. Dorsal profile of body gently curved from tip of snout to origin of rayed dorsal fin; slightly posteroventrally slanted along base of fin, nearly straight from insertion of posteriormost dorsal-fin ray to caudal peduncle. Slight median keel immediately anterior of origin of rayed dorsal fin. Ventral profile of body smoothly convex from tip of lower jaw to caudal peduncle. Ventral surface of body transversely flattened anteriorly.

Head obtusely pointed in profile, interorbital region flattened. Fronto-parietal fontanel evidently extending from rear of ethmoid to supraoccipital; anterior portion narrower transversely than posterior section. Parietals completely separated, frontals in contact only at epiphyseal bar. Upper jaw longer than lower jaw even when not protracted. Nostrils approximate, anterior opening smaller, round; posterior crescent shaped, partially closed by flap of skin separating nostrils. Eye relatively large. Large, horizontally ovoid "adipose eyelid" (a thick transparent connective tissue layer) extending from anterior of vertical drawn through border of anterior nostril posteriorly over orbit onto anterior portion of opercle. Adipose eyelid thicker anteriorly, with ovoid, vertically elongate opening overlying pupil.

Lower jaw edentulous, rounded in ventral view, anterior margin fleshy. Upper jaw highly protractile, maxilla extending under anterior portion of infraorbital series. Upper jaw with single series of functional teeth. All teeth tricuspidate, 9 or 10 teeth on each side of upper jaw; teeth becoming progressively larger medially. Gill arches highly modified, with vertically expanded epibranchials and ceratobranchials. Surfaces of these expanded gill-arch elements with series of fleshy ridges aligned nearly perpendicular to longitudinal axis of bones. Gill rakers extending along surfaces of expanded ceratobranchials and epibranchials; each raker associated with fleshy ridge. Gill membranes narrowly attached medially to urohyal.

Scales cycloid, firm. Pored lateral line scales between supracleithrum and hypural joint 63 to 73 [73]; 5 to 7 pored lateral line scales extending beyond hypural joint onto base of caudal fin; canals in lateral line scales straight. Scales in transverse series from lateral line to origin of rayed dorsal fin 11 or 12 [11]. Scales below lateral line in transverse series to origin of anal fin 7 or 8 [7]. Body squamation extending onto base of caudal-fin rays. Axillary process of pelvic fin formed by single enlarged scale.

Vertebrae 39 (2).

Rayed dorsal fin obtusely pointed, first and second branched rays longest, subequal. Dorsal-fin rays ii,9. Adipose dorsal fin of moderate size, unscaled. Anal fin obtusely pointed, first and second branched rays longest, subequal; anterior branched rays approximately one and one-half times length of posteriormost rays. Anal-fin rays ii,7. Pectoral fin pointed, reaching slightly over one-half distance to vertical through insertion of pelvic fin. Pectoral-fin rays 16 to 18. Dorsalmost ray of pectoral fin corresponding in position to groove along side of body formed by connective tissue ridge extending posteriorly from posterior margin of cleithrum. Pelvic-fin pointed, extending slightly over one-half distance to anus. Pelvic-fin rays i,8 or i,9 [i,9] (typically i,9).

*Coloration in preservative.*—Overall coloration of adult specimens fixed in formalin and preserved in ethanol light tan. Head darker on dorsal portions with uniform scattering of small dark chromatophores on upper lip, section of snout anterior and dorsal of adipose eyelid, and across interorbital region and dorsal portions of head. Dorsally situated field of scattered chromatophores extending posteroventrally onto opercle, becoming progressively less dense ventrally; with few, widely scattered chromatophores on opercle ventral of horizontal through lower border of eye. Overall coloration of body darker dorsally; each body scale, other than on ventral portions of body, with corresponding, posteriorly concave, crescent-shaped series of chromatophores. Overall chromatophore field on body increasing in density dorsally, masking crescentic chromatophore series of individual scales. Distinct dark, slightly horizontally ovoid spot with somewhat irregular margins on midlateral surface of body. Spot commencing at scale 28 to 30 of lateral line and extending 12 scales horizontally and 5 scales dorsally. Pigmentation of spot consisting of chromatophores both medial to scales and in epithelial layers overlying scales. Spot centered distinctly posterior of vertical through insertion of posteriormost dorsal-fin ray. Deep lying dusky band extending along midlateral surface of body from posterior margin of midlateral spot to caudal peduncle. Caudal fin dusky, particularly on ventral lobe; rays outlined by series of chromatophores. Rayed dorsal fin dusky. Adipose dorsal, anal, pectoral and pelvic fins with scattered chromatophores.

Overall coloration of juveniles (26.2–35.1 mm SL) fixed in formalin and preserved in alcohol tannish brown. Distribution of chromatophores generally as in adults, but chromatophore fields of juveniles less dense. Midlateral body spot relatively smaller than in adults, extending only 5 scales horizontally and 3 scales vertically. No indication of dusky band between midlateral body spot and caudal peduncle. Median rayed fins with scattered chromatophores. Adipose dorsal fin and paired fins hyaline.

*Etymology.*—The specific name, *notata,* from the Latin for mark, refers to the prominent spot on the midlateral surface of the body.

*Ecology.*—*Bivibranchia notata* was captured in the Rio Tapajós along the river margin in a mixed school with *B. protractila.* Specimens of the latter species from the same locality have faint dusky patches on the midlateral surface of the body which correspond in position to the very dark spot present in *B. notata.*

*Remarks.*—The specimens that are the basis for the species description fall into two distinct size classes, with the holotype (MZUSP 28657) and the paratype from the holotypic locality (USNM 268049) being twice the average standard length of the six paratypes from Barreirinha (MZUSP 23712 and USNM 268562). The specimens of both size classes agree well in meristics but the larger individuals from Alter do Chão differ from those captured at Barreirinha in the relative greatest body depth, distance from origin of dorsal fin to hypural joint, head length, snout length and interorbital width (see Table 1). These differences are presumably a function of the different size classes being compared.

Vari (1985) synonymized *Atomaster* Eigenmann and Myers (1927) in *Bivibranchia* Eigenmann (1912) as a consequence of the large number of synapomorphies uniting these two taxa and the few differences in squamation separating them. One of the two characters noted by Eigenmann and Myers (1927:565) as distinguishing *Atomaster* from *Bivibranchia* was the distinct difference in scale size (=number of scales in a longitudinal series) in the two genera. *Bivibranchia notata* with a lateral line scale count of 63 to 73 is intermediate in that feature between the 49 to 55 scales of *B. protractila* Eigenmann and *B. bimaculata* Vari on the one hand, and the 81 to 90 scales of *Atomaster* (=*Bivibranchia*) *velox* Eigenmann and Myers on the other. The intermediate position of the new species with respect to this character eliminates the trenchant differences in scale counts between the nominal genera, and lends further support to the synonymization of *Atomaster.*

Table 1.—Morphometrics of *Bivibranchia notata,* new species. Standard length is expressed in mm; measurements 1 to 10 are proportions of standard length; 11 to 15 proportions of head length.

| | Holotype | Paratypes (7) | | |
|---|---|---|---|---|
| | | USNM 268049 | USNM 268562 + MZUSP 23712 | Average |
| Standard length | 68.3 | 66.6 | 26.2–35.1 | 34.7 |
| 1. Greatest body depth | 0.20 | 0.20 | 0.18 | 0.183 |
| 2. Snout to dorsal-fin origin | 0.48 | 0.48 | 0.47–0.54 | 0.508 |
| 3. Snout to anal-fin origin | 0.84 | 0.84 | 0.79–0.84 | 0.824 |
| 4. Snout to pelvic-fin origin | 0.56 | 0.57 | 0.54–0.60 | 0.572 |
| 5. Snout to anus | 0.77 | 0.77 | 0.75–0.78 | 0.762 |
| 6. Origin of rayed dorsal fin to hypural joint | 0.53 | 0.54 | 0.48–0.51 | 0.502 |
| 7. Least depth of caudal peduncle | 0.08 | 0.08 | 0.08 | 0.080 |
| 8. Pectoral-fin length | 0.17 | 0.18 | 0.18–0.20 | 0.190 |
| 9. Pelvic-fin length | 0.14 | 0.15 | 0.13–0.15 | 0.142 |
| 10. Head length | 0.27 | 0.28 | 0.31–0.34 | 0.314 |
| 11. Snout length | 0.31 | 0.28 | 0.36–0.37 | 0.346 |
| 12. Orbital diameter | 0.28 | 0.29 | 0.26–0.29 | 0.282 |
| 13. Postorbital head length | 0.37 | 0.37 | 0.35–0.40 | 0.376 |
| 14. Interorbital width | 0.33 | 0.32 | 0.26–0.30 | 0.294 |
| 15. Gape width | 0.12 | 0.13 | 0.11–0.13 | 0.124 |

*Comments on other Amazonian Bivibranchia species.*—The original description of *Bivibranchia velox* (Eigenmann and Myers, 1927) was based on a series of specimens collected by Dr. Carl Ternetz in the middle and upper portions of the Rio Tocantins system, whose mouth lies outside the main Amazon basin. Vari (1985) recently cited the species as an element of the lower section of the Rio Tocantins. In the course of this study, a series of juvenile specimens of *B. velox* were found intermingled with a large series of juvenile *B. protractila* from Belo Monte on the Rio Xingu (see "Comparative Material Examined"). This represents the first record of *B. velox* from the main portion of the Rio Amazonas basin. The Xingu specimens agree with the original description of *B. velox* (Eigenmann and Myers, 1927) other than in possessing cycloid scales rather than the ctenoid scales typical of *B. velox.* This difference in scale form may be a function of the different sizes of the involved specimens (Eigenmann and Myers' specimens 104+ mm (SL?), Rio Xingu specimens, 30–56 mm SL).

*Bivibranchia protractila* was originally described by Eigenmann (1912) from the Essequibo River of Guyana. Steindachner (1917:16) subsequently listed the species from Boa Vista, Conceiçao, Serra Grande and the Rio Parima in the Amazon basin. Eigenmann and Myers (1927), in turn, extended the known range of the species to the upper Río Orinoco, the Rio Negro, the upper Rio Tocantins and the region of Santarem. Material collected by one of us (MG) has shown that *B. protractila* is also a component of the ichthyofauna of the Rio Xingu, the lower portions of the Rio Tapajós, and is present in the Rio Machado, a tributary of the middle Rio Madeira (see Fig. 2 and "Comparative Material Examined").

The examined specimens of *Bivibranchia protractila* from the Essequibo River of Guyana lack any pronounced pigmentation patterns. Amazonian material of the species, alternatively, range from straw colored, plain bodied individuals

Fig. 2. Map of northern South America showing the distribution of Amazonian *Bivibranchia* specimens cited in this paper: *Bivibranchia notata,* new species, localities 1 (MZUSP 28657 holotype and USNM 268049 paratype), and 2 (USNM 268562 and MZUSP 23712 paratypes); *Bivibranchia velox* (Eigenmann and Myers), locality 3; *Bivibranchia protractila* Eigenmann, localities 1, and 3 to 7. Localities: 1, Alter do Chão; 2, Barreirinha near São Luís, and Itaituba; 3, Belo Monte; 4, Tucurui; 5, Rio Marauia; 6, Bem Querer; 7, Rio Machado. See "Comparative Material Examined" and listing of holotype and paratypes for further locality and collection data.

similar to those from the Essequibo system, to specimens with distinct midlateral markings. In its most developed condition the latter pigmentation pattern consists of two patches of chromatophores with irregular borders. The larger, anterior spot occurs on the midlateral surface of the body and is centered distinctly posterior of the vertical through the insertion of the posteriormost dorsal-fin ray. A second smaller elongate pigmentation patch is located on the caudal peduncle and extends posteriorly onto those scales covering the base of the middle rays of the caudal fin. Within a single sample of *B. protractila* from the Rio Tapajós at Itaituba (USNM 268048) there is found a continuum from plain bodied specimens, through individuals with faint midlateral marks, to those specimens with distinct pigmentation patches. Faint markings in comparable positions are evident on specimens captured in the Rio Negro and Rio Tocantins systems, but no pigmentation patches were obvious in individuals from the Rio Xingu. The factors contributing to this pigmentary variability within and between populations of this species are unknown.

*Comparative material examined.*—In additional to the specimens listed below, the specimens cited in Vari (1985) were also examined for this study. All of the following material was collected in Brazil by M. Goulding unless otherwise noted.

*Bivibranchia velox* (Eigenmann and Myers): 50 specimens, MZUSP 28656, Pará, Rio Xingu, Belo Monte; 58 specimens, USNM 268490, data as for preceding.

*Bivibranchia protractila* Eigenmann: Pará: 9 specimens, USNM 268086, Rio Tocantins, Tucurui, coll. M. Jégu; 17 specimens, USNM 268489; Rio Tapajós, Alter do Chão (taken with holotype of *B. notata*); 16 specimens, USNM 268048, Rio Tapajós, Itaituba; 5 specimens, USNM 268047, Rio Xingu, Belo Monte; 100 specimens, USNM 268055, data as for preceding. Amazonas: 10 specimens, USNM 268050, Rio Marauia at confluence with Rio Negro; 13 specimens, USNM 268051, Rio Marauia, cachoeira do Bicho-Acu. Roraima: 55 specimens, USNM 268052, Rio Branco, cachoeira do Bem Querer. Rondonia: 22 specimens, USNM 268054, Rio Machado, Paracauba; 12 specimens, USNM 268053, Rio Machado, Jauari.

## Acknowledgments

Drs. Heraldo Britiski, Naércio Menezes, and José Lima de Figueiredo generously provided research facilities at MZUSP and made available the *Bivibranchia* holdings of that institution. Dr. Michel Jégu provided access to materials of *B. velox* and *B. protractila* from the Rio Tocantins in the collection of the Instituto Nacional de Pesquisas da Amazônia, Manaus. The paratypes of *B. notata* from Barreirinha were collected by the Expediçao Permanente de Amazônia under the direction of Dr. Paulo E. Vanzolini (MZUSP). Mr. Andrew G. Gerberich provided technical assistance at USNM. Figure 1 was prepared by Mr. Theophilus Britt Griswald. This paper benefited from the comments and suggestions of Dr. Stanley H. Weitzman and Dr. Wayne C. Starnes. We would like to thank all these individuals for their assistance and interest. Research associated with this project was partially supported by the I.E.S.P. Neotropical Lowland Research Program of the Smithsonian Institution.

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# INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE

% British Museum (Natural History)
Cromwell Road
London SW7 5BD

3 July 1985

The following Opinions and a Direction have been published by the International Commission on Zoological Nomenclature in the *Bulletin of Zoological Nomenclature,* volume 42, part 2 on 27 June 1985:

*Opinion No.*
1298 (p. 124) *Tyrophagus* Oudemans, 1924 (Acarina): clarification of name of type species.
1299 (p. 128) *Athyreus* Macleay, 1819 and *Glyptus* Brullé, 1835 (Insecta, Coleoptera): conserved.
1300 (p. 130) TEIIDAE Gray, 1827 given nomenclatural precedence over AMEIVIDAE Fitzinger, 1826 (Reptilia, Sauria).
1301 (p. 134) *Artemia* Leach, 1819 (Crustacea, Branchiopoda): conserved.
1302 (p. 137) *Nabis capsiformis* Germar, [1838] (Insecta, Heteroptera, Nabidae): conserved.
1303 (p. 139) *Coccus* Linnaeus, 1758 and *Parthenolecanium* Šulc, 1908 (Insecta, Hemiptera, Homoptera): type species designated.
1304 (p. 142) *Melithaea* Milne Edwards & Haime, 1857 and *Isis ochracea* Linnaeus, 1758 (Coelenterata, Anthozoa): conserved.
1305 (p. 144) *Bapta candidaria* Leech, 1897 is the type species of *Lambrocabera* Inoue, 1958 (Insecta, Lepidoptera).
1306 (p. 146) *Ledella bushae* Warén, 1978 is the type species of *Ledella* Verrill & Bush, 1897 (Mollusca, Bivalvia).
1307 (p. 148) *Ptinella* Motschulsky, 1844 and *Nephanes* Thomson, 1859 (Insecta, Coleoptera): conserved.
1308 (p. 150) *Aphis callunae* Theobald, 1915 (Insecta, Hemiptera): conserved.
1309 (p. 152) *Geoemyda* Gray, 1834 and *Rhinoclemmys* Fitzinger, 1835 (Reptilia, Testudines): conserved.
1310 (p. 154) *Eutermes exitiosus* Hill, 1925 (Insecta, Isoptera): conserved.
1311 (p. 156) *Corisella* Lundblad, 1928 and *Krizousacorixa* Hungerford, 1930 (Insecta, Heteroptera): conserved.
1312 (p. 158) *Heliothis* Ochsenheimer, 1816 (Insecta, Lepidoptera): gender and stem designated.
1313 (p. 160) *Testudo scripta* Schoepff, 1792 and *Emys cataspila* Günther, 1885 (Reptilia, Testudines): conserved.
1314 (p. 162) *Hydrophorus nebulosus* Fallén, 1823, is the type species of *Hydrophorus* Fallén, 1823 (Insecta, Diptera).
1315 (p. 165) *Eolis alderi* Cocks, 1852 is the type species of *Aeolidiella* Bergh, 1867 (Mollusca, Gastropoda).

1317 (p. 169) *Tupus* Sellards, 1906 (Insecta, Protodonata): conserved.

1318 (p. 171) (Opinion correcting the ruling given in Opinion 92.) *Lacerta velox* Pallas, 1771 is the type species of *Eremias* Wiegmann, 1834 (Reptilia).

1319 (p. 173) *Nomioides* Schenck, 1866 (Insecta, Hymenoptera): designation of type species.

1320 (p. 175) *Hydrodamalis* Retzius, 1794 and *Manatus inunguis* Natterer in Pelzeln, 1883 (Mammalia, Sirenia): conserved.

1321 (p. 177) Grant of nomenclatural precedence to EPHYDRIDAE Zetterstedt, 1837 over HYDRELLIIDAE Robineau-Desvoidy, 1830 (Insecta, Diptera).

1322 (p. 180) *Buprestis nana* Paykull, 1799, non Gmelin, 1790 (Insecta, Coleoptera): conserved.

1323 (p. 182) *Byrrhus semistriatus* Fabricius, 1794 (Insecta, Coleoptera): conserved.

1324 (p. 185) *Diademodon* Seeley, 1894 and *Diademodon tetragonus* Seeley, 1894 conserved by the suppression of *Cynochampsa* Owen, 1859 and *Cynochampsa laniaria* Owen, 1859 (Reptilia, Therapsida).

1325 (p. 188) *Capsus ater* Jakovlev, 1889 (Insecta, Hemiptera, Heteroptera): not rejected as a junior homonym of *Cimex ater* Linnaeus, 1758.

1326 (p. 190) *Cimex quadripunctatus* Fabricius, 1794 (Insecta, Hemiptera, Heteroptera): conserved.

1327 (p. 192) *Holocentropus* McLachlan, 1878 (Insecta, Trichoptera): conserved.

*Direction No.*

118 (p. 195) Corrections to three entries in the Official List of Family-Group Names in Zoology: ARGYNNIDAE, APATURIDAE, LIMENITIDINAE (Insecta, Lepidoptera).

The Commission regrets that it cannot supply separates of Opinions.

R. V. MELVILLE
Secretary

# INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE

% British Museum (Natural History)
Cromwell Road
London SW7 5BD

3 July 1985

The Commission hereby gives six months notice of the possible use of its plenary powers in the following cases, published in the *Bulletin of Zoological Nomenclature,* volume 42, part 2 on 27 June 1985 and would welcome comments and advice on them from interested zoologists.

Correspondence should be addressed to the Secretary at the above address, if possible within six months of the date of publication of this notice.

*Case No.*

940 *Southernia* Allgen, 1929: proposed conservation by the suppression of *Southernia* Filipjev, 1927 (Nematoda).

2210 *Folsomia candida* Willem, 1902 (Insecta, Collembola): proposed conservation by the suppression of *Entomobrya cavicola* Banks, 1897.

R. V. MELVILLE
Secretary

PROC. BIOL. SOC. WASH.
98(4), 1985, pp. 1065–1066

# BIOLOGICAL SOCIETY OF WASHINGTON PROCEEDINGS

## 112th Annual Meeting, 30 May 1985

Dr. Donald Davis called the meeting to order at 1:02 PM and welcomed the twenty members of the Society present. Dr. Leslie Knapp, who had asked to be replaced as Treasurer of the Biological Society, announced with a palpable sense of relief that Dr. Don Wilson had been selected to fill out his term by the Council of the Society.

Dr. Knapp presented the Treasurer's report emphasizing the increased worth of the Society over the past year. He attributed the financial gains to increased page charges for the *Proceedings,* and to growing membership resulting from the recruiting efforts of Drs. Meredith Jones and Raymond Manning. Dr. David Pawson enquired whether the Society's outlay for advertisement in the Allen Press Cooperative Subscription Catalog is balanced by income from new subscription orders. Dr. Knapp responded that the catalog citation relieves the Treasurer of answering numerous inquiries regarding subscription rates and that, if desired, the need for the listing could be reexamined next year.

Following the Treasurer's presentation, Dr. Davis reported that the Council had approved expenses of up to $4,298.66 (equivalent to interest from the Society's First Variable Rate Fund account in 1984) to purchase a microcomputer and software for the Society. The equipment will be used by the Treasurer to maintain subscription and financial records and a publications inventory. Dr. Davis thanked Dr. Knapp for his unstinting efforts for the past five years as the Society's Treasurer. Members in attendance demonstrated their appreciation of Dr. Knapp's dedicated work for the Society with sustained and spirited applause.

Dr. Brian Kensley, Editor of the *Proceedings of the Biological Society of Washington,* reported that Volume 97, with a new, two-tone cover format, had been issued in four parts with a total of 972 pages. Approximately 50 pages in each part were subsidized by the Society. He noted that the average delay between manuscript acceptance and publication was 6–8 months for authors paying full page charges, and 8–12 months for manuscripts with subsidized page charges. Dr. Kensley thanked Dr. Stephen Cairns for serving as Acting Editor for extended periods during the year. He also thanked Dr. George Steyskal for his invaluable, long-standing service as editor and advisor to the *Proceedings* on nomenclatorial matters.

Dr. Davis reiterated Dr. Kensley's thanks to Stephen Cairns and George Steyskal on behalf of the Society. He described the Council's plan to sponsor a mini-course on nomenclature, to be presented in a series of lectures by Dr. Steyskal. Dr. Davis will seek financial support from the National Museum of Natural History for four or five lectures on scientific names and biological nomenclature.

Dr. Meredith Jones summarized the arrangements for publication, as *Biological Society Bulletin* Number 6, of the proceedings of the Hydrothermal Vents Symposium sponsored by the Society in December 1983. Most of the 37 manuscripts have been edited and are ready for publication. They total 918 manuscript pages, the equivalent of approximately 725 printed pages. Part of the Bulletin will be an up-to-date bibliography on hydrothermal vents with over 1000 entries. Dr. Jones anticipates that manuscripts will be sent to the publisher in July. The bulletin will be available for distribution in November, and will be sold for $30.

The Secretary announced that he would be leaving Washington for a curatorial position at the Los Angeles County Museum. He noted that the nominating committee would need to consider secretarial candidates, preferably from the Washington area, for the September ballot. Dr. Davis thanked the Secretary for his services to the Society and, there being no additional new business to discuss, the meeting was adjourned at 1:15 PM.

Respectfully submitted,
Gordon Hendler
Secretary
4 June 1985

# INFORMATION FOR CONTRIBUTORS

*Content.*—The *Proceedings* of the Biological Society of Washington contains papers bearing on systematics in the biological sciences (botany, zoology, and paleontology), and notices of business transacted at meetings of the Society. Except at the direction of the Council, only manuscripts by Society members will be accepted. Papers will be published in English (except for Latin diagnosis/description of plant taxa which should not be duplicated by an English translation), with a summary in an alternate language when appropriate.

*Publication Charges.*—Authors will be asked to assume publication costs of page-charges, tabular material, and figures, at the lowest possible rates.

*Submission of manuscripts.*—Manuscripts should be sent to the Editor, *Proceedings* of the Biological Society of Washington, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

*Review.*—One of the Society's aims is to give its members an opportunity for prompt publication of their shorter contributions. Manuscripts will be reviewed in order of receipt by a board of associate editors and appropriate referees.

*Presentation.*—Clarity of presentation, and requirements of taxonomic and nomenclatural procedures necessitate reasonable consistency in the organization of papers. Telegraphic style is recommended for descriptions. Literature should be cited in abbreviated style (author, date, page), except in botanical synonymies, with full citations of journals and books (no abbreviations) in the Literature Cited section.

The establishment of new taxa must conform with the requirements of the appropriate international codes of nomenclature. Authors are expected to be familiar with these codes and to comply with them. New species-group accounts must designate a type-specimen deposited in an institutional collection.

The sequence of material should be: Title, Author(s), Abstract, Text, Acknowledgments, Literature Cited, Author's (s') Address(es), Appendix, List of Figures (entire figure legends), Figures (each numbered and identified), Tables (each table numbered with an Arabic numeral and heading provided).

Manuscripts should be typed, double-spaced throughout (including tables, legends, and footnotes) on one side of 8½ × 11 inch sheets, with at least one inch of margin all around. Manuscripts in dot-matrix will not be accepted. Submit a facsimile with the original, and retain an author's copy. Pages must be numbered on top. One manuscript page = approximately 0.5 printed page. Underline singly scientific names of genera and lower categories; leave other indications to the editor.

Figures and tables with their legends and headings should be self-explanatory, not requiring reference to the text. Indicate their approximate placement by a pencil mark in the margin of the manuscript.

Illustrations should be planned in proportions that will efficiently use space on the type bed of the *Proceedings* (12.5 × 20 cm) and should not exceed 15 × 24 inches. Figures requiring solid black backgrounds should be indicated as such, but not masked.

Art work will be returned only on request.

*Proofs.*—Galley proofs will be submitted to authors for correction and approval. Reprint orders will be taken with returned proof.

*Costs.*—Page charges @ $60.00, figures @ $10.00, tabular material $3.00 per printed inch.

All authors are expected to pay the charges for figures, tables, changes at proof stage, and reprints. Payment of full costs will probably facilitate speedy publication.

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