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FIVE NEW PARASITIC COPEPODS FROM CALIFORNIA INSHORE FISH

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A collection of parasitic copepods sent to me by Mr. Edmund Hobson of the U. S. Bureau of Sport Fisheries and Wildlife, U. S. Department of Interior, contained a number of new species. One of these (*Caligus hobsoni* Cressey) has been reported elsewhere. This paper reports on five more, one of which constitutes a new genus of taeniacanthid. The entire collection plus additional new species will be reported on later.

All material has been deposited in the Smithsonian Institution, Division of Crustacea.

Mr. Hobson was assisted in the collecting by Mr. Lloyd D. Richards of the U. S. Bureau of Sport Fisheries and Wildlife.

Taeniastrotos new genus

Diagnosis: Bomolochiidae, Taeniacanthinae. First thoracic segment fused to head. Thoracic segments 2, 3, and 4 free. Postantennal process (maxillary hook) present. First antenna 7-segmented. Padlike process present between bases of first antenna on ventral rostral area. Second antenna, mandible, and first maxilla as in other members of the subfamily. Second maxilla with reduced terminal segment bearing 3 weak setae. Maxilliped well-developed and posterior to mouthparts. Rami of legs 1–4 3-segmented (segmentation of the rami of leg 1 incomplete). Terminal endopod segment of leg 4 without lateral spine. Leg 5 2-segmented, armed as in other members of the family. Leg 6 represented by 3 setae on the area of egg sac attachment.

The male is unknown.

Type species: *Taeniastrotos californiensis* new speices.

Etymology: From Greek, masc. The generic name is a combination of *Taeniacanthus* and *Anchistrotos*, the two genera to which the new genus seems most closely related.

Remarks: The new genus can be separated from all other genera of the Taeniacanthinae by the reduced nature of the second maxilla and the lack of a lateral spine on the last endopod segment of leg 4. This is the first record of a taeniacanthin from the eastern Pacific and it is not surprising that it would be an undescribed form when one considers the high rate of endemism in that area.

Taeniastrotos californiensis new species

Figures 1–11

Material studied: Holotype ♀ (USNM 126240), and 7 paratype ♀♀ (USNM 126241) were collected from the body surface of *Paralebrax nebulifer* (Giard) at La Jolla, California 2 October 1968.

Female: Body form as in figure 1. Total length 1.5 mm. Greatest width 0.65 mm (measured at widest part of cephalon). Cephalon comprises a little more than one-third total body length. First thoracic segment completely fused with head. Thoracic segments bearing legs 2, 3, and 4 free; each narrower than the one before. Genital segment small, only slightly longer than first abdominal segment and somewhat wider than long. Abdomen 4-segmented, 89 μ, 83 μ, 59 μ, and 83 μ in length respectively. Caudal rami (fig. 2) about three times as long as wide (94 μ × 30 μ); armed with one lateral, four terminal, and one inner subterminal setae, longest seta 519 μ in length.

First antenna (fig. 3) 7-segmented; armed with setae as in the figure, an aesthete present on the penultimate segment. A padlike process, somewhat triangular, its broadest portion projecting slightly beyond the anterior margin of the body, present between the bases of the first antennae on the ventral rostral area (see fig. 3). A heavily sclerotized postantennal process present (see fig. 3). Second antenna (fig. 4) similar to that of other species in the subfamily; bearing one short thick spine, three longer spines, and three setae at tip (longest bearing a few plumosities).

Mandible (see fig. 5) a simple bladelike appendage bearing two unequal broad spines at tip. First maxilla (see fig. 5) consisting of a small lobe bearing a long plumose seta directed posteriorly, a bladelike blunt seta directed anteriorly, and two smaller setae. Second maxilla (see fig. 5) 2-segmented; terminal segment small, bearing three weak setae. Maxilliped (fig. 6) basal segment unarmed, terminal segment in form of a stout claw.

Legs 1–4 biramose. Leg 1 (fig. 7) exopod with plumose setae on the outer distal corners of each of the first two segments; terminal segment with two weak and five well-developed setae: endopod segmentation in-

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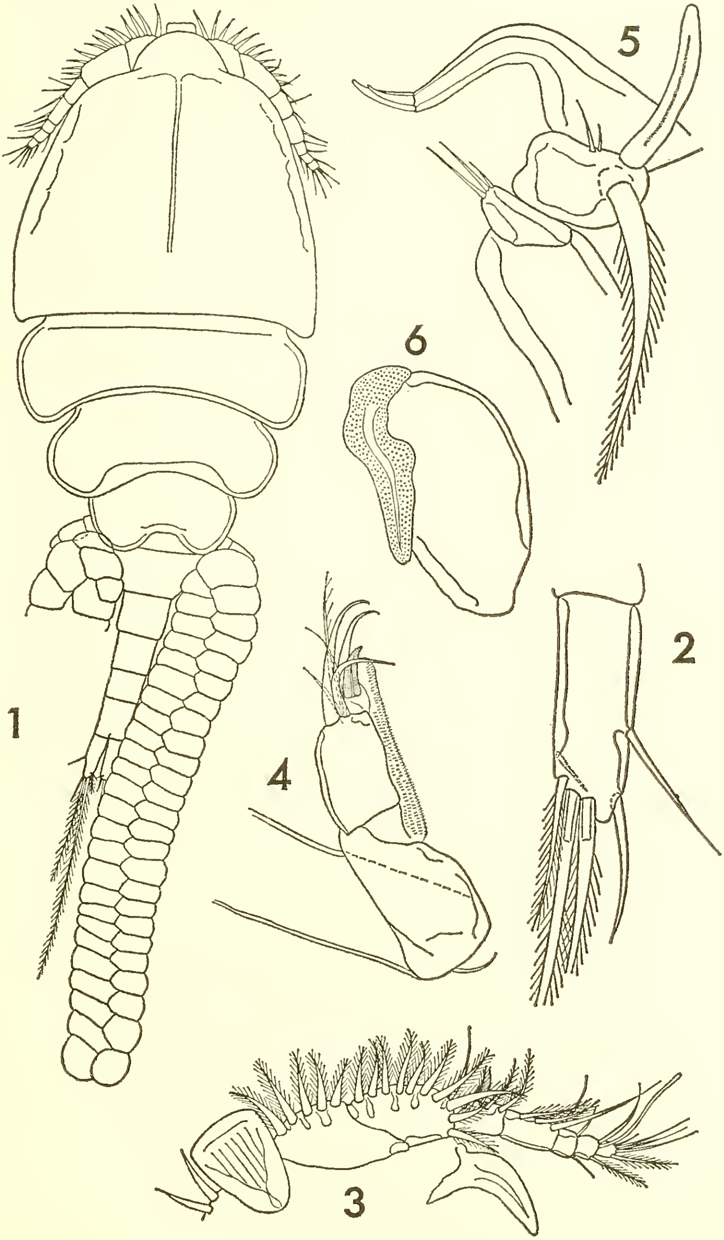
FIGS. 1–6. *Taeniastrotos californiensis* n. gen., n. sp. female: 1, dorsal; 2, caudal ramus, ventral; 3, first antenna; 4, second antenna; 5, mouthparts; 6, maxilliped.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complete but ramus bearing eight well-developed setae. Leg 2 (fig. 8) exopod spines on outer distal corners of first two segments plus first spine on last segment with conspicuously serrate edges; endopod second segment with spinelike process on outer distal corner, last segment distalmost spine finely plumose and sclerotized on basal half but distal half hyaline and naked. Basipod of leg 2 with two comblike rows of spines. Leg 3 (fig. 9) similar to leg 2 but with only one row of comblike spines on basipod, and additional serrate spine on last exopod segment, and terminal spine on last exopod segment normal. Leg 4 (fig. 10) exopod with serrate spines on all three segments, otherwise armed as in the figure; endopod last segment with a short terminal spine on outer distal corner and a long seta on inner distal corner, no lateral spine. Leg 5 (fig. 11) 2-segmented; basal segment with a long plumose seta and a row of spinules on outer distal corner; last segment with an outer lateral spine and an inner and outer spine terminally separated by a slightly longer seta, a small patch of spinules is present near the base of the inner spine. Leg 6 represented by two long setae on the midlateral margins of the genital segment at the area of egg sac attachment.

Egg sacs long (1.1 mm) and containing about 100 eggs arranged in two rows.

Male: Unknown.

Remarks: The species is named for the type locality (California). *Anchistrotos pleuronichthydis* Yamaguti 1939 has a first maxilla with the blunt anteriorly directed seta as in the new species described here. However, it differs from *californiensis* on other points and may represent a form intermediate between the new genus described here an *Anchistrotos.*

Bomolochus longicaudus new species

Figures 12–22

Material studied: Holotype ♀ (USNM 126242), a single ♀ paratype (USNM 126243) was collected from the gill cavity of *Paralebrax nebulifer* (Giard) 8 August 1968, and additional material from the same host (1 ♀ 6 August 1968, 3 ♀♀ 1 October 1968, and 1 ♀ 2 October 1968). An additional female was collected from the gill cavity of *Paralebrax clathratus* (Giard) 10 October 1968. All material was collected at La Jolla, California.

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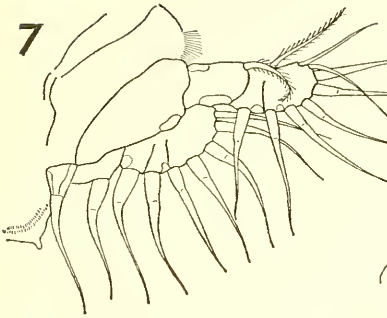
Figs. 7–11. *Taeniastrotos californiensis* n. gen., n. sp., female (cont.): 7, first leg; 8, second leg; 9, third leg; 10, fourth leg; 11, fifth leg.

Figs. 12–16. *Bomolochus longicaudus* n. sp., female: 12, dorsal; 13, caudal rami, ventral; 14, first antenna; 15, second antenna; 16, mouthparts.

Figs. 17–20. *Bomolochus longicaudus* n. sp., female (cont.): 17, maxilliped; 18, first leg; 19, second leg; 20, third leg.



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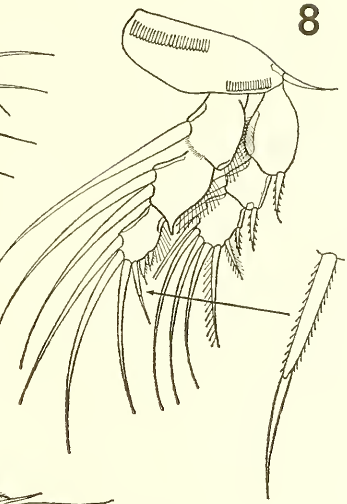

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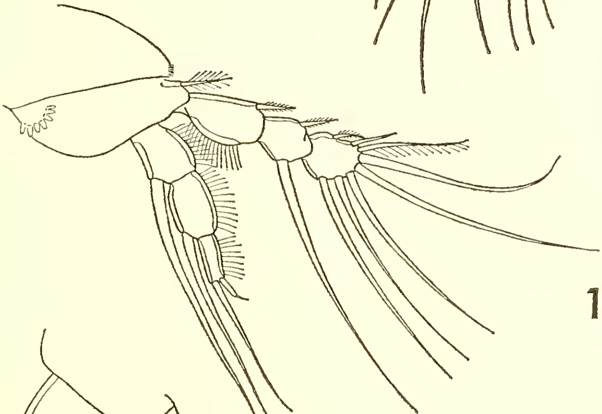

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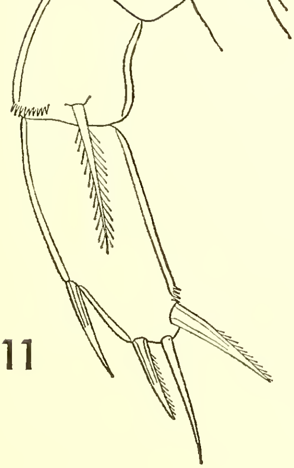

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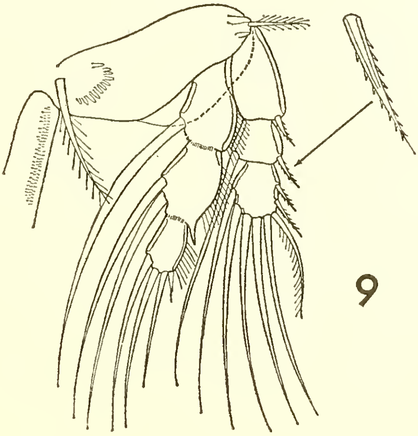

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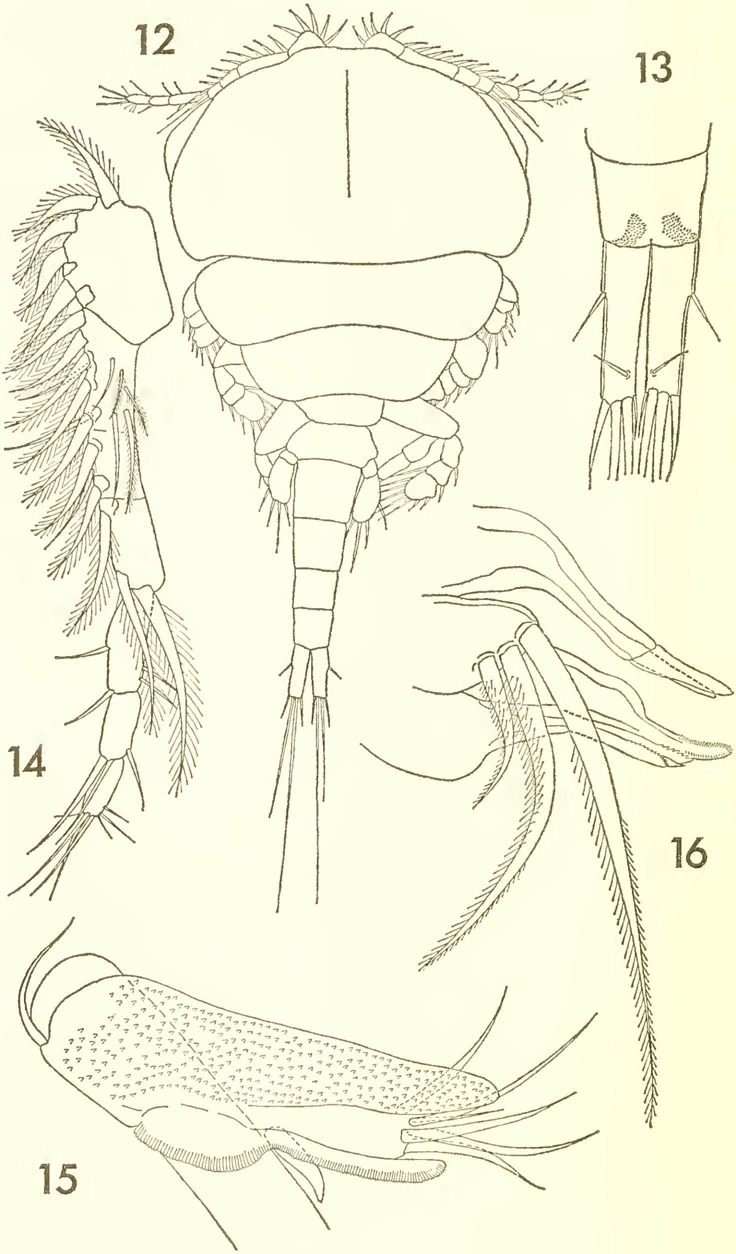
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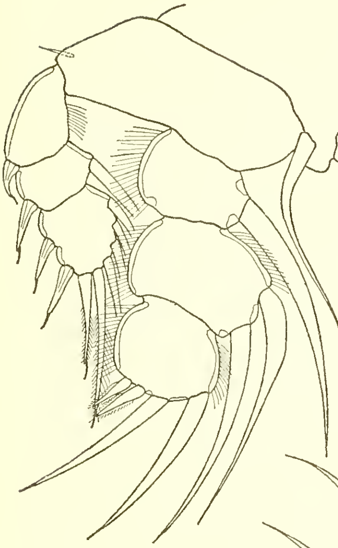

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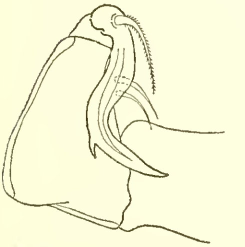

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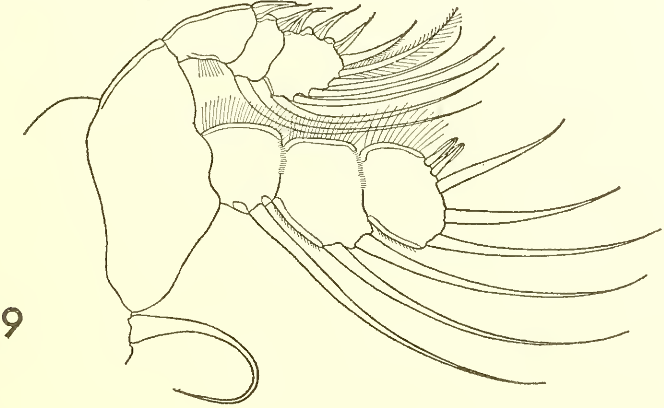

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Female: Body form as in figure 12. Total length 2.03 mm. Greatest width 1.01 mm (measured at widest part of cephalon). Cephalon comprises about one-third total body length. First thoracic segment fused with head. Thoracic segments bearing legs 2–4 free. Genital segment about as wide as long (approx. 200 μ). Abdomen 3-segmented; 147 μ, 136 μ, and 124 μ in length respectively, second and third segments each slightly narrower than preceding one, last segment with two patches of spinules ventrally. Caudal rami (fig. 13) about three times as long as wide (162 $\mu \times$ 50 μ); each ramus with four terminal, one subterminal, and one lateral setae, longest seta 600 μ long.

First antenna (fig. 14) with five distinct segments, second segment weakly subdivided making the actual number of segments difficult to ascertain; each segment armed with setae as in the figure. Second antenna (fig. 15) basically as in other members of the genus, spinules on surface not arranged in definite rows. Mouthparts as in other members of the genus except first maxilla (see fig. 16); first maxilla with very long inner seta, reaching nearly to the base of first legs. Maxilliped (fig. 17) terminal claw with accessory spine.

Legs 1–4 biramose. Leg 1 (fig. 18) exopod segmentation incomplete, two weak spines present on outer margin of ramus and six terminal to inner setae; endopod 3-segmented, first two segments with an inner seta on each and last segment with five terminal setae. Leg 2 (fig. 19) exopod outer five spines on ramus without fringes or hairs, terminal spine with fine hairs along inner margin; exopod last segment with two short outer spines each with a hyaline fringe, both rami with additional setae as in the figure. Leg 3 (fig. 20) similar to leg 2 except for a reduction in the number of spines and setae. Leg 4 (fig. 21) exopod similar to legs 2 and 3; endopod first two segments each with a short seta on inner distal corner, last segment with an inner and an outer short spine and a short terminal seta between. Leg 5 (fig. 22) 2-segmented; basal segment wtih a patch of spatulate spinules on distal third, last segment armed as in other members of the genus except for patches of spatulate spinules as shown in the figure. Leg 6 represented by three long setae at the point of egg sac attachment.

None of the material was ovigerous.

Male: Unknown.

Remarks: This species may be separated from all other species of the genus, except the following new species, by the nature of the first maxilla with its exceptionally long inner seta. *B. longicaudus* can be easily separated from the following new species on the basis of characters to be discussed following the description of this second species of *Bomolochus*.

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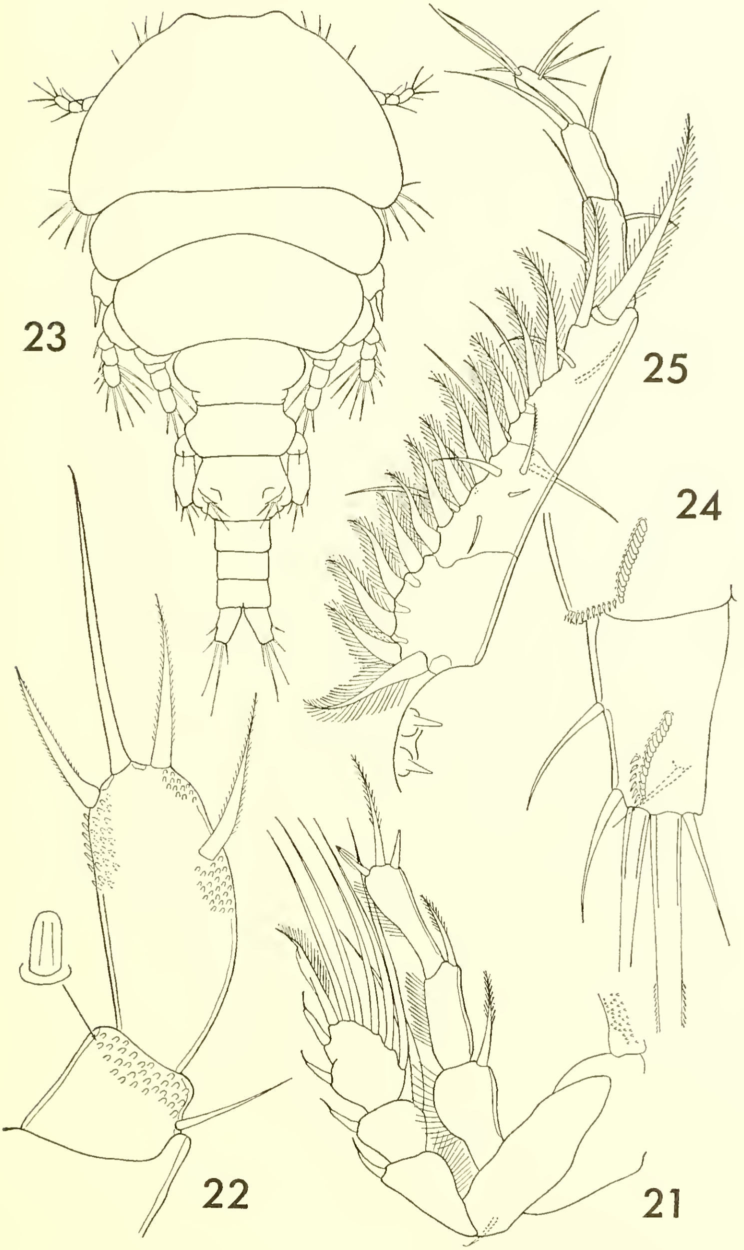
Figs. 21–25. *Bomolochus longicaudus* n. sp., female (cont.): 21, fourth leg; 22, fifth leg. *Bomolochus prolixus* n. sp., female: 23, dorsal; 24, caudal ramus, ventral; 25, first antenna.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Bomolochus prolixus new species

Figures 23–32

Material studied: Holotype ♀ (USNM 126244), 4 paratype ♀♀ (USNM 126245) were collected from the gill cavity of *Pleuronichthys coenosus* Giard, and additional material from the same host (1 ♀ 12 July 1968, 1 ♀ 6 August 1968, 2 ♀♀ 6 August 1968, 1 ♀ 16 October 1968, and 1 ♀ 15 January 1969). All material was collected at La Jolla, California.

Female: Body form as in figure 23. Total length 1.6 mm. Greatest width 0.58 mm (measured at widest part of cephalon). Cephalon comprises about one-fourth total body length. First thoracic segment fused with head. Thoracic segments bearing legs 2–4 free. Genital segment wider than long (132 μ × 103 μ). Abdomen 3-segmented; 118 μ, 94 μ, and 118 μ in length respectively, second and third segments each slightly narrower than preceding one. Caudal rami (fig. 24) longer than wide (100 μ × 65 μ); bearing setae as in the previous species and two rows of spinules, spinules of the outer row of the usual pointed nature but the inner row spinules are spatulate (similar rows occur on the last abdominal segment).

First antenna (fig. 25) similar to *B. longicaudus*, second, third and fourth segments weakly articulated giving the appearance of a long second segment. Second antenna (fig. 26) also similar to preceding species but spinules on surface arranged in definite rows. Mouthparts as in *B. longicaudus*. Maxilliped (fig. 27) terminal hook with accessory process.

Legs 1–4 biramose. Leg 1 (fig. 28) exopod 3-segmented and clearly articulated; outer spine on first segment somewhat recurved with heavy fringe on outer edge and attenuated at tip, spine on second segment and first two spines on last segment with sclerotized basal half, a hyaline distal portion and a small discrete tip giving whole spine the appearance of being composed of three parts: endopod as in *B. longicaudus*. Leg 2 (fig. 29) as in *B. longicaudus* except terminalmost spines on exopod with an outer hyaline fringe. Leg 3 (fig. 30) as in *B. longicaudus* except for patch of spinules on basipod and other minor variations in armature as indicated by the figure. Leg 4 (fig. 31) armed as in *B. longicaudus* but endopod segments not elongated as in *longicaudus*. Leg 5 (fig. 32) 2-segmented; first segment with large patch of spinules on outer distal corner, second segment with usual lateral seta and three terminal spines or setae, inner and outer spines pinched at distal third, terminal and outer borders with spinules as in the figure. Leg 6 represented by three long setae at area of egg sac attachment.

None of the material was ovigerous.

Male: Unknown.

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FIGS. 26–30. *Bomolochus prolixus* n. sp., female (cont.): 26, second antenna; 27, maxilliped; 28, exopod of first leg; 29, second leg; 30, third leg.

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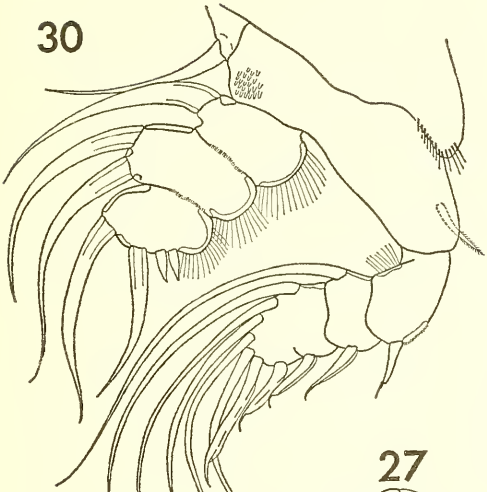

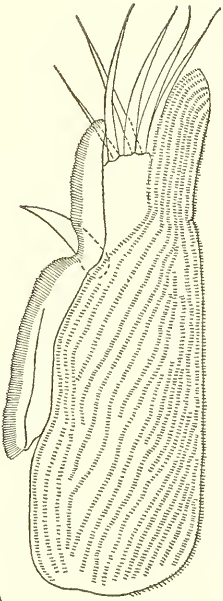

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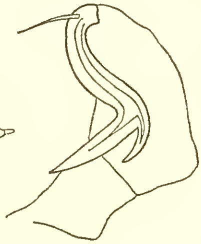

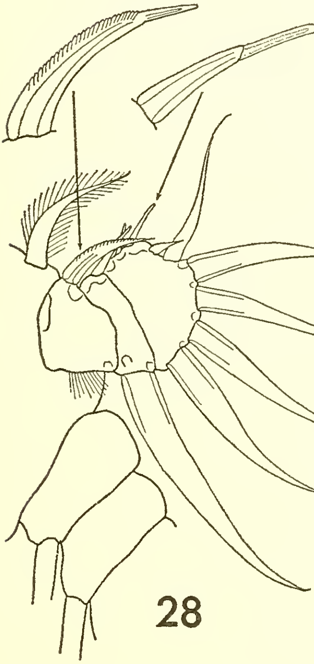

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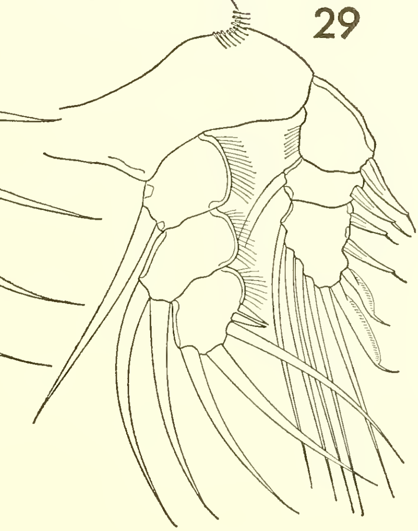

Remarks: This species, like *B. longicaudus*, can be separated from all other species of the genus on the basis of the first maxilla. It can be separated from *longicaudus* by the nature of the caudal rami, the distinct rows of spinules on the second antenna, the nature of the fourth leg endopod, and the many other variations in the armature of the legs.

Bomolochus spinulus new species

Figures 33–45

Material studied: Holotype ♀ (USNM 126246) and 43 paratype ♀♀ (126247) from the gill cavity of *Scorpaena guttata* Giard collected at La Jolla, California, 10 October 1968. Other material from the same host (2 ♀♀ 12 July 1968, 1 ♀ 14 October 1968, 39 ♀♀ 15 October 1968, 5 ♀♀ 16 October 1968, and 29 ♀♀ 16 October 1968) from *Oxylebius pictus* Gill (1 ♀ 9 December 1968) from *Sebastodes mystinus* (Jordan and Gilbert) (3 ♀♀ 24 September 1968 and 1 ♀ 14 October 1968) and from *Sebastodes serranoides* Eigenmann and Eigenmann (8 ♀♀ 12 September 1968 and 1 ♀ 12 September 1968). All other material collected at La Jolla, California.

Female: Body form as in figure 33. Total length 1.49 mm. Greatest width 0.87 mm (measured at widest part of cephalon). Cephalon slightly less than one-third body length. Thoracic segments bearing legs 2–4 free. Thoracic segment bearing leg 4 small and scarcely visible dorsally. Genital segment about as wide as long (200 μ). Abdomen 3-segmented, 224 μ, 200 μ, and 112 μ long respectively. Caudal rami about twice as long as wide (142 $\mu \times 60 \mu$); longest seta 768 μ long, patch of spinules on ventral distal surface (comparable patch on last abdominal segment also).

First antenna (fig. 35) armed as in the figure, an aesthete present on penultimate segment; segmentation weak giving the appearance of 5 segments. Second antenna (fig. 36) generally as in other members of the genus except claw at base of last segment well-developed and in the form of a hook. Mandible (fig. 37) bladelike with two fringed processes at tip. Labrum with two lateral patches of spinules on posterior corners. First maxilla of usual form with two inner long setae and two outer short ones.

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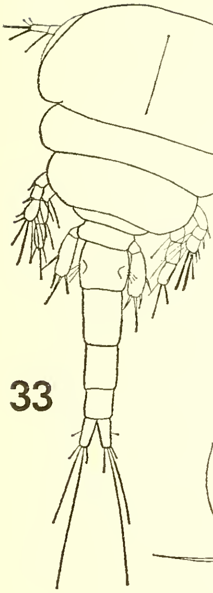
Figs. 31–37. *Bomolochus prolixus* n. sp., female (cont.): 31, fourth leg; 32, fifth leg. *Bomolochus spinulus* n. sp., female: 33, dorsal; 34, caudal ramus; 35, first antenna; 36, second antenna; 37, mandible.

Figs. 38–44. *Bomolochus spinulus* n. sp., female (cont.): 38, paragnath; 39, first maxilla; 40, maxilliped hook; 41, first leg; 42, second leg; 43, third leg; 44, fourth leg.

Figs. 45–52. *Bomolochus spinulus* n. sp., female (cont.): 45, fifth leg. *Lepeophtheirus paulus* n. sp., female: 46, dorsal; 47, abdomen and caudal rami, ventral; 48, first antenna; 49, postantennal process; 50, second antenna; 51, postoral process; 52, maxilliped.



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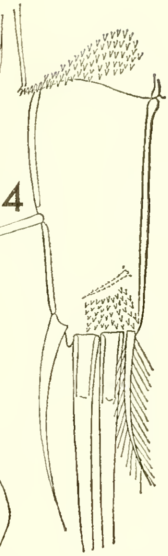

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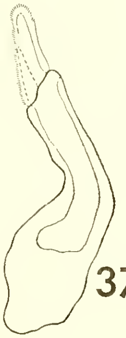

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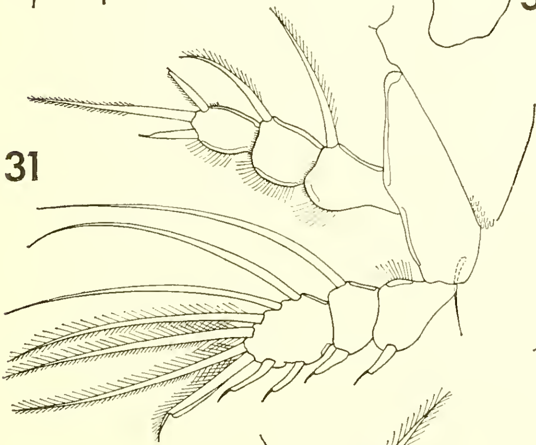

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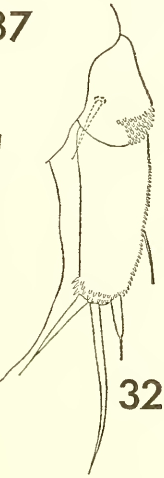

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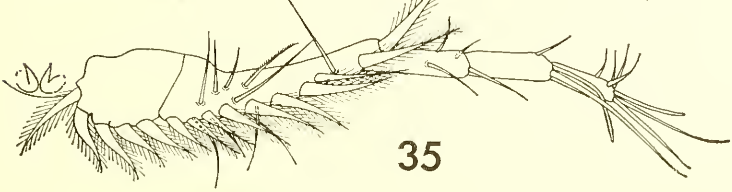

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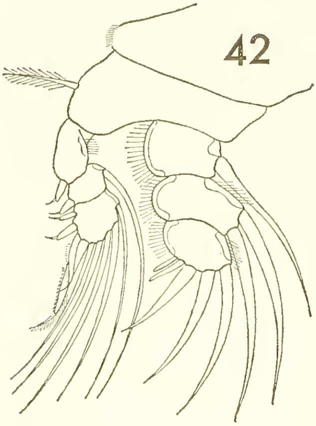
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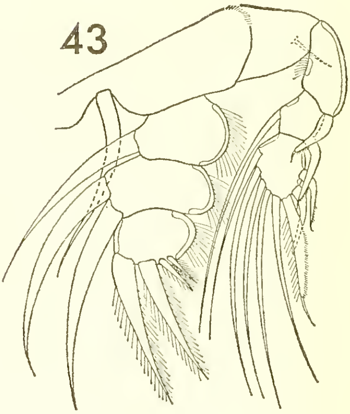
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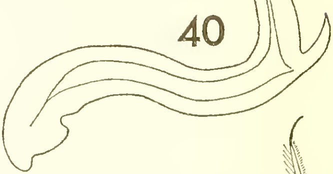
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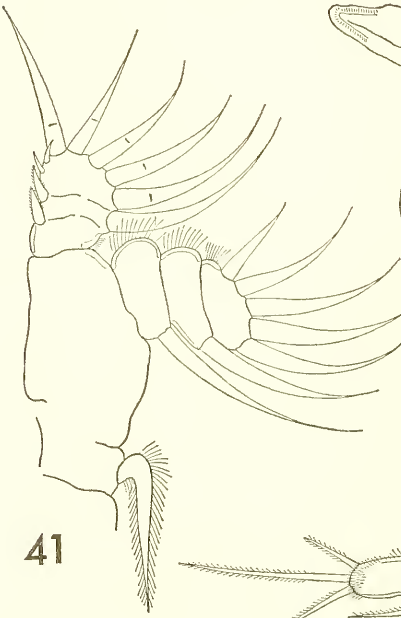
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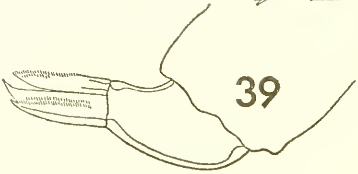
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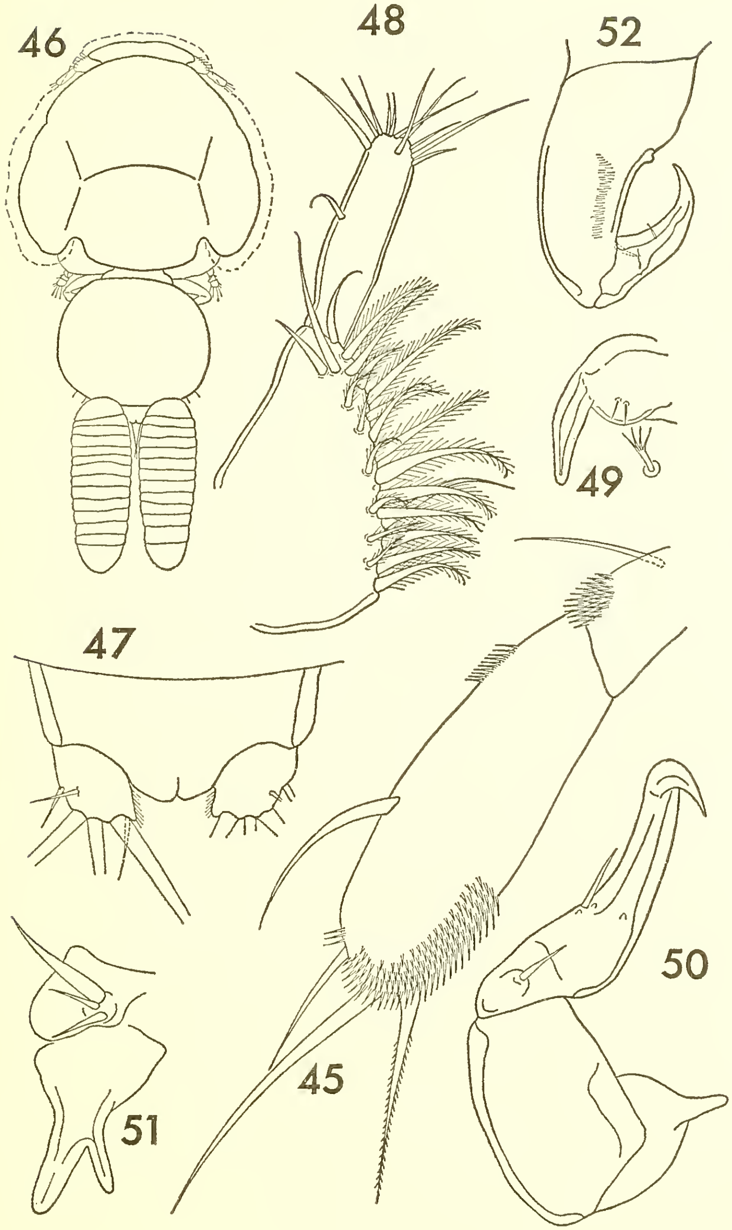
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Paragnath in the form of a lobe with a patch of spinules and a striated tip (fig. 38). First maxilla (fig. 39) as in other members of the genus. Maxilliped hook (fig. 40) S-shaped and with an accessory process.

Legs 1–4 biramose. Leg 1 (fig. 41) both rami clearly 3-segmented, rami armed as in the figure. Leg 2 (fig. 42) exopod last segment two terminalmost spines with spinose fringe, penultimate spine somewhat overlapping ultimate spine: otherwise armed in the usual manner. Leg 3 (fig. 43) exopod spines on first two segments angular in shape and recurved inwardly, first two spines on last segment similar in nature but not as conspicuously recurved. Leg 4 (fig. 44) similar to other members of the genus except for prominent patches of spinules on outer distal corners of endopod segments. Leg 5 (fig. 45) 2-segmented and armed in usual manner, patches of spinules on both segments as in the figure. Leg 6 represented by three setae at the area of egg sac attachment.

Egg sac containing approximately 100 eggs and about 0.95 mm long.

Male: Unknown.

Remarks: This new species can be distinguished from all other species of *Bomolochus* except *B. attenuatus* Wilson 1913 by the nature and position of the outer spines on the exopod of leg 3. *Bomolochus spinulus* is closely related to *B. attenuatus.* The nature of the outer spines on leg 3 is the same in both species. Both species have patches of spinules on the endopod of leg 4 plus a patch of spinules on the ventral posterior surface of the caudal rami. They can be separated based on the following differences: the hooklike spine on the second antenna of *attenuatus* extends to the tip of the terminal setae whereas that of *spinulus* is only half the length, the last abdominal segment of *attenuatus* bears a row of spinules on the posterior ventral surface as opposed to a patch of spinules in the same area on *spinulus.* The holotype of *B. attenuatus* was examined for this comparison. *Bomolochus attenuatus* was described from *Scorpaena plumieri* from Jamaica.

Lepeophtheirus paulus new species

Figures 46–61

Material studied: Holotype ♀ (USNM 126248), allotype ♀ (USNM 126249), and 4 paratypes (USNM 126250, 3 ♀ ♀, 1 ♂) were collected from the roof of the mouth of *Sebastodes serriceps* (Jordan and Gilbert) at La Jolla, California 22 July 1968. Additional material was collected from the same species of host and at the same locality (1 ♀, 4 ♀ ♀ 1 ♂, 1 ♀ 19 July 1968; 2 ♀ ♀ 1 ♂ 22 July 1968; 2 ♀ ♀, 3 ♀ ♀ 26 July 1968; 20 ♀ ♀ 30 September 1968; 6 ♀ ♀ 10 October 1968).

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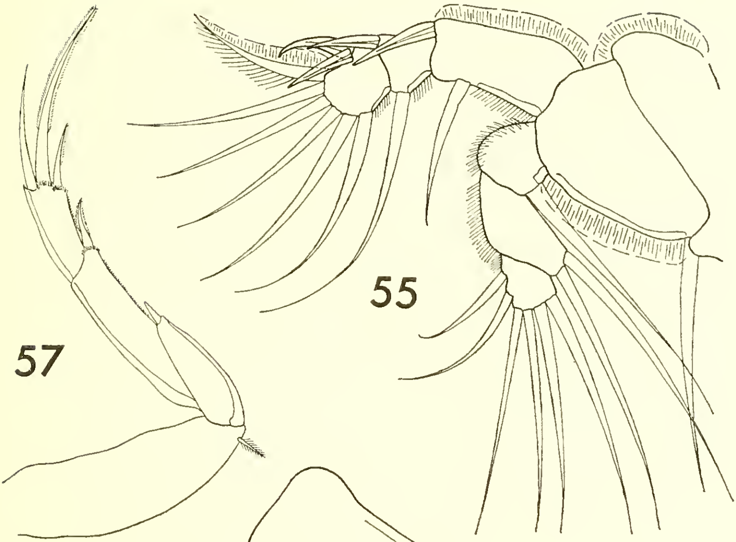
FIGS. 53–58. *Lepeophtheirus paulus* n. sp., female (cont.): 53, sternal furca; 54, first leg; 55, second leg; 56, third leg; 57, fourth leg; 58, fifth leg.



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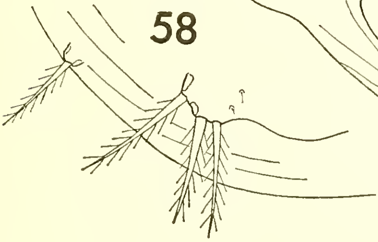

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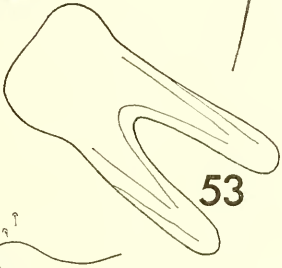

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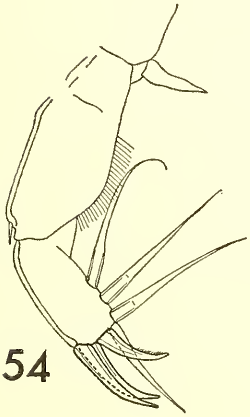

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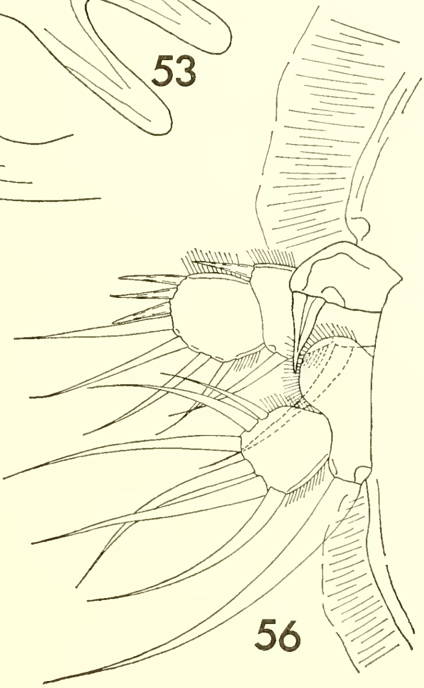

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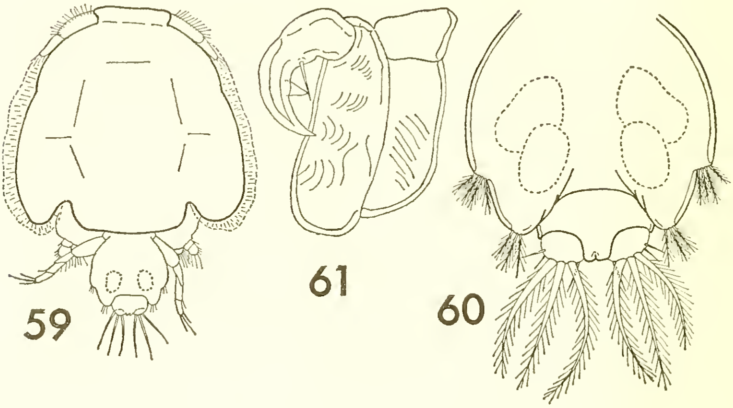

Figs. 59–61. *Lepeophtheirus paulus* n. sp., male: 59, dorsal; 60, genital segment, abdomen, and caudal rami; 61, second antenna.

Female: Body form as in figure 46. Total length 1.3 mm. Greatest width 1.3 mm (measured at widest part of cephalon). Five specimens measured for length and width all measured the same as above. Cephalon comprising about one-half total body length. Genital segment nearly round, slightly wider than long (1.2 × 1.0 mm). Abdomen (see fig. 47) short (159 μ) and 1-segmented. Caudal rami (see fig. 47) short and about as wide as long, bearing one lateral, 2 subterminal, and three terminal plumose setae, longest seta 336 μ long.

First antenna (fig. 48) 2-segmented and armed as in the figure. Postantennal process (fig. 49) with single outer hooklike process, 2 sensory hairs on base and a sensory hair with terminus split into four hairs located near base. Second antenna (fig. 50) with well-developed hook bearing two setae. Mandible as in other members of genus bearing 12 teeth. First maxilla (fig. 51) a simple lobe bearing three setae. Second maxilla as in other members of the genus. Postoral process (see fig. 51) bifurcate, outer tine larger than inner. Maxilliped (fig. 52) hooklike, a rugose area present on surface of basal segment. Sternal furca (fig. 53) with rounded tines.

Legs 1–3 biramose. Leg 1 (fig. 54) exopod with three terminal spines and four terminal to inner setae, endopod a simple, weakly developed process near base of exopod. Leg 2 (fig. 55) rami 3-segmented; exopod segments with a total of four well-developed spines on outer margins and spines oriented along same axis as ramus, endopod with setae as in the figure. Leg 3 (fig. 56) exopod basal segment with a well-developed spine oriented so as to lie over the following segment, endopod 2-segmented and both rami armed with setae as in the figure. Leg 4 (fig. 57) last segment with three terminal setae, median seta longest. Leg 5 (fig. 58) located at posterior corners of the genital segment and consisting of an anterior lobe bearing a single seta and a posterior lobe bearing three setae of about equal length. Leg 6 absent.

Egg sac short (1.45 mm) and bearing about 12–15 eggs each.

Male: Body form as in figure 59. Total length and width of three specimens 1.4 × 0.85 mm, 1.5 × 0.98 mm, and 1.4 × 0.82 mm. Cephalon comprising about three-fourths total body length. Genital segment wider than long (442 μ × 384 μ). Abdomen (fig. 60) 1-segmented and short (106 μ). Caudal rami armed as in the female. Appendages as in the female except second antenna (fig. 61) with rugose patches on basal segments and accessory tooth on claw. Leg 6 represented by three plumose setae near junction of genital segment and abdomen.

Remarks: This new species can be separated from all other species of *Lepeophtheirus* by the nature of the fourth leg. In *L. paulus* the middle seta is longer than either of the other two. Typically the outer seta is longest or at least as long as the middle. In other respects this species is most closely related to *L. elegans* Gussev 1951.

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THE GENERA *STHENELANELLA* MOORE AND *EULEANIRA* HORST (POLYCHAETA, SIGALIONIDAE)

By Marian H. Pettibone
Smithsonian Institution, Washington, D.C.

In connection with a review of the genera in the polychaete family Sigalionidae, it was determined that *Euleanira* Horst (1916) should be referred to *Sthenelanella* Moore (1910). Four species have heretofore been referred to the two genera. They include the following:

Sthenelanella Moore, 1910: S. *uniformis* Moore, 1910. California.
S. *atypica* Berkeley and Berkeley, 1941. Southern California. Referred to S. *uniformis* (see below).
S. *polymorpha* Hartmann-Schröder, 1962. Chile. Not *Sthenelanella* (see page 437).
Euleanira Horst, 1916: *E. ehlersi* Horst, 1916. Dutch East Indies. Referred to *Sthenelanella* (see below).

Type-specimens of S. *uniformis* and S. *atypica*, deposited in the Smithsonian Institution (USNM), *E. ehlersi*, deposited in the Zoological Museum Amsterdam (ZMA) and Rijksmuseum Natural History Leiden (RNHL), were re-examined.

This study was aided in part by a grant from the National Science Foundation (GB-1269). For the loan of type-specimens, I wish to extend thanks to S. van der Spoel of the Zoological Museum Amsterdam and to J. van der Land of the Rijksmuseum Natural History Leiden. The manuscript benefited from the suggestions of M. L. Jones and J. L. Barnard, both of the Smithsonian Institution.

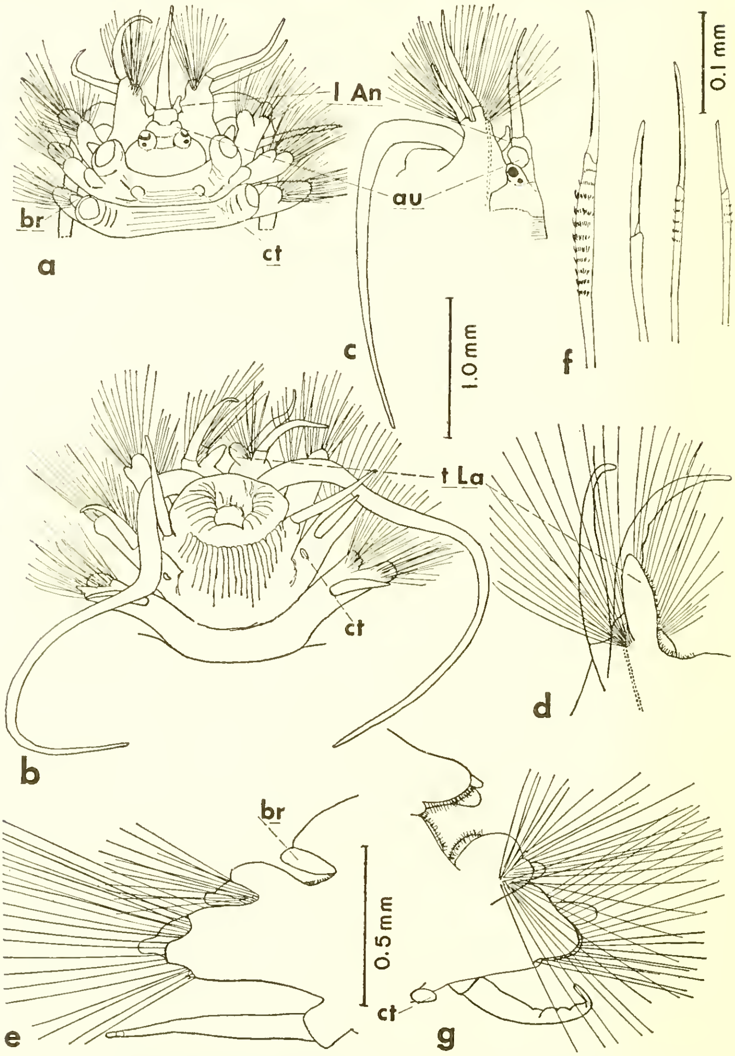

FIG. 1. *Sthenelanella uniformis* (Syntypes of S. *atypica*, USNM 32849): a, Anterior end, dorsal view, elytra on segments II and IV removed; pharynx partially extended causing tentacular parapodia to be spread apart; posterior part of prostomium hidden by segment II; b, anterior end, ventral view; c, prostomium and tentacular parapodium, lateral view; d, tentacular parapodium, inner view, showing tentacular lamella; e, parapodium from segment II, posterior view; f, neurosetae from same; g, parapodium from segment III, anterior view. (au, auricle; br, branchia; ct, ctenidia; l An, lateral antenna; t La, tentacular lamella).

FAMILY SIGALIONIDAE

Genus *Sthenelanella* Moore, 1910

Type-species: *S. uniformis* Moore, 1910, by monotypy. Gender: feminine Synonym: *Euleanira* Horst, 1916. Type-species: *E. ehlersi* Horst, 1916, by monotypy. Gender: feminine.

Diagnosis: Body slender, depressed, with segments up to 75. Elytra numerous pairs, arranged on segments 2, 4, 5, 7, then alternate segments to 25 or 27, then continuing on all segments to end of body. Branchiae short, conical, lateral to dorsal tubercles or elytrophores from segment II on. Without dorsal cirri. Prostomium rounded, fused with tentacular segment (I); ceratophore of median antenna with lateral auricles and short style; lateral antennae very short, fused to tentacular parapodia; palps long, slender, tapered, emerging lateral to tentacular parapodia, without palpal sheaths; 2 pairs eyes on raised ocular areas lateral to ceratophore of median antenna; tentacular parapodia uniramous, extending anteriorly medial to palps, each with single aciculum, 2 tentacular cirri, well-developed fan-shaped bundles of capillary setae, and medial tentacular lamella. Parapodia of segments II-IV directed anteriorly; buccal segment (II) with ventral buccal cirri longer than following ventral cirri. Parapodia biramous, with rami closely united, with notopodial ctenidia; without parapodial stylodes. Notopodia with conical acicular lobes and inflated rounded upper lobes; notosetae simple, capillary, spinous; beginning about segment 16, additional long threadlike notosetae formed from notopodial spinning glands. Neuropodia with rounded presetal and postsetal lobes. Neurosetae forming vertical bundles, all compound, with blades short, sickle- and rod-shaped; blades of neuropodia II-IV longer; some with spinous stems. Ventral cirri slender, tapered and subulate. Pharynx with 13 or more pairs distal papillae and 2 pairs interlocking teeth. Occupy long, tough, fibrous tubes.

Sthenelanella uniformis Moore

Figures 1–3

Sthenelanella uniformis Moore, 1910, p. 391, pl. 33, figs. 105–112.—Hartman, 1939, p. 69, pl. 18, figs. 226–231; 1961, p. 54; 1968, p. 169, figs. 1–6.

Sthenelanella atypica Berkeley and Berkeley, 1941, p. 26, pl. 5, figs. 1–3.

Stenelanella [sic] *uniformis*.—Reish, 1968, p. 72.

Material examined: CALIFORNIA, *Albatross* in 1904 (exact locality unknown)—Holotype *S. uniformis* (USNM 17385). SOUTHERN CALIFORNIA, G. E. MacGinitie, collector, off Corona del Mar, 22–31 meters; off Balboa—34 Syntypes *S. atypica* (USNM 3248–32850).

Description: As in generic diagnosis. Length up to 26 mm, width 2–3 mm, including parapodia, and 3–4 mm, including setae; segments up to 70. Elytra delicate, transparent, on all segments from segment 27 on; first elytral pair round, with fringe of short, crowded papillae on anterior margin; rest of elytra subreniform to oval, smooth or with scattered sensory

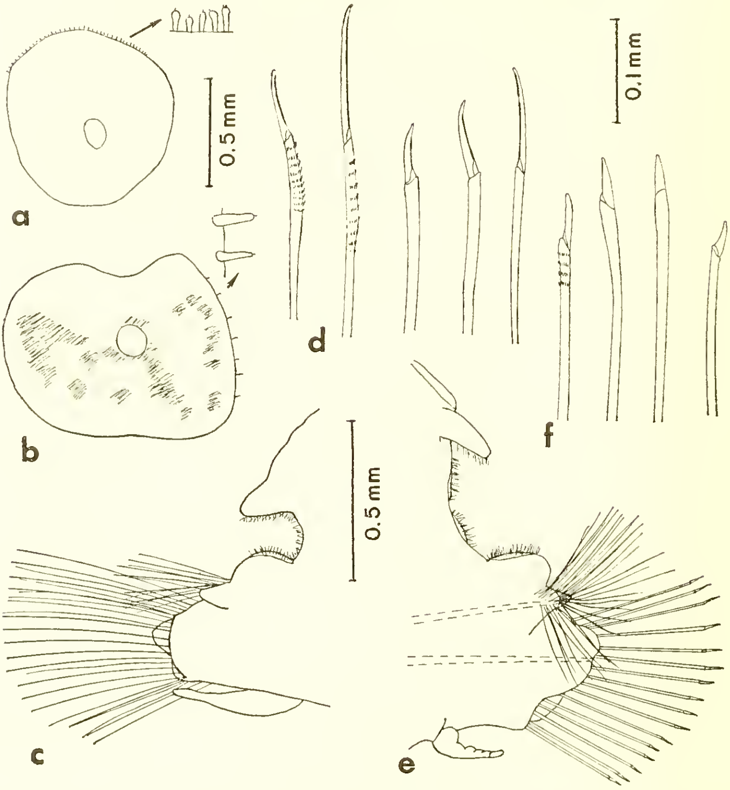

FIG. 2. *Sthenelanella uniformis* (Syntypes of *S. atypica*, USNM 32849): a, First elytron; b, anterior elytron; c, parapodium from segment IV, posterior view; d, neurosetae from same; e, parapodium from anterior region (segment 13), anterior view; f, neurosetae from same.

papillae on lateral margin; anterior elytra with rust-colored mottled pigmentation (fig. 2a, b). Prostomium with posterior part hidden dorsally by segment II, with ceratophore of median antenna equipped with lateral auricles in middle of ceratophore; inflated ocular areas lateral to base of ceratophore with 2 pairs of eyes, the anterior pair larger than posterior pair; upper tentacular cirri subequal in length to median antenna; lower tentacular cirri shorter, subequal in length to ventral buccal cirri of segment II; lateral antennae short, subulate, on inner dorsal bases of tentacular parapodia; capillary setae finely spinous and smooth; ciliated elongate-conical tentacular lamellae medial to setal bundles (fig. 1a-d). Neurosetae of segments II-IV with distal stems with variable number spinous rows; blades elongate, slender, slightly hooked, with walls ir-

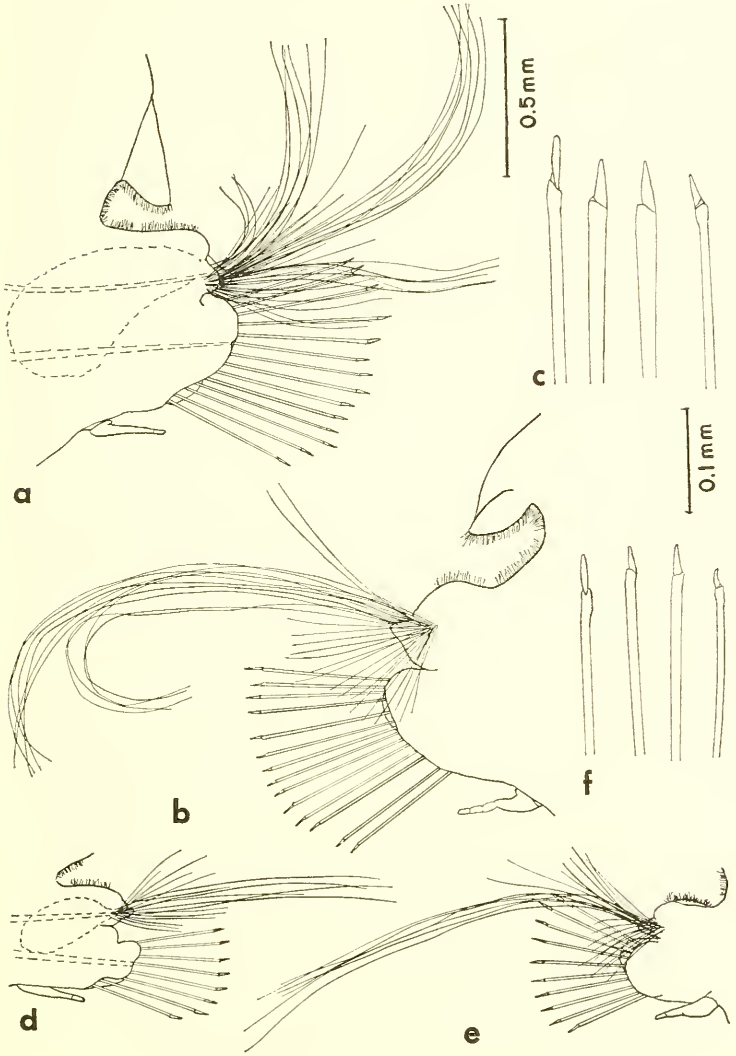

FIG. 3. *Sthenelanella uniformis* (Syntypes of S. *atypica*, USNM 32849): a, Middle parapodium, anterior view; position of notopodial spinning gland dotted in; b, middle parapodium, posterior view; c, neurosetae from same; d, posterior parapodium, anterior view; e, posterior parapodium, posterior view; f, neurosetae from same.

regularly thickened on inner sides (figs. 1f, 2d); segment III encroached upon by segments II and IV, without dorsal cirri but with conical dorsal tubercles and small branchiae; pair of small knobs or ctenidia dorsally, medial to dorsal tubercles between sements II and III; additional pair of ctenidia ventrally on segment III (fig. 1a, b, g).

Notopodia of parapodia forming conical acicular lobes and inflated rounded upper lobes with ciliated ctenidia; two additional ctenidia between notopodia and branchiae (figs. 2,e,f; 3a-f). Notosetae capillary, coarsely spinous, forming loose spreading bundles. Beginning on about segment 14, notopodia provided with large oval spinning glands from which slender threads emerge, extending far beyond the parapodia and eventually becoming incorporated in their fibrous tough tubes. Neuropodia diagonally truncate, with subequal rounded presetal and postsetal lobes; presetal lobes with slight acicular notch. Neurosetae with blades short; upper blades rod-shaped, rest conical, pointed. Ventral cirri short, subulate, with bulbous area on upper basal part and with terminal joint. Pharynx with 2 pairs chitinous teeth and 13 or more pairs papillae (13 + 13; 14 + 15; 13 + 15). Tubes much longer than worms, branched, with walls thick, tough, felted, covered with mud or sand (fig. 6, in Hartman, 1968).

Distribution: Southern California, Gulf of California to Ecuador. Littoral to 73 meters, in silty, sandy, and muddy bottoms.

Remarks: The feltage notosetae and spinning glands were overlooked by Moore (1910), but were observed by Hartman (1939) and the Berkeleys (1941). Hartman (1961) questionably referred *Sthenelanella atypica* to S. *uniformis*. The species is very common at shelf and slope depths off southern California (Hartman, 1961).

Sthenelanella ehlersi (Horst), new combination

Figures 4, 5

Euleanira ehlersi Horst, 1916, p. 12, figs. 1, 2; 1917, p. 122, pl. 27, figs. 1–5.—Day, 1967, p. 101.

Material examined: *Siboga* station 2, Madura Strait, Dutch East Indies, 7° 25′ S, 113° 16′ E, 56 meters—2 Syntypes (ZMA 218); 1 Syntype (RNHL 1190).

Description: As in generic diagnosis. Length up to 25 mm, width 2.5 mm, including parapodia, and 3.5 mm, including setae; segments up to 75. Elytra delicate, transparent, on all segments from 25 on; first elytral pair round, with few scattered sensory papillae on outer border; rest of elytra subreniform to deeply sinuous on external border; anterior elytra with transverse bands of brown pigment (fig. 4a,g,h). Prostomium with ceratophore of median antenna equipped with lateral auricles on middle of ceratophore; inflated ocular areas lateral to base of ceratophore with 2 pairs of eyes, the anterior pair larger than posterior pair; median antenna and upper and lower tentacular cirri subequal in length; lateral antennae short, digitiform, on inner dorsal bases of tentacular parapodia and addi-

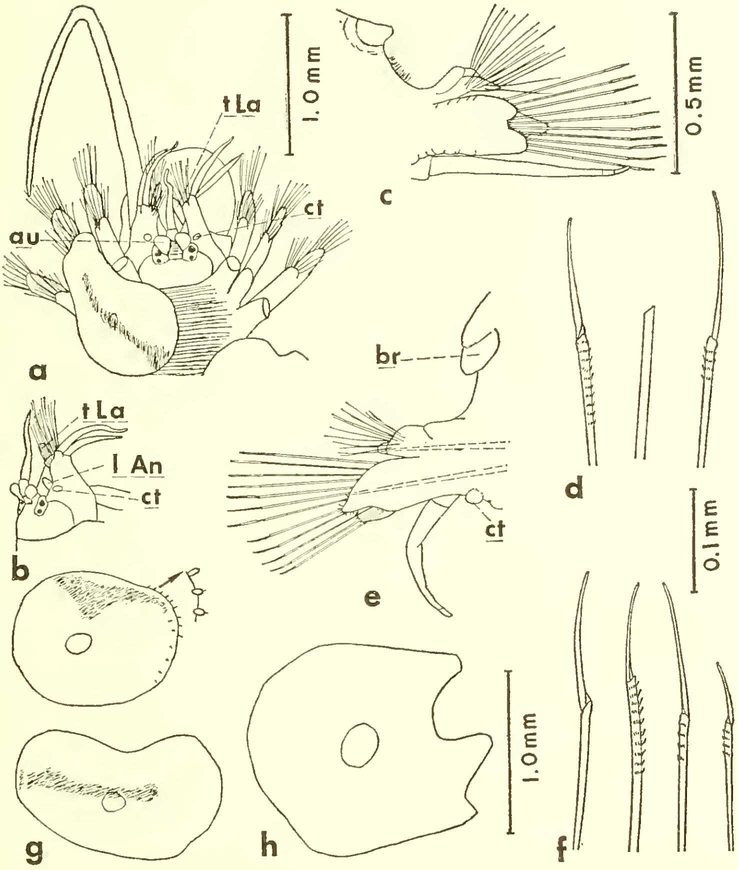

FIG. 4. *Sthenelanella ehlersi* (Syntype of *Euleanira ehlersi*, ZMA 218): a, Anterior end, dorsal view, pharynx partially extended; first left and first two right elytra removed; right palp missing; lateral antennae on inner dorsal sides of segment I hidden from view; b, prostomium and tentacular parapodium (I), lateral view; palp missing; c, parapodium of segment II, posterior view; d, upper, middle, and lower neurosetae from same (blade of middle ones missing); e, parapodium of segment III, anterior view; f, upper, middle and lower neurosetae from same; g, first two right elytra; h, middle right elytron. (au, auricle; br, branchia; ct, ctenidia; l An, lateral antenna; t La, tentacular lamella).

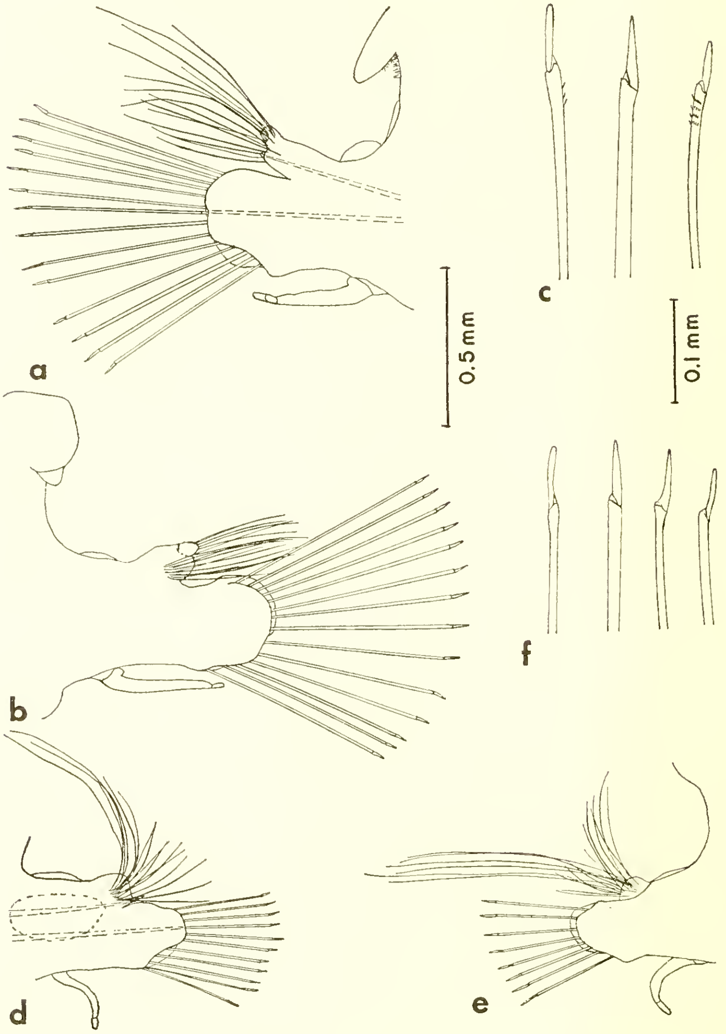

FIG. 5. *Sthenelanella ehlersi* (Syntype of *Euleanira ehlersi*, ZMA 218): a, Middle parapodium, anterior view; b, same, posterior view; c, upper, middle and lower neurosetae from same; d, posterior parapodium, anterior view; position of spinning gland dotted in; e, posterior parapodium, posterior view; f, upper, middle and lower neurosetae from same.

tional small oval ctenidia on their dorsal bases; elongate-conical tentacular lamellae medial to setal bundles (fig. 4a, b). Neurosetae of segments II-IV with distal stems with variable number spinous rows or these lacking; blades elongate, slender, slightly hooked (fig. 4d, f); segment III without dorsal cirri but with conical dorsal tubercles and small branchiae; pair of small knobs or ctenidia ventrally (fig. 4e).

Notopodia of parapodia forming small rounded lobes with single prominent ctenidia and slight indication of additional ctenidia (fig. 5a, b, d, e). Notosetae capillary, finely spinous. Middle and posterior notopodia provided with oval spinning glands from which long fine threads emerge (fig. 5d, e). Neuropodia with rounded presetal and postsetal lobes, the presetal lobes somewhat narrower. Neurosetae with short blades; upper and lower blades rod-shaped; rest conical, pointed (fig. 5c, f). Ventral cirri short, subulate, with bulbous area on upper basal part and with terminal joint. Pharynx not extended and not examined. Tubes fibrous, stiffened with mud (Day, 1967).

Distribution: Dutch East Indies; South Africa (Natal). In 56 meters (shallow to deep—Day, 1967).

Remarks: The spinning glands and long feltage notosetae were overlooked by Horst (1916, 1917) but were observed by Day (1967), who found specimens encased in fibrous tubes stiffened with mud. Due to the opaque body, it is difficult to detect on which segment the spinning glands begin. Day (1967) indicated that the elytra occurred on all segments from 21 on, instead of segment 25, as observed on the Syntypes.

KEY TO THE SPECIES OF *STHENELANELLA*

1. Anterior elytra with mottled pigmentation (fig. 2b); middle and posterior elytra with external margins entire. Without oval ctenidia on dorsal bases of tentacular parapodia (I) (fig. 1a). With pair of oval ctenidia or knobs dorsally between segments II and III (fig. 1a) .... *S. uniformis* Moore

1′. Anterior elytra transversely banded (fig. 4a, g); middle and posterior elytra with external margins deeply sinuous (fig. 4h). With pair of oval ctenidia on dorsal bases of tentacular parapodia (I) (fig. 4a, b). Without oval ctenidia or knobs dorsally between segments II and III (fig. 4a) .... *S. ehlersi* (Horst)

Species of *Sthenelanella* are unique among the Sigalionidae in having notopodial spinning glands which form notopodial threads that contribute to their tough fibrous tubes, similar in this regard to some species of Polyodontidae. Their neurosetae—all compound, with short blades—sets them apart from most of the other species of Sigalionidae.

Sthenelanella polymorpha Hartmann-Schröder (1962), from Chile, does not agree with the above diagnosis of *Sthenelanella* in a number of characters, such as the relatively short palps, poorly developed tentacular parapodia, and the shape of the parapodial lobes which lack spinous capillary notosetae and spinning threads.

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PANDANUS DECUS-MONTIUM, A NEW SPECIES FROM THE SOLOMON ISLANDS

By Benjamin C. Stone
School of Biological Sciences, University of Malaya, Kuala Lumpur

Among the extensive collections of plants made in recent years by the Forest Department of the British Solomon Islands is a set of specimens representing the following new species of *Pandanus*. Although as yet known only from staminate flowering collections, the form of the leaves makes it very likely that which includes *Pandanus nemoralis* Merr. & Perry *P. paludosus* the species is a member of the Section *Curvifolia* B. C. Stone, Merr. & Perry, and *P. buinensis* Merr. & Perry, all of which are endemic to the Solomon Islands. They conform in having the fruits (simple or 1-seeded drupes) aggregated in cephalia, and with horizontal rounded-reniform central stigmas, and vegetatively in having rather broadly elliptic leaves, strongly narrowed toward the base, which in life are downwardly curved (hence the sectional name). The present newly proposed species has, as may be seen from the accompanying illustrations, leaves of this type, with a markedly narrowed and folded leaf-base.

Although the species is here typified by a BSIP (British Solomon Islands Plants) collection, I cite also specimens collected by myself and L. J. Brass some years ago which were devoid of flowers or fruit. Its striking appearance, at once noticeable in the field, convinced me that it was new to science, but until now no suitable (flowering) collections have been seen. It is gratifying now to be able to describe this plant, which has been named "decus-montium" (ornament of the mountains) to emphasize its attractive appearance.

Explanation of Figure 1

Fig. 1. *Pandanus decus-montium* new species.— *Upper left*: Habit (Stone 2358, Malaita). *Upper right*: Habit (Stone 2358). Note markedly flattened leaf-bases. *Upper center*: Staminal phalange, enlargement (BSIP 1836). *Lower left*: large juvenile leaf, and small leaf from sucker-shoot, of BSIP 1836 (LAE). *Lower right*: Staminate flowering branch, with small leaves BSIP 1836 (LAE).

Pandanus decus-montium new species (Sect. *Curvifolia*)
Fig. 1.

Arbor ad 10 m alta, stipite laeve cicatricata sparse ramosa, ramis erectis, e basi pauci-radicante radicis gralliformibus ad 2 m altis. *Folia* anguste oblanceolata usque ad 90 cm longa et 8 cm lata (in planta juvenili) vel minora, 30 cm longa et 2.5 cm lata (in planta senili), apicem versus acuta basem versus angustata et valde uniplicata pallidiora, marginibus apicem versus crebre spinuloso–serratis, costis dorsaliter apicem versus similiter spinuloso-serratis, basem versus inermibus vel subsparse aculeatis, aculeis antrorsis 1 mm longis, plicis apicalibus ventraliter spinulosis. Lamina foliorum supra viridis infra glauca basem versus pallida applanata. *Inflorescentia* foeminea ignota; mascula terminalis bracteata racemoso-spicata, bracteis ca. 11, inferioribus foliaceis, basi navicularibus chartaceis, superioribus toto navicularibus apice acuto costis marginibusque spinulosis. *Spicae* masculae ovoideae ca. 3 cm longae et 1.5 cm latae albobrunneae. Phalanges staminorum 5–8 mm longae, staminibus ca. 7–13 umbellatim dispositis, filamentis fere 2 mm longis, antheris orbicularibus utrinque emarginatis 0.8–0.9 mm longis non apiculatis albidis.

Holotypus: BRITISH SOLOMON ISLANDS: GUADALCANAL. Mount Austen, alt. 1000 ft. "by stream on coral limestone; slender tree 30 ft tall with conical crown; bole smooth, olive, with raised sinuous leaf-scars; branches in twos or threes, upward-pointing, slender. Plants clumped. Young stems unbranched and bearing much larger leaves in a very open spiral; as stems branch their leaves get smaller. A few stilt roots to 6 ft. Male tree, flowers fawn-color, subtended by brown papery bracts." 9 May 1963, *T. C. Whitmore BSIP. 1836* (BSIP); isotypes LAE! SING! K.

Additional specimens: BRITISH SOLOMON ISLANDS: MALAITA. Kwara-ae District, Kwalo, ridge about 1 mi. northeast of Tantalau Village, ca. 1200 ft. alt. "Erect slender tree with terminal crown of large leaves and a few lateral simple branches bearing small leaves; trunk somewhat triquete-cylindric, ringed by subdistant leaf-scars and bearing scattered, short, blunt prickles; base of trunk with several short, down-curved proproots which are also prickly. Leaves in 3 distinct spirals, leaf-bases conspicuous by being flattened (folded); above the vase 6–8 inches each leaf margin is then flattened horizontally; the M-shape of most pandan leaves is scarcely noticeable. No flowers or fruit seen." 23 September 1957, *B. C. Stone 2358* (BISH!).

SAN CRISTOVAL. Hinuahaoro, 900 m. alt., "tree to 10 m. high, stems solitary, or several erect from a curved or horizontal common stock, raised several feet from the ground on stout prickly proproots. Stem with numerous lateral small upturned branches. Leaves not over 1 m. long, glaucous beneath, of soft texture, numerous in 3 spirals. Sterile." 22 September 1932, *L. J. Brass 2918* (A!).

Vernacular names: "apapola" (BSIP 1836); "ahole" (Stone 2358).

I would like to acknowledge the helpful advice of Dr. T. C. Whitmore and of G. F. C. Dennis in connection with the preparation of this paper.

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USE OF MALE EXTERNAL GENITALIC DETAILS AS TAXONOMIC CHARACTERS IN SOME SPECIES OF *PALAEMONETES* (DECAPODA, PALAEMONIDAE)[1]

By Laurence E. Fleming
Mississippi State University[2]

The various species of shrimp belonging to the genus *Palaemonetes* are currently identified and classified on the basis of the spinose ornamentation of several different body sites. Because of overlap and variation, identification and relationships are difficult to determine.

The taxonomic characters currently in use for *Palaemonetes*, with the possible exception of cheliped proportions, are probably subject to ecological modifications. This is especially true of spinose ornamentation. On the other hand, the structures utilized in amplexus in most Crustacea are usually stable and in so far as is known, are little affected by ecological factors. This is especially true in many Malacostraca where male appendages have been particularly useful in taxonomic and evolutionary studies.

In this study the external genital details of the second pleopod of male *Palaemonetes* were examined and evaluated as taxonomic characters for identification. The study was limited to the epigean species of the Gulf Coastal Plain of the United States and its coastal waters. Stable, and unique for the species, setal ornamentation of the tip of the appendix masculina of the second pleopod and equally stable gross morphology of the second pleopod provide potentially valuable characteristics for the systematic study of Palaemonidae.

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Species Studied: Holthuis (1949, 1952) listed six epigean species of *Palaemonetes* as occurring in the United States, and five of these are known from the state of Mississippi and adjacent waters (*ibid.*): *P.* (*P.*) *kadiakensis* Rathbun, 1902; *P.* (*P.*) *paludosus* (Gibbes, 1850); *P.* (*P.*) *vulgaris* (Say, 1818); *P.* (*P.*) *pugio* Holthuis, 1949; *P.* (*P.*) *intermedius* Holthuis, 1949. Specimens of these species from Mississippi were the principal source of information although most specimens of *P. paludosus* were collected in St. Charles and St. James parishes, Louisiana.

Additional material was available from various sources, and specimens from four Gulf states (Mississippi, Louisiana, Texas, and Alabama) were analyzed. Material studied included five collections from two counties in Alabama, 21 collections from five parishes in Louisiana, two collections from two counties in Texas and 42 collections from 15 counties in Mississippi.

Following initial evaluations, type specimens of these species at the Smithsonian Institution were examined and the conclusions validated. Other types at SI were also examined for the same characteristics to determine if the proposed criteria could be applied to other species of the genus. These species, studied by means of type material at SI, are: *P.* (*P.*) *schmitti* Holthuis; *P.* (*P.*) *suttkusi* Smalley; *P.* (*Alaocaris*) *antrorum* Benedict. Type material of *P.* (*P.*) *eigenmanni* Hay and *P.* (*P.*) *hiltoni* Schmitt were also examined at SI, but the pleopods were disarticulated, shriveled or in some way damaged and little use could therefore be made of this material.

Procedures: Specimens of *Palaemonetes* were collected by means of dip nets, seines, and on occasion, use was made of boat-drawn trawls and plankton nets. The specimens were collected from large and small ponds, roadside sloughs, running streams, inlet bayous of the Mississippi Sound of the Gulf of Mexico and from the Gulf of Mexico itself. Freshwater species were found to be the most abundant in floating, submerged and emergent aquatic vegetation such as duckweed (*Spirodela* sp. and *Lemna* sp.), water hyacinth (*Eichhornia* sp.), pondweed (*Potamogeton* spp.) and bladderwort (*Utricularia* sp.). Brackish and marine species were mostly obtained from growths of eelgrass (*Vallisneria* spp.).

A total of 1582 specimens were studied in detail: 845 specimens of *P. kadiakensis*, 169 specimens of *P. paludosus*, 430 specimens of *P. pugio*, 71 specimens of *P. vulgaris*, and 67 specimens of *P. intermedius*.

Individuals were randomly selected and the second left pleopods removed and temporarily mounted on slides using Monk's Mounting Medium (5cc corn syrup, 5cc fruit pectin, 3cc of water with thymol added as a preservative). Each pleopod was placed in precisely the same position on the slide. Then a careful examination of each pleopod was made using a compound microscope. To further validate the conclusions drawn, several pleopods were dismounted from their position on the slide, rearranged in exactly the opposite position, and again subjected to microscopic examination.

Concluding these studies, camera lucida drawings were made of selected representative pleopods. Two sets of drawings were made of each. One drawing was made under the low power (35×) of a compound microscope to reveal the structure of the entire pleopod, and another drawing was made under the high power (450×) of the tip of the appendix masculina of each male specimen. The coverslips of the slides were then ringed with "Permount" to insure their permanency.

Following this, *in situ* camera lucida drawings were made of the second right pleopod of randomly selected specimens using a magnification of 38× on a stereoscopic microscope. This was done to validate the accuracy of the orientations and interpretations of disarticulated appendages.

OBSERVATIONS

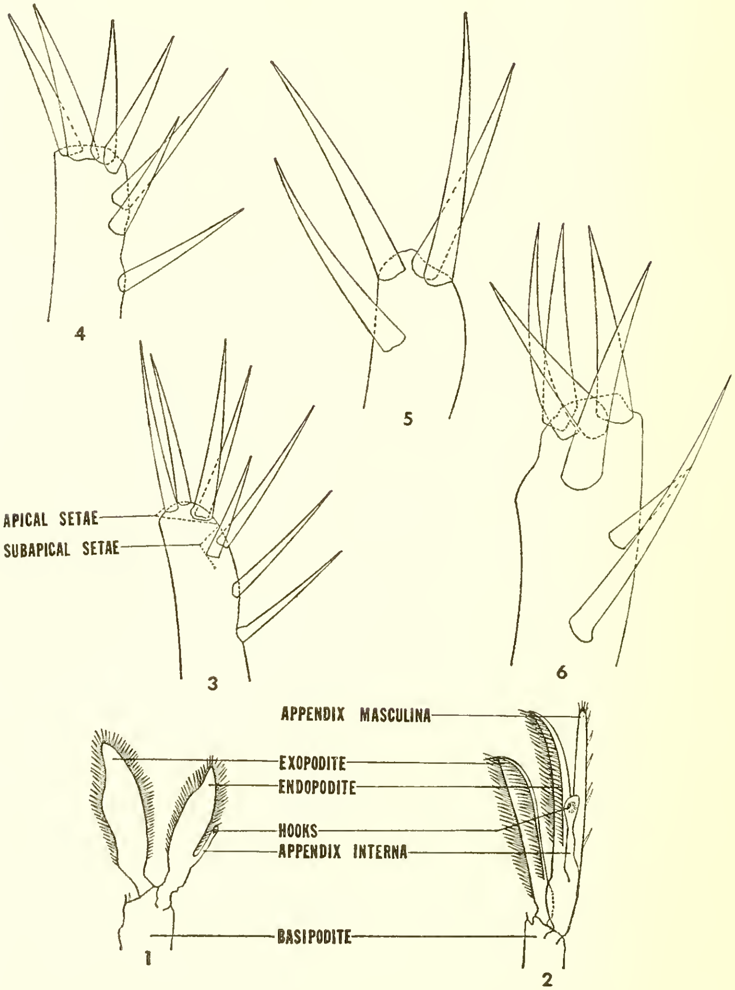
In all of the specimens examined, the general appearance of the external secondary sex characters of the five different species seem to resemble Meehean's (1936) description of those of *P. paludosus* (probably *P. kadiakensis*). In *Palaemonetes* the first two pairs of pleopods exhibit sexual dimorphism and modification. The first pair of pleopods (which are not copulatory organs) are relatively unmodified but the inner ramus (= endopodite proper) of the male is approximately three times as long as that of the female. In both sexes the endopodite and exopodite are heavily armed with plumose setae. The second pair of pleopods (the pair exhibiting the greater modification) have the endopodite modified to include a non-podomere appendix interna (= retinaculum of Meehean, 1936) arising from the inner margin in both sexes (Figs. 1 and 2). Between the endopodite proper and the appendix interna of the male an accessory process arises near the base of the appendix interna and is termed the appendix masculina (*op. cit.*).

Interspecific variability of the second pleopod of male specimens of *Palaemonetes* were found. The gross morphology of the various parts of the pleopod varies in such factors as proportional lengths of certain parts, shape of the tip of the appendix interna and overall shape of the appendix masculina. Another species specific feature is the setal ornamenation of the tip of the appendix masculina. The number of apical setae and the number of subapical setae are sufficient to identify most species, except *P. vulgaris* and *P. intermedius* which are identical in this respect.

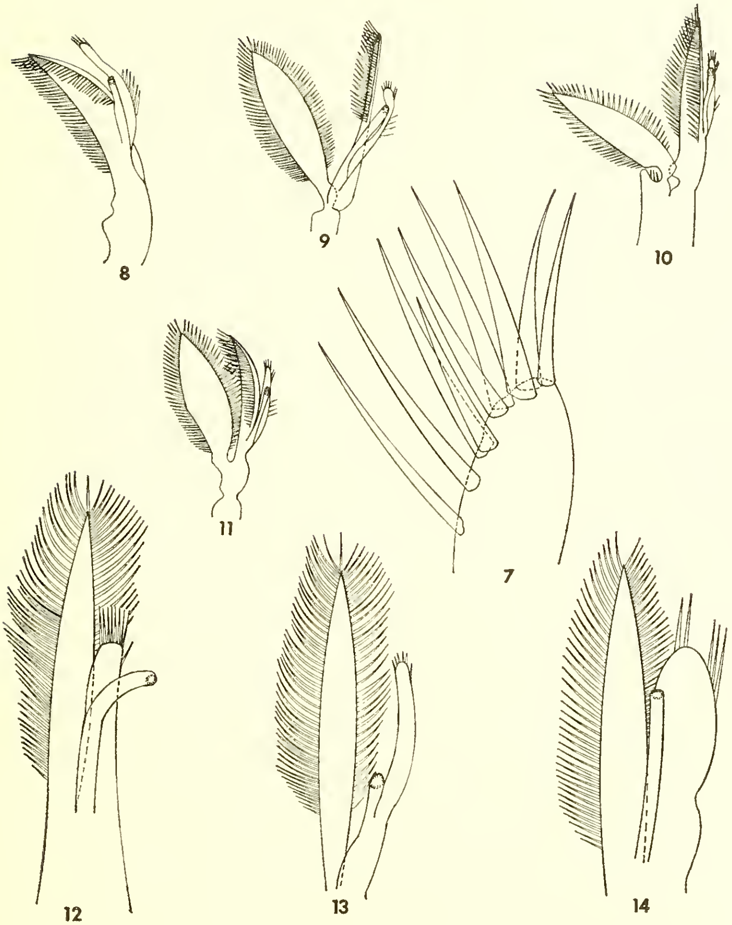
P. intermedius (Fig. 3) is used as an example to illustrate the position of the apical setae in reference to the subapical setae. There are four apical setae and two subapical setae in *P. intermedius* and *P. vulgaris* (Fig. 4). There are three apical setae and one subapical seta in *P. kadiakensis* (Fig. 5); four apical setae and one subapical seta in *P. paludosus* (Fig. 6); five apical and one or two subapical setae in *P. pugio* (Fig. 7).

In summary, the setal ornamentation of the appendix masculina is specifically unique in the species of *Palaemonetes* examined, with the one exception, as stated above, involving *P. vulgaris* and *P. intermedius*. All the other species are easily separable using this character alone.

Study of the gross morphology of the pleopod reveals differences in proportions of two structures: (1) extent of the appendix interna along the



Figs. 1–6. Second pleopod of various species of *Palaemonetes*. 1. Mesial view of *P. kadiakensis* Rathbun illustrating gross morphology of a female pleopod. 2. Mesial view of *P. paludosus* (Gibbes) illustrating gross morphology of a male pleopod. 3. Tip of appendix masculina of *P. intermedius* Holthuis showing setal ornamenation. 4. Tip of appendix masculina of *P. vulgaris* (Say) showing setal ornamentation. 5. Tip of appendix masculina of *P. kadiakensis* Rathbun showing setal ornamentation. 6. Tip of appendix masculina of *P. paludosus* (Gibbes) showing setal ornamentation.



FIGS. 7–14. Second male pleopod of various species of *Palaemonetes.* 7. Tip of appendix masculina of *P. pugio* Holthuis showing setal ornamentation. 8. Mesial view of *P. kadiakensis* Rathbun illustrating specific gross morphology; exopodite concealed. 9. Mesial view of *P. pugio* Holthuis illustrating specific gross morphology. 10. Mesial view of *P. vulgaris* (Say) illustrating specific gross morphology. 11. Mesial view of *P. intermedius* Holthuis illustrating specific gross morphology. 12. Mesial view of *P. schmitti* Holthuis (from the Canal Zone) illustrating specific gross morphology. 13. Mesial view of *P. suttkusi* Smalley (from Mexico) illustrating specific gross morphology. 14. Mesial view of *P. antrorum* Benedict (a subterranean species) illustrating specific gross morphology.

appendix masculina and (2) extent of the appendix masculina along the endopodite proper.

The appendix interna extends along slightly more than the proximal one-half of the appendix masculina in *P. kadiakensis* (Fig. 8); along less than the proximal one-half of the appendix masculina in *P. paludosus* (Fig. 2); along the proximal three-fourths of the appendix masculina, and in some specimens the appendices may even be subequal in *P. vulgaris* (Fig. 10). In *P. pugio* (Fig. 9) and *P. intermedius* (Fig. 11) the appendix interna extends along the proximal two-thirds of the appendix masculina. Through the use of this character all species except *P. pugio* and *P. intermedius* can be distinquished.

The appendix masculina extends to the distal one-third of the endopodite proper in *P. vulgaris* (Fig. 10) and *P. pugio* (Fig. 9); to the distal one-fourth of the endopodite proper in *P. intermedius* (Fig. 11); to the distal one-eighth of the endopodite proper in *P. kadiakensis* (Fig. 8); to the distal one-tenth of the endopodite proper, and in some specimens the two appendices are subequal in *P. paludosus* (Fig. 2). Thus, *P. vulgaris* and *P. pugio* are alike in this character.

The shape of the tip of the appendix interna in *P. paludosus* (Fig. 2) is large and flat or paddle-shaped while in all other species it is small and round.

The overall shape of the appendix masculina differs in two species from the shape of the structure in the other three species. In *P. kadiakensis* (Fig. 8) and in *P. pugio* (Fig. 9) the appendix masculina is gently curved laterad, with the curve in both species occurring in the approximate area of the limit of extent of the appendix interna along the appendix masculina. In *P. paludosus* (Fig. 2), *P. vulgaris* (Fig. 10), and *P. intermedius* (Fig. 11) the appendix masculina is straight. In *P. paludosus* the appendix masculina is straight and stiffened in comparison with the appendix masculina of *P. vulgaris* and *P. intermedius*.

A summary of the various features of the second pleopod of these five species is given in Table 1. The types of all are comparable with the figures (Figs. 1–11) and Table 1.

Type material from areas outside of the Gulf Coastal Plain was examined at SI and found to exhibit species unique characteristics. In *P. schmitti* (Fig. 12) there is a very complicated setal ornamentation (eight long apical setae); one short subapical seta; and the appendix interna turns upward and outward. In *P. suttkusi* (Fig. 13) there are five very short apical setae arranged in a circle; one short subapical seta; and the appendix interna is very short and straight. In *P. antrorum*, a subterranean species, (Fig. 14) there are two long apical setae; three long subapical setae; the appendix interna is relatively straight; and the appendix masculina is very stout.

DISCUSSION

Although Holthuis' revision (1952) of the subfamily Palaemoninae now serves as the primary source for all taxonomic work in this group, specific,

TABLE 1. Characteristics of second pleopod of certain species of *Palaemonetes.*

	Appendix masculina				Appendix interna	
Species	Number of apical setae	Number of subapical setae	Shape of tip	Extent along endopodite proper	Shape of tip	Extent along appendix masculina
kadiakensis	3	1	curved	To proximal ⅞	small, round	slightly more than proximal ½
paludosus	4	1	straight	To proximal 9/10	large, flat or paddle-shaped	less than proximal ½
pugio	5	1–2	curved	To proximal ⅔	small, round	equal to proximal ⅔
vulgaris	4	2	straight	To proximal ⅔	small, round	slightly more than proximal ¾
intermedius	4	2	straight	To proximal ¾	small, round	equal to proximal ⅔
schmitti	8	1	straight	To proximal ⅔	small, round	slightly more than proximal ¾
suttkusi	5	1	curved	To proximal ⅚	small, round	less than proximal ½
antrorum	2	3	straight	To proximal ⅔	small, round	equal to proximal ⅔

subgeneric and generic characters utilized by him exhibit overlap, variability and, in some cases, indistinctiveness which tend to make the identification of certain specimens extremely difficult. Some characters are difficult to evaluate. For example, the pleura of the fifth abdominal segments are used as a diagnostic character in the separation of *P. pugio*, *P. vulgaris*, and *P. intermedius* yet these features are intraspecifically mutable.

The use of the second pleopod of the male as a source of taxonomic characters in *Palaemonetes* would alleviate many difficulties now encountered in identifying species of *Palaemonetes* and in so doing would make a contribution to the taxonomy of the group. Further, evolutionary and interspecific relationships probably can be better evaluated with more stable characters.

Holthuis (1952) noted that *P. vulgaris*, *P. pugio* and *P. intermedius* are very similar and for a long time have been confused under the name *P. carolinus* and *P. vulgaris.* He listed the characters that he used to separate them and then concluded by stating that, although the three species can be generally easily separated, there are examples, especially with juveniles, when identification of a specimen is difficult. I should note that the use of details of the male external genitalia in identification does not remove the difficulties in identifying juveniles and females; its value lies in the increased confidence its use imparts to identifications of adult male specimens.

The separation of *P. vulgaris* from *P. intermedius* is extremely difficult with the use of the characteristics of the appendix masculina. Differentiation between the two, in fact, can be attained solely through the use of the proportional lengths of the appendix interna and appendix masculina. Further, the significance of these two characters has yet to be determined, especially with reference to other characteristics of the two populations.

There is similarity in larval development of *P. pugio*, *P. intermedius*, and *P. vulgaris* (Broad, 1957; Broad and Hubschman, 1962). Broad and Hubschman (1963) working with *P. kadiakensis* larvae and Dobkins (1963) working with *P. paludosus* larvae found that the larval development of the freshwater forms could be distinquished from the salt water forms by the tendency toward condensation of the stages, larger eggs and larger larvae of the freshwater forms.

From this information, together with that gathered from studies on the male second pleopod, one concludes that *P. pugio*, *P. vulgaris*, and *P. intermedius* are indeed related. *P. pugio*, however, is conspicuously different and easily separable, and thus specifically distinct from either *P. vulgaris* or *P. intermedius. P. vulgaris* and *P. intermedius*, on the other hand, are visibly identical in such a varying array of features and perceptibly different in so few characters that they could be conspecific. This view cannot be supported satisfactorily or refuted until more information is provided, particularly detailed populational and ecological data. For the time being, at least, there are distinct morphological differences between the two and there are no evidences of interbreeding. Therefore, they are best considered specifically distinct. *P. kadiakensis* and *P. paludosus* are clearly morphologically distinct from each other and from the other species. Thus, they, too, represent separate species. Examination of type material at the United States National Museum confirmed the distinctiveness of the morphological features of the gential apparatus of the male second pleopod of the five species of *Palaemonetes* studied.

Epigean species of *Palaemonetes* from areas outside the Gulf Coastal Plain of the United States apparently also are specifically unique in these characteristics as revealed by type specimens from Mexico and the Canal Zone examined at SI. Subterranean species of *Palaemonetes* probably also may be similarly identified if studies made on type material of *Palaemonetes* (*Alaocaris*) *antrorum* Benedict, 1896, at SI are any indication.

SUMMARY

1. The second pleopod of the male may be used in taxonomic evaluation of epigean species of *Palaemonetes*.

2. *P. kadiakensis*, *P. paludosus* and *P. pugio* can be easily separated from one another, and all can be differentiated from *P. vulgaris* and *P. intermedius* using counts of apical and subapical setae of the tip of the appendix masculina; *P. vulgaris* and *P. intermedius* cannot be distinquished using this character.
3. The relative length of the appendix interna can be used to distinquish *P. kadiakensis, P. paludosus* and *P. vulgaris,* although *P. pugio* and *P. intermedius* are indistinguishable by this character.
4. The relative length of the appendix masculina is distinctive in *P. paludosus, P. kadiakensis* and *P. intermedius,* but similar in *P. vulgaris* and *P. pugio.*
5. The tip of the appendix interna is large and flat or paddle-shaped in *P. paludosus*; it is small and round in all other species.
6. The appendix masculina is curved laterad in *P. kadiakensis* and *P. pugio* and straight in all other species; it is decidedly stiffened in *P. paludosus.*
7. Studies of the second pleopod and statements of other students suggest that *P. intermedius* and *P. vulgaris* may be conspecific, but they are considered here as distinct species; all other species are clearly distinct.
8. Studies made on type specimens of *P. schmitti, P. suttkusi* and *P. antrorum* at USNM revealed that they likewise may be separated from each other and from other species by these criteria.

ACKNOWLEDGMENTS

The writer wishes to express his sincere appreciation to Dr. J. F. Fitzpatrick, Jr., for his assistance and supervision of this study and for reviewing the manuscript. Dr. Fitzpatrick was not only an invaluable counsel throughout the course of this research but a constant source of encouragement. Dr. Perry C. Holt, Virginia Polytechnic Institute, carefully read the manuscript and made helpful suggestions. Drs. Gordon Gunter and Walter Abbott generously allowed use of facilities at the Gulf Coast Research Laboratory, and Mr. J. Y. Christmas and Mr. G. P. Garwood made museum specimens available; Mrs. Shirley Dimmick provided numerous aids in securing literature and information on *Palaemonetes.* Dr. James Franklin Payne and Mr. Shih-ming Chien were generous with help in collecting specimens. Dr. M. Saeed Mulkana is especially thanked for his help and assistances far too numerous to enumerate. Dr. Roger F. Cressey, Division of Crustacea, Museum of Natural History, Smithsonian Institution, kindly made it possible for me to study type specimens of *P. schmitti, P. suttkusi* and *P. antrorum.*

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PROCEEDINGS
OF THE
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CONTRIBUTIONS TO A REVISION OF THE EARTHWORM FAMILY LUMBRICIDAE

V. *EISENIA ZEBRA* MICHAELSEN, 1902[1]

By G. E. Gates
Zoology Department, University of Maine, Orono

Twenty species of lumbricid earthworms, brought by man from Europe since 1500 A. D. (Gates, 1966 and 1967), have been found to be variously domiciled in North America. Another species, that may eventually become widely distributed throughout the continent, is now added to the list. At least one more, perhaps others, will be added later.

American material and data were supplied by Mr. Salvatore Billeci. For comparison, an identified series of the same species from Wales was provided by Dr. K. Sylvia Richards.

Eisenia Malm, 1877 (emend. Gates, 1968)

Eisenia zebra Michaelsen, 1902

Eisenia veneta var. *zebra* Michaelsen, 1902. Mitt. Naturhist. Mus. Hamburg, 19, p. 39 (Type locality, Chosta, Kreis Sotschi, Transcaucasia. Type, supposedly in the St. Petersburg Mus.)

Helodrilus (*Eisenia*) *venetus* var. *zebra,* Michaelsen, 1910. Ann. Mus. Zool. Acad. Sci. St. Petersburg, 15, p. 3.

Dendrobaena veneta var. *zebra,* Pop, 1943. Ann. Hist. Nat. Mus. Hungarici, (Zool.), 36, p. 22. Brinkhurst, 1962, Proc. Zool. Soc. London, 138, p. 325. Gerard, 1964, Linnean Soc. London, Synopses British Fauna, No. 6, p. 39, etc.

Material examined: San Francisco, California, 1–3–20(+), received on several occasions from S. Billeci. Identified specimens, from Britain, 1–1–32, provided by K. Sylvia Richards.

External characteristics: Size, 51–96 by 5 (an aclitellate) to 8 mm. Segments, 83–153 (Table), 113–153 (unamputated specimens). The majority of the unamputated worms have segment numbers in the range of 127–147. The average for 44 unamputated specimens (Table, Nos. 10–59 but

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[1] From research financed by the National Science Foundation.

Typhlosole termination and segment number in *Eisenia zebra*

Serial number	Typhlosole ends in segment	Atyphlosolate segments	Soma segments	Serial number	Typhlosole ends in segments	Atyphlosolate segments	Soma segments
1	78	5	83	31	121	16	137
2	79	4	83	32	121	19	140
3	83	4	87	33	122	14	136
4	88	7	95	34	122	15	137
5	93	10	103	35	122	17	139
6	94	6	100	36	123	13	136
7	94	8	102	37	123	14	137
8	98	8	106	38	123	16	139
9	98	11	109	39	123	17	140
10	101	12	113	40	125	15	140
11	106	10	116	41	125	16	141
12	109	8	117	42	126	8	111
13	109	11	120	43	126	16	142
14	109	12	121	44	128	14	142
15	110	16	126	45	128	15	143
16	110	18	128	46	128	15	143
17	111	15	126	47	129	15	144
18	112	16	128	48	130	4	134
19	112	18	130	49	130	8	138
20	114	15	129	50	130	14	144
21	117	15	132	51	130	15	145
22	117	19	136	52	130	16	146
23	118	16	134	53	130	16	146
24	118	17	135	54	131	16	147
25	119	8	127	55	131	17	148
26	119	15	134	56	132	16	148
27	119	18	137	57	135	8	143
28	120	8	128	58	137	10	147
29	120	15	135	59	137	16	153
30	120	18	138				

NOTES

Worms numbers 2, 9, 14, 17 were posterior amputees having each an obviously regenerated periproct.

The typhlosole of No. 12 was rudimentary in the 108th–109th segments, having been reduced after posterior amputation.

Those of Nos. 1–9 not already mentioned probably were old posterior amputees. Those numbered 25, 28, 42, 49, 57 are believed to be posterior amputees.

Coelomic cavities of the last few segments in Nos. 40 and 41 were filled with brown bodies of various sizes and shapes.

excluding 12, 28, 42, 48, 49, 57) is 136.5. The mean number of segments for 47 specimens is 136.4681, with a standard deviation of 8.5539 and a standard deviation of the mean of 1.2477. A majority of the worms have segments in a range of 134–148, which is about the size of the range for the majority of *E. hortensis* (Gates, 1968b). Color, dark red to slate, in transverse bands, leaving a fairly wide uncolored band centered at each intersegmental furrow, sparse in some portion of the dorsum in ix–x. Soma, posteriorly almost transversely rectangular in cross section with *b* and *d* setae at the four corners. Prostomium epilobous, tongue open (all). When the pre-oral lobe is drawn more or less completely inside the buccal cavity, the lobe is demarcated from the tongue by a transverse furrow. Such a condition is called "combined pro- and epilobous". Several worms were almost tanylobous. The periproct often is large, with an anterior portion showing evidence of differentiation of another metamere, such as presence of a dorsal pore (which may not be functional) or presence of setae more anteriorly. If both conditions are recognizable the area was counted as two segments even though not yet demarcated from each other by an intersegmental furrow. Secondary annulation, lacking.

Setae, present from ii, widely paired, *CD* ca. = or very slightly < *AB*, *BC* slightly < or ca. = *AA* < *DD* < ½C. Nephropores, inconspicuous, actual pores never seen, locations occasionally recognized, probably at *B* in xiv, xv usually, at or above *D* in first few segments, elsewhere varying irregularly and with asymmetry between a ventral level just above *B* and a dorsal level above *D*. First dorsal pore, at 4/5 (1 specimen), 5/6 (35), pores at 9/10, 10/11 of clitellate individuals occluded.

Clitellum, saddle-shaped, reaching down below *C*, dorsal pores occluded, intersegmental furrows not obliterated, (xxvi)–xxxiii (4), xxvi–xxxiii (29), xxvi/eq-xxxiii (1), xxvii–xxxiii (7), (xxvii)–xxxiii (1), xxviii–xxxiv (1). Tubercula pubertatis, longitudinally placed, often bounded laterally by a distinct furrow, median borders often uncertain and seemingly just including *b* setae, anterior and posterior borders usually uncertain, xxix–xxxi (10), xxix/eq-xxxii/eq (10), xxix/eq-xxxii (4), xxx–xxxi (14), xxx–xxxii/eq (1), xxx–xxxii (4). Sometimes a nearly circular portion in each of xxx and xxxi seems more prominent.

Genital tumescences, slight, boundaries very indistinct, including some or all of the setae in ix or xii, *a,b* separately in xxviii–xxxi (2), xxviii–xxxii (3), xxix–xxx (3), xxix–xxxi (3), xxix–xxxii (17).

Internal anatomy: Septa, 5/6–12/13 slightly strengthened, 13/14–15/16 muscular and increasingly thickened posteriorly.

Special longitudinal muscle band at mD, present from 5/6. Pigment, red, in circular muscle layer. Peritoneum blistered away from musculature in dorsum of ix–xi. Broad transverse stripes of pigment sometimes are associated with the dorsal peritoneum anteriorly.

Calciferous sacs and lamellae, lacking in x. Esophagus widest in xi–xii where the lumen is narrow. Usually no marked external constriction at insertion of 11/12. Lamellae are largest in xi in which segment the gut always is whiter or redder than anteriorly or posteriorly. Esophageal valve, in xiv (35). Intestinal origin, in xv (35). That portion of the intestine belonging in xv occasionally has been drawn back into gut lumen of xvi. Gizzard, mostly in xvii, but fenestration dorsally of 17/18 and 18/19 contributes to an appearance of greater posterior extent. Typhlosole, present from region of xxii, at first with widened and flat ventral face. A cross section at first has an inverted T-shape but subsequently is obviously though only slightly bifid. The typhlosole ends as shown in the table but, when there was no posterior amputation, in region of the 101st to 137th segments, usually in the 110th–130th. Up to 18 intestinal segments were atyphlosolate.

Dorsal blood vessel, single, recognizable forward only to 5/6. However, in one worm, a small section of the trunk among the pharyngeal glands was blood-filled and traceable to a bifurcation under the brain. Ventral trunk, complete, bifurcating over subpharyngeal ganglion. Subneural trunk, complete, bifurcating at anterior end of the nerve cord, adherent to cord but when distended coming easily away. Extra-esophageal trunks, median to hearts, turning up to dorsal trunk in xii (35). Hearts, in vii–xi (35), none seen in vi.

Nephridia, vesiculate. Bladders, elongately sausage-shaped, transversely placed in *BD* or reaching beyond *D*, joined at lateral end by looped tubule, narrowing as they pass downward and into parietes close to *B* but without a distinct duct.

Holandric. Testes and male funnels free in coelomic cavities. Male funnels, polyplicate, sometimes complexly so and then rosette-like. Male gonoducts, without epididymis (35), passing straight laterally to parietes, disappearing from sight in an anterior portion of the atrial glands in xiv. Seminal vesicles, 4 pairs, smallest in x, the last pair largest and at height of maturity extending in posterior pockets of 12/13 back to level of 14/15.

Ovaries, each with a terminal egg string that may contain 4–7 ova (35). Ovisacs, present in xiv (35). Spermathecae, in ix and x (35), each with a short and slender but definitely coelomic duct. Ampulla, spheroidal to ovoidal, occasionally more or less reniform to almost bilobed.

TP glands, acinous, more or less conspicuously protuberant into the coelomic cavities, just lateral to *B*. Atrial glands, acinous, usually entirely within the body wall which is markedly bulged into the coelomic cavities of xiv–xvi in the median portion of *BC*. An equatorial cleft is obvious in xv. Setal follicles of ix (2), xii (24) are enlarged, conspicuously protuberant in the coelom, each surrounded by a rosette of acinous supraparietal glands. Setae of those follicles are of the usual genital sort. The body wall ventrally in *BB* of xvi–xxiii is blistered away from the musculature and the space between peritoneum and muscles is filled with a delicate coagulum. GS glands were not certainly distinguished among the blisters.

Reproduction: Spermatozoal iridescence on male funnels of clitellate worms showed that maturation of sperm had been completed. Iridescence in the spermathecal ampullae proved the worm had copulated. In absence of any contra-indication, reproduction accordingly can be assumed to be amphimictic.

Some of the spermatophores obtained were found to contain sperm.

Distribution: Outside of Russia, *E. zebra* had been found in Turkey, Wales, England, Ireland, but records for extra-Russian areas are few.

Cocoons: Color, a light lemon-yellow, perhaps becoming brown later. Shape, tapering slightly at each pole to a protuberance. One terminal protuberance usually is markedly thicker than the other but length and shape of each free end vary considerably. Micrometer measurements supplied by Mr. Billeci are as follows: Diameter, at thickest equatorial portion, 0.1415, 0.143, 0.144, 0.145 (twice), 0.146 inches. Average of the six measurements, 0.144 inch. Length, exclusive of the polar appendages, 0.125, 0.126, 0.138, 0.154, 0.155 (twice), 0.158 (twice), 0.159, 0.165, 0.186, 0.201 inches. Average of twelve cocoons, 0.1568 inch.

Spermatophores: One was noted on each of four worms, two were seen on each of two worms. Always discoidal and transparent, shape varied from subcircular to elliptical. Each had a small, opaque central thickening that contained sperm. Locations: across 27/28, in *AB* or centering at *B*, or extending across all of xxviii–xxix and centering at *A*.

Autotomy: No. 1 had half completed breaks in body wall, on left side only, at 102/103 and 93/94. No. 2 had a half completed break on left side at 80/81. No. 3 had completed a break on the right side at 89/90. No. 4 had a completed break in ventral body wall only at 88/89, but at 103/104 the break had been completed—the parts held together only by cuticle.

Regeneration: Absence of head and tail regenerates, except for four periprocts, in a total of more than 60 specimens seems unusual especially in comparison with its relative *Eisenia foetida* (Savigny, 1826).

Abnormality: Three spermathecae were present in x (1).

Parasites: Long nematodes were present in the ventral blood vessel (2 hosts). Seminal vesicles of ix,x (1 worm) were filled with small cysts and similar cysts were present in coelomic cavities of x–xi.

Remarks: From an anterior portion dorsally of a worm that was about to be put on hook there came out a creamy yellow fluid. The liquid, which may have been from distended spermathecae, had a strong odor, according to Mr. Billeci and two of his party, like that of decaying bananas.

SYSTEMATICS

Eisenia veneta (Rosa, 1886) has been at one time or another in five lumbricid genera, *Allolobophora*, *Bimastos*, *Dendrobaena*, *Eisenia*, *Helodrilus*. At present some European specialists place the species in *Dendrobaena* while others refer it to *Eisenia*.

Eisenia, recently redefined (Gates, 1968a) in accordance with conservative somatic anatomy, lacks calciferous sacs. The calciferous gland opens directly, *i.e.*, without intervention of sacs, into the gut lumen in xi. The calciferous gland of specimens identified by Michaelsen as the typical form of "*Helodrilus venetus*" was studied by Smith (1924, p. 27). He stated that the anterior end of the gland was in x as Omodeo (1952, p. 190) also thought. Actually a portion of the gut belonging in xi had been herniated into x as Omodeo later (1954, p. 128) discovered.

Insofar as the calciferous gland and "var. *typica*" are concerned Rosa's *veneta* probably can go in *Eisenia*. However, confirmation is required from other somatic anatomy.

Sixteen varieties of *E. veneta* were given Latin names by European zoologists. Some still are in use. One, var. *hortensis* Michaelsen, 1890, now more adequately characterized (Gates, 1968b) is recognized as a species. Another, var. *hibernica* Friend, 1893, subsequently will be shown to be distinct. Other taxa are distinguishable at present from each other, if at all, only by characters of dubious systematic value (*cf.* Omodeo, 1952, p. 8 and/or Gerard, 1964, p. 38–39). The definition of "f. *typica*" (Gerard, 1964, p. 38) almost covers the entire range of variation in all varieties. By 1893 Rosa himself already had referred to his "*veneta*" individuals with a clitellum extending from xxiv, xxv, xxvi, or xxvii through xxxiii or xxxiv.

Information as to existence of types of Rosa's *veneta*, as well as material of various varieties (including f. or var. "*typica*"), has been unobtainable. Michaelsen's variety, so far as can be discovered from the literature, has been recognized on several occasions without difficulty. Populations from which the present samples were obtained seemingly are amphimictic. The taxon described above accordingly must be regarded as a species. If specific distinctness from Rosa's f. "*typica*" is demonstrable, Michaelsen's name probably can be retained. At least it has priority over remaining unplaced varietal names.

Further discussion of most relationships should be postponed until other varieties of *veneta* have been adequately characterized.

In America, *E. zebra* is easily distinguished from its congeners: From *E. foetida*, by its thicker soma, greater number of segments, wider pairing of setae, more posterior invariant section of the clitellum, more posterior anterior margin of tubercula pubertatis, calciferous lamellae largest in xi (rather than xii), a more posterior typhlosole termination (usually in region of 110th–130th rather than 80th–98th segments), a more posterior junction of extra-esophageal and dorsal trunks (in xii instead of ix–x), absence of epididymis in male gonoducts, greater development of atrial glands, presence of TP glands and of acinous, supraparietal GS glands. Many of such characters were derogated or ignored by previous specialists.

From *E. hortensis* (*cf.* Gates, 1968b), by the larger soma, greater number of segments, more obvious restriction of pigment to transverse intrasegmental bands, invariant portion of the clitellum comprising xxviii–xxxiii (rather than xxviii–xxxii), typhlosole termination usually in 110th–130th (rather than 72'd–92'd) segments, etc.

Enterion roseum Savigny, 1826, (common in America), according to American and some European zoologists is in *Eisenia*. Other Europeans refer it to *Allolobophora*. The species belongs in neither genus but determination of its proper position awaits further lumbricid revisions. Savigny's species is readily distinguished from all *Eisenia* spp. by presence of calciferous sacs in x and by the U-shape of nephridial vesicles.

ADDENDUM

European lumbricids now domiciled in North America are: *Allolobophora chlorotica* (Savigny, 1826), *A. limicola* Michaelsen, 1890, *A. longa*

Ude, 1895, *A. muldali* Omodeo, 1956, *A. trapezoides* (Duges, 1828), *A. tuberculata* Eisen, 1874, *A. turgida* Eisen, 1874, *Dendrobaena mammalis* (Savigny, 1826), *D. octaedra* (Savigny, 1826), *D. rubida* (Savigny, 1826), *Eisenia foetida* (Savigny, 1826), *E. hortensis* Michaelsen, 1890, *E. rosea* (Savigny, 1826), *E. zebra* Michaelsen, 1902, *Eiseniella tetraedra* (Savigny, 1826), *Lumbricus castaneus* (Savigny, 1826), *L. festivus* (Savigny, 1826), *L. rubellus* Hoffmeister, 1843, *L. terrestris,* Linnaeus, 1758, *Octolasion cyaneum* (Savigny, 1826), *O. tyrtaeum* (Savigny, 1826).

E. zebra, like three other species, has not been intercepted from earth with plant shipments.

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THE MONOGENEAN PARASITIES OF AFRICAN FISHES. X. TWO ADDITIONAL *DACTYLOGYRUS* SPECIES FROM SOUTH AFRICAN *BARBUS* HOSTS[1]

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The first African *Dactylogyrus* species were reported by Price and Gery (in press). At this time approximately 20 species of this genus are known from various regions of the continent.

This study consists of an account of two additional species of *Dactylogyrus* recovered from South African fishes. One of these, *D. myersi* new species, was recovered from the gills of *Barbus trimaculatus* Peters. The other, *D. varicorhini* Bychowsky (1957), was harbored by *Barbus kimberleyensis.* This latter dactylogyrid was initially reported as a parasite of *Varicorhinus capoeta* taken in the Soviet Union. Paperna (1961) recovered this monogenean species from both *Barbus canis* and *Varicorhinus damascinus* in Israel, both cyprinid species native to that country.

The occurrence of the same parasite species on different host genera separated by thousands of miles is deemed of sufficient importance to warrant discussion at a later point.

Materials and Methods: The authors extend their thanks to R. McC. Pott, Professional Officer, Provincial Fisheries Institute, Lydenburg, Republic of South Africa for donation of branchial materials utilized in this study and for identification of host species.

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Host specimens were captured by seine and/or gill nets. Branchial materials were frozen and then preserved in 3.5 percent formalin prior to shipment to the United States. Gills and recovered parasites were then treated as prescribed by Price (1966) and measurements made as recommended by Price and McMahon (1967). Appropriate measurements and illustrations were made with the aid of a calibrated filar micrometer ocular and a camera lucida, respectively. Anatomical terms employed were those recommended by Hargis (1958) and by Price and Arai (1967). Average measurements are given first, followed by minimum and maximum values enclosed in parentheses. All measurements are expressed in microns.

Research on Monogenea is steadily increasing. These parasites are being described from the fishes of many countries where monogenetic trematodes were previously unknown. A check of available recent literature indicates that well over 400 species have been described within the past 10 years. This figure becomes more meaningful when it is realized that less than 1000 species of Monogenea were known in 1957.

The senior author foresees an increasing number of taxonomic inconsistencies and other difficulties which could be considered a natural consequence of working in a difficult area of research. I firmly believe, however, that the situation would be vastly improved if all authors would include whole mount illustrations of new species.

In a letter some time back, Dr. W. J. Hargis, Jr. (Director, Virginia Institute of Marine Science, Gloucester Point, Virginia), mentioned the "hook and anchor" methods of many workers in Monogenea. After working with these parasites for some time, I now fully realize the import of this. I would like to recommend that future new species have no status unless a whole mount for each is provided. As a former "hook and anchor" worker, I now feel that merely depicting sclerotized structures constitutes at best an inadequate approach to taxonomic studies.

Dactylogyrus myersi new species

Host: *Barbus trimaculatus* Peters; family Cyprinidae.
Locality: Pongolo River, Lydenburg, Republic of South Africa.
Location of parasite on host: Gill filaments.

Number studied: 12.
Holotype: USNM Helm. Coll. No. 70561.
Paratype: USNM Helm. Coll. No. 70562.

Description: A dactylogyrid of moderate size, provided with a smooth cuticle, length 323 (298–339); greatest body width 94 (86–102), near midlength. Anterior cephalic lobes well-developed, lateral lobes vestigial. Pharynx prominent, quite muscular and subspherical in outline (both dorsal and ventral views). Two pairs of eyespots, all members about equal in size. Head organs (either side) consist of four glandular structures connected by a common duct; duct terminates in larger pharyngeal gland. Peduncle short and stout, with result that haptor is not well differentiated from body proper (Fig. 1: whole mount).

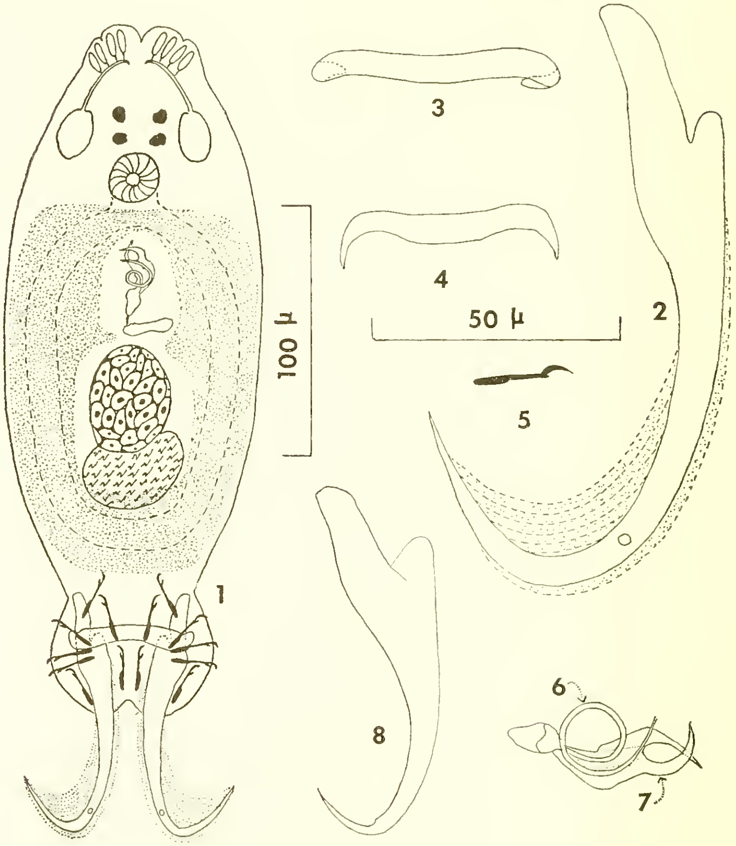
One pair of anchors (dorsal) (Fig. 2). Each anchor composed of: (1) a solid base equipped with well-defined deep and superficial roots, (2) a solid shaft and (3) a solid point; shaft and point meet in a continuous arc. A perforation occurs through anchor near junction of shaft and point. Anchors relatively long, *ca.* one-third as long as overall body length, anchor length 107 (100–112); width of base 18 (16–21). Anchor bases connected by a bar which is atypical for genus: ends are sheet-like and partially encircle anchor bases, length 47 (43–52) (Figs. 3, 4).

Haptoral hooks 14 (seven pairs), similar in shape and size (Figs. 1, 5) and arranged five pairs ventral on haptor, two pairs dorsal (Mizelle and Crane, 1964). Each hook composed of: (1) a solid elongate base, (2) a solid shaft and (3) a sickle-shaped termination provided with an opposable piece. Hooks range from 20 to 24 in length. The so-called "additional" hooks of *Dactylogyrus* (Mizelle and Price, 1963) are considered not to be hooks at all, but to be vestiges of a ventral pair of anchors, disappearing as evolution progressed. These structures were not observed in *D. myersi.*

Copulatory complex composed of a cirrus and a basally articulated accessory piece (Figs. 6, 7). Cirrus tubular, of a narrow diameter and arranged in a coil of *ca.* 1.5 turns; diameter of coil 25 (22–28). Accessory piece of unusual structure for genus; whereas most dactylogyrids possess accessory pieces with simple rami, those of the present form cross over each other distally. Length of accessory piece 28 (25–31). Testis postovarian, subspherical in outline and slightly smaller than ovary. Vas deferens appears to loop over intestinal limb, but not observed with certainty. Prostatic reservoir bipartite. Vagina not observed with certainty.

Intestine bifid, limbs simple and becoming confluent posteriorly. Vitellaria well-developed; co-extensive with intestinal crura.

Etymology: This species is named in honor of Dr. George S. Myers of the Division of Systematic Biology of Stanford University, in appreciation of the vast amount of ichthyological information he has furnished to the senior author.



Figures 1–7. *Dactylogyrus myersi* new species. 1, Entire worm (ventral view). 2. Anchor. 3, 4. Dorsal bar. 5. Hook. 6. Cirrus. 7. Accessory piece.

Figure 8. Anchor of *D. varicorhini* Bychowsky, 1957.

Discussion: Although *Dactylogyrus* can be considered a rather morphologically homogeneous group, the present new species does not appear to have any very close relatives. *D. myersi* possesses three characters which are considered to be atypical for *Dactylogyrus*: (1) a bar with modified ends which partially encircle the anchors, (2) relatively large anchors with a perforation near the junction of shaft and point and (3) an accessory piece in which one primary ramus crosses over the other.

Dactylogyrus varicorhini Bychowsky, 1957

Host: *Barbus kimberleyensis*; family Cyprinidae.
Locality: Pongolo River, Lydenburg, Republic of South Africa.
Number studied: Twenty-six.

Previously Reported Hosts and Localities: (1) *Varicorhinus capoeta*, in the Soviet Union, by Bychowsky (1957), (2) *Barbis canis*, in Israel, by Paperna (1961) and *Varicorhinus damascinus*, in Israel, by Paperna (1961).

Discussion: This species of *Dactylogyrus* is readily identified by reference to the anchors, which differ appreciably from those of the other approximately 375 species of this genus. An anchor is depicted in Fig. 8.

The specimens in our possession agree quite well with the morphological descriptions of *D. varicorhini* furnished by Bychowsky (1957) and Paperna (1961). In size, our specimens are intermediate between those described by these authors.

As noted above, *D. varicorhini* has been recovered from species of the cyprinid genera *Varicorhinus* (Soviet Union and Israel) and *Barbus* (Israel and South Africa). It is interesting to note that a given species of parasite occurs on different host genera which are separated by thousands of miles.

In a similar situation (Price and Yurkiewicz, in press) several specimens of the monogenean genus *Dogielius* Bychowsky (1936) were recovered from host specimens belonging to the genus *Labeo* in South Africa. The original report by Bychowsky concerned the host genus *Schizothorax*. The African and Soviet forms were separated by thousands of miles, as in the case of *Dactylogyrus varicorhini*. Paperna (1961) reported *Dogielius* from *Varicorhinus* in Israel.

One possible explanation for the occurrence of specific parasites on widely separated hosts involves early stages in the evolution of cyprinid fishes. Many ichthyologists believe that the cyprinids (family Cyprinidae) had their origin in Asia (Norman and Greenwood, 1963; Lagler, Bardach and Miller, 1962). These fishes likely evolved from a characoid ancestor. As Myers (1967) put it: "Cyprinoid fishes evolved in Asia from some toothless characoid which got across the Tethys from Africa. In Eurasia, the cyprinids blossomed into the largest familial group of the Ostariophysi, and in the Tertiary invaded both Africa (across the greatly shrunken Tethys) and North America (via a Bering land bridge)."

As the cyprinids underwent a veritable explosion of speciation, certain of them apparently migrated toward Europe and the Northwestern part of the Soviet Union. Others, as Myers (*op. cit.*) pointed out, crossed what remained of the Tethys Sea into Africa. It is conceivable that an ancestral minnow gave rise to two similar groups; one group headed northwest, the other southwest. The ancestral form was likely a *Barbus*-like form; offspring gave rise to *Barbus* as we know the genus today. This genus maintained its identity and also gave rise to both *Schizothorax* and *Varicorhinus*.

Parasitological inference is that the genera *Schizothorax*, *Varicorhinus* and *Barbus* are quite closely related. Paperna (1961) concurs in this. Crass (1964) places some doubt upon the validity of *Varicorhinus*, believing that the genus might well be synonymous with *Barbus*.

If it is accepted that the cyprinid genera above are very closely related, there remains only the necessity of accepting the well-established tenet of parallel evolution that similar hosts harbor similar parasites to theortically account for the wide-spread occurrence of the parasites discussed here.

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TAXONOMIC STATUS OF THE SHREW, *NOTIOSOREX* (*XENOSOREX*) *PHILLIPSII* SCHALDACH, 1966 (MAMMALIA: INSECTIVORA)

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Among 129 mammals collected in southern Oaxaca in 1964 by Allan R. Phillips and William J. Schaldach, Jr., were four short-tailed shrews, all tentatively identified as *Cryptotis mexicana* (Coues). Schaldach later discovered that two of the specimens had only three "unicuspids" in each upper toothrow instead of four (the normal complement for Recent species of the genus *Cryptotis* Pomel). Further examination convinced him that three (one lacking skull) of the four specimens represented an undescribed taxon; he assigned the fourth to *Cryptotis mexicana machetes* (Merriam).

The only Recent New World shrews that normally have but three "unicuspids" in each upper toothrow are representatives of the genera *Notiosorex* Coues and *Megasorex* Hibbard, which many authors consider as congeneric (*Notiosorex* having priority). Although Schaldach (1966: 289–290) questioned the "natural validity" of dental formulae as criteria for generic determinations of shrews, he apparently failed to consider the possibility that his specimens might represent a genus normally characterized by the presence of more than three upper "unicuspids." Instead, he relied entirely on the dental formula for generic allocation and (*op. cit.*: 289) named and described *Notiosorex phillipsii*, setting it off in a separate subgenus (*Xenosorex*) characterized by its close resemblance to *Cryptotis* in characters other than number of teeth.

In his review of the Soricidae, Repenning (1967) placed

Notiosorex and *Cryptotis* in separate tribes (Neomyini and Blarinini, respectively) representing phylogenetic lineages that probably have been distinct since early Miocene time (*op. cit.*: 61). This naturally aroused questions as to the identity and status of *Notiosorex phillipsii.* Furthermore, my examination of the holotype and paratypes of *N. phillipsii* revealed that on the basis of external characters they cannot be distinguished from the specimen assigned to *C. mexicana* caught at the same locality, and that cranially the specimen of *mexicana* and the two *phillipsii* accompanied by skulls differ only in the presence or absence of the minute fourth upper "unicuspid."

To determine the correct generic identity of *phillipsii*, the one paratype (KU 114226) and the notes taken on the holotype (UNAM 8445) and the other paratype (UNAM 8447) were compared with representatives of each of *N. crawfordi* (Coues) and *N. evotis* (Coues), the two nominal species of *Notiosorex*, with *Megasorex gigas* (Merriam), and with representatives of four species of *Cryptotis*—*C. pergracilis nayaritensis* Jackson, *C. mexicana mexicana* (Coues), *C. goodwini* Jackson, and *C. magna* (Merriam). The four species of *Cryptotis* were chosen as representatives of morphologically distinct lineages within that genus. Characters used by Repenning (*op. cit.*) to distinguish the Blarinini (p. 37) and Neomyini (p. 45) were evaluated and then applied to the study of *phillipsii.* Characters used in diagnoses of the genera *Cryptotis* (p. 39), *Notiosorex* (p. 55), and *Megasorex* (p. 56) were treated in a like manner. Osteological and dental terminology and most of the diagnostic characters used herein are from Repenning (*op. cit.*), except that diagnostic characters have been modified slightly where necessary to encompass the range of variation in Recent taxa. The characters discussed below were chosen as most demonstrative of relationships.

Dental formula: In *Cryptotis* the dental formula is 1–5–3/1–2–3 in Recent species and all known fossil species except *C. adamsi* (Hibbard), in which it is 1–6–3/1–2–3. In *Notiosorex* and *Megasorex* the dental formula is 1–4–3/1–2–3, the same as in specimens of *phillipsii.*

Cingular structure of "unicuspids": In *Cryptotis* a more-or-less distinctly developed cingular cusp, usually pigmented, is situated on the posterior end of the lingual cingulum of each anterior upper "unicuspid." In *Notio-*

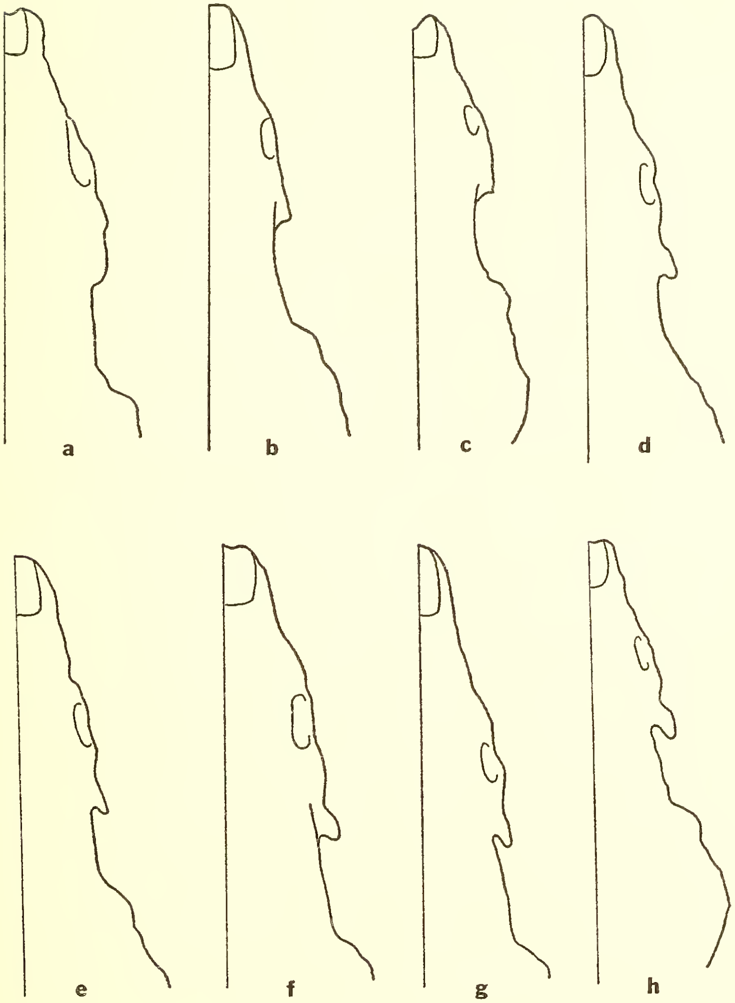

FIGURE 1.—Dorsal outlines of skulls of (a) *Megasorex gigas* (99538), (b) *Notiosorex evotis* (90581), (c) *N. crawfordi* (89210), (d) *N. phillipsii* (114226), (e) *Cryptotis mexicana mexicana* (29533), (f) *C. magna* (99539), (g) *C. goodwini* (64610), and (h) *C. pergracilis nayaritensis* (105408) showing degree of development of zygomatic process of maxillary. KU catalogue numbers (in parentheses) apply to respective drawings in Figs. 1–4.

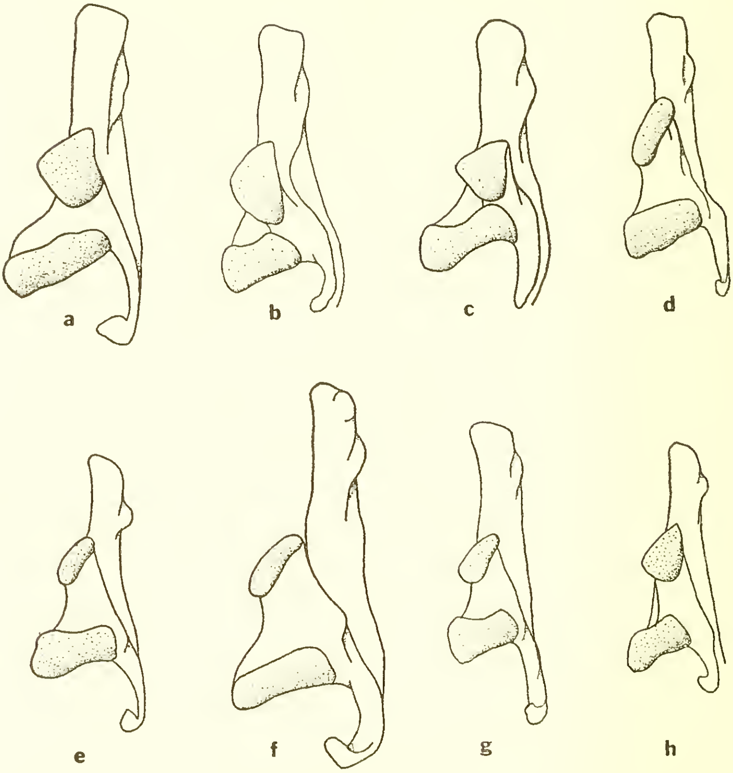

FIGURE 2.— Mandibular articulation in (a) *Megasorex gigas,* (b) *Notiosorex evotis,* (c) *N. crawfordi,* (d) *N. phillipsii,* (e) *Cryptotis mexicana mexicana,* (f) *C. magna,* (g) *C. goodwini,* and (h) *C. pergracilis nayaritensis.*

sorex and *Megasorex* the entire lingual cingulum may be elevated, forming a cingular ridge that never is pigmented. Pigmented cingular cusps are present in *phillipsii* and are similar to those in the species of *Cryptotis* examined.

Pigmentation of teeth: In *Cryptotis* all teeth except the fourth upper "unicuspid" are pigmented, the degree of pigmentation varying in different taxa. In *Notiosorex* the tips of the paracone of P4, protoconid of ml, and some of the more anteriorly-situated teeth are variably pigmented. In *Megasorex* pigmentation is lacking or at best slight. In *phillipsii* the tips of the teeth are pigmented as in *Cryptotis.*

Degree of development of zygomatic process of maxillary: In *Cryptotis* the zygomatic process of the maxillary extends posterior from a place

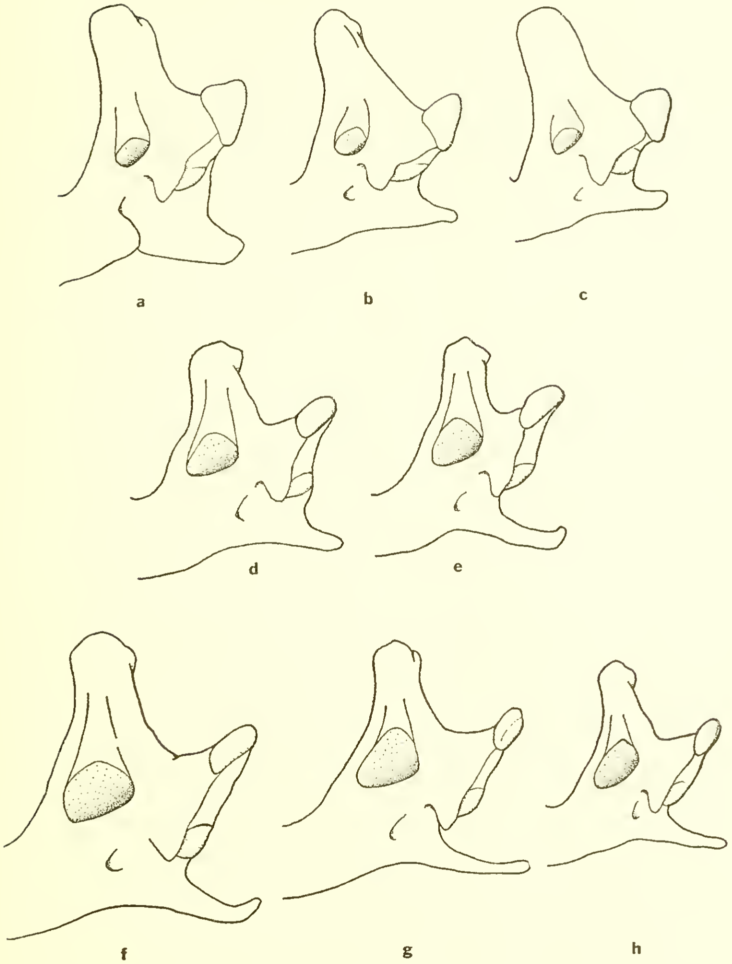

FIGURE 3.—Structure of internal temporal fossa in (a) *Megasorex gigas*, (b) *Notiosorex evotis*, (c) *N. crawfordi*, (d) *N. phillipsii*, (e) *Cryptotis mexicana mexicana*, (f) *C. magna*, (g) *C. goodwini*, and (h) *C. pergracilis nayaritensis.* Note, as in other figures, the similarity between *phillipsii* and *C. mexicana.*

opposite the metacone or metastyle of M2 as a short but distinct process from which the masseter muscle originates. In *Notiosorex* the process originates opposite the metastyle of M2 and either does not extend posteriad (*N. crawfordi*) or does so only as a minute process that probably

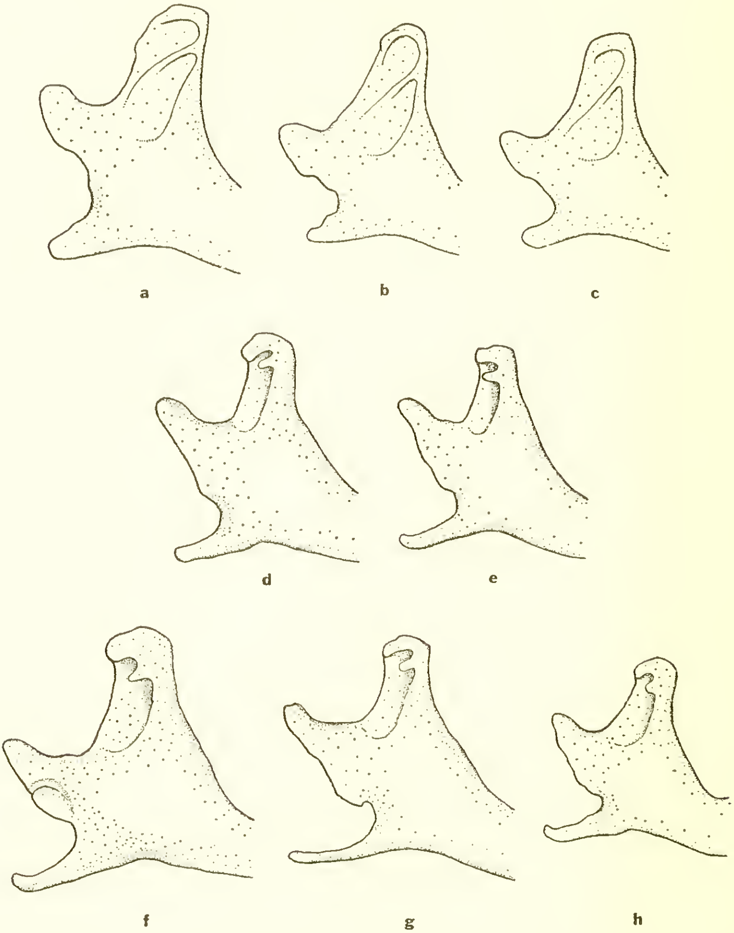

FIGURE 4.—Location of external temporal fossa in (a) *Megasorex gigas*, (b) *Notiosorex evotis*, (c) *N. crawfordi*, (d) *N. phillipsii*, (e) *Cryptotis mexicana mexicana*, (f) *C. magna*, (g) *C. goodwini*, and (h) *C. pergracilis nayaritensis*.

lacks significant muscular attachment (*N. evotis*). In *Megasorex* the process originates posterior to M2 and does not extend posteriad. In *phillipsii* the zygomatic process of the maxillary originates and extends posteriorly as in *Cryptotis* (Fig. 1).

Mandibular articulation: In *Cryptotis* the lingual condylar emargination is at least partially (usually considerably) filled with bone, varying in different species, so that the interarticular area is broad. In *Notiosorex* and *Megasorex* the lingual condylar emargination is not filled, resulting in a narrow interarticular area; the lower condyle is offset lingually (more so than in *Cryptotis*) from the lower sigmoid notch, and is usually separated from that notch by a small groove. In *phillipsii* the mandibular articulation is identical with that of *Cryptotis* (Fig. 2).

Structure of internal temporal fossa: In *Cryptotis* the internal temporal fossa tends to be large, triangular, and excavated dorsally in such a fashion that a basin is formed above the fossa proper. In *Notiosorex* and *Megasorex* the fossa tends to be small, deep, and round, lacking all but a hint of excavation. The structure of the internal temporal fossa in *phillipsii* is identical with the condition found in *Cryptotis* (Fig. 3).

Location of external temporal fossa: In all species examined of *Cryptotis* the external temporal fossa is situated high on the coronoid process, extending down no farther than the superior sigmoid notch. In *Notiosorex* and *Megasorex* the fossa is situated low on the coronoid process, the ventral margin often extending as low as the lower articular facet. In *phillipsii* the fossa is situated as in *Cryptotis* (Fig. 4).

As shown above, specimens referred to "*Notiosorex* (*Xenosorex*) *phillipsii*" clearly share morphological affinities, excepting dental formula, with *Cryptotis* rather than *Notiosorex*. Examination of the specimens of *Cryptotis mexicana* mentioned above and of additional material (ENCB 3413–14; AMNH 213758–59, 214152, 214803–06, 214808–09; UMMZ 112572) from near the type locality of *phillipsii* demonstrated that the fourth upper "unicuspid" is variable in size and development in that population, and that absence of the tooth does not constitute a valid taxonomic character even at the subspecific level. Therefore, *Xenosorex* hereby is transferred to the genus *Cryptotis* (in which it becomes an available junior synonym), and *phillipsii* is placed in the synonymy of *Cryptotis mexicana peregrina* (Merriam). The complexities of specific allocation of the nominal subspecies of *C. mexicana* is beyond the scope of the present paper, but will be discussed in a forthcoming review of Middle American shrews of the genus *Cryptotis*.

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PROCEEDINGS
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A NEW PUFFER FISH, *SPHOEROIDES PARVUS*, FROM THE WESTERN GULF OF MEXICO, WITH A KEY TO SPECIES OF *SPHOEROIDES* FROM THE ATLANTIC AND GULF COASTS OF THE UNITED STATES

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Our taxonomic studies of the puffers (family Tetraodontidae) in the Atlantic Ocean and adjacent waters have revealed that the dominant inshore representative of the genus *Sphoeroides* Anonymous in the western Gulf of Mexico is an undescribed and endemic species. This discovery is especially relevant to the controversy concerning the relationship of the fish faunas of the eastern and western Gulf of Mexico. Baughman (1950: 118), Ginsburg (1952: 101), and Briggs (1958: 244) considered the faunas to be relatively distinct, and the latter author cited ecological evidence from Hedgpeth (1954: 206) to justify this view. Hildebrand (1954: 232) held the opposite opinion, and pointed to the apparent lack of evidence for endemic forms in the western Gulf of Mexico.

We are grateful to the following persons and their institutions (with abbreviations used in this paper) for loan of material: James C. Tyler, Academy of Natural Sciences of Philadelphia (ANSP); Frederick H. Berry, (formerly of) U.S. Bureau of Commercial Fisheries, Brunswick, Georgia (BLBG); Donald Moore, U. S. Bureau of Commercial Fisheries, Galveston, Texas (BLGT); Charles E. Dawson, Gulf Coast Research Laboratory (GCRL); Royal D. Suttkus, Tulane University (TU); Victor G. Springer, Smithsonian Institution (USNM); Herbert T. Boschung, University of Alabama (UA); Carter R. Gilbert, University of Florida (UF); Henry H. Hildebrand,

FIGURE 1. *Sphoeroides parvus* n. sp., A. holotype, 79.7 mm SL. Mobile Bay, Alabama, 8 August 1967. B. paratype, FSU 15365, from same series as holotype, 75.3 mm SL.

University of Corpus Christi, who supplied material from the Institute of Marine Science, University of Texas (IMS); and C. Richard Robins, University of Miami Marine Laboratory (UMML). Additional material was from the Florida State University (FSU) collection. Our especial thanks are extended to James R. Martin who aided in the collection of material, and to Dr. Victor G. Springer who reviewed the manuscript.

The terminology, counts, and measurements follow Hubbs and Lagler (1958: 19–26) except for the modifications discussed by Shipp and Yerger (1969: 425).

Sphoeroides parvus new species

Least puffer

Fig. 1

Sphoeroides marmoratus. Gunter, 1945: 84.

Sphoeroides nephelus. Hildebrand, 1954: 320. Hildebrand, 1955: 218 (in part). Reid, 1955: 331. Hoese, 1958: 347. Miller, 1965: 103.

Sphaeroides nephelus. McFarland, 1963: 100. Parker, 1965: 218.

Holotype: USNM 203248, an adult female 79.7 mm standard length (SL), collected in a shrimp trawl near the center of Mobile Bay, Alabama, by R. L. Shipp and J. Martin, 8 August 1967.

Paratypes: Twenty-five series comprising 382 specimens from the northern and western Gulf of Mexico. FLORDIA: UMML 2618 (1 specimen, 62 mm SL), Apalachicola, 10 October 1950. UF 4437 (8, 54–69), Choctawhatchee Bay, East Pass, 11 December 1954. UF 2731 (2, 52–57), Pensacola, 3.5 mi. E of Inerarity Pt., 15 August 1953. BLBG (1, 53), lower Pensacola Bay, between ship channel and south shore from Big Lagoon to USCG station, 20 February 1964. ALABAMA: UA 62 (5, 47–64), Gulf Shores, 29 April 1950. FSU 15364 (35, 32–54), Mobile Bay, 8 August 1967. FSU 15365 (176, 21–90), taken with holotype. UA 296 (15, 48–86), Mississippi Sound, 15 November 1952. UA 397 (5, 46–97), Mississippi Sound, 5 December 1953. UA 1290 (17, 47–79), Mississippi Sound, 18 April 1964. MISSISSIPPI: UA 625 (22, 30–58), Mississippi Sound, 18 October 1957. LOUISIANA: TU 9381 (1, 51), Lake Pontchartrain, 2 mi. W of South Draw, 30°10′N, 89°55′W, 5 November 1954. TU 22573 (14, 41–67), Gulf of Mexico, off Grand Terre, 12 December 1959. ANSP 97647 (51, 42–75), Barataria Bay, 24 November 1931. TU 19038 (2, 80–90), Cameron, W bank Calcasieu River, 28 April 1957. TEXAS: BLGT Gus 1 E25 (1, 56), 29°10′N, 89°42′W, January 1963. BLGT Gus 4 W1 (3, 58–62), 29°01′N, 95°05′W, 2–7 March 1963. BLGT Gus 3 W13 (1, 62), 28°19′N, 96°21′W, 1–6 April 1963. ANSP 98279 (Oregon station 3829) (2, 54–56), 28°17.5′N, 93°57.5′ W, 16 September 1962. BLGT Gus 1 W11 (2, 51–87), 27°42′N, 97°05′W, 2–5 February 1963. ANSP 98275 (2, 50–55), 26°18′N, 97°11′W, September 1962. IMS 624 (1, 118), Aransas Bay, July 1956. MEXICO: IMS 614 (3, 62-71), off Pta. Frontera, 29 July–6 August 1951. IMS 619 (8, 63–75), Campeche to Champoton, 10–16 February 1951. IMS 622 (4, 80–85), W of Campeche, 27–29 July 1951.

Ten paratypes from FSU 15365 (Alabama, see above) have been sent to each of the following institutions and assigned the indicated museum number: American Museum of Natural History, AMNH 27399; Field Natural History Museum, FNHM 74783; and Museum of Comparative Zoology, MCZ 46203.

Other specimens: ALABAMA: UA 286 (1, 104), Mobile Bay, 11 October 1952. MISSISSIPPI: GCRL V65: 1284 (1, 51), S of Horn Island, 28 August 1959. LOUISIANA: USNM 155990 (1, 70), Breton Island, 12 March 1931. GCRL V66: 311 (1, 51), S of Grand Isle, 23 October 1958. TEXAS: USNM 156492 (3, 63–86), Freeport, Texas, January–May, 1947. USNM 118648 (1, 88), Aransas Pass, 8 July 1941. USNM 155989 (1, 111), Aransas Pass, 4 April 1929. USNM 155992 (1, 111), Corpus Christi Bay, 11 November 1926. USNM 73580 (1, 64), Corpus Christi, 29 November 1891. ANSP 98263 (1, 71), Pt. Isabel, 30 November 1947.

Diagnosis: One of the smallest puffers (rarely exceeds 100 mm SL), distinguished from other members of the genus by a combination of characters: absence of lappets on dorsal surface of body, absence of deeply pigmented spot in pectoral fin axil, snout short, interorbital region broad, flat (least bony interorbital width 25% or more of snout length), and integument heavily covered by prickles, which do not extend posteriorly beyond level of anus.

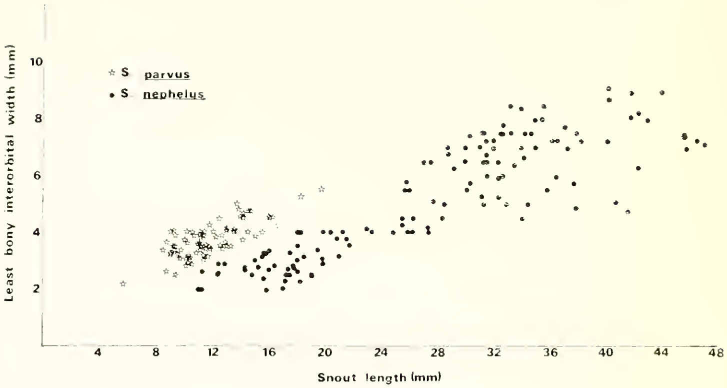


FIGURE 2. Relationship between least bony interorbital width and snout length in *Sphoeroides nephelus* and *S. parvus*. (Data on *S. nephelus* from Shipp and Yerger, 1969).

Superficially, *Sphoeroides parvus* most closely resembles *S. nephelus* (Goode and Bean) and *S. maculatus* (Bloch and Schneider). It differs from both species by the lack of a deeply pigmented spot at the axil of the pectoral fin. It further differs from *S. nephelus* in having a broad flat interorbital region, a shorter snout [interorbital width less than one-fourth snout length (Fig. 2)], and an irregular placement of the ventral-most lateral spots (in *S. nephelus* these are arranged in an even row along the ventrolateral body angle, see Fig. 3). It differs from *S. maculatus* (Fig. 5D) in having the shape of the ventrolateral markings chiefly round rather than vertically elongate, the prickles on the ventral surface not extending beyond the anus, and by the absence of tiny jet-black specks over most of the pigmented body surface.

Description: Body size small, snout short (18 percent SL), interorbital region flat to slightly concave, very broad (5 percent SL). Anterior body surface covered with close-set prickles or dermal spines, exposed in both uninflated and inflated specimens; dorsally, prickles extend posteriorly to dorsal fin origin, and ventrally almost to anus.

Morphometric data for the holotype and 20 paratypes are given in Table I.

Fin ray counts of 50 type specimens chosen at random from throughout the range of the species are as follows (the value including the holotype is italicized): dorsal rays *8* (in 43 specimens), 9 (7); anal rays 6 (4), *7* (45), 8 (1); pectoral rays (both sides counted separately) 13 (1), *14* (33), *15* (62), 16 (4).

Coloration: Ground color on dorsal surface brown or grey with scattered, indistinct blotches or spots; laterally ground color fades slightly above ventrolateral body angle; lower sides and ventral surface unpig-

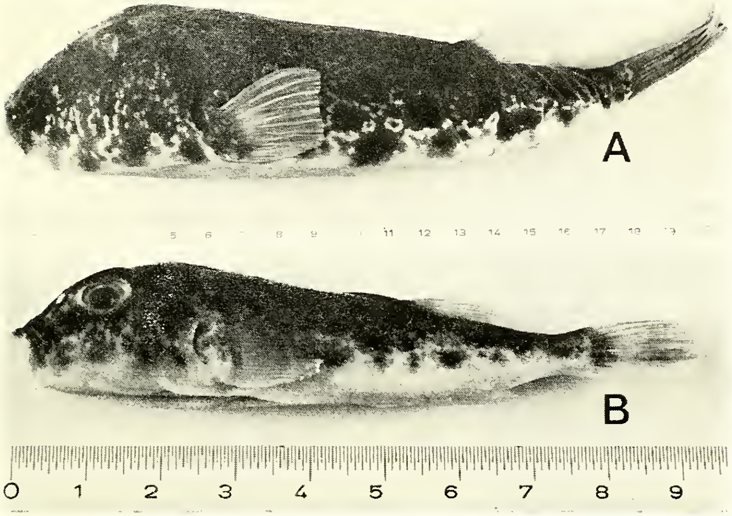


FIGURE 3. A. *Sphoeroides nephelus*, FSU 15606, 182 mm SL, Key Largo, Monroe Co., Florida, 29 December 1967. B. S. *parvus*, paratype, FSU 15365, 75.3 mm SL, Mobile Bay, Alabama, 8 August 1967. Note interspecific differences: size of adults, arrangement of lateral spots, and snout length.

TABLE 1. Measurements of the holotype and 20 paratypes of *Sphoeroides parvus* expressed in percent of standard length.

		Paratypes*	
	Holotype	Range	Mean
Standard length	79.7	56–97	72.1
Head length	36.1	33.4–38.5	35.7
Snout length	17.9	16.6–19.4	17.8
Least bony interorbital width	5.5	4.4–6.3	5.1
Pectoral fin length	15.9	15.5–21.2	17.8
Depressed dorsal fin length	17.9	16.0–20.1	18.3
Depressed anal fin length	13.7	12.7–18.2	15.4
Caudal fin length	20.2	18.7–23.4	20.9
Snout to dorsal origin	71.4	66.0–74.8	70.5

*FSU 15365 (4 specimens); UA 397 (4); ANSP 97647 (2); TU 19038 (2), 22573 (1); BLGT: Gus 1 E25 (1), Gus 1 W4 (3), Gus 1 W11 (2), Gus 3 W13 (1).

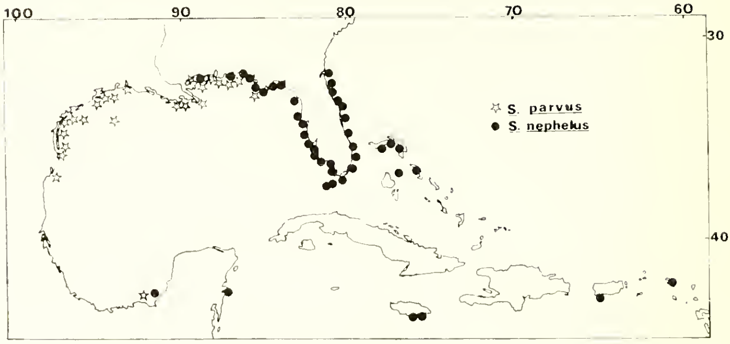


FIGURE 4. General distribution of two species of *Sphoeroides* based on specimens examined. Distribution of S. *nephelus* is included (based on Shipp and Yerger, 1969) to indicate distributional patterns and zone of sympatry with S. *parvus*.

mented. Lateral blotches or spots slightly more distinct than those on dorsum; not always arranged in an even row, but tend to border ventral boundary of ground color. Spot present in pectoral fin axil in few specimens, but rarely more intensely pigmented than others on body. Indistinct dark bar present between eyes. Dorsal and lateral surfaces often with vague white specks, which may appear bright green in live specimens. A few black specks on cheeks in some larger specimens. No other noteworthy color marks appear in live specimens except for yellow or gold cast over much of lateral and ventral surfaces. All fins unpigmented except caudal, which may have an indistinct pigmented area near its base and another near its distal end.

Adult size: S. *parvus* is the smallest known species of *Sphoeroides* in the Atlantic Ocean and adjacent waters; the largest specimen examined was 118 mm SL. Several authors previously noted the small size of this puffer in the western Gulf (Gunter, 1945: 84; Hildebrand, 1954: 320; Reid, 1955: 449; Miller, 1965: 103). Hildebrand (1955: 218) reported a 91 mm (total length) female with nearly ripe ovaries. We have examined females as small as 55 mm SL and males 47 mm SL which were sexually mature. The closely related species on the Gulf and Atlantic coasts do not mature until a much larger size is attained (about 70 mm SL in S. *maculatus*, usually more than 100 mm SL in S. *nephelus*), and commonly exceed 150 mm SL (Fig. 3).

Distribution: S. *parvus* occurs from Apalachicola Bay, Florida, westward throughout the western Gulf of Mexico. S. *nephelus* is the dominant form in the clear waters of northwest Florida to Pensacola, but S. *parvus* replaces it in the muddy waters of Mobile Bay and westward (Fig. 4). The senior author has examined many hundreds of puffers captured by shrimp boats in Mobile Bay, and not one S. *nephelus* was found. This is further verified by personal communication with the shrimpers who trawl both the clear and muddy localities. Specimens of S. *nephelus* west of Florida are rare. In the southwestern Gulf of Mexico, Hildebrand (1955: 218) reported both forms from the Campeche shrimp grounds, but S. *parvus* was much more abundant.

Zoogeography: *Sphoeroides parvus*, S. *maculatus*, and S. *nephelus* constitute a closely related species complex. *Sphoeroides parvus*, found in the northern and western Gulf, is more closely allied morphologically to S. *maculatus*, which occurs in the Atlantic from Canada to northeastern Florida (Shipp and Yerger, 1969: 426), than to S. *nephelus*, a predominantly West Indian species which occurs on both coasts of Florida. We believe that prior to the existence of the Florida peninsula, a continuous population of puffers (the progenitor of S. *maculatus* and S. *parvus*) was found around the southern coast of the United States. The emergence of this peninsula split the population into two, one isolated in the Atlantic, the other in the Gulf. Simultaneously the projection of this peninsula into the tropical waters of the Caribbean provided suitable habitat for the northward dispersal of S. *nephelus* from West Indian stocks. One or both of these factors, a land barrier and competition with a closely related species, apparently has maintained the isolation between the two original coastal populations, and speciation has ensued. Meanwhile S. *nephelus* is probably prevented from further dispersal northward and westward by ecological barriers. The distribution of S. *nephelus* and S. *parvus* in the Gulf of Mexico closely matches the ecologically distinct habitats described by Hedgpeth (1954: 206).

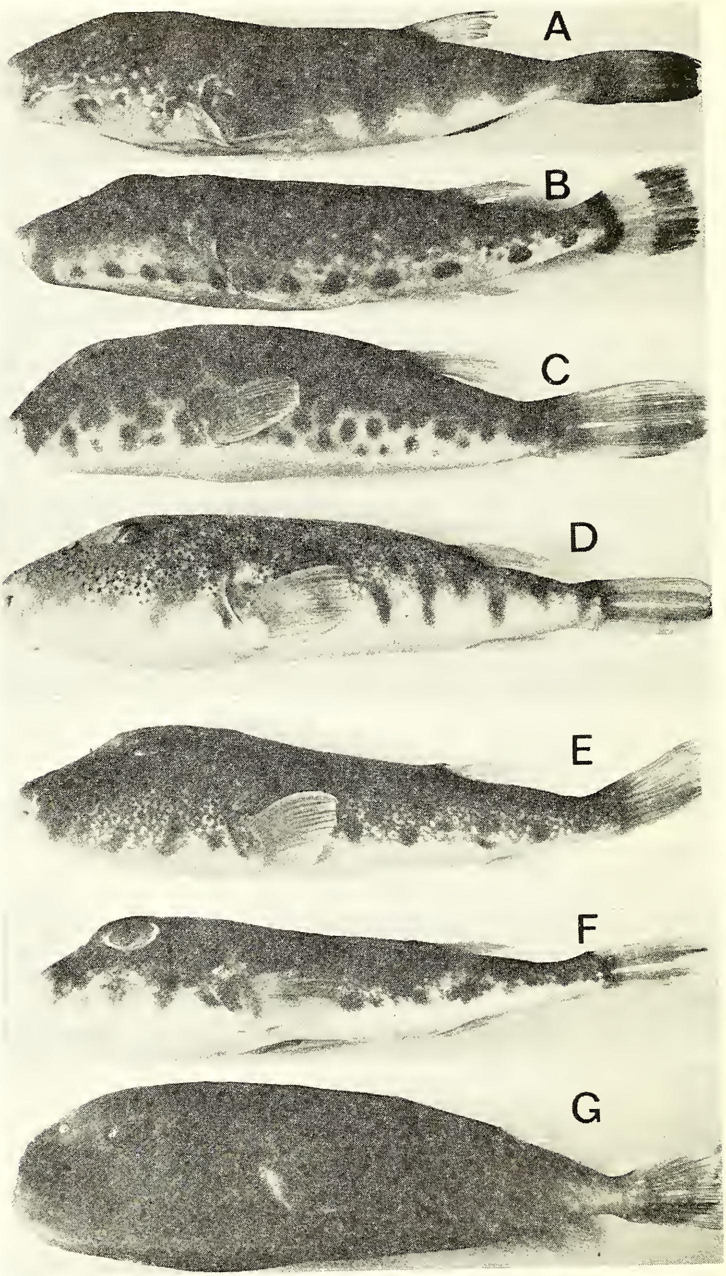
This hypothesis supports that proposed by Springer (1959) for an explanation of the strikingly similar distribution of the blenniid fishes, *Chasmodes bosquianus* and *C. saburrae*, although the geologic dates which he suggested for various shorelines may be erroneous.

Among other species of fishes with distributional patterns similar to S. *parvus* in the northern and western Gulf are the sole, *Gymnachirus texae* (see Dawson, 1964), the sparid, *Stenotomus caprinus* (see Caldwell, 1955), and the cyprinodont, *Fundulus confluentus pulvereus* (see Relyea, 1965).

KEY TO SPECIES OF *SPHOEROIDES* ON THE ATLANTIC AND GULF COASTS OF THE UNITED STATES

Although the status of the puffers in the Southern and Eastern Atlantic Ocean and parts of the Caribbean has not yet been studied satisfactorily, the species which occur on the shores of the United States (Atlantic and Gulf of Mexico) are now sufficiently well known to provide a key to facilitate their identification.

1A. Lappets (small fleshy tabs) present on dorsum; either a single, black pair on the dorsum about one-half the distance between the posterior margins of the orbits and the dorsal fin origin, or many tan lappets (most easily seen when specimens are im-


A
B
C
D
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G

mersed in water) scattered on the posteriolateral and dorsolateral surfaces 2

1B. Lappets absent 3

2A. A single pair of black lappets present on the dorsum. Cheeks often marbled. From one to five poorly defined dark blotches present on the lateral body surface posterior to the pectoral fin .... S. *dorsalis* Longley, Marbled puffer. Widespread in western Atlantic and adjacent waters, in relatively deep water (10–50 fathoms). Fig. 5A.

2B. Many tan lappets present on the posterior portions of the body, usually concentrated near the ventrolateral body angle. No marbled pattern on cheeks. Five to eight (usually six or seven) sharply defined, rounded lateral spots posterior to the pectoral fin bordering the ventrolateral body angle .... S. *spengleri* (Bloch), Bandtail puffer. Widespread in the western Atlantic and adjacent waters, in shallow water. Fig. 5B.

3A. Body variously mottled, not uniformly pigmented. Caudal dusky, sometimes with pigment concentrated at base and distal end, giving an indistinct barred appearance. Least bony interorbital width 8.5 percent or less of SL 4

3B. Body uniformly pigmented, except usually a few scattered spots on dorsal and lateral surfaces. Caudal dusky except for distal tips which are usually lighter. Least bony interorbital width 9 percent or more of SL 7

4A. One or two distinct, white, interorbital bars, the posterior often connected by a posterior perpendicular extension to a dorsal pattern of coarse white arches and circular markings .... S. *testudineus* (Linnaeus), Checkered puffer. Widespread in Caribbean, southern Gulf of Mexico, and warmer waters of the western Atlantic, in shallow water. Fig. 5C.

4B. One vague, dark interorbital bar. No dorsal pattern of coarse white arches 5

5A. Several (usually six-eight) distinct, vertically elongate bars posterior to pectoral fins. Dorsal and lateral surfaces in mature speci-

←

FIGURE 5. A. *Sphoeroides dorsalis*, ANSP 105185, 127 mm SL, Tobago. B. *Sphoeroides spengleri*, ANSP 104555, 111 mm SL, Columbia. C. *Sphoeroides testudineus*, FSU 11928, 86 mm SL, Jupiter Inlet, Florida. D. *Sphoeroides maculatus*, UF 11773, 171 mm SL, Georgia. E. *Sphoeroides nephelus*, UMML 1366, 197 mm SL, Cocoa, Florida. F. *Sphoeroides parvus* FSU 15365, 84 mm SL, Mobile Bay, Alabama. G. *Sphoeroides pachygaster*, BLBG, Silver Bay 2190, 132 mm SL, Atlantic Ocean, off South Carolina.

mens (above 70 mm) covered with tiny (1–2 mm) jet-black spots. Prickles on ventral surface extend posteriorly beyond the anus, usually to the anal fin origin. Pectoral rays 15–17, usually 16 ....

.... *S. maculatus* (Bloch and Schneider), Northern puffer. Western North Atlantic, from Newfoundland to northeast Florida, usually in shallow water. Fig. 5D.

5B. Spots present posterior to pectoral fins. No tiny jet-black spots on dorsal or lateral surfaces. Prickles present or absent, but when present, do not extend beyond the anus. Pectoral rays usually 14 or 15 (rarely 13 or 16) 6

6A. Spot at axil of pectoral fin more intense than any other on body. Bony interorbit usually concave; least bony width narrow, more than 4 in snout. Adults commonly exceed 125 mm SL ....

.... *S. nephelus* (Goode and Bean), Southern puffer. Caribbean, eastern Gulf of Mexico, and Atlantic coast of Florida, in shallow water. Fig. 5E.

6B. Spot at axil of pectoral fin absent, or if present, rarely more intense than other spots on body. Bony interorbit nearly flat; least bony width broad, less than 4 in snout. Not known to reach 120 mm SL ....

.... *S. parvus* Shipp and Yerger, Least puffer. Northern and western Gulf of Mexico, in shallow water. Fig. 5F.

7A. Body smooth. Caudal short, more than 6 in SL ....

.... *S. pachygaster* (Müller and Troschel), Blunthead puffer. Most of western Atlantic, in relatively deep water (30–100 fathoms). Fig. 5G.

7B. Prickles on dorsal and ventral surface. Caudal moderately long, about 5 in SL ....

.... *S. trichocephalus* (Cope), Hairy puffer. Known from one specimen washed ashore at Rhode Island. Not figured.

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PROCEEDINGS
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CHAPINIA ELBELI TENDEIRO, A SYNONYM OF *CHAPINIA FASCIATI* ELBEL (MALLOPHAGA: MENOPONIDAE)

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Tendeiro (1967) described *Chapinia elbeli* from two males and one female off *Tockus alboterminatus stegmanni* (Neumann), but Elbel (1967) previously described *C. fasciati* from *T. f. fasciatus* (Shaw) as type host with paratypes from *T. a. suahelicus* (Neumann).

Through the courtesy of Dr. Tendeiro, the holotype, allotype and paratype of *C. elbeli* were examined and appear to be morphologically identical with *C. fasciati* from the type host, from *T. a. stegmanni* in the American Museum of Natural History, and from *T. a. australis* (Roberts) in the United States National Museum.

Tendeiro stated that *C. elbeli* differed from *C. fasciati* and from other members of the *lophocerus* species group in the male genitalia by the external indented swelling near the posterior end of the parameres, by the two fingerlike posterior points of each lateral horn, and in the female by the absence of sclerital hooks on each side of the midline of the ventral sclerite between the vulva and anus. In addition he stated that the female anal fringe had 62 setae. Although not mentioned or illustrated by Elbel, the indented swellings on the parameres are present in all members of the *lophocerus* species group, and are the sockets from which the parameres are split posteriorly, a character which separates the other two species groups from the *lophocerus*. An examination of Tendeiro's specimens shows that both males do indeed possess two rounded posterior points on each lateral horn of the genitalia as in *C. fasciati*, and the female does have sclerital hooks on each side of the midline of the ventral sclerite between the vulva and anus as in all members of the *lophocerus* species group. However, the female anal fringe has 64 setae in Tendeiro's specimen, 66 and 68 in a specimen each from the American Museum of Natural History and the United States National Museum. Thus, the range of the anal fringe of *C. fasciati* is 64–86 rather than 70–86 as given by Elbel. *C. camuri* Elbel has an anal fringe of 60–64 setae; but *C. fasciati* from both host species, including Tendeiro's specimen, has the ventral sclerite between the vulva and anus elevated medially between the sclerital hooks more than in *C. camuri*.

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NOTROPIS XANTHICARA, A NEW CYPRINID FISH FROM THE CUATRO CIÉNEGAS BASIN, NORTH-CENTRAL MÉXICO

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The *lutrensis-ornatus* group of the subgenus *Cyprinella* of *Notropis* (Gibbs, 1957) includes in the middle Río Grande and adjacent drainages a number of nominal and undescribed forms related to *Notropis proserpinus* (Girard). *Notropis proserpinus*, as understood by us, lives in clearer waters of the lower Pecos River system from southern New Mexico (Koster, 1957) south and east to the Devil's River and San Felipe Spring, Val Verde County, Texas. Koster's implication (p. 68) that this species is present in the lower Río Grande Valley, New Mexico, is unverified. *Notropis lepidus* (Girard) inhabits spring-fed waters of the Nueces, Frio, Medina, and Guadalupe River systems in Texas (Hubbs, 1954). *Notropis rutilus* (Girard) is in similar habitat in the ríos Salado and San Juan, northern México. And, two undescribed species, one from the basin of the Río Conchos, Chihuahua, México (Salvador Contreras B. and Minckley, unpublished), and the other from the semi-isolated Bolsón of Cuatro Ciénegas, central Coahuila, northern México (Minckley, 1969), complete the assemblage. The present contribution describes the Cuatro Ciénegas form, and is one in a series of papers resulting from research supported by N.S.F. Grants GB-2461 and GB-6477X. Thanks are due the curators of various museums for aid in obtaining specimens, the personnel who assisted in collections, and persons who assisted in analyses. Permission to collect in various states, and in Mexico, readily granted, is gratefully acknowledged.

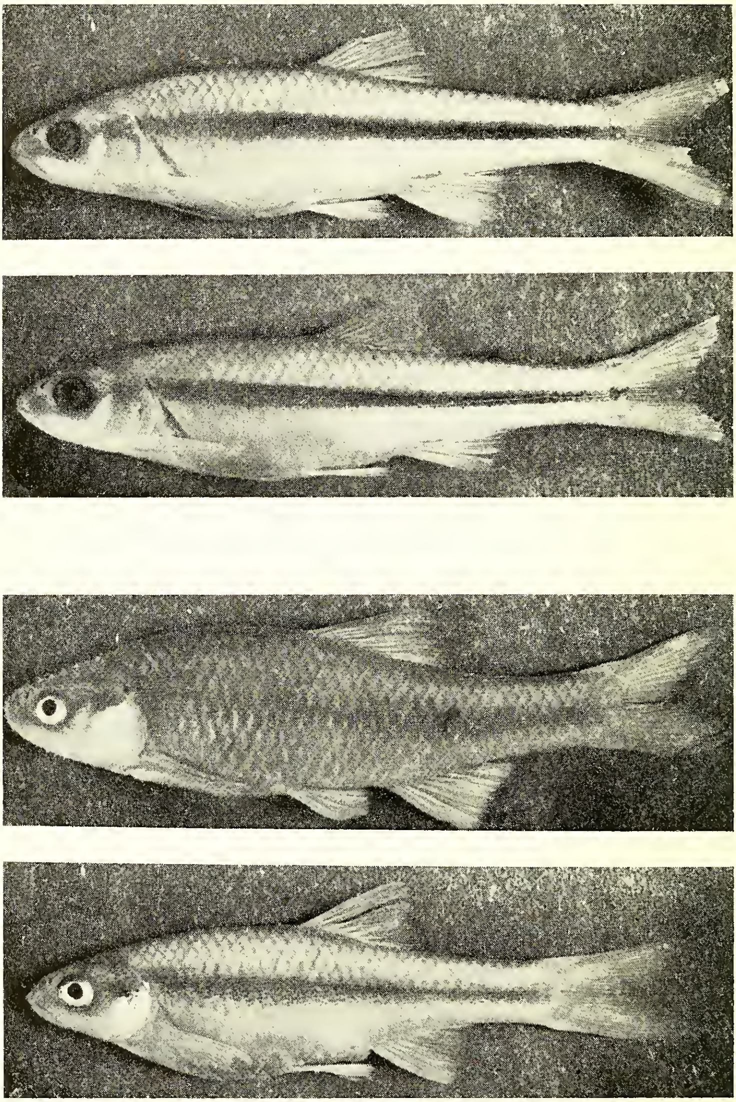

Figure 1. Male and female paratypes of *N. xanthicara* (KU 7404; upper) and a male and female of *N. rutilus* from the Río Salado de los Nadadores (KU 7347; lower).

Notropis xanthicara new species

(*Notropis* sp., Minckley, 1969)
Cuatro Ciénegas shiner (Fig. 1)

Diagnosis: *Notropis xanthicara* is a member of the subgenus *Cyprinella* of *Notropis*, as delimited by Gibbs (1957), and is most closely related to the nominal *N. rutilus*, from which it probably arose. The new species may be distinguished from the latter, and from other members of the subgenus, by the following combination of characters: body terete, not obviously slab-sided; lateral-line scales usually 34, often 33; anal fin-rays usually eight; pharyngeal teeth 4–4, slender and hooked, with serrated grinding edges; lower jaw included; lateral band black, discrete, about one scale-row wide, extending to, but not through, eye, appearing again as as a pre-ocular streak on each side of snout; scale pockets weakly outlined on abdomen; belly immaculate, with black peritoneum showing through midline; predorsal streak broad and diffuse; postdorsal streak faint to absent; gular area variably darkened, interopercular area and anterior part of breast sometimes bearing melanophores; breeding male predominantly yellow, especially on head and fins; nuptial tubercles on snout of breeding males separated from those on dorsum of head by a distinct hiatus.

Material: About 1,000 specimens of *Notropis xanthicara* were examined, from throughout the Cuatro Ciénegas basin. Detailed locality data are provided only for the holotype and for paratypes. Information on non-type material of *N. xanthicara*, and on comparative material of *N. rutilus*, is by river system only. Detailed reports on range and variation of the entire species-group are in preparation. The abbreviations for depositories are as follows: ASU = Collection of Fishes, Arizona State University, Tempe; KU = Museum of Natural History, University of Kansas, Lawrence; UMMZ = University of Michigan Museum of Zoology, Ann Arbor; and UNL, Laboratorio de Vertebrados, Universidad de Nuevo Léon, Monterrey. Additional materials, loaned by Tulane University and the University of Texas, will be reported later. All localities in the Cuatro Ciénegas basin are given in kilometers (km) from the center of Cuatro Ciénegas. Field data has been revised to correspond to the detailed map published by Minckley (1969), and reproduced here in simplified form as Figure 2.

Notropis xanthicara: Holotype—UMMZ 188782, a mature, tuberculate male, 45 millimeters (mm) long, collected 6 April 1961 by R. R. Miller and family, C. L. Hubbs, D. R. Tindall, and W. L. Minckley, Río Puente Colorado, 8.5 km south and 0.7 km west of Cuatro Ciénegas, Coahuila, México. Paratypes—UMMZ 179834, 11 specimens, collected with the holotype; ASU 969, 8 specimens, collected at the type locality, 10 June 1964. ASU 2316, 185 specimens, collected 25 December 1965, Río Churince, 14.7 km south and 7.0 km west. UMMZ 179202, 46 specimens, collected 6 April 1961; UNL 703, 6 specimens, and UNL 709, 105 specimens, collected 26 and 27 August 1964, respectively, all from Posos de la Becerra, 11.4 km south and 6.7 km west. ASU 3728, 68 specimens,

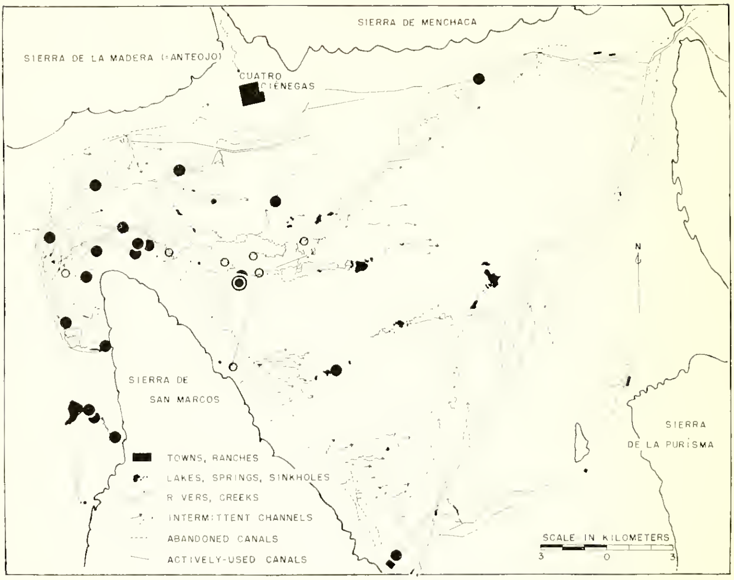

FIGURE 2. Distributional records for *N. xanthicara* in the Cuatro Ciénegas basin, Coahuila, México; dots = localities for specimens in museums, open circles = field observation of the species, and the circle dot = the type locality (map modified from Minckley, 1969).

collected 16 August 1968, Río Garabatal, 6.7 km south and 8.8 km west. KU 7404, 72 specimens, collected 17 April 1963, Canal de Julio, 3.4 km south and 1.2 km east. UMMZ 179860, 53 specimens, collected 9 April 1961, Río Mesquites, 8.2 km south and 0.8 km west. Additional material (non-types)—Río Churince system (see Minckley, 1969, for details on intra-basin drainages; numbers of specimens are in parentheses): ASU 1658, 1747, 2332; KU 7389; UMMZ 179878 (99 fish). Posos de la Becerra-Río Garabatal system: KU 7374, 7383; UMMZ 179827 (56). Lagunas de Juan Santos: UNL 714 (45). Río Mesquites system: ASU 2268; KU 7363, 7394 (151). Río Puente Chiquito system: UMMZ 179205 (125). Canal de Saca del Fuente: ASU 945 (2). Tío Candido system: UMMZ 179221 (1). Santa Tecla system: KU 7421 (5).

Notropis rutilus: E. G. Marsh collection (discussed later): UMMZ 130377, 130387. Río Salado system: ASU 913, 1723; KU 7347; UMMZ 130366, 130369, 130398, 179805, 179812; UNL 439, 688, 697. Río San Juan system: UMMZ 97420–7 (97421 = topotypes), 124425, 146980, 162131; UNL 29, 648.

Description and Comparisons: *Notropis xanthicara* is similar in most respects to *N. rutilus*, differing principally in features of pigmentation and in its slender, more delicate structure (Fig. 1). Fin-rays of the new form are especially fragile. Anal rays, counted as the last two sharing a common base, number eight in 264 of 283 fish, ranging from seven (two fish) through nine (17 fish). A similarly strong mode of eight anal rays is present in 447 counts available for *N. rutilus* (six rays in one; seven in five; eight, 371; and nine, 70).

Length of the dorsal fin in *N. xanthicara* is usually equal to or greater than depth of body. In *rutilus* the length of the dorsal fin is most often less than greatest depth of body. Shape of the dorsal is similar in both species: the fin is square to slightly concave at its distal margin, and the anterior rays reach approximately to the tip of the last, when the fin is depressed. The anal fin of *xanthicara* tends to be slightly falcate, especially in larger adults, with the first rays extending past the tip of the last when depressed. In *rutilus*, the distal border of the anal fin is squared to slightly falcate, but the first ray usually falls short of the tip of the last (except in some breeding males). Caudal fins are large in both forms, but in *xanthicara* the upper lobe is slightly more expansive, and the lower more elongate and acutely tipped.

Standard lengths range from 30.2 to 56.0 mm in *N. xanthicara* (149 fish) and from 30.0 to 60.0 mm in our sample of *rutilus* (447 fish). Origin of the dorsal fin is slightly more posterior in *N. xanthicara*. Ranges which follow mean values represent, first, the over-all range obtained, and second, the range of means for 13 samples of *xanthicara* and for 23 populations of *rutilus*. Predorsal length averages 54.1 per cent of standard length (49.5–59.5; 53.1–55.6) in *xanthicara*, and is almost identical in *rutilus*, 53.3 per cent (50.0–58.0; 51.2–55.7). Dorsal-fin origin is behind the insertion of the pelvic fins in both species. Prepelvic lengths are more different than predorsal lengths, averaging 52.2 per cent of standard length for *xanthicara* (48.6–56.3; 50.3–53.7), and 50.2 per cent for *rutilus* (46.9–55.0; 48.8–51.7).

The paired fins are relatively small in *N. xanthicara*. The pectoral fins are acutely tipped, then gently rounded on their distal margins. They extend 2/3 to 3/4 of the distance to the pelvic-fin bases, and are slightly longer in males. Pectoral fins of *rutilus* from the Río Salado system are similar, as are those of non-breeding specimens from the Río San Juan basin. However, some samples of males of *rutilus* from San Juan have expansive, elongate pectoral fins. The pelvic fins of *xanthicara* are pointed, with an almost-straight distal margin. Pelvic fins of *rutilus* are more rounded and often longer.

Mean numbers of lateral-line scales differ slightly. About 66 per cent of the 149 *N. xanthicara* counted have 34 scales in the lateral series; 21 per cent has 33 (mean 33.9, range 33–36). In the sample of 447 *rutilus*, about 42 per cent has 34 scales, and 40 per cent has 33 (mean 33.6, range 32–36). The holotype of *xanthicara* has 35 lateral-line scales, and lacks a lateral canal on the three posterior scales on the left side; although some scales are regenerated, the canal appears normal on the right side and such aberrations are rare in the series examined. The lateral line is gently decurved in *xanthicara,* and there is little pigmentation associated with it except where it passes through the discrete lateral band. *N. rutilus* has a strongly decurved lateral-line canal, and melanophores are often positioned as small spots or crescents along the canal at scale margins.

The head of the new form is attenuate, slender dorso-ventrally, and its length averages 26.6 per cent of standard length (23.1–29.1; 24.8–28.0). Head length in *rutilus* is similar, averaging 26.1 per cent (22.9–30.2; 24.7–28.8), but it is more blunt (Fig. 1). These slight differences reflect in part the longer snout of *xanthicara,* 8.0 per cent of standard length (6.2–9.5; 6.8–8.8), as opposed to an average of 7.1 per cent for *rutilus* (5.3–9.0; 6.6–8.2). Orbital lengths are very similar, 9.0 per cent (6.4–11.9; 8.1–10.6) and 8.4 per cent (6.4–11.3; 7.7–9.3), respectively. The mouths of both species are oblique, more so in young, and lower jaws are reduced and included within the upper; the angles from the mandibles to the lower side of the head are abrupt (Fig. 1).

Body depth and width of *N. xanthicara,* respectively, average 21.7 per cent (17.8–25.6; 19.1–23.3) and 12.4 per cent (10.0–14.9; 11.1–13.5) of standard length, as opposed to 23.1 per cent (18.9–28.1; 21.3–25.5) and 12.2 per cent (8.6–17.4; 10.5–14.3) for *rutilus.* Variation is high as a result of sexual, seasonal, and individual variations. The slenderer body of *xanthicara* is reflected, however, in the less variable measurement from the dorsal origin to the anal origin, which averages 25.3 per cent for the new form (21.2–27.8; 23.5–26.3) and 27.0 per cent for *rutilus* (23.2–32.8; 25.3–29.1). The discrete lateral band of *xanthicara* emphasizes its slightly slenderer body and gives the impression of an elongate fish (Fig. 1). Depth of caudal peduncle averages 10.3 per cent (8.9–13.2; 9.6–11.0) of standard length, and its length averages 23.1 per cent (18.8–26.1; 21.7–24.0) in *xanthicara*; *rutilus* has a thicker, slightly longer caudal peduncle, depth 11.1 per cent (9.3–15.3; 11.0–12.4) and length 24.1 per cent (20.3–28.2; 23.2–25.1).

Pigmentation of *N. xanthicara* is highly diagnostic. The external aspect is dominated by a discrete, blue-black lateral band that extends from the darkened two to five (usually four) rays of the middle caudal fin, through a diffusely-broadened caudal spot, to the back of the eye, becoming variably diffuse, downward, onto the opercle. The cornea is relatively unpigmented, but the band continues as a pre-ocular bar that terminates about 2/3 of the way along the snout. The lateral band of *rutilus* is much less discrete, and is highly variable in expression. Slight blackening of the central caudal fin-rays in *rutilus* is separated from the lateral band by a depigmented area just over the end of the hypural plate. The band usually broadens slightly below the dorsal-fin base, and it may almost disappear as it passes anteriad, especially in breeding individuals. The lateral pigmentation is scarcely evident above the opercles of *rutilus,* and the preocular component usually is obscured by darker snout pigmentation.

The body of *N. xanthicara* is pallid except for the lateral band. Scale margins on the dorsum are diffusely pigmented, giving a cross-hatched appearance (intensive in breeding individuals), but melanophores are scarce and randomly distributed on the ventro-lateral surfaces. The belly is surficially immaculate, with the peritoneum showing through at the midline. Cross-hatching on the upper sides and back of *rutilus* is accompanied by pigmentation of the intervening spaces, giving a much darker aspect. Melanophores often extend below the lateral band, especially onto the abdomen. The belly of *rutilus* is white, and the usually-speckled peritoneum does not show through at the midline. The pigmentation of the peritoneum of *rutilus* ranges from dusky to speckled, but it is invariably black or dark brown in *xanthicara.*

The predorsal streak of *N. xanthicara* is broad and diffuse; a postdorsal streak often is lacking. The predorsal streak is interrupted by a narrow, relatively depigmented band at the nape, marking the passage of the supratemporal canal, then broadens to a heart-shaped or sub-hexagonal spot over the parietal and posterior part of the frontal bones. This spot is bounded anteriorly by another, transverse, elliptical, depigmented area. There is a second, heart-shaped area of large melanophores over the frontal bones, between the orbits, then fine melanophores dust the snout and (variably) the upper part of the upper lip. The arc of the lower part of the lower lip is similarly dusted with melanin, and this leads medially into a dusky gular streak. The streak may involve the extreme anterior part of the breast in some darker fish, but it is sometimes absent in lightened individuals. Except for a circumorbital scattering of melanophores, and an occasional larger one, the cheeks, lower parts of the branchiostegal rays, and the medial parts of the mandibles are silvery white.

Both a predorsal and a postdorsal streak are present in *N. rutilus*, the latter less distinct. Details of dorsal head pigmentation are typically masked by dark melanophores that may extend to the tip of the snout and to the tip of the upper jaw. There is strong circumorbital melanization. The gular streak is typically dark, and extends back to include the anterior part of the breast in some individuals.

There are deep-lying melanophores associated with the bases of both the anal and dorsal fins in both species. However, these are often masked by other pigment in *N. rutilus.* Pigmentation of the fins themselves in non-breeding individuals of *xanthicara* is mostly restricted to melanophores lining each delicate ray. The dorsal fin has a dark anterior margin, resulting from greater concentrations of pigment along the leading rays. In some fish elongate melanophores darken the interradials of the distal third of this fin. There is a tendency for concentration of pigment on the procurrent caudal fin rays of *xanthicara*, which, along with the caudal extension of the lateral band, gives an impression of a distinct triad of caudal spots in individuals with more intense pigmentation. The anal fin is sparsely pigmented, except at its base. The pelvic fins have a darkened leading edge, but the remainder is clear. The pectoral fins are blackened anteriorly, with scattered melanophores posteriorly, and distally darkened on rays and interradials in some individuals. Pigmentation of the fins of *rutilus* is exaggerated over that of *xanthicara*, especially in the dorsal fin which often appears sooty gray. The procurrent and major unbranched caudal fin-rays are blackened, but no pattern is evident.

Breeding males of *N. xanthicara* are exceedingly colorful. The following notes, transcribed in edited form from field observations of the holotype and male paratopotypes, span most variations that we have seen: head brassy-gold over dorsum and onto snout, color interrupted on sides of snout and on opercles by dark melanophores, but continuing ventrally on opercle; yellow continuing on dorsum to caudal fin, overlying gray or brown ground color that is distinctly cross-hatched. Lateral band intensely prominent; sides below lateral band pinkish-orange; belly white, slightly suffused with yellow; pectoral fins lemon-yellow in center, color more intense anteriad and with a dark black, leading edge; pelvic fins with a dark leading edge margined posteriad by an irridescent, bluish line (milky-white in some), then the remainder of the fin yellow; anal fin transparent distally and proximally, yellow centrally; caudal fin intense yellow in belly of lobes, light yellow proximally, with procurrent rays and central rays black; dorsal fin yellow-orange, opaque, with milky-white pigments proximally, edged with black; cornea yellow, reflecting blue dorsally; pupil jet black.

Breeding colors of male *N. rutilus* are to be detailed elsewhere. For purposes of comparison they consist of a greenish-yellow over-all aspect on the body, more intensely yellow below. The opercles and sides of the head are yellow and the dorsum of the head and snout are green or orange-green (the latter is rare). The fins are milky-yellow to bright yellow, except for the dorsal which sometimes is blackened. Very little black pigmentation is evident, except in the dorsal fin, and the lateral band is often totally masked.

Tuberculation of breeding males of both species consists of strong organs on the dorsum of the head, separated from smaller ones on the snout by a narrow, pre-narial hiatus. Tubercles often appear on the chin, and granulations are present on the cheeks and gular areas. *N. rutilus* usually develops small tubercles on the nape, while *xanthicara* does not. There is a strong band of densely concentrated tubercles above the anal base and along the lower sides of the caudal peduncle in both forms. This rarely extends more than half the length of the peduncle in *rutilus*, but may go to the procurrent rays of the caudal fin in *xanthicara*. Tubercles develop on all fins, those on the pectorals usually as a double row on the second through fifth rays and as single rows on the sixth and (rarely) seventh rays. On other fins, tubercles vary in occurrence on the second through fourth or fifth rays; they are rarely present on the dorsal or caudal fins.

Etymology: The name "*xanthicara*" is a compound of the transliterated Greek words "*xanthos*" (yellow) and "*cara*" (or "*kara*"; top of head), that describes part of the breeding coloration of the new form. "*Kara*" is a neuter noun; its use in a compound name dictates retention of its ending. We, however, follow general usage (Hubbs and Hubbs, 1958) in treating *Notropis* as masculine.

Discussion: *N. xanthicara* presently is allopatric to other species of *Notropis*. Intensive collecting in the Río Salado de los Nadadores, just east of the Cuatro Cíenegas basin, and elsewhere, has produced only *N. rutilus*. Conversely, samples from the canals on the north and northeast (outlet) sides of the basin have produced no specimens of either species, and *xanthicara* prevails (though rare) in parts of the basin where *rutilus* might be expected. E. G. Marsh, Jr. collected a *Notropis* at two places within the Cuatro Ciénegas basin in 1939, most likely from Canal de La Angostura (Minckley, 1969). These specimens (UMMZ 130377, 130387) correspond with *rutilus* in all critical characters of pigmentation, and in features of body proportions and meristics. In more than 50 seining collections in that canal since 1960, *Notropis* was taken only once, and they are *xanthicara* (KU 7374). As noted above, shiners are very rare on the north side of the basin. Perhaps more intensive manipulation of canals in that area now than in the past excludes these fishes.

Some specimens of *N. rutilus* from the Río Salado de los Nadadores have pigmentation approaching that of *xanthicara*. This is especially evident in non-breeding fish. We have been unable to define intermediacy of these samples on the basis of other characters, and presently consider this a response to the clarity of water in that stream. However, it is possible that hybridization influence, the selective introgression of pigment characters, has occurred between *xanthicara* and the downstream population of *rutilus*; the problem is under additional study.

Five specimens from Laguna de los Fresnos (Santa Tecla system; KU 7421) differ somewhat from other *N. xanthicara*. They tend to have long heads (27.2 per cent of standard length, range 25.4–28.6), with reduced snouts (7.4 per cent, 6.8–7.9) and large eyes (10.2 per cent, 9.4–11.7). Their body depths and the measurement from dorsal to anal-fin origin are high (22.6 per cent [21.1–25.1] and 27.0 per cent [25.5–28.7], respectively), tending toward *rutilus*. Pigmentation of these fish is darker than usual for *xanthicara*, and is much more similar to that species than to *rutilus*; their peritonea are black. The Santa Tecla system is largely disjunct at present, partially a result of canalization, and has been studied less than other parts of the Cuatro Ciénegas basin. Nevertheless, 17 collections have been made in the system, and only one included shiners. We consider the Los Fresnos specimens to be a form of *xanthicara*, deferring speculation on their status until additional material becomes available.

There seems little doubt that *N. xanthicara* is derived from *N. rutilus* or its progenitor, probably in isolation in the large springs and spring-fed streams of the basin it now inhabits. Isolation of the Cuatro Ciénegas basin has undoubtedly occurred sporadically for millenia; levels of differentiation of aquatic organisms living there range from endemic subfamilies and genera in molluscs (Taylor, 1966), through vertebrates and invertebrates that do not differ from animals living outside (Minckley, 1969).

N. xanthicara is intermediate to these extremes, and probably dates to later Pleistocene. The other five described endemic fishes range from *Cyprinodon bifasciatus* Miller (1968), which is considered an ancient, pre-Pleistocene, relict, through the distinct, but less highly differentiated *C. atrorus* Miller, *Lucania interioris* Hubbs and Miller (1965), *Gambusia longispinis* Minckley (1962), and *Xiphophorus gordoni* Miller and Minckley (1963). Three cichlids and a darter (Percidae) remain to be described, which will elevate the total endemic fish component of the basin to more than 50 per cent (10 of 18 known species). Other species, a catfish, *cf. Ictalurus lupus* (Girard), a largemouth bass, *Micropterus salmoides* (Lacépède), and a sunfish, *Lepomis megalotis* (Rafinesque), all are different from the forms outside the basin, though probably not more than subspecifically.

N. xanthicara occurs widely in the Cuatro Ciénegas basin (Fig. 2), but has never been taken in shallow marshes or in larger, terminal lakes. It is most abundant in the upper reaches of streams, just below their origins in limnocrenes, and often concentrates at the transition dividing lentic and lotic conditions. In streams and canals the fish lives in groups of three to 25 individuals in zones of shear between current and backwater, or moves near the bottom in current. In day time they are rarely on bottom, but forage at the surface and inspect almost all floating objects at any depth. At night, the fish rest on the bottom in eddies, in groups of four to more than 30 individuals, and are lethargic in the spotlight of a diver. Nothing has been observed on the breeding activities of this species.

N. rutilus tends to concentrate above and below riffles, with aggregations of nuptial males often occurring on the swiftest riffles and females remaining in associated eddies or pools.

The most common associates of *N. xanthicara* are the Mexican tetra, *Astyanax fasciatus mexicanus* (Filippi) and *Dionda episcopa* Girard, the roundnose minnow, both in the springs and in streams. Both other species tend to favor swifter waters, however, and are more active and aggressive. At one time or another, *N. xanthicara* has been caught in association with most other fishes in the basin (Minckley, 1969), except for those that characterize marshes or saline lakes (*C. atrorus*, *L. interioris*, and *G. longispinis*).

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BIOLOGICAL INVESTIGATIONS OF THE DEEP SEA. 50. THE VALIDITY AND GENERIC POSITION OF *PENTAGONASTER PARVUS* PERRIER (ECHINODERMATA, ASTEROIDEA)[1]

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When Perrier reported on the sea stars collected by the *Blake* (1881, 1884), one of the new species he described was *Pentagonaster parvus.* Verrill (1899: 151–156) examined the syntypes of *Pentagonaster parvus* and concluded that they were young specimens of *Goniaster americanus* Verrill (= *Asterias tessellatus* Lamarck). I have examined the syntypes of *P. parvus*, as well as many other specimens. I have also examined many young specimens of *Goniaster tessellatus* and have concluded that *Pentagonaster parvus* is a valid species belonging to the genus *Tosia.*

This research was supported by the National Science Foundation through grant GB-4936. I am grateful for the assistance of Dr. Lowell P. Thomas of the Institute of Marine Sciences, University of Miami, Dr. H. B. Fell of the Museum of Comparative Zoology, Harvard and Miss Maureen E. Downey of the U.S. National Museum.

Tosia parva (Perrier, 1881)

Pentagonaster parvus Perrier, 1881, p. 19; 1884, pp. 36, 37, 231, pl. 7, figs. 7–8.—Sladen, 1889, pp. 265, 267, 746–747.—?H. L. Clark, 1898, p. 5.

Goniaster americanus (pars) Verrill, 1899, pp. 154–156, pl. 26, fig. 6.

Plinthaster dentatus (pars) Gray, et al., 1968, fig. 25.

Material studied: 22 specimens from the following localities: Lectotype: R = 10.5 mm, r = 7.5 mm, R/r = 1.4; *Blake* sta. 253, off Grenada,

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[1] Contribution No. 1098 from the Institute of Marine Sciences, University of Miami.

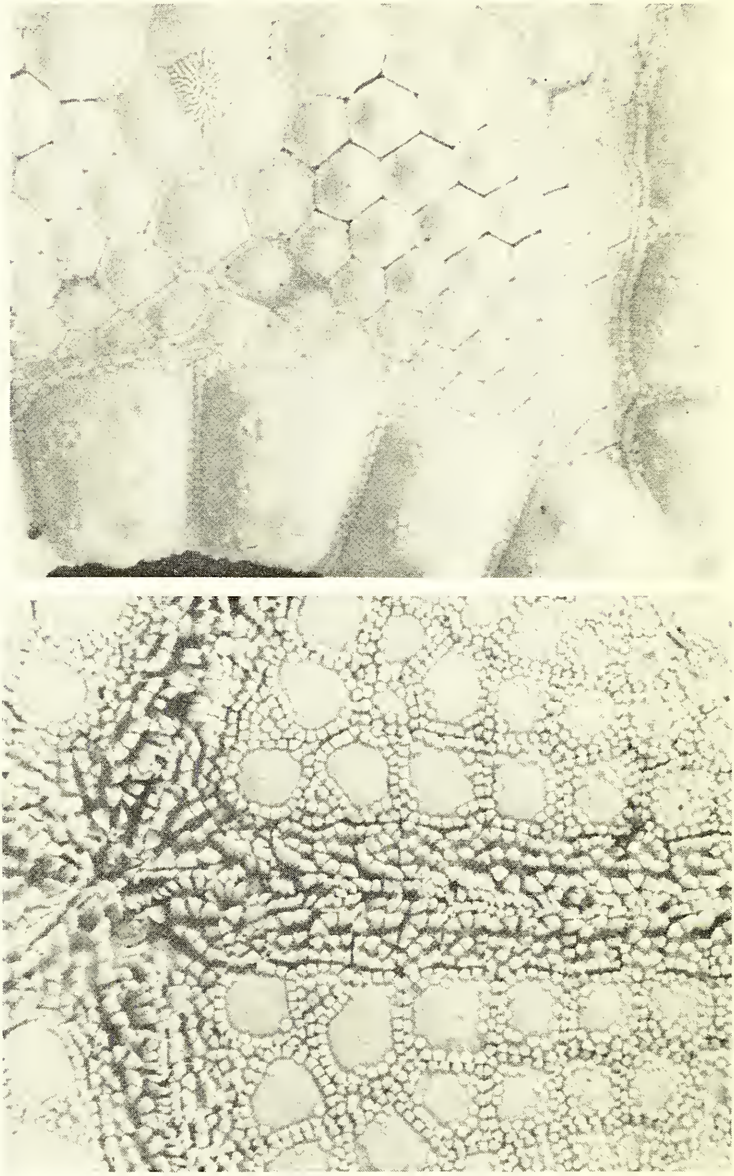

FIG. 1. *Tosia parva* (Perrier). Top, specimen from *Pillsbury* sta. 707, abactinal view, 6.1×.—Bottom, specimen from *Silver Bay* sta. 2263, actinal view, 7.8×.

168 m, 1878–79, MCZ 417.—Paralectotypes: *Blake*, West Indies, 172–229 m, 1877–79, MC 4283, (3 spec.).—1 spec., M/V *Silver Bay* sta. 2263, 33°04′N, 78°12′W, 30 m, 28 July 1960, UMML 40.149.—1 spec., R/V *Hernando Cortez* sta. E, 27°36′N, 84°13′W, 73 m, 4 January 1966, USNM E10851.—1 spec., M/V *Silver Bay* sta. 3496, 20°53′N, 73°42′W, 183, 4 November 1961, UMML 40.159.—1 spec., R/V *Pillsbury* sta. 478, 11°33′N, 62°09′W, 597 m, 2 August 1966, UMML 40.235.—2 spec., R/V *Pillsbury* sta. 707, 11°22′N, 62°22′W, 79 m, 19 July 1968, UMML 40.236.—13 spec., R/V *Pillsbury* sta. 734, 11°01′N, 63°35′W, 60–71 m, 22 July 1968.

Diagnosis: R not greater than 30 mm; $R/r = 1.3$–1.8. Abactinal and marginal plates bearing scattered granules in centers. Peripheral granules of abactinals in radial areas fused. Actinals surrounded by more than single row of granules. Five compressed adambulacral furrow spines; nine to ten mouth furrow spines.

Description: Five arms. $R = 22$ mm, $r = 46$ mm, $R/r = 1.5$. General from pentagonal to arcuate pentagonal.

Five primary plates conspicuously larger than other abactinals. Abactinal plates slightly convex; each surrounded by single row of large, flattened, rectangular granules. Granules surrounding plates in radial areas fused so that each plate surrounded by flattened, calcareous ring. Center of each abactinal plate bearing one to six round granules embedded in deep pits. Papulae confined to large radial areas.

Inferomarginals and superomarginals corresponding throughout wide interbrachial arc. Eight massive superomarginal plates; each surrounded by single row of small, rounded granules. Clusters of one to twelve round granules, similar to those of abactinals, scattered about each plate. Double row of large, flattened granules, similar to those surrounding abactinals along suture between superomarginals and inferomarginals. Granules twice as large at angle formed by two adjacent superomarginals and corresponding inferomarginals. Each enlarged granule bearing single, very small, rounded granule. Terminal plate small, naked. Ten massive inferomarginal plates; granulation similar to superomarginals.

Actinal intermediate area large; plates arranged in five chevrons. Actinal plates large, flat, rhombic; each plate surrounded by two to three irregular rows of coarse, rounded granules. Most plates having large naked central area; some plates bearing one to four scattered granules in central area.

Adambulacral plates square with straight furrow margin bearing five subequal, compressed furrow spines with blunt, rounded tips. Subambulacral spines in three to four irregular rows of three to five short, blunt spinules slightly taller than granules of actinal plates.

Each mouth plate bearing nine to ten furrow spines, similar to adambulacral furrow spines, but more strongly compressed, median spine being most compressed; median spine only slightly enlarged. Rest of plate covered by ten to twelve pyramidal spinules, slightly taller than subambulacral spines of adambulacrals.

Anus prominent, subcentral. Madreporite roundly triangular, about two-thirds as large as adjacent abactinal plates; located approximately one-third the distance from center of disk to middle of interbrachial arc. No pedicellariae.

Type: Museum of Comparative Zoology, cat. no. 417 (lectotype).

Type-locality: off Grenada, 168 m, *Blake* sta. 253.

Distribution: This species is found throughout the Antillean province, extending from 50 miles south of Cape Fear, North Carolina to Trinidad. Its bathymetric range is 30–597 m.

Discussion: The smallest specimen examined measures R = 6 mm. All its characters are the same as in an adult, except the peripheral granules of the abactinals of the radial areas are not yet fused.

The smallest specimen of *Goniaster tessellatus* I examined (R = 9 mm) is distinguished from *Tosia parva* by having naked superomarginals and the abactinal and actinal plates completely covered by granules. Specimens as small as R = 11 mm already have abactinal spines forming.

Pentagonaster parvus Perrier belongs in *Tosia* because of its pentagonal form, actinal granulation and lack of pedicellariae. It is distinguished from all other species of *Tosia* by its central abactinal and marginal granules. It is the only species of *Tosia* not from Australian waters and is a Tethyan relict.

The specimen collected at *Blake* station 253 is designated the lectotype and the type locality is restricted to off Grenada, 168 m. The specimens collected by the *Blake* at stations 32, 276 and 296 have been placed together and it is impossible to determine which specimen is from which station. These three specimens are designated the paralectotypes.

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A NEW SPECIES OF CAPRELLID (CRUSTACEA: AMPHIPODA) FROM OREGON

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In my paper on the Caprellidae of the Western North Atlantic (1968, p. 52) I discussed the species then known to be associated with echinoderms. Four species were listed which had been found clinging to sea stars. A fifth, belonging to an undescribed species, was brought to my attention by Irwin Polls and Dennis S. Greenley of Oregon State University. This species is herein described as new and named in honor of one of the collectors of the holotype.

Caprella greenleyi new species
Figure 1

Material examined: Oregon, Boiler Bay, collected by Irwin Polls and Dennis S. Greenley, intertidal from the starfish *Henricia leviuscula*, 1 ♂ holotype USNM 123523, 1 ovig. ♀ allotype USNM 123524, 1 ♀ paratype USNM 123525.

Description: Male holotype: Body and appendages robust and covered with microtubercles, pereonites 3 and 4 with anteriorly directed pleural projections. Length 2.7 mm.

Antenna 1 approximately length of pereonites 1 and 2, flagellum uniarticulate. Antenna 2 slightly shorter than antenna 1, flagellum uniarticulate.

Mouthparts typical of *Caprella* (McCain, 1968, p. 18).

Gnathopod 1 typical of genus, grasping margin of dactylus and propodus serrate, propodus with 2 proximal grasping spines. Propodus of gnathopod 2 broad, approximately 2/3 as wide as long, grasping margin with 2 proximal grasping spines and medial notch; dactylus massive and scimitar-shaped.

Propodus of pereopods 5–7 with 2 proximal grasping spines.

Abdomen typical of genus.

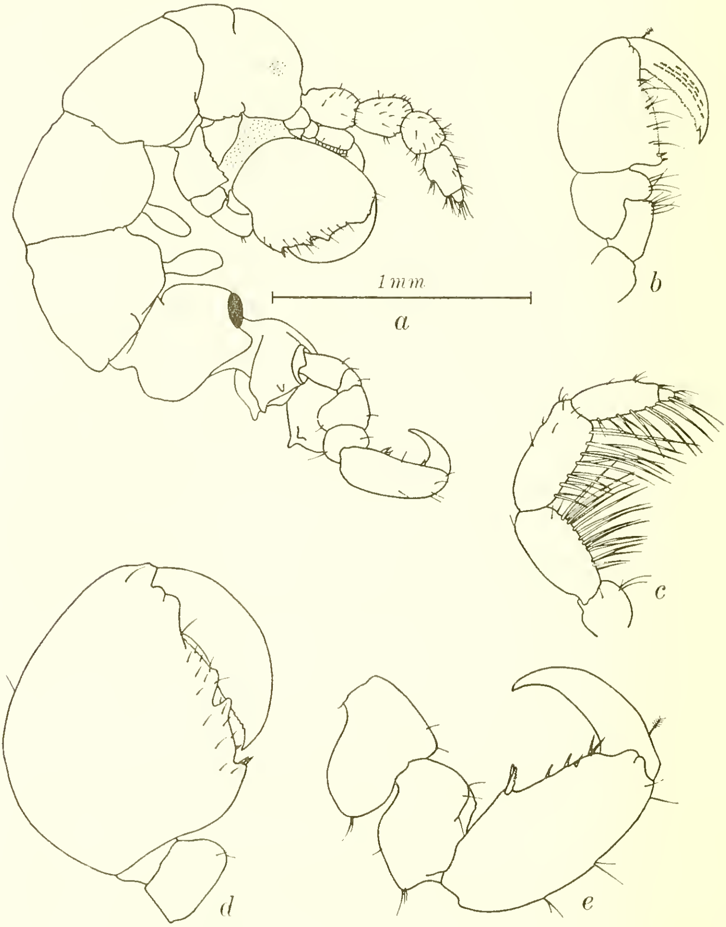

FIGURE 1. *Caprella greenleyi* new species. Male holotype: *a*, lateral view; *b*, gnathopod 1; *c*, antenna 2; *d*, gnathopod 2; *e*, pereopod 7.

Remarks:

This species can be distinguished from the other species of *Caprella* due to its small size, 2.7 to 3.6 mm, and the large broad propodus of gnathopod 2 with a massive, scimitar-shaped dactylus.

The male holotype and an ovigerous female of 3.6 mm were found clinging to a specimen of *Henricia leviuscula* which measured 6 cm from disk to arm tip. The female paratype measured 3.5 mm and was collected from a smaller *Henricia* of 1.6 cm. The caprellids were noticed after the sea stars were returned to the Yaquina Marine Biological Laboratory where they were held in tanks for study. A field examination of numerous specimens of *Henricia* failed to yield any other specimens of *C. greenleyi.*

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SYRINGONOMUS TYPICUS NEW GENUS, NEW SPECIES (ENOPLIDA: LEPTOSOMATIDAE) A MARINE NEMATODE INHABITING ARENACEOUS TUBES.

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Several collections of marine nematodes have been obtained from epibenthic trawls taken by the Woods Hole Oceanographic vessel, ATLANTIS II, on transects from Woods Hole, Massachusetts to Bermuda. Numerous specimens in one of these collections were partially enclosed in tubes, the latter usually cylindrical in shape and constructed of adhering particles of sand. The lengths of the tubes vary considerably due in part to breakage, but each has similar construction, and, with few exceptions, each accommodated a single nematode. Thirty-nine nematodes were removed from tubes and examined more carefully. Of this number, six are of species as yet unidentified. The remaining 33 are males, females and juveniles of a new genus and new species described below:

Syringonomus new genus

Diagnosis: Same as that of Leptosomatinae Filipjev, 1916. Body slightly tapered anteriorly and posteriorly. Cuticle smooth. Tail bluntly conical. Cephalic setae short. Cephalic capsule present, but apparent only in optical section. Amphid a small, indistinct pore. Stoma unarmed. Eyespots absent. Gubernaculum consisting of small, paired structures, lateral to distal ends of spicula; corpus of gubernaculum and lateral anterior projection absent. Setiform subventral supplements present, ventromedian supplements absent. Caudal glands and spinneret present.

Etymology: The name *Syringonomus* is derived from the Greek *Syringos* meaning tube, and *nomos* meaning a place for living.

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*Visiting Research Associate.

Syringonomus typicus new species

Specimens: *Holotype* (Male): National Museum of Natural History Number 39489.

Allotype (Female): National Museum of Natural History Number 39493.

Paratypes (Males): National Museum of Natural History Numbers 39490 thru 39492.

Paratypes (Females): National Museum of Natural History Numbers 39494 thru 39515.

Paratypes (Juveniles): National Museum of Natural History Numbers 39516 thru 39539.

Measurements:

Holotype: L = 5.377 mm; a = 65.9; b = 7.3; c = 37.9
Allotype: L = 4.936 mm; a = 40.1; b = 7.1; c = 41.8; V = 61.5.
Male Paratypes[*]: L = 6.061 mm; a = 64.1; b = 8.5; c = 42.7.
L = 5.979 mm; a = 64.6; b = 8.3; c = 48.6.

Female Paratypes:
L = 3.32 – 4.94 mm (4.23 mm ± 0.51 mm)
a = 31.5 – 46.4 (38.5 ± 4.3)
b = 5.4 – 7.1 (6.3 ± 0.6)
c = 23.1 – 51.0 (40.8 ± 7.9)
V = 51.6 – 66.2 (63.4 ± 3.8)

Description: Body slender and gradually tapering anteriorly (Fig. 1B); posteriorly, body of nearly uniform diameter to level of anus, then tapering to form bluntly conical tail (Figs. 2A and B). Head diameter at level of cephalic setae 30.0 μ – 34.7 μ (32.3 μ ± 1.5 μ). Body diameter at base of esophagus 71.0 μ – 89.5 μ (82.6 μ ± 7.3 μ) in males, 76.5 μ – 102.0 μ (91.6 μ ± 7.4 μ) in females[**]; at mid-body length 81.5 μ – 96.0 μ (91.6 μ ± 5.8 μ) in males, 83.0 μ – 126.0 μ (110.5 μ ± 13.7 μ) in females; at level of anus 76.5 μ – 100.0 μ ± 6.7 μ).

Cuticle smooth. Head with circle of six cephalic papillae and second circle of 10 cephalic setae (Figs. 1A and B); longer cephalic setae 4.0 μ – 6.0 μ, shorter 2.5 μ – 4.7 μ. Distance from anterior extremity of head to level of cephalic setae 12.0 μ – 19.0 μ (14.3 μ ± 2.1 μ). Somatic setae equally short and sparse. Amphid an obscure circular pore approximately 1.0 μ in diameter, located 14.4 μ – 23.3 μ (19.6 μ ± 2.3 μ) from anterior extremity of head (Figs. 1A and C). Males with inverted lyre-shaped pattern on cuticle immediately posterior to amphid; pattern crenate and with (Fig. 1C) or without posteriorly directed central process. Cuticle thickened at level of pattern (Fig. 1C). Cephalic capsule present, but situated anterior to cephalic setae and visible in optical section only (Figs. 1A, B, and C).

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[*] One male sectioned.

[**] Measurements of males are given separate from those of females only where the mean values appear to differ significantly; otherwise measurements of males and females are combined.

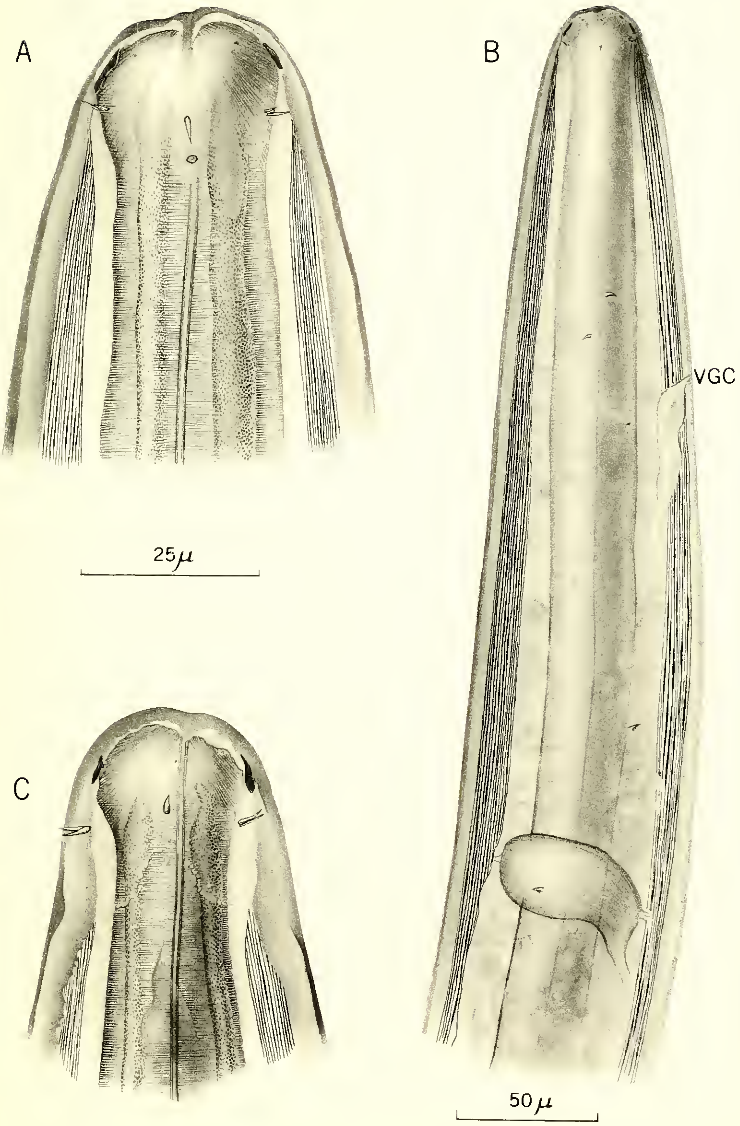

FIG. 1. *Syringonomus typicus* new species. A. Lateral view of female head (allotype). B. Lateral view of head and neck of female (allotype). Ventral gland cell, VGC. C. Lateral view of male head (holotype).

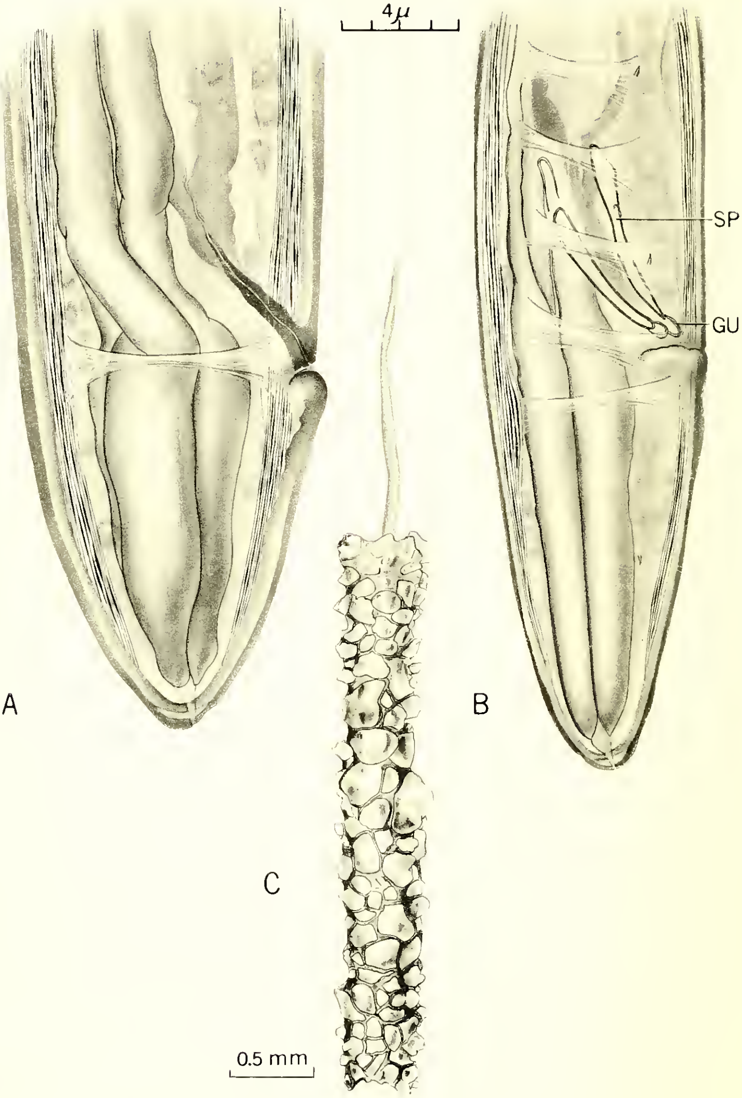

FIG. 2. *Syringonomus typicus* new species. A. Lateral view of female tail (allotype). B. Subventral view of male tail (holotype). *Spiculum*, SP; Gubernaculum, GU. C. Anterior end of specimen extending from arenaceous tube.

Head rounded without lips or microlabia. Stoma narrow, not morphologically distinct from lumen of esophagus. Teeth absent (Figs. 1A and C).

Some specimens with indistinct duct and pore of ventral gland (Fig. 1B), apparently absent in others. Distance from anterior extremity of head to ventral gland pore 15.0 – 24.6 (19.2 ± 4.0) per cent of esophagus length.

Esophagus cylindrical, 628 μ – 790 μ (717 μ ± 58 μ) long in males, 556 μ – 717 μ (664 μ ± 45 μ) in females. Eyespots absent. Pseudocoelom with large, lobate cell on each lateral side of esophagus base.

Caudal glands outstretched and extending anterior to rectum. Cuticle of tail terminus with median, crescent-shaped lamella. Caudal gland pore slightly ventral to terminus. Caudal setae sparse, terminal setae absent.

Males—Diorchic, testes opposed and outstretched. Spicula paired, equal in length, slightly arched, and 72 μ to 75 μ long. Gubernacula small, tube-like structures, one lateral to distal end of each spiculum; apophyses and lateral anterior projections absent (Fig. 2B). Dorsoventral copulatory muscles sparse, posterior region of body not curved ventrally. Each side of body with two to four setiform subventral supplements; setae approximately 3 μ long, first pair 30 μ to 37 μ, second 113 μ to 120 μ, third 132 μ and fourth 149 μ anterior to cloacal vent; setae furthest anterior slightly closer to ventromedian line. Ventromedian supplements absent. Tail length 120 μ – 142 μ (131 μ ± 10 μ).

Females—Didelphic, gonads opposed and reflexed; vulva 1.87 mm – 3.17 mm (2.60 mm – 0.41 mm) from anterior end. Tail length 85 μ – 144 μ (106 μ ± 16 μ).

Type Locality: Sediment from epibenthic trawl taken between 39° 37.0′ N, 66° 47.0′ W and 39° 37.5′ N, 66° 44.0′ W at 3,806 meters depth on 24 August, 1966.

Discussion: Specimens of *Syringonomus typicus* possess characters typical of the subfamily Leptosomatinae. They most closely resemble species of the genera *Leptosomella* Filipjev, 1925, *Leptosomatides* Filipjev, 1918, *Paraleptosomatides* Mawson, 1956, *Leptosomatina* Allgen, 1951, and *Leptosomatum* Bastin, 1865. *Leptosomella* differs in having long cephalic setae and an acutely conical tail. *Leptosomatides* and *Paraleptosomatides* differ in having complex gubernacula, supplements, and well developed, setiform, subventral supplements, the more anterior ones on cuticular elevations. *Leptosomatina* differs in having long cephalic setae, armed stoma, and complex gubernaculum with caudally directed apophyses. Finally, *Leptosomatum,* whose members most closely resemble *Syringonomus,* differs in not having the lyre-shaped pattern and thickened cuticle on the head of the males. By the latter two characters, *Syringonomus* may be distinguished also from all other genera of this subfamily.

The presence of a ventral excretory cell is insufficiently documented to be relied upon at this time as a diagnostic character.

A striking feature of the specimens under consideration is that they were found inhabiting hollow, cylindrical tubes constructed of sand particles and an adhesive mortar. The lengths of the tubes range from 1.0 mm to 3.0 mm, and the width from 0.5 mm to 2.0 mm. The diameter of the sand particles in the tubes range from 138 μ to 588 μ with an average diameter of 362 μ. The average diameter of sand particles from the tube constructed of the finest sand was 189 μ, and 428 μ in the case of the tube constructed of the coarsest particles. The particles are primarily quartz.

The lumen of each tube is lined with a thin layer of what is presumed to be identical to the mortar between sand particles. The lining varies from light yellow in some tubes to dark brown in others. The lining and mortar become dark blue when treated with equal volumes of 2 percent hydrochloric acid and 2 percent postassium ferrocyanide demonstrating both contain ferric compounds.

Of particular interest is the question of whether or not *Syringonomus typicus* is responsible for the construction of the tubes. Obviously, the organism involved must possess a means of producing the lining and mortar. Many marine nematodes possess caudal glands that secrete an adhesive, usually employed for attachment to a substrate, and many possess lateral hypodermal glands, the function of which is as yet unknown. While no nematodes are known to construct tubes, either or both kinds of glands could conceivably secrete a substance that would serve as mortar in forming arenaceous tubes. If this were the case, one might expect the glands involved to be particularly well-developed and perhaps modified in other respects. However, specimens of *Syringonomus typicus* do not have what could be readily identified as lateral hypodermal glands, and while they do possess caudal glands and a spinneret, they are not exceptionally well-developed or unusual in other respects. Therefore, while it appears that this species of nematode is an inhabitant of these tubes, there is little evidence to suggest they construct them.

Our further attempts to learn the identity of the organism responsible for construction of the tubes resulted in their being examined by a taxonomist of foraminiferans, who identified them as tubes most likely constructed by *Rhabdammina abyssorum* M. Sars, 1868. Descriptions of the general features of the test of this species are given by Carpenter (1875) who has found that the test is typically triradiate, the rays diverging at equal angles from a central cavity and each ray with an orifice at its extremity. He states further, however, that quadri- and pentaradiate forms occur as well as single, straight tubes. The latter form "often exceeds half an inch" in length.

The walls of the test of this species, according to Brady (1884), are composed chiefly of coarse sand, the grains of which are variable in size. Brady also found that the walls of tests from the North Atlantic are various shades of light reddish-brown, and chemical analysis of the mordant demonstrated the presence of peroxide of iron.

The descriptions of the test of this foram closely conform to that of the tubes inhabited by the nematodes, except that the latter are shorter and always in the form of a straight tube. It is concluded, therefore, that the specimens of *Syringonomus typicus* in our collections are within broken pieces of the tests of *Rhabdammina abyssorum*. To what extent these nematodes dwell in these tubes, and to what extent, if at all, they are ecologically adapted to a tube-dwelling existence, must await further study.

Acknowledgments: The authors wish to express their appreciation to Mrs. Carolyn Bartlett Gast for preparing the illustrations; to Ruth Todd of the Geological Survey for identifying the foraminiferan tubes; and to Dr. Jack Pierce, Department of Paleobiology, Smithsonian Institution, for determining the diameters of the sand particles.

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PROCEEDINGS
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AUSTRALAUGENERIA POTTSI, NEW NAME FOR *POLYNOE LONGICIRRUS* POTTS, FROM THE MALDIVE ISLANDS (POLYCHAETA: POLYNOIDAE)

By Marian H. Pettibone
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The original description of the polynoid polychaete *Polynoe longicirrus* Potts, 1910, was based on material collected by Mr. J. Stanley Gardiner in 1899 from four localities in the Maldive Islands: South Male, North Male (" off a Gorgonian"), South Nilandu, and Fadifolu. Syntypes from one of these localities, that of South Nilandu, are now deposited in the British Museum (Natural History), having been transferred from the Cambridge Museum. As pointed out by Augener (1922, p. 10, footnote) and Hartman (1959, pp. 103, 108, Catalogue), *Polynoe longicirrus* Potts, 1910, is a junior homonym of *Polynoe* (*Lepidonotus*) *longicirra* Schmarda, 1861. In my recent paper on "A review of some species referred to *Scalisetosus* McIntosh" (Pettibone, 1969, p. 25), I indicated that Potts' *Polynoe longicirrus* might prove to belong to *Australaugeneria* Pettibone and that the type-specimens needed to be re-examined. Such re-examination has now confirmed my earlier supposition and Potts' species is herein given a new name and re-described.

I wish to thank David George of the British Museum (Natural History) (BMNH) for the loan of the type-specimens and Fenner A. Chace, Jr., of the Smithsonian Institution for critically reading the manuscript. This study was aided in part by a grant from the National Science Foundation (NSF GB-1269).

FAMILY POLYNOIDAE MALMGREN

Genus *Australaugeneria* Pettibone, 1969; emended

Type-species: Polynoe rutilans Grube, 1878, by original designation.

Emended diagnosis: Buccal segment (II) without notosetae (type-

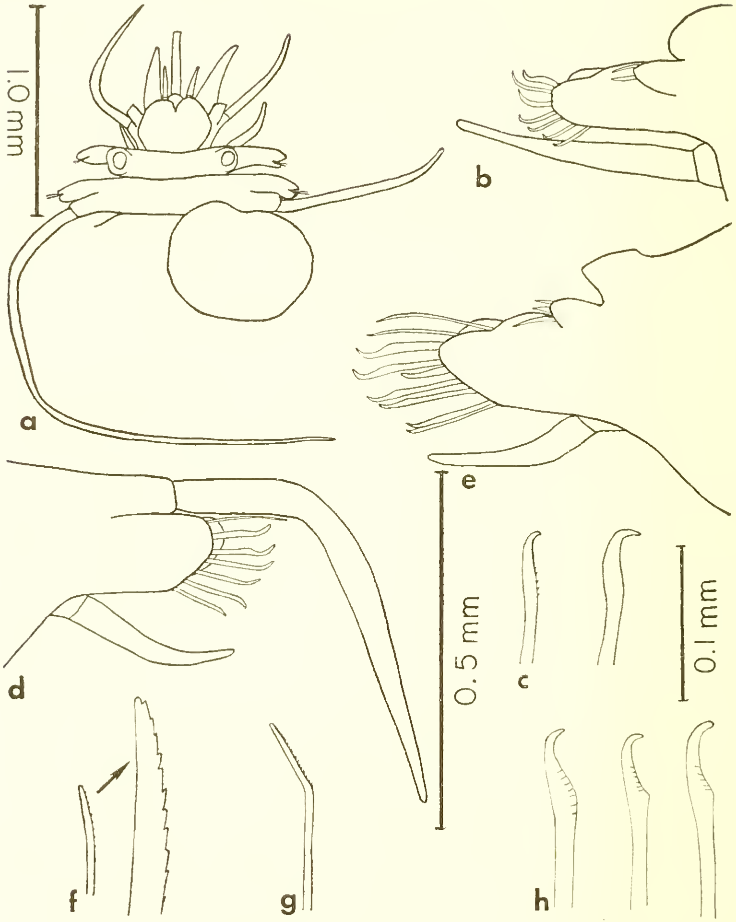

FIGURE 1. *Australaugeneria pottsi* n. name (Syntypes of *Polynoe longicirrus* Potts, BMNH 1924: 3: 77): a, Dorsal view anterior end, tip of antenna broken, upper tentacular cirri and first pair elytra missing; b, elytrigerous parapodium from segment II, anterior view; c, neurosetae from same; d, cirrigerous parapodium from segment III, posterior view; e, elytrigerous parapodium from segment IV, anterior view; f, notoseta from same and tip magnified; g, upper neuroseta from same; h, middle and lower neurosetae from same.

species) or notosetae few in number. Presetal neuropodial lobes of segments II and III enlarged, hoodlike (type-species) or only slightly enlarged.

Australaugeneria pottsi new name
Figs. 1–3

Polynoe longicirrus Potts, 1910, p. 336, pl. 18, fig. 9, pl. 20, fig. 29, pl. 21, figs. 37, 38.—Augener, 1922, p. 10 (footnote). Not *Polynoe* (*Lepidonotus*) *longicirra* Schmarda, 1861.

Scalisetosus longicirrus (Potts).—Hartman, 1959, p. 108. [HOMONYM.]

Material examined: South Nilandu, Maldive Islands, Indian ocean, J. S. Gardiner collection—3 syntypes of *Polynoe longicirrus* Potts (BMNH 1924: 3: 77). [Three anterior fragments of 12, 16 and 20 segments; posterior fragment of 9 segments; and 6 middle fragments.]

Description: Body small, flattened, tapered gradually posteriorly. Length 6.5–7.5 mm, width, including setae, 2 mm, segments 37–38. Elytra 15 pairs, arranged on segments 2, 4, 5, 7, alternate segments to 23, 26, 29, and 32. Elytra large, covering dorsum, soft, translucent, smooth, without tubercles or papillae. Prostomium bilobed, with lobes rounded anteriorly, without distinct cephalic peaks; ceratophore of median antenna in anterior notch, with style long and tapered; lateral antenna with distinct ceratophores, inserted ventrally, with styles very short; ventral palps short, stout, tapered; no eyes visible (fig. 1a). Tentacular parapodia (I) achaetous, with 2 pairs long tentacular cirri. Buccal segment (II) with ventral buccal cirri slightly longer than following ventral cirri; without nuchal fold; notopodia small, each with 2 short notosetae; neurosetae hooked; presetal neuropodial lobe longer than postsetal lobe but not especially enlarged (fig. 1a-c). Neurosetae of segments 3 and 4 also more strongly hooked than following neurosetae (fig. 1d-h). Parapodia subbiramous (figs. 2a, b, 3a, b). Notopodia small, conical, confined to middle of neuropodial lobe; notosetae few in number (2–7), short, more slender than stouter type of neurosetae, slightly curved, with serrated border and blunt, slightly bidentate tips (figs. 1f, 2c, 3c). Neuropodia elongate, diagonally truncate distally, deeply notched dorsally and ventrally, forming anterior and posterior rounded lobes, former slightly longer than latter. Neurosetae of 2 types: upper few (2–5), slender, bent, spinous, with tips blunt (figs. 1g, 2d, 3d); middle and lower neurosetae slightly more numerous (6–8), stout, wider subdistally, smooth or faintly spinous on enlarged part, with slightly hooked tips (figs. 2e, 3e). Dorsal cirri with elongate cylindrical cirrophores and long filamentous styles (figs. 1d, 2a, 3a). Dorsal tubercles inconspicuous. Ventral cirri short, subulate, extending slightly beyond neuropodial lobes. Two dorsal transverse ciliated bands per segment.

Distribution: Indian Ocean (Maldives). May be found on gorgonians (Potts, 1910).

Remarks: *A. pottsi* differs from the two previously described species of *Australaugeneria* from the Philippine Islands and southwest Australia, *A.*

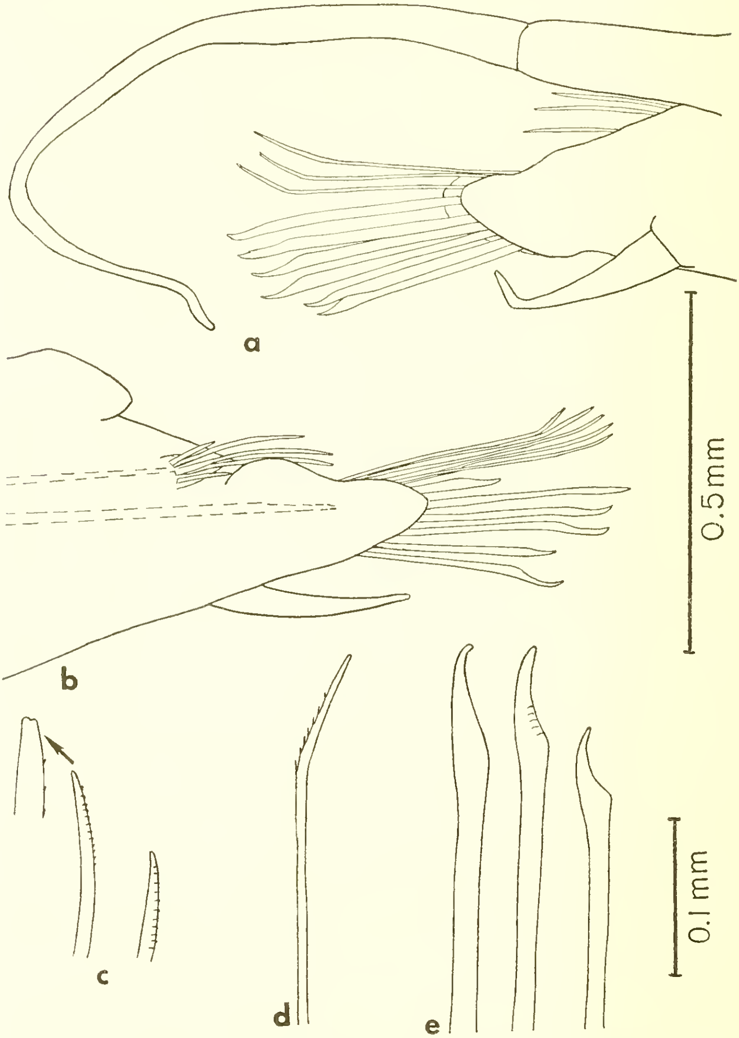

FIGURE 2. *Australaugeneria pottsi* n. name (Syntypes of *Polynoe longicirrus* Potts, BMNH 1924: 3: 77): a, Middle cirrigerous parapodium, posterior view; b, middle elytrigerous parapodium, anterior view; c, notosetae from same and tip magnified; d, upper neuroseta from same; e, middle and lower neurosetae from same.

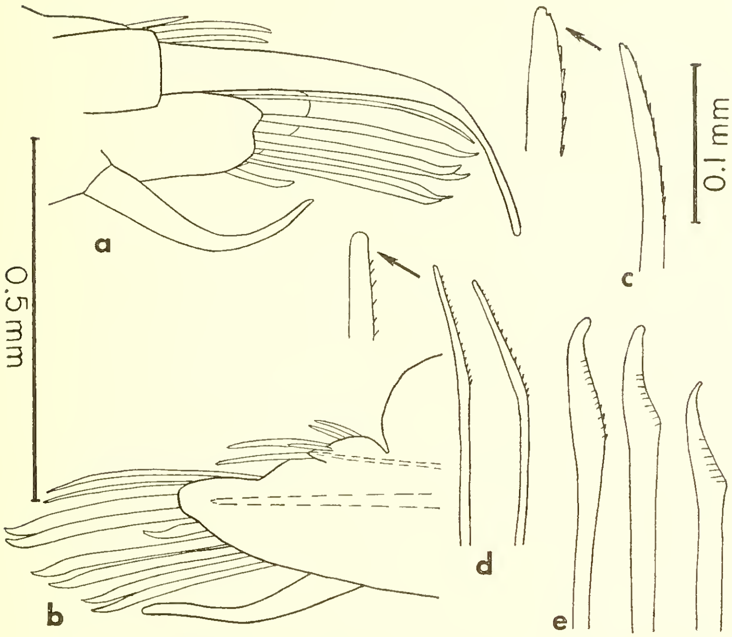

FIGURE 3. *Australaugeneria pottsi* n. name (Syntypes of *Polynoe longicirrus* Potts, BMNH 1924: 3: 77): a, Posterior cirrigerous parapodium, posterior view; b, posterior elytrigerous parapodium, anterior view; c, notoseta from same and tip magnified; d, upper neurosetae from same and tip magnified; e, middle and lower neurosetae from same.

rutilans (Grube, 1878) and *A. michaelseni* Pettibone, 1969, in that the parapodia of segments II and III are less modified, i.e., the presetal neuropodial lobes are not especially enlarged or hoodlike, the neurosetae are not as strongly hooked, and two notosetae are present in segment II and not absent, as in the other two species. *A. pottsi* agrees more closely with *A. rutilans* in having the notosetae more slender than the stoutest neurosetae, curved, with spinous rows and bifid tips, and not smooth, stout, spikelike, as in *A. michaelseni.* The notopodia are short and confined to the middle of the neuropodial lobes in *A. pottsi* and *A. rutilans* and not extending to near the distal tips of the neuropodia, as in *A. michaelseni.*

In her Catalogue of the Polychaeta of the World, Hartman (1959, p. 108) referred *Polynoe longicirrus* Potts, 1910, to *Scalisetosus*, perhaps following a suggestion by Augener (1922, p. 10, footnote) that it might be a *Scalisetosus*-like form. As indicated by Pettibone (1969), it does not agree with *Scalisetosus* McIntosh.

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THE POSTLARVAE AND JUVENILE STAGES OF TWO SPECIES OF *PSEUDOSQUILLOPSIS* (CRUSTACEA, STOMATOPODA) FROM THE EASTERN PACIFIC REGION

By Raymond B. Manning
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This report was prompted by a study of the West African stomatopods in which two gonodactylid postlarvae, 30 to 33 mm in length, were encountered in collections from the Gulf of Guinea. These specimens resembled members of the genera *Parasquilla* and *Pseudosquillopsis*. One of these had been identified by Schmitt (1926) as the postlarva (first littoral stage) of *Parasquilla ferussaci* (Roux, 1830) although it differs in several respects from an earlier account of the postlarva of that species by Giesbrecht (1910).

As a result of comparing these specimens with the postlarvae and adults of other members of the family, their identity has been established, diagnostic characteristics of the postlarvae of *Pseudosquillopsis* can be summarized, and four species can be recognized in the genus.

Prior to this study, the genus *Pseudosquillopsis* was considered to comprise three species: *P. cerisii* (Roux, 1828) from the Mediterranean Sea, *P. dofleini* (Balss, 1910) from Japan, and *P. lessonii* (Guérin, 1830) from the eastern Pacific region (Serène, 1962; Manning, 1963). Two additional species, *P. monoceros* (H. Milne-Edwards, 1837), from Chile, and *P. marmorata* (Lockington, 1877), from California, have been described, but most authors including Miers (1880), Bigelow (1894) and Schmitt (1940), synonymized these species with *P. lessonii*, usually without comment. However, Miers did note (1880, p. 114) that "*P. marmorata*, Lockington (P. Cal. Ac. Sci.

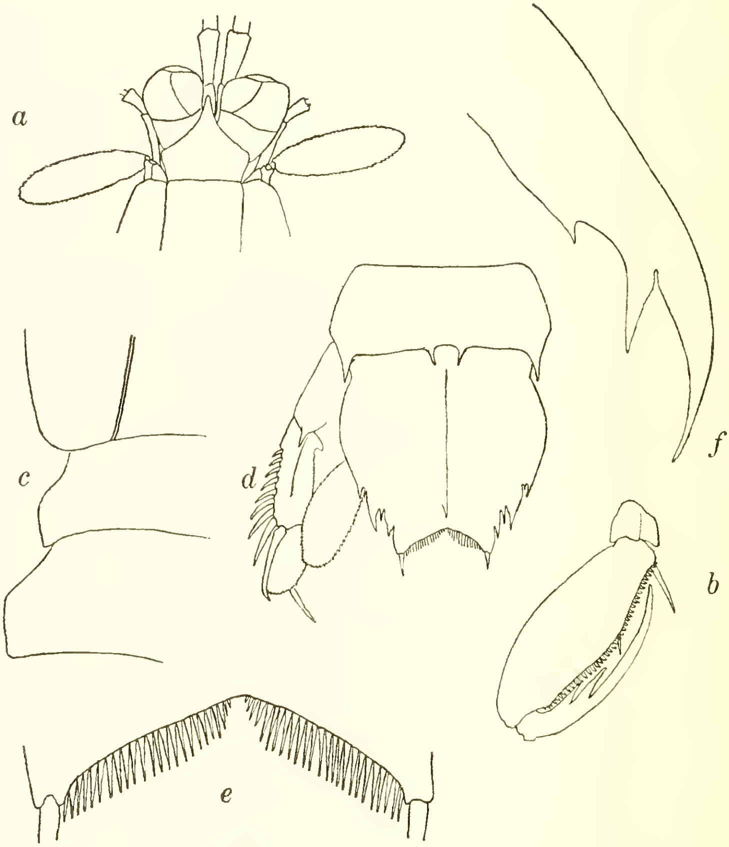

Figure 1. *Pseudosquillopsis marmorata* (Lockington), female postlarva, TL 26.5 mm: *a*, anterior portion of body; *b*, raptorial claw; *c*, lateral processes of sixth and seventh thoracic somites; *d*, sixth abdominal somite, telson, and uropod; *e*, submedian denticles of telson; *f*, basal prolongation of uropod. (Setae omitted).

p. 33, 1877), from San Diego, California, either belongs to this species [*lessonii*] or is very closely allied to it."

The postlarvae and juveniles treated here clearly show that two species of *Pseudosquillopsis* occur in the eastern Pacific region, and *P. marmorata* (Lockington) is recognized as a distinct species.

In their postembryonic development, all stomatopods seem to possess a single postlarval stage, at the termination of their pelagic larval life. The larval-postlarval molt results in dramatic structural changes involving a transition toward the characteristic facies of the benthic adult stages (Manning, 1962; Alikunhi, 1967). In many species, postlarvae can be correlated with the adult only by rearing them as was done by K. H. Alikunhi (1967) in India. Bigelow (1931) was able to associate the postlarvae with the adults of several different species of *Pseudosquilla* in the Indo-West Pacific region without utilizing rearing techniques. Studies on the postlarvae are badly needed to provide basic ontogenetic information in the stomatopods and to allow the specific identification of the postlarvae of each species. In addition, postlarval characters may augment or help to clarify concepts of interspecific relationships.

I am indebted to Thomas E. Bowman, Horton H. Hobbs, Jr., and Anthony J. Provenzano, Jr., for commenting on various portions of the manuscript. The illustrations were made by my wife Lilly with the support of the Research Awards Program of the Smithsonian Institution.

All specimens are in the collection of the Division of Crustacea, National Museum of Natural History, Smithsonian Institution.

POSTLARVAL STAGES OF EASTERN PACIFIC *PSEUDOSQUILLOPSIS*

Pseudosquillopsis marmorata (Lockington, 1877)

Squilla marmorata Lockington, 1877, p. 33. [Type-locality: San Diego, California].

Figure 1

Material: 1 ♂, 29 mm[1]; 2 ♀, 27–28 mm; Bahia Ballenas, Baja California; 3 May 1888; *Albatross*.— 1 ♂, 25 mm; 4 ♀, 25–27 mm; Bahia San Roque, Baja California; 9–10 February 1950; L. McHugh.— 1 ♀, 27 mm; San Carlos Bay, Gulf of California; electric light hung over side at night at anchorage; 30 March 1940; E. F. Ricketts.— 1 ♀, 28 mm; Gulf of California; University of California; LXXXIII-H1.—1 ♂, 28 mm; same; LXVII-H1.

Description: TL 25–29 mm; cornea trilobed, inner portion subdivided into 2 lobes (Fig. 1*a*); antennular peduncle 61–75 percent of carapace length; width of antennal scale 26–36 percent length; rostral plate pen-

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[1] In the postlarvae of *Pseudosquillopsis*, at least, males can be recognized by the presence of the buds of the copulatory tubes at the base of the third pair of walking legs.

TABLE 1. Summary of basic data for postlarvae and juveniles of *P. lessonii* and *P. marmorata*.

	Postlarvae		Juveniles	
	lessonii	*marmorata*	*lessonii*	*marmorata*
Number of specimens	2	10	1	1
Total length (mm) (TL)	30–32	25–29	35	40
Carapace length (mm) (CL)	5.7–6.0	4.8–5.4	6.7	7.7
Corneal index: range	356–375	327–386	—	—
mean	365	365	335	335
Antennular peduncle, as percent CL: range	75	61–75	—	—
mean	75	66	87	78
Antennal scale width, as percent length: range	37–38	26–36	—	—
mean	38	33	29	23
Distance between submedian teeth of telson, as percent telson width: range	38–46	46–56	—	—
mean	42	50	36	30
Submedian denticles of telson	17	21–25	—	17

tagonal, length and width subequal, apex not extending beyond cornea, anterolateral angles rounded (Fig. 1*a*); carapace lacking carinae; superior margin of propodus of claw pectinate, dactylus of claw with 3 well-formed teeth (Fig. 1*b*); exposed thoracic somites lacking lateral carinae, lateral processes of sixth and seventh somites rounded laterally, angled posteriorly (Fig. 1*c*); anterior 4 abdominal somites unarmed, fifth abdominal somite with posterolateral spines; sixth abdominal somite not carinate, with 2 pairs of posterior spines, intermediates absent (Fig. 1*d*); telson with median carina, remainder of carinae absent (Fig. 1*d*); submedian teeth of telson widely separated, 20–25 submedian denticles present on inner surface of each submedian tooth (Fig. 1e); basal prolongation of uropod produced into 2 spines, outer longer, with smaller third spine on inner margin, remainder of inner margin smooth (Fig. 1*f*).

Pseudosquillopsis lessonii (Guérin, 1830)

Squilla lessonii Guérin, 1830, pl. 4, fig. 1; 1838, p. 40 [*S. cerisii* in text] [Type-locality: Peru].

Figure 2

Material: 1 ♂, 32 mm; 1 ♀, ca. 30 mm; Punta Carretas, Peru; in stomachs of *Neothunnus macropterus, Katsuwonus pelamis, Sarda*; Enrique M. del Solar.

Description: TL 30–32 mm; cornea trilobed, inner portion subdivided into 2 lobes (Fig. 2*a*); antennular peduncle 75 percent of carapace

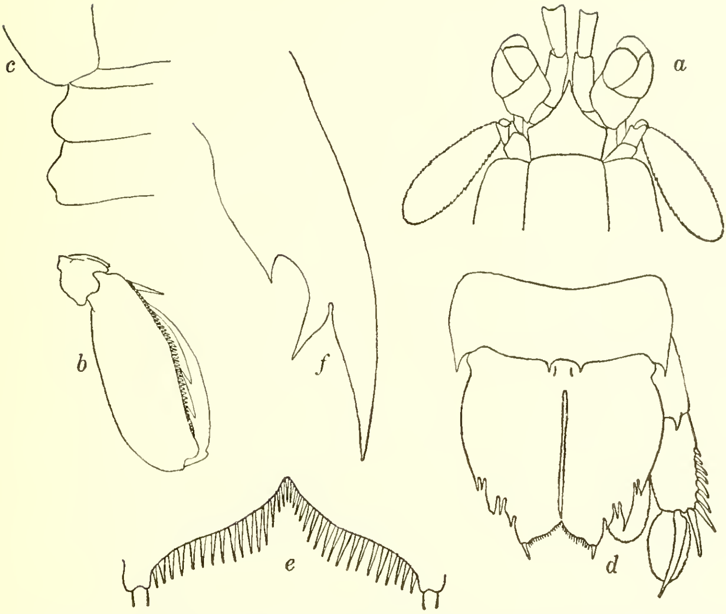

FIGURE 2. *Pseudosquillopsis lessonii* (Guérin), male postlarva, TL 32 mm: *a*, anterior portion of body; *b*, raptorial claw; *c*, lateral processes of sixth and seventh thoracic somites; *d*, sixth abdominal somite, telson, and uropod; *e*, submedian denticles of telson; *f*, basal prolongation of uropod. (Setae omitted).

length; width of antennal scale 37–38 percent length; rostral plate pentagonal, length and width subequal, apical spine not extending beyond cornea, anterolateral angles rounded (Fig. 2*a*); carapace lacking carinae; superior margin of propodus of claw pectinate, dactylus of claw with 3 well-formed teeth (Fig. 2*b*); exposed thoracic somites lacking carinae, lateral processes of sixth and seventh somites rounded (Fig. 2*c*); anterior 4 abdominal somites unarmed posterolaterally, fifth somite with posterolateral spines; sixth abdominal somite with 2 pairs of posterior spines, intermediates absent; posterolateral spinule present (Fig. 2*d*); telson with single median carina, submedian teeth of telson widely separate, 17 submedian denticles present on inner surface of each submedian tooth (Fig. 2*e*); basal prolongation of uropod produced into 2 spines, outer longer, with smaller third spine on inner margin, remainder of inner margin smooth (Fig. 2*f*).

COMPARISON OF POSTLARVAL STAGES

The postlarvae of both *P. marmorata* and *P. lessonii* can be recognized as postlarvae by the form of the cornea, for the cornea is trilobed in that

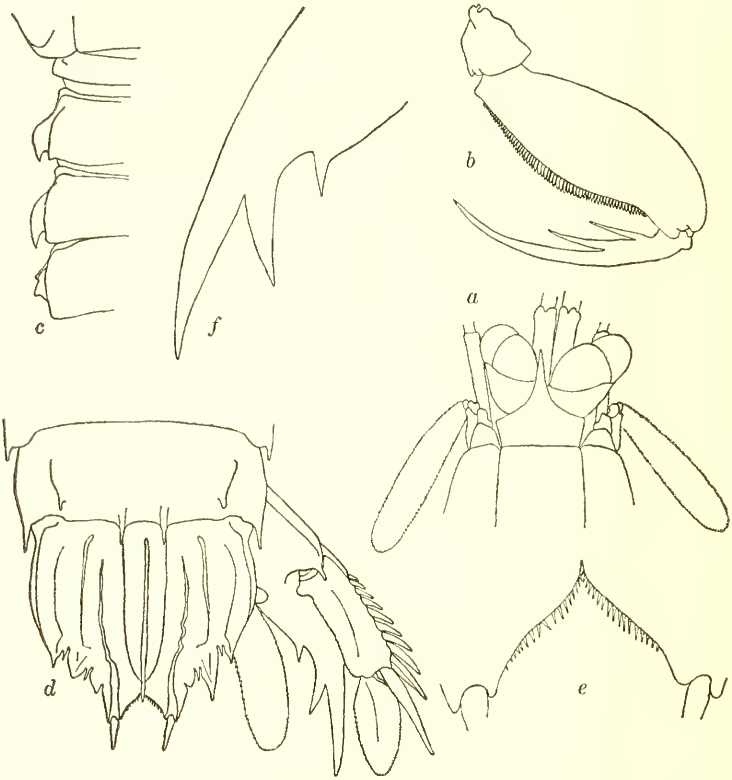

FIGURE 3. *Pseudosquillopsis marmorata* (Lockington), juvenile female, TL 40 mm: *a*, anterior portion of body; *b*, raptorial claw; *c*, lateral processes of exposed thoracic somites; *d*, sixth abdominal somite, telson, and uropod; *e*, submedian denticles of telson; *f*, basal prolongation of uropod. (Setae omitted).

stage of both species. The cornea (Figs. 1*a*, 2*a*) is divided into inner and outer half by a longitudinal line of cells, and the inner half is further subdivided into two lobes. The shape of the eye is characteristic of the postlarval stage in this genus.

The postlarvae can be identified with *Pseudosquillopsis* by the pentagonal rostral plate, ornamented anteriorly with a long apical median projection, the presence of pectinations on the propodus and three well-formed teeth on the dactylus of the raptorial claw (Figs. 1*b*, 2*b*), and the form of the basal prolongation of the uropod which terminates in two distal spines with a smaller spine on its inner margin (Figs. 1*f*, 2*f*).

The postlarvae of species of *Pseudosquilla* differ from those of *Pseudosquillopsis* in having a slenderer raptorial claw with the propodus lacking pectinations and dactylus unarmed (the monodactyla stage) and in having the basal prolongation of the uropod terminate in two spines with no additional spines on the inner margin. The postlarvae of species of *Parasquilla*, which as adults resemble *Pseudosquillopsis* in many features (Manning, 1963), differ from those of *Pseudosquillopsis* in having a short, rounded rostral plate.

As in the postlarvae of many other species of gonodactylids, the telson in *Pseudosquillopsis* postlarvae lacks most of the dorsal ornamentation characteristic of adults; only the median carina is present. The carination and spination of the sixth abdominal somite are similarly reduced, for in the postlarvae only the submedian and the lateral spines are present, the intermediates being absent, and the spines that are present are not mounted on carinate ridges.

The postlarvae of *P. marmorata* may be distinguished from those of *P. lessonii* by several features. First, the postlarvae of *P. marmorata* are smaller than those of P. *lessonii*; the 10 specimens of *marmorata* available for study range in total length from 25 to 29 mm, whereas the two specimens of *lessonii* examined possess total lengths of 30 and 32 mm. The carapace lengths of the postlarvae of *marmorata* range form 4.8 to 5.4 mm, whereas the carapaces of the two specimens of *lessonii* measure 5.7 and 6.0 mm. The antennal scale of *marmorata* is slenderer than that of *lessonii*, for in the former species the width of the scale is 26–36 percent of the length, whereas in *lessonii* it is 37–38 percent of the length. The apices of the submedian teeth of the telson are further apart in *marmorata* than *lessonii*; in *marmorata* the distance between the submedian teeth ranges from 46–56 percent (mean 50 percent) of the telson width, whereas in *lessonii* the distance between the submedian teeth is 38 and 46 percent (mean 42 percent) of the telson width.

The best feature for distinguishing postlarvae of the two species is the shape of the lateral process of the sixth and seventh thoracic somites. In *marmorata* (Fig. 1*c*) these processes are flattened laterally and angled posterolaterally, whereas in *lessonii* (Fig. 2*c*) they are broadly rounded laterally and posterolaterally.

JUVENILE STAGES OF EASTERN PACIFIC *PSEUDOSQUILLOPSIS*

Pseudosquillopsis marmorata (Lockington)

Figure 3

Material: 1 ♀, 40 mm; La Plata Island, Ecuador; sand, shale, rock, in 45–55 fms; dredge; Hancock Galapagos Expedition, Sta. 212–34; 10 February 1934.

Description: Cornea bilobed, outer margin of eye longer than inner (Fig. 3*a*); rostral plate pentagonal, elongate, apical spine not extending beyond cornea, anterolateral angles acute but not sharp (Fig. 3*a*); carapace with marginal carinae on posterior fourth; superior margin of prop-

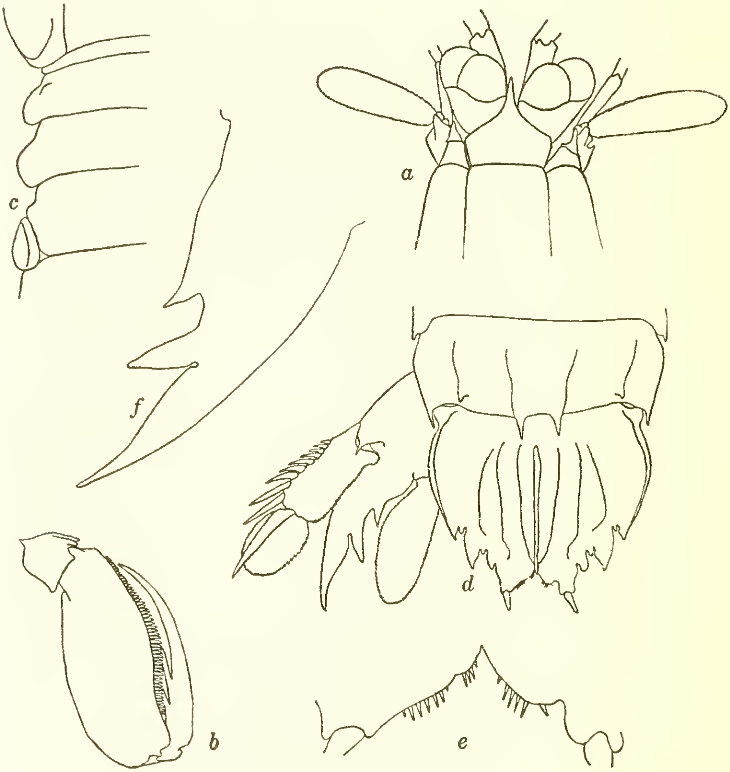

FIGURE 4. *Pseudosquillopsis lessonii* (Guérin), juvenile male, TL 35 mm: *a*, anterior portion of body; *b*, raptorial claw; *c*, lateral processes of exposed thoracic somites; *d*, sixth abdominal somite, telson, and uropod; *e*, submedian denticles of telson (damaged); *f*, basal prolongation of uropod. (Setae omitted).

odus of claw pectinated, dactylus with 3 well-formed teeth (Fig. 3*b*); sixth and seventh thoracic somites with lateral carina, lateral processes produced into posterior spine (Fig. 3*c*); fifth abdominal somite with posterolateral spines; sixth abdominal somite with 3 pairs of spined carinae (Fig. 3*d*); telson with median carina and 5 pairs of dorsal carinae, submedians extending onto submedian teeth (Fig. 3*d*); submedian teeth of telson separate, submedian denticles present 17 (Fig. 3*e*); basal prolongation of uropod produced into 2 spines, outer longer, with smaller third spine on inner margin, remainder of inner margin smooth (Fig. 3*f*).

Pseudosquillopsis lessonii (Guérin)
Figure 4

Material: 1 ♂, 35 mm; bight on south side of San Juan Bay, Peru; 15°20′S, 75°10′W; bottom dredge; 21 March 1941; M. J. Lobell.

Description: Cornea bilobed, outer margin of eye longer than inner (Fig. 4*a*); rostral plate pentagonal, length and width subequal, apical spine not extending beyond cornea, anterolateral angles rounded (Fig. 4*a*); carapace with marginal carinae on posterior fourth; superior margin of propodus of claw pectinate, dactylus with 3 well-formed teeth (Fig. 4*b*); lateral processes of sixth and seventh thoracic somites lacking carinae at TL 35 mm, lateral processes rounded posterolaterally (Fig. 4*c*); fifth abdominal somite with posterolateral spine; sixth abdominal somite with 3 pairs of spined carinae (Fig. 4*d*); telson with median carina and 4 pairs of dorsal carinae, laterals absent at TL 35 mm, submedians interrupted, not extending onto submedian teeth (Fig. 4*d*); submedian teeth of telson separate, submedian denticles present (damaged in available specimen); basal prolongation of uropod produced into 2 spines, outer longer, with smaller third spine on inner margin, remainder of inner margin smooth (Fig. 4*f*).

COMPARISON OF JUVENILE STAGES

The juveniles of eastern Pacific *Pseudosquillopsis* species have assumed most of the characters of adults. The cornea is bilobed, with the outer margin of the eye longer than the inner (Figs. 3*a*, 4*a*); there is no trace of the third portion of the cornea found in postlarvae. The rostral plate is similar to that of adults, but in the two eastern Pacific species, the anterolateral angles of the plate in juveniles are unarmed (Figs. 3*a*, 4*a*). The marginal carina is present on the carapace; apparently it is well-formed even in the first juvenile stage. The carinae and spines of the sixth abdominal somite are well-developed, although the carinae are not so strong as in adults. Most of the characteristic carinae of the telson (median and five pairs) are present in the juvenile stage of *marmorata*, TL 40 mm, but in the juvenile of *lessonii* examined, TL 35 mm, the lateral carinae are not developed; the juvenile of *lessonii* also lacks the thoracic carinae which are clearly developed in the larger specimen of *marmorata*.

The major difference between the young stages and adults are the presence of small submedian denticles, 17 in *marmorata* and an indeterminate number in *lessonii*, between the widely separate submedian teeth of the telson. In adults of *Pseudosquillopsis* the submedian teeth are appressed basally and the submedian denticles are completely absent.

The juvenile of *P. marmorata*, even at TL 40 mm, the smallest specimen examined, show the posterolateral spines on the lateral processes of the sixth and seventh thoracic somites (Fig. 3*c*). This character will distinguish this species from the other species in the genus at all sizes beyond the postlarval stage.

The antennular peduncle is not so long in juveniles of *P. lessonii*, TL 35 mm, as it is in adults, TL 70 or more.

TABLE 2. Characters of different stages of *Pseudosquillopsis.*

	Postlarvae	*Juveniles*	*Adults*
Size (mm)	25–33	20–50	70
Cornea	Trilobed	Bilobed	Bilobed
Rostral plate	Triangular, with long apical spine; rounded laterally	Same	Spined laterally in 2 species
Carinae on carapace	None	Reflected marginals	Reflected marginals
Claw	3 teeth, propodus pectinate	Same	Same
Sixth abdominal somite	2 pairs of non-carinate spines	3 pairs of carinate spines	Same
Carinae on telson	Median	Median and 4–5 pairs	Median and 5 pairs
Submedian denticles of telson	Present	Present	Absent
Basal prolongation of uropod	Long outer spine, with 2 smaller spines on inner margin	Same	Same

The two available juveniles are not of comparable age, as evidenced by the better development of carination in the specimen of *marmorata* at TL 40 mm than in the specimen of *lessonii* at TL 35 mm. Both specimens, however, are clearly subadults, and as such have been used to show transition in development between the postlarva and the adult. Rearing experiments obviously are needed to provide more detailed information on changes in postlarval development and the stages and sizes at which they occur.

GENERAL DISCUSSION

The two postlarvae from the Gulf of Guinea which prompted this study clearly can be identified as the postlarvae of *Pseudosquillopsis.* They are tentatively identified with *P. cerisii* (Roux, 1828), the only species of the genus known from the eastern Atlantic region. The postlarvae of *P. cerisii,* TL 30–33 mm, are very similar to those of *P. lessonii,* TL 30–32 mm. However, the apex of the rostral plate in the postlarva of *P. cerisii* is shorter and blunter than that of the postlarva of *P. lessonii,* and the distance between the apices of the submedian teeth of the telson is greater in the postlarva of P. *cerisii* than in that of *P. lessonii.*

Characters of postlarvae, juveniles, and adults of members of the genus *Pseudosquillopsis* are summarized in Table 2. The early stages are distinctive but are clearly referable to *Pseudosquillopsis,* which was heretofore based on characters afforded by adults only. The most important difference between young specimens and adults is the presence of submedian denticles on the telson in the former and their absence in the adult stage.

Young specimens, possibly including both postlarvae and juveniles, of

P. dofleini (Balss) from Japan have been recorded by Komai (1927). He noted that in the smallest specimen, TL 20 mm, the inner margin of the basal prolongation was unarmed. He also noted that the eyes of his small specimens were subsimilar to those adults. In view of the latter observation, his specimens were probably juveniles rather than postlarvae. From the length of the smallest specimens recorded by him, TL 20 mm, it might be assumed that the postlarvae of *P. dofleini* are smaller than those of the remaining species of the genus.

Adults of the two Eastern Pacific species of the genus, which have the anterolateral angles of the rostral plate armed with spines and also have a smooth inner proximal margin on the basal prolongation of the uropod, are more closely related to each other than to either the Atlantic species or the one found in the Indo-West Pacific region. Indeed, the extra-American species, *P. cerisii* and *P. dofleini*, both of which have spinules proximally on the basal prolongation of the uropod, are extremely difficult to separate.

In his description of *P. dofleini*, Balss (1910) noted that it differed from *P. cerisii* in having the basal prolongation of the uropod armed with spinules; small spinules are definitely present on the basal prolongation in the only specimen of *P. cerisii* I have examined, a male, TL 87 mm, from Naples, Italy, and these spinules have been noted by other authors as well (see Serène, 1962, fig. 2c). The spinules in *P. dofleini* apparently differ from those found in *P. cerisii* in that they increase in size distally, with the distalmost not markedly smaller than the innermost of the three terminal spines on the basal prolongation, whereas all of the spinules are small in P. *cerisii.* In other respects *P. dofleini* and *P. cerisii* resemble each other very closely.

The rostral plate is unarmed anterolaterally in the single specimen of *P. cerisii* which I have examined. Serène (1962, p. 16), in his diagnosis of *Pseudosquillopsis*, stated that the anterolateral angles were armed in *P. cerisii* and *P. lessonii*, but the plate is rounded anterolaterally in the specimen I examined.

The species placed in *Pseudosquillopsis* share the following features as adults: cornea bilobed, with outer margin of eye longer than inner; carapace lacking cervical groove, ornamented with short marginal carinae only; propodus of raptorial claw stout, superior margin lined with numerous short, blunt projections; dactylus of claw armed with three teeth; dorsal surface of telson ornamented with median carina and 5 pairs of dorsal carinae; submedian teeth of telson with bases appressed, submedian denticles completely suppressed; basal prolongation of uropod terminating in 2 spines, outer larger, with smaller third spine on inner margin. More detailed diagnoses have been provided by Serène (1962) and Manning (1963), both of whom also commented on the relationships of *Pseudosquillopsis* to *Parasquilla* and *Pseudosquilla.*

The provisional key to the species of *Pseudosquillopsis* presented below may have to be revised when more material of *P. dofleini* is available for study.

PROVISIONAL KEY TO ADULTS OF *PSEUDOSQUILLOPSIS*

1. Inner half of basal prolongation of uropod with spinules; rostral plate rounded laterally 2
   Inner half of basal prolongation of uropod smooth or with low, rounded tubercles; rostral plate with lateral spines 3
2. (1) Spinules on inner margin of basal prolongation of uropod increasing in size distally, inner spine of basal prolongation not markedly larger than distalmost spinule .... *P. dofleini* (Balss, 1910): Japan.
   Spinules on inner margin of basal prolongation of uropod small, not markedly increasing in size distally, outermost much smaller than inner spine .... *P. cerisii* (Roux, 1828): Mediterranean Sea, Gulf of Guinea.
3. (1) Antennular peduncle as long as or longer than carapace; lateral processes of sixth and seventh thoracic somites rounded posterolaterally .... *P. lessonii* (Guérin, 1830): Peru, Chile, Juan Fernandez Island.
   Antennular peduncle shorter than carapace; lateral processes of sixth and seventh thoracic somites spined posterolaterally .... *P. marmorata* (Lockington, 1877): southern California, Gulf of California, Galapagos Islands.

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PROCEEDINGS
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BIOLOGICAL SOCIETY OF WASHINGTON

FRESHWATER TRICLADS (TURBELLARIA) OF NORTH AMERICA. I. THE GENUS *PLANARIA*.[1]

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The genus *Planaria* was established by O. F. Müller (1776: 221) to separate the free-living lower worms from the parasitic trematodes which retained the older name *Fasciola.* Originally *Planaria* comprised all known Turbellaria living in fresh water, in the sea, and on land and, besides these, the present Nemertina or Rhynchocoela. The extent of the genus was gradually narrowed as newly established genera were separated from it, chiefly by Dugès (1828), Ehrenberg (1831), and Örsted (1843 and 1844). After Ehrenberg's revision of the system, which first introduced the name Turbellaria, *Planaria* was restricted to turbellarians with branched intestine ("Dendrocoela") which possessed two eyes. Örsted, who further refined the systematic arrangement of the "flatworms," separated the polyclads ("Cryptocoela") from the Dendrocoela and applied the name *Planaria* mainly to triclads, both freshwater and marine, including also the many-eyed species which Ehrenberg had separated from *Planaria.* In 1844 (p. 51) he removed from it the new genus *Dendrocoelum* on the basis of its intestinal branching. In the following years the name *Planaria* was used rather indiscriminately for many turbellarian forms. With the progress of the studies of the internal structure of the various turbellarian taxa in the second half of the nineteenth century it gradually became restricted to freshwater triclads.

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Even today the common name "planarian" may signify any triclad species (freshwater, land, and sea planarians for Paludicola, Terricola, and Maricola).

It was not until the twentieth century that further important studies were reflected in the classification of the freshwater triclads. Thus Komárek (1926) proposed a more "natural" system of the Paludicola for the European representatives of this group. He established the genera *Dendroplanaria* (for Müller's *Fasciola torva*), *Fonticola*, and *Albiplanaria*, revived Hesse's (1897) *Euplanaria*, and restricted the generic name *Planaria* to Dana's (1766) *Hirudo alpina*.

The present system of the freshwater triclads, which is in principle being followed by modern authors, was introduced by Kenk (1930). The suborder Paludicola or Probursalia of the order Tricladida is divided into two families, the Planariidae and the Dendrocoelidae. A third family, Kenkiidae, split off from the Planariidae by Hyman (1937) appears not to be justified and has not been accepted by some later planarian workers (e.g., de Beauchamp, 1961: 103; Mitchell, 1968: 615–618).

The two families are distinguished by the arrangement of the muscle fibers in the internal muscular zone of the pharynx, which in the Planariidae consists of two distinct layers, a layer of circular fibers adjoining the internal epithelium, followed by a layer of longitudinal fibers; in the Dendrocoelidae the internal muscular zone is represented by a single layer of intermingled circular and longitudinal muscle fibers. Fortunately, this characteristic can be recognized even in sexually immature specimens, while many of the generic and specific features used in the identification of the smaller taxa concern primarily the reproductive system.

Komárek's (1926) restriction of the genus *Planaria* to *P. alpina* and its immediate relatives was untenable, since the species *alpina* was not included among the species assigned to the genus *Planaria* when it was first established by O. F. Müller (1776). Kenk (1930: 293) therefore selected *Fasciola torva* Müller (1774) as the type of the genus and presented a definition of the genus, slightly emended in a later paper (1935: 111): Planariidae whose oviducts—without embracing the stalk of the bursa copulatrix (or forming a loop around it)—unite to a common oviduct which opens into the genital atrium. Male atrium without radial muscle plates. Adenodactyl present, constructed according to the *Planaria torva* type. (An analysis of the adenodactyl was given by Kenk, 1930: 159.)

In this narrower sense the genus *Planaria* comprises very few species, scattered over three continents: *P. torva* (Müller, 1774) with its probable synonym *P. onegensis* Zabusov (1901), in Europe and possibly Asia; *P. kempi* Whitehouse (1913), in India; and *P. dactyligera* Kenk (1935), in North America.

A detailed review of the present status of the type species, *Planaria torva*, has been presented recently by Ball, Reynoldson and Warwick (1969).

Planaria dactyligera dactyligera Kenk, 1935

Type material: Holotype, from Mountain Lake, Giles County, Virginia, 2 slides of sagittal sections, U. S. National Museum No. 39461. Paratypes in the author's collection.

The species *Planaria dactyligera* has been described in detail in an earlier paper (Kenk, 1935: 105–110) from material collected in several localities in Virginia. Examination of specimens from North Carolina made it advisable to distinguish two subspecies of this species. The principal characteristics of the typical form from Virginia may be briefly recapitulated here.

External features: Mature animals are up to 13 mm long and 1.75 mm wide. The dorsal side is darkly pigmented, gray, brown, or black; the ventral surface, somewhat lighter. The anterior end is truncate, with almost straight frontal margin and rounded lateral (auricular) edges. In the quietly gliding animal there may be an insignificant narrowing or neck behind the auricles. Eyes are normally two, placed rather close together (about ⅓ the width of the head at the level of the eyes) and removed from the frontal margin by a distance slightly less than the width of the head.

Reproductive system: The main features distinguishing the species from its relatives are in the anatomy of the reproductive system (cf. Kenk, 1935, figs. 25 and 27). The testes are predominantly ventral and occupy a pair of broad bands, one on either side of the midline, extending from a short distance behind the eyes to about the level of the mouth opening. The vasa deferentia expand in the region of the pharynx to form a pair of sinuous spermiducal vesicles (or false seminal vesicles), filled with sperm, as is typical for freshwater triclads in general. They approach the bulb of the penis from the antero-lateral sides. The two oviducts (or ovovitelline ducts), which in their main course accompany the ventral nerve cords, turn upward and medially in the region of the copulatory complex and unite in the space above the male atrium and below the stalk of the copulatory bursa to form the common oviduct.

There is no distinct common genital atrium developed, as the various cavities of the copulatory organs meet in the immediate vicinity of the genital aperture: from the anterior side the male atrium, dorsally the duct of the copulatory bursa, and posteriorly the opening of the adenodactyl. The male atrium is more or less cone-shaped, duplicating the shape of the penis which it encloses.

The penis consists of a spherical bulb embedded in the mesenchyme and a conical papilla protruding into the male atrium. At the transition between the two parts is a cavity (the shape of which may vary according to the contraction or expansion of the organ), the seminal vesicle. This cavity receives from its anterior side the two vasa deferentia which have entered the bulb from the sides and have formed a few convolutions within the bulb, with a common opening. From the seminal vesicle the ejaculatory duct emerges as a tapering, straight canal which opens at the tip of the papilla. Many gland ducts penetrate the penis bulb from the surrounding mesenchyme and open into the seminal vesicle.

The muscular coat underlying the outer epithelium of the penis papilla consists of two layers: a circular layer adjoining the epithelium, followed by a layer of longitudinal fibers. The thickness of this muscle coat is about equal to, or slightly greater than, that of the wall of the male atrium.

The common oviduct formed by the union of the paired oviducts enters the posterior part of the male atrium from the dorsal side or from the left. The terminal parts of the paired oviducts and almost the entire common oviduct receive very numerous gland ducts filled with an intensely eosinophilic secretion.

The copulatory bursa is a large sac lying between the pharyngeal pouch and the bulb of the penis. Its duct or stalk, running dorsally to the male atrium, curves postero-ventrally and joins the atrial complex close to the gonopore. There is no distinct posterior portion or vagina developed.

The adenodactyl is a large hollow organ lying behind the genital aperture and opening close to the aperture without a prominent protruding papilla. Its heavy muscular wall is pierced by numerous gland outlets emptying its inner cavity.

Distribution: The type locality of *Planaria dactyligera dactyligera* is Mountain Lake, Giles County, Virginia, near south bank of the lake. It has been collected also in Rockbridge, Highland, and Albemarle counties, Virginia (Kenk, 1935: 109). Fite (1952), who studied a nematode parasitic in the pharynx of this species, collected his material at Twin Springs near the Mountain Lake Biological Station of the University of Virginia, in Giles County.

Chandler (1966: 11) reports that he collected some, mostly immature, planarians near Bloomington, Monroe County, Indiana, which he tentatively identified as *Planaria dactyligera*. He kindly sent me a slide of the problematic species for examination. The preliminary identification proved to be erroneous.

Planaria dactyligera musculosa new subspecies[3]

Type material: Holotype, from Ossipee, Alamance County, North Carolina, 4 slides of sagittal sections, U. S. National Museum No. 39462. Paratypes, 13 series of sagittal and transversal sections, in the author's collection.

External features: Mature specimens attain a length up to 11 mm and a width of 1.3 mm. The head is truncate, with the frontal margin slightly bulging in its entire extent (Fig. 1*a*) or in the central portion (Fig. 1*b*). In quiet gliding either of these two shapes may be assumed transitorily. The lateral edges are rounded. A very slight narrowing (neck) may be seen behind the head, then the body margins gradually diverge, remain parallel for some distance, converge again behind the pharyngeal region, and meet in the bluntly pointed posterior end. There are two eyes, lying close together (less than ⅓ the width of the head at the level of the eyes) and farther distant from the frontal margin than from the lateral margins.

The pigmentation of the dorsal surface is usually dark, almost black, appearing somewhat cloudy under magnification. Only the two eye patches are free of pigment. There are, however, lighter areas visible above the pharynx and, in sexually mature specimens, above the copulatory complex. The ventral side is also pigmented, but in a lighter hue than the dorsal side. The mouth opening is visible as a distinct white spot, the gonopore is not quite as clearly discernible. Freshly hatched young are unpigmented, white, and acquire their pigmentation gradually during their gowth and development. Animals kept in cultures in the dark tend to be more lightly pigmented than specimens in their natural habitat.

The pharynx is inserted at about the middle of the body, its length being approximately ⅙ the body length. The mouth and the gonopore divide the posterior half of the body into three almost equal thirds.

As is seen from this description, *Planaria dactyligera musculosa* cannot be distinguished from *P. d. dactyligera* by its external features. It also resembles closely some pigmented species of *Phagocata* (*P. velata* [Stringer], *P. vernalis* Kenk, *P. crenophila* Carpenter, and at least one other, undescribed, species of this genus) as well as *Hymanella retenuova* Castle.

Internal characters: The anatomical characteristics of *Planaria dactyligera musculosa* conform in most particulars with those of the typical form (cf. Kenk, 1935: 105–109). The body pigmentation obscures the intestinal branching in the living specimens. The anterior end of the prepharyngeal intestinal ramus extends far into the head, forming a straight, unbranched diverticulum which reaches to a level anterior to the eyes (Fig. 1*b*).

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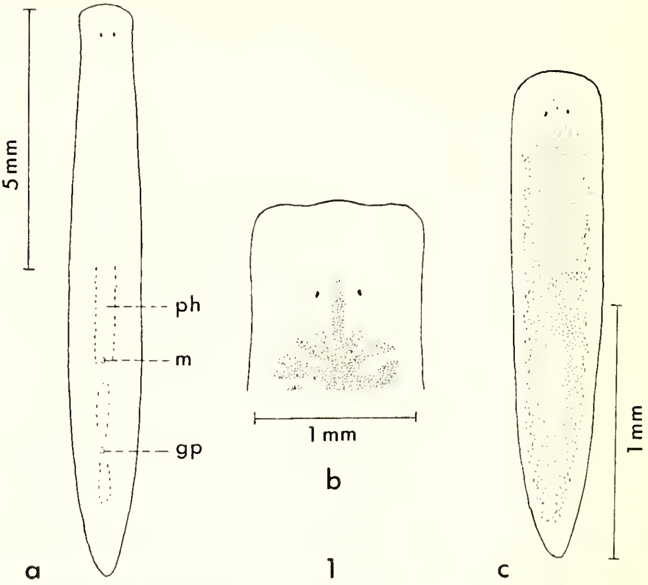
[3] *musculosus*, Latin, muscular, referring to the circular muscle layer of the penis papilla.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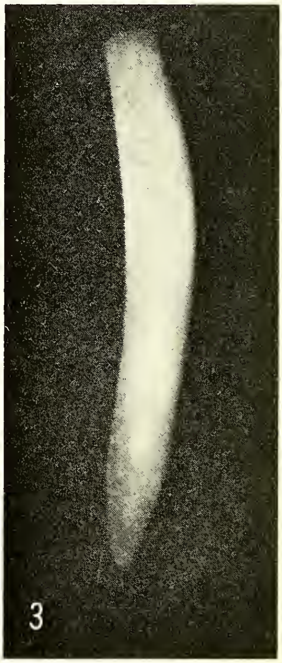
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The testes are predominantly ventral, but individual follicles may be displaced dorsally or, at full maturity, may occupy the entire dorsoventral diameter of the body. The testicular zone of each side extends from a level behind the eyes to approximately the level of the mouth opening. The ovaries (with large parovaries), vitellaria, ovovitelline ducts, and vasa deferentia do not deviate from the conditions seen in the typical form. There are, however, distinct differences in the copulatory apparatus of the two subspecies.

A semidiagrammatic view of the copulatory apparatus of *Planaria dactyligera musculosa*, with particular reference to its muscular and glandular differentiations, is shown in Figure 4. In comparing this figure with the corresponding diagram for *P. dactyligera dactyligera* (Kenk, 1935, Fig. 27), the differences in the proportions of the individual organs should be disregarded, as the present figure is based on an unusually well extended specimen while that of the type-species shows a certain amount of longitudinal contraction such as is commonly encountered in preserved planarians.

In the new subspecies, the large copulatory bursa (*b*) regularly shows numerous lobes or diverticula projecting mainly in the lateral direction. The bursa duct (*bd*) gradually widens as it curves toward the gonopore, but shows no histologically distinct or sharply demarcated vagina. It opens into the atrial complex close to the gonopore (*gp*).

The penis consists of a spherical bulb containing loosely arranged muscle fibers running in more or less concentric layers, and the end parts of the sinuous and highly muscular vasa deferentia (*vd*). The bulb is pierced by numerous gland ducts which enter it from a wide area of the surrounding mesenchyme and open into the seminal vesicle (*vs*).

The two vasa deferentia empty, by a common opening, into the cavity of the penis which shows an anterior wider part (seminal vesicle, *vs*) and tapers posteriorly to a narrower ejaculatory duct which opens at the tip of the papilla. One of the chief distinguishing features of the new subspecies is the extraordinary development of the external circular muscle layer (*mp*) at the basis of the penis papilla. The thickness of this layer is several times the thickness of the muscle layers of the male atrium (while in *P. dactyligera dactyligera* the corresponding muscle layers are about equal in thickness).

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FIG. 1–3. 1. *Planaria dactyligera musculosa*. a. Quietly gliding animal; *gp*, gonopore; *m*, mouth; *ph*, pharynx. b. Anterior end, showing position of eyes and intestine. c. Freshly hatched young; the shaded area indicates the extent of the intestinal trunks and branches. 2. *Planaria dactyligera musculosa*, photograph from life, ×9. 3. *Planaria occulta*, photograph from life, ×9.

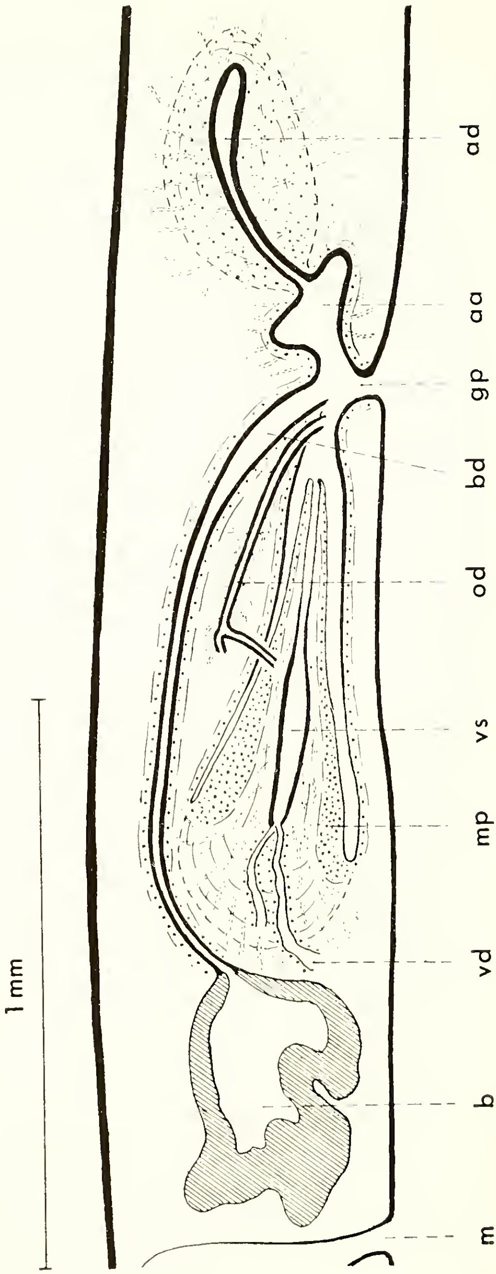


FIG. 4. *Planaria dactyligera musculosa*, semidiagrammatic view of copulatory organs in sagittal section. *aa*, atrium of adenodactyl; *ad*, adenodactyl; *b*, copulatory bursa; *bd*, bursa stalk; *gp*, gonopore; *m*, mouth; *mp*, circular muscle layer of penis papilla; *od*, common oviduct; *vd*, vas deferens; *vs*, seminal vesicle.

The second difference between the two forms concerns the relation of the adenodactyl (*ad*) to the atrial complex. The adenodactyl is a large ovoid or pear-shaped organ with a thick muscle coat of chiefly circular fibers, very densely arranged, with the corresponding cell nuclei forming a peripheral layer. Its elongated cavity opens into a separate part of the genital atrium (*aa*) which narrows anteriorly and connects with the general atrial complex very close to the genital opening (*gp*). There is no distinct papilla of the adenodactyl protruding into this chamber. The epithelium of the chamber is pierced by very many gland outlets originating in the mesenchyme.

In summary, the main distinguishing characteristics of the new subspecies are (1) the thick circular muscle layer at the base of the penis papilla and (2) the presence of a highly gandular antechamber between the gonopore and the adenodactyl.

Distribution: The first specimens of *Planaria dactyligera musculosa* were sent to me by Dr. T. E. Powell, Jr., of the Carolina Biological Supply Company. They had been collected at the "Sawdust Pile Location" in Ossipee, Alamance County, North Carolina, in November 1966. The majority of the animals were sexually mature.

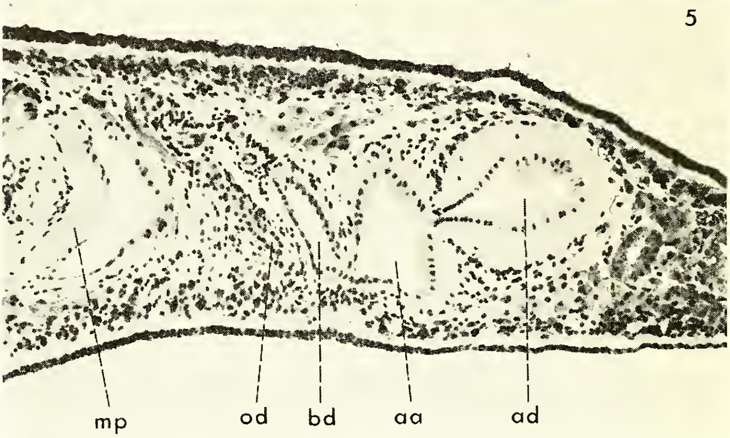
Additional specimens were collected on 13 June 1968 in two localities on the grounds of the Warren Laboratories of the Carolina Biological Supply Company, off U. S. Highway 158, 3 miles E of Warrenton, Warren County, North Carolina. One was a stream near the side entrance road to the Laboratories, the other on the airport road. The specimens were small, immature, but matured in the laboratory cultures.

Reynierse and Ellis (1967) report that they used *Planaria dactyligera* in an experiment on planarian behavior. Since they had obtained their animals from the Carolina Biological Supply Company (personal communication), we may safely assume that their planarians belonged to the subspecies *P. d. musculosa.*

Longest (1966: 39–41) reported *Planaria dactyligera* from Abita Springs State Park, St. Tammany Parish, Louisiana. Examination of his slides showed that his specimens belonged to the subspecies *musculosa.*

Parasites: Small nematodes were occasionally observed in the mesenchymatous zone of the pharynx. They apparently were capable of moving freely through the tissue as no cysts were formed around them. The holotrichous ciliate, *Sieboldiellina planariarum* (Siebold) occurred in the lumen of the intestine and sometimes in the pharyngeal pouch. Some of the specimens were infested with the peritrichous ciliate epizoite, *Urceolaria mitra* (Siebold), attached mainly to their dorsal surfaces.

Observations in laboratory cultures: Cultures of *Planaria dactyligera musculosa* were kept in spring water in a constant-temperature chamber at about 14°C, and fed beef liver and/or *Tubifex* which were readily taken. The worms produced cocoons all year round. The cocoons are ellipsoidal, rather variable in size, the longest diameter measuring 0.8–1.7 mm, the shortest 0.6–1.0 mm. When deposited they are attached to



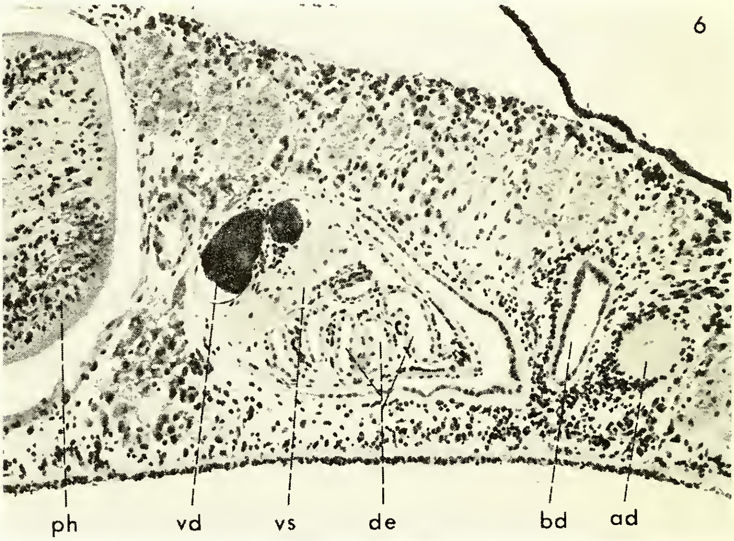


FIG. 5–6. 5. *Planaria dactyligera musculosa,* sagittal section of copulatory complex, showing the adenodactyl (*ad*) with its atrial chamber (*aa*), the terminal part of the bursa duct (*bd*), the thick muscular coat (*mp*) of the penis papilla (excentrically cut), and part of the common oviduct (*od*), ×113. 6. *Planaria occulta,* sagittal section through copulatory complex, showing the position of the pharynx (*ph*), vas deferens (*vd*), seminal vesicle (*vs*), the convoluted ejaculatory duct (*de*), and parts of the bursa duct (*bd*) and adenodactyl (*ad*), ×113.

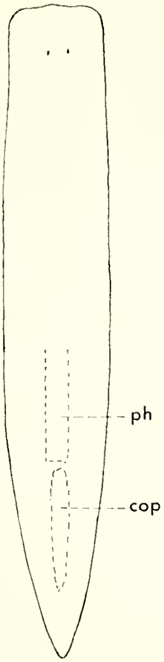


FIG. 7. *Planaria occulta*, outline drawing of gliding animal, *cop*, copulatory complex; *ph*, pharynx.

the substrate by a colorless jelly-like substance, the long axis being parallel to the surface of the substrate (bottom or side wall of the aquarium). They easily loosen their attachment when the cultures are handled. As is the rule in triclad cocoons, the freshly laid egg capsule is of a light reddish-brown color and darkens in a few days to become dark brown to almost black. Three to 14 young hatched from a single cocoon after 3–4 weeks. The freshly hatched young (Fig. 1*c*) vary in size from 1.5 to 3 mm in length. They are unpigmented, white, with a rounded head end. As they grow in size, they gradually become pigmented and acquire the typical truncate head shape characteristic of older specimens.

No asexual reproduction by fission was observed during 28 months of culturing.

Planaria occulta new species[4]

Type material: Holotype, from Duffield, Scott County, Virginia, 2 slides of sagittal sections, U. S. National Museum No. 39463. Paratypes, sagittal and transversal sections of 7 specimens, in the author's collection.

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[4] *occultus*, Latin, hidden, alluding to the subterranean occurrence in a well.

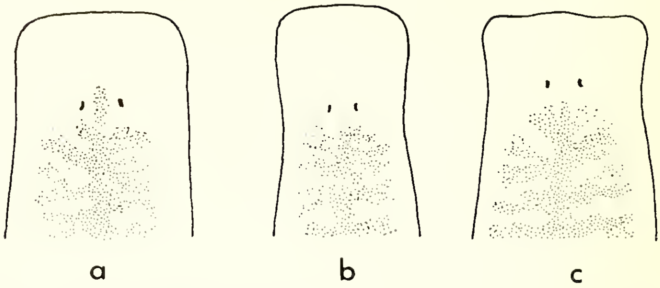

Fig. 8. Anterior ends of three similar planarian species: *a*, *Planaria occulta*; *b*, *Phagocata morgani*; *c*, *Phagocata oregonensis*.

External features (Fig. 3): Mature specimens measure up to 9 mm in length and 1.5 mm in width when gliding quietly. The species is without body pigment, appearing white when the intestine contains no colored matter; even with the intestine filled, the head, the lateral margins of the body, and the places occupied by the pharynx and copulatory apparatus are always white. The head is truncated, with a slightly convex frontal margin and rounded lateral edges (Fig. 8a). In quiet gliding it may transitorily present a moderately bulging median section (Fig. 7). There is no neck constriction behind the head. The lateral margins gradually diverge, soon become parallel, start converging again in the region of the pharynx, and meet at the moderately pointed posterior end. There are two eyes, rather far removed from the frontal margin, their distance from each other amounting to about one-fourth the width of the head at eye level. The distance of each eye from the lateral margin is smaller than that from the frontal margin. No supernumerary eyes, such as frequently occur in normally two-eyed planarians, have been observed in this species. The pharynx is inserted at about the middle of the body and amounts in length to approximately one-fifth the body length. In sexually mature specimens, the copulatory complex occupies the anterior three-fourths of the postpharyngeal region.

At first glance, *Planaria occulta* resembles the common *Phagocata morgani* (Stevens & Boring) with which it shares its geographic area, and other unpigmented species of *Phagocata* of North America (*P. nivea* Kenk, *P. oregonensis* Hyman), Europe, and Japan. Unfortunately not all these species have been adequately described in the living state. In comparing specimens in good physiological condition during gliding locomotion, one may discover subtle differences between these various species, differences which are entirely obscured in the preserved animals. Figure 8 shows such a comparison between *P. occulta* (*a*), *P. morgani* from a spring in Rock Creek Park in Washington, D. C. (*b*), and *P. oregonensis* from Portland, Oregon (*c*). It will be noticed that in *P. occulta* the anterior intestinal ramus ends at a level anterior to the eyes, while in the

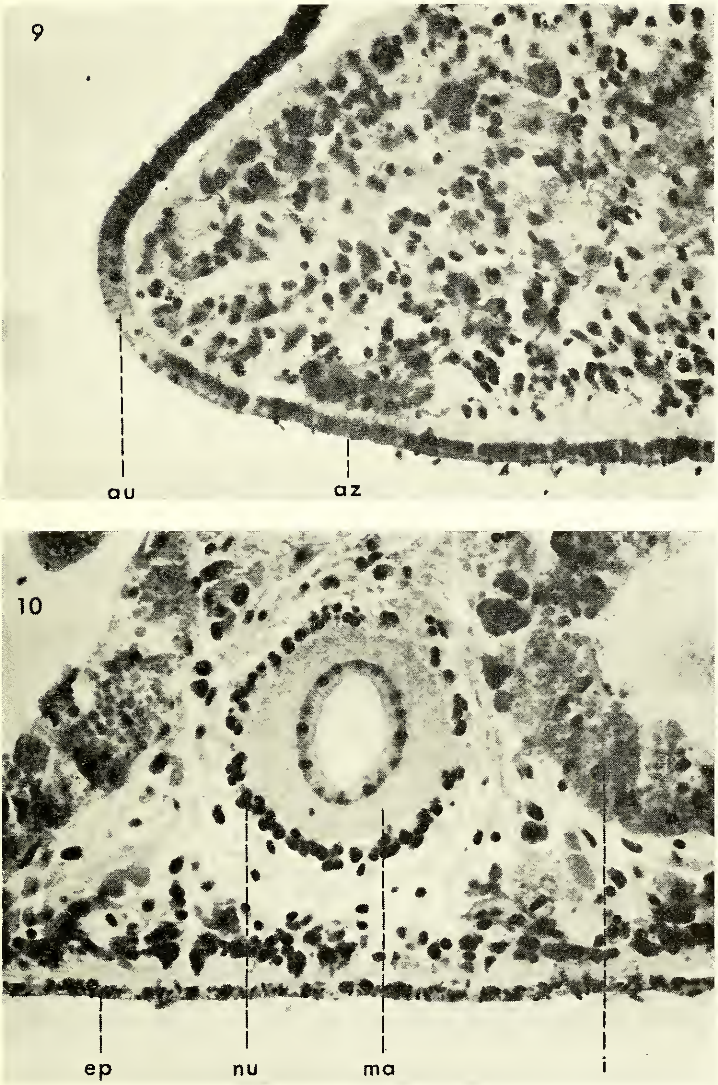

FIG. 9–10. *Planaria occulta.* 9. Paramedian section through the anterior end, showing the auricular sense organ (*au*) and the marginal adhesive zone (*az*), ×310. 10. Cross section of postpharyngeal region at the level of the adenodactyl; *ep*, ventral surface epithelium; *i*, intestinal epithelium; *ma*, muscle layer of adenodactyl; *nu*, layer of muscle cell bodies and nuclei. ×310.

adult *P. morgani* and *P. oregonensis* the intestine is confined to a region posterior to the eyes. It must be mentioned, however, that freshly hatched young of *P. morgani* show an anterior extension of the intestinal ramus between the eyes similar to that of *P. occulta.*

The locomotion of *Planaria occulta* is a smooth gliding. No "crawling" movements such as are observed in many other species have been seen even upon mechanical stimulation of the animal (to which they react by a brief contraction of the body, followed immediately by continued gliding).

Integument: The epithelium of the general surface shows no peculiarities, the cells of the dorsal epithelium being somewhat taller than those of the ventral side (about 12 μ and 8 μ, respectively, depending somewhat on the contraction of the body). No distinct adhesive organ is developed. A narrow band of gland openings runs ventrally along the margins of the body, the marginal adhesive zone (Figs. 9 & 11, *az*). This band is interrupted only in the center of the frontal margin of the head by a very short (30 μ–35 μ) gap. The secretion of the adhesive glands is granular and strongly eosinophilic.

Sense organs: In addition to the eyes, there are other sensory structures discernible in the head region. The auricular sense organs occupy the lateral parts of the frontal margin and consist of strips of modified epithelium, densely ciliated and containing only few rhabdites which are generally much shorter than those of the surrounding epithelia. There are no sensory pits or grooves developed, as the organs form the very edge of the margin, being separated from the adhesive gland zone by a narrow band of normal surface epithelium. Another sensory area, a small patch with similarly modified rhabdite-free epithelium, lies on the ventral side of the head, immediately behind the gap of the marginal adhesive zone.

Digestive system: The pharyngeal muscles conform with the typical arrangement in the family Planariidae, the muscle fibers of the internal zone forming two separate layers, an inner circular and an outer longitudinal one. The external muscle zone consists likewise of two layers, a layer of longitudinal fibers underlying the outer epithelial covering, followed by a layer of circular fibers. There is no third (longitudinal) layer developed. The anterior intestinal ramus which, as indicated above, extends in the head region to a level in front of the eyes, bears on either side 6 to 9 branches; each posterior ramus, 13 to 19 shorter and less profusely ramified branches.

Reproductive system: The numerous testes occupy a longitudinal zone on either side of the midline, each zone extending from a short distance behind the head to approximately the level of the mouth opening. In a prepharyngeal cross section (Fig. 11) one may see on each side one to six more or less rounded testicular follicles (*t*), situated in the ventral parts of the mesenchyme, mainly below the intestinal branches (*i*) and above the ventral nerve cords (*n*). Individual testicles, particularly at full maturity, may penetrate dorsally in the spaces between the branches of the

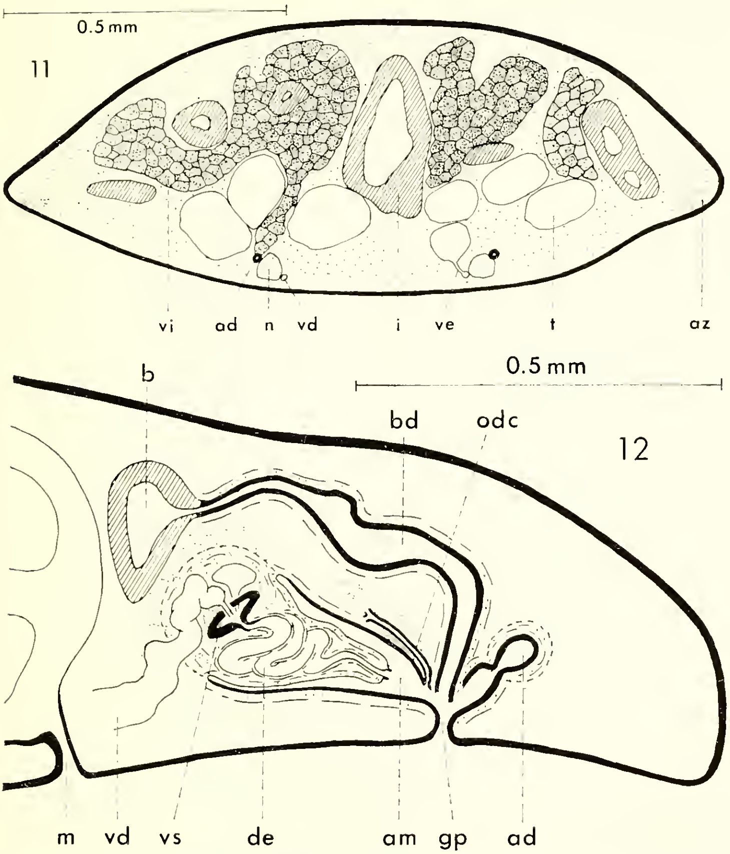

FIG. 11–12. *Planaria occulta.* 11. Transversal section of prepharyngeal region. 12. Semidiagrammatic view of copulatory apparatus in sagittal section. *ad*, adenodactyl; *am*, male atrium; *az*, marginal adhesive zone; *b*, copulatory bursa; *bd*, bursa stalk; *de*, ejaculatory duct; *gp*, gonopore; *i*, intestine; *m*, mouth; *n*, ventral nerve cord; *od*, oviduct; *odc*, common oviduct; *t*, testis; *vd*, vas deferens; *ve*, vas efferens; *vi*, yolk glands; *vs*, seminal vesicle.

intestine. From each testicle a delicate duct, the vas efferens (*ve*), proceeds ventrally to open into the likewise very thin-walled sperm duct or vas deferens (*vd*) of the corresponding side, which runs along the medial border of the ventral nerve cord, close to the subcutaneous muscle layer of the ventral surface. In the region of the pharynx the vasa deferentia expand greatly in diameter and are seen as a pair of tortuous tubes filled with sperm, the false seminal vesicles (or spermiducal vesicles according to Hyman's [1951: 113] terminology). At the level of the penis they bend upward and enter the bulb portion of the penis from the sides.

The rather small spherical ovaries or germaries are in the typical position, a short distance behind the eyes, adjoining the medial side of the ventral nerve cords. Each ovary is accompanied by more voluminous, lobate masses of cells extending toward the dorsal side, the parovaries. The cytoplasm of these cells stains dark blue with Ehrlich's hematoxylin. The oviducts or ovovitelline ducts start from the lateral surfaces of the ovaries, each beginning with a slightly widened portion, the seminal receptacle. They run caudally along the dorso-lateral side of the ventral nerve cords (Fig. 11, *od*). On their course they connect with numerous yolk glands or vitellaria (*vi*) which, at full maturity, represent voluminous masses occupying chiefly the dorsal and lateral portions of the mesenchyme from the level of the ovaries to almost the posterior end of the body.

The copulatory apparatus (Fig. 12) occupies, in sagittal sections, the greater part of the postpharyngeal region. The genital aperture or gonopore (*gp*) is situated far caudally, its distance from the mouth opening (*m*) being about twice the distance from the tail end of the body. There is no distinctly developed common genital cavity or atrium, as the various ducts of the copulatory complex meet almost at the gonopore: from the anterior side the male atrium (*am*), dorsally the duct of the copulatory bursa (*bd*), and from the caudal side the outlet of a small cavity connected with the adenodactyl (*ad*). The "male" atrium encloses the papilla of the penis and receives in its posterior portion the mouth of the common ovovitelline duct (*odc*). Its lining is an epithelium of cubical, ciliated cells below which are two layers of muscles, a layer of circular fibers and below it one of longitudinal fibers.

The male copulatory organ or penis consists of a moderately developed spherical bulb embedded in the mesenchyme a short distance behind the pharyngeal pouch, and a conical papilla pointing caudally and somewhat toward the ventral side. The bulb consists of a loose arrangement of muscle fibers between which there are very numerous gland ducts containing a fine-grained faintly eosinophilic secretion. These ducts originate from cell bodies lying in the surrounding mesenchyme and open within the bulb into a rather small, usually antero posteriorly compressed cavity, the seminal vesicle (*vs*). Each vas deferens (*vd*), which retains its expanded shape as spermiducal vesicle, enters the penis bulb laterally, forming a few convolutions within the bulb, and finally narrowing to a short canal which opens into the seminal vesicle. At the border between the penis bulb and the penis papilla the seminal vesicle connects with the ejaculatory duct (*de*). This is, in its main portion, a highly convoluted tube of about even diameter. Only its terminal part gradually narrows and straightens out in the axis of the papilla, to open to the outside at its tip. This opening is encircled by a small collarlike projection of the papilla. The space between the outer wall of the papilla and the convolutions of the ejaculatory duct contains a very loose parenchyma, often giving the impression of an empty space. This condition, as well as the fact that the ejaculatory duct does not have the typical shape of a straight tube makes it possible to speculate whether the ejaculatory duct is not capable of evagination (like the cirrus of trematodes and cestodes, or the proboscis of nemerteans). Evidence of a partial eversion was seen in at least one of the eight specimens sectioned.

The epithelium lining the seminal vesicle consists of columnar to cubical cells perforated by the numerous gland ducts which have penetrated the penis bulb from the outer mesenchyme. The lining of the ejaculatory duct is a cubical, the outer covering of the penis papilla a flattened epithelium. Both epithelia have associated muscular layers: circular and longitudinal fibers on the papilla and chiefly longitudinal fibers on the ejaculatory duct.

The copulatory bursa (*b*) is a more or less rounded sac situated in the mesenchyme immediately behind the pharyngeal pouch, lined with a rather tall glandular epithelium. Its duct or stalk (*bd*) proceeds from its dorso caudal side posteriorly as a rather narrow canal, then gradually widens forming some convolutions above the atrium, and, after narrowing slightly, bends ventrally and opens into the atrial complex close to the gonopore. There is, therefore, no enlarged terminal section or vagina present. The duct is lined with a cubical epithelium which bears cilia at least in the distal (posterior) part of the canal. It is surrounded by a well-developed muscle coat of circular fibers adjoining the epithelium, followed by a layer of longitudinal fibers.

The two ovovitelline ducts, which accompany the ventral nerve cords in the anterior part of the body, deviate from their course at the level of the penis, ascend dorsally along the wall of the male atrium and unite in the space between atrium and bursa stalk. The common oviduct (*od*) thus formed runs postero ventrally along the roof of the atrium and opens, without further differentiations, into the posterior portion of the atrium. The paired oviducts from the place where they are separated from the nerve cords, and the entire unpaired or common oviduct receive many gland ducts with an intensively eosinophilic secretion from the surrounding mesenchyme. These glands are generally termed "shell glands" although their function is doubtful and probably has nothing to do with the formation of the shell of the cocoon.

The adenodactyl (*ad*) is a very distinct ellipsoidal or almost spherical hollow organ situated near the ventral side a short distance posterior to the gonopore. It consists mainly of a highly muscular covering enclosing a round cavity. The muscle fibers of the organ are very densely arranged, mainly in a circular direction, with their cell bodies and nuclei forming a distinct peripheral layer (Fig. 10, *nu*). Gland ducts seem to penetrate the muscular coat from the outer mesenchyme, but do not show up clearly after staining with hematoxylin and eosin. The lumen of the adenodactyl opens into a small compartment of the genital atrium which extends posteriorly from the vicinity of the gonopore. There may be a small papilla protruding from the adenodactyl into this compartment, or this papilla may be entirely absent, depending on the state of contraction of the copulatory complex. The cavity of the adenodactyl is lined with a cubical ciliated epithelium. In the sections examined, the cavity was usually empty, without an accumulation of secretions.

Distribution: *Planaria occulta* has so far been found in only one locality, a hand-dug well, about 4 m deep, just east of the town of Duffield, Scott County, Virginia, on the property of Mr. Corbett Brown. The first specimens brought to my attention were collected by Dr. John R. Holsinger and Mr. Sam Pinkerton on 11 March 1967. They were preserved in formalin and showed the reproductive system well developed. A second lot of sexually mature specimens, collected 8 April 1967 by Dr. Holsinger, were received in the living state. On 26 November 1968 I visited the locality, submerged some liver bait in the well, and collected next morning about 100 specimens of various sizes, the majority having developed reproductive structures. The water temperature at that time was 11.8°C.

Ecology: It is difficult to decide whether the hypogean occurrence of the species is obligate, as the surface waters of the geographic area have not been examined systematically. The fact that sexually mature animals were collected in March, April, and November makes it probable that their sexual maturity is not of a seasonal nature. In the laboratory the aniamls kept very well in spring water cultures at 14°C and accepted beef liver and *Tubifex* worms as food. However, no egg capsules were deposited during five months of culturing, nor was there any evidence of asexual reproduction by fission.

Taxonomic position: The general arrangement of the various parts of the copulatory apparatus and the presence of a hollow adenodactyl place the species in the genus *Planaria*. While the remaining species of this genus *P. torva*, *P. kempi*, and *P. dactyligera*, form a closely related group with many characteristics in common, the new species occupies a somewhat isolated position. Apart from the lack of body pigment (which is also occasionally seen in *P. torva*, see Reisinger [1963: 685], and in the cavernicolous subspecies *P. torva stygia* Kenk [1936: 7]), some features of the copulatory apparatus deviate considerably from the conditions seen in the type-species of the genus. Among these, the most outstanding difference concerns the anatomy of the penis: the presence of a sinuous, probably eversible ejaculatory duct. The adenodactyl likewise differs in some details from that of *P. torva*.

Parasites: All specimens of *Planaria occulta* sectioned or investigated in squash preparations were heavily infested with the holotrichous ciliate *Sieboldiellina planariarum* (Siebold), a parasite commonly found in *P. torva* (see Meixner, 1928: 604, etc.) and other freshwater triclads. The ciliates were always found in the rami and branches of the intestine, less often in the pharyngeal pouch, and occasionally in the copulatory bursa. This latter observation supports the interpretation maintained chiefly by Steinböck (1966: 167, etc.) that the bursa is a derivative of the intestine which has retained many of the functions of that organ as well as part of its chemical environment.

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INTRODUCTION

The Biological Society of Washington has periodically assembled to hear scientific lectures and papers since its founding in December, 1880. The two main functions of The Society through the years have been sponsoring meetings and publishing a scientific journal, The Proceedings. The membership of The Society is chiefly composed of systematists, and this has been reflected in the subject matter of The Proceedings and the meetings.

As demands for research and service in systematics grow ever more insistent, collections—the systematist's singlemost important tool—grow larger and their efficient maintenance becomes increasingly complex and costly. It was considered timely, therefore, to identify and discuss aspects of the plethora of problems besetting the managers and users of natural history collections. To this end The Biological Society devoted its Autumn 1968 meeting to the topic *Natural History Collections, Past—Present—Future.*

The Biological Society is grateful to the speakers, many of whom are not members, for their conscientious efforts in preparing and presenting a stimulating program. We also thank The Smithsonian Institution for making available to The Society facilities for the meeting.

The following papers were presented at the meeting, chaired by Ernest A. Lachner and arranged by Daniel M. Cohen and Stanwyn Shetler, which took place on October 11, 1968.[1]

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[1] An additional paper not included here entitled "Entomological Collections—The Dilemma of Success" was presented by Donald Duckworth, Smithsonian Institution.

ART AND SCIENCE AS INFLUENCES ON THE EARLY DEVELOPMENT OF NATURAL HISTORY COLLECTIONS

By Philip C. Ritterbush
Smithsonian Institution, Washington, D. C.

Cabinets of curiosities and treasure chambers, those early antecedents of the natural history collection, may seem to us to have been not at all scientific in their organization or scope and thus to have had little scientific value. Not until the time of Linnaeus and Lamarck do we find collections being used to generate classifications, which has until quite recently been the primary scientific use to which they have been put. But before the collection could serve this or any other scientific purpose it had to be acknowledged that the specimens corresponded to the natural world, that they could represent living entities as they have actually existed. This belief need not involve us in questions about the reality of classifications (important though these have been as determinants of the character of modern collections) because it bespeaks a much more basic presupposition, namely that the external world of living forms was real and thus might be reliably represented by specimens. It was this basic presupposition that the forerunners of the natural history collection helped to establish.

The manner in which individuals perceive their surroundings is greatly affected by their social institutions (Berger and Luckmann, 1966, 19–34 and 121–22). Ecclesiastical institutions dominated early medieval Christian Europe to the extent of claiming and exercising the right to determine which modes of human experience could be designated as real. Abjuring direct means of knowing, the Church aspired to ethical and spiritual accomplishments which could be experienced only indirectly, through symbolism or ritual. As aids to attain-ing significant spiritual experiences the Church maintained extensive visual arrays of symbolic figures and designs, of which some cathedrals were astonishingly well developed examples, instructing the people and offering them opportunities for sustained emotional involvement. "In ages for which religion and poetry were a common possession, the basic images lived in the conscious mind; men saw their place and destiny, their worth and guilt, and the process of their existence, in terms of them" (Farrar, 1949, 13–14). The material world was significant only as a symbol for a spiritual reality of vastly more consequence. To the author of the twelfth-century *De Bestiis* a dove had two wings as the Christian had two ways of life, active and contemplative. Its eyes were golden because that is the color of ripe fruit and thus of the wise maturity of the church. Its feet were red for the church moved through the world with her feet in the blood of martyrs. Its blue wings reflected thoughts of heaven (Mâle, 1913, 30). One of the most widely known works on the significance of natural objects was the *Physiologus*, a very ancient bestiary presenting symbolic interpretations of animal fables. Symbolism gave a rigorous and all-embracing conception of the world (Huizinga, 1924, 204–5) within which descriptions of natural entities for their own sake were usually mere "interpolations" (Crombie, 1952, 8). The naturalistic techniques of illustration developed during classical times had been virtually lost (Evans, 1933).

The most prominent works of art in churches throughout the Middle Ages reflected the symbolic program, but in lesser works such as decorative architectural details and borders of illuminated manuscripts the artists of the time were free to pursue a more independent course. From sources such as the capitals of columns (Jalabert, 1932) and ornamented books of hours it appears that there gradually developed during the thirteenth century a reinvigorated naturalism, reflecting an increasingly widespread ability to perceive the natural object as an entity in its own right. Around the beginning of the thirteenth century the ornamental foliage of capitals of columns in French cathedrals ceased to be generalized and abstract and came to portray recognizable species of plants. By comparison

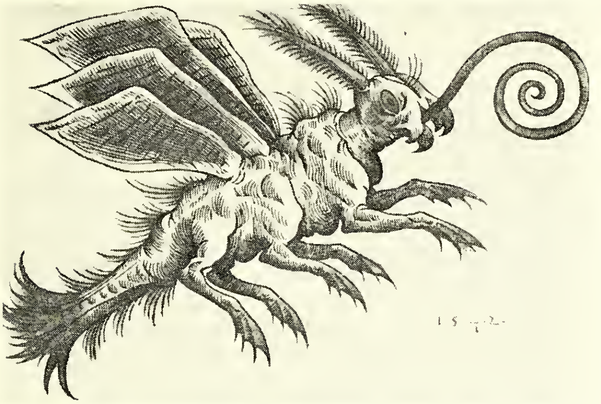

FIG. 1. Anonymous woodcut, "Natürliche Contrafaytung des Herrn oder Künigs der Chavalette," signature and date 1542 added in ink. Border dimensions 18 × 12.5 cm. MS.F13,f88a, Sammlung Wickiana, Zentralbibliothek, Zürich.

to the stylized illustrations of writings on medical topics artists of the time were equally far advanced in their portrayals of skeletons and anatomical features. In general these artistic manifestations of naturalism took place a century or more in advance of naturalistic descriptions or portrayals of organisms by learned writers. It would seem to be a consequence of ecclesiastical control of the most socially important processes of perception that naturalistic portrayal began as a minority tendency on the part of artists rather than writers and other systematic thinkers with whom ecclesiastical authorities were more concerned. Lynn White, Jr. in an important article postulated that these artistic developments were the beginnings of a later and more general shift in attitudes favoring naturalism and more concrete representation even of divine phenomena, as in the eucharistic cult with its tangible sacraments which became prominent at the same time. Such developments, of course, greatly favored the establishment of scientific attitudes (White, 1947, 427–31).

A striking example of the distortions of perception induced by the symbolic view of reality may be found in accounts of periodic European infestations of the migratory locust with illustrations portraying it as a demonic and malevolent crea-

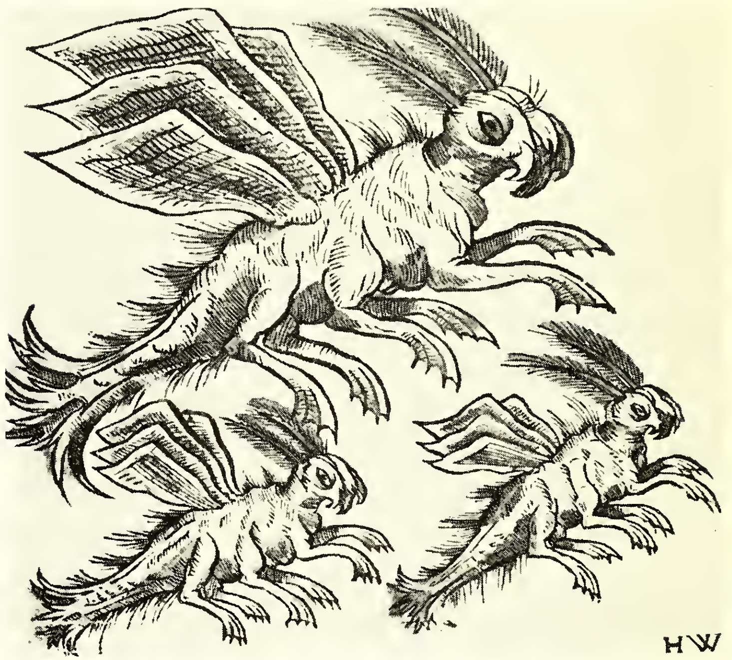

FIG. 2. Monogrammist HW, "Natuerliche Contrafeyhung des gewaltigen flugs der Heuschrecken . . . ," dated 1556. Border measurement 18 × 16 cm. MS.F13,f80, Sammlung Wickiana, Zentralbibliothek, Zürich.

ture. There is an allegorical drawing by Albrecht Dürer (1471–1528) in the Museum at Rennes in which locusts are depicted as devils writing script and carrying various sinister objects (Blanck, 1957, 6). Such an illustration shows the influence of prevailing theological conceptions of the locust as an instrument of divine vengeance. During the plague of 1542 one observer claimed to find the words IRA DEI on the wings of locusts, which he took as evidence that they were indeed messengers of divine wrath (Schönwälder, 1960, 413). After the infestations of 1542 and 1556, each extending through wide areas of Italy and central Europe, woodcuts were made showing locusts as fabulous beings with exaggerated antennae, webbed feet, a forward-pointing spiral appendage (in the 1542 drawing), and brush-like tails (Fig. 1 and 2). These illustra-

FIG. 3. Realistic depiction of migratory locust by Pisanello, ca. 1430. Musée de Louvre, Paris. Photo credit: Cliché des Musées Nationaux.

tions were published as parts of broadsides printed to carry news of the locust plagues and thus may be taken to represent attempts to record the events. There is strong confirmatory evidence that there indeed were plagues of locusts when reported (Baccetti, 1954, 278; Waloff, 1940, 225) yet visualizations strayed exceedingly far from their objective basis. As late as the middle of the sixteenth century it was possible for a would-be chronicler to have before him a locust yet perceive and record a chimera, as the socially derived mode of perception imposed itself upon the data of experience. The early drawings of the locust were frequently so schematized as to be unrecognizable. One of the most experienced students of medieval illuminated manuscripts reproduces two drawings from the late thirteenth and early fourteenth centuries in which peasants are filling sacks with migratory locusts. The captions are erroneously given as "Man and butterfly, pursuing with hood." (Randall, 1966, Pl. LXXI, figs. 342, 343).

In the Louvre there is a drawing executed over a century earlier, by Pisanello (1380–1456), in careful naturalistic detail, clearly recognizable as *Locusta migratoria* and lacking any of the fantastic features attributed by the artists of the later woodcuts (Fig. 3). The naturalistic illustration had been far advanced for its day and the later woodcuts may be taken to show a persistence in popular culture of the fabulous tendencies in depictions of creatures influenced by prevalent medieval concepts of reality. This interpretation posits a gradual change in modes of perception by which naturalism appeared first as an esthetic motive in the decorative arts and then grew in importance until it became the basis for more accurate scientific representations of creatures based upon direct observation unhindered by conceptual distortions.

Leonardo da Vinci (1452–1519) exulted in the knowledge he gained from direct observation. It is significant that the most profound Renaissance conception of the scientific value of naturalistic perception was that of an artist, who indeed conceived of painting as the highest form of knowing. Leonardo's avowal that "All our knowledge originates in our senses" (Stites, 1968, 222) sharply contrasts with the verbal procedures by which contemporary academicians still sought to substantiate their beliefs. Leonardo praised the power of drawings to describe a "whole arrangement," far superior to verbal descriptions which conveyed "but little perception of the true shapes of things" (Zubov, 1962, 57). From 1485 he had conducted serious anatomical studies based upon numerous dissections. He advocated consecutive drawings to show how different systems composed an organ and also sequential drawings to depict the same structure from several directions, and he tried also to represent living things in their dynamic aspect. His ideal was the geographic atlas showing all major provinces of a subject. The artist must progress beyond naive perception to discerning visual examination of objects. He must "know how to see" (*saper vedere*). Leonardo was especially contemptuous of beliefs that immaterial spirits, lacking extension and the capacity to exercise force, could intervene in the everyday world. His observations clearly demonstrate the important consequences for scientific knowledge which would follow from learning to see.

One may perhaps mark the turning point in the application of naturalistic perception to biology in the work of Vesalius (1514–1564). In the well-known scene of an anatomical theater that appears as the title page of *De humani corporis fabrica* (1543) there is a bearded man holding a closed book while pointing to the dissection in progress as though to admonish a nearby student that more is to be learned from reality than books. Indeed, it required only the most cursory observation to demonstrate that men do not lack a rib even though Moses wrote that God took one from Adam or that the human liver does not have the five lobes which Galen ascribed to it.

We might note that the most important forerunner of Vesalius, Giacomo Berengario da Carpi (c. 1460–1530), was praised by Cellini for his interest in art and possessed a considerable art collection. The splendid woodcuts commissioned and perhaps partly executed by Vesalius established the importance of biological illustration, and they reveal something of their artistic legacy in the landscapes of the Euganean Hills near Padua drawn in the background of the plates of "muscle-men," as well as in the poses of the figures, taken from antique statuary. Perhaps mindful of the dissections carried out by the artists Antonio Pollaiuolo (1429–1498) and Benozzo Gozzoli (1420–c. 1497), as well as Leonardo, the recent biographer of Vesalius observes that "The impulse to naturalistic anatomical depiction seems to have come from the art world rather than the medical." We should also note his observation on the extent to which Vesalius owed his success to the reviving naturalistic mode of vision: "Vesalius had an extraordinarily well-developed visual sense, and it is apparent in his verbal descriptions of anatomical structures" (O'Malley, 1964, 18 and 118). The *Historia animalium* of Conrad Gesner (1551) and *De historia stirpium* of Leonhart Fuchs (1542), both profusely illustrated works, were published at about the same time, indicating that the use of realistic illustrations had become established (Nissen, 1963; Ziswiler, 1965; Blunt and Stearn, 1950).

The ability to discern and portray accurately the characteristics of the form of organisms, a talent at odds with the prevailing official mode of the time, owed its origin to artists and illustrators. The further extension of this ability in society would depend upon the extent to which men could learn to see in naturalistic rather than in symbolic terms. The phenomenological foundations of biological science were laid by naturalistic artists several centuries before the prevailing views came to ascribe the force of evidence to direct observation and objective portrayal of specimens from nature. Thus we should be on the lookout for new institutions serving to apply the artists' mode of perception to the social enterprise of ascribing reality to man's experience. The cabinet of curiosities, the early forerunner of the natural history collection, served a mediating function of this kind.

In the evolution of natural history collections the visual arts played a role which seems to have been central but which is difficult to define. There were no public museums until the eighteenth century. Scientific collections evolved slowly from the private treasure chambers of nobles and kings. Virtually the only natural objects found in these collections were fabulous or prized for their rarity. In the collection of Jean, Duc de Berry (1340–1416) there was a wonder cabinet with giants' bones, sea monsters, carved crystals, and some genuine articles such as ostrich eggs and polar bear skins. By the sixteenth century there were about a dozen outstanding large collections of princely treasure such as that of Archduke Ferdinand of Tirol (1520–1595) at Schloss Ambras (Schlosser, 1908). In these collections natural history objects were combined with gems cut into natural forms, montages of shells, and decorative items made from natural substances. The word cabinet is used sometimes of the collections as a whole and sometimes of the chests containing smaller items. The Kunst-und-Naturalienkammer set up by the Elector Augustus I (1530–86) of Saxony comprised seven rooms of the Royal Palace in Dresden, with works of both fine and decorative arts intermingled with natural history objects (Wittlin, 1949; Schuster, 1929; Murray, 1904; Bedini, 1965).

One of the most elaborate of the cabinets ever built to store such intermingled collections of nature and art objects is preserved in Uppsala. It was made by Philip Hainhofer of Augsburg (b. 1578), whose paintings and collages are occasionally remembered as examples of optical illusions, many based upon natural form. He was a dealer in natural rarities and art who oversaw the preparation of one celebrated cabinet in 1617

FIG. 4. Gem and art peak of the Gustavus Adolphus Kunstschrank (1625–26). The vessel is 42 cm long and the work of H. C. Lencker, an Augsburg silversmith. From Böttiger, 1910, Plate 12.

for Duke Philipp II of Pomerania, which was brought to Berlin to hold part of the royal collection and destroyed during World War II (Lessing and Brüning, 1905). The Uppsala cabinet, which was prepared in 1625–26, rises in several tiers of ebony drawers and contains numerous doors opening onto facades of cameos and rare woods. It is crowned by a carved coconut, coral, and silver drinking vessel with statuettes of Neptune and Venus atop a distinctive montage of minerals (quartz, citrine, hematite, barite, ores, and semiprecious stones) and shells (Fig. 4).

In the centuries following wealthy private collectors and

FIG. 5. Works of art and natural objects combined in a seventeenth-century collection, painted by Frans Francken the younger (1581–1642), "Eine Kunst und Raritätenkammer" (undated), 74 × 78 cm, Kunsthistorisches Museum, Vienna.

scholars also formed collections. Here, too, we find coins and other antiquities, shells and marine specimens, gems, and paintings indiscriminately jumbled together, as in the remarkable painting by Frans Francken the younger (1581–1642) showing a gentleman's collection and its owner discoursing over books with his friends in an adjoining room (Fig. 5). In the collection of Ulisse Aldrovandi (1527–1605) at Bologna works of art were arranged as ethnological curiosities or as examples of the materials of which they were made while natural objects and imitations were placed together (Schlosser, 1908, 108). An illustration of the collection of the pioneer marine biologist Ferrante Imperato (1550–1625) in Naples shows one wall lined with cabinets for works of art and the

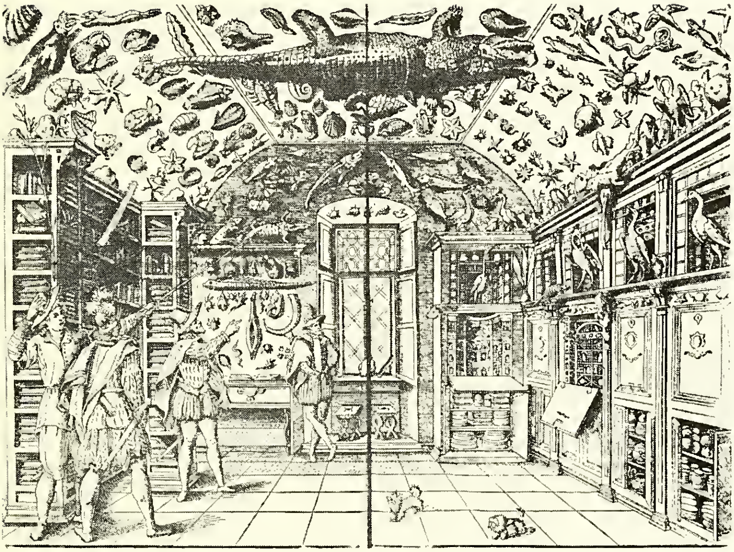

FIG. 6. Objects of art and nature combined in an early collection. Frontispiece, Ferrante Imperato, *Dell'historia naturale* . . . (Naples: C. Vitale, 1599).

ceiling covered with marine productions arranged without regard for their biological affinities (Fig. 6). In 1725 the collection of Sir Hans Sloane (1660–1753), which was to form the nucleus of the British Museum, included 5497 minerals and fossil substances, 804 corals, 8226 vegetable substances, 200 volumes of dried plants, 3824 insects, 3753 shells, 1939 echinoids, fishes, crustaceans, etc., 568 birds and 185 eggs, 1194 quadrupeds, 345 reptiles, 507 human objects, 1169 miscellaneous artificial and natural objects, 302 antiquities, 81 large stone seals, 319 pictures, 54 mathematical instruments, 441 vessels and carved mineral objects, 136 illuminated books, 20,228 coins and medals, 580 volumes of prints, and 2666 manuscript volumes (Murray, 1904, I, 137–38).

The inclusion of the fine and decorative arts in these collections affords a clue to the intricate cultural change that was occurring. The princely collection with fabulous or exceedingly rare animals was gradually succeeded by a collection representative of the animal or plant kingdom. The decorative objects so important to the early collections dwindle by proportion until by the eighteenth century one finds collections made up exclusively of natural objects. It would seem that the works of art in the collections functioned as catalysts in an unconscious transfer of authority from the artists' perception to the naturalists' reliance upon the objects themselves. We have today none of the collections as they were; objects of art and nature once regarded together have become the separate responsibilities of distinct departments in modern museums (Hutchinson, 1965.) Further study of inventories and descriptions of sixteenth and seventeenth-century collections is surely desirable to clarify and define the effect of art works upon the perception of natural objects and changing conceptions of reality as they have represented it. Such a correlation of the contents of collections with the conceptual development of biology would be a welcome contribution to the history of scientific thought.

Toward the end of the sixteenth and throughout the seventeenth century realistic still-life paintings of flowers and insects became immensely popular in the Low Countries (Bergström, 1956; Warner, 1928; Bernt, 1948). Paintings by Jan Brueghel the elder (1568–1625), Ambrosius Bosschaert the elder (1573–1621), Roelandt Savery (1576–1639), Daniel Seghers (1590–1661), Jan Davidsz. de Heem (1606–1683), Otto Marseus van Schrieck (c. 1619–1678), Abraham Begeyn (c. 1637–1697), Abraham Mignon (1640–1679), Rachel Ruysch (1664–1750), Jan van Huysum (1682–1749), and others frequently portrayed flowers in precise detail with recognizable species of insects situated near them in lifelike poses, while snails and snakes often appear. One of the earliest and most interesting of these painters was Georg Hoefnagel (1542–1600), whose works showed many exotic insects brought to Europe for the first time (Kris, 1927; Bergström, 1963).

The style of these works is usually termed "scientific naturalism." One leading scholar has attributed the realism of Dutch and Flemish flower painting to the "philosophy which claimed that the quality of reality belongs exclusively to the particular things directly perceived by the senses" (Panofsky, 1953, I, 8). The flowers frequently symbolize mortality and sometimes the

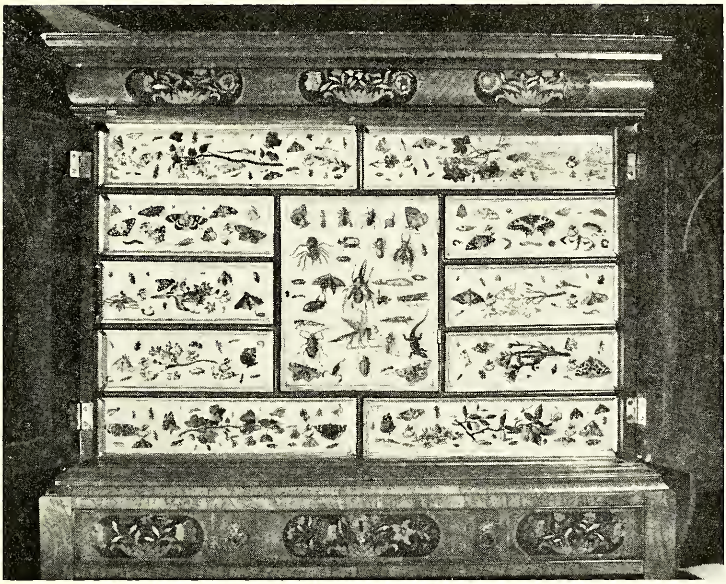

FIG. 7. The painted surface of the Smithsonian cabinet of curiosities, attributed to Jan van Kessel. 42¼ in × 26¼ in. External marquetry decoration appears above and below the painted surface.

insects are allegorical representations (Bergström, 1955), but the overwhelming impression created by these numerous works is one of fascination with their immediate colorful subject matter. They thoroughly document the force and persistence of naturalism as an artistic motive throughout the period of the development of the natural history collection.

In 1964 the Smithsonian Institution acquired some months after its sale at Sotheby's (March 11, lot 88) an exceptionally interesting work in this genre which serves to remind us of the close links between naturalism and cabinets of curiosities (Fig. 7). It is a seventeenth-century veneer and marquetry cabinet, an unsigned work of Flemish or English craftsmanship, with ten drawers and a central door panel whose veneer surfaces are painted white and on which appear scores of insects, painted approximately life-size, after the manner of the well-known Flemish still-life painter Jan van Kessel (1625–1679), who is well represented in major European museums. Many of the individual insects and even their arrangement in the panel compositions are identical to those in signed works by van Kessel. The entire composition closely resembles that of a set of seventeen paintings on copper signed and dated 1658 bought by the Amsterdam firm Gebr. Douwes in England in 1923 and sold by them to a Mr. van Valkenberg in 1924. This set is probably the same as that sold by the Fievez firm in Brussels in 1935 and that exhibited by the Hallsborough Gallery in London in 1956, and since sold to an anonymous buyer (personal communications from Evert J. M. Douwes and the Hallsborough Gallery; also Hallsborough, 1966). A separate, virtually identical set was exhibited in Amsterdam in 1934 by the firm of P. de Boer and then broken up (personal communication, P. de Boer). Both sets on copper were probably prepared for the fronts of cabinets, either as decoration or explicit commentary on cabinets of curiosities.

The Smithsonian cabinet is not as intricate in detail as most van Kessels; it was probably copied in England from one of the sets on copper or possibly executed in van Kessel's own studio in Antwerp. The latter would be more likely if the place of the cabinet's manufacture could be established as Flanders, but its manner of decoration was virtually an international style, so that it is very difficult to assign individual pieces to one country or another. The dimensions of the Smithsonian cabinet are more regular in inches than in pieds and pouces, the system of measurement in use on the Continent at the time, which suggests that it was fabricated in England. At any rate, its design clearly reflects van Kessel's work of 1658 and the tradition by which naturalism had come to be associated with cabinets of curiosities.

The insects and plants, as was true of most work of the genre, were almost certainly copied from sketchbooks (a practice that enabled artists to produce their works throughout the year, not just when flowers were in bloom and insects on the wing). It is also of interest that van Kessel executed works in which creatures were portrayed almost as in the dioramas of museums (usually considered a nineteenth-century innovation). In the Museé de Dijon are two undated works of this type: one, "L'eau," shows a seal, giant squid, and numerous fish on a

FIG. 8. The central panel of the Smithsonian cabinet of curiosities, attributed to Jan van Kessel. 12⅝ in × 15½ in. The figure derived from the locust woodcuts appears in the lower center.

beach; the other, "La terre," shows stags, peacocks, roses and other plants, and two hawks tearing at a dead game bird. Another painting sold by the firm of Nystaad in Lochem in 1947, entitled "The night," portrays a lively group of bats, badgers, and wildcats in a nighttime landscape.

It is in the central panel of the Smithsonian cabinet, with exotic insects and arachnids from the Americas (Fig. 8) that we encounter an image which reminds us of the progress made toward naturalistic representation in the century or so preceding. Here, slightly altered, but with unmistakable thickened antennae and forward-pointing spiral appendage is the migratory locust figure seen previously in the sixteenth-century broadsides! Before seeing those earlier illustrations in the Zürich library I had supposed that this was an illustration of a "humbug" fabricated by curio merchants (Misson, 1699, I, 134–35; Ripley, 1965; Ritterbush, 1964, 145 n.). To find the sixteenth-century illustrations of the locust was to discover an unexpected element of continuity linking the fabulous images of a symbolic age to the progress of realistic natural knowledge based upon the objects themselves, but only as a single survival amidst an array of realistic portrayals. If the collection was gradually transformed from an artistic aggregation to a purposeful instrument of scientific inquiry it was because men of science had learned to see, largely as a result of the vivid accomplishments of artists who had so far preceded them in employing naturalistic vision. A treatise on museums and collections published in the early eighteenth century included as its dedicatory legend a verse which seems aptly to summarize this history (C. F. Neickelius, 1727):

What in this world can more delight
  Than the nobility of creatures studied as they really are?
What can excite joy and wonder in the soul
  More than viewing the reality of nature?

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VERTEBRATE FOSSIL COLLECTIONS— A FRAGMENTARY DOCUMENT

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The fossil record plays a unique role in the study of biology, for it provides our only appreciable access to the time dimension of evolution as an historical process. To expatiate momentarily upon the obvious, the most nearly universal characteristic of the fossil record is the fact that it is fragmentary. The causes of this fragmentary nature—structure and mode of life of plant or animal, age, and pure chance—also introduce a bias into the fossil record. We need not concern ourselves with the causes, but the fact that the record is fragmentary and biased has a strong influence on the study of paleontology, particularly of the vertebrates, and on the role of museum collections in this study.

In practice there are two vertebrate paleontologies, one concerned with animals which have lived since the end of the Mesozoic Era, and the other with animals that became extinct before that time. The difference between the two is determined by three factors, one biological, the degree of similarity of the organisms to living forms, and a second geological, the degree of similarity of past to present physical circumstances of the earth's surface. The third factor, completeness of the record, is a product of both biological and geological influences.

The Cenozoic Era, the approximately 70 million years that have elapsed since the end of the Mesozoic, is often called the Age of Mammals, in reference to the fact that the dominant terrestrial vertebrates of this interval are mammals very similar in general to living forms. Lineages of the major orders of living mammals can be traced with a high degree of confidence in the changing faunas of the Cenozoic. The younger the faunas in question, the more directly can their components be compared with living animals, and although this comparison becomes somewhat more difficult as one goes back in time, the mammals of even the earliest Cenozoic are sufficiently similar to those of the present day to afford a basis for direct comparison. This is also true of Cenozoic amphibians (frogs and salamanders) and reptiles (crocodilians, lizards and snakes, turtles, and scattered relatives of *Sphenodon*).

Terrestrial vertebrate faunas prior to the Cenozoic were dominated by reptiles, most of the Mesozoic by dinosaurs, and the late Paleozoic and earliest Mesozoic by synapsid, or mammallike reptiles. Each of these groups was preeminent for about 130 million years, almost twice as long as the mammals have thus far enjoyed their supremacy. The most striking characteristic of these animals is the difference between them and the reptiles—or anything else—living today. Dinosaurs are often compared with birds, to which they are closely related, and synapsids can be compared with their descendants the mammals, or with unrelated reptiles such as turtles, with which they have many habitus features in common. But this is a far cry from comparing an early Cenozoic horse with *Equus*, or a Miocene arctoid carnivore with living dogs or bears. No terrestrial tetrapod of the present is closely comparable to either dinosaurs or synapsids in its general organization, in the way it makes its living. As a consequence, one is restricted to methods of classic comparative anatomy in working out relationships of pre-Cenozoic tetrapods, and resolution of all problems, whether taxonomic or functional, must be based for the most part upon the remains themselves, with only peripheral or analogical reference to living animals.

Geological aspects of Cenozoic time are similarly much more nearly comparable to present-day conditions than are those of earlier time. The major subdivisions of the fossil record, the Paleozoic, Mesozoic, and Cenozoic Eras, are related in some degree to long-term phases of mountain-building (tectonic cycles) over large parts of the earth. The cycle in which we find ourselves today was initiated at the beginning of the

Cenozoic and is still active. It has molded and continues to mold the general configuration of land masses (including major topography and drainage), and in doing so controls deposition of sediments and preservation of fossils.

Presumably the tectonic cycles of the Paleozoic and Mesozoic exercised the same influence over physical conditions on continental surfaces and over preservation of the faunas of those times. But the earth movements of each tectonic cycle result in the destruction of large parts of the features formed during preceding cycles, and in consequence much of the Paleozoic and Mesozoic record has been lost. Because present-day tectonics are essentially a continuation of the Cenozoic cycle, a far larger proportion of the Cenozoic terrestrial fauna is still preserved and exposed on the surfaces of all continents except Antarctica and perhaps Australia. Cenozoic faunas therefore tend in general to be more nearly complete and continuous than those of earlier time.

Destruction is selective. The higher the land, the more quickly it is eroded, and upland faunas are therefore rare even in the Cenozoic, except in its most recent phases. With a few notable exceptions, upland faunas are unknown in the Paleozoic and Mesozoic.

Tectonic activity of the current cycle has broken up the record of earlier eras both temporally and geographically. Except for bits and pieces, the long history of the dinosaurs is adduced from three segments of time totalling a good deal less than half their overall record. The earliest segment is that of the Upper Triassic, of perhaps 5 million years' duration, best represented in South Africa, Brazil and Argentina, western United States, and western Europe. The second segment, straddling the boundary between Jurassic and Cretaceous, lasted no more than 15 million years and perhaps as little as 5 million, and is best represented in western United States, western Europe, and Tanzania. The third segment is that of the Upper Cretaceous, of about 30 million years' duration, best represented in western United States and Outer Mongolia.

The history of synapsid reptiles as such (omitting Mesozoic mammals) extends essentially from the origin of reptiles some-time in the early Pennsylvanian to the end of the Triassic. The record is perhaps more nearly continuous temporally than that of the dinosaurs, but is sharply broken geographically. Approximately the first half, to the end of the Lower Permian, is best represented in the United States, while the second half is preserved in Russia, South Africa, Zambia, and Tanzania, and Brazil and Argentina.

The general effect of the characteristics of Cenozoic tetrapods and their record is to permit taxonomy and faunistics of the organisms to be studied in considerable detail. Species populations can often be recognized on the basis of preserved material, and confirmed, at least by analogy, by comparison with living populations. At higher stratigraphic levels, studies of rates of origin and longevity of genera and species in terms of absolute time are possible. In general, the most significant taxonomic work is concentrated below the level of order. Because of the relatively continuous record, studies of distribution are more meaningful, and the question of past migration can be approached directly. The occasional presence of such paleontological exotica as upland faunas gives students of this time period a better perspective for explicitly ecological faunal studies. Around its periphery, vertebrate paleontology of the Cenozoic merges imperceptibly into the more strictly biological disciplines of mammalogy and herpetology.

Few of these approaches are effective in the study of pre-Cenozoic tetrapods. Disjunction of the record makes questions of distribution and migration almost meaningless, for although we know where the animals were, we can never be sure of where they weren't. Because dinosaurs and synapsid reptiles are so different from living animals in morphology and biological requirements, and because we cannot be confident that the natural sampling of fossilization has preserved biologically relevant populations, in most cases we cannot confidently recognize reproductively isolated natural populations in the fossil material. Species designations are used to keep the picture consistent with neozoological practice, but in general the lowest operational taxonomic unit appears to correspond most closely to the genus of neozoology. Much of the significant work is concentrated at about the level of subclass.

Study of Paleozoic and Mesozoic vertebrates is therefore broad-brush paleontology. Although its low-level taxonomy is shaky, it provides an overall view of vertebrate evolution which since Darwin's time has gone far to document true relationships between vertebrate classes. Another approach, which has become more feasible in recent years as more material has become available, is the study of the functional anatomy of these outlandish beasts, which ultimately may provide insight into the selective forces that produced differentiation to such a high taxonomic level. Vertebrate paleontology of the Paleozoic and Mesozoic draws most heavily from comparative anatomy among the strictly biological disciplines, both in the classic approach and (by analogy) in studies of function.

The value of museum collections to vertebrate paleontology of whatever period is directly related to the fragmented quality of the record, for we can never predict what unprepossessing scrap of a fossil will next fill a gap in our knowledge. For Cenozoic specialists, identifiable bits often provide valuable data extending temporal or geographic range of mammal species. Fragments of crocodilians, turtles, and lizards identifiable no more closely than to subclass may contribute to the understanding of past climatic conditions, for these reptiles were presumably more restricted than mammals by climatic requirements. For the student of dinosaurs or synapsids, bits and pieces of ear, braincase, or jaw have contributed to resolution of problems of function and of high-level taxonomic relationships. This principle is also valid, of course, with respect to continuing field programs. One can predict only very generally what he will find in a given area, and it is only by sustained methodical collecting that these unexpectedly valuable pieces of the jigsaw puzzle accumulate.

In spite of its incompleteness, the fossil record is so enormous that no single institution can hope to cover more than a small part of it comprehensively, and few institutions are large enough to have a completely representative collection in all areas. Economic factors dictate that most museums that include vertebrate fossils concentrate on a more or less regional coverage. As a consequence, collections themselves represent additional fragmentation of available material.

The reason that vertebrate paleontology has been so successful in piecing together the torn-up manuscript with which it must work is that the material has in fact been available, if scattered. Great strides have recently been made in the interesting transitional areas between amphibians and reptiles, and between reptiles and mammals. Although both were triggered by discovery of new specimens, both were properly consolidated and documented by exhaustive reexamination of old material, some of it having been available for about 150 years. These developments have stimulated activity in these and related areas, and more information may be expected momentarily, but if the potential of this sort of work is to be realized, collections must remain readily available. The question is not only how to make room for new and significant material, but how to do this and at the same time keep existing collections efficiently accessible.

A final point to emphasize is that for the decipherment of the morphology and general organization of extinct vertebrates, paleontologists are restricted to a single organ system, the skeleton. Fortunately, the vertebrate skeleton is biologically plastic, and readily reflects the former presence of many soft parts, as well as certain aspects of growth and development. But in order to interpret these features effectively, the vertebrate paleontologist is very dependent upon collections of preserved specimens of present-day animals. For some problems, such as direct comparison of populations, he requires skeletons or suites of skeletons. For others, such as those involving comparative anatomy, he requires alcoholic specimens for detailed dissection. In summary, then, because of the incompleteness of primary materials, the continuing effectiveness of vertebrate paleontology requires that as much material as possible be available, not only fossils, but also relevant Recent specimens. In this field it is possible, in large measure, to compensate for the lack of what we can't get by accumulating an abundance of what we can.

FOSSILS—THE HOW AND WHY OF COLLECTING AND STORING

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Introduction

Fossils, like eggplant and okra, are a matter of taste in the American community of naturalists. They are loved by a few specialists, tolerated by a few more broad-minded individuals, actively disliked by some extremists, but essentially ignored by the bulk of the populace. Accordingly, it is appropriate to review the ways that fossils arrive at museums, and their resulting fate, if only to bring these remains of organisms into the lifestream of natural-history collections.

No one knows how many fossils are still to be recovered from sedimentary rocks; no one even knows the far smaller total of the millions of fossils already collected and scientifically stored. Accordingly, this lack of knowledge provides an ideal opportunity for the fabrication of fact. The combined U.S. Geological Survey-Smithsonian Institution collection housed in the Museum of Natural History of the Smithsonian at Washington certainly contains more fossils than any other collection in North America and probably in the world. It is probably safe to add that many universities store only a token number of fossils in collections, though there are some impressive lots on a few selected campuses. Most collections outside Washington, D. C., are in State geological survey collections or in a limited number of major but somewhat smaller museums. Some oil companies maintain large numbers of microfossils, but these are out of the public domain.

Using a dirty crystal ball, one arrives at the figure of less than 25 percent and greater than 10 percent for the part of the

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[1] Publication authorized by the Director, U. S. Geological Survey.

Nation's fossil collection that is in Washington, D. C. Roughly 20 percent of the Museum of Natural History storage space in Washington is devoted to fossils of the U. S. Geological Survey-Smithsonian Institution collection. However, this particular fossil collection has a far greater significance than just as a large percentage of the total American scientific material, for the Washington-stored fossils contain more specimens that have a documentary function than any other collection. Washington-based persons may be provincial and still do a fair job of study, but sooner or later paleontologists from other areas should visit Washington to look at types and special collections.

It is obvious from the preceding statements that the remarks expressed in this note are necessarily my own. Without attempting to degrade the variety of opinion in other fields of natural history, each reader should be informed quite clearly that paleontologists are highly individualistic in all facets of their activity. The reader is hereby warned that future statements made are entirely unsupported opinion. They apply mainly to fossils stored in Washington, and to their custodians, but might be more generally applicable if the underlying biases happen to strike a local and familiar chord.

Why Collect?

There is little sense in beating the dead horses of inherent curiosity, pushing back frontiers of science, search for the unknown, and other cliches to answer the question of why a person collects natural-history objects. A paleontologist collects fossils because he is professionally interested in them; others collect fossils to derive information or enjoyment from their possession. The paleontologist occupies an intermediate position between the pure compiler of geologic data and the pure lover of objects.

The latter might be mentioned first, though he does not deserve such harsh condemnation as mere "object lover." Amateur collectors are rare in the United States; the semi-pro who supplements his income by sale of fossils is even rarer. They may gather important collections, and they should be encouraged, but their overall contribution is negligible, especially when compared with the contribution of the amateur in Europe. There are probably fewer qualified amateur collectors now than in past years; the era between the Civil War and World War I was their heyday.

Field geologists and stratigraphers form the large group that uses information derived from study of fossils. The former are concerned with rocks of varying ages in a limited area; the latter are concerned with rocks of a more restricted age over a broader area. Both are concerned with questions of time or depositional environment of the rocks, and they pick up fossils to obtain evidence bearing on these points. It is my guess that more than 50 percent of the fossils in Washington were collected primarily to answer the problem of age of rocks. The percentage may be only slightly less in other large collections.

Paleontologists suffer many disadvantages in their studies because their specimens are incomplete in a variety of ways when compared with the biota that may be obtained in the Holocene. However, they do have one remarkable advantage over the neontologists in that collecting fossils is a four-dimensional operation involving latitude, longitude, altitude, and, uniquely, time. Others may write learned tracts on evolutionary theory, but only the paleontologist can collect one form at the bottom of a sequence of rock and another, related but slightly different, at the top. This element of time is the key factor in paleontology and is a dimension lacking in neontology.

In a crude way, one can draw a parallel between the field geologist awaiting the word of the paleontologist as to the age significance of a petrified form, and a quarantine inspector awaiting the word of an entomologist as to the identity of an insect before deciding whether to permit entry of a boatload of bananas. Another sort of time factor also enters here, for most paleontologists are of the opinion that anyone else's collection of fossils not only can, but should, wait to be examined. Paleontologists in museums, surveys, and groves of academe, often in good conscience, may delay months and even years in producing an answer to an inquiry about the age of a rock; bananas cannot wait that long. In contrast, the paleontologist employed by the oil company currently drilling a well is under even more pressure than a banana inspector.

Paleontology is closely tied to geology. In the past, although vertebrate paleozoology *in toto* and paleobotany in part were ignored by the field geologists as sources of useful data, invertebrate paleozoology was bound nearly hand and foot to the effort of age determinations. For the past few decades, this tie has loosened as the principal masses of sedimentary rocks were given relative age dates of moderate precision. This has also come about because of a shift of interest toward other problems in geology and a shift toward more biological topics in paleontology.

Under no circumstances should these remarks be interpreted to mean that the job of even approximate dating by fossils has been completed, or that it has been even locally accomplished with maximum precision. More accurate relative dates remain a prime job for the paleontologist. This close association of fossils and stratigraphy has been overemphasized in the past and is underemphasized in the present. As in many other situations, the middle ground is probably the route to pursue. Even with the relaxation of the stratigraphic tie, the paleontologist still obtains a large fraction of his material from the nonpaleontologist. The relation of geologist to paleontologist is certainly closer and more mutually meaningful than that of, say, geneticist to entomologist. Such relations should be encouraged.

How To Collect

When one asks a paleontologist how he collects fossils, the answer is generally a curt reply such as "meticulously." There are a variety of techniques, governed mainly by the kind of fossils and the kind of sediment which encloses them. Some people swear by a 1-pound hammer with a chisel end and a 14-inch handle; others swear at it. So many common-sense features are involved in collecting that a brief general summary on the subject was reviewed as being "downright inane."

In spite of this opinion, I believe that much remains to be discussed and written on the subject of fossil collecting. Although professional collectors have been employed permanently, this luxury is largely a thing of the past in the United States. Today, people continue to provide inadequate locality information when they submit collections of fossils for examination and do such silly things as write labels in water-soluble ink. If anything, the ability to obtain useful fossils, ship them, and have the collection arrive in reasonable shape and containing the proper information has lessened as interest in fossils has declined among nonpaleontologists.

Collecting may be reduced to two fundamentals. First, find a specimen, and second, retain it at least for a significant time interval. Expressions commonly heard are that collections were made, but after several years of just having them take up space, the fossils were discarded. Alternatively, one hears of the proverbial mountain slope littered with fossils, but they were not collected because the age of the formation was known. These are the hallmarks that distinguish the mere seeker of geologic data from the true paleontologist.

The real trick in the field is finding the first fossil in a sedimentary rock. Once this has been collected at the outcrop, the others come far more readily. Even knowing that years ago fossils were collected in the general area is a help. If the rock is a shale that breaks down to a mud and washes away, this first key fossil may be left as a lag deposit. Crawling on hands and knees, with nose at ground level, is the time-honored way of locating it. If the rock is harder, the hammer comes into operation. It may be more poetic to "bring the hammer into play," but even when the day is cool and the rock fairly friable, pounding on an outcrop for extended time periods is hard work.

The point here is that both of these operations have built-in limitations on the number of specimens that may be collected in a short time. The available collecting time at the outcrop, and the weight one person can easily carry for a short distance, have been the factors governing the amount of material that leaves the outcrop. To collect more than three or four bags of fossils at any one outcrop is unusual. If bulk samples can be collected rapidly, they are commonly of the type that requires extensive preparation prior to detailed studies of fossil content.

Thus, this kind of upper limit also holds for those who study microfossils. The time involved in taking a channel sample or digging a trench to collect fresh material may become significant. In comparison, for example, with a marine zoologist accustomed to collecting on a shallow-water reef, the paleontologist is a modest collector.

Extrinsic factors important to fossil collecting are not well understood. It is a general rule that one side of a roadcut will yield more specimens than another. Whether this is a regional feature or whether the phenomenon is related to local factors such as vegetation, runoff, or microclimate have never been investigated. Why some fossils in some rocks may be replaced by other minerals is a major mystery. The conditions that dissolve shells but leave their impressions are poorly understood in detail. The list could be continued.

Intrinsic factors also enter into collecting. There is no substitute for experience; some rocks just look right for a particular kind of fossil. In many respects, this is the same as a biologist knowing the life habitats of a desired living animal or plant specimen. This type of information can seldom be imparted except by word of mouth on the outcrop. At least one attempt was made to gather these esoteric tidbits as part of general work on techniques, but the results were far from satisfactory. The principal point distilled is that collecting is a full-time activity. It is possible and often necessary for the paleontologist to carry on more purely geologic work, such as mapping the area or measuring the thickness of a rock layer, but these have to be done before or after the collecting.

There is an interesting minor support of this hypothesis. In field-work in the western United States, a paleontologist visiting a field man may find more arrowheads in a few days than the field geologist finds in a season. The geologist strides across the landscape to get the big picture, but the paleontologist stays at one spot or shuffles along looking at the ground for his pet objects. Slow motion is also a fine way to avoid most rattlesnakes.

One final word should be said about general collecting. It would be nice if the various disciplines could assist one another. In olden days, travel was commonly by train from one outcrop to another. Because there was time between trains, some paleontologists used to obtain insects for their colleagues. It was a nice gesture and one that might be continued even in these days of more rapid transport, if there was a clear indication of what other people would like to have collected.

How To Store Fossils

In the how and why of collecting, the why is the easier to answer, or to at least open the floodgates of rhetoric. Once the fossils are safely inside a building, the how to store them is far easier than the why of retention. Compared with other natural-history objects, fossils are paradise for a curator.

Naturally, catastrophic events may cause serious losses. Type specimens lost during the great Chicago fire and the flood at Dayton, Ohio, still cause problems to a few specialists, but, hopefully, natural-history specimens today are as safe from such events as might be expected. Good collections are still in temporary repositories, and undoubtedly a quantity of important material will be discarded as some universities remove paleontology from the curriculum, but increasingly the odds against accidental loss are being lowered.

For convenience, collected natural-history subjects may be divided into three categories. First, living organisms, which are stored with great difficulty in zoos and arboreta. Second, recently dead objects, which must be pressed, vermin-protected, or bottled. Finally, dead things, which do not require watering and which do not deteriorate. About the only difficulty in prospect for a museum fossil is a coating of the ever pervading dust. The present-day air-conditioning expert would try to seduce us into believing that this problem has been solved; it is better to put one's faith and one's specimens in closed cases.

With fossils, one is not troubled by evaporation among alcoholics, which to the museum-oriented person does not mean unexplained staff absenteeism. One is not concerned with material drying to powder. Except for rare specimens replaced by pyrite, fossils do not pick up moisture from the air. Fossils are not edible, and though occasional labels and locality numbers may be lost to particularly desperate cockroaches or rats, such events have been fairly rare in the past and are essentially a thing of the past. Fossils do not change color after years of storage, nor do they smell.

About the only obvious and painful drawback to fossil storage is weight. The average collection of fossils, microfossils excepted, is heavier than the average collection of almost anything else in a museum. One drawer, 28 inches by 22 inches, full of particularly stony fossils, like colonial corals, requires complete attention during a moving operation. Drawers of fossils can be stored to a height of 9 feet, but an administrator, before making a decision for high-level storage, should be required to carry at least one drawer to the floor. There is a general rule of nature (Gumperson's Law) that the heaviest drawers are always at the top; for any case over 5 feet high this may become hazardous. It is also well known that museums that stack drawers rather than place them in cases, keep the needed specimens in the bottom drawer of a stack (Saunders' Corollary).

It is a wise idea to remember always that even though fossils are thoroughly dead, they still retain the ability to move. When specimens hop from one tray to another, the net result may be that two otherwise useful collections will have to be discarded. Trays with deep sides are not a luxury item. Because it is simply no longer feasible to put locality numbers on every specimen, stuffing the smaller specimens in glass bottles has been a technical breakthrough. Clear plastic boxes may well be worth however much more they cost; if they do come into general use in the near future, it will be about five decades since paleontologists stopped putting their prize fossils into cardboard pillboxes. Folded stand-up labels, in contrast to those that lie flat, are such a menace to retaining fossils where they belong and so antediluvian that examples should be put on special exhibit in the chamber of horrors.

There has been a tendency in unsympathetic administrative environments to equate storage of dead items with dead storage. If fossils cannot be seen easily, they will not be studied. Some of the greatest advances that have been made in paleontology stem from some things no more complex than making aisles wide enough so that drawers may be moved in and out of cases easily. Lighting adequate to permit specimen examination in a storage area has done more for overall clarification of species problems than the most sophisticated hardware of biometry.

WHY DO WE BOTHER TO KEEP FOSSILS?

There are so many reasons not to keep collections that one hesitates to open this question for discussion. Collections take up space, and space is money. They take up time, and time is money. About the only reason for keeping them is for the sake of honesty. If less painful words are needed, collections are kept for purposes of documentation and scientific verification, as well as to provide raw material for new studies. The Washington, D. C., collection includes more specimens that should be retained for purposes of biologic and geologic documentation than any other in America. There may be some merit in the view that once an optimal or critical size is reached, the importance of a collection increases more rapidly than its bulk.

A gifted mathematician may derive four from two plus two. Once this is published, another specialist with the proper computation can verify this discovery. In marked contrast, a relative date based on a fossil occurrence or a biological description of it is not nearly so tidy. No matter how good the printed description or how accurate the figures, sooner or later they are found wanting. If a paleontologist is smart, he will never completely trust the published work of another, but will look at the specimens in question. If he is particularly intelligent, he will not even trust his own published work and will continue to reexamine his fossils.

Systematic biology is an additive science and does not make great strides forward to major unifying natural laws. It does not lend itself to the sporadic quantumlike great leaps forward that have characterized the history of the physical sciences. Like all other kinds of systematics, paleontology moves forward at a crawl, building its monumental truths a dust particle at a time. We will probably never know with the precision of a mathematician the absolute stratigraphic range or total biologic diversity of a single extinct species, let alone the millions of such species that are in various stages of study, from those still awaiting collection on the outcrop to those in the latest published monograph.

However, every bit of new information throws a faint glimmer onto the overall biologic-stratigraphic system, and old material ought to be reexamined in this light, no matter how feeble the light may be. The great weight of fossil specimens described and those yet to be described is good ballast to keep the hot-air balloon of theory from rising too high. For the paleontologist, particularly, one battle cry is *alpha taxonomy forever!*[1] For this sort of old-fashioned work, one needs to look at specimens.

If one agrees that material should be kept, the logical position is to store it in the most useful system. This presumes a purpose in study, but the true paleontologist really has two purposes. One is biology and the other is stratigraphy. As a consequence, varying shades of schizophrenia infect the collections. In Washington, Geological Survey collections are stored in stratigraphic order and National Museum collections are stored partly in stratigraphic order, but mainly in biologic order. Types are stored in alphabetical order, for "convenience," an infelicitous expression if there ever was one. This dual system is found at most institutions that retain fossils. Of course, the outsider immediately objects that a unique specimen cannot be in two systems at the same time. This is absolutely true, but the dual system still works somehow and is used in most major collections throughout the world. Once the details of a particular local arrangement are understood in a museum, the paleontologist readily pursues his specimens up, down, and sideways through the collection.

The precise arrangement of the individual lots within a stratigraphic or biologic series is a subject for violent argument. One quick way to provoke argument is to state complete opposition to any arrangement by numerical sequence, for this is a simple method to follow; such simplicity is a trap. Collections should be in a subject matter arrangement just exactly the same way books are arranged in a library. Often the particular bit

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[1] Editor's italics—author's exclamation point.

of information desired lies in the adjacent collection, just as the book you finally choose is adjacent to the one you originally thought you wanted.

A few words should be said about mechanics, because a poorly kept collection is a powerful administrative argument for discarding all fossils. In the part of the Washington megafossil collection that seems in best arrangement, the crucial element in the system is the one person whose job it is to keep track of things. About 40,000 collections are involved in this 70 year accumulation. Given a locality number, a particular lot may be located in 2 to 3 minutes. Because there is a logical arrangement, a blind search for fossil data on a restricted age and area basis can be run in less than half an hour. The only trouble with the system is inadequate manpower to bring all collections into proper curatorial shape within the system. We can keep current, more or less, but the backlog from past years is not reduced.

Automatic data processing will not help one iota in typing locality descriptions or preparing specimens. Some persons assume that an old system is necessarily outdated, whereas a more correct assumption is that the system has been time-tested and found to be successful. The classical methods have been "debugged," to use the current argot. Changing them may not be a wise investment of time or money.

The storage situation may be a bit more complicated with microfossils because one cannot simply look at the specimens with a hand lens. However, the same general principle holds, in that the collections should be arranged in a logical order. The nomenclatural situation within the field of foraminiferal studies is chaotic and is expected to get worse. The one reed left to cling to is the system of filing microfossil slides in alphabetical order by the original name. It works. Other kinds of microfossils may be filed by other arrangements.

This leads to the conclusion that the best system for any institution to follow is that which satisfies the workers most closely concerned. If this sounds trite, silly, and obvious, the other side of the coin is that an institution should be willing to stand the expense of major reshuffling as workers and ideas change. Libraries reshelve books when necessary and survive the process. Paleontologists generally are too xenophobic and ergophobic to put collections in the order that yields maximum information for their own purposes.

Granted that all published or cited material should be kept, something should be said about the residue. Many institutions, but particularly universities, tend to hang onto material too long. Much rock gathered during the preparation of a thesis should be discarded; the good material should be properly curated and saved. Junk brought in decades ago by field men and never cited can be discarded. Fossils do not age materially, but accompanying data may become obsolete. A collection "Carboniferous, Indian Territory" was important last century, but its time of significance is long past. To give another example, the push today is in paleoecology, but the collections made by prior generations are too biased to yield automatically the new data needed without additional field investigations. Field investigations in any area of natural history, including paleontology, always seem to yield collections!

Although it is easy to say discard unnecessary material, it is most difficult to do. One general rule to follow is that no one under 40 should be permitted to discard collections gathered by earlier workers. Often biologically poor material may be stratigraphically important and vice versa. Unless one has done fieldwork in rocks of a particular age and area, the best course is keep all the material already available for that age and area in storage. It is far better to err on the side of keeping too much than to discard an unmarked type specimen.

The time to discard is before collections are given numbers. Inadequate collections should be promptly abandoned and not left in odd corners, following the current method of continuing the sins of our predecessors. Proper curation is a thankless task which is generally shirked. Shame on all of us. If a fossil is worth keeping, it is worth keeping well.

Much as one hates to weaken a particular point, I must admit that although there are many good reasons for consolidating and discarding collections, economy is not one of them. One of the most expensive operations is to selectively prune collections. It is possible to work for a year and empty one or two storage cases.

Unless there is someone who has adequate time and cares enough to put the fossils in some order, all that results from collecting is a random arrangement of limited value. At the risk of annoying people further, a minor semantic needle should be emplaced. In my ancient Funk and Wagnalls, the word "collection" implies unorganized and promiscuous character similar to that of assemblage. This is hairsplitting, but it just could be that parts of our collection are properly so designated.

THE FUTURE

Scientists are supposed to make predictions, probably to prove that they are human and can be as mistaken as anyone else. Long-range predictions are better to make because the audience to whom the prediction was made is no longer around to ask questions. The alternative and next best method, which is followed here, is to make conflicting predictions, so that one prediction of the two may prove right.

Growth rates of collection bulk might be meaningful. By averaging a sample of palynologists, coral specialists, elephant hunters, and other assorted paleontologists, I have arrived at a figure of three museum cases 3 feet high per year. As these cases occupy 6.6 square feet and are usually stacked two high, space may be used at a rate of 10 square feet per year, plus all-important aisle space. Fifteen square feet of growth per man year is an authoritative wild guess. Thus, the new paleontologist starting out should be assured of 450 feet of space to fill with his collections, not counting what he will inherit in his specialty.

Unfortunately, collections simply do not grow this way. A better comparison is with growth studies of fish. If a large number of infant minnows are crowded into a small tank, they are stunted. When these stunted fish are transferred to a larger aquarium, however, they immediately grow to normal size. Available space determines the size of collections, not vice versa. Paleontologists assigned to new quarters with fresh storage space fill it rapidly and then are cramped until the next building provides a quantum jump. This principle has been checked at several localities and holds for at least North America and Europe.

It is also safe to predict that no extensive buildings for paleontologists in these regions are anywhere obvious on the horizon. Even more important, administrators have not been trained to think of large collections as scientific instruments. Major advances in other fields are accompanied by major investments in hardware. Probably the same principle applies in paleontology. Cyclotrons, sounding rockets, and radio telescopes really are not that different from new buildings filled with old organisms. Larger collections and advances in the field go hand in hand.

Another consideration beside storage space to fill is source of fossils. Most fossils gathered to date have been the product of long-time weathering processes. Once specimens are picked up from the outcrop surface, years of weathering are needed before others may be released. Some conservation-minded professors have preserved favorite outcrops only by extorting from a class all fossils collected and then sprinkling them back on the outcrop for next year's crop of budding experts to find. Most classic localities in this country have been picked or hammered clean of specimens.

Worse still, new exposures are not being developed for fossils. Lots of fossils once came from limestone quarries, obtained by the workers who were crushing stone by hand. Today, the rock is untouched by human hands from quarry face to cement bag. Railroad cuts used to be wonderful places to find fossils, but is there anyone still alive who can remember the last time a new railroad line was laid out. Highway cuts ought to be fine for collecting and were so for many years. No one is opposed to major erosion control, but the highway engineers think of erosion the same way as prohibitionists think of alcohol and consider even a tiny amount sinful. To see grass being sown on potentially highly fossiliferous roadcuts before even the concrete slab is poured is most discouraging. It is fairly safe to state that the bulk of the fossils that can be obtained easily from the weathered crust of the United States have been obtained and are stored away.

Having demonstrated why collections will not markedly increase in size, let me now take the counter argument. The wave of the future is already upon us, without any plans for coping with it. Paleontologists have known for hundreds of years that some fossils have been replaced by minerals that are insoluble in certain acids. Because of this, some outcrops have yielded choice fossils, or a specimen might be cleaned with a toothbrush soaked in acid, or one or two specimens might be freed from the rock matrix by placing the matrix in an acid-filled beaker.

Three decades ago, one of the senior National Museum paleontologists noted that chemical change of fossils persisted through the thickness of the rock. This fact was not new; more than half a century ago, fossil corals were dissolved from rocks and sold. However, he put an entire limestone block in acid, and then another, and another, and another. . . . The results have shaken the paleontologic world. The specimens obtained have been strikingly beautiful and highly significant both biologically and stratigraphically.

Perhaps even more significant for this discussion is the bulk of silicified fossils. By spending the same time at the outcrop, collecting limestone blocks rather than loose fossils, the number of specimens increases by many orders of magnitude. One hundred good specimens of a species from a single locality has been exceptional in the past. Now, a number of species are known from an entire case of choice material.

Silicified fossils are not sturdy. We have leaped from storing rocks to storing objects as delicate as butterflies. One does not pile up a heap of silicified fossils in the corner of a drawer. Good ones should be chemically hardened. They ought to be stored on cotton and even packaged individually. They have to be protected from the sudden jerk and slam of the conventional drawer with the sticking runners. When these fossils were first shipped between museums 20 years ago, the only known method was to imbed them in wax, and some have never been cleaned free of it. It has taken years just to stumble on the obvious idea of shipping them packed in sawdust. The field is wide open for new techniques.

All these new factors, brought into the picture by silicified fossils, mean a tremendous increase in space; I have no estimates other than "lots more." If field funds, preparation facilities, and technical assistance were optimum and permitted paleontologists to really move into the silicified fossil business in a businesslike way, the entire character of the collections could be changed in two decades.

Methods employed in obtaining silicified megafossils do not work for all paleontologists. Certainly, those who work on microsfossils and micro-microfossils should not be slighted, but one seldom has thought of them as requiring a great deal of space. However, new chemical and mechanical techniques have demonstrated that fossils are to be found in almost all sedimentary rocks. Today, it is a question whether the microscope slides or the black boxes and cameras take up more area. Suddenly the micropaleontologist wants a great deal more from life than space for a one burner stove to boil his pot of mud and a desk drawer to store slides. He may never individually require as much space as the bulldozer-wielding whale collector, but there are many more of the people working on the little bugs. Curiously enough, when prepared residues are retained along with their fossil content, more space is needed; no one throws away residues because there may be a need later to search in them for more microfossils.

This leads me to the final set of summary predictions. We will need substantially new buildings and much better handling and storing techniques for silicified fossils. Probably the best method will be to organize two separate collections, based entirely on the mechanical strength of the fossils. As a parallel development, microfossils are amenable to an organized, fully automated specimen storage and retrieval system. The paleontologist need only punch a few buttons on his room console to have the necessary slides moved into his microscope field.

For a century and a half, fossil storage has been essentially unchanged. Twenty years from now it will be all different. I have no idea where the money for a major national investment in paleontology will be obtained. The physicists became fat off of radar, and the chemists have done fairly well as a result of the atomic bomb. If, as a result of the moon race, the first extraterrestrial hand sample is fossiliferous,[1] perhaps paleontology will also reach the land of cornucopia. Until that golden day, collect new old fossils and keep them, no matter how tight the quarters, for only in this way will life continue to flow in the dry bones.

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[1] Unfortunately, it wasn't and further the photographs of Mars do not look particularly promising as a nice place to visit, let alone live. However, there is always the hope of Venus or litter dropped by UFO's.

THE ROLE OF THE NATIONAL PARASITE COLLECTION IN VETERINARY PARASITOLOGY

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Almost every individual during his lifetime has at least once become a collector of objects purely from curiosity or for the love to determine the quantity and variety of objects which can be accumulated. Naturally, pride is taken in the collection and in its exhibition. This is probably the way natural history collections first began, and no doubt many individuals still think of them in this light. Many collections, however, now constitute working tools in research as essential as are the experimental animals or laboratory equipment used. Among these is the parasite collection herein discussed. It was primarily started, and is still used today, to determine what parasites cause disease, their geographic distribution and animal hosts, and the diagnostic characters by which the parasites may be identified, including their various immature forms. This information is essential for treatment, control, quarantine, and research purposes. The collection is described herein, along with an index to the literature on parasites with which it is used, and some examples are given of its current and future roles as a working tool in veterinary parasitology.

Parasite Collection And Index To Parasitological Literature

Animal disease workers in the U. S. Department of Agriculture recognized the need for a parasite collection and index to the literature on parasites over 76 years ago when they established the National Parasite Collection and the Index-Catalogue of Medical and Veterinary Zoology. The latter is a compendium of the world's literature on parasitology. Both of these working tools are maintained at the Beltsville Parasitological Laboratory where they are used by the some forty scientists at the Laboratory, as well as many visiting scientists. The records of the Collection enable investigators to find quickly essential information on the parasites deposited therein; the Index-Catalogue serves the same purpose with respect to the world's literature on parasites. The history of the Collection and a detailed description of the various parts and publications of the Catalogue are given elsewhere (Becklund, 1969a, b).

The Index-Catalogue consists of an Author Catalogue, and four Parasite-Subject Catalogues, namely: Parasites (subdivided by taxonomic groups), Hosts, Subject Headings (e.g., biochemistry, cultures, immunology, etc.), and Treatment. All information is recorded on 3″ × 5″ cards which are filed in approximately 1500 drawers. Over 100 publications comprising more than 20,000 pages have been issued under the title Index-Catalogue of Medical and Veterinary Zoology.

The Collection is composed of parasitic protozoans, cestodes, trematodes, nematodes, pentastomes, lice, mites, ticks, and other miscellaneous parasites. Approximately 65,000 lots, consisting of one to many specimens each, have been accessioned. Most of the specimens were collected during research and regulatory activities of the U. S. Department of Agriculture and state animal disease agencies. The procedure for the deposit of specimens in the Collection, so that they, and all information about them, can be easily found, is as follows:

1. All pertinent information on the name of the parasite, host, location in or on the host, geographic locality in which collected, and collector's and identifier's names and dates are recorded on accession numbered (Collection number) forms; this information is also recorded by Collection number in books and on labels that are placed with the specimens. 2. Each lot of specimens is assigned a storage number which designates its location in the Collection, and this number is recorded with the

aforementioned information. (Most liquid preserved material is stored in two-ounce square bottles in numbered wooden racks holding several bottles. Slides are stored in numbered wooden boxes holding 25 slides each.) 3. A Parasite Index and a Host Index are maintained on cards by recording, for each lot of specimens, the name of the host, Collection number, and storage location number under the name of the parasite in the Parasite Index; and the name of the parasite, Collection number, and storage location number under the name of the host in the Host Index.

CURRENT USES OF THE PARASITE COLLECTION IN VETERINARY PARASITOLOGY

The Parasite Collection is a depository for specimens that have been mentioned in published reports. Specimens designated by authors as type material, as well as those that represent new host and distribution records or various forms in the life cycle of a species, are regularly deposited. In addition, the Collection and its records serve scientists in various ways. The following are a few examples:

Description of new species from man and animals: The thousands of authoritatively identified specimens in the Collection are invaluable for comparative purposes to determine species that are new to science. Several hundred new species of parasites have been described by U.S.D.A. scientists. During the last five years the Laboratory's personnel have described new species from various hosts, including man, marmoset, mountain goat, deer, alpaca, vicuna, and an African lizard. Among these, the species described from man is particularly important. It has reportedly caused over 900 cases of human capillariasis in the Philippines, some of which were fatal (Chitwood, *et al.*, 1968).

Provide information on the parasites of domestic animals in North America: A checklist of parasites of domestic animals in the United States and Possessions, and Canada, was prepared in 1945 (Dikmans) and revised in 1964 (Becklund). It was prepared for use in teaching, in research, and in regulatory quarantine activities from information in the Collection records and Index-Catalogue, and by examining many specimens on deposit. This checklist gives the common and scientific names of the parasites, location in or on the host, intermediate hosts in the life cycle, if any, and geographical distribution. One hundred and twenty-one species of parasites were listed from cattle, 119 from sheep and goats, 92 from equines, 72 from swine, 132 from dogs and cats, and 179 from chickens, turkeys, pigeons, pheasants, ducks, and geese.

Provide information on ticks of veterinary importance on imported animals and items: For many years ticks that were removed from domestic animals, exotic wild animals, and items offered for entry and imported into the United States were identified and deposited in the Collection. Many of the ticks are of medical and veterinary importance; therefore, the species, hosts or items on which they were found, origin, and locality where collected, were recorded for regulatory and research purposes (Becklund, 1968). The ticks were removed from cattle, horses, numerous kinds of zoo animals ranging from hedgehogs to elephants, beef, cattle hides, palm leaves, mailbags, medicinal herbs, bird guano, and hair, from many parts of the world. This study revealed that: (1) The ticks represented nine genera and 37 species; (2) most of the exotic ones were males; females apparently drop off at foreign quarantine stations and while the imports are en route; (3) native as well as exotic ticks on imported animals can be vectors of exotic diseases; and (4) harmful ticks can occur on unexpected strange items and abnormal hosts.

Provide specimens to establish differential characters to distinguish between species: American sheep are hosts to several species of thread-necked strongyles. The various species are very similar, morphologically, and have been confused with one another for more than 70 years. Reports of the pathogenicity, treatment, incidence, hosts, etc., of the various ones are therefore questionable. A study of hundreds of specimens of these worms comprising 90 lots of specimens in the Collection revealed that instead of two common species and three rare ones, American sheep are parasitized by three common species and three rare ones. This study of specimens enabled investigators (Becklund and Walker, 1967) to establish morphologic characters to readily identify the species and determine their geographic distribution. Subsequent work with additional specimens from the Collection (Stringfellow, 1968) revealed a hitherto unrecognized structure of the worms that is useful in their identification.

Provide information on the probable transmission of parasites between domestic and wild animals: Parasites in the Collection and information in the Index-Catalogue were used to supplement findings from a study of the parasites found in 18 bighorn mountain sheep in Montana (Becklund and Senger, 1967). The known number of bighorn sheep parasites was increased from 34 to 51 species. Thirty-six of these 51 species are known parasites of domestic sheep and 18 parasitize cattle in North America. Thus, in regions where these animals graze on the same range land, parasites are probably interchanged between bighorn sheep and domestic sheep and cattle.

Provide specimens used to evaluate malformations in parasites resulting from an antiparasitic chemical: At necropsy, sheep suffering from haemonchosis and receiving therapeutic doses of phenothiazine had numerous deformed male specimens of the large stomach worm (Becklund, 1960). The percentage of deformed male worms in populations exposed to the drug ranged from 0 to 47 percent, whereas the percentage in unexposed populations, many of which were obtained from those placed in the Collection from 1900 through 1939, before the advent of phenothiazine, ranged from 0 to 0.3 percent. The parts of the worms affected, because of their prominence and normally characteristic conformation, are used in systematics; consequently the antiparasitic somewhat weakens current competence to distinguish species. In some respects, the deformities studied are similar to those recently reported in human medicine involving thalidomide.

Future Uses Of The Parasite Collection In Veterinary Parasitology

Parasitologists hope to rear parasites through their entire life cycle without the host (*in vitro* cultivation). Great strides have been made recently along this line of research and nematodes of domestic ruminants have been reared *in vitro* from the eggs to adults (Leland, 1967). Parasites so reared are unique and should be compared with specimens from animals to establish their normality before their cultivation is considered a complete success. Because of their uniqueness, and the possibility of correlating their structure and development with nutritional deficiencies in the culture media, representative specimens have a place in the future of the Collection. This was recognized by Schiller (1965), who has deposited *in vitro* reared specimens and indicated their Collection number in his report.

Events of the past strongly suggest that the Collection will continue to be an essential working tool. Specimens will probably be needed for the evaluation of any change in morphology, pathogenicity, or host of parasites. Such changes could result from research activities, such as the use of X-irradiated larvae to produce immunity in animals, or from adverse environmental conditions which affect the host or the parasite, such as pollution, pesticides, or radiation. Hence, a problem today is deciding what kind and how many specimens are needed to fulfill future needs.

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THE NATIONAL COLLECTIONS AS BIOLOGICAL STANDARDS

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Gathering of natural history objects must be as old as man himself and a reflection of his inherent curiosity in the world about him. These objects, at first, must have had primarily utilitarian interest, having some real or suspected property of direct survival advantage. Eventually we can imagine that certain aesthetic properties such as color and form began to be important. Later, as he became ever more sophisticated and less concerned with daily survival, such objects were gathered in "cabinets of Curiosities"—pretty stones, fossil bones, brightly colored butterflies, etc. They may have served much the same purpose as modern coffee table picturebooks—as conversation pieces. Ultimately, specimens of the natural world were recognized as important documentation of the kinds of organisms, their geographic distribution, their variability, and their evolutionary history. Systematic collections as biological standards began with that realization, and, with the literature their study has generated, they are still the basic tools of the systematic biologist.

The natural history collections of the U. S. National Museum had a very early origin in the enormous collections brought to the Smithsonian by Spencer Fullerton Baird and added to by virtually every serious biologist since. Increasing by about one million specimens annually, they now total somewhere between 50 and 60 million. One cannot speak of the growth of this major scientific resource without acknowledging the very large contributions to the National Collections made by the Geological Survey, the Fish and Wildlife Service, and the

Department of Agriculture entomologists, by whatever titles these groups may have been known earlier. While the care of the collections is the legislated responsibility of the Smithsonian Institution, they are what they are because of many, many years of cooperative development.

While these National Collections have grown both qualitatively and quantitatively and provide an almost unparalleled research resource, it can be said that we have not yet reached maturity in one important aspect. Although we often receive type materials and important sets of material documenting a particular study, we have not achieved the stature in this country that the British Museum has achieved in Britain, where to have one's collections incorporated is a mark of scientific distinction. Rather than relying on legislation, we must demonstrate our willingness, even eagerness, to serve as the Nation's repository of biological standards, which, like physical standards, must be preserved at a site that has a reasonable chance of caring for them in perpetuity.

It might be well at this point to consider the question of who uses these standards and for what purposes, especially in view of the increasing costs in time, space, and dollars to maintain them. The collections *are* used constantly by systematists in universities (many of whom have disposed of such collections), as well as those in other museums. Last year (1967) we sent 372,886 lots and/or specimens to other researchers over the world. In addition, we hosted 1,195 student or professional research biologists who spent 7,003 man-days in our museum. Most of this sort of use is obviously a service to the systematic community but others use the standards as well. After the Pacific testing of nuclear devices, concern developed in many quarters about radioactive contamination of the environment, especially of resident plants and animals. But how could anyone guess what the condition of the biota was before the tests? Specimens in the National Collections from early expeditions in the test area provided the answer to that question—a biological standard provided the basis for solving this important problem. Other examples of the use of these standards are plentiful. I wonder if the historian considering the development of American culture can be really thorough without an understanding of the role of the undisturbed biota on which the colonists depended and with which they contended. How can we talk about restoring the quality of the environment without referring to these standards to learn *what* lived *where* and *when*? Another less obvious application of biological standards, that is collections, is in understanding such dramatic, evolutionary explosions as occurred in *Rubus*, the blackberry genus. Before the development of agriculture in the eastern half of the country, the species of this genus were nicely separated from each other by ecological and geographic factors of one sort or the other, but as the forests were leveled to make farm land, new opportunities opened up for once-separate species to commingle genetically and the result has been chaotic for the systematic botanist. His understanding of the environmental situation in the earliest part of the history of this region illuminates the subsequent man-made confusion. The list of examples could be very long, but I doubt that anyone here, at least, will question the importance and value of the National Collections, or that they are used. At this point, I should like to mention the obvious, that the collections to be valuable for future problem-solving must be housed, cared for, and added to—and these present real, very difficult problems.

One of the most critical has always been that of space for housing collections. Growth of collections, even under normal circumstances, is difficult because of space and financial limitations, but we are at this moment entering a period of unparalleled expansion of various types of field biology. When the International Biological Program and the numerous large, federally-supported environmental studies get underway, the enormity of the problem of caring for the mountains of documentary collections that surely should result staggers the imagination. All of us, to varying degrees, will be faced with the problem of how to process these materials so that they are available to biologists generally, systematists, physiologists, ecologists, and perhaps even the molecular types as well. As the numbers of collections grow, there is increasing difficulty with even bringing together the existing specimens of a particular group, and an even more formidable task of gathering and synthesizing the data attached to the specimens. The mundane problem of housing and caring for these constantly expanding collections poses serious space and time-use problems requiring our most serious consideration of the quality, the nature, and the methods of curating the collections. At one point, I questioned that very much thought was given to what is added to the National Collections, for I am sure we can all agree that undisciplined growth is detrimental to their long-term usefulness. Within the past year we have begun to write what may be termed a rationale for collections growth, and I have been pleased to see numerous examples of correspondence that indicate real judgment on the part of the curators in rejecting substantial collections. In earlier times of our history, as well as that of other collections centers, there may have been more justification for considering the largest collection the most important but the attention given to qualitative considerations is very important at this point in our history.

Aside from being more selective in adding to the National Collections than at times in the past, how can we solve, or at least ameliorate, the problem of space for collections? One approach is to give serious thought to the *nature* of the materials we maintain. Why should each systematics center strive for world-wide, in-depth coverage of all groups of organisms? Isn't it possible to think of an organized sharing of the responsibility of developing the degree of coverage required by the needs of biological research? There *is* precedent for this. Twenty or 30 years ago, several of the large systematic botany centers, all with deep interests in Latin American plants, got together and agreed to divide the job of developing tropical plant collections. Each center concentrated on collecting and studying the plants of a single country or region. In addition, each institution shared representative collections from their special regions with all the others of this informal consortium. The plan worked remarkably well and to some extent it is still observed by the participants. Perhaps the cooperation achieved in that instance could serve as a model for broad consideration of collections-space problems.

Another way of looking at the problem, one that has been suggested previously, is that of inter-institutional transfer of blocks of collections on a long-term loan basis when the borrowing institution has a specialist not represented on the staff of the loaning institution. It is perhaps unnecessary to state the obvious, that there is no center in existence that can hope to employ a specialist for each of even the largest groups of organisms. Could a collection not under active study by a specialist at one institution be housed with a specialist at another? To do this, we would have to develop common curatorial standards that would ensure that the collections of the one institution were cared for equally well by the borrower. We often assume this for present-day, smaller loans and sometimes are disappointed but surely we could determine the standards for specimen cases, the kind and frequency of application of fumigants, and the sort of fire-protection required for preserving each other's collections.

A second major problem of the National Collections, a problem shared with all other Federal systematic centers, is that of grossly inadequate supportive assistance—technicians, aids, research assistants and the like. For the past ten months I have chaired an interagency panel charged with a consideration of the state of health of systematics in the Federal system—some of the panel members are surely in this meeting. We learned that the average level of support is about one supportive person to each professional which is about 30 percent of what has been recommended as adequate for scientists in Federal laboratories. It can scarcely be denied that employing well-trained, experienced scientists and then using substantial parts of their time in non-scientific tasks is the most absurd sort of inefficiency. These problems of space for the collections and the curatorial assistance to manage them must be solved if the National Collections are to continue to be useful biological standards in the future.

One of the most important developments for systematic biology is that of data processing technology as it can be brought to bear on repetitive, non-scientific chores. Efforts are being made, mostly at the pilot-project level, by several museums to assemble the data associated with some collections in a machine-retrievable form. If one assumes even ten facts in association with each of our 50 million specimens, it is obvious why progress in systematic biology is slow but it also suggests that the task of computerizing even major parts of such an enormous data-base requires very careful planning and decision-making. Machines can handle the problem of cataloging and retrieving published data as well, but the annual exponential growth both in collections and literature makes action increasingly urgent. For data-processing applications to have the greatest usefulness, cooperative data-banks based on inter-institutional agreement will be important. To achieve this cooperation there should be some agreement about *what* information will be deposited in the bank to answer *what* sort of questions. The expense of the automatic data-processing operation is such that the bank should neither contain trivial information nor be queried for it. While it is imperative that we develop a common system, or at least compatible ones, the provincialism of many of us seems to indicate that this will be one of the major problems that may be solved for us by the funding sources and the computer hardware people. In this respect, we need a common approach among the principal natural history museums such as the New York art museum consortium has evolved; a united viewpoint still breeds confidence and attracts the support of others. At the same time we are attempting to develop national cooperation, we need to consider how we can work closely with major collections centers in other parts of the world. Free access of systematic information is necessary for the maintenance of the position of systematic biology and closely allied biological disciplines as primary contributors to science.

As we have heard from some of the preceding speakers, a beginning has been made in the area of recording information associated with new collections and to some extent with the older collections as well. While it may well be impractical to think of computerizing the data on all 50 million collections, this surely should not discourage us from storing data at some appropriate level and in some instances to the specimen level.

I think we must face the fact that one of the most substantial problems in the area of data-handling is ourselves. Our generally narrow specialties often lead us into a sort of scientific isolationism, an inwardly directed concern for our own interests. We are often constrained by a traditional mode of operating, which we feel uncomfortable about discarding or modifying. Consequently, as we face the increasingly critical need to recover data from collections and associated literature, we may respond by burrowing more deeply in our traditional methods of data-gathering and data-handling with consequent loss of time for a function that is not always recognized as part of the systematic job—interpretation of the data we gather and organize. The Museum of Natural History, with the strong backing of the administration above, is seeking appropriated funds for carrying out the kinds of data-processing applications that will make the information in the National Collections more available to the entire scientific community. The pilot programs now current in the museum, supported by the HEW contract, is an effort in which we can all share the leadership role that is so appropriate for those of us associated with these Collections. It is *not* an effort of one person or even of a small group of curators, but rather a means of getting started toward the long-range goal of making the collections more significant for ourselves and for our colleagues, many of whom expect us to provide such leadership.

If the National Collections are biological standards, then we who are the keepers must be prepared to lead, to discard the traditional when it no longer meets needs, for if the standards fail to provide the information needed to solve problems, they will cease to have importance to anyone but ourselves.

DOES ANTHROPOLOGY NEED MUSEUMS?

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You can be a museum, or you can be modern, but you can't be both. —Gertrude Stein (refusing to leave her collection to the Museum of Modern Art).

Rien ne me paraît ressembler autant à un bordel qu'un musée. On y trouve le même côté louche et le même côté pétrifié. . . . Dans l'un et l'autre endroit on est, d'une certaine manière, sous le signe de l'archéologie; et si j'ai aimé longtemps le bordel c'est parce qu'il participe lui aussi de l'antiquité, en raison de son côté marché d'esclaves, prostitution rituelle.—Michel Leiris, Chargé de Département d'Afrique Noire, Musée de l'Homme (1939: 41).

Museum anthropologists often bewail the present state of anthropology in museums, not infrequently blaming this on a wrong turning taken by some of the most prestigious areas of anthropology a few decades ago. If only the leaders of our field could be brought to recognize their mistakes, they would again send their students to museums and the Golden Age might return—so the argument runs. The principal part of this paper is an attempt to summarize the objective facts about the relations between museums and the mainstream of anthropology in the past and at present, trying to strike a balance between the bias of non-museum anthropologists who tend to overlook the role of museums (especially in the past) and the bias of museum anthropologists who tend to exaggerate the importance of museums (especially in the present). Recognition of the objective situation is, I believe, a necessary prerequisite to policy decisions and to attempts at reformation. It is especially necessary for museum anthropologists and museum administrators, whatever their wishes for the present and hopes for the future, to admit the minuscule role and the low prestige of museum work in present-day ethnology. Of course

I believe that I am also correct in the value judgments I make about the present situation and in the suggestions I present for plans for the future. But I realize that these sections of the paper may be considered controversial, and the reader should evaluate the two parts of the paper separately.

If we adopt for a moment the usual, historically naive, *ex post facto* outlook on the history of science, the beginnings of anthropological collecting can be traced even before Aristotle and Classical Greece. There is much archeological evidence for the collecting of what would today be anthropological specimens in prehistoric times—exotic objects and heirlooms have been valued for almost as long as we have any evidence at all on human culture. In more recent times, parallels to anthropological collections, and forerunners of them, can be seen in collections of military trophies, in holy relics and the offerings of the faithful kept in Greek and Roman temples and medieval European churches, and in the powdered mummies, unicorn horns, and other magico-medical items collected by early European physicians and pharmacists. However, these collections served motives and functions different from those of modern museums. Collections of curiosities and archeological specimens formed by the Chinese gentry and royalty in the 12th century provide closer functional parallels to modern anthropological collections (W. Trousdale, pers. communic., 9 Dec. 1968), but these are outside the historical tradition from which modern anthropology and modern Western museums developed.

The real institutional beginnings of modern museums lie in the Cabinets of Curiosities which came into vogue soon after 1500 A.D. (Murray 1904; Hodgen 1964: 114–23). The surviving catalogues and descriptions of these Cabinets show that anthropological specimens formed a very important part of them: many of the "artificial curiosities" (as opposed to the "natural curiosities") they contained would today be classified as anthropological, and the pieces in modern anthropological collections which have the longest histories of continuous preservation in collections are a few items which entered Cabinets of Curiosities in the early 16th century, such as some

Mexican pieces sent back to Europe by Cortez after the conquest of Mexico in 1519 which survive in the Museum für Völkerkunde in Vienna (Nowotny 1960).

Cabinets of Curiosities were important for the early development of geology, biology, and archeology. The concept of "archeological ages as technological stages" grew in large part from the typological classifications of archeological artifacts in Cabinets of Curiosities and in the first museums; the earlier recognition of the typological similarity between stone weapons collected among contemporary North American Indians and the "thunder stones" of European archeology provided an early impetus to the notion of cultural evolution. But these Cabinets were of practically no significance for the development of ethnology, which grew instead out of written collections of customs—compendia from travellers' accounts and from classical literature of such things as religious customs and marriage customs—a different kind of collecting, which began at about the same time as Cabinets of Curiosities but independent of them (Hodgen 1964: 123–206). There were no efforts to compile systematic published accounts of the ethnological objects in Cabinets of Curiosities, and very little attention was devoted to developing logical classifications of these specimens (there were of course published catalogues, and published collections of such lists, but these show little or no effort to develop logical or any other classifications of ethnological objects [Klemm 1837 contains a useful description and bibliography]).

The beginnings of true anthropological collections in museums, the separation of these collections from other natural historical and historical collections into distinct museum departments of anthropology and into independent anthropological museums, date from around 1840.[1] This was also the period

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[1] The precise dates usually given are often in fact rather arbitrary, for the older museums evolved slowly by the amalgamation and subdivision of previous collections, becoming distinct and public by a series of steps. However, the Ethnographical Museum in Leningrad was established in 1836 (Troufanoff 1966: 232), the National Museum of Ethnology, Leiden, dates itself from 1837 (Anonymous 1962: 3), and the founding of the Ethnographical Collection of the National Museum of Denmark can be dated 1841 or 1849 (Birket-Smith 1968: 34–35). Frese (1960: 10) gives a summary chart of the founding dates of European and North American anthropological museums (but the source of his data does not always distinguish the founding dates of anthropology sections from those of the superordinate museum or museum organization).

of the beginnings of modern anthropology with its emphasis on the central importance of field research by the anthropologist himself. The founding dates of the earliest professional societies of anthropologists fall into the same period (Société ethnologique de Paris, 1838; American Ethnological Society, 1842; Ethnological Society of London, 1843).

What can be called the Museum Period of anthropology runs from the 1840's to about 1890.[2] During this time there was no university training in anthropology, so anthropologists were all people originally trained in other fields. Almost all anthropological research was done by museum anthropologists, or by amateurs, or by some other mavericks whose university teaching responsibilities lay in other fields. Physical anthropology was still largely a branch of human anatomy rather than a part of anthropology, and most of its practitioners were associated with medical schools. A nearly unique exception was the Bureau of American Ethnology, which was founded in 1879 and continued as a separate branch of the Smithsonian, administratively independent from the U. S. National Museum (despite the inauguration in 1883 of a Department of Anthropology in the Museum). The staff of the B.A.E. conducted the most extensive and the most important anthropological research in the United States during the last decade of the Museum Period and the first decade or two of the ensuing period. The gathering of museum collections during fieldwork, and studying them later on in the museum, was however an important and respectable part of anthropological research during this Museum Period. The emphasis was on classification and typologies and geographical distributions. But museum collections were only marginally related to the development of theories of cultural evolution, which was the main focus of interest of anthropology during this period. At the beginning, and in the prehistory of anthropology, typological studies of artifacts (both archeological and ethnological) were important for the development of ev-

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[2] This periodization—Museum Period 1840–1890, Museum-University Period 1890–1920, University Period 1920 to date—is developed from that implied by Collier and Tschopik (1954). While it reflects primarily the United States situation, a similar sequence obtains in other parts of the world. The second period probably began two or three decades earlier in France and Germany, and lasted three or four decades longer there and elsewhere in Europe.

olutionary theories—and also for the initial developments in the now-discredited German "culture-historical" school. But interest soon shifted to social evolution, and a good deal of the most important anthropological work done during this period had no relation to museum collections and could have been conducted equally well if they had not existed at all: research on kinship terminology, on the forms of marriage and the family, on religion, has never depended at all on museum collections. Figure 1 shows that in the major German, British, and American journals the proportion of ethnological articles which made any reference to museum collections never rose above 20 percent during this period.

The next historical period of anthropology ran from about 1890 to about 1920. We can call this the Museum-University Period. The formal teaching of anthropology in universities began in the 1880's and 1890's in both England and the United States, and in France, Germany, and the Netherlands rather earlier (Quatrefages was appointed to a Chair of [Physical] Anthropology at Paris in 1855 while Chairs in the Ecole d'Anthropologie were inaugurated in 1875; Bastian was made Dozent für Ethnologie in Berlin in 1867; future administrators for the Dutch East Indies received anthropological training from 1870). Still nearly all the jobs were in museums, most of the teaching was done by anthropologists who also had museum appointments, and museums supported most of the field work. Museum collections remained important for research—in fact, they became perhaps even more important, for the theoretical developments of this period often used museum collections as evidence, on such questions as the relative importance of diffusion as opposed to independent invention, the relation between cultures and their natural environments, and in the applications of concepts from biology in developing the notions of culture-areas and the age-area techniques of pseudo-historical reconstruction. The Bureau of American Ethnology continued to serve in effect as the research arm of Smithsonian anthropology; its collections were curated in the separate Department of Anthropology of the U. S. National Museum, while much of the publication and some of the fieldwork of the few anthropologists in the Museum was supported by the B.A.E.

In New York a somewhat similar relationship was worked out by Franz Boas, the founder of academic anthropology in the United States: between 1895 and 1905 he held a joint appointment in the American Museum of Natural History and at Columbia University, and used the museum as a base for his own and his students' fieldwork and its financing, from which museum collections resulted.

Yet the importance of museum collections for the anthropology of this time should not be exaggerated. The chart (Fig. 1) shows that in ethnology in the United States there was a steady decline in their importance from a peak at 1900; the situation in Great Britain and Germany is less clear, but here too such collections were never the major focus of research. This was the period of the rapid growth of fieldwork as the *sine qua non* of ethnological research, and the collecting and study of material objects played a relatively minor role in this fieldwork. In archeology, too, such important developments of this period as the application of the stratigraphic method were not derived from work with museum collections as such.

In 1905 Boas resigned from the American Museum of Natural History in a conflict over the emphasis to be given research; similar difficulties damaged anthropology in the University Museum in Philadelphia somewhat later. Darnell (1968) has described these difficulties as conflicts between the increasing professionalization of anthropology and the growth of teaching departments with interests beyond material culture, on the one hand, and the focus of museums (and museum administrators and trustees) on objects, their collecting, care, and exhibit, on the other hand. Beginning about 1920 we can speak of the University Period of anthropology, which continues up to the present. With the gradual increase in university teaching of anthropology, the balance shifted until the majority of anthropologists was not employed in museums. The proportion of museum anthropologists has been steadily declining, particularly rapidly during the last 20 years with the really explosive growth of college and university enrollments in anthropology courses. Universities and foundations took over the support of most fieldwork.

A measure of the relative importance for ethnology of museum collections, and of material objects whether or not in museums, is the proportion of papers which touch on these topics in the leading journals in the United States, Great Britain, France, and Germany (Fig. 1).[3] By this measure interest in objects in American ethnology declined even more sharply beginning in 1920 than it had before. In France, the decline did not begin until the following decade—perhaps additional evidence of the marginality of many aspects of French anthropology until after World War II which has recently been noted by a French historian of the field (Mercier 1966: 104). The corresponding decline in Great Britain did not begin until 1940; this is a surprising difference between British and American anthropology, which may indicate that the school of "social anthropology" which came to dominate British anthropology beginning about 1930 and soon had marked influences on ethnology in the United States and elsewhere, was less antagonistic to studies of material objects than is usually supposed (e.g. by Hutton 1944, Collier 1962)—or perhaps the dominance was real but was inadequately represented by the editorial practices of the journal examined. The German curves are of very little significance for nearly 30 years following 1930; German anthropology has only recently begun to recover from the damage done to it by the Nazis.

This brings us to the present, where anthropology is in the situation of having the responsibility for huge and irreplaceable collections which represent a large investment over many years of time, thought, care, and money, but seemingly have very little importance for current anthropological research, especially ethnological research. During the last 15 years, North American anthropologists have published at least 10 papers deploring the situation of museum anthropology (actually ethnology) (Collier and Tschopik 1954; Shapiro 1958; Fenton 1960; Mason 1960; Collier 1962; Collier and Fenton 1965; Borhegyi 1965; Sturtevant 1966; Dockstader 1967; McFeat 1967);

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[3] For each country the journal examined is the main vehicle of publication for papers on ethnology without restrictions as to the geographical area or sub-topic treated. The definition of ethnology applied in the counts is the one implied by an exhaustive partition of anthropology into ethnology, archeology, linguistics, and physical anthropology. Abstracts, notices of meetings, book reviews, letters, and similar brief communications, and papers on non-ethnological topics, were not counted.

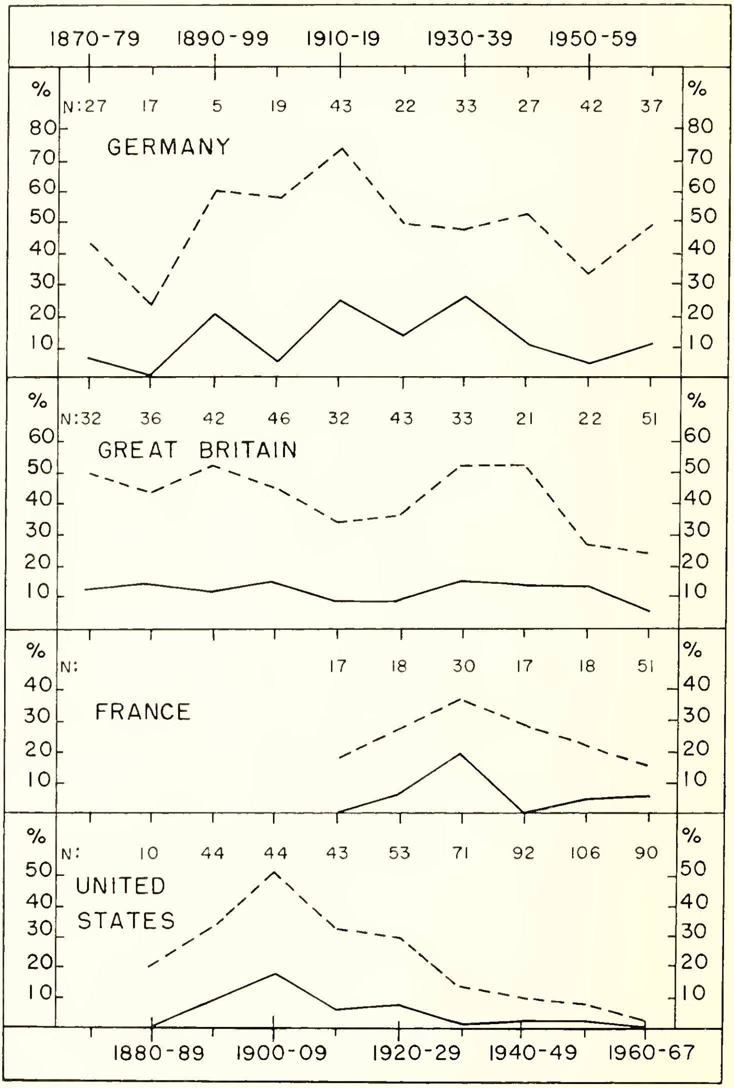

FIGURE 1. Interest in Material Culture and Museum Collections in Ethnology. Dashed lines show the percentage of all papers on ethnology which are concerned (at least in part) with material culture; solid lines show the percentage of all papers on ethnology which are based (at least in part) on museum collections. Sources: American Anthropologist (1888–1967); l'Ethnographie (1913–1965) and l'Homme (1964, 1967);

the most extensive treatment of this and related problems is a monograph by a Dutch anthropologist (Frese 1960). I know of no British, French, Scandinavian, or German papers which parallel these (although they may exist), but conversations with museum anthropologists from these countries over the last year or two have convinced me that the situation is not very different in Europe.

Although it is customary to write about "anthropology" and museums, in fact some distinctions between the sub-fields of anthropology must be drawn before a sensible answer can be given to the question posed at the head of this paper. Anthropology is quite sharply divided into four sub-fields, and one of the most marked differences between them is the use they make of museum collections. These four sub-divisions are linguistics, physical anthropology, archeology, and ethnology.[4]

The relation between linguistics, the scientific study of language, and the usual museum anthropological specimens, is nil. This is true of anthropological linguistics, which is based on the field study of languages which are still spoken and to a lesser extent on written records of them made in relatively recent times. The U. S. National Museum is perhaps unique among museums in including in its collections extensive linguistic archival materials useful for anthropological linguists. Those linguists who study extinct languages known only or largely through documents recovered archeologically—for example

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[4] This represents more or less standard American usage, except that (for good reasons) I prefer the somewhat old-fashioned and museum-oriented label "ethnology" for what is often now called "cultural anthropology" or "social and cultural anthropology." In Europe these four fields (and folklore) are less often viewed as components of a single larger discipline. Tendencies in Europe towards integrating the fields and in America towards incorporating into anthropology studies of Euro-American cultures have as yet had little effect on the organization of museums, whose buildings, collections, and bureaucracies cause them to lag behind universities in the reorganization, amalgamation, and subdivision of traditional departments.

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Journal of the (Royal) Anthropological Institute (1872–1964) and Man N.S. (1967); Zeitschrift für Ethnologie (1871–1967). Every third volume of each journal was scored (with some adjustments for France during W.W. I and Germany during W.W. II); these scores were then lumped by decade. N = number of papers on all ethnological topics in that decade's sample.

Mesopotamian clay tablets or Egyptian inscriptions or papyri—are not anthropological linguists and the museum specimens they study are only rarely kept in anthropological museum collections.

Physical anthropology deals with human biology. Thirty and more years ago, osteometry based on museum collections was a major interest of the field (although anthropometry of the living was also important). In recent years sub-specialties such as human genetics and primate ethology which have little or nothing to do with museum collections have been growing, and classical osteometry and anthropometry have nearly disappeared. Research on human paleontology, paleodemography, and paleopathology still depends on skeletal material, but the older museum collections are often of little value (especially for demographic studies) because they rarely constitute proper samples of the ancient populations. Present research concentrates on newly excavated materials, and the new necessity to keep even fragmentary specimens sometimes poses storage and cataloguing problems.

An indication of the relation of museum collections to research is the proportion of new accessions which come in without specific data on their sources. Practically no such specimens are now accepted into the physical anthropology collections in the U. S. National Museum; bones not accompanied by precise information as to their spatial and temporal provenience are not worth accepting and preserving, because they cannot be used for research.

Specialists in physical anthropology are a small minority of the total number of anthropologists, and very few museums maintain collections in this area. It is, however, becoming difficult to find properly qualified curators for these collections since the research of most physical anthropologists no longer depends on museum specimens.

Archeology, which is the study of fossil cultures, of cultural evidence recovered largely through excavations, is the part of anthropology for which museum collections are most important. The whole subject rests directly on the study of material objects and material remains, used as evidence for deductions regarding the human past. Of course the purpose of research is not the simple amassing of museum specimens—an activity which archeologists call "pot hunting" and consider to be mere vandalism. Rather, advances come through new fieldwork, new methods of observing, recording, and interpreting, and the publication of these results. However, most archeologists consider that a major part of their responsibilities for documenting their results consists in providing a properly catalogued museum collection, because publication alone does not provide adequate data for future research, which must continually check back with previously excavated specimens in order to set the new work into context and in order to reinterpret the old results in terms of new typologies and new descriptive techniques. Archeology thus has an important "taxonomic" base in museum collections, much like some of the natural sciences.

As with physical anthropology, undocumented specimens are normally not accepted into museum collections. In recent years well over 90 percent of the archeological specimens added to the U. S. National Museum collections have come from excavations by professional archeologists. Furthermore, archeologists have little hesitation in deciding what parts of their field collections should be kept in the museum collections and what parts can be discarded after they have been recorded. Hindsight sometimes shows that mistakes have been made, but the central position of material objects in the research means that at a given period there is good agreement on what must be kept for documentation.

Even though most current research depends on new field studies, there remain many important museum collections resulting from older excavations which have never been adequately studied. The occasional archeologist who analyzes and publishes these old collections is not felt by his peers to be wasting his time, and such studies can be expected to increase with the rapid destruction of archeological sites in many parts of the world in the construction of dams, highways, and industrial plants, the expansion of cities, and the increasing use of earth-moving machinery in agriculture. Much of Classical archeology already depends on the study of existing museum specimens, often with inadequate contextual data (this is one of the respects in which this field is peripheral to, or outside, anthropological archeology). On the other hand archeologists working in some parts of the world are forced to do without museum collections because they are prohibited from exporting their excavated materials while local museums are still unable to preserve them for future research.

Ethnology, the fourth sub-field of anthropology, is the study of living cultures, especially by means of the sort of fieldwork known as ethnography, which requires participant observation (extended periods of face-to-face relations with members of the society being studied, observations and interviews conducted on the spot by the ethnologist himself). A minor strand in ethnology makes use of contemporary written documents about now-extinct societies or the past stages of existing societies, but this "ethnohistory" depends heavily on methods developed by ethnographic fieldwork.

Ethnology is today the central field of anthropology, the one which holds together the four sub-fields. Anthropological linguistics, archeology, and physical anthropology are parts of anthropology largely by virtue of their interrelations with ethnology, and particularly because of the central position held by the (ethnological) concept of culture in definitions of the coverage and the methodological and theoretical emphases of the non-ethnological sub-fields. There are some kinds of linguistics, archeology (or prehistory), and human biology which are non-anthropological in terms of the methods, interests, training, and professional self-identification of their practitioners, while there are no professional ethnologists who are not anthropologists in this sense. This formulation—which is probably acceptable to most non-ethnologist anthropologists, at least in North America—does not deny the fact that linguistics, archeology, and physical anthropology have varied relations between each other and with disciplines outside anthropology. For example, archeology is more closely dependent on several of the natural and physical sciences than is ethnology, and in turn can contribute to their historical aspects in ways that ethnology cannot. It is also true that many of the interests and methods of ethnology depend on contributions from the other fields of anthropology, and from other disciplines such as psychology, sociology, economics, and history. But anthropology remains a single subject, with sub-divisions. Some observers believe that it will not (and sometimes that it should not) remain so, that increasing specialization will lead to fragmentation. But this specialization often overlaps sub-field boundaries, so that the discipline may well become a network rather than a rigid set of four pigeonholes. I believe that the sub-fields will (and should) continue to offer more to each other than to outside disciplines. If museums need anthropology, they must include ethnology.

But ethnology is the anthropological sub-field which has the most ambiguous relation to museum collections. Ethnologists study culture, and they often boast that, in contrast to practitioners of the other social sciences and humanities, they study both all cultures and all aspects of culture. A classification of the aspects of culture useful for present purposes is a common one which distinguishes three major classes: material culture, social culture, and mental culture. To characterize these roughly, material culture is concrete artifacts or manufactures, social culture is behavior, and mental culture is ideas, knowledge, and beliefs.[5] Only material culture can be represented in museum collections, and it is perfectly possible—indeed it is usual—to study social and mental culture without paying any attention to material culture, to artifacts, and therefore to museum collections. Material culture studies themselves are of course not limited to work with museum collections, for the contexts of the objects in the social and cognitive systems of their makers and users is a primary interest.

As with the other sciences represented in natural history museums, collections are relevant to only some kinds of anthropology and often not to those areas in "the forefront of research" (cf. Crompton 1968). But there is a significant difference: for the core area of anthropology, "systematics" and "basic descriptions" based on or documented by museum collections are

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[5] See Osgood 1951 for these categories, defined on a somewhat different basis. The definition which I prefer for both theoretical and methodological reasons puts the locus of "culture" in the minds of its bearers, which makes the term "mental culture" redundant and requires rewording of the labels for the material and social results of culture: perhaps "cultural materials" (i.e. artifacts) and "cultural behavior." If artifacts are thus viewed as reflections of culture rather than part of culture, they are of no less value as documents or evidence on a major aspect of culture, on the varieties of specifically human cognition and behavior.

not now and have never been fundamental in any sense to other research. Artifacts and museum collections of them play no role as ethnological "standards" or "vouchers"; the units of ethnological study are bounded, identified, and classified without regard for museum collections. This would not be important for museum anthropology if ethnologists were really equally interested in all aspects of culture. But as has already been indicated, this is not the case. From the beginning, research on material culture has been less important in ethnology than research on social and mental culture.

In 1967 the three major general anthropological journals in the United States, England, and France published 65 papers on ethnological topics. Of these, only five dealt with material culture; among even these, three were based on field observations and made no reference to museum collections. The overwhelming majority—60 to 63 out of 65—could have been written if there were no anthropological museum collections at all. Even the research of most museum ethnologists does not involve material culture or museum specimens. Most modern ethnologists have never studied museum specimens, have never collected for a museum, have never even been in a museum storage area. Yet I suppose at least 90 percent of museum ethnological specimens have never been studied.

In a few decades, anthropologists will surely look back on the present time as the last period when it was possible to collect hand-made traditional artifacts, and to document their production, local terminology, and uses by field studies, before they were completely replaced by mass-produced manufactured goods of the "international style." Nearly every ethnographer could collect now; hardly anyone does. No anthropological museum seems able and willing to provide funds to encourage collecting by the hundreds of ethnographic field researchers now at work. The budgets of most museum anthropology departments do not regularly include sufficient funds to purchase even the useful collections which are offered. When funds are available, high prices tend to go for showy pieces without documentation bought on the art market. If items collected by a trained ethnographer with proper scientific documentation can be bought, the price paid normally covers only the actual costs of purchasing, packing, and shipping the specimens. Yet there are many ethnographers (especially outside the United States) who lack sufficient funds to support their own fieldwork and who would readily devote some extra time and attention to making a properly documented collection if they were offered a reasonable mark-up over their out-of-pocket expenses, which could be used to help pay for their other work.

As recently as ten years ago, an ethnologist on the British Museum staff wrote that in the United Kingdom, "collecting in the field is rarely possible for most museum officials in charge of ethnographical collections" (Cranstone 1958: 7), and the situation has changed little since then. In the United States and a few other countries funds are not so short and the policies of large museums regarding fieldwork by their staffs are not so restrictive. Yet over the last four years, nearly two-thirds of the specimens added to the ethnological collections in the U. S. National Museum were not collected by ethnologists, but were collected under non-scientific conditions by untrained people and hence lack essential documentation as to provenience, age, functions, and so forth. Of course non-anthropologists can collect materials which are scientifically useful. However, a set of directions and suggestions on how to make an adequate field collection of ethnographic specimens which the U. S. National Museum published in 1967 was the first such guide published in English since 1902; the last one in French is dated 1931 and the last in German, 1914 (Sturtevant 1967; Holmes and Mason 1902; Musée d'Ethnographie 1931; Ankermann 1914).

The relative unimportance of collections is demonstrated by the growing tendency to separate them from the associated scientific staff, public exhibits, museum administrative space, and classrooms. The more convenient centrally located space is repeatedly being found to be too valuable to use for storing specimens. But if the specimens were really significant for research, it would be as inconceivable as it is for research libraries to locate them several miles away from the researchers (usually without plans for a regular service to transport people and objects between the two locations). What is objectionable is not the separation of the collections from the exhibits, but storing the specimens miles away from the associated records and the scientific staff.[6]

As Crompton (1968), Washburn (1967, 1968), and others have pointed out, when research on collections is infrequent and of low prestige museums naturally seek other justifications for existence—popular exhibits, general education—and the staff members tend to become administrators, showmen and public relations experts, and museologists, rather than subject-matter specialists. The results for research on the collections and even for their preservation are obviously disastrous; that this is not hypothetical can be seen from the history of many museums (see, e.g., the cases described in Whitehill 1967). Anthropological collections are even more liable than some others to suffer, for many kinds of anthropological specimens require constant attention to prevent deterioration, many are of high value on the art market, and research on them is at a particularly low ebb. Some recent examples of the results are pertinent: a naturalist in charge of a museum overrides his anthropologist curators and authorizes the loan of important ethnological specimens for decorating politicians' offices; an ethnologist museum director sells unique ethnographic specimens catalogued in his museum, both at the public sales desk at his institution's front door and through profit-making dealers in "primitive art"; one archeologist museum director trades important well-documented early ethnographic specimens from his museum to a private individual in exchange for an easily duplicated collection of non-excavated archeological sherds; another archeologist in charge of a museum orders each of his curators to select specimens for sale at a private auction to his socialite "friends of the museum"; one major anthropological museum charges visiting researchers $50 to open an exhibit case in order that displayed specimens may be studied; an ethnologist chairman of a department in another museum suggests that a qualified visiting student prepare the first thorough descriptive cat-

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[6] Such plans for removing the anthropological collections are in various stages of completion at least in the British Museum and the Horniman Museum in London, the Peabody Museum at Harvard, and the U. S. National Museum. The Museum of the American Indian in New York has operated with such a separation for many years.

alogue of one of the most important collections under his care, and then refuses to allow the student to complete the catalogue by including those pieces in the collection which have been solidly built into modern exhibits on the grounds that it is too much trouble to remove them for study. As one of the small group of research users of ethnographic collections, my own experiences on study visits to some 15 of the 20 or so largest and most important general ethnographic collections in the world are significant. Two of these museums flatly refuse to allow serious researchers to photograph their specimens; most have no special facilities for visitors to use for photography, and many have not even any space where a visitor can arrange items to photograph even though he has brought all his own equipment; none, in my experience, has convenient locations for studying the specimens in or immediately adjoining all storage areas; most find it difficult—and some impossible—to remove exhibited items for study (but all try to put their most important specimens on exhibit, often with catalogue numbers hidden); usually some 10 to 20 percent of the specimens a visitor selects for study from the catalogue descriptions cannot be located (and in a recent visit to a national museum of anthropology in Europe, 83 percent of the specimens I identified in the working catalogue could not be found); always a visitor cannot help but feel that he is imposing on the inadequate professional and supporting staff—a visitor interested in serious research on the collections is so unusual that he is bound to disrupt the museum routines. The usual state of the storage and the catalogues and other records has to be seen to be believed; one seriously wonders whether present collections will survive any better than have the pitiful remnants of 17th and 18th century collections (cf. Washburn 1968).

But let me switch hats to my role as curator. An ethnologist with curatorial responsibilities, while recognizing these disgraceful conditions, must also consider the allocation of his own time and energies. What should be done to improve and preserve the collections is obvious; but the results of his work would be seen and appreciated by a very small proportion of his colleagues, and given the severe limitations in funds, personnel, and space all museums suffer from, it would be a difficult struggle to get even a small part of the help so obviously needed to do a proper job. The criteria by which his professional standing is evaluated both by his anthropological peers and by the museum authorities who pay and promote him have almost nothing to do with the state of the collections under his care. Curators with any ambition and regard for their own potentialities quickly and repeatedly decide to devote themselves to the research and publication which will advance anthropology (and their own careers) right now rather than in some distant future. Such ethnologists are "square pegs in round holes" or "in the wrong pew"—to quote the common opinion of museum archeologists and of the few really good and productive museum ethnologists who do focus their research on the collections under their care. But there are nowhere near enough good round pegs to fill the holes in museums. The alternative to supporting square pegs is to hire museum ethnologists who are not in the mainstream of ethnology, which further degrades the attractiveness of museums for active anthropologists of whatever specialty. There are a few such people now in museums; among them are some of the better curators, but also some of the worst: lacking peers, they are less constrained by outside judgments of their actions and easily fall into autocracy, isolation, high-handed treatment of research visitors, and disposal of scientifically vital collections through sale or exchange to individual collectors and dealers and to other (especially art) museums. The administrative structure of many independent and some university museums only supports these tendencies, for boards of directors and boards of supervisors tend to consist of financiers, businessmen, politicians, and others who are interested in the financial status of the organization and in its reception by the general public, but who cannot and do not exercise any informed scientific supervision over a director gone berserk.

What can be done? It is a problem for museum anthropology as a whole, not just for museum ethnology. Although collections are central to the research of archeologists and some physical anthropologists, but only to a very small minority of ethnologists, the answer is not to separate out the archeologists and physical anthropologists and their collections. Not only would this be disastrous for museum ethnology, but it would be deleterious for museum archeology and physical anthropology, for anthropology is fundamentally a single field and few anthropologically-oriented archeologists and physical anthropologists would stay in fragmented departments where they would be peripheral to the centers of unified anthropological research and teaching.

The best hope is for the increase of the quantity, quality, and prestige of ethnological research based on museum collections. Broad justifications for the importance of ethnological research on material culture (which in turn will require attention to artifacts in museums) are not difficult to formulate:

1. Man is preeminently the tool-using animal, so that an understanding of his physical and cultural evolution and his relation to the non-human environment requires knowledge of his adaptive use of materials in its full cultural variety in historic as well as prehistoric times.

2. Ethnology is not fulfilling its mandate when it neglects material culture in favor of social and mental culture. In many respects the material basis clearly underlies, limits, and determines other aspects of human social life. It is particularly surprising that the technological aspects of our own and other cultures are not more studied by anthropologist members of a society so dominated and harassed by technological advances and technological problems. If anthropologists do not fill this gap, it will be filled by others who lack some of the special advantages of an anthropological training and outlook, in particular the emphasis on functionalism which leads to studies of the integration of artifacts with non-material aspects of culture.[7]

3. Artifacts, and especially dated artifacts in museum collections, provide essential evidence for the history of cultures. Ethnological artifacts are an important link between the societies whose remains are recovered in the more recent parts of archeological sequences, and their historical successors. Furthermore, archeologists depend heavily on ethnological analogies

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[7] The last two points were emphasized for me in conversations respectively with P. J. C. Dark and J. C. Ewers.

for understanding the functions and contexts of the fragmentary artifacts on which they must base their paleo-ethnography and prehistoriography. For ethnohistorians museum collections are crucial historical documents whose potentials are only beginning to be appreciated (cf. Fenton 1967).

4. In non-literate societies only artifacts provide models and evidence of the past apart from those "stored in human memory" (and subject to the vagaries of human memory); this surely has important consequences for the members of those societies (Goody and Watt 1968: 29), as it certainly does for the evidential value of artifacts for both contemporary and subsequent outside observers. Both informants' and recorders' biases are less significant here than with either oral or written testimony. The artifacts stored in museums provide a vast body of quite direct cultural evidence which should be analyzed and re-analyzed.

But general statements such as these on the importance of material objects for human life, and on how unjustifiably museum collections of them are being neglected, are not going to convince students nor shift the research interests of established professionals. When the statements come from a museum anthropologist they sound like petty and self-serving complaints which are easily taken as attempts to denigrate the real accomplishments and importance of other more active lines of current research. What causes shifts in research emphases is the discovery of quite specific problems and methods that are attractive because they promise advances clearly related to other important interests of the discipline. If such problems and methods can be worked out from studying museum collections, this in turn will raise the prestige of more pedestrian research done on the same media. Attention should therefore be devoted not just to urging more research on artifacts, but to improving the methods of research on museum collections and particularly to adapting interesting developments from other, more prestigious and more advanced fields. Such applications are more likely to be made by the "square pegs" with other interests whose employment puts them into proximity to the collections, than they are by "round pegs" attracted to museums by the traditional kinds of research on ethnological collections.

In fact, there are already indications from several different directions of a revivification of ethnological research on material culture. While this is not the place to go into details, an enumeration of some of these tendencies (or potential tendencies) helps to justify optimism about the future of anthropological museum collections. From archeology may be mentioned the application of attribute analysis to ethnographic specimens as well as archeological ones, and the increasing importance of detailed and specific ethnographic analogies in archeological interpretations. From other interests of ethnology (and linguistics) come: recognition of the advantages of concrete artifacts as the basis for componential analysis and for other applications of etic/emic or ethnoscientific methods, generative analysis, semiology, and other semantic approaches; the involvement of art and artifacts in studies of symbolic classification; an increased interest in field studies of non-Western art, from various points of view (partly influenced by lessening ethnocentrism in Western art appreciation and art history); the use of specimens, especially dated ones, as historical documents on both non-literate and literate cultures; and the recognition of the utility of artifacts in museum collections for the critical assessment of ethnographic illustrations both as ethnological documents and as part of the history of Western art. These trends may be summed up as an increasing attention to classification, semantics, and symbolism—in general, the rise of a variety of structuralist methods—and in diachronic studies more inclusive definition of the kinds of "documents" which are relevant.

It is not only developments in anthropological theory and method that encourage confidence in the wider recognition of ethnological museum collections as the important resources they indeed are. In France, at least, there is already an obvious increase in student interest in material culture and museum collections: one of the demands of the protesting students of May and June 1968 was for access to museum collections and introduction to their study (Hélène Balfet, pers. communic., 15 Feb. 1969). The combination of the increasing difficulty of access to foreign areas for fieldwork, the very rapid Westernization of technology everywhere, and the explosive increase in the number of anthropologists who must publish or perish, will almost certainly also lead to more research on ethnological museum collections.

Meanwhile there are several organizational modifications which can improve museums as research environments for anthropologists and help to save their collections for the time when they will be vital for anthropology.

Museum specimens are unique cultural and historical documents; we must find out what and where this evidence is. There are about 200,000 ethnological specimens in the U. S. National Museum, somewhat over one and one-half million in all United States museums, and perhaps four and one-half million in all museums of the world.[8] A pilot study at the University of Oklahoma has developed procedures for preparing an inventory of all of these, which would incorporate most of the errors in existing museum catalogues (for example, the U. S. National Museum must have several hundred, perhaps several thousand, specimens catalogued as "locality unknown, probably North America" or some equivalent of this) but would provide the basis for later correction and amplification. This study indicates that it would require about 140 man-years to prepare an "index ethnographicum" or "union catalogue" for the United States alone, at a cost of approximately 50 cents per specimen for preparing and key-punching the inventory sheets —any computer operations will add to this cost figure (Ricciardelli 1967b, 1967c). Somewhat over half the specimens in the United States are in the five largest museums, which should surely be left to do their own indexing; they have or can get the needed skilled staff, and this will make partial completion of the project less than half as expensive and nearly as useful as full completion, for anyone will know that he must search these major museums for relevant specimens whereas without an inventory he will miss most of the others which are widely scattered in smaller museums. As soon as possible these large museums should modify their present cataloguing systems to make

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[8] These figures are based, respectively, on (1) a careful count of a stratified sample of the specimens described in the USNM catalogue cards, conducted by the author and Gordon D. Gibson in 1965 and 1966; (2) the North American estimate made by Ricciardelli (1967a) from several lines of evidence carefully considered; (3) my own extrapolation from the latter, which is merely an informed guess.

them compatible with the projected continent-wide computerized index, so that future accessions can be fed into the system immediately, before the index is extended backward to include the older materials. Similar schemes are being considered at least in the United Kingdom and France; there is reason to hope that all will be compatible. As Jean Cuisenier has pointed out (pers. communic., 30 Dec. 1968), the use of computers is spreading so rapidly that the modern student generation takes them for granted; our museum collections are in danger of becoming useless if young scholars are not able to use computers to retrieve information on them.

Most research on ethnological collections depends heavily on the minority of specimens which have some documentation, at least dating, and the older collections of this sort are particularly valuable. So a committee of the International Council of Museums (ICOM) and J. C. Ewers with the Committee on Anthropological Research in Museums of the American Anthropological Association are both considering another type of inventory to compile location lists for older dated specimens without waiting for these to appear in the full inventories of all museum ethnological holdings.

The problem of the conflict between curatorial and research duties is perhaps even more acute in ethnology than in other museum fields, because of the wider gap between the usual research interests of present and prospective curators and their housekeeping responsibilities. Complete separation of research and curatorial staff is risky: in many if not most museums the collections and the necessity for exhibiting and caring for them provide the front which justifies the museum budget; if it is made to appear that research and curation are completely distinct, research becomes more vulnerable to budget cuts; but it is well known from much experience that collections without associated research staff cannot long survive. On the other hand, giving the research staff full curatorial duties has the untoward consequences for both the collections and the research which we have already outlined. One solution is to develop further the practice already existing in most large museums, where the scientific staff supervises a "supporting staff," paid less and with lower academic credentials, which does most of the actual curatorial labor. But it is difficult to locate, train, and keep adequately skilled people for such clearly second-class jobs. The status and responsibilities of these positions could be raised by lifting the career ceiling on them and assigning to their upper ranks some such title as "Curator of Collections," with truly commensurate responsibilities. A few museums already do this, and the practice should be extended. We need the museum equivalent of Librarians and Archivists. Professionalization of this sort does carry the dangers that Washburn (1967) has pointed out. The scientific staff—subject-matter specialists—must maintain scientific guidance over collections policy, and museum tables of organization should be planned with this in mind. It may be anachronistic in this society, but an effort must be made to emphasize apprenticeship training rather than preparation in some academic museology. Certainly the knowledge and experience needed to curate museum collections is more specialized, more different as between the collections of different sciences, than is the case for collections of books or manuscripts. An anthropological museologist, an entomological museologist, and an art-gallery museologist could not come from a similar background of academic and practical experience.

Finally, some important modifications of the museum concept are needed at least by anthropology. For one thing, anthropology does not belong in a natural history museum. In fact, the United States is behind the rest of the world in this respect: except in North America, Australia, and New Zealand, nearly all important anthropological collections are either housed in independent museums of anthropology or of man, or they are joined with collections of history, folklore, prehistory, and Classical archeology, while natural history collections are separately housed (Frese 1960: 15–32). A justification for the separation which is of particular force for the modern world is that given by the Director of the National Museum of Anthropology of Mexico in describing its origins in 1910: "Until that year the museum had remained one of "Natural History." But at that time all the natural history collections were removed to another museum thus abandoning, I hope forever, the placing of indigenous cultures in the same building as animals, which gives visitors inaccurate ideas about native peoples and their cultures" (Bernal 1966: 132). Another reason for removing anthropology from natural history museums is the quite different character of the collections, which are more like those of history and art in their unique qualities as historical documents and in the problems of acquisition and protection, and which are related to ongoing research in quite a different manner. Some anthropologists (especially some archeologists) now in natural history museums point to the advantages of a close association with the natural scientists with whom they find many areas of scientific collaboration, especially with the rise of an ecological approach to human cultures. But there are equally strong reasons, from some other areas of anthropological interest, for urging the benefits of a closer association with the historians, art historians, and technologists who are found in other kinds of museums. Another advantage of a separate Museum of Anthropology or Museum of Man is that it is easier to broaden its mandate for collecting and curating so that it will include all the sorts of physical objects on which anthropological research is based. The Musée de l'Homme and the Musée des Arts et Traditions Populaires in Paris, and the Department of Anthropology and the Center for the Study of Man (now planning a new Museum of Man) of the Smithsonian, and probably a few other museums, already define their museum function as essentially that of archiving: the usual museum collections of artifacts and skeletal materials, and in addition still and cinema photographs, drawings and paintings, sound recordings, anthropological manuscripts, and books. Many of these additional materials are at least as crucial for future research as are specimens and yet are not being systematically archived by any other institutions; the physical and administrative museum structure is more suitable for this task than is that of any university department.

With new museums comes the rare opportunity for a major advance in anthropological exhibit techniques. Any museum anthropologist will recognize the advances associated with the inauguration, in order, of the Pitt Rivers Museum in Oxford, the Natural History Building of the U. S. National Museum, the American Museum of Natural History, the Musée de l'Homme, and lastly, the Milwaukee Public Museum in 1963–71 and, in 1964, the new building of the National Museum of Anthropology in Mexico City. It is past time for a radical new approach. Borhegyi has recently well described the problem:

> Through [museum] exhibits, million of people can be exposed to the inherent dangers of nationalism, ethnocentrism, and racial and religious prejudices. Yet museum exhibits in general, and natural history museums in particular, instead of stirring the imagination of visitors, tend to perpetuate the visitors' stereotypes of "savages" and "quaint primitive" cultures. The anthropology exhibits keep on cultivating the romanticism of the visitor by showing exotic "tribal" peoples in "peculiar" attires, amidst prettily staged sentimental settings, or appeal to his sense of the macabre by the inevitable showing of mummies, skeletons, and shrunken heads. . . . Museum anthropologists continue to be primarily object and tribal rather than subject or concept oriented in their exhibits, and most of them rightfully deserve the title of "keepers" . . . rather than "doers." (Borhegyi 1969)

Perhaps three new approaches to exhibits would be particularly effective in a new Museum of Anthropology:

1. Exhibits should catch up with the principles of modern anthropology, rather than continuing simply to illustrate the "culture areas" elaborated for museum exhibits over 60 years ago. In particular the relevance of anthropological knowledge to some of the difficulties of the modern world should be stressed.

2. Some exhibits, perhaps changing ones, should illustrate current research, especially that being conducted by anthropologists on the museum staff.

3. Anthropology, as the only social science well established in museums, seems the ideal field to study the educational effectiveness of various exhibit techniques, to conduct research on visitor reactions. I am by no means an expert on the topic, but I have the impression that this is an underdeveloped research area. The rapid specialization and technological improvement of exhibit techniques seems to have occurred without reference to studies of what visitors actually prefer or bene-

fit from (and these last may not be the same). A recent wide-ranging bibliography of museum visitor surveys lists only 124 titles, published and semi-published, nearly all of them very brief papers, on studies in all sorts of museums between 1897 and 1966, and very few of these report anything approaching sophisticated controlled experiments (Borhegyi and Hanson 1968a; cf. Washburn 1961; Borhegyi and Hanson 1968b).

Although anthropological museum exhibits certainly need improvement, there is a real danger that attention to exhibits will intrude on the time and support for curators' research. Certainly no exhibit program should be conducted without both the technicians to do the actual work, and funds to hire outside experts on a short-term basis to help plan the scientific aspects of the exhibits. Down the exhibits road lie the museums feared by research-oriented curators, where emphasis on exhibits, popular education, visitor attendance, advertising, and income-producing museum shops erodes support for scientific research, drives scholars off the staff, and runs a grave risk of destroying the collections and turning the museum into a mere entertaining sideshow.

Crompton has recently urged that "it is time . . . that we recognized that the functions of maintaining collections, designing exhibitions and running sophisticated research programs cannot be carried out by a single person. It must also be recognized that successful scientific research is usually coupled with stimulation provided either by fellow workers or students or teaching or all three. Unless natural history museums are prepared to recognize this, it will not be possible for them to create strong scientific programs." He also outlines the manner in which a successful university museum may avoid many of the problems of ensuring active research by its curators, by integrating the museum administratively with the teaching departments (in reality, subordinating the museum to the departments) (Crompton 1968). A non-university museum must invent the equivalent of teaching departments. Opportunities must be provided for curators to take leave to teach in universities, and fellowships and facilities must be offered to attract students and university faculty members to museums—and not only for research and teaching related to the museum collections. Museums have some advantages over universities as bases for anthropological research; among these is the freedom from the academic schedule which allows extended fieldwork at any time of the year. Particularly in ethnology it is customary for the most intensive and important fieldwork to be done early in the scholar's career, often just before he receives his Ph.D. In the usual situation he must then postpone publishing the full results; by the time his teaching duties become less time-consuming and he can get leave from his university, he has family and other responsibilities which prevent another lengthy period of isolation for fieldwork. The same is true, to a somewhat lesser extent, for the other sub-fields of anthropology. It is becoming ever more clear that advances in ethnology depend on advances in ethnography; yet ethnography suffers from the structure of academic careers. Museum-based research, both fieldwork and publication, for younger anthropologists is a solution. If after a few years they move to university teaching positions, the museum and the science have gained by supporting them during their most productive research years, and the university has gained by acquiring teachers who are already experienced and productive research workers.

As Fenton (1960) has suggested, a redefinition of anthropological museums in terms of the Alexandrian museum as a community of scholars and students would be a large step forward. Collections will be increasingly important, and there are serious problems in preserving them and in taking advantage of the short time remaining in which we will be able to use fieldwork to improve our understanding of existing museum specimens and to acquire the new and properly documented collections which we owe to our successors. But the new Museums of Man must be research organizations, with the collections of artifacts and other documents under the care of Curators of Collections, supervised by the scientists who are supported to do good anthropology whether or not this is directly related to the collections. In such an enviroment we can be quite sure that the collections will survive, that research on them will increase, and that museums can significantly advance anthropology as a whole.

Anthropology does indeed need museums. But it needs the

Very Model of a Modern Anthropology Museum, not an equivocal and petrified institution which reminds one of a bordello.[9]

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[9] I am indebted to many colleagues for comments and criticisms which helped me to improve an earlier draft of this paper. I hope the 15 or so who may see that they influenced me—sometimes surely insufficiently—will forgive me for not listing their names.

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THE ROLE OF MUSEUM COLLECTIONS IN ORNITHOLOGICAL RESEARCH

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Periodically the curator of any large collection of birds must ponder the future course of development of the collections in his care in keeping with changing research needs. His plans will probably be influenced by limitations of budget, space, and assistance; and to varying degrees the development of the collection may be out of his control. The United States National Museum, for example, is a repository for birds collected for federal agencies and as such houses rich collections of North American birds from nineteenth century railroad surveys, boundary surveys, the Biological Survey, and other sources. Today it receives specimens from medical research units of several governmental departments engaged in the study of arthropod-borne viruses. Like other museums, the U. S. National Museum has acquired large collections from privately financed expeditions. Particularly in the past, the research of leading ornithologists was molded in part fortuitously by the advent of such collections simply because ornithological research consisted mainly of naming new forms, reporting on new collections, writing faunal works, and revising and classifying taxa. Even at the turn of the century, Robert Ridgway, an esteemed curator of birds at the U. S. National Museum, differentiated between scientific ornithology as practiced by the curator, and popular ornithology—the study of habits, songs, nesting and other aspects of life-histories. Charged with the responsibility of publishing the ornithological results of work by the government, he produced a taxonomic synthesis of North and Middle American birds, based largely upon the collections of others (Ridgway, 1901). This life work secured his reputation as a leading ornithologist.

It was during Ridgway's time, however, that study of the living bird began to take its place with taxonomy as truly scientific ornithology. Today a tabulation of research papers in a major American ornithological journal, The Auk, would show only about 25 percent that deal with classification and distribution; an even smaller percentage of these papers are authored by curators of museum collections. Although there has been a decline in the proportion of research projects based on specimens to those not requiring collections, the actual number of workers who rely on specimens for their research has not declined. Furthermore, specimens are now used not only for traditional research activities but also in connection with other aspects of the biology of birds. In general the research career of a museum curator is less influenced by incoming collections now than in the past; rather, collections are increasingly influenced by a curator's research. Ornithology has reached the stage where the curator, in planning the growth of his collections, must first decide what is worthwhile research.

Research on birds in museums has changed because of the breadth of achievement of scientific ornithology as defined by Ridgway. About 8700 species, and between three and four times that many subspecies of birds are presently recognized; in the past ten years only about 5 new species and some 30 subspecies have been described per year. Some of these new species were recognized through restudy of museum specimens; others were taken in the field by collectors working in new areas—today notably within Peru and the Philippines. In general, however, the description of new species is no longer an important ornithological activity in that classifications are rarely upset by the addition of the new forms. By contrast, the description of fossil forms continues to provide new insights into adaptive radiations of the past.

The general outlines of geographical distribution of birds are known; indeed the final volumes of a distributional check-list of the species and subspecies of birds of the world begun in 1931 by James L. Peters are now nearing completion (Peters, 1931). In addition to systematic and faunal treatises for most regions of the world we now have well illustrated pocket field guides for such areas as Argentina, Mexico, the West Indies, North America, Europe, Russia, East Africa, South Vietnam, Thailand, Japan, New Zealand, and the oceans. Most major collections in larger American museums have been documented in reports of one kind or another, and many of the larger families of birds have received taxonomic revision in the last 50 years, some indeed receiving multiple treatment.

What then, are the current directions of ornithological research? Although description of new forms has tapered off there is still considerable interest in distributional and faunal problems, particularly concerning South America, Africa, and tropical Asia. In addition, systematic work continues apace with ever-changing concepts and methods (see Sibley, 1955; Mayr, 1959). The museum worker of today thinks very differently from his counterpart of 100 years ago and he uses such varied approaches to systematics as comparative biochemistry, behavior, song structure, and functional anatomy, as well as the more traditional ones. Museum workers and others using collections have also dealt with the analysis of population variation and modes of speciation using large samples and quantitative methods, with the adaptive significance of anatomical structures, with modes of evolution on islands, with the origin and history of avifaunas, and with a variety of other problems. Although the limits of higher categories of birds are well established the phylogenetic relationships of the families and orders are little understood; these are being studied from the viewpoints of comparative anatomy, behavior, and biochemistry. There have been recent attempts to understand the adaptive significance of the diverse patterns of reproductive biology, migration, and molt, that have been described from the study of specimens and living birds. Variation in characters such as bill and wing length, measured on study skins, is playing a role in the development of ecological theory, particularly in regard to concepts of niche, competition, and species diversity. It is because of the increasing emphasis on comparative biology of birds on the part of workers who utilize specimens that we should reexamine the nature of our specimens and collections to see that they continue to serve traditional functions and at the same time meet new needs.

The nature of the specimen itself in part determines its usefulness or potential as a research tool. A typical bird specimen is made by removing and discarding nine of the bird's ten organ systems, filling the remaining integumentary system with cotton, sewing it up in such a way that the inner portion of the wings can never be studied, and affixing a label. In another kind of preparation, nine organ systems are again discarded, leaving only the skeletal system. Skeletons are not emphasized in most bird collections although their importance is gaining in many museums. Still less in favor is the spirit specimen—a bird with all ten organ systems intact and preserved in alcohol. The early skeleton and spirit collections, often abhorrent to the skin taxonomist, owe their existence less to ornithologists than to workers in museum divisions of comparative anatomy. Other specimens once of great moment but now rarely consulted are the empty egg shells and the empty nests. All of these preparations are the traditional tools of the ornithological curator's trade.

For a single organ system, the bird's skin and feathers contain much information; it is this part of the bird that meets the environment and this part to which other birds react. Feathers are therefore subjected to many selection pressures and they have evolved an enormous diversity of structure, pigment, pattern, and molt sequences. (Because feathers of the folded wings of a bird skin are difficult or impossible to study, the molt pattern of the wings should be routinely recorded on specimen labels, and some spread-wing specimens should be prepared.) Taxonomic information from the integumentary system applies chiefly to relationships at the infraspecific and specific levels because differences often reflect geographic isolation, or the need for reproductive isolation between closely related sympatric forms. Plumage patterns are fairly stable in some groups, thereby serving also as indicators of generic relationships.

In the bird's skeleton the long history of common descent within an order or family is often reflected by peculiarities of the relationships of bones. In addition, by its proportions the skeleton strongly reflects behavior patterns of feeding and locomotion that may characterize related groups or unrelated ecological counterparts. Comparative and functional osteology therefore have served as useful bases for establishing the higher taxonomic levels and for understanding structural adaptation.

Spirit specimens, like skeletons, have provided important foundations for delineating higher taxa through comparative anatomy (for example see Fürbringer, 1888), and will probably retain their importance for future studies of phylogenetic relationships.

In the past, skins were studied by taxonomists—skeletons and spirit specimens by anatomists. Anatomists (and paleontologists) had to be content with the few anatomical specimens that were prepared along with the multitudes of skins obtained on expeditions. Anatomists have therefore become used to working with one or a few specimens, often with incomplete data, but many skeletons (preferably at least ten of each sex) are needed to encompass natural variation and to avoid erroneous conclusions based on artifacts of preparation. Spirit specimens are also needed in large series because several organ systems may be destroyed during dissection of any one system. Some collectors "pickle" specimens that are too damaged to skin, when in fact there is nothing more useless than a badly damaged anatomical specimen. The data vital for skin labels are equally vital for anatomical specimens. Today anatomists are a vanishing breed, but many ornithologists undertake anatomical studies for the solution of ornithological problems. It is increasingly apparent that many questions in avian biology and taxonomy cannot be answered by using skin collections alone. The traditional skin collection should therefore give way to balanced collections for each species, including skins, skeletons, and spirit specimens, as well as neonatal young, eggs, and nests. Any curator who fails to develop all of these kinds of collections is simply limiting the research potential of the museum at a time when the need for diversity of approach to problems is rapidly increasing.

To a limited degree wholly new kinds of collections are becoming a part of the ornithologist's bag of tools. The Library of Natural Sounds at Cornell University, containing about 300 miles of tape, can be called upon for comparative study of bird songs. Files of X-rays may be regarded as supplementary collections, and slide collections of comparative histology will probably be available some day. Samples of egg whites and blood may be stored temporarily until permanent records of their chemical properties are made and filed. Comparative study of birds in the field is like an extension of the specimen, especially when documented by photographs or motion pictures. Methods of storing and making available such new "specimens" are in general not well developed.

Having examined the specimens let us now look at the merits and demerits of different kinds of collections in the light of present research trends. Collections made today or in the future are likely to be of three different sorts: Those of a general nature made with no biological problem in mind but intended to increase representation of certain portions of a museum's holdings; collections designed for the solution of a particular ornithological problem; collections designed for the solution of a non-ornithological problem. The need for general collections from all parts of the world has diminished with the advancing development of traditional ornithology, but the need for improving world-wide representation in the larger museums and regional representation in smaller museums continues because of the value of collections as seed sources for ideas. In other words, although it is often possible to assemble enough specimens from many museums to answer a given question, the question might not have been asked without sufficient representation of species or specimens in any one museum to show that a problem existed. Important research museums should therefore inventory their holdings and attempt to fill in gaps within the overall scope of their collections. This job could be done by a collection manager and trained collectors, leaving the research curator free to specialize.

Collections intended to solve a problem, whether or not an ornithological one, are sometimes analogous to a laboratory experiment in which most of the variables are controlled. Birds vary by age, sex, season, color phase, geographical origin, ecological situation, and physiological cycle. To study the causes and properties of any one variable the other variables can be minimized by selective collecting. Only in a specialized collection are adequate series of the critical specimens likely to be obtained. Examples of such collections are: sibling species taken just after their complete molt for comparison of subtle color differences in fresh feathers; series taken across zones of allopatric hybridization for study of gene flow in populations; specimens taken at regular time intervals throughout the year to determine the molt and breeding regimen of a population; comprehensive collections from a given locality and season for ecological or faunal comparisons with other such collections.

Examples of non-ornithological problems requiring collections are: determination of the role of a given species or regional population of birds in carrying viruses or their arthropod vectors; evaluation of the involvement of a species or local avifauna in the destruction of an agricultural crop. Here the virus, parasite, or stomach contents are the primary collections whereas the bird specimen may be retained only for species verification. The ornithological value of such studies could be slight or great depending on the degree to which factors of ornithological importance were added to the initial research objectives.

Specimens derived from a specialized project will, in some cases, be obtained in much larger series than necessary to fill in the desired representation in the museum's general collection. This is particularly vexing when large birds are involved. If space is a problem one could argue for discarding such specimens at the conclusion of the study on the grounds that their intended purpose had been served. For reasons mentioned later I believe they should be retained or distributed to other museums.

What sorts of data should be associated with specimens in future collections to enhance their usefulness for research? This question has been dealt with in different ways by others (for example, Miller, 1940; Van Tyne, 1952; Parkes, 1963). Traditionally, the principal data recorded with each specimen has been the locality, date, sex, and collector. Of these, the first three, and to a lesser extent the last, are objective data that everyone can (usually) interpret without ambiguity. Other types of data are often added to the label today, as they were indeed by some of the earlier collectors—skin colors, weight, amount of fat, stomach contents, presence of brood patch, breeding condition, molt, etc. Some of these data are subjective in that they can be misinterpreted by a research worker unless they were carefully qualified or described by the preparator. For example, body weight may be recorded to a tenth of a gram—but how fat was the bird, and how much did the fish in its stomach weigh? Body feathers may be said to be molting, but was the bird really molting or was it just replacing some feathers lost accidentally? What unrecorded soft or liquid foods were eaten, leaving no trace in the stomach? Does "testes enlarged" necessarily indicate breeding and does "skull unossified" indicate immaturity? Such data are of greatest use when qualified so as to minimize their subjectivity. Subjective data should not be confused with items such as "sex," the determination of which requires recognition of sometimes tiny and confusing internal organs and is therefore subject to error, but not to interpretation.

The integrity of the specimen label determines the scientific usefulness of the specimen and of the collection. Data on labels are subject to errors stemming from carelessness, ignorance, and fraud. To reduce errors of carelessness the label should be made out at the time of collection and preparation, and attached to the specimen by the preparator rather than transcribed from a field book by someone else later, and associated with the specimen on the basis of a field number. Errors of ignorance can be reduced (and subjective data enhanced) by training collectors in those aspects of avian biology that are pertinent to the production of a useful label. Knowledge of the source of data on a label can be useful to the scientist in judging the likelihood of errors of all kinds and it follows that the name of each person who records data must appear clearly on the label. In collections made for non-ornithological purposes or in large ornithological expeditions it is sometimes the case that only the name of the project, or the sponsor, or the principal investigator, appears on the label. One is then at a loss to know who recorded the data.

In an attempt to facilitate research and curation of certain collections, the Smithsonian Institution is developing an electronic data processing system (EDP) capable of storing, sorting and printing out much of the data associated with specimens (Galler, et al., 1968). The advent of computer technology may seem to be an argument for amassing more general collections with more data on the labels because the computer is capable of sorting and combining voluminous amounts and diverse kinds of information. The research value of an EDP printout, however, is limited by the accuracy of the data and by the difficulties inherent in subjective data, compounded by the nagging possibility of operational errors. There is the danger that printouts of specimen data, if readily available, would generate a rash of research based on printouts without reference to the specimens—hence without critical evaluation of the accuracy, reliability, or significance of the data. Many questions will not be answerable by the data selected for inclusion in EDP; any attempt to rectify this difficulty by recording "complete" data in the field is self-limiting in that it would leave little time to obtain and prepare specimens. Specialized data cannot be gathered by untrained assistants. The alleged research and curatorial values of computerizing all museum collections are limited by these and other difficulties, and they must be weighed against the costs (in time and money) of setting up and operating the system. Although the practicality of a shot-gun application of EDP to all ornithological collections is doubtful, data processing could be a useful tool in some research projects if the data were gathered in such a way that important questions could be answered within the capabilities and limitations of the machine.

As a preliminary step in planning research on museum specimens it would be useful to know in which museums or collections the desired specimens could be found. This need could be most simply satisfied if each museum were to publish an inventory of its holdings by species (or subspecies if possible). More useful would be a composite inventory of all museum collections following the form of the Union List of Serials, in which the serials would be replaced by bird species (or subspecies), and the libraries by museums (with a rough indication of numbers of specimens). Even an incomplete compendium would be immediately useful and would gain in importance as additional museums incorporated their inventories. This would be a modest undertaking compared with the Union List of Serials, which records the representation of over 150,000 titles in 956 cooperating libraries.

In ornithology I anticipate that general collecting will continue to decline as all portions of the world become better represented by specimens, and that incoming collections will be geared more for answering particular biological questions than for producing conventional collection reports. I believe, however, that a balance between general and special collections should be maintained because of the value of general collections for bringing to light the unexpected.

Curators will have to decide whether or not to retain special bird collections that have served their purpose in answering a particular problem. In deciding we must remember that collections cannot be duplicated with the ease of a chemist duplicating a precipitate and that their research potential surely exceeds that realized in any one study. In some respects their usefulness increases with time; over a period of 50, 500, or 1000 years specimens may, like fossils, provide the evidence for evolutionary change and rates. (After all, what are fossils but skeleton collections that have been housed in rock rather than boxes?) Also, specimens become important historical documents as particular environments on earth are changed or lost. Another reason for retaining collections is that the published word represents opinion and is subject to error; as ideas change and as the literature becomes distrusted after a period of years reference to the specimen is required again (Berlioz, 1960). If a museum cannot provide accessible storage space for increasing collections an effort should be made to distribute at least parts of long series to other museums or to teaching institutions.

Emphasis in museum ornithology will probably remain for some time on various aspects of the comparative biology of birds and on the processes of speciation and differentiation of the higher categories—problems that may be served by someone working in behavior, ecology, ecological physiology, cytogenetics, or biochemistry as well as in more traditional aspects of systematics. To justify occupying a museum position, however, a curator should apply his interests toward understanding the diversity of birds through comparative studies that in some way derive support from collections. Diversity of approach to collections may be the key to continued viability of museum research as we expand from traditional functions into comparative biology.

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MALACOLOGICAL COLLECTIONS—DEVELOPMENT AND MANAGEMENT

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As a curator in the Recent mollusk section of a large museum, one is often confronted with the question from interested visiting members of the public: "How many shells do you have here in all these cabinets?" One usually reacts by recalling the figure cited for Mollusks in the most recent annual report: "10,058,888" or "somewhat in excess of 10,000,000." The properly impressed visitor often counters with the predictable phrase: "Oh my, but where do they all come from?"

Before going into the answer to that question, at the outset, I should like to emphasize a fact which I believe is largely lost to many persons who like to think "collectively" about collections. Collections of shelled mollusks *are* different from many other kinds of natural history collections. A living *shelled mollusk* is just that; it comes in at least two major parts, the shell and the soft animal which forms the shell. And mollusk collections are almost universally curated in at least two parts also: (1) a collection of dried shells, arranged usually according to the most accepted classification and (2) a collection of preserved soft animals, maintained separately from the dry shells and arranged so as to provide some means of rapid access for study in conjunction with the shells.

This system of collection storage in which two collections actually are maintained may appear unwieldy to many, and it is true that it has come down to us from the last century, although altered in many ways as new materials and methods of handling and storing mollusks came to light. Because the system is old, however, does not mean by definition that it is bad, nor impossible to work with, nor that it should be changed immediately. It means that it is the most satisfactory compromise reached so far for the maintenance of a collection of important animals. By common agreement of Malacologists, the molluscan exoskeleton or shell is the most important single diagnostic tool for the discrimination of species. The collateral softparts contribute additional information concerning species identity and supraspecific relationships.

The collection of dry shells is somewhat unique among categories of biological specimens, although obviously it has much in common with certain other groups of invertebrates, and strangely enough, mammals and birds and, of course, minerals and fossils. But the shell is often a very durable object which endures handling and storage much better than the majority of other specimens. Its catalogue number may be written directly upon it, as well as upon associated labels containing habitat and locality data. Modern shell collections are usually stored directly according to their classification, beginning at one end with the most "primitive" forms and proceeding through the more "advanced" ones. I have often heard the question: "Do you have a card file of the species present in your collection and perhaps a cross-reference file to their geographic data?" No, we do not—and it would be nice to have such a reference, especially one provided by a computer by which specimen data could be extracted in all imaginable ways and correlated. Perhaps when classification of mollusks reaches a sufficiently stable point, it will be profitable to enter their data into such a system. At present, only certain groups are ready for ADP. But we do *not* make lists of the collection, because the collection is arranged in such a way as to form its own list and species may be arranged geographically within this system. One who is familiar with the classification of mollusks can work easily with such a collection after a brief orientation based on individual collection idiosyncrasies.

Mollusks differ also from many other groups in the degree of interest with which they are favored by the layman or amateur. "Breathes there the man (or woman, or child) with soul so dead" that he has never stooped down and picked up a shell during a visit to the seashore? It may be added that a goodly percentage of these persons carry their shells straight to the curator of mollusks for identification! It is doubtful that any other group of animals is so widely collected by man. Their popularity has often brought on invidious comparison to stamp collecting, another extremely well participated hobby throughout the years.

These introductory remarks have been intended to place in proper prospective the mollusk collection. To the professional malacologist, it is a vehicle for his research, often oriented toward systematic and zoogeographical pursuits. Few groups of mollusks are adequately understood as yet. Some, especially commercially productive ones, have been thoroughly explored and their biology and classification are well known. But tens-of-thousands remain to be studied, and the most feasible way to study the systematics and distribution of these animals is through large series in museum collections.

The question was posed earlier: where did our collections of mollusks come from, that is, how did they develop. In discussing the development of Malacological Collections, I shall limit myself to only a brief consideration of collections outside of the United States, but since collections began abroad, we must start there.

In the writings of Aristotle we find considerable mention of mollusks and so it is apparent that they were important objects of man's interest at a relatively early date. Shells unearthed from the rubble of Pompeii indicate a collection of some sort had been put together there, not only of specimens from the Mediterranean, but from the Indo-Pacific region. Cicero's writings make mention of shell collecting as a relaxation from the tribulations of war and government. It is said that the first large-scale expedition in search of shells took place in 40 A.D. when Caligula led his troops down to the sea in Gaul as if to embark on an invasion of Britain; having drawn them up in battle formation, he ordered them to collect shells—which he called 'the spoils of conquered ocean.'

Our knowledge of the development of Malacology during the Middle Ages, as it is with so many branches of knowledge, is limited to the literature produced in the monasteries. Some quite recognizable species were illustrated in the exquisite illuminated manuscripts of that day.

With the coming of the Renaissance and the age of discovery, natural history cabinets flourished throughout Europe, usually in the hands of rich men who had the time and finances to accumulate such collateral wealth. During this period the first small museums of natural history specimens came into being and some of their most popular contents were well known to have been the shells of mollusks. These collections often were accumulated by or found their way into the hands of noblemen who enlarged them and saw to it that they were conserved. By the 17th and early 18th centuries several of the royal houses of Europe had amassed large collections of shells. The celebrated Linnaeus was commissioned by the queen of Sweden to arrange her shells and upon her collection are based a number of the molluscan species in the 10th edition of "Systema Naturae." Thus, gradually through the assimilation of small and private shell collections by the rich and by royalty, rather massive holdings were acquired which eventually had established for their conservation the Natural History Museums which we know today.

Concerning the development of Malacology in the United States, I should like to quote from an address made by William Healey Dall to the Biological Society of Washington at its 8th Annual Meeting 80 years ago in 1888. Dall said, "I may divide the study of Mollusca in this country into three periods, although these are connected by many intermediate links. The infancy of the science, with a Linnaean classification, has no representation in American conchological literature, which sprang, full-grown, like Minerva from the head of Jove, from the Lamarckian school of Europe. The first period might fitly bear the name of its inaugurator, Thomas Say. It is characterized by a rapid advance in the determination of the fauna, the classification of the species, and the exploration of vast areas. It extended from 1817 to 1841.

"The second period should bear the name of Dr. A. A. Gould. It was inaugurated by his report on the Invertebrata of Massachusetts (1841), and characterized by the broader scope of investigation, and interest in geographical distribution, the anatomy of the soft parts, and the more precise definition and exact discrimination of specific forms, as exemplified in his writings.

"The third period would be appropriately called after Dr. William Stimpson, who eagerly adopted the radical changes in classification rendered necessary by the discoveries of Loven, and [who] stood ready to welcome the theory of evolution with all the light it shed in dark places."

The name of Thomas Say is much revered in American Malacological circles. He is called the "father" of that branch of science in this country, and was early associated with the first institution in our country to boast a collection of mollusks, The Academy of Natural Sciences of Philadelphia, established in 1812. There were many natural history societies in the years that followed, small local groups of persons who gathered to discuss, collect and study various facets of our new country's natural history. In New England, the Boston Society of Natural History superseded the Linnean Society in the early 1830's. The Smithsonian Institution made its appearance in the middle 19th century with an "instant" mollusk collection accumulated as a result of the U. S. Exploring Expedition. Data gathered for a history of the Division of Mollusks of the U. S. National Museum by Dr. Harald A. Rehder show the Smithsonian collection of mollusks had its beginning as early as 1840 with the organization of the "National Institution for the Promotion of Science" established in part as a repository for the Exploring Expedition collections. In 1860 the Agassiz museum in Cambridge opened with the beginnings of a mollusk collection which would one day absorb the specimens brought together by the Boston Society of Natural History as well as many large private collections.

Of the several large museum mollusk collections of this country today, four of the largest are located in the east: they are at the Museum of Comparative Zoology, the American Museum of Natural History, the Philadelphia Academy and the Smithsonian Institution. Others are at the Museum of Zoology, University of Michigan, the California Academy of Sciences, San Francisco, at Stanford University and at the Los Angeles County Museum. The large collections maintained in these museums are partly the result of specimens returned by expeditions mounted wholly or in part for the purpose of collecting natural history specimens. But they are in large part also the result of the donations by individuals of anywhere from single specimens to entire private collections consisting of thousands of specimens. And so it was that my original example, the Smithsonian collection of mollusks, came to be estimated to number in excess of 10 million specimens.

I will base my remarks on management of Malacological collections upon my general knowledge of these practices gained through association with the Smithsonian-Division of Mollusks. The task of managing or curating the largest collection of mollusks in the United States, if not in the world, has not been something to be faced by any one curator, for obviously the collection has developed through time. At one time the standard procedure for preparing the shells was to glue them onto glass plates or cardboard or wooden plaques and to inscribe these with the names and other data. Rehder's manuscript history describes how Dall, who as the first virtual curator of mollusks, inherited the collection so prepared for the Smithsonian by P. P. Carpenter. He struggled with these mounted specimens, remounting them as they fell off their plates. Dall, prodded by this unwieldy and space consuming curatorial procedure, finally removed the specimens from the plates and placed them in vials and small trays, each lot with its data-containing label, thus instituting the space conserving procedures used today.

With today's vastly improved transportation more and more persons are getting into the field—more and more both large and small expeditions are being mounted and many of these are bringing back mollusks. Over the past twenty years we have managed to accession an average of 58,000 specimens per year, over a million altogether, the real total of specimens received being in excess of that figure because some collections have not yet been accessioned. On this basis we may plan to expand our collection by approximately 12 percent every 20 years if we keep constant the rate at which material is coming in. Given the personnel and equipment for processing, cataloguing and storage this is not an overwhelming addition to keep up with. But it must be stressed that the rate of addition seems to be on the increase.

We hear a great deal these days that space available for collections is finite and that steps must be taken to fit material into present space. What can be done in the case of mollusks to help the space situation and still maintain an optimum of systematic and geographic coverage and an ample biological series for comparison of morphological variation?

1. Curatorially for many years our dry collection has been at the forefront of any of its size that I have seen. As new material is added to the collection the classification is constantly being updated and old material, which lacks data or which is in poor condition and was kept only because it was the sole example of a species is weeded out. In this way a surprising amount of "bulk" is removed from the collection, making room for pertinent material. Also, as groups of mollusks are critically reviewed during monographic work, their curation is brought up to date. Collections of dry mollusks are admirably adapted for concise storage and anyone examining the Smithsonian collection will find that it contains an enormous amount of material very compactly stored.

2. In addition to careful curatorial procedures some selectivity must be practiced in the acceptance of material for the collection initially and in the retention of specimens already received. At one time we felt that we were compelled to accept and retain almost any collection thrust upon us. The sheer weight of collections which have been known to accumulate in what might be called "such indiscriminate accepting" has shown this to be a mistake. We like to be asked but retain the right to say "no"! Then too, during the processing of large collections, it is often expedient to reserve a portion of many lots for profitable exchanges with other institutions, in this way reducing the bulk to our own collection.

3. A third way of controlling to some degree the sorts of material received for the collection is through specialization. This may take the form of limiting oneself to a particular class, order, or smaller group or by limiting the geographic area of one's major interest. The tendency in Malacology today is to specialize, although those of us who received their training in the "Old School" are used to working in two or more very different major groups more or less interchangeably, for instance:

gastropods and bivalves. A division of labor in the phylum, with responsibilities spread among several curators can make feasible a more efficient curatorial team so long as their goals are somewhat similar. Geographic specialization is practiced to some degree in collections of mollusks. For instance, the Smithsonian collection has lately emphasized the Indo-Pacific faunal area, whereas the MCZ favors the western Atlantic. Both institutions, nevertheless, try to maintain a collection which is balanced and can be utilized for world-wide studies.

There are doubtless many other ways to exert a conscious influence over the development of a museum collection of mollusks, but the preceding three: Careful curation, selectivity and systematic or geographic specialization seem to me to be the most natural ones and they avoid the process of subjectively eliminating large portions of material to make way for others.

For the immediate future I can see a need for the continuance of an orderly accumulation of additional material to collections of mollusks. At the same time, I feel strongly that we should have farthest from our minds the concept that mere accretion is an end in itself. We need to study this material and create a classification which in time may sort itself out to being something near a "natural order." Until this is done I am of the opinion that we will do well to bear in mind two quotations credited to G. Brown Goode in 1895. I think they balance each other nicely. The first: "Curators are apt to err on the side of saving too much"; the second: "A finished museum is a dead museum."

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AUTOMATION IN MUSEUM COLLECTIONS[1]

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Introduction

For a little over a year now several of us in the Smithsonian have been associated with a project designed to investigate possible uses of electronic data processing (EDP) for computer storage and retrieval of specimen-associated data. The project has been funded under a contract with the Office of Education of the Department of Health, Education, and Welfare. It is a joint effort by members of the staff of the Museum of Natural History and Information Systems Center, Smithsonian Institution.

The project is based on the thesis that a museum collection is more than an assemblage of inanimate objects or dead organisms; it is a vast information resource which we cannot adequately use with current methods of record keeping. A second factor, which is also quite important, is that collections are continually growing at a rapid rate. In the Department of Invertebrate Zoology alone, the collections are increasing by at least 200,000 specimens per year. This trend is hardly likely to change in the near future, and if specimen-associated data in the collections is too difficult to obtain now, it will be even less available in the future. If computerized data record-keeping systems are going to be developed and used, the project must be started now. Delays will only increase the difficulties and the cost.

The MNH project was designed to set up record-keeping systems in three separate areas of the museum: marine rocks, un-

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der the supervision of William Melson, Department of Mineral Sciences; oceanic birds, under the supervision of George Watson, Department of Vertebrate Zoology; and marine crustaceans, particularly stomatopods, under the author's supervision. Donald F. Squires, then Deputy Director of the Museum, was among the first to recognize the need for data processing in the museum and it was he who sought and obtained support to initiate the pilot project.

In Crustacea, the project is designed to aid management of the collection, to aid curation, and to enhance the collection as a research tool. Our primary aim was to update some of our techniques of collection management, and to develop techniques which would allow us to manipulate specimen-associated data without having to return to the collection every time we work with the data.

The overall MNH project has been divided into two phases: (1) to build a data bank based primarily, but not exclusively, on three separate collections, and (2) to manipulate the data in various ways to evaluate the overall costs of not only various portions of the project but also the costs of general handling and processing of museum collections, regardless of the ultimate use and method of storage and retrieval of the data.

The first 18 months of the contract, ending in December, 1968, have been concerned with entering the data, building up the base, and solving the innumerable problems that arose at every step. The next phase will deal principally with interrogation of the data base.

My remarks are designed to give a progress report on activities in Crustacea, an idea of some of the different problems which we have encountered and some of the results of the project.

We are not alone in the scientific community in our interest in developing a system for storage and retrieval of specimen data. The British Museum (Natural History) and the National Museum of Canada are both working on developing such a system, and system development is being considered by over 30 museums around the world. More than 70 representatives of universities, museums, zoological parks, and botanical gardens met in Mexico City, in 1967 to discuss "Information Problems in the Natural Sciences." Bullis and Roe (1967), reporting on a bionumeric code used by the Bureau of Commercial Fisheries Exploratory Fishing Base, Pascagoula, Mississippi, noted that faunal data resulting from their exploratory fishing operations necessitated development of computer methodology for handling the data.

Those of us associated with the MNH project are not the only ones in the museum working with different applications of data processing. In the Department of Botany, Stanwyn Shetler is applying EDP to the broad Flora of North America Project, and Mason Hale is developing a type-catalog, and a list of general accession records and invoice data in Botany have been computerized for some time. James Peters, Department of Vertebrate Zoology, has pioneered within the museum in developing computer programs to carry out time-consuming statistical analyses commonly used in taxonomic studies.

In a recent article on curation of invertebrate collections, Emerson and Ross (1965, p. 337) noted that: "The ideal method for cataloguing specimens and the retrieval of catalogue and specimen information would be a punch card or magnetic tape system. Vast amounts of information could be stored in a relatively small space and retrieved within seconds. Unfortunately, none of the museums in the United States has yet installed such a system."

Background

The Division of Crustacea was most fortunate to receive through the foresight and industry of members of its forerunner, the Division of Marine Invertebrates, a remarkable file of specimen records in a 3 × 5 card format. This card file, consisting of about 125,000 entries, serves as a guide or index to the collection, a source of information on loans and holdings in general (management data), and a basic source of specimen-associated data. The existence of the record file, in a museum where specimen records, other than specimen labels and catalog books, are in general absent, is a tribute to the perseverance and foresight of such people as Mary Jane Rathbun, Waldo L. Schmitt, and Fenner A. Chace, Jr. The Marine Invertebrate catalog system has existed for approximately 70 years.

Our new system in Crustacea was designed as closely as possible to that already in existence in the Division. We wanted to show that we could continue the basic operations of documentation and cataloging of the collection and prepare the data for computer storage at the same time.

Briefly, let me summarize the pre-computer method of cataloging. A cataloger would compile the data necessary for each entry, hand enter it into a ledger catalog, hand-write the label, type two copies of a specimen data card (one copy was to be filed in the species file, the other to be filed in a geographic file), and type a neck label for the jar.

In 1965, we instituted a change in the cataloging procedure by installing a typewriter system in which a punched-paper tape could be generated during the initial typing of the data. The machine used is a CDC (SCM) Typetronic 2816 with two typewriter consoles, one featuring microelite type (with 16 characters to the inch) and one featuring standard elite type (12 characters to the inch). As the data is entered on the specimen label on the microtypewriter, the machine generates a punched paper tape which can then be used to reproduce automatically on the other typewriter as many 3 × 5 cards as needed for the files. The jar neck label also can be typed from the tape. The system was developed with the expectation that some day the data on the paper tapes could be converted to magnetic tape, but it was installed almost two years before we received support for the MNH project.

The cards, labels, and neck labels are printed in long perforated strips which are much easier to feed into the typewriter. Pink cards and distinctly-marked neck labels are used for types. Originally, we planned on printing up three sets of 3 × 5 cards, one for the species file, one to be filed in numerical order as a replacement for the permanent ledger catalog, and one for the geographic file. Henry B. Roberts, Senior Museum Specialist in the Division of Crustacea, did most of the work involved in developing the new card format from the old one.

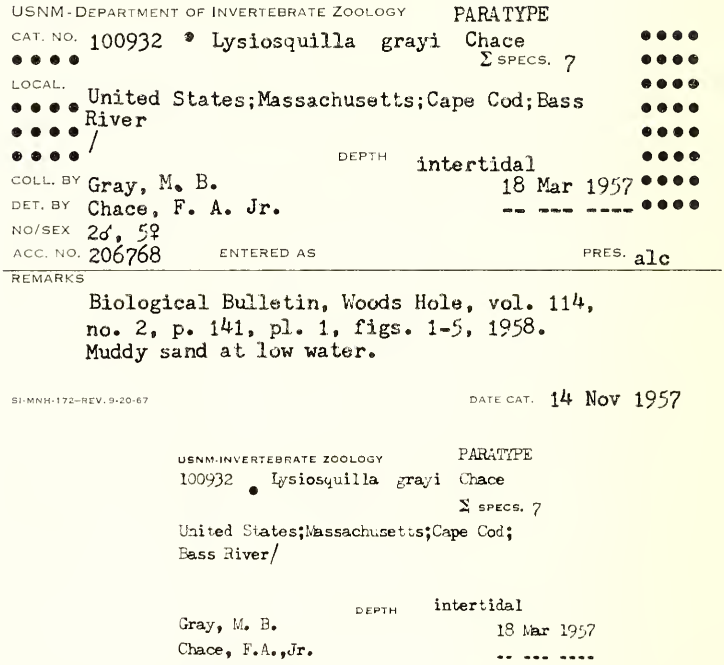
At the time the program was started, Smith-Corona-Marchant (SCM) (now Control Data Corporation) was the only manu-

Table 1. Data Organization, Division of Crustacea.

Field Name	Maximum Length
Nomenclature type	15 spaces
Catalog number	8 "
Genus name	21 "
Subgenus name, if used	21 "
Species name	21 "
Subspecies name, if used	21 "
Author	50 "
Total number of specimens	5 "
Location I: Continent, country, ocean	30 "
Location II: State, province, island group	30 "
Location III: County, parish, small island	30 "
Location IV: City, lake, miscellaneous	70 "
Latitude and Longitude	48 "
Collection Gear	20 "
Depth	20 "
Collector	20 "
Collector's number	12 "
Date of collection	11 "
Identifier	33 "
Date of identification	11 "
Number and sex of specimens	45 "
Accession number	10 "
Type of entry (gift, etc.)	13 "
Publication information	45 "
Preservative	3 "
General remarks, and overflow from 180a	45 "
General remarks	45 "
General remarks	45 "
General remarks	30 "
Data cataloged	11 "

facturer of a system with a micro-elite typewriter. Since then, we have learned that SCM no longer will manufacture the Typetronic. Fortunately, perhaps, for those who require the micro-typewriter, Friden now manufactures one and can supply a system comparable to the Typetronic.

A more detailed account of the development and use of the cataloging procedure was given by Squires (1966).



USNM-DEPARTMENT OF INVERTEBRATE ZOOLOGY PARATYPE
CAT. NO. 100932 * Lysiosquilla grayi Chace
Σ SPECS. 7
LOCAL. United States;Massachusetts;Cape Cod;Bass River
/
DEPTH intertidal
COLL. BY Gray, M. B. 18 Mar 1957
DET. BY Chace, F. A. Jr. -- --- ----
NO/SEX 2♂, 5♀
ACC. NO. 206768 ENTERED AS PRES. alc
REMARKS
Biological Bulletin, Woods Hole, vol. 114, no. 2, p. 141, pl. 1, figs. 1-5, 1958.
Muddy sand at low water.

SI-MNH-172—REV. 9-20-67 DATE CAT. 14 Nov 1957

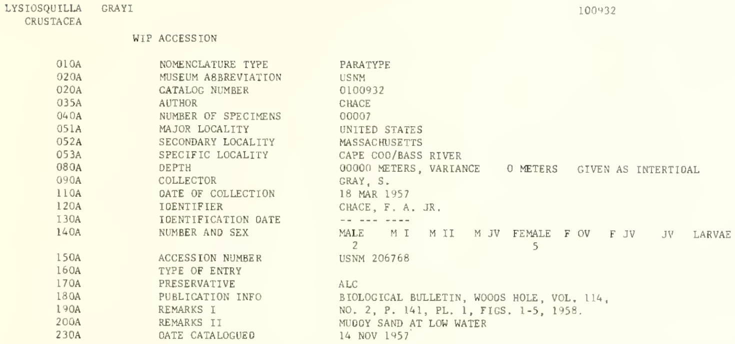
USNM-INVERTEBRATE ZOOLOGY PARATYPE
100932 • Lysiosquilla grayi Chace
Σ SPECS. 7
United States;Massachusetts;Cape Cod;
Bass River/
DEPTH intertidal
Gray, M. B. 18 Mar 1957
Chace, F.A.,Jr. -- --- ----

FIGURE 1. Catalog card and corresponding label used in Division of Crustacea, Smithsonian Institution.

TYPES OF DATA ENTERED

In our cataloging operation in Crustacea, the basic unit is a lot; each lot contains one or more specimens. Basic data for each lot are collected and verified by a cataloger who may receive the lot with no more data than name, number and sex of specimens, identifier and date identified, station number and vessel, and accession number. These data are expanded by the cataloger to include as much of the information shown in Table 1 as possible.

Each of these types of information must be entered on the original 3 × 5 card (Figure 1) which we retain in the division file. In Crustacea we use data assigned to 30 different fields; often some of these items are left blank. In the experiment on birds some 39 fields are used and in minerals approximately 140 fields have been identified.



```
LYSIOSQUILLA   GRAYI                                                                     100932
   CRUSTACEA
                 WIP ACCESSION

       010A              NOMENCLATURE TYPE          PARATYPE
       020A              MUSEUM ABBREVIATION        USNM
       020A              CATALOG NUMBER             0100932
       035A              AUTHOR                     CHACE
       040A              NUMBER OF SPECIMENS        00007
       051A              MAJOR LOCALITY             UNITED STATES
       052A              SECONDARY LOCALITY         MASSACHUSETTS
       053A              SPECIFIC LOCALITY          CAPE COD/BASS RIVER
       080A              DEPTH                      00000 METERS, VARIANCE    0 METERS   GIVEN AS INTERTIDAL
       090A              COLLECTOR                  GRAY, S.
       110A              DATE OF COLLECTION         18 MAR 1957
       120A              IDENTIFIER                 CHACE, F. A. JR.
       130A              IDENTIFICATION DATE        -- --- ----
       140A              NUMBER AND SEX             MALE    M I   M II   M JV  FEMALE  F OV   F JV    JV   LARVAE
                                                      2                          5
       150A              ACCESSION NUMBER           USNM 206768
       160A              TYPE OF ENTRY
       170A              PRESERVATIVE               ALC
       180A              PUBLICATION INFO           BIOLOGICAL BULLETIN, WOODS HOLE, VOL. 114,
       190A              REMARKS I                  NO. 2, P. 141, PL. 1, FIGS. 1-5, 1958.
       200A              REMARKS II                 MUDDY SAND AT LOW WATER
       230A              DATE CATALOGUED            14 NOV 1957
```

FIGURE 2. Work-in-progress listing for same entry as shown in Figure 1.

Our limiting factor here is perhaps the number of characters we can enter on a 3 × 5 card. The system we use has the capability of storing some 4000 characters per catalog entry; we have used less than 800 in developing the data card in Crustacea.

The first two lines include the basic information pertaining to that log, catalog number, name, and total number of specimens; these are the initial data used by those who work with the files and are coincidentally the basic invoice data.

Data on the card down to and including the "Determined by" level on the card also appears on the specimen label. The remainder of the information appears in the ledger catalog and on the card, but not on the label. The label for this same lot is also shown in Figure 1. Card size was determined by the existing files and label size was determined by the size of our basic specimen vial for smaller specimens.

Upon completion of our cataloging process for a series of specimens, the tape generated by the Typetronic is forwarded to the Computer Center where the data are converted by the computer to magnetic tape. Then the data items are reshuffled by the computer to produce a Work-In-Progress Listing (WIP), a preliminary printout (Figure 2). We use this now for a second proofing of the original entry. The machine will automatically mark several kinds of errors, including erroneously marked fields, fields with no data, spelling errors in the data, data in wrong fields, etc.

Corrections may be made at any of the steps in the cataloging process. The punched paper tape can be corrected after the card and label have been proofread, and corrections of data on the WIP listings can be keypunched to update the data in the computer.

We have the potential of retrieving data items by field or by any combination of fields. Further, the data can be rearranged by fields in any format which one might require.

Note that depths are converted to meters; if a depth range is given in the original entry, the midpoint is the first depth given in the printout. In printouts, the midpoint (in meters), the range (in meters) and the original entry, as given in feet, meters, or fathoms, are all reproduced. All depth conversions are automatic.

We have left several fields vacant in the section entitled REMARKS. These can be used for habitat information, for references to field notes or color photos, and so on. These fields are unrestricted at the present time.

The basic card system in Crustacea is extremely adaptable. Although designed for marine organisms, it has been modified with little effort to include crayfishes where locality data may be centered on drainage system and where information on associated species, cross-referenced to field notes, is required. We are now adapting the format to free-living marine nematodes and to cephalopods.

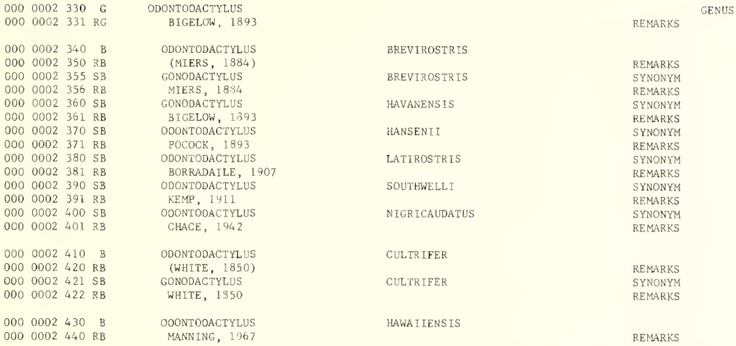
I want to discuss here in a little more detail two of the types of information entered and used, Nomenclature and Geography.

NOMENCLATURE

The system is designed so that a taxon is a focal point for entry and retrieval of data. For each group a master taxa list must be compiled and entered.

In preparing the master list for the stomatopods, I have included major synonyms. The entries for one species, *Odontodactylus brevirostris* (Miers), are shown in Figure 3.

Data on this species can be requested by using any of the synonyms or the senior synonym in the query. Few of our collections are up to date nomenclatorially for few of us have the help required to keep up with the name changes. By being able



```
000 0002 330  G      ODONTODACTYLUS                                                        GENUS
000 0002 331 RG         BIGELOW, 1893                                             REMARKS

000 0002 340  B        ODONTODACTYLUS                  BREVIROSTRIS
000 0002 350 RB         (MIERS, 1884)                                             REMARKS
000 0002 355 SB        GONODACTYLUS                    BREVIROSTRIS               SYNONYM
000 0002 356 RB         MIERS, 1884                                               REMARKS
000 0002 360 SB        GONODACTYLUS                    HAVANENSIS                 SYNONYM
000 0002 361 RB         BIGELOW, 1893                                             REMARKS
000 0002 370 SB        ODONTODACTYLUS                  HANSENII                   SYNONYM
000 0002 371 RB         POCOCK, 1893                                              REMARKS
000 0002 380 SB        ODONTODACTYLUS                  LATIROSTRIS                SYNONYM
000 0002 381 RB         BORRADAILE, 1907                                          REMARKS
000 0002 390 SB        ODONTODACTYLUS                  SOUTHWELLI                 SYNONYM
000 0002 391 RB         KEMP, 1911                                                REMARKS
000 0002 400 SB        ODONTODACTYLUS                  NIGRICAUDATUS              SYNONYM
000 0002 401 RB         CHACE, 1942                                               REMARKS

000 0002 410  B        ODONTODACTYLUS                  CULTRIFER
000 0002 420 RB         (WHITE, 1850)                                             REMARKS
000 0002 421 SB        GONODACTYLUS                    CULTRIFER                  SYNONYM
000 0002 422 RB         WHITE, 1850                                               REMARKS

000 0002 430  B        ODONTODACTYLUS                  HAWAIIENSIS
000 0002 440 RB         MANNING, 1967                                             REMARKS
```

FIGURE 3. Synonymy of *Odontodactylus brevirostris* (Miers) as stored in the computer Directory of Names.

to identify and label synonyms, entries in the data bank under any of the names can be retrieved.

A separate directory of names is maintained and, as catalog entries are added, the names are checked against the directory; entries accompanying names not in the directory are rejected as are entries under misspelled names.

Neither the user nor the cataloger need be familiar with the numericlature used by the machine; only knowledge of the nomenclature is required.

We have also developed a hierarchical classification, for we believed that data must be retrievable not only at the specific level but at any of several taxonomic levels. In Crustacea we have compiled a hierarchy down to suborder, to which we can eventually add families, genera, subgenera, and species. A portion of the crustacean hierarchy is shown in Figure 4. The numbers on the right are the numericlature; those on the left are part of a sequence of numbers required to enter the data originally and are not related to the numericlature.

Our numerical code of 26 digits was developed to allow maximum flexibility in adding to the hierarchy at any level and to maintain the specific name as the key to entry and retrieval of data. Neither the cataloger nor the scientist user needs to know the entire number sequence; it is internal in the computer.

```
SEPT 26, 1968        HIGHER TAXA NUMERICLATURE LISTING

GROUP          TYPE
PAGE-LINE      LVL     TAXA                        NUMERICLATURE

0000029125      C LEPTOSTRACA                      1 032 008 000 0000 0000 000000 00

0000030130      O NEBALIACEA                       1 032 008 001 0000 0000 000000 00

0000031140      C RHINOCARINA                      1 032 009 000 0000 0000 000000 00

0000032150      C CERATIOCARINA                    1 032 010 000 0000 0000 000000 00
0000032160     SC CERATOCARINA                     1 032 010 000 0000 0000 000000 01

0000033170      C NAHECARIDA                       1 032 011 000 0000 0000 000000 00

0000034200      C SYNCARIDA                        1 032 012 000 0000 0000 000000 00

0000034205      D ANASPIDACEA                      1 032 012 001 0000 0000 000000 00

0000034206      D BATHYNELLACEA                    1 032 012 002 0000 0000 000000 00

0000035209      C PERACARIDA                       1 032 013 000 0000 0000 000000 00

0000036220      D THERMOSBAENACEA                  1 032 013 001 0000 0000 000000 00

0000037230      D SPELAEOGRIPHACEA                 1 032 013 002 0000 0000 000000 00

0000037235      O MYSIDACEA                        1 032 013 003 0000 0000 000000 00

0000039250      O CUMACEA                          1 032 013 004 0000 0000 000000 00
0000039260     SO SYMPODA                          1 032 013 004 0000 0000 000000 01

0000040270      O TANAIDACEA                       1 032 013 005 0000 0000 000000 00
0000040280     SO CHELIFERA                        1 032 013 005 0000 0000 000000 01
0000040290     SO ANISOPODA                        1 032 013 005 0000 0000 000000 02

0000041300      O ISOPODA                          1 032 013 006 0000 0000 000000 00

0000042310      O AMPHIPODA                        1 032 013 007 0000 0000 000000 00
0000042320     SO LAEMODIPODA                      1 032 013 007 0000 0000 000000 01

0000042325      C EUCARIDA                         1 032 014 000 0000 0000 000000 00

0000043330      O EUPHAUSIACEA                     1 032 014 001 0000 0000 000000 00

0000044340      O PYGOCEPHALOMORPHA                1 032 014 002 0000 0000 000000 00

0000045350      O DECAPODA                         1 032 014 003 0000 0000 000000 00

0000046358      C HOPLOCARIDA                      1 032 015 000 0000 0000 000000 00
```

FIGURE 4. A portion of the crustacean classification used in the MNH project.

The hierarchy, to order, was arbitrarily selected and entered into the computer. Aspects of classification can be updated at any time and categories below order can be entered at any time. The classification of invertebrates proposed by Blackwelder (1963) was used as the basis for the hierarchy.

Assume that we have completed sections in Crustacea and now plan to enter any other invertebrate group. The hierarchy will accommodate 999 families under any order, and, further, up to 9 additional families can be entered at some future time between any 2 of the original entries, [without changing the numericlature assigned to the original families entered]. Similarly, up to 99 genera can be assigned to each family and 9 genera can be added between any of two of the original genera. The number of species that can be entered originally in each genus is 9999, with room to add 99 between any 2 of the original entries.

Data can be entered by genus or higher category only and also be retrieved by those categories. Data associated with such designations as variety, forma, species near *xus*, new species, etc., can also be entered and retrieved. The system is flexible enough to handle subgenera and subspecies as well.

GEOGRAPHY

Emerson and Ross (1965) and Levi (1966) have commented on the importance of locality data in collections of invertebrates, and other authors have cited one or more methods of recording geographic data, including distance and direction from a known point to a locality (10 mi. N., 4 mi. E) (Riemer, 1954; Hutchison, 1964), use of township, section, and range (Axtell, 1965), legal description (Wheeler, 1965), and so on. In studies on marine animals, latitude and longitude (Axtell, 1965; Steward, 1965) or Marsden Square are commonly used. All of these methods have specific applications; none are used exclusively by all taxonomists.

For these reasons we have had to develop our own geographical code, called the Global Reference Code, designed by Reginald Creighton, Anthony Piacesci and Dick King of the Smithsonian Information Systems Center when it became apparent that existing methods of storing retrieving geographic data had too many limitations. Creighton and his colleagues are preparing a paper on development of the Code.

The Global Reference Code is a hierarchical system in that several levels, from the general, such as Pacific Ocean, to specific, such as Manila Bay are used, with room for four levels of complexity. Locality data may be entered by latitude and longitude or by name.

Latitude and longitude are assigned to specific localities by hand, and a separate geographic data bank is maintained by the computer.

The smallest area defined by the GRC is a two-minute square. All data referring to localities within each two-minute square can be retrieved and printed out as originally entered.

The following example will demonstrate the flexibility of the system. Soldier Key is a small island on the eastern edge of southern Biscayne Bay, Dade County, Miami, Florida. It may be identified, in different collections within the museum, as (a) Soldier Key, (b) a small isolated key 10 miles south of Key Biscayne, Miami, (c) a key north of Elliot Key, Biscayne Bay, or (d) it may have been identified originally by its coordinates or by compass bearing and range from a point. If information on species found at Soldier Key is required, the computer will select and print out all of the data given above, as originally entered.

This has numerous benefits, for we can retrieve data by latitude and longitude, ocean, county, state, drainage system, Marsden Square, or by any of existing methods of recording locality data.

Eventually, as the geographic data bank develops, routines can be developed so that it can be searched for specific geographic data and reenter these into the catalog record automatically.

RESULTS

Initially there was a serious lag between development of computer programs for data storage and manipulation, as well as development of formats for geography, so that by the time the programs were ready a large series of records had accumulated awaiting entry into the system. We then learned that all of our entries accumulated in this period had to be redone for a variety of reasons, primarily because the fields for each entry had not been identified correctly. The beginning and end of each field must be flagged or marked by the typewriter operator and the flag, an asterisk or an exclamation point, must appear on the tape, or, as far as the computer is concerned, the fields cannot be identified and the record is invalid.

Although we believed we had designed the system so that we could eventually phase out the ledger catalog, i.e., it would be replaced by a card file in numerical order, we quickly learned that a ledger or equivalent, in the form of a work sheet, was required in order to prepare and arrange the data. We still use the ledger and we have dropped, at least temporarily, the numerical card file.

Now that the geographic data bank and the Global Reference Code has been developed and is functional, we should be able to replace the geographic card in our cataloging operation.

I have noted above that we learned that verification and assembly of data by a cataloger, in preparation for the actual typing operation, required the use of a ledger catalog or data entry sheet of some sort. From an operational point of view it was much simpler for the trained cataloger, a data specialist, to work with the specimens in an area not necessarily adjacent to the typewriter. Alcoholic collections are too messy for the basic work to be done at or near the typewriter. Initially, we used the cataloger not only as a data specialist but also as a typewriter operator. We have learned from our first year of operations that the cataloger can be reserved for the data-verification aspects of the operation, and that the data can be entered by a clerk-typist. Further, a clerk-typist can enter data far faster than any one cataloger can prepare it.

As we recataloged the stomatopods, data for the types was entered along with data for all of the other specimens in the collection. In working with the preliminary printout, the Work-In-Progress listing, of the data from the types, it became apparent that it would be relatively simple to reformat the data and generate a type-catalog by the computer.

A program has been developed and the printout has been requested. We expect to obtain in one printout an alphabetized list of the types, as cataloged under their original names, along with a list of the current names for those that have changed since the original description.

Another finding is that our data input is not completely satisfactory, for we need the capability of including more habitat data. We had reserved space under "Remarks" for habitat data, reference to field records, color notes, and so on. In the case of many of our specimens, there is relatively little information available other than locality, date, and collector. Now the number of records with habitat data is so slight that our inquiries can be worded so that only records with information in the "Remarks" section are printed. We will be working on this.

On the cards themselves, we have reserved space at the bottom to edge-punch the cards with the basic data for invoices; catalog number, name, and total number of specimens. If the cards were punched as they were processed, we could eventually be in a position to generate invoices of loans from our cataloged collection by stacking cards, in the order desired, in the Typetronic reader and let the machine automatically type out the basic data. Unfortunately, edge punching obliterates any entries in the "Remarks" section so we have not implemented this as yet.

Possible Experimental Programs

During the second part of the project we plan to begin manipulation of the data base built up during the first 18 months of operation. Interrogations designed to test the capabilities of the system and to provide information as retrieval costs might include the following:

(1) List and count all species in genus represented in collection.
(2) Determine number of species in given collection and state source.
(3) List all materials identified from accession Z.
(4) What species of Family X occur together in depth range X–Y in the northwestern Atlantic. Plot distribution pattern of each species.
(5) What species in genus X are not represented in the collections.
(6) List by accession number material of family Y from the eastern Pacific not yet identified to species.
(7) List species occurring at island X.
(8) List species collected by ALBATROSS at Sta. X.
(9) List type-species of family X or order Y not represented by materials in collection.

In addition to working out various queries and testing the system, I would like to work on several items. I have already noted that in some cases adequate data, available from field notes, etc., cannot be entered on the 3 × 5 specimen card. I would like to develop a station data Directory, similar to our geographic Directory, in which all data pertaining to a particular station or collection could be entered and also be available for combination with the basic catalog data by the computer.

For example, Dr. Waldo L. Schmitt kept extensive field notes which relate directly to many specimens now in the crustacean collection. If we could enter all of this by station number and have the computer add this data to each printout record, we could greatly increase the amount of information available on each specimen. For the purposes of management of our collection, this information is not neccessarily needed in our species file. Its value for research purposes is obvious.

Similarly, data from Smithsonian expeditions and other expeditions as well might be stored and tied to the specimen record by the station number.

We also plan to develop a basic catalog card for parasites and commensals from our crustacean holdings which will emphasize host and ecological data.

During the coming year we plan to investigate various applications of the computer and the computer-based specimen data bank to our routine operations. The possibilities are unlimited. We should be able to generate invoices giving complete specimen data, lists of holdings for visitors, lists of holdings for exchange purposes, as well as a machine-generated catalog in tabular form which could be bound and retained as a permanent record. Entry of present unidentified material (identified to family or genus level, but not species level), would enhance our abilities to make our collections and these data available to visitors.

Development of off-campus storage facilities for inactive collections, in my opinion, is dependent on development of banks of data associated with those collections; removal of collections to off-campus facilities without documentation of the material would be tantamount to destruction of the material.

I would also like to see the museum develop methods for computer storage of records from the literature as well as data associated with specimens in our collection.

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THE HERBARIUM: PAST, PRESENT, AND FUTURE[1]

By Stanwyn G. Shetler[2]
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The herbarium as an institution dates back more than four centuries, but the origins of plant collecting for medical and proto-scientific purposes trace back even further to the time of the medieval herbalists. To some of today's biologists the herbarium is an anachronism in the modern scientific world, and their voice of reproach has seemed to grow ever more deafening, especially to the ears of the curator. In response have come some eloquent defenses of the herbarium and its historical significance to science and human welfare (e.g., Beaman *et al.* 1965, Cronquist 1966). Notwithstanding frequent optimistic predictions, however, today the herbarium faces critical challenges to its future existence. Quantitative gains too often are being mistaken for progress and good health, while in fact the physical facilities, staff, operational procedures, collection strategy, and intellectual *raison d'être* of the herbarium are not

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[1] This paper, given at the symposium under the title "The Future of the Herbarium," has been expanded greatly in the statistical portions dealing with the past and present of the herbarium. "A herbarium," as Lawrence (1951) defines it, "is a collection of plant specimens that usually have been dried and pressed, are arranged in the sequence of an accepted classification [can be purely alphabetical], and are available for reference or other scientific study." Cronquist (1966) would add that "a herbarium can be a very useful teaching aid or an absorbing hobby. . . ." It is beyond the intent of this paper to review the extensive and widely scattered literature on the history, philosophy, apologetics, and methodology of herbaria.

[2] I am deeply indebted to Elaine R. Shetler and Nancy L. Howard for help in abstracting, keypunching, and compiling the statistics, and to James J. Crockett and Shigeko I. Rakosi, Smithsonian Information Systems Division, for taking care of the computer programming and processing. Dr. John H. Beaman, Curator of the Beal-Darlington Herbarium of Vascular Plants, has kindly cooperated in supplying information on the Michigan State University Herbarium. Acknowledgment is due also to Mildred J. Davenport and Betty Scott for assistance on the manuscript. Financial support was provided by a grant (Sg0621054/C-1) from the Smithsonian Research Awards Program.

keeping pace with the times. Future prospects are being forecast on the basis of the past or present significance of the herbarium without due regard for its changing role. Consequently, the prognoses are at best too optimistic and at worst delusive or irrelevant.

In many respects, to be sure, the ills of the modern herbarium are only symptomatic of the greater malaise that besets the whole of classical botany and indeed biology (Bonner 1963, Laetsch 1963, Shetler 1963, Smith 1964, Engledow 1968). On the one hand, the traditional disciplinary approach to biology, which has tended to partition it into botany and zoology and then into kinds of plants and animals, is giving way to the levels-of-organization approach, which is topical and cuts across the classic groupings of organisms. On the other hand, descriptive biology at the higher levels of organization is becoming unfashionable and is being supplanted aggressively in curriculums and graduate research programs by descriptive and experimental molecular biology. Fortunately there are scientists who understand the importance of descriptive biology at the higher levels and can counteract the trend to supplant rather than complement such biology with molecular biology (e.g., Mayr 1968).

Faced with the crisis in classical biology, the museum, that citadel of descriptive biology of which the herbarium is but a special case, is remarkably healthy and viable today even in many universities. In some instances, in fact, other, seemingly more favored scientific facilities have taken second place to the museum. There is always the overwhelming physical reality of a large collection of specimens that cannot be ignored easily, although it is precisely this attribute that increasingly has become a negative factor whenever the future of a museum is at stake.

Whether the omens for the future seem favorable or unfavorable the time has arrived for curators to take a realistic look at the current plight of the herbarium and to make some frank assessments of future needs and prospects. This must be done at the risk of a misuse of findings among our critics. I hope that this paper will provoke more dialogue among herbarium curators, administrators, and plant systematists at large concerning the future of the herbarium and thereby lead to a more exhaustive study of the question than I am able to offer.

SOURCE OF STATISTICS

The herbarium fraternity, thanks to the pioneer efforts of Professor Lanjouw (*see* "Introduction," Lanjouw and Stafleu 1959), has been polling itself for many years concerning herbarium resources. This work has been carried out under the auspices of the International Bureau for Plant Taxonomy and Nomenclature of the International Association for Plant Taxonomy (IAPT), with headquarters in Utrecht, Netherlands. The results have been published in *Index Herbariorum, Part I: The Herbaria of the World* (hereinafter abbreviated *I.H.*), now in its fifth edition (Lanjouw and Stafleu 1964), with a sixth due this year. This compilation, though it has obvious shortcomings, is invaluable and unique: no other group of biologists, to my knowledge, has such a concise, worldwide digest of its research collections. Other, complementary reference guides published by the IAPT are an index to plant collectors (Lanjouw and Stafleu 1954, 1957), an index to institutional wood collections (Stern 1967), a directory of plant taxonomists (De Roon 1958), and a directory of botanical gardens (Howard *et al.* 1963). Together these reference works constitute a gold mine of information that could be exploited more fully if they were computerized for easy permutation and comparison of the data. Perhaps this will be done in future editions.

My analysis is based largely on statistics abstracted from the most recent edition (5th) of *I.H.* and permuted by computer. Dated 1964, this edition is effective only through 1963, thereby providing a 5-year supplement (1959–63 inclusive) to the fourth edition (Lanjouw and Stafleu 1959). Ten data fields were formatted on an IBM card, and a card was keypunched for each herbarium treated in the text. Geographic data were supplemented from a world atlas. The ten fields are: (1) official herbarium abbreviation (e.g., US for U. S. National Herbarium, Smithsonian Institution),[3] (2) city, (3) state or prov-

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[3] In the discussion that follows, I sometimes have given only the standard abbreviation of a herbarium in lieu of the full name, so that the general reader will be spared meaningless details. With the abbreviation, taxonomists who are interested can look up the specifics in *I.H.*, which they usually have close at hand.

ince (only for Australia, Brazil, Canada, China, Great Britain, India, Mexico, USA, USSR), (4) country, (5) continent or region, (6) year of founding, (7) number of specimens, (8) number of staff, (9) organizational status (university, government, private), and (10) type of plants (phanerogams, cryptogams, general).

With the aid of a Honeywell 1250 computer, a directory (Shetler *et al.* 1968) was produced indexing the herbaria alphabetically by: (1) abbreviation; (2) city; (3) country and state or province within country; (4) continent, country within continent, and state or province within country; (5) organizational status and country within status; and (6) type of plants and country within type. Also, the herbaria were ordered by (7) year of founding, (8) size of collection, and (9) size of staff. In the process of indexing, certain statistics were computed by machine, and still other statistics have been computed manually from the printout for the purposes of this paper.

Of the 1,188 herbaria listed in *I.H.* (1964) at least by name and abbreviation, only 941 are actually treated or mentioned in the text, and 8 of these (BM-SL, G-DC, ND-G, SAM, SARF, STE-VB, TM, TRV) are incorporated with other herbaria and do not have separate statistics.[4] This leaves 933 herbaria for which at least some data are given. Unless otherwise indicated, all statistics and comparisons are based on an analysis of data provided for these 933 herbaria.

Index Herbariorum is intended to cover only public, institutional herbaria. Collections in the hands of private individuals are not considered part of the public domain of science and are not assigned standard abbreviations (mark of official recognition) nor included in *I.H.* The hundreds, probably thousands, of private herbaria in the world are usually small, seldom exceeding a few hundred or thousand specimens. In at least one case, however, a private collection is known to number about 150,000 specimens, a not insignificant herbarium. Of

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[4] The alphabetical index to herbarium abbreviations registers 247 herbaria omitted from the text, all but one (GUA) being small British institutional herbaria taken from Kent's book (1957) and listed in *I.H.* to provide conveniently their official abbreviations. Twelve of the 941 herbaria treated or mentioned in the text are not included in the index: BM-SL, CHIS, CHISA, G-DC, KL, KLA, KLU, KRA, ND-G, SARF, TENN, TM.

course many institutional herbaria began as private collections.

Even as a register of public herbaria, *I.H.* still falls short of completeness after 30 years of data-collecting and updating. Of the 167 herbaria reporting for the first time in the 5th edition, which represent about 18% of the 933 herbaria treated, only 13 report a founding date in the years (1959–63) since the 4th edition appeared. Thus even in the latest edition of *I.H.* over 16 percent of the main entries (92 percent of new entries) are entries that should have appeared already in the 4th edition if not before. The real total of public institutional herbaria has not been approached. We know in the case of Great Britain, thanks to Kent's book (1957), that almost five times as many institutional herbaria have escaped full treatment in *I.H.* as have been treated (246:50). Every country, no doubt, has its own small, unnoticed herbaria in municipal, county, and state or provincial museums, schools, and parks. The United States, for example, has many, often quite valuable though local herbaria in national parks. For the most part, these obscure herbaria, which so far have either failed to respond to questionnaires or have escaped the notice of the compilers of *I.H.*, are small and inactive with respect to the national and international commerce of plant taxonomy. It is likely that the number of scientifically important herbaria in the world is about 1,000, i.e., approximately the number now treated in *I.H.* Doubtlessly some important herbaria, particularly in the USSR, China, and Southeast Asia, have not yet reported, but at the same time some of the tiny herbaria already treated in *I.H.* are relatively unimportant to the pursuit of systematics. Having said this, I hasten to add that in a real, if relative, sense all herbaria are scientifically important. It is to be hoped that eventually *I.H.* can be a complete worldwide register of institutional herbaria. If the 5:1 ratio of unreported to reported herbaria of Great Britain were to hold throughout the world, then there could be as many as 5,000 institutional herbaria. If Kent's data are a safe guide to the size of the smaller, unreported herbaria of the world, then such herbaria have anywhere from 200 to 75,000 specimens and average almost 5,000 specimens/herbarium. At this rate, 1–1.5 million specimens should be added to the *I.H.* figure just for Great Britain, and on a worldwide scale this could mean an additional 18–20 million specimens.

The problem of missing data is bothersome because many herbaria did not report complete information. Number of specimens was reported by 78 precent of the 933 herbaria and year of founding by 79 percent, while 85 percent listed the names of one or more staff members. Perhaps some of the 15 percent not listing staff in fact do not have any staff. Except where otherwise indicated, the statistics of this paper are based on the herbaria actually reporting and are not extrapolated to account for all 933 herbaria treated in *I.H.*, to say nothing of the 247 mentioned but not treated in *I.H.* or of any estimated world total of herbaria. It should be kept in mind, therefore, that in reality the figures would be higher, perhaps much higher, in all categories if data were available for all public herbaria. The bias of missing data probably affects the statistics for most countries about the same, but there are some notable exceptions. The herbarium resources of mainland China cannot be assessed realistically because 73 percent of the entries in *I.H.* for Chinese herbaria (excluding Taiwan) do not include number of specimens or the names of staff. For the USSR, only 58 percent of the included herbaria report staff and only 60 percent report number of specimens. French herbaria report number of specimens in even fewer cases (57 percent). Some of the smaller countries have not reported any staff or specimen totals.[5]

Concerning the reliability of the data in *I.H.*, the questions, When is a herbarium actually founded?, What is a specimen?, and, Who is a staff member?, naturally arise.

Establishing the founding date of a herbarium can be a quite subjective matter. The U. S. National Herbarium,[6] for example,

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[5] Countries not reporting any staff (total number of herbaria in parentheses): British Honduras (1), Ecuador (2), Greenland (1), Lebanon (1), Nicaragua (1), Paraguay (1), Ryukyu Islands (1), and Seychelles (1); countries not reporting any specimen totals: Azores (1), British Solomon Islands (1), Ecuador (2), Greenland (1), Korea (2), Nicaragua (1), Paraguay (1), Ryukyu Islands (1), and Tunisia (1).

[6] The U. S. National Herbarium, as the Smithsonian's plant collection has long been designated in the international taxonomic fraternity, is administered by the Department of Botany of the Institution's National Museum of Natural History. Technically speaking, therefore, "U. S. National Herbarium" is a term of convenience for the collections themselves and not an official organization with a staff and administrative status. For practical purposes, however, it can be so regarded in many contexts.

gives a founding date of 1868 in *I.H.* This was the year when a Smithsonian herbarium was organized in Washington, D. C., under the care of the U. S. Department of Agriculture, but shortly after its founding in 1846 the Smithsonian Institution had already come into possession of plant collections made under federal auspices as early as 1840 (Stern 1966). It was not until 1894, however, that the U. S. National Herbarium was officially established at the Smithsonian. A further example is the herbarium of the Komarov Botanical Institute in Leningrad, said in *I.H.* to have been founded in 1823, but which actually was an outgrowth of collections started almost at the inception in 1714 of the forerunner medical garden (*cf.* Shetler 1967, Lipschitz and Vassilczenko 1968). In *I.H.*, the founding dates of the medical garden and herbarium are distinguished from each other. Even when, as in this case, the distinction is made in *I.H.* between the founding dates of the herbarium and its mother institution, choice of starting point may be entirely subjective.

The overwhelming majority of specimens reported in *I.H.* are of the conventional herbarium type, but it is clear that other types of specimens (fossils; wood samples; fossil or wood thin sections; pollen, spore, and other anatomical microscope slides) frequently are included in the totals. Cryptogamic specimens are especially problematic. There is no uniform way of counting them; yet generally they are not tallied separately in *I.H.* One must assume that the confounding effects of cryptogamic and other kinds of specimens are spread over all herbaria.

To judge by the few herbaria giving exact figures for totals, one would conclude that only about 3 percent of the world's herbaria actually maintain precise counts of specimens held. Furthermore, it is not possible to know in any given case how many of the specimens of the total are mounted as opposed to unmounted or available for consultation as opposed to being in storage and unavailable.

The criteria for reporting staff obviously varied from one herbarium to another. In general, only professional curatorial-research staff are listed, but some universities and research institutes have reported whole faculties or groups of faculties, so inflating their actual staffs that it is impossible to know how many persons play an active role in the herbarium. Other institutions have included directors or administrators who have nothing to do with the herbarium and in fact may not even be botanists, while still others have included technical staff such as preparators. In the future, herbaria should be encouraged to report total number of technical and clerical staff, without names, and to distinguish, as some herbaria have already done, between active curators on the one hand and associated researchers and emeritus or honorary curators on the other hand, so that an accurate picture of the world's professional manpower devoted to the maintenance of herbarium collections can be ascertained.

Lacking any sound basis for consistently distinguishing between different kinds of staff in *I.H.*, I have simply counted all persons listed for each herbarium. If we can assume that the excesses of one are cancelled by the deficiencies of another, then we can assume that the total figures yield a reasonably fair report of professional curatorial manpower in the world's herbaria. Given this rough level of manpower estimation, I have ignored cases of duplication. About 2 percent of the names appear twice, but often it is not possible to know whether the curator was holding two positions or had moved to another herbarium too recently for his name to have been removed from the roster of the first herbarium.

Notwithstanding its limitations and shortcomings, *Index Herbariorum* provides an excellent statistical abstract of the world's herbarium resources for which the compilers must be given full credit. Even though the data in specific cases may be suspect, this should not invalidate collective statistics and comparisons unless there is evidence of systematic bias. I hope that my paper will have the positive effect of stimulating curators to help in correcting and refining the data in future editions of *I.H.* where necessary.

To supplement the data of *I.H.* and make my analysis more vivid and contemporary, I have selected two American herbaria for brief case study. As an example of a university herbarium, I take the Michigan State University (MSU) Herbarium. A recent symposium, held about the time when the 5th edition of *I.H.* was issued, focussed attention on the MSU Herbarium and the problems of university herbaria in general. This herbarium, with its approximately 200,000 specimens, characterizes active university herbaria of small to moderate size. The U. S. National Herbarium will serve as my example of a large non-university herbarium. For statistics on the National Herbarium I have drawn freely from the excellent status reports of the Smithsonian's Department of Botany that were prepared for internal purposes recently by Stern (1966) and Hale (1967).

GROWTH OF WORLD'S HERBARIUM RESOURCES

All of the tables (1–16), compiled from the 5th edition of *I.H.* (1964), are placed at the end of the paper.

Chronology of Herbarium Founding

The first institutional herbarium was founded about 425 years ago in 1545 at the University of Padua in Italy[7] (*see* Tables 5–12). Only 12 more herbaria were to be founded during the next 200 years, including four others in the 16th century and four in the 17th century. Among the latter were two, formed in 1635, which today are among the world's most renowned herbaria, namely, the phanerogamic (P) and cryptogamic (PC) herbaria of the *Muséum National d'Histoire Naturelle* in Paris. The first half of the 18th century saw only four herbaria established, but the second half brought a minor burst of 32 foundings. Several of the great herbaria of Europe and the British Isles took origin during this period. Thus herbarium formation did not begin in earnest until about 1750. The year 1753, when Linnaeus published his revolutionary *Species Plantarum*, was only the second in history in which two herbaria were founded (British Museum, London; University of Vienna, Austria), and the decade of the 1750s was the first in history in which more than two (five) herbaria were formed. Henceforth, the number of herbaria formed per decade, plotted in Fig. 1 for every decade from 1750–59 to 1950–59, began to rise, only twice dipping below the level of the 1750s. Of the 21 decades from the 1540s to the 1740s, by contrast, there were 10

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[7] The founding date for the university herbarium at Pisa, Italy, is given in *I.H.* as "before 1850," but the botanic garden of the university, which may have maintained a dried plant collection early in its history, is said to have originated in 1543. The analysis deals, of course, only with herbaria in existence.

in which no herbarium was founded, 9 in which only a single herbarium was formed, and 2 (1560s, 1630s) when two herbaria were founded.

Prior to 1750, only one herbarium (Mauritius, 1737) had been formed outside the continent of Europe. Several herbaria came into being in the British Isles during the next 50 years, and the first herbarium of the New World was founded in 1772 at Winston-Salem, North Carolina, in the United States. A year later the second and only other New World herbarium to be founded prior to the 19th century was formed at Charleston, South Carolina, where the collections of Stephen Elliott, pioneer botanist of the Carolinas, have been kept. Neither of these herbaria ever advanced far. The first *principal* herbarium of the United States, though actually the fourth to be founded in this country, was organized in 1812 at the Academy of Natural sciences of Philadelphia (given as first American herbarium by Jones and Meadows 1948). In Asia, the first herbarium was established in 1793 at Calcutta, India, and a second was not formed until almost 25 years later. The first herbaria of South America and Africa were not formed until the 1800s, in 1808 (Rio de Janeiro, Brazil, RB) and 1855 (Cape Town, South Africa, SAM), respectively.

Up to the year 1800, i.e., for over 250 years, only 45 herbaria had been founded, 94 percent of these in Europe and the British Isles. During the next 50 years (1800–49) the pace of founding quickened markedly, and 76 herbaria, about 1.5/year, were formed. Well over half of these were formed in Europe and the British Isles, but a dozen were founded in North America and a handful elsewhere. The rise and spread of the herbarium as a scientific institution had really begun. Thus, while only 13 herbaria had been established in the entire world prior to 1750, the British Isles and North America each had about this many by 1850. By contrast, however, Asia, the Australasian-Pacific Island region, and South America were not to achieve about a dozen herbaria each until 1900, more than 350 years after the very first herbarium was organized, and Africa could not claim this milestone until the first decade of the present century had passed.

During the 1800s, 270 (37 percent) of the present 933 herbaria were established, at an average rate of 2.7/year. By the late 1830s one or more herbaria were being created virtually every year, and, according to the official record (*I.H.*), over the 125-year period from 1839 to 1963 there have been only 5 years (1841, 1843, 1851, 1866, 1961), including only one in the present century, when new herbaria have not been founded. The real explosion in herbarium building has come during the present century. Thus far (1900–63) 420 herbaria, 57 percent of the total number, have been founded, averaging 6.6/year, which is more than twice the rate for the 19th century and exactly triple the overall rate (2.2/year) for the whole 419-year period (1545–1963). Of these 419 years there have been 239, of which 234 occurred prior to 1839, when not a single new herbarium was formed.

The golden age of herbarium-founding began about the middle of the 19th century and lasted for about 100 years (Fig. 1). The 1850s witnessed a sharp upswing to 30 in the number of herbaria founded per decade, and from there the general trend was upward until the 1920s when 91 herbaria, the all-time high for a single decade, were formed. The peak year was reached in 1890 when 20 herbaria were founded. There have been only 13 other years in history, all in the 20th century, when 10 or more herbaria were founded in a single year; these vintage years, in order of decreasing number of herbaria formed, have been: 1930 (15 herbaria); 1920 (14); 1935, 1947 (13); 1918, 1925, 1946 (12); 1900, 1922, 1923, 1924, 1950 (11); and 1932 (10). Since the 1920s, the founding of new herbaria has declined sharply.

The 100-year herbarium boom has coincided roughly with a similar golden age of exploration and description in plant systematics and biology generally, which was initiated by the great pioneer biologists of the late 18th and 19th centuries and, it appears, is now drawing to a close in mid-20th century. A pivotal factor in the United States, both in the flourishing of explorative-descriptive biology and in the rise of the herbarium, was the passage by the U. S. Congress of the first (1862) and second (1890) Morrill acts (sponsored by Representative Justin Smith Morrill), providing for the establishment and support of land-grant colleges to promote, among other studies, the agri-

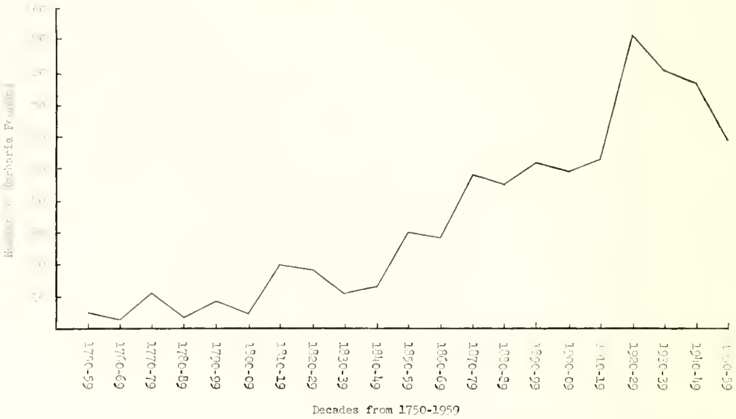

FIG. 1. Number of Herbaria Founded Per Decade from 1750 to 1960.

cultural sciences. Some of the most outstanding herbaria in the United States today are to be found in land-grant institutions tracing their starts to this legislation. Although the influence and support of the land-grant acts continue, reinforced by additional legislation as recently as 1960, the impetus of the agricultural college, which so profoundly affected the course of herbarium development in America, was largely dissipated after the first few decades of the present century. This development in America must be regarded as having influenced the worldwide trend as well, given that the USA can claim nearly a quarter of the world's herbaria today.

Herbarium-founding has by no means stopped today, despite the sharply declining rate since the 1920s. If, as so frequently is done, one looks only at the present and ignores the historical trend, then herbaria appear to be growing and spreading more rapidly than ever, which actually is true in some parts of the world where the last five or ten years have chalked up a larger roster of foundings than the first 200–350 years (cf. Tables 5–12 and next section). Worldwide, about 300 years passed before the first 100 herbaria were formed, but the last 100 of the 933 herbaria have been founded in just over 17 years (Table 14)! During the most recent 5-year period for which statistics are available, 13 herbaria have been founded—as many as were founded during the entire first 200 years (to 1750). Obviously the herbarium is far from being a dead institution. Yet it also must be noted that the annual rate of foundings has decreased from 6.6 herbaria/year during the first 63 years of this century to 4.2 during the last 10 years and 2.6 during the last 5 years of this period.

Geography of Herbaria

The world's herbarium resources are analyzed by continent or region in Tables 1 and 2 and by country (top 22 countries only) in Tables 3 and 4.

Today's 933 herbaria are located in 104 countries, averaging about 9 herbaria, or 1 percent of the total, per country. In fact, however, only 22 countries have the average 9 herbaria or more. Of the 104 countries, 37 have only one herbarium, 77 have five or less, and 95 have twenty-five or less. The top five countries and their numbers of herbaria are: USA (244), Great Britain (50), Canada (48),[8] USSR (43), and France (42). Only the first place of the United States is clearly established, and this is true whether the criterion is number of herbaria, number of specimens, or number of staff. The ranks of the other countries change when the latter two criteria are used; Canada drops to 13th place when ranked by number of specimens but only to 5th place by number of staff, while France places 2nd and Great Britain 3rd by both of these standards. The rank of the USSR cannot be determined confidently with the available statistics in *I.H.* because of the relatively large number of herbaria not reporting full data; quite possibly the USSR ranks next to the USA. Likewise, in reality China might rank among the top five, but the highly incomplete data place her out of the running.

The 10 leading countries have 63 percent of the world's herbaria; none of the other 94 countries has as many as 20 herbaria. In the United States, every state has at least one herbarium, and

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[8] On behalf of the Systematics and Phytogeography Section of the Canadian Botanical Association, W. K. W. Baldwin of the National Herbarium of Canada (CAN), Ottawa, has been making a special study of Canadian herbaria during the past few years in an effort to provide better data for the forthcoming 6th edition of *Index Herbariorum*. His progress reports, which have been distributed but not published, reveal that there are more than 60 herbaria in Canada at the present time. I have not attempted to incorporate his incomplete results here.

California leads with 27. Half of the USA's 244 herbaria are found in California and six other states: Texas, 22; Michigan, 19; Massachusetts, 17; Pennsylvania, 14; New York, 12; and Ohio, 10. If the continents of Europe and North America are treated broadly, as follows, then each is seen to have about a third of the world's herbaria: Europe + British Isles = 327 herbaria; North America (including Mexico and Central America) + West Indies = 315 herbaria. Asia places a distant third place with 114 herbaria or, including the Australasian-Pacific Island region, with 158 herbaria.

The 933 herbaria of the world are found in 669 cities, averaging 1.4/city. Thus, inefficient and wasteful as it may be to maintain two or more facilities and collections within the same city, such duplication has been common practice. Historical precedent or petty institutional sovereignty and politics too often seem to outweigh the scientific logic and simple economics of consolidation. Ironically, moreover, it seems to be a universal fiscal principle of bureaucracies, at least governmental ones, that two small units often can command greater total support than one large, consolidated unit.

As mentioned earlier, the herbarium was an almost exclusively European institution for more than 200 years. Then slowly it was transplanted to foreign soil by European naturalist explorers turned settlers, and over the years the geographic focus of active herbarium-founding has tended to shift more or less in phase with the shifting thrust of European and, eventually, North American exploration and colonization. An indigenous tradition did not take hold in North America until well into the 19th century nor in Asia and Australasia until as late as the early 20th century in some parts. Only in quite recent years has the herbarium become truly indigenous in Africa and South America.

This shifting focus of activity can be documented statistically. Table 14 compares the geographical distribution of the first 100 herbaria founded with the geographical distribution of the last 100 founded, i.e., counting back from 1963, the most recent year for which *I.H.* gives data. The figures, which can be read directly as percentages, speak for themselves.

During the recent 25-year period from 1939 to 1963, inclusive, 150 herbaria were founded, and North America (including Mexico but excluding Central America and the West Indies) led with 42, followed by Africa with 28, Europe with 26, South America with 21, and Asia with 19. If only the last 10 years of this period are considered, then Africa noses out North America by one herbarium (9:8). Herbarium-founding has tapered off greatly in Europe, where on the continent not a single new herbarium was formed during one recent 5-year period (1954–59), and several countries apparently have not founded a new herbarium this century; nevertheless, it is quite remarkable that any herbaria at all are still being started here, as at Aarhus, Denmark, in 1963. This speaks well for the continuing vitality of descriptive botany in Europe. In North America, the focus of active herbarium-founding is shifting from the United States to Canada. A surge of herbarium-building in Mexico comparable to that taking place recently in Canada has yet to begin.

The countries of Africa and South America probably never will experience a herbarium boom to equal that experienced in Europe or North America. For one thing, Europeans and North Americans continue to do a large portion of the tropical collecting and research and, therefore, to carry most of the spoils of exploration back to their home institutions. Furthermore, the present rapid evolution of biology away from the descriptive stages, the accelerating pace of the race to conclude the botanical exploration of the earth, and the growing worldwide concern about overpopulation and its destruction of our natural environment—all seem to be foreclosing on any new herbarium boom of the scale witnessed in north temperate regions by the last 100 years. The coming of rapid, easy means of transportation during the present century has greatly stimulated and facilitated worldwide exploration. Seemingly, however, modern means of travel have served mainly to aggrandize the long-established herbaria and have stifled rather than stimulated the creation of new herbaria, because in a jet age the remotest parts of the world are but a research grant away from any would-be collector's home base. At the same time, representing a growing, unpredictable counterforce, which in many countries (e.g., in Africa) already has curbed explorations by foreigners and spurred much new, indigenous herbarium-building, is the rising tide of nationalism that generates demands for national science and scientific institutions.

Obviously, many factors may govern the development of herbaria within a country. Size of home territorial area may be least among them, witness Great Britain and the countries of Europe. By contrast, the huge size and floristic diversity of the Soviet Union have been major factors in keeping most Russian botanists at home through the years, while at the same time this size and diversity have enabled them to amass large and rich collections (Shetler 1967). The impact of the land-grant legislation in the United States, discussed above, demonstrates the obvious point that the development of herbaria within a country is closely dependent on the general level of educational, scientific, and economic development of the country as a whole. A country that does not have mature scientific traditions and institutions also will not have well-developed herbaria nor the scientific and educational foundations to support them. Every country goes through a predictable golden age of its own with respect to the formation of indigenous herbaria, and this curve is a minor reflection of the country's curve of overall development. Political considerations, especially as they have governed the national and international movements of botanical collectors and their specimens, have often limited the character and scale of herbarium-building in a country at least for a time. The prime modern example of this is to be found in China.

Organizational Status of Herbaria

About 59 percent of the world's herbaria are university-affiliated, 34 percent government-affiliated, and 7 percent independent. This classification does not indicate necessarily the source of funds. In the United States, for instance, virtually no public herbarium operates entirely on private funds today; county, state, or federal funds provide at least some support. The dominance of university herbaria speaks for the importance traditionally accorded to plant collections in academic botancial research and education. The rapid increase of herbaria in North America during the past 100 years has been due in large part to the rapid increase of state and provincial universities, many of which have botany departments or botanical gardens with associated herbaria. The influence of the land-grant acts in the United States has already been mentioned, and to this should be added the exemplary, early influence of prestigious schools and teachers. Concerning the development of the herbarium as an integral element of university botany, it would be hard to overestimate the profound influence of men like Asa Gray (1810–88) and Liberty Hyde Bailey (1858–1954) or of the institutions they served. Since the time of Asa Gray, some of America's foremost academic botanists, indeed scientists, have been herbarium scholars who have made the university herbarium a primary locus of research and teaching. In the United States today, Jones and Meadows (1948) point out, ". . . almost without exception no first-class university has a second-class herbarium . . . ." "Likewise," they comment, "there seems to be a very close connection between development and utilization of the herbarium and the vigor and prestige of a botanical department." Chairmen of university botanical departments would do well to savor these observations. Surely the same kinds of comments about the historic role of academic herbaria could be made for many countries.

When only the 17 largest herbaria, with 2 million or more specimens each, are considered, then 53 percent are seen to be government-affiliated, 35 percent university-affiliated, and 12 percent independent. The relatively higher percentage of government-affiliated herbaria in this group than among herbaria at large reflects the fact that government herbaria are often among the earliest to be founded in a country and they tend to receive greater and more stable support through the years than other herbaria, enabling them to grow larger than others.

Types of Herbaria

Historically, it has not been customary to develop cryptogamic and phanerogamic herbaria as separate institutions, although many general herbaria have been organized into different laboratories or divisions for different groups of plants. According to available data in *I.H.*, only about 6 percent of the world's 933 herbaria are strictly cryptogamic herbaria. Among these, however, are some world-famous institutions, including three with a half-million or more specimens: *Laboratoire de Cryptogamie, Muséum National d'Histoire Naturelle,* Paris (PC, 1.2 million); Farlow Herbarium of Cryptogamic Botany, Harvard University, Cambridge, Massachusetts (FH, 1 million); and National Fungus Collection, U. S. Department of Agriculture, Beltsville, Maryland (BPI, 675,000, including Smithsonian fungus collections). One must hasten to add that there are other large cryptogamic collections (e.g., at Komarov Botanical Institute, Leningrad, 1 million specimens) that are not organized as independent herbaria. In reporting data for future editions of Index Herbariorum, institutions should attempt to distinguish more carefully, the kinds of collections they hold so that a better picture of the world's resources by plant groups can be gained.

Size of Collections

With 724 (78 percent) of the 933 herbaria reporting size of collection, specimens total about 148 million. If one were to assume that the same average per herbarium (ca. 205,000 specimens) holds for the 22 percent not reporting size of collection, then the extrapolated total for the 933 herbaria would be 190 million specimens. Furthermore, if to the 190 million were added specimens hidden away in national parks and the small herbaria of municipal, county, and state or provincial museums, schools, and parks, then surely the world total for institutional herbaria would reach 200–225 million and possibly as high as 250 million specimens.

Over 131 million, almost 90 percent, of the 148 million specimens are held by the 22 countries with 9 or more herbaria each (Table 3). With few exceptions the countries having the most herbaria also have the most specimens, although the ranking is different. Some of the European countries that have had herbaria for a very long time rank comparatively much higher in number of specimens than in number of herbaria (e.g., Czechoslovakia). About 78 million of the 148 million specimens are concentrated in Europe. This is more than double North America's 36 million specimens, and European herbaria also average more than twice as many specimens per herbarium as North American herbaria (Table 1).

As a country, the United States of America, with 34 million based on 86 percent of its herbaria reporting size of collection, leads the world in total number of specimens. It has about a quarter of the world's specimens (23 percent) as well as herbaria (26 percent) (Table 3). Apparently it is the only country that has more than 20 million specimens. The nearest competitor, France, has less than half as many specimens (nearly 15 million); however, this figure is based on only 57 percent of the herbaria reporting size of collection, so that the real total could be well over 20 million. Of the 95 countries for which specimen totals can be compiled from *I.H.*, 48 report 100,000 or less, and only 3, including the USA, report more than 10 million. Over a third of the countries have totals between 25,000 and 250,000 specimens. The average for the 95 countries is just under 1.6 million/country, although only 10 percent of the countries have totals that fall into the range of the average, i.e., 1–2 million.

Compared by average size of herbarium, the USA, with its 160,142 specimens/herbarium, falls far behind other countries. The top four countries, their herbaria being the only ones to average more than a half-million specimens each, are: Switzerland (994,286/herbarium), Sweden (965,875/herbarium), Czechoslovakia (650,000/herbarium), and France (609,067/herbarium). These are countries with long herbarium traditions where the existing network of herbaria has been stabilized for some time, and few if any new herbaria are still being formed.

Forty-five countries have at least one herbarium each with as many as 100,000 specimens; 25 countries have at least one herbarium with 500,000 or more specimens; 19 countries have at least one herbarium with 1 million or more specimens; and 11 countries can claim at least one herbarium of 2 million or more specimens. Only 6 countries of the world—France, Great Britain, Italy, Switzerland, USA, USSR—can boast at least one herbarium of 3 million or more specimens (Table 13).

The statistics in Table 15, based on the 724 herbaria reporting size of collection in *I.H.*, give a good indication of the size-class distribution of the world's herbaria. As expected, most herbaria are relatively small, and few are really large. It appears that almost half of the world's herbaria have no more than 25,000 specimens and that almost three-quarters have no more than 100,000 specimens; about 10 percent have 250,000 or more, and only about 5 percent have a million or more specimens.

The 39 "big league" herbaria reporting 1 million or more specimens are listed with appropriate statistics in Table 13 in order of decreasing size. This list includes 9 herbaria of the United States, the country with the largest number of herbaria that have 1 million or more specimens. There are 17 herbaria with 2 million or more specimens each, and together they have 57 million specimens, more than a third of the total 148 million. The 10 herbaria with 3 million or more specimens together have a total of 41 million specimens. Thus it would appear that 25–30 percent of the world's herbarium specimens are concentrated in 1–2 percent of the world's herbaria, namely, the world's very largest herbaria. It is certain that at least some of the 209 herbaria for which collection size is not given in *I.H.* (e.g., herbarium of British Museum in London) belong in Table 13, but there is no way to take these into account. One must assume that in relative terms this table gives an accurate picture of the world's largest herbaria and their holdings and staff.

The largest herbarium in the world unquestionably is the herbarium of the Royal Botanic Gardens at Kew near London, England, which in 1963 could boast a staggering 6.5 million specimens. Second place is open to question, however. On the basis of the data in Table 13, the clear choice is the *Muséum National d'Histoire Naturelle* in Paris *if*, ignoring the administrative separation into two herbaria (P and PC), the 5 million phanerogamic and 1.2 million cryptogamic specimens are added together to make a total of 6.2 million. On the basis of the phanerogamic herbarium alone, the Paris museum may stand in third place behind the Komarov Botanical Institute in Leningrad, where the phanerogamic and cryptogamic collections, which are administered as one herbarium, total between 5 or 6 million specimens. The Leningrad herbarium has about 1 million cryptogamic specimens, but there is some confusion concerning the number of phanerogamic specimens, whether 4 or 5 million (*see* footnote, Table 13). Inasmuch as cryptogams are included in the Kew and Leningrad totals, it seems only fair that Paris be compared on the same basis. The herbarium of the British Museum is not included in Table 13, but already in 1951 it was estimated by Lawrence (p. 231) to have 4 million specimens. As of 1963, therefore, it might have placed second or third in size among the world's herbaria. One of the world's largest herbaria (ca. 4 million specimens) until World War II was located in Berlin, but it was destroyed in the war.

The largest herbaria of the New World are found in the United States, and it is a matter of interpretation which places first, second, and third. According to Table 13, the herbarium of the New York Botanical Garden and the U. S. National Herbarium at the Smithsonian Institution, Washington, D. C., were, with 3 million specimens each, tied for first place in 1963. Frequently, however, the six herbaria of Harvard University (A, AMES, ECON, FH, GH, NEBC), Cambridge, Massachusetts, are combined when size comparisons are made, and if this is done Harvard takes the lead, as of 1963, with 3,540,150 specimens. But if this is done for the Harvard herbaria then the National Fungus Collection at Beltsville, Maryland (just outside Washington, D. C.), which includes the Smithsonian's mycological specimens, should be considered part of the U. S. National Herbarium, and the combined total, as of 1963, was 3,675,000 specimens. If, furthermore, the other herbaria of the Washington area (LCU, MARY, NA, USFS) are added to this figure, then the grand total is 4,335,000 specimens. By the same token, the 294,000 specimens of the Brooklyn Botanic Garden should be added to the specimens of the New York Botanical Garden to give a total of 3,294,000 for greater New York City. In terms of specimens available within the city, therefore, Washington is first, followed by Cambridge and then New York.

The smallest herbarium on record is located in Siena, Italy, and had 492 specimens in 1963. It happens also to be the 9th oldest herbarium in the world, being founded in 1691. This is the only herbarium reporting less than 500 specimens, although three others (HNT, SEY, SPH) report just 500.

The general rate of collection growth is difficult if not impossible to determine even for a given time period. Clearly the relative growth rate has been slowing down through the years as the bulk of the world's collections has been increasing steadily. Absolute growth, i.e., in terms of actual number of specimens coming into herbaria, has increased greatly over the past 100 years or more as the number of herbaria and botanical collectors has increased, but there is definite indication that even absolute growth is on the decline now. Compared to the total of about 124 million specimens registered in the 1959 edition of *I.H.*, the total in the 1964 edition is about 24 million higher. The 13 herbaria founded in the period 1959–63, inclusive, report a total of only 145,000 specimens; obviously, these herbaria do not account for a significant portion of the 24-million increase. Between editions of *I.H.* the U. S. National Herbarium increased by about 300,000 specimens or 11 percent, as computed on the 1958 base of 2.7 million. If one assumes that herbaria in general increased their holdings by about 10 percent during the 5-year period (i.e., 2 percent/year), then 12–13 million of the 24 million specimens would represent the growth of collections in previously registered herbaria. This is about 2.5 million specimens/year, a not unlikely figure for the whole world. The other 11–12 million of the 24-million-specimen increment probably are contributed by the more than 150 herbaria reporting for the first time in the 1964 edition of *I.H.* even though they were founded before 1959 and should have been reporting in 1959 or before. Their specimen total does not represent new growth, except perhaps for about 10 percent of it.

Today, growth relative to the size of existing collections could be averaging as low as 1 percent per year among herbaria in general, meaning an annual worldwide increment to herbaria of 1.5–2.0 million specimens. Probably the rate lies closer to 2 percent per year, however, because some herbaria are growing several times this rate (e.g., Michigan State University Herbarium, 5–10 percent/year). During the last five years Canadian herbaria have been growing at an average rate of more than 6 percent/year (W. K. W. Baldwin correspondence, 1969).

Manpower

Size of professional staff ranges from 1 to 46, averaging about 4, persons per herbarium and totals 3,158 persons for the 794 herbaria (85 percent of 933) that list one or more staff members. The frequency distribution of the 794 herbaria by size of staff is as follows:

1 staff member	199 herbaria	25 percent
1 or 2 members	395	50
5 or less members	640	81
10 or less members	742	93
11–46 members	52	7

Only 11 herbaria, listed in Table 16, report 20 or more staff members (as of 1963). About 75 persons (2.4 percent of 3,158) are listed for two jobs in *I.H.*, so that the total number of different individuals is under 3,100 and the average is about 3.9/herbarium. (Double employment cannot be distinguished easily from accidental duplication; *see* "Source of Statistics.") Extrapolating with this average, one concludes that the full 933 herbaria are in the care of more than 3,600 individual curators. If 2–3 percent of the 3,600 serve in two capacities, then the total number of professional positions occupied is over 3,700.

Distribution of herbarium staff by continent or region is shown in Table 2. The largest concentration is in Europe (36 percent). North America (25 percent) takes second place, followed by South America (11 percent). If the data for Asian herbaria were more complete, this continent probably would place third. There are 96 countries out of the total 104 for which the staff members of at least one herbarium are listed in *I.H.* Of the 96 countries, 37 report 5 or fewer staff members, while 73 report 25 or less; 9 countries report more than 100 staff members. Only two countries, the United States with 667 and France with 220, report more than 200 staff members. The USA has over 21 percent of the world's herbarium force, based on these statistics, and France has 7 percent. (By comparison, the USA has 26 percent of the world's herbaria and 23 percent of the specimens, while France has about 5 percent and 10 percent, respectively.) The 21 countries that lead in total number of staff are among the 22 countries that lead in total number of herbaria, listed in Tables 3 and 4, although the ranking differs, as can be seen in Table 4. Finland, included in the tables, has 30 curators and ranks 23rd in staff size, whereas Belgium, not included in the tables, has 31 curators and ranks 22nd in staff size. Except for Belgium, therefore, Tables 3 and 4 include all countries with 30 or more staff members as of 1963.

Few if any of the world's herbaria would claim to be staffed adequately, and almost every curator would consider himself overworked. Yet there are no absolute standards by which one may judge the adequacy of professional (or technical and clerical) staffing. Instinctively, one can say that any herbarium with less than one full-time curator is understaffed or that any person holding down two curatorial positions, as about 2 percent of the world's curators apparently do, is overworked. Saying this hardly sheds light on the general question. There are, however, two useful ratios that measure objectively the relative adequacy of staffing of a herbarium or country: (1) average number of specimens per curator, and (2) average number of curators per herbarium. Thus herbaria or countries can be compared with each other or with the world as a whole by their specimen:curator ratios. Likewise, countries can be compared with each other or with continents or the world as a whole by their curator:herbarium ratios. To be sure, these ratios may bear little relationship to the level of activity in particular cases, especially where a significant fraction of the curators identified with an institution or country are not actually engaged in herbarium research and curation; nevertheless, these ratios are the only objective measures of staffing we have. Other factors being equal, an above-average curator:herbarium ratio reflects a favorable staffing situation, while an above-average specimen:curator ratio, i.e., more than the average number of specimens per curator, reflects an unfavorable staffing situation.

Average curator:herbarium and specimen:curator ratios are given in Table 2 for continents or regions and Table 4 for the 22 countries with the most herbaria. As already mentioned, there is an average of 4 curators/herbarium among the 794 herbaria reporting staff. South America, as a continent, leads the world with an average of 5.5 curators/herbarium, followed by Europe with 5.0/herbarium. North America trails with 3.0/herbarium. Among the 22 top countries, the Netherlands leads with 10.9 curators/herbarium, while the United States trails with 3.0/herbarium. The favorable South American ratio appears to reflect aggressive herbarium growth on this continent and also a liberal concept of reckoning staff (*see* below). The relatively high European ratio seems to be a more authentic representation of the true situation.

The average number of specimens/curator among the 794 herbaria is about 47,000. The herbaria of the British Isles lead the world with an average of almost 95,000 specimens/curator, while contineta! European herbaria follow with 78,000/curator. The lowest ratio is to be found in the West Indies, where each man curates an average of about 6,000 specimens. Ignoring Madagascar, where there are only 3 herbaria, the second lowest average for a large region, about 10,000 specimens/man, is found in South America. By country, Switzerland leads with about 170,000 specimens/man, followed by Czechoslovakia (134,000/man) and the USSR (87,000/man). The high ratio of specimens to curators in Europe and the British Isles reflects the existence here of old, very large herbaria. In general, the European countries rank above average both in curators to herbaria and in specimens to curators.

In North America, the United States, with about 50,000 specimens/man, ranks near the world average, while Canada, with 19,000/man, and Mexico and Central America together, with about 10,000/man, rank well below the world average. On the basis of curators/herbarium, the United States, Canada, and Mexico and Central America all rank below the world average at 3.0, 3.2, and 3.3, respectively. Among North American herbaria, therefore, those of the USA are the least well staffed.

As a group, the world's largest herbaria appear to be seriously understaffed. The 17 herbaria with 2 million or more specimens (Table 13) have among them 38 percent of the world's 148 million specimens but only 8 percent of the world's 3,158 curators. The 11 herbaria with the largest professional staffs (20 or more members each) have 19 percent of the world's herbarium specimens but only 11 percent of the world's curators. If one computes ideal professional staff size for these 11 herbaria on the basis of the worldwide average of about 47,000 specimens/curator, the results, given in Table 16, are very interesting. By this standard some herbaria prove, as expected, to be grossly understaffed, but others, surprisingly, seem to be even more grossly "overstaffed," if indeed one may speak of any herbarium being overstaffed. Certainly the staff figures of individual herbaria must be regarded with some skepticism and be interpreted in the most cautious, relative terms, because of the lack of uniformity among institutions in reckoning who is a professional staff member. Thus, for example, the herbaria at Montpellier, São Paulo, and Buenos Aires report essentially all faculties of their respective botanical institutes instead of just those persons who actually might be considered to belong to the professional curatorial staff. Probably Kew ranks first in number of authentic herbarium staff, which means that the largest staff in 1963 totalled about 40 professional persons. Despite individual discrepancies, it is noteworthy that the 11 herbaria as a group have only about half (56 percent) of the professional staff that they should have to meet average conditions.

It may seem unfair to measure the adequacy of staffing in large and small herbaria by the same specimen:curator ratio, because the small herbarium must have a relatively larger staff for its size than the large herbarium. The maintenance of any herbarium, regardless of its size, entails certain basic curatorial tasks and functions, and minimum staff size, obviously, is one person. The larger the herbarium, the more efficient it becomes in terms of number of specimens that a curator can manage. Tending to counteract this gain in efficiency, however, is the greater workload of the large herbarium, which gains in service responsibilities to the scientist and layman as it gains in size and thereby general usefulness and visibility. It is problematical, therefore, whether the large herbarium should be measured by a different specimen:curator yardstick than the small herbarium.

For purposes of discussion I have assumed until now that the more than 3,000 persons listed in *I.H.* are all professional curators, because there has been no other firm basis on which to analyze professional manpower in the world's herbaria. In fact, as already indicated ("Source of Statistics"), this is not a safe assumption. While the *I.H.* figures may give a roughly accurate picture of the number and deployment of the world's *herbarium-affiliated* botanists, although even this can be disputed, given the kind of peripheral scientific staff that one finds listed for some herbaria, quite clearly the more than 3,000 persons who are listed for the 794 herbaria reporting staff do not all engage actively in curatorial work or work that can be construed as contributing directly to the building and maintenance of these herbaria. Many are associated researchers or administrators who have few if any routine curatorial responsibilities. This is not to denigrate the essential, if sometimes indirect or intangible, contribution of such personnel to the well-being of the collections and the scientific life of the herbarium. Yet it should be recognized that probably no more than 1,500 to 2,000 of the approximately 3,000 staff are really curators. The extrapolated figure for all 933 herbaria would be 1,800–2,400 curators.

Finally, professional staff represent only part of the world's herbarium manpower. To their number must be added the technical and clerical supporting staff. At the U. S. National Herbarium, the ratio of supporting to professional staff has tended in recent years to remain at about 1:1. This certainly is neither the best nor the worst ratio among the world's herbaria. If for comparative purposes we may assume that it is an average ratio, then all figures given for professional staff should be doubled to project total herbarium manpower. It seems likely that upwards of 7,500 persons, working in one capacity or another, are employed in the 933 herbaria treated in *I.H.* Considering that these 933 herbaria could represent a fifth or less of the world's public institutional herbaria (*see* "Source of Statistics"), one must conclude that at the least there must be well over 10,000 persons employed in herbarium-related work (profession, technical, or clerical) and at the most there could be upwards of 35,000 or even more persons manning the world's herbaria. Probably the truth lies somewhere between these extremes.

THE MODERN PREDICAMENT

On 8 May 1964, a symposium was convened at Michigan State University on the theme "The Herbarium in the Modern University" to dedicate new quarters for the university's herbarium, founded in 1863. (These quarters, in a renovated old building, had been occupied since the summer of 1963.) The event was a resounding success. On short notice, 160 persons, representing 49 institutions, attended. Thus the taxonomic community responded to this herbarium pulse-taking with a vitality that few would have predicted. Later, when the symposium was published, John H. Beaman, curator of vascular plants and organizer of the symposium, could write (Beaman, Rollins, and Smith 1965, p. 113), "The attention which the program attracted was an effective demonstration of the high level of current interest in the herbarium as a resource for taxonomic teaching, research, and service." As local administrators said convincingly what their subordinate curators wanted to hear and as the speakers optimistically tallied up several hundred years of achievements, pointing to unprecedented growth and activity at present, those attending found themselves engulfed in a euphoria of hope and prosperity. The National Science Foundation, indispensable patron of American science, was duly represented by the director of the Systematic Biology Program, who then was Walter H. Hodge, himself a botanist. Dr. Hodge presided and, while acknowledging such chronic and worrisome problems as inadequate public understanding, financing, staffing, and facilities, was able to conclude his summation on an upbeat with the welcome appraisal that the herbarium today is "progressing rather than regressing."

During the first week of September 1968, just *five* years after the renovated building had been occupied, a demolition crane moved into position, and its great iron ball began swinging. In exactly one-half day, less time than it took for the dedication, the building that was opened with fanfare and great hopes in May 1964 was reduced to a pile of rubble! The pendulum of progress had swung, pulverizing a modern university herbarium "to make way," in the words of *Fortune* magazine writer Duncan Norton-Taylor (1967), "for the driveway to the new Administration Building." For the second time in six years the whole collection of plants had to be moved, at last to truly new quarters, but again at great cost in effort and lost research time.

To be sure, I have not told the whole truth. The curators knew when they first occupied it that this newly renovated building could serve only as an interim home for the herbarium during the indefinite period between vacating the original quarters and moving into some permanent quarters yet to be planned and built. They did not know how very temporary the interim quarters were to be. Now the herbarium is located in the recently built Plant Biology Laboratories, where it occupies twice as much floor space as it had occupied in its original quarters. So well off is the herbarium, in fact, that for the first time its fortunes are even cause for a certain amount of envy at the university.

But is this momentary good fortune illusory? The present quarters also are a temporary refuge—hopefully for no more than 10 years. A truly permanent home is to be provided some day in a new museum building not yet begun. Furthermore, the two curators who are mainly responsible for developing and maintaining the herbarium (Beaman and H. A. Imshaug, curator of cryptogams)[9] must run a full research and teaching program for graduate and undergraduate students while also trying to manage a collection of more than 200,000 specimens, to which are accessioned about 10,000 specimens/year. This is 100,000 specimens/man, twice the national average, and at this rate of accessioning the herbarium should be gaining a new professional staff member every 4–5 years.

The Michigan State University Herbarium certainly is not impoverished; neither are the responsible university administrators myopic. Quite to the contrary, it is a university herbarium of unusual vitality with indefatigable curators and with administrators who thus far have demonstrated uncommon understanding and foresight. Yet this is precisely the point: the university herbarium today (indeed the herbarium in general) seems at best to lead a fragile existence, and no amount of activity and leadership can cover up the ever-present stresses and strains that threaten this existence constantly. As Beaman (1965, p. 113) writes, "The herbarium is the oldest, most essential, most expensive, and most difficult to develop of all facilities for the study of systematic botany. Consequently, the occupancy of new quarters by a herbarium, however modest, is an event of note." Wrapped up in his words is the paradox of the herbarium, especially in the university setting: es-

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[9] This is a good case in point of how the number of staff listed in *Index Herbariorum* may bear little relationship to the number actually responsible for most or all of the curating. Of the 10 persons listed, only 2 (Beaman and Imshaug) were, as of 1963, carrying much of the burden of curation.

sential but too expensive to be developed, accommodated, and maintained adequately. The elements of crisis or collapse, namely, collections that continually are outgrowing facilities, staff, and other resources and a science that constantly is changing, are always present. The slightest erosion, therefore, of the historic scientific and intellectual foundations of the herbarium can precipitate instant crisis, and this is what we seem to be witnessing with increasing frequency as classical botany comes under the molecular gun. Confused by challenges of the scientific worth of the herbarium, administrators may need little persuasion to decide that the herbarium is an expensive, latter-day white elephant, which in terms of resources demanded is a facility that drains more than it adds to a modern science program.

The Michigan State University symposium dealt only with university herbaria. In the international commerce of taxonomic research, however, the large nonuniversity herbaria are crucial institutions. What then is the state of affairs in such large herbaria as the U. S. National Herbarium at the Smithsonian Institution? Today, with 3 million specimens, it is one of the ten largest herbaria in the world and one of the three largest in the New World. The bulk of these specimens has been accumulated during the present century. As Stern (1966, p. 8) has said, "it is a safe assumption . . . that there is no serious research of any scope which can be executed in systematic botany in the United States without some recourse to the plant specimens of the U. S. National Herbarium." One might amend this statement by saying that any taxonomist in the world wishing to conduct serious research on temperate North American plants surely will need to take recourse to collections of the U. S. National Herbarium, among others in the United States, at some time during his study.

By some standards the U. S. National Herbarium has often seemed the rich uncle among herbaria in the United States. As the largest of the few American herbaria with direct access to appropriated federal funds, it appears to occupy a favored position.[10] During the past few years the Smithsonian's Depart-

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[10] Direct appropriation is not the only form of federal support in the USA. Since the National Science Foundation was formed, large, though inadequate, amounts of

ment of Botany has indeed experienced unprecedented growth and prosperity. In 1965, the department and its herbarium were able finally to occupy new quarters, a move culminating years of dreams. A year later hopes were raised (Stern 1966) for the acquisition of new metal cases to replace the more than 2,200 archaic, inefficient wooden cases, which are not insect-proof. For the first time in history the National Herbarium seemed to be heading toward a fully modern facility, even if, as at Michigan State University, the quarters were hardly designed for a herbarium (e.g. a plant-drying facility was not included in the plans!). The staff of full-time professional botanists had grown to an all-time high of 16.

Already this hard-won improved status has begun to erode, as the inexorable growth of the collections continues without a concomitant increase in space and staff. At present, in fact, the department has a smaller full-time professional staff (13)[11] and less available office space (1.2 rooms/man instead of the original 2/man), which is occupied to the point of crowding, than when it moved in 1965. Although the specimens per curator ratio is only one index of staffing adequacy, yet it is significant that on this basis the department should have about five times its present number of full-time curators, to say nothing of supporting staff (Table 16), just to meet average conditions. The professional botanists continue to do much of the routine curatorial work because of the perennially unfavorable ratio of curatorial assistants to curators which temporarily may reach as high as 1:2 but usually is 1:3–4. Owing largely to understaffing, some 200,000 specimens, as many as the Michigan State University Herbarium comprises altogether, must remain in dead storage, freezing nearly a fourth of the available storage cases. Specimen storage space probably will reach saturation conditions in the herbarium in less than 10 years, by which time

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federal support have been granted to many American herbaria for research and facilities. This fact sometimes is overlooked, and the myth arises that the National Herbarium is the only federally supported herbarium in the USA.

[11] This number, unlike the figure of 21 in *I.H.*, excludes resident emeritus curators, honorary research associates, collaborators, postdoctoral associates, and long-term visiting scholars who usually swell the professional ranks by 10–15 persons a year but do not have obligatory curatorial responsibilities, although frequently they contribute much help. It includes, however, several full-time staff botanists of the department who have little or no responsibility for the collections.

virtually all working space in the herbarium will be occupied by cases. Some parts of the herbarium already are so overcrowded that specimen filing is difficult if not impossible. The effort to replace the wooden cases in toto collapsed, and as of today only a relatively few have been replaced.

Meanwhile, the National Herbarium continues to be very active, and the workload only increases. Over the 10-year period from 1958 to 1967, about 700,000 incoming specimens—41,000 to 120,000/year and averaging 70,000/year—have been processed as gifts, exchanges, or specimens collected by or for the herbarium's botanists. During the same period, 20,000 duplicate specimens/year of the 70,000 have been turned around and sent out on exchange, while 37,000 specimens/year have been mounted for addition to the herbarium, leaving about 13,000/year that of necessity have gone into dead storage. Thus some 50,000 specimens have been retained, which means that every year the herbarium should be adding at least one new professional botanist and commensurate supporting personnel just to cope with the inflow and processing of material. Incoming exchange has averaged 25,000 specimens/year, leaving an accumulating exchange deficit of 5,000/year. Duplicate exchange usually is a deficit operation for the large herbarium, which by virtue of its size and importance must cooperate in many more exchanges than the small or medium-sized herbarium. To attempt to balance the books is futile: the more specimens sent out, the more that come back, and the total inflow always seems to outstrip the outflow. If, therefore, the National Herbarium suddenly were able to find the extra 5,000 exchange duplicates each year to meet the deficit, any balance would only be momentary, because the cooperating institutions would be stimulated quickly to send us still more specimens, perhaps doubling or tripling our annual deficit. Loans for research also have increased steadily from the 16,700 specimens borrowed from the National Herbarium in 1961 to the 41,500 sent out in 1967, averaging about 25,000/year over the 1958–67 period. Finally, requests for identifications keep rising, and nearly 180,000 identifications were made over these 10 years. In short, the National Herbarium, like any large herbarium, is big business.

To a greater or lesser extent, nearly every herbarium in the world is faced with the problems, dare I say predicament, of the Michigan State University Herbarium or the U. S. National Herbarium (e.g., *see* Rollins *et al.* 1967–68). Regardless of the category of transaction, there seems to be no way to stem the rising workload and service demand. At the same time the intellectual foundations of the herbarium seem to be crumbling within science today with an ever-increasing tempo making it harder and harder for herbaria to justify and secure the kind of support needed. Given the intensifying predicament, serious crisis cannot be far away. It is regrettable, therefore, that inner-circle conclaves like the 1964 symposium do not, for all their timely challenges and encouragements, challenge any of the sacred cows or age-old premises of the herbarium mentality. The handwriting, it would seem, is on the wall, and the message should cause concern if not alarm. If through rosy glasses a move to new quarters means growth and prosperity, plain sight might reveal that it really means harassment and retrenchment, with the collections being chased from one temporary asylum to another, never gaining a permanent berth in their own right and always being put out of mind administratively by another wishful promise. It is becoming critical, surely, for curators to interpret the signals correctly.

Clearly it is time to establish new relevancies and strategies for the herbarium. Considering that herbarium growth potentially is limitless, it is not surprising that the kind of statistics cited above give administrators uneasy feelings. Unless there are new objectives with rational limits and strategies that go beyond merely asking for bigger and better facilities, the current predicament is likely to deepen into an insoluble crisis, locally and generally.

ECONOMICS OF HERBARIA

Investments and Costs

To my knowledge, a thorough analysis of capital investment and cost of operation has never been made for herbaria. This important task will require lengthy study to produce complete and reliable results, and herbaria, at least on a national basis, should attempt it as a basis for seeking more federal support. It is, in fact, an almost impossible task, given the great variation of facilities and expenditures from one herbarium to another, not to mention the problem of currency differences between countries. My cost analysis, which is rough and sketchy, is based on extrapolation from the situations at the Michigan State University Herbarium and especially at the Smithsonian's U. S. National Herbarium. I may be presumptuous to attempt this, but surely some hints of costs are needed.

The cost of herbarium space and equipment is approximately $50/sq. ft. at Michigan State University and approximately $100/sq. ft. at the Smithsonian Institution, where, however, the density of stored specimens per square foot is about double that of Michigan State. Consequently, the static cost of housing specimens is about $2/specimen in both cases. Projected on a national scale at this rate, the capital investment for herbaria in the United States is at least $70 million today, and the worldwide investment is nearly a third of a billion dollars. Even if the average cost were only $1/specimen the worldwide investment would be $150 million.

In any herbarium, the specimen storage cases are the main item of equipment. The U. S. National Herbarium housed its 3 million specimens as of 1963 in about 2,200 cases.[12] Figured at $100/case, which was the minimum cost of replacement at that time, these 2,200 cases represented an investment of almost a quarter of a million dollars. Using the National Herbarium's average of about 1,350 specimens/case, one can extrapolate, and on this basis the USA had some 25,000 cases as of 1963, while there were about 110,000 in the world. (Phanerogamic specimens average only about 1,000/case, whereas some of the cryptogamic groups average more than 1,350/case.) At $100/case or its equivalent in other currencies, these totals represent investments of about $2.5 million in the USA and about $11 million in the world.

Overall operating expenditures vary from year to year and herbarium to herbarium. One of the problems of cost estimation, given the budget of a herbarium, is to separate research costs from curatorial and herbarium-service costs. Thus, for example, the Smithsonian's Department of Botany operated with

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[12] Each case has 24 compartments.

about $400,000 in Fiscal Year 1968 (July 1967–June 1968), including granted as well as appropriated funds, which averages over $0.12/specimen for the approximately 3.25 million specimens on hand by this time. These funds covered salaries and operating funds for all research and curatorial activities, however, and probably no more than half of the total sum, i.e., about $0.06/specimen, was expended to support the U. S. National Herbarium per se. For Fiscal Year 1968, therefore, one might extrapolate that the USA spent at least $4 million on the nation's herbaria, including research and curation, and that at least $2 million of this went directly to the support of herbarium curation and service. The comparable figures for the whole world would be nearly $20 million and $10 million, respectively.

The routine operation of a herbarium includes accessioning, loaning and borrowing, exchanging, sorting and filing newly mounted specimens, identifying plants, answering public enquiries, and other activities. Figures on a few of these operations will indicate how rapidly the expense of operating a herbarium mounts.

The cost of sorting and filing newly mounted specimens varies greatly, depending especially on the training and experience of the person who does the work. Other things being equal, a professionally trained botanist can sort and file much more rapidly and efficiently than a technical assistant, but in either case the speed and efficiency are direct functions of experience. The botanist will earn two or three times more money per hour and should, therefore, be three or four times more efficient than the technical assistant, but this is not likely because the botanist will file less mechanically and will take time out to solve more problems. At the U. S. National Herbarium, where sorting and filing are shared by botanists and assistants, it costs a minimum of $0.10/specimen and an average closer to $0.15/specimen for the whole process, which, for 50,000 specimens/year, represents an annual bill of $5,000–$7,500 or even more. Extrapolating on the basis of $0.15/specimen and assuming that the annual growth rate of collections is about 1.5 percent (*see* "Size of Collections"), one can estimate that the yearly cost of sorting and filing newly mounted specimens is a minimum of $75,000 in the USA and $330,000 in the world. These calculations also assume, for the sake of argument, that all newly accessioned specimens are being mounted and filed promptly.

Loan transactions constitute big business at the U. S. National Herbarium, where today about 1 percent of the total collection goes out on loan in a year. Personnel of different levels are required to process these loans, but the total cost, by my estimation, is equivalent to a professional man-year at $13,000–$15,000. Thus the cost averages upwards of $0.50/specimen. Extrapolating, the annual rate of loaning would be about 350,000 specimens in the USA, costing about $175,000, and about 1.5 million in the world, costing about $750,000. These are, of course, very rough estimates.

The cost of public service is, like all other activities of the herbarium, difficult to estimate. One important facet of public service is plant identification. During the most recent 10-year period for which there are statistics, the U. S. National Herbarium averaged about 18,000 identifications/year for professional and lay persons. This represents less than half of the requests actually made. At a very minimum this identification service has cost $1/specimen, and a more realistic average figure would be at least $2–$3/specimen. The rate depends on the percentage of the identifications made for professional persons, who require an authoritative precision not required by the public. By the time he consults both the collections and the literature, a botanist not infrequently spends an hour or two on a single specimen; therefore, the cost can mount quickly to $5–$20/specimen. In recent years, some Smithsonian botanists have identified up to 4,000 specimens/year, mostly for professional colleagues. Taking the rock-bottom figure of $1/specimen and the rate of identification of the National Herbarium, I estimate the annual bill for the USA to be something over $200,000 and for the world about $1 million. The true costs are probably double these figures at least.

Dividends

One would be foolish to attempt to put a dollar figure on the full value of the herbarium to science and society, because in a very real sense this value is incalculable. At the same time, herbaria do cost big money, as we have seen, and the public has the right to ask, as it frequently does, what the payoff is. Curators are justified, therefore, if not duty bound, to consider what dividends can be reaped from their collections and activities.

The worth of the herbarium to the scientific community can be evaluated in part by the amount of money invested in herbarium-based research. With respect to the United States, some interesting data on research investment can be found in the statistics of the National Science Foundation. Over the last six years (1963–68), the NSF, through its Systematic Biology Program, has awarded grants totalling $10,653,500 for studies in systematic botany (excluding viruses and bacteria). This is an average of almost $1.8 million/year, and during the last two fiscal years (1967, 1968) the amount awarded has averaged about $2 million/year. Of the money awarded, about 40 percent ($4.25 million) has gone to floristic and monographic studies, which are vitally dependent on the herbarium, while another 40 percent has gone to studies that are much less dependent on the herbarium but are likely to require it at some stage just the same. In other words, about 80 percent of the money awarded has gone into researches that are to some degree herbarium-based. This represents about $1.4 million/year or, if only floristic and monographic researches are considered, about $0.7 million/year. The above figures are based only on grants made by the Systematic Biology Program. It must be added that environmental and other biologists who receive grants through other NSF programs frequently conduct researches that require the use of the herbarium. The money spent through the Systematic Biology Program represents, therefore, only the most direct and visible of NSF's investments in herbarium-based research.

Much herbarium-based research is done in the United States each year without financial support from the NSF. There probably are about 1,000 plant systematists in the United States. On the basis of the past two years the NSF would seem to be supporting only about 14 percent of these American taxonomists (about 140 out of 1,000). (To the 80 new grantees each year must be added about 60 continuing grantees; the average grant lasts about 21 months.) The 14 percent have been commanding nearly $2 million/year, but they constitute the "rich cousins" of the taxonomic fraternity. Probably, the other 86 percent do not average more than 10–15 percent of the almost $15,000/man/year that the NSF-supported scientists have available for research. At 10 percent or $1,500/man for the other 86 percent, the annual investment for research in plant systematics in the United States becomes $3.3 million ($2 million from NSF for 140 systematists + $1.3 million from other sources for 860 systematists). The 10 percent estimate could be much too low, of course. Carrying our extrapolation to its conclusion, we can estimate that 80 percent of the $3.3 million, i.e., $2.64 million, goes into herbarium-based researches of some type, while 40 percent, i.e., $1.32 million, goes to the support of floras and monographs, which cannot be produced without the herbarium. Thus a $70 million herbarium investment supports $2.64 million worth of research each year, although much more research could be supported annually with the same investment.

There is another means of evaluating the worth of the herbarium to science in America. Given that the existence of the herbarium is vital to the existence of the discipline of plant systematics, we can say that in the United States today's 1,000 systematists are supported as a research fraternity by the $70 million herbarium investment. At an average salary of $12,000/year, the annual price tag of this fraternity is $12 million. Add to this the $3.3 million used to pay for their research, and we have a scientific enterprise costing $15 million annually that could not exist as we know it today without the historical investment in the herbarium.

The cost of a service is also a measure of the value of the service rendered. Thus in the previous section ("Investments and Costs") the costs to herbaria of storing and lending specimens for research and of identifying plants for scientists and the public, which probably are the two most important services of the herbarium, are discussed.

The public user community is essentially the citizenship at large, and its dependence on the herbarium can only be evaluated in terms of specific kinds of requests such as for plant identifications. At any large herbarium, identification, like specimen lending, is big business. The annual bill for identification would be much higher if the manpower were available to meet the real demand.

CHANGING ROLE OF HERBARIUM

Historically, herbaria were the personal collections of private individuals who preserved plant specimens to document ceremonial or medicinal uses or to satisfy cultural or scientific curiosity. The collector, if a serious scholar, was both scientist and curator. He traded duplicate specimens with colleagues as a means of diversifying his own herbarium and of notarizing his own finds. A man of means (e.g., of royalty) could hire a curator and commission collectors to obtain the necessary specimens for duplicate exchange, but his herbarium remained a personal property for his own amusement and his curator's, if not his own, study.

The emergence of botany as a science in the 17th and 18th centuries invested dried plant collections with a new significance and thereby brought about the institutionalization of the herbarium. Private collecting has never ceased, of course, but today the herbarium is highly institutionalized. Not only is the herbarium an essential scientific institution, but in the organizational sense it has become a public institution, governed by museums, universities, botanical gardens, and other corporate bodies. The modern herbarium, in addition to being a place of research, is a large service bureau. As already indicated several times, herbaria in the aggregate represent big business, and running a major herbarium calls for businesslike methods. The private little collections that once could be known in their entirety and be managed "out-of-pocket" by their sole curators have become so massive in many cases that no single curator could hope to know their limits or to discharge all their tasks. Large herbaria require the cooperation of several to many curators.

The fact is that although more than four centuries have passed since the first institutional herbarium was formed curatorial mentality and practice are still characterized strongly by the personal entrepreneurship of a private collector. The transition from the personalized, private herbarium to the collective, public herbarium, with its corporate research and service responsibilities extending over many generations of curators and citizens, has been made imperfectly at best in most instances. Curators, whether they have curated a small herbarium or some part of a large herbarium, have always tended to shape their collections according to their own scientific and management concepts. Often too little thought has been given to the implications of being part of a much larger system that must survive the lives and whims of individuals. Small, one-man herbaria may be able to withstand the consequences of generation after generation of subjective curation, but large herbaria must have objective standards or in time they become a hodgepodge of curatorial idiosyncrasies. Thus, a large herbarium, instead of being curated by a uniform, generalized system, may be curated as several autonomous or semi-autonomous fiefdoms. Sometimes each fiefdom has its own familial and generic concepts or filing system.

Some subjectivity is essential, of course, because in the final analysis the herbarium is not only a facility and a resource but also an instrument of taxonomic research. If the instrument has shaped the science, so has the science shaped the instrument. The science of systematic botany itself is changing, however, and becoming less descriptive. As it becomes less descriptive, it tends to become less subjective; therefore, the herbarium should become less a subjective instrument of research and more an objective source of information. Such evolution in function demands new ground rules for collection building and management.

The life cycle of plant taxonomy, whether one thinks of the historical development of the science or of the knowledge about a particular flora or group of plants, has had at least four recognizable phases thus far (cf. Valentine and Löve 1958): descriptive (exploratory), floristic-phytogeographic, systematic, and biosystematic (including chemosystematic). A fifth, ecosystematic phase is just beginning. These are relative states of progress in the development of taxonomic knowledge, of course, and as such describe not only chronological stages in time but also phases of activity going on simultaneously within the taxonomic community at any given period of time. Collection building has tended to reflect this changing cycle of taxonomic approaches, i.e., the character of the collections being accumulated has been influenced by the type of taxonomy being done. Obviously, there is no perfect system for arranging the herbarium so that it will serve these five phases—or any other phases—of plant systematics equally well, nor can a curator change the physical arrangement of his herbarium to conform to the latest thinking every time some new research fad comes along. The bewildering array of systems and partial systems in use among herbaria today, which often are long since outgrown or overgrown and of which no two seem to be alike, stand like ancient shipwrecks as mute testimony to the navigational errors of past curators who tried to keep pace with the times by arranging part or all of their collection according to current taxonomic concepts, only to have these concepts change faster than they could rearrange the specimens consistently.

The herbarium first became a scientific institution when taxonomic botany, indeed all of biology, was almost entirely descriptive, and the principles of organization and use established then have largely dictated practice ever since. Through the years botanical exploration has been a chief stimulus for herbarium-founding, witness the geographical shift of focus of new herbarium development from Europe to North America and Asia and thence to Africa and South America in phase with the general exploration and development of these regions of the world. During the descriptive-exploratory stage the herbarium takes shape as a repository of exemplars of the new forms of plant life coming off the collector's conveyor belt from exotic regions. The descriptive or alpha taxonomist deftly and expertly sorts from this conveyor, sifting the known from the unknown. The known are filed and the unknown are described and published as quickly as possible. At this stage the paramount function of the herbarium is to provide, for purposes of identification and diagnosis, easy and logical access to the exemplars of already-described taxa, and the primary task of the curator-taxonomist is to keep his incoming material described up to date, which requires that he know his previous collections intimately and have them neatly classified and filed away.

The curator who likes to assign a place to every specimen has little difficulty in doing so while the herbarium is high on diversity and low on variability in its representation of the plants in nature. As soon as a second specimen of a known taxon appears, however, the exemplar approach begins to break down, and each succeeding specimen further erodes the homogeneity of the taxon and complicates the task of identification and novelty-recognition. Therefore, specimens additional to the types not only have less value intrinsically than the types but also constitute in reality a nuisance factor because they obfuscate the nice boundaries that could be drawn on the basis of single exemplars. The pigeonhole mentality is difficult if not impossible to outgrow. For purely practical reasons every specimen must have a place to rest, and, regardless of the phase of taxonomic development, identification, comparison, and diagnosis tend to remain the primary functions of the herbarium and therefore dictate its arrangement. By the same token, the herbarium botanist faces the danger of becoming trapped with these functions, never having a chance to indulge in the broader aspects of systematics.

Once the majority of the novelties have been discovered, attention turns to floristics and phytogeography. In this second phase of taxonomy the curator-taxonomist monitors the conveyor of incoming material for new and interesting distribution records, and geography becomes a major parameter by which he tries to sort and arrange his specimens. Now the currency of study is not the taxonomic novelty, but the geographic novelty, with endemism, disjunction, and the ebb and flow of floristic or phytogeographic elements being major themes of interest. Generally, the curator-taxonomist will be especially interested in only one or a few regions; consequently, his subdivisions will be precise in these cases and very coarse for the rest of the world. In time, such gerrymandered systems become clumsy and meaningless as natural geographic arrangements; they also become loaded with political anachronisms as the boundaries of countries change. It probably is fair to say that hardly any herbarium in the world uses a fully modern geographic scheme of which it wholly approves. The geographic mentality fostered by this phase of taxonomic development can lead easily to absurd extremes in herbarium-packing of specimens of the same species for purposes of documenting local distribution.

The third or systematic phase raises taxonomy and the use of the herbarium above the level of pure description to the philosophy of relationships. The herbarium now becomes an active instrument of the curator-taxonomist as he tries to arrange the specimens according to how they should be classified, and, as mentioned before, most modern herbaria reflect some earlier system of classification. A large herbarium hardly is amenable to further manipulation as new systems are proposed. Furthermore, seldom is it possible even to keep current the older system in use, if it is a phylogenetic one.

In the fourth, biosystematic phase, we see the need for large, in-depth collections (population samples) of the taxa under study. Most curators are justifiably reluctant to store large samples of individual taxa because they cannot cope physically with the specimens. Moreover, in terms of the traditional and still prime functions of the herbarium, this represents unconscionable duplication. Yet no biosystematist wants to see his samples treated as "duplicates" and split up for inter-institutional exchange. Also, the biosystematist needs a herbarium that provides easy access to other kinds of specimen data than the traditional name and place of collection.

The recent, ecological phase of systematics has only begun. The next decade will bring, I believe, a solid alliance between taxonomists and ecologists and the emergence of what can be called "ecosystem taxonomy." Surely the International Biological Program (IBP) will develop intense pressures for this. The ecosystem taxonomist, as contrasted with his predecessors, will be less concerned with the absolute precision of his identifications and the phylogenetic hierarchy of his organisms and more concerned with the general, statistical patterns of distribution as they correlate with environmental factors, including pollutants; he will also be concerned especially with the interrelationships and coevolution of different plants and of plants and animals, including man. Thus he will need a much more flexible access to the data locked up in the herbarium than we now have; furthermore, he will call for more sophisticated ecological data-keeping.

The picture is clear. The herbarium was designed for the purposes of a descriptive science that dealt mainly with the questions of what and where, but it has had to survive fundamental changes in this science and now finds itself in an era when the questions are mainly how and why. The fact is that the herbarium has never really adapted to the modern biosystematic and ecological era, and unless it does it will become largely irrelevant in time. We have not yet overcome the problem of providing flexible, multi-access to a data bank that can have only one physical structure, ordered by one parameter, in this case the scientific name. The sharp decline in the founding of new herbaria since the 1920s seems only to be a specialized reflection of a general decline in descriptive biology. The herbarium is after all the chief resource of the descriptive plant systematist, and any deterioration of his status inevitably will decrease the demand for the tools of his trade. Collectors have pushed to the limits of the temperate regions and pressed on into the tropics. Perhaps, especially with new temperate and tropical flora projects in progress and with greatly expanded tropical exploration and research, the 1960s and 1970s will prove in retrospect to have reversed the downward trend in descriptive systematics and herbarium-founding, but this seems doubtful, given the present-day climate of biology and science. Despite the secondary resurgence of such activity particularly in tropical regions, the downward trend appears to be inevitable and irreversible. The golden age of herbarium-founding, has passed.

Strategy For The Future

As a physical creature, the herbarium has grown through more than 400 years until today it has achieved menacing proportions. Not just a few curators are virtually enslaved by the sheer burden of the routine daily transactions and public service, when in fact they should be practicing science. At the same time the science, too, has changed, so that altogether the forces of change and growth have conspired to make it difficult for today's herbarium botanist to be both curator and scientist. Descriptive taxonomy is a fairly natural and easy byproduct of curatorial activities, and it thrives on a constant inflow of new material. To the biosystematic, ecosytematic, or experimental taxonomist, however, curation is largely an encumbrance, a service to perform as the price of being a professional taxonomist.

The herbarium, no less than the library, continues to fulfill an absolutely vital role in science and in practical human affairs as a data bank and information system, even though increasingly it creaks from an overburdened, arthritic curatorial machinery and suffocates in the clutch of the time-honored but outmoded and inflexible ground rules of research and public service. Being an institutional giant and in many respects an overaged one, it faces hazards of survival that are not small. There are those today—and their number is growing—who see the herbarium as an economic millstone and an intellectual dinosaur in the modern scheme of science. The truth, however, is that the herbarium is beginning to be tapped for a whole new generation of scientific and public questions. As the concern rises about the quality of our natural environment and the ecological principles that control this quality, public officials are being forced to come up with instant ecological histories and forecasts. The conservation of natural resources, including plant and animal communities and particularly endangered species, has become a burning public concern. Ecology and conservation quickly reduce themselves to relationships among organisms. Museums, herbaria included, are the repositories of vast amounts of raw and standardized data about the earth's organisms. The alert curator is not surprised, therefore, that the rising emphasis on environmental biology is giving new significance and urgency to the business of museums. Unfortunately, herbaria, like museums in general, are not ready for the increased demands of the era of environmental biology.

The time for new premises and strategies is upon us. The principal challenge is to "get with it" in trying to reshape the herbarium for the age of environmental biology and the computer, to meet the contingencies not only of a changing science (biosystematics, chemosystematics, ecosystem taxonomy, etc.) but also of a moody, ecologically conscious society who want to know how to survive. We must hope that the world's herbaria will unite at different levels (local, regional, national, international) to develop a blueprint for action. Meanwhile, several of the necessary steps to be taken are obvious.

(1) Every herbarium is both a scientific organization and a public service bureau, and the time has come to accept the full import of this dual nature and reorganize accordingly. The day is past when the taxonomic scholar can be both scientist and curator. Our goal must be to isolate the functions of the herbarium, which are the tasks of the curator, from the research of the herbarium, which is the responsibility of the scientist, i.e., taxonomic scholar. Only in this way can the herbarium rise to meet the increasing service demands and at the same time remain a viable scientific research institution.

The scientific and the service functions of the herbarium can and should be performed by different staffs. As a public service bureau, the herbarium should be organized like a modern library and staffed by a cadre of professionally trained, librarian-like technical experts and aides who specialize in the herbarium's functions, e.g., accessioning, filing, lending, identifying, etc. Libraries are not organized on the premise that only scholars can order, purchase, catalog, shelve, and loan the books, and neither should herbaria be organized on this premise. After an overall systems and cost analysis of input, processing, storage, and output, herbaria should departmentalize and staff appropriately. Non-research personnel, whose professional rewards do not depend on publication, can be trained to perform most if not all curatorial and public service functions of the herbarium just as well as, if not better than, research scientists. As a scientific organization the herbarium should become an institute for advanced studies, organized and staffed according to disciplines and programs, not by curatorial responsibilities. A strong link and intimate cooperation should be maintained between the curators and the scientists, however, because the latter will need to continue to guide curatorial policy.

(2) The computer must be brought into the herbarium without further delay. A new day has dawned in information science, and the meaning of this for museums has been pointed out repeatedly in recent years (Sokal and Sneath 1966, Squires 1966, Crovello 1967, Rogers *et al.* 1967, Soper and Perring 1967). The constant growth of collections impels us to find more efficient means of storing the specimens and accessing the data. A computer system for information retrieval (IR) provides the

ideal answer to the problem of data access and allows great freedom in the physical arrangement of the specimens. Data can be retrieved without necessarily taking recourse to the specimens, and the cross-indexing power of the computer enables one to find specimens when necessary regardless of the physical storage system. The latter capability makes the computer an important tool for managing herbarium transactions (loans, exchanges, accessions, etc.) as well as for providing flexible access to the embedded data. Various control lists can be generated that profile the strengths and weaknesses of the herbarium with respect, for example, to geographic or taxonomic representativeness of the collections. Such profiles could put curatorial decision-making on a much more objective basis, especially as regards the accessioning of new material.

Every specimen carries both objective data (e.g., geographic and other label data), which may require little or no professional interpretation, and subjective data (e.g., morphological traits), which may require highly professional interpretation that can only be made after study of the specimen itself. In a manual system, neither kind of data can be retrieved without actually seeing the specimen, and this requires transporting either the specimens to the investigator or the investigator to the specimens. An IR system can bring the objective data from the specimens to the investigator without burdening anyone with handling the specimens themselves. Once a magnetic record of a collection is created, one can in effect rearrange an entire herbarium just to answer a single question and do it, perhaps, with less effort and cost than to process a loan of a few hundred specimens. Even with only a few descriptors per specimen recorded, many combinations are possible, and one is able to ask complex questions and thereby to locate precise subsets of specimens or compile specific data from randomly scattered places in the herbarium—all without moving a single specimen. The investigator is free to decide on the basis of his answer whether he needs to see the specimens. To be sure, there are certain risks to retrieving and using data without seeing the specimens; for example, the risk of misidentification. Nevertheless, there are many instances in scientific research and public service when these risks are tolerable.

Herbarium curators have in large measure lost control of their vast data bank, now comprising an unmanageable 200 million specimens or more over the world. Given the advanced state of computer technology today, there scarcely is a defense any longer for continuing to add to this overburden of specimens without simultaneously capturing the data for management and retrieval. The high cost of developing and implementing an electronic data processing (EDP) system will prohibit indiscriminate input and force curators to make some hard decisions about the specimens and data to be preserved. Thus the process of computerizing data can serve as a much-needed quality control mechanism. If a specimen does not carry data worth computerizing, then it can hardly be worth preserving and filing in the herbarium for all time. No longer can we afford to presume on our successors by adding to their future curatorial burden under the blithe assumption that while the specimen was not worth our time and money it might be worth theirs.

The place to begin is with select subsets of our herbarium collections (e.g., types) and with newly accessioned material. It is doubtful whether herbaria will ever have the resources to input the whole 200-million-specimen backlog, and, considering the quality of the data of many older specimens, one can raise serious questions as to whether this should be done even if the resources were available. Instead, we must concentrate on what I might call the "forelog."

(3) All herbarium operations need to be examined carefully and modernized if necessary, not only with respect to EDP, but also in the light of the current state of science, the growing shortage of staff and space, and the growing public and professional demand for herbarium-based information. We have seen that herbarium operations today are expensive; even a 1 percent increase in efficiency would effect significant savings. Courage will be needed to abridge or abandon outmoded practices. To cite one prominent example, the time-worn specimen exchange procedures badly need scrutiny and appropriate streamlining. Particularly the larger herbaria need to shake loose from the iron grip of the book-balancing exchange mentality.

In the present day, duplicate exchange is in some respects an anachronism. The world hardly lacks for large, representative herbaria, and the number of herbaria has increased to the point where it is difficult if not impossible for an institution to draw rational limits to its exchanges. Today's rapid means of travel and communication leave little excuse for building up numerous herbaria with duplicates of the same collections. In the framework of population biology, moreover, it is questionable whether there is such a thing as a "duplicate" specimen.

One way to modernize exchange practice would be to establish a cooperative exchange center or clearinghouse which manages transactions by computer and provides specimen-sorting service as needed. Each herbarium would trade and balance books with the system, not with every herbarium from which it happened to receive duplicates. The exchange center could abide by the wishes of donors in distributing their sets of specimens by sending them only to specified recipients. On the contrary, the center could honor the wishes of recipients by sending them only the kinds of material they requested. In many cases, specimens might be exchanged directly between donor and recipient after clearing the transaction with the exchange center. Such a system surely would reduce the inefficiency and increase the effectiveness and order of the exchange process and thereby serve the general good. It could only be established by cooperative effort, however.

(4) The herbarium needs strengthened intellectual foundations, including ties with some of the newer biological and environmental disciplines. This can be achieved by exploiting the herbarium through EDP systems as a vital data bank for biologists other than systematists and by organizing broad, preferably interdisciplinary research programs that require herbarium resources and data and at the same time engender the kind of national and international planning and cooperation that will give the world's herbaria as a group more cohesion, singular and self-respecting voice, and 20th-century relevance. Given the present experimental and molecular scientific climate, we can say that the herbarium is truly at the crossroads, and it will surely fall if it loses its intellectual underpinnings and fails to adapt to the communications revolution by com-

puterizing. Literally, therefore, "united we stand and divided we fall."

(5) Finally, the herbarium needs a new, more solid financial base. This means greater national support, which can come only through cooperative planning. Herbaria are a special kind of national research archive and instructional tool, deserving of regular, dependable subsidy. National support cannot be sought on any rational basis, however, until herbaria show a willingness to operate less like competitive, private enterprises and more like the units of a functioning system. Every herbarium that ever makes a loan or accepts an exchange or gift of specimens is part of a national and international network, participating in the commerce of taxonomy. Any government would be less than prudent to sink large sums of money—and the herbarium is a colossus that could absorb unlimited funds—into its herbaria without first requiring conscious cooperation that takes cognizance at a planning level of the actual network formed by the existing herbaria and divides the responsibilities so that duplication of resources and services is minimized.

In the United States federal support for herbaria over the years has been trivial compared to the needs, and unfocussed with respect to the national interest. The time is ripe for a national strategy. During the 6-year period from 1963 to 1968, the Systematic Biology Program of the National Science Foundation granted less than 2 percent of its funds for collection maintenance per se, and for botany this amounted to about $30,000/year, totalling less than $200,000 out of $10 million for the whole period. If a matching dollar had been put up for every dollar spent on herbarium research, the amount would have totalled at least $4 million and perhaps as much as $8 million—or $0.7–$1.3 million/year. This would have brought an average of about $15,000–$30,000 to every herbarium in the country during 1963–1968. Surely, for every dollar spent on fieldwork there should be a matching dollar for collection curation. Too often research proposals in systematic botany take the availability of herbarium collections and services for granted, when in fact they should be asking for the funds to purchase this accessibility and service just as they ask, for example, for funds to pay publication costs. Ironically, curators as curators are probably the most thanked people in biology, but as individuals they are taken for granted for the many thankless tasks they must perform personally.

It would be unfair to imply that NSF support for herbaria has been confined to the relatively few dollars that have come directly through the Systematic Biology Program. In addition there have been grants for facilities and more recently the Office of Science Information Services at NSF has been supporting the development of computer systems for biological data. Nevertheless, the total investment has certainly not met the needs.

Many American herbaria, especially in the smaller colleges and universities, serve primarily a teaching function. Teaching herbaria are vital to the nation's science programs and should be supported as educational facilities. Their subsidy should be commensurate to the teaching programs they support. The small teaching collection has a way of escalating into a larger and larger research collection, demanding space and resources that exceed the teaching value of the herbarium to its home institution. Such escalation may show commendable industry on the part of the local curator, but it may also pose hard questions about duplication of resources for the national funding agency that is asked to pick up the tab.

At present the United States has only one National Herbarium, but many other American herbaria receive federal support. What is needed as a framework for greater federal support is for all university, government, and private research herbaria in this country to organize themselves into a full network of national herbaria. Then each could be recognized and financed to fulfill a particular role. Some herbaria might concentrate on broad geographic and systematic coverage, while others concentrate on particular regions or systematic groups. State and local governments might be induced to support a complementary network of state and local herbaria, perhaps with some matching federal funds if national scientific standards and objectives were being met. Any national system must steer a middle course between centralization and decentralization of resources and management. The lesson of the Berlin herbarium, destroyed in World War II, has taught taxonomists the wisdom of a certain amount of decentralization and duplication of important collections.

Part of the price of increased federal support, it is clear, will be the loss of a certain amount of autonomy, because herbaria will have to agree on their roles and stick to them. While there may be no limit to the number of small teaching herbaria that can serve a useful function, a nation only needs so many large research herbaria of a given geographical or systematic specialty. The latter statement is especially true in a day when the costs of transporting scientists or specimens may be cheaper than the costs of maintaining essentially duplicate research herbaria. Thus the further development of teaching and research herbaria cannot be left to chance if the United States is to have a national strategy for support. The whole point of a national plan would be, not to compel anyone to do anything, but to identify the role that each herbarium should play and then subsidize the herbarium accordingly.

Progress Toward Goals

The ideas presented here certainly are not new (e.g., *see* Sokal and Sneath 1966). On an individual basis, many herbaria have taken or attempted some of the steps proposed, in some cases long ago. But the destiny of the herbarium as an institution can only be decided by cooperative planning and action. Herbaria must unite to persuade national policy planners to support them, and they must unite to train a pool of technical experts who can take the burden of curation off the backs of the scientists. Operational procedures like duplicate exchange cannot be modernized unilaterally. A herbarium only hurts itself if it tries this. Likewise, no single herbarium has the necessary resources or force of authority to develop and implement a herbarium-wide data processing system. On the international level, the International Bureau for Plant Taxonomy and Nomenclature, with headquarters in Utrecht, Netherlands, has done much to increase cooperation. Many of the problems can be solved only by active collaboration at the national level, however. Eventually, such national collaboration can lead to more formal international planning and cooperation. Fortunately, at present a number of museum and herbarium directors in the United States have become quite concerned about the future of museum collections and of systematic biology in general, and two or three studies are underway to determine the feasibility of greater national cooperation and financial support in the USA.

Within the last few years several pilot projects in applying electronic data processing to museum collections have been undertaken, which must be nurtured and expanded to embrace all herbaria. The Smithsonian Institution now has programs going to computerize data from selected portions of its collection of about 60 million specimens. One of the projects, headed by Mason E. Hale, is designed to produce an automated register of type holdings in the U. S. National Herbarium. The cooperation of other herbaria is being sought so that the Type Register can in time become a union list of worldwide holdings. Another highly significant development is the TAXIR (Taxonomic Information Retrieval) system and research program of David J. Rogers and group at the University of Colorado, financed by the National Science Foundation. Two other noteworthy data-automation projects are under way at the herbarium of the National Museum of Canada in Ottawa (James H. Soper) and at the Herbario Nacional del Instituto de Biologia, Universidad Nacional de México (Arturo Gomez-Pompa).

North American plant taxonomists have just embarked on an immense new cooperative program, Flora North America, which holds much promise for bringing about greater herbarium coordination. Flora North America is organized to produce a concise treatise of the vascular plants of the continent north of Mexico, but the project is deeply committed to bringing flora-preparation into the computer age. Information systems concepts are being exploited to develop a flora data bank, which inevitably must involve the herbarium and the botanical literature (Morse *et al.* 1968, Shetler 1969). Such a data bank should help to translate the herbarium to many people and to make it more relevant than ever as we enter the era of environmental biology.

CONCLUSION

The quantitative growth of the world's herbaria has overwhelmed us and become an end in itself, such that we spend all of our time packing away specimens for a research day that never comes. At the same time we find ourselves incapable of retrieving the most elemental information. The time is here if not past when a qualitative innovation in herbarium building and management is needed. To face the future the world's herbaria need a new strategy based squarely on electronic data processing systems and a businesslike understanding of the service and storage demands of the modern herbarium. The computer makes possible a whole new concept of data banking in the herbarium—the first real innovation since the specimen case replaced the herbalist's scrapbook—and the environmental biologist and ecosystem ecologists have already created the demand for this kind of data access. The herbarium community must unite in phrasing its needs and organize to meet and support them cooperatively. Today herbarium botany, like big science generally, requires big money, and this calls for big but responsible organizing premises and programs. Otherwise, the herbarium ceases to be relevant in terms that the taxpayer or even another scientist can understand.

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Table 1. Distribution of Herbarium Resources by Continent or Region. I. Specimens.

Continent or Region[1]	Number of Herbaria[2] (Percent)	Number of Specimens (Percent)	Herbaria Reporting Number Specimens[3] (Percent)	Average Number Specimens/Herbarium[4]
North America	291 (31.2)	36,125,822 (24.4)	250 (86)	144,503
Europe	274 (29.4)	77,609,223 (52.5)	200 (73)	388,046
Asia	114 (12.2)	8,182,524 (5.5)	70 (61)	116,893
South America	75 (8.0)	3,150,211 (2.1)	59 (79)	53,393
Africa	54 (5.8)	2,417,483 (1.7)	49 (91)	49,336
British Isles	53 (5.7)	14,355,161 (9.7)	38 (72)	377,767
Malaysia–N. Guinea	18 (1.9)	1,735,000 (1.2)	14 (78)	123,929
Australia	16 (1.7)	3,149,000 (2.1)	15 (94)	209,933
West Indies	13 (1.4)	218,700 (0.15)	11 (85)	19,882
Mexico–C. America	11 (1.2)	243,007 (0.16)	7 (64)	34,715
New Zealand	7 (0.8)	472,500 (0.32)	6 (86)	78,750
Pacific Islands	3 (0.3)	190,000 (0.13)	2 (67)	95,000
Madagascar	3 (0.3)	64,000 (0.04)	3 (100)	21,333
Greenland	1 (0.1)	——	0 (0)	——
TOTAL	933 (100)	147,912,631 (100)	724 (78)	204,299

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[1] According to arbitrary geographic breakdown: Europe includes Iceland, Azores, and Madeira Islands; Asia includes Japan and Taiwan; Pacific Islands include Hawaii, Fiji, and British Solomon Islands; and Mauritius and the Seychelles are lumped with Madagascar.

[2] Tables 1–4 are ranked by decreasing number of herbaria.

[3] Percentage computed from: Herbaria Reporting Number Specimens/Number of Herbaria.

[4] Number of Specimens/Herbaria Reporting Number Specimens.

TABLE 2. Distribution of Herbarium Resources by Continent or Region. II. Manpower.

Continent or Region[1]	Number of Staff (Percent)	Herbaria Listing Staff[2] (Percent)	Average Number of Staff/ Herbarium	Average Number of Specimens/ Man[3]	Founding Dates[4]	
					Oldest	Youngest
North America	799 (25.3)	262 (90)	3.0	47,384	1772 (SC)	1963 (HNT)
Europe	1151 (36.4)	231 (84)	5.0	77,879	1545 (PAD)	1963 (AAU)
Asia	303 (9.6)	82 (72)	3.7	31,635	1793 (CAL)	1962 (BUA)
South America	350 (11.1)	64 (85)	5.5	9,763	1808 (RB)	1963 (UB)
Africa	174 (5.5)	54 (100)	3.2	15,311	1855 (SAM)	1962 (UNN)
British Isles	179 (5.7)	45 (85)	4.0	94,971	1753 (BM)	1955 (KLE)
Malaysia–N. Guinea	56 (1.8)	16 (89)	3.5	35,408	1817 (BO)	1954 (CLP)
Australia	61 (1.9)	16 (100)	3.8	55,064	1857 (MEL)	1954 (AD,NT)
West Indies	23 (0.7)	7 (54)	3.3	6,051	1846 (TRIN)	1958 (FPDB)
Mexico-C. America	18 (0.6)	6 (55)	3.3	10,415	1887 (CR)	1950 (ITIC)
New Zealand	25 (0.8)	6 (86)	4.2	18,900	1865 (WELT)	1946 (OTA)
Pacific Islands	13 (0.4)	3 (100)	4.3	21,923	1889 (BISH)	1933 (SUVA)
Madagascar	6 (0.2)	2 (67)	3.3	6,400	1737 (MAU)	1962 (SEY)
Greenland	—	—	—	—	1906 (DISKO)	1906 (DISKO)
TOTAL	3158 (100)	794 (85)	4.0	54,370	1545	1963

[1] Geographic order as in Table 1.

[2] Percentage computed from ratio of Herbaria Listing Staff/Number of Herbaria (*cf.* Table 1).

[3] Computed from ratio of Average Number Specimens per Herbarium/Average Number of Staff per Herbarium (before rounding) rather than from ratio of Number of Specimens/Number of Staff, because more herbaria reported number of staff than number of specimens (*cf.* Table 1).

[4] Herbaria are identified in this and all subsequent tables by standard abbreviations of Lanjouw and Stafleu (1964).

TABLE 3. Distribution of Herbarium Resources by Country.[1] I. Specimens.

Country	Number of Herbaria (Percent)	Number of Specimens (Percent)	Rank by Number of Specimens	Herbaria Reporting Number of Specimens (Percent)	Average Number Specimens/ Herbarium
1. United States of America	244 (26.2)	33,629,722 (22.7)	1	210 (86)	160,142
2. Great Britain	50 (5.4)	13,954,661 (9.4)	3	35 (70)	398,705
3. Canada	48 (5.1)	2,656,100 (1.8)	13	41 (85)	64,783
4. U.S.S.R.	43 (4.6)	10,577,997 (7.2)	4	26 (60)	406,846
5. France	42 (4.5)	14,617,600 (9.9)	2	24 (57)	609,067
6. Italy	38 (4.1)	5,174,677 (3.5)	8	27 (71)	191,655
7. Brazil	37 (4.0)	1,020,743 (0.7)	28	31 (84)	32,927
8. China	33 (3.5)	1,665,000 (1.1)	20	9 (27)	185,000
9. Germany	32 (3.4)	7,933,800 (5.4)	5	24 (75)	330,575
10. Japan	21 (2.3)	2,297,000 (1.6)	15	15 (71)	153,133
11. Argentina	18 (1.9)	1,625,800 (1.1)	21	14 (78)	116,129
12. Australia	16 (1.7)	3,149,000 (2.1)	11	15 (94)	209,933
13. India	16 (1.7)	1,820,452 (1.2)	18	13 (81)	140,035
14. South Africa	14 (1.7)	1,105,338 (0.7)	25	14 (100)	78,953
15. Austria	13 (1.4)	3,712,000 (2.5)	10	10 (77)	371,200
16. Portugal	13 (1.4)	1,280,502 (0.9)	23	10 (77)	128,050
17. Sweden	11 (1.2)	7,727,000 (5.2)	6	8 (73)	965,875
18. Switzerland	11 (1.2)	6,960,000 (4.7)	7	7 (64)	994,286
19. Spain	10 (1.1)	982,000 (0.7)	29	8 (80)	122,750
20. Czechoslovakia	9 (1.0)	4,550,000 (3.1)	9	7 (78)	650,000
21. Finland	9 (1.0)	2,018,300 (1.4)	16	9 (100)	224,256
22. Netherlands	9 (1.0)	2,736,380 (1.8)	12	9 (100)	304,042
TOTAL[2]	737 (79.0)	131,194,072 (88.7)	—	566 (77)	231,792

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[1] Table includes only countries with 9 or more herbaria reporting; average number of herbaria/country is 9. Statistics organized as in Table 1.

[2] Totals cover only herbaria in table, but percentages are based on comparisons with totals for all herbaria.

TABLE 4. Distribution of Herbarium Resources by Country.[1] II. Manpower.

Country	Number of Staff (Percent)	Rank by Number of Staff	Herbaria Listing Staff (Percent)	Average Number of staff/ Herbarium	Average Number of Specimens/ Man	Founding Dates	
						Oldest	Youngest
1. United States of America	667 (21.1)	1	219 (90)	3.0	50,419	1772 (SC)	1963 (HNT)
2. Great Britain	171 (5.4)	3	42 (84)	4.1	81,606	1753 (BM)	1955 (KLE)
3. Canada	140 (4.4)	5	44 (92)	3.2	18,972	1820 (MTMG)	1958 (SAFB)
4. USSR	122 (3.9)	7	25 (58)	4.9	86,705	1770 (MW)	1947 (CHIS, PZV, TAA)
5. France	220 (7.0)	2	35 (83)	6.3	66,444	1635 (P,PC)	1958 (ABT)
6. Italy	115 (3.6)	8	31 (82)	3.7	44,997	1545 (PAD)	1960 (TSB)
7. Brazil	166 (5.3)	4	32 (86)	5.2	6,149	1808 (RB)	1963 (UB)
8. China	33 (1.0)	21	9 (27)	3.7	50,455	1929 (SYS)	1950 (PE)
9. Germany	102 (3.2)	9	30 (93)	3.4	77,782	1751 (KR)	1960 (HEID)
10. Japan	71 (2.2)	13	21 (100)	3.4	32,352	1875 (TH)	1958 (MAK)
11. Argentina	123 (3.9)	6	17 (94)	7.2	13,218	1812 (BA)	1955 (BAFC)
12. Australia	61 (1.9)	15	16 (100)	3.8	55,064	1857 (MEL)	1954 (AD, NT)
13. India	84 (2.7)	12	14 (88)	6.0	21,672	1793 (CAL)	1956 (ASSAM, BSD, BSI)

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[1] Same order of countries as in Table 3; statistics organized as in Table 2. Other countries with 20 or more staff, according to rank and with number of herbaria in parentheses, are: 22nd, Belgium (31); 24th, Hungary (25), New Zealand (25); 25th, Denmark (24), Turkey (24); 26th, Egypt (21), Philippines (21); 27th, Poland (20).

TABLE 4. (*Continued*)

Country	Number of Staff (Percent)	Rank by Number of Staff	Herbaria Listing Staff (Percent)	Average Number of Staff/ Herbarium	Average Number of Specimens/ Man	Founding Dates	
						Oldest	Youngest
14. South Africa	53 (1.7)	16	14 (100)	3.8	20,855	1855 (SAM)	1942 (RUH)
15. Austria	45 (1.4)	17	12 (92)	3.8	82,489	1748 (W)	1925 (HALLST)
16. Portugal	64 (2.0)	14	12 (92)	5.3	20,008	1772 (COI)	1948 (LISC)
17. Sweden	97 (3.1)	11	11 (100)	8.8	79,660	1758 (S)	1948 (SPL)
18. Switzerland	41 (1.3)	18	10 (91)	4.1	169,756	1588 (BAS)	1931 (ZSS)
19. Spain	38 (1.2)	19	8 (80)	4.8	25,000	1781 (MA)	1945 (SANT)
20. Czechoslovakia	34 (1.1)	20	7 (78)	4.9	133,824	1875 (PRC)	1940 (SLO)
21. Finland	30 (0.9)	23	9 (100)	3.3	67,277	1828 (H)	1934 (HEL)
22. Netherlands	98 (3.1)	10	9 (100)	10.9	27,922	1575 (L)	1923 (FNM)
TOTAL Based on Table 4	2,575 (82)	1–21, 23	627 (85)	4.1	50,949	1545	1963
TOTAL Based on All Countries	3,158 (100)	1–45	794 (85)	4.0	46,837	1545	1963

Table 5. Oldest and Youngest Herbaria.

	Location	Year of Founding	Number of Specimens
	I. Founded before 1750		
1.	Padua (PAD), Italy	1545	229,000
2.	Rome (RO), Italy	1566	400,000
3.	Bologna (BOLO), Italy	1567	———
4.	Leiden (L), Netherlands	1575	1,800,000
5.	Basel (BAS), Switzerland	1588	200,000
6.	Paris (P), France	1635	5,000,000
7.	Paris (PC), France	1635	1,200,000
8.	Floriana (ARG), Malta	1675	10,000
9.	Siena (SIAC), Italy	1691	492
10.	Amsterdam (AMD), Netherlands	1700	175,000
11.	Torino (TO), Italy	1729	50,000
12.	Reduit (MAU), Mauritius	1737	13,500
13.	Vienna (Wien: W), Austria	1748	2,500,000
	II. Founded in 1959–63[1]		
1.	Addis Ababa (ETH), Ethiopia	1959	6,000
2.	Tampa (USF), Florida, USA	1959	48,000
3.	Victoria (SCA), Cameroun	1959	1,400
4.	Arcadia (LASCA), California, USA	1960	25,000
5.	Heidelberg (HEID), Germany	1960	———
6.	Monrovia (LIB), Liberia	1960	2,500
7.	Trieste (TSB), Italy	1960	11,000
8.	Baghdad (BUA), Iraq	1962	5,000
9.	Nsukka (UNN), Nigeria	1962	———
10.	Port Victoria (SEY), Seychelles	1962	500
11.	Aarhus (AAU), Denmark	1963	25,000
12.	Brasilia (UB), Brazil	1963	20,000
13.	San Marino (HNT), California, USA	1963	500

[1] All of these but the Tampa herbarium first appeared in *Index Herbariorum* with the 5th edition (1964); the Tampa herbarium was reported in the 4th edition (1959) but without data.

TABLE 6. Herbaria Founded in Europe since 1950 (1951–63).[1]

	Location	Year of Founding	Number of Specimens
1.	Berlin (BSP), Germany	1955	3,200
2.	Avon (ABT), France	1958	20,000
3.	Funchal (MADJ), Madeira	1958	1,500
4.	Heidelberg (HEID), Germany	1960	———
5.	Trieste (TSB), Italy	1960	11,000
6.	Aarhus (AAU), Denmark	1963	25,000

[1] The earliest 12 herbaria to be founded in Europe are listed in Table 5.

TABLE 7. Oldest and Youngest Herbaria of the British Isles.

	Location	Year of Founding	Number of Specimens
	I. Founded before 1850		
1.	London (BM), England	1753	———
2.	Cambridge (CGE), England	1761	450,000
3.	Edinburgh (E), Scotland	1761	2,000,000
4.	Glasgow (GL), Scotland	1780	170,000
5.	Dublin (DUB), Ireland	1790	25,500
6.	Bristol (BRISTM), England	1820	13,400
7.	Manchester (MANCH), England	1821	3,000,000
8.	York (YRK), England	1822	8,000
9.	Norwich (NWH), England	1825	20,000
10.	Warwick (WAR), England	1836	6,000
11.	Torquay (TOR), England	1844	———
12.	Ipswich (IPS), England	1846	15,000
	II. Founded since 1950 (1951–63)		
1.	Exeter (EXR), England	1953	25,000
2.	Keele (KLE), England	1955	1,000

Table 8. Oldest and Youngest Herbaria of North America and the West Indies.[1]

	Location	Year of Founding	Number of Specimens
	I. Founded before 1850		
1.	Winston–Salem (SC), North Carolina	1772	600
2.	Charleston (CHARL), South Carolina	1773	———
3.	Middlebury (MID), Vermont	1800	3,000
4.	Philadelphia (PH), Pennsylvania	1812	1,000,000
5.	Montreal (MTMG), Quebec	1820	55,000
6.	Philadelphia (PHIL), Pennsylvania	1821	———
7.	Geneva (DH), New York	1822	16,000
8.	Boston (MCP), Massachusetts	1823	14,000
9.	West Chester (DWC), Pennsylvania	1826	12,000
10.	Amherst (AC), Massachusetts	1829	84,000
11.	Albany (NYS), New York	1836	430,000
12.	Ann Arbor (MICH), Michigan	1838	1,000,000
13.	Saint John (NBM), New Brunswick	1842	15,000
14.	Madison (WIS), Wisconsin	1849	360,000
	II. Founded since 1950 (1951–63)		
1.	Calgary (UAC), Alberta	1951	12,000
2.	Sioux Falls (AUG), South Dakota	1951	1,000
3.	Calgary (CFB), Alberta	1952	5,000
4.	Halifax (NSPM), Nova Scotia	1952	———
5.	Ottawa (CCO), Ontario	1952	10,000
6.	Quebec (QFB), Quebec	1952	12,000
7.	Baton Rouge (LSUM), Louisiana	1954	5,000
8.	Saint John's (NFLD), Newfoundland	1954	8,000
9.	Chicago (CHI), Illinois	1955	20,000
10.	Swarthmore (SWC), Pennsylvania	1955	4,200
11.	Mayaguez (FPDB), Puerto Rico	1958	4,000
12.	Saskatoon (SAFB), Saskatchewan	1958	2,000
13.	Tampa (USF), Florida	1959	48,000
14.	Arcadia (LASCA), California	1960	25,000
15.	San Marino (HNT), California	1963	500

[1] No herbaria were founded in Mexico or Central America during these years.

TABLE 9. Oldest and Youngest Herbaria of Asia.

	Location	Year of Founding	Number of Specimens
	I. Founded before 1900		
1.	Calcutta (CAL), India	1793	1,000,000
2.	Dehra Dun (DD), India	1816	300,000
3.	Peradeniya (PDA), Ceylon	1817	85,000
4.	Eskisehir (ESK), Turkey	1832	725
5.	Coimbatore (MH), India	1874	124,525
6	Tokyo (TH), Japan	1875	10,000
7.	Sapporo (SAP), Japan	1876	130,000
8.	Sapporo (SAPA), Japan	1876	85,000
9.	Tokyo (TI), Japan	1877	500,000
10.	Hong Kong (HK), Hong Kong	1878	30,000
11.	Simonoseki (YAM), Japan	1883	12,000
12.	Tomsk (TK), USSR	1885	357,000
13.	Rawalpindi (RAW), Pakistan	1893	60,000
	II. Founded since 1950 (1951–63)		
1.	Istanbul (ISTO), Turkey	1952	2,800
2.	Allahabad (BSA), India	1955	7,072
3.	Yokohama (YNU), Japan	1955	10,000
4.	Dehra Dun (BSD), India	1956	22,125
5.	Poona (BSI), India	1956	85,000
6.	Shillong (ASSAM), India	1956	70,130
7.	Tokyo (MAK), Japan	1958	380,000
8.	Baghdad (BUA), Iraq	1962	5,000

Table 10. Oldest and Youngest Herbaria of Australasia and the Pacific Islands.

	Location	Year of Founding	Number of Specimens
	I. Founded before 1900		
1.	Bogor (BO), Indonesia	1817	1,000,000
2.	Melbourne (MEL), Australia	1857	1,500,000
3.	Wellington (WELT), New Zealand	1865	200,000
4.	Christchurch (CANTY), New Zealand	1867	20,000
5.	Singapore (SING), Malaya	1875	400,000
6.	Adelaide (AD-U), Australia	1875	———
7.	Brisbane (BRI), Australia	1880	500,000
8.	Auckland (AKU), New Zealand	1883	12,500
9.	Honolulu (BISH), Hawaii	1889	160,000
10.	Rydalmere (DAR), Australia	1890	9,000
11.	Kuching (SAR), Sarawak, Borneo	1895	25,000
12.	Sidney (NSW), Australia	1896	750,000
	II. Founded since 1950 (1951–63)		
1.	Adelaide (AD), Australia	1954	150,000
2.	Alice Springs (NT), Australia	1954	15,000
3.	Laguna (CLP), Philippines	1954	1,000

Table 11. Oldest and Youngest Herbaria of Africa.

	Location	Year of Founding	Number of Specimens
	I. Founded before 1900		
1.	Cape Town (SAM), South Africa	1855	———
2.	Cape Town (BOL), South Africa	1867	137,000
3.	Durban (NH), South Africa	1882	89,000
4.	Grahamstown (GRA), South Africa	1889	100,000
5.	Kampala (KAW), Uganda	1898	25,000
	II. Founded since 1950 (1951–63)		
1.	Cairo (CAIH), Egypt	1951	16,000
2.	Lourenco Marques (LM), Mozambique	1951	20,000
3.	Mahalapye (MAH), Bechuanaland	1951	1,345
4.	Salisbury (CAH), Southern Rhodesia	1955	12,000
5.	Dedza (NYAS), Nyasaland	1956	4,500
6.	Elisabethville (EBV), Congo	1956	30,000
7.	Rabat (RAU), Morocco	1957	———
8.	Luanda (LUAI), Angola	1958	12,000
9.	Addis Ababa (ETH), Ethiopia	1959	6,000
10.	Victoria (SCA), Cameroun	1959	1,400
11.	Monrovia (LIB), Liberia	1960	2,500
12.	Nsukka (UNN), Nigeria	1962	———

TABLE 12. Oldest and Youngest Herbaria of South America.

	Location	Year of Founding	Number of Specimens
	I. Founded before 1900		
1.	Rio de Janeiro (RB), Brazil	1808	115,000
2.	Buenos Aires (BA), Argentina	1812	80,000
3.	Santiago (SGO), Chile	1830	68,742
4.	Rio de Janeiro (R), Brazil	1842	350,000
5.	Cordoba (CORD), Argentina	1870	135,000
6.	Belem (MG), Brazil	1871	33,500
7.	Georgetown (BRG), British Guiana	1879	25,000
8.	La Plata (LP), Argentina	1884	220,000
9.	Montevideo (MVM), Uruguay	1890	50,000
10.	Buenos Aires (BAB), Argentina	1899	140,000
	II. Founded since 1950 (1951–63)		
1.	Buenos Aires (IAA), Argentina	1951	600
2.	Paraopeba (PMG), Brazil	1951	6,500
3.	Cruz Das Almas (IAL), Brazil	1952	8,000
4.	Curitiba (IPB), Brazil	1952	5,000
5.	Salvador (BAH), Brazil	1952	2,490
6.	Manaus (INPA), Brazil	1954	13,018
7.	Porto Alegre (BLA), Brazil	1954	2,500
8.	Recife (URM), Brazil	1954	32,000
9.	Buenos Aires (BAFC), Argentina	1955	5,000
10.	Rio de Janeiro (HB), Brazil	1958	25,000
11.	Brasilia (UB), Brazil	1963	20,000

TABLE 13. Largest Herbaria in the World.[1]

	Location	Year of Founding	Number of Specimens	Rank by Size	Number of Staff
1.	Kew (K), England	1853	6,500,000	1	41
2.	Leningrad (LE), USSR[2]	1823	6,000,000	2	34
3.	Paris (P), France	1635	5,000,000	3	22
4.	Geneva (G), Switzerland	1817	4,000,000	4	5
5.	Lyon (LY), France	1925	3,800,000	5	2
	[Cambridge (A, AMES, ECON, FH, GH, NEBC),[3] Massachusetts, USA	1864–1923	3,540,150		32]
6.	Florence (FI), Italy	1842	3,500,000	6	6
7.	Montpellier (MPU), France[4]	1890	3,150,000	7	46
8.	Manchester (MANCH), England	1821	3,000,000	8	3
9.	New York (NY), New York, USA	1891	3,000,000	8	11
10.	Washington (US), D. C., USA	1868	3,000,000	8	21
11.	Stockholm (S), Sweden	1758	2,850,000	9	9
12.	Vienna (W), Austria	1748	2,500,000	10	9
13.	Chicago (F), Illinois, USA	1893	2,350,000	11	5
14.	Budapest (BP), Hungary	1870	2,000,000	12	11
15.	Edinburgh (E), Scotland	1761	2,000,000	12	12
16.	Jena (JE), Germany	1895	2,000,000	12	1

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[1] List includes 9 top-ranking herbaria of North America, which together represent 7 different size ranks. Ranking 10th, with 750,000 specimens (size rank 8), is Stanford (DS), California, USA, founded in 1896, with 5 staff members; 11th, with 700,000 specimens (size rank 9), is Cambridge (A), Massachusetts, USA, founded in 1872, with 10 staff members; and 12th, with 675,000 specimens (size rank 10), is Beltsville (BPI), Maryland, USA, founded in 1869, with 8 staff members. The top-ranking Canadian herbarium, founded at Montreal (MT), Quebec, in 1920, is 13th, with 600,000 specimens (size rank 11 for North America) and has 3 staff members; worldwide, MT is the 50th largest herbarium and falls into the 31st size rank.

[2] Figures in *Index Herbariorum* (1964) and other sources (*cf.* Shetler 1967) indicate that the Leningrad herbarium has about 6 million specimens, but more recently the number 5 million is being claimed (Lipschitz and Vassilczenko 1968).

[3] When combined as one, herbaria of Harvard University rank here, but see comments in text under "Size of Collections."

[4] Staff size includes several faculties and is misleading.

Table 13. (*Continued*)

	Location	Year of Founding	Number of Specimens	Rank by Size	Number of Staff
17.	Prague (PRC), Czechoslovakia	1775	2,000,000	12	17
18.	Leiden (L), Netherlands	1575	1,800,000	13	30
19.	St. Louis (MO), Missouri, USA	1859	1,700,000	14	6
20.	Brussels (BR), Belgium	1870	1,600,000	15	15
21.	Copenhagen (C), Denmark	1759	1,500,000	16	16
22.	Lund (LD), Sweden	1770	1,500,000	16	34
23.	Melbourne (MEL), Australia	1857	1,500,000	16	6
24.	Munich (M), Germany	1813	1,500,000	16	12
25.	Zürich (Z), Switzerland	1834	1,500,000	16	9
26.	Cambridge (GH), Massachusetts, USA	1864	1,485,000	17	11
27.	Helsinki (H), Finland	1828	1,400,000	18	14
28.	Uppsala (UPS), Sweden	1785	1,400,000	18	18
29.	Prague (PR), Czechoslovakia	1818	1,300,000	19	3
30.	Berlin (B), Germany	1815	1,250,000	20	16
31.	Berkeley (UC), California, USA	1872	1,225,000	21	11
32.	Paris (PC), France	1635	1,200,000	22	29
33.	Cambridge (FH), Massachusetts, USA	1919	1,012,150	23	1
34.	Ann Arbor (MICH), Michigan, USA	1838	1,000,000	24	7
35.	Bogor (BO), Indonesia	1817	1,000,000	24	6
36.	Calcutta (CAL), India	1793	1,000,000	24	11
37.	Göteborg (GB), Sweden	1926	1,000,000	24	3
38.	Oslo (O), Norway	1863	1,000,000	24	9
39.	Philadelphia (PH), Pennsylvania, USA	1812	1,000,000	24	9
	TOTAL: 1–17		56,650,000		255
	TOTAL: 1–39		85,522,150		531

TABLE 14. Comparison of Geographical Distribution of First 100 and Last 100 Herbarium Foundings.

Continent or Region	First 100 Herbaria (1545–1840)	Last 100 Herbaria (1947–1963)[1]
Africa	0	17
Asia	4	13
Australia	0	3
British Isles	10	2
Central America	0	1
Europe	69	13
Malaysia–New Guinea	1	2
Mauritius	1	0
Mexico	0	2
North America (excl. Mexico)	12	26
Seychelles	0	1
South America	3	15
West Indies	0	2

[1] The "Last 100" really number only 99, because to add one more would have required selecting one from among the 12 founded in different parts of the world in 1946.

TABLE 15. Frequency Distribution of Herbaria by Size of Collection.

No. Specimens in Herbarium	No. Herbaria		Percent Total Herbaria	
	Actual	Cumulative	Actual	Cumulative
0–1,000	19	19	2.6	2.6
1,001–25,000	295	314	40.7	43.3
25,001–100,000	202	516	27.9	71.2
100,001–250,000	102	618	14.1	85.3
250,001–500,000	53	671	7.3	92.6
500,001–1,000,000	20	691	2.8	95.4
1,000,001–2,000,000	20	711	2.8	98.2
2,000,001–3,000,000	6	717	0.8	99.0
3,000,001–4,000,000	4	721	0.6	99.6
4,000,001–6,500,000	3	724	0.4	100.0

TABLE 16. Herbaria with 20 or More Staff Members.

	Herbarium Abbreviation and Location	Number of Staff		Number of Specimens
		Actual	Ideal	
1.	MPU, Montpellier, France	46	67	3,150,000
2.	SP, São Paulo, Brazil	45	2	85,000
3.	K, Kew, England	41	139	6,500,000
4.	LE, Leningrad, USSR	34	128	6,000,000[1]
5.	LD, Lund, Sweden	34	32	1,500,000
6.	L, Leiden, Netherlands	30	38	1,800,000
7.	PC, Paris, France (cryptogams)	29	26	1,200,000
8.	P, Paris, France (phanerogams)	22	107	5,000,000
9.	U, Utrecht, Netherlands	22	7	350,000
10.	BAB, Buenos Aires, Argentina	21	3	140,000
11.	US, Washington, D. C., USA	21	64	3,000,000
	TOTALS	345	613	28,725,000

[1] Probably should be 5,000,000; *see* footnote, Table 13.

SUMMARY

By Daniel M. Cohen and Ernest A. Lachner
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The stage for the Symposium was set by Ritterbush, who placed the topic in broad perspective. He postulated the basis for the foundation of early collections as naive interest in the "rare and fabulous," bound by a stylized and symbolic concept of natural objects. He made the point that collections had no scientific value until art and nature were divorced and collections were acknowledged as examples of the content and diversity of the real world of nature.

The earliest scientific uses of natural history collections still constitute a prime reason for their existence. To this must be added, however, the early discovery that patterns of similarities and differences among organisms could be organized into heirarchies, which serve as basic documentation for the theory of evolution. Most speakers proceeded from these two basic assumptions. Even so, Rosewater for mollusks and Duckworth for entomology pointed out that descriptive and synthetic studies in which collections are used in traditional ways are far from complete and that existing resources are by no means commensurate with the uncompleted task. Yochelson and Hotton emphasized that in the elucidation and comprehension of phylogeny, fossil collections are unique in allowing consideration of the time dimension. The fossil record is sparse and intermittent; additional collecting is vital. Continued re-evaluation of existing collections of both fossil and Recent organisms is necessary.

Several speakers described the practical value of collections. Becklund, in particular, through use of color transparencies in his presentation, vividly demonstrated the importance of an animal parasite collection. He also described a system of curating that maintains high standards of documentation and allows easy access to stored materials. Yochelson discussed the value of fossils in aging geological formations and Zusi and Duckworth pointed out the value to agriculture of collection-based studies on birds and insects. The importance of collections as biological standards was treated by Cowan.

Sturtevant reviewed the degree of dependence upon collections of the various branches of anthropology and concluded that although collections are necessary for some kinds of research, they are now subordinate to the main objectives of anthropology. He reasoned that over-all, anthropology can not prosper in a collection-oriented natural history museum, and that anthropological collections and those who use them belong in a framework of man-centered studies. He pointed out, however, many parellel problems in the acquisition and storage of anthropological and natural history collections. The plight of anthropological collections is even more serious than that of plant and animal collections, for even though they constitute an irreplaceable resource which is potentially the basis for much important research, there is presently little interest in collection-based research in anthropology. Therefore, interest is correspondingly small in supplementing and maintaining collections.

Proceeding under the assumption that collections are necessary for the solution of problems in both basic and applied science, speakers demonstrated the inadequacy of existing facilities and suggested ways of meeting the increasingly burdensome problems of housekeeping. Shetler, in particular, presented hard facts and figures documenting the burden carried by herbariums. Yochelson reviewed the plight of fossil collections and made a growth projection.

Few museum administrators or systematists would propose a halt to collection growth. The problems then are how much should collections grow and how can they efficiently be used and maintained?

Several speakers discussed selective collection growth by group or geographical region and advocated specialization by museums. We suggest that although this may help efficient use of collections, it hardly contributes to a solution of the space problem. Little is gained if the reduction of crowding in one museum increases it in another. Zusi found that even in a group as well known as birds, general collections are still important. He also commented that studies of the comparative biology of organisms will require not only the maintenance of traditional kinds of museum collections but also the storage of specimens prepared in many ways. Data taken from living organisms will also require systematic storage. In birds for example, photographs, tapes of songs, and samples of egg whites and blood will require permanent or temporary curating and storage. Duckworth commented on similar problems in insects, particularly regarding different morphological stages in the insect's life history. Modern procedures in taxonomy, combined with greater ease of data processing, not only allow, but demand the consideration of larger samples than in the past. Then too, as man modifies the earth with increasing vigor, species once so common that they were barely worth retaining in collections are now found only in collections. Specimens that today may be considered candidates for the trash can could be our only prepollution (chemical-nuclear-thermal) record of a disappearing environment—a biological base line of irreplaceable value. Sturtevant made analogous comments on collecting anthropological objects.

Much of the ultimate value of collections lies in what we do not know about them. Given such a situation, the specialists' educated guess is our best guide as to what and how much to save. Regarding our present level of attainment in systematics, there is no doubt that collection size must not remain on a plateau based on present holdings. Expand they must!

We suggest that many major collections are not efficiently housed. Historically, research collections grew in association with display museums and are located in the high-density population centers of cities, where land costs are high and architectural requirements dictate the construction of elegant, prohibitively expensive structures. Little imagination would be required to house researchers, libraries and larger collections in less costly quarters—away from display museums. Divorcing the two may sacrifice part of a museum's integrity, but this is far less costly than arbitrarily stopping growth of collections.

Good housekeeping was stressed by many speakers as vital to maintaining access to collections and information about them. The recognition of professional collection managers was suggested several times as a step that would relieve researchers of routine curating. The most widely discussed measure was electronic data processing (EDP). Shetler viewed it as a significant innovation in collection and information maintenance on an international basis. Manning described an EDP project currently in operation, and Sturtevant noted its use in anthropological collections. Zusi questioned the general applicability of EDP to bird collections but suggested that it could be useful in some research projects. Becklund and Yochelson felt that cost mitigates against EDP for their special curatorial needs. Unfortunately, no cost figures for EDP were presented. Any thorough assessment of the future of EDP in the management of collections must be based on the premise that, although EDP can supplement collections, it cannot replace them. Also, the quality of information coming out of a system is limited by the quality of information fed into it.

In conclusion, we note that to maintain natural history collections adequately is expensive; to neglect them is too costly to contemplate. The compromise of funding them inadequately is coming increasingly nearer the latter alternative.

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PROCEEDINGS
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THE IDENTITY OF *OLIGODON CYCLURUS* (CANTOR, 1839) AND REVALIDATION OF *OLIGODON BREVICAUDA* (STEINDACHNER, 1867) (SERPENTES: COLUBRIDAE)

By Simon M. Campden-Main
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Simotes brevicauda was described by Steindachner (1867: 61) on the basis of a single specimen lacking precise locality data from "Cochinchina." Boulenger (1894:219) placed it in the synonymy of *Simotes cyclurus* (Cantor). Since that time, Steindachner's *brevicauda* has appeared in the literature only as a synonym of *Oligodon cyclurus* (Cantor). I have recently examined its holotype, and find that it represents a valid species of the genus *Oligodon*. *Oligodon brevicauda* (Steindachner) is a secondary homonym of *Oligodon brevicauda* Günther (1862:58), and a new name must be proposed.

Oligodon analepticos new name

Simotes brevicauda Steindachner 1867:61.

Holotype: Nat. Mus. Wien 16530 from "Cochinchina," collected by Verreaux in 1865.

Diagnosis: Scales smooth, in 19 rows at neck, reducing to 17 rows between 80th and 97th ventral, reducing to 15 rows between 95th and 117th ventral. Maxillary teeth 10 or 11, last three abruptly enlarged and recurved. Venter immaculate.

Redescription of holotype: Rostral large; visible from above. Parietals longer than frontal; distance from frontal to rostral less than half length of frontal. Loreal present. Eight upper labials, fourth and fifth bordering eye. Eye also bordered by presubocular, preocular, supraocular and two postoculars. Temporals $\frac{2}{1} + 2$. Scales smooth, reducing as follows $19 \frac{3+4(93)}{3+4(92)} 17 \frac{4+5(114)}{4+5(113)} 15$. Ten maxillary teeth. Ventrals 162; caudals 44. Twelve dark brown blotches on body, separated by series of three darker reticulations; two dorsal blotches on tail. Venter immaculate. Length of head 22.7 mm. Length of tail 71.0 mm. Total length 620.0 mm. Sex: female.

Additional specimens referred to O. analepticos: Nat. Mus. Wien 19166:1–4, Annam; USNM 95080, 90409, Bao Loc; USNM 146178–79, Fyan; Nat. Mus. Wien 19167:1, 19167:2, Phuc Son; USNM 144218, 13 km. west Poste M'Drak; USNM 164373, near Bong Son; USNM 163859, near Chu Lai. All localities are in Vietnam.

There has been, and still is, considerable confusion as to the validity of several taxa now referred to the genus *Oligodon*. Perhaps the most confusing are the members of the *cyclurus* group. This is at least partially due to the inadequate original description of Cantor (1839:50), in which he described *Coronella cyclura* but failed to designate a type locality. Subsequently the holotype of *cyclura* has been lost, leaving very little on which to form an opinion as to the identity of Cantor's species. In the interest of nomenclatural stability, it seems best to designate a neotype, thus establishing a type locality in the area where most specimens that recent workers have assigned to *cyclurus* have been collected. I, therefore, designate as the neotype USNM 72067, a male collected in Bangkok, Thailand, by Hugh M. Smith on September 8, 1934.

Oligodon cyclurus (Cantor)

Coronella cyclura Cantor, 1839:50.
Oligodon cyclurus-Smith, 1943:202.

Neotype: USNM 72067 from Bangkok, Thailand, collected by H. M. Smith, September 8, 1934.

Diagnosis: Scales smooth, in 21 rows at neck, reducing to 19 rows between 95th and 113th ventral, reducing to 17 rows between 108th and 152nd ventral. Maxillary teeth 10, rarely 9 or 11, last three abruptly enlarged and recurved. Venter immaculate.

Description of neotype: Rostral large, visible from above. Parietals longer than frontal; distance from frontal to rostral less than half length of frontal. Loreal present. Eight upper labials, fourth and fifth bordering eye. Eye also bordered by presubocular, preocular, supraocular, and two postoculars. Temporals $2 + \frac{1}{2}$. Scales smooth reducing as follows $21\,\frac{4+5(105)}{4+5(105)}\,19\,\frac{4+5(111)}{4+5(112)}\,17$. Ten maxillary teeth. Ventrals 162; caudals 44. Fourteen dark brown dorsal blotches on body, separated by series of three darker reticulations; four dorsal blotches on tail. Venter immaculate. Length of head 17.5 mm. Length of tail 71.0 mm. Total length 456.0 mm. Sex: male.

Additional specimens referred to O. cyclurus*:* USNM 70324, 70326, 72066–72069, 75683, 75684, 76122, 79472–79474, 81838, 83432, 94757, 94758, 100994, 101287, Bangkok; USNM 70355, 101290, Lam Tong Lam; USNM 94931, Sam Roi Yot; USNM 76090, Pichit. All localities are in Thailand.

Oligodon analepticos may easily be distinguished from *O. cyclurus* by both geography and by dorsal scale row count. In all specimens examined from Thailand and Laos the dorsals reduce from 21 to 19 then to 17, as opposed to all South Vietnamese specimens which reduce from 19 to 17 then to 15 scale rows. On the basis of material examined sympatry can not be demonstrated.

I am indebted to Dr. Joseph Eiselt (Naturhistorisches Museum, Wien, Austria) for the loan of the holotype of *Simotes brevicauda* Steindachner, and other material. Drs. J. A. Peters and G. Zug reviewed and commented on the manuscript.

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PROCEEDINGS
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DESCRIPTIONS OF ADDITIONAL FORMS OF BIRDS FROM PANAMÁ AND COLOMBIA

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The descriptions and other information presented in the following pages have come to my attention during continuing studies of the collections of birds from Panamá and Colombia in the U.S. National Museum. They include comparisons made in collections in other institutions, in addition to those available in Washington.

Metallura primolinus recisa new subspecies

Characters: Similar to *Metallura primolinus primolinus* Bourcier,[1] but with bill shorter and more slender; slightly duller green on dorsal surface; male with dark throat patch smaller, narrower.

Description: Type, USNM 436,301, ♂, from Páramo de Frontino, 3600 meters elevation, Antioquia, Colombia, collected by M. A. Carriker, Jr., 29 August 1951 (original number 21030). Upper surface from the forehead to the upper tail coverts, including the lesser wing coverts, metallic dark cress green; upper surface of tail dull metallic green; primaries, secondaries and greater wing coverts dull purplish black; middle wing coverts faintly dull bronze; feathers in front of eye tipped with rufous; under surface, including under wing coverts, like back, but faintly more yellowish green; a narrow, elongated gorget, extending from the chin down the center of the foreneck, viewed by direct illumination, shining light metallic green; seen from the opposite angle, dull black, the individual feathers tipped and edged lightly with cinnamon; center of abdomen barred centrally with dull green, tipped narrowly with dull cinnamon-buff, producing a mixed pattern; a prominent white tibial tuft on either side; under tail coverts basally dark metallic green, tipped with cinnamon; edge of wing lined narrowly with cinnamon; under surface of tail bright metallic green.

Female, foreneck pale cinnamon, with the individual feathers tipped

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[1] *Metallura primolinus* Bourcier, Rev. et Mag. Zool., ser. 2, vol. 5, July, 1853, p. 295. (Vicinity of Laguano, Napo, Ecuador.)

with a spot of metallic dark green; breast similar, but with the base color pale cinnamon, varying to white, and the green spots much larger, in some areas covering the base color; otherwise like the male.

Immature male, with no gorget, and with very slight indication of the markings of the female on foreneck and breast.

Measurements: Males (8 specimens), wing 54.9–60.2 (58.2), tail 36.2–40.7 (39.2), culmen from base 14.2–15.2 (14.8) mm.

Females (7 specimens), wing 54.0–57.0 (55.0), tail 35.1–37.9 (36.7), culmen from base 13.8–15.0 (14.7) mm.

Range: The higher levels of the Páramo de Frontino, in the Cordillera Occidental, western Antioquia, Colombia.

Remarks: Typical *Metallura primolinus primolinus* is known mainly from specimens taken in the Andean chain in northern Ecuador, mountains which in effect continue directly north through Colombia as the Cordillera Central. The record for the species in the Páramo de Frontino is the most northern at present, and is in the western division of the Cordillera. It seems probable that *M. p. recisa* is confined to the latter range.

Peters (1945, p. 119) lists *primolinus* as a race of *williami*, a species of similar general appearance but with the tail wholly deep blue, being brilliant shining blue on the under surface. The entirely green tail of the populations of *primolinus* are so definitely distinct in the specimens seen that it is appropriate to treat it as a separate species.

It should be noted that Bourcier named *Metallura primolinus* in honor of the son of Count Primoli, grandson of Prince Charles Lucien Bonaparte. As the word is of masculine gender it stands in apposition to the generic name.

Measurements of typical *M. p. primolinus* from Ecuador are as follows: Males (4 specimens), wing 55.4–59.9 (58.5), tail 36.6–39.5 (38.4), culmen from base 16.3–17.4 (17.0) mm.
Females (11 specimens), wing 55.3–58.0 (56.7), tail 35.0–39.6 (36.9), culmen from base 15.8–17.5 (16.8) mm.

Etymology: The subspecific name for this race is from the Latin adjective *recisus*, meaning short, in reference to the bill.

Specimens examined in comparisons: Metallura primolinus primolinus, Ecuador—above Baeza, ♂, 3 ♀; Papallacta, 5 ♂, 7 ♀.

Sittasomus griseicapillus enochrus new subspecies

Characters: Similar to *Sittasomus griseicapillus veraguensis* Aldrich,[2] but with the under surface from throat to abdomen paler, more greenish; under tail coverts lighter, more cinnamon-brown; crown, hindneck and back paler, faintly more greenish gray; rump and upper tail coverts lighter cinnamon-brown.

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[2] *Sittasomus griseicapillus veraguensis* Aldrich, Sci. Publ. Cleveland Mus. Nat. Hist., vol. 7, 31 August, 1937, p. 83. (Río Mariato, 16 kilometers east of Golfo de Montijo, Veraguas, Panamá.)

Description: Holotype, USNM 411264, ♂, from 6 kilometers north of Colosó, northern Department of Bolívar, Colombia, collected 20 October 1948, by M. A. Carriker, Jr. (original number 14127). Crown and hindneck dark grayish olive; back and scapulars dull buffy brown; rump and upper tail coverts tawny; lesser and middle wing coverts hair brown; greater coverts and primary coverts with inner webs chaetura drab, outer webs drab; secondaries externally between russet and tawny; inner webs distally fuscous-black except at tip; primaries fuscous-black, with the outer webs dull ochraceous-tawny; foreneck and breast light grayish olive; abdomen washed lightly with deep olive-buff; under tail coverts ochraceous-tawny; inner under wing coverts very pale buffy white, changing externally to grayish olive; inner webs of secondaries and primaries toward base light ochraceous-buff.

Measurements: Males (3 specimens), wing 75.6–81.0 (79.1), tail 71.8–75.0 (73.2), culmen from base 16.0–16.2 (16.1), tarsus 16.1–16.8 (16.5) mm.

Female (1 specimen), wing 72.3, tail 67.5, culmen from base 15.8, tarsus 16.2 mm.

Remarks: As a species *Sittasomus griseicapillus*, the Olivaceous Woodcreeper, has been little known in northern Colombia. Currently, the few records have been listed under the subspecies name *levis*, which is the race now confined to the Province of Chiriquí in western Panamá, with *S. g. veraguensis* covering the area from eastern Veraguas east through Darién. As I have found *veraguensis* in Darién on Cerro Malí, a spur of Cerro Tacarcuna on the border between Panamá and Colombia, it is probable that *veraguensis* extends into the latter country.

In addition, in the series of specimens collected by M. A. Carriker, Jr., I find that, as listed beyond, *S. g. tachirensis* Phelps and Phelps, Jr., named from Táchira in western Venezuela, ranges west to the central Magdalena valley in Colombia. Further, the somewhat darker population *S. g. perijanus* Phelps and Gilliard, described from the Venezuelan side of the Sierra de Perijá, extends across to the Colombian side of this mountain range in northwestern Magdalena and western Guajira.

It is probable that the race *enochrus* occupies the area from northern Bolívar west through northern Córdoba. In size it is like *veraguensis*, in which the wing in males ranges from 74.0 to 80.4, with an average of 78.0 mm. The other two here recorded for Colombia are slightly larger, as shown by the following measurements of males:

Sittasomus g. tachirensis (8 specimens), wing 80.2–86.8 (83.6) mm.
Sittasomus g. perijanus (5 specimens), wing 78.6–87.7 (82.5) mm.

Etymology: The name for this race has been taken from the Greek *enochros*, meaning rather pale.

Specimens examined in comparisons: Sittasomus griseicapillus levis, Panamá—Chiriquí: Sereno, ♀; Santa Clara, 2 ♂; El Volcán, 8 ♂, 10 ♀; Boquete, 3 ♂, ♀.

Sittasomus griseicapillus veraguensis, Panamá—Los Santos: Los Asientos, ♂, ♀. Herrera: Parita, ♂; Portobellilo, ♀. Province of Panamá:

La Campana, ♂; Utivé, ♂; Pacora, ♂; Chepo, ♂, ♀; Chimán, ♂. Darién: Cerro Malí, ♂, ♀; Cana, ♂, ♀.

Sittasomus griseicapillus tachirensis, Colombia—Caldas: Hacienda Sofía, 2 ♂, ♀. Antioquia: La Bodega, ♂, ♀. Bolívar: Volador, 2 ♂. Norte de Santander: Convención, 2 ♀; Guamalito, ♂, ♀; Buenos Aires, 3 ♂.

Glyphorhynchus spirurus pallidulus new subspecies

Characters: Similar to *Glyphorhynchus spirurus sublestus* Peters,[3] but paler, more grayish olive on lower surface; above, paler, less reddish brown; rump and upper tail coverts brighter, lighter cinnamon-rufous; chin and upper throat slightly paler buff.

Description: Holotype, USNM 423458, ♂, from Charco del Toro, Río Majé, Province of Panamá, Panamá, collected 28 March 1950, by A. Wetmore and W. M. Perrygo (original number 16004). Forehead, adjacent to base of bill, very narrowly pale gray; crown olive-brown; forehead with very narrow, faint shaft lines of pale buff; hindneck, back, scapulars and wing coverts between bister and snuff brown; alula Saccardo's umber; primary coverts dull black, with outer webs between bister and snuff brown; rump and upper tail coverts between tawny and russet; secondaries russet; primaries deep olive, with outer webs cinnamon-brown; tail russet, with shafts ferruginous; narrow superciliary streak dull buff; side of head behind eye olive-brown, the auricular area streaked lightly with dull gray; chin and upper throat pinkish buff, spotted lightly with olive-brown; lower foreneck, uppermost breast, and side of neck somewhat dark buffy brown, with lanceolate shaft lines of buffy white, narrower laterally, broader at center; lower breast, sides and abdomen grayish brown (between buffy brown and citrine-drab) with narrow dull white shaft lines on breast; under tail coverts Dresden brown, with shaft lines of dull white; axillars and under wing coverts white, with a spot of sepia on outer side near center; a band of pale cinnamon-buff across the inner webs of the secondaries and inner primaries.

Measurements: Males (17 from eastern provinces of Panamá and Colón, Darién and San Blas), wing 71.7–75.5 (73.9), tail 62.8–69.9 (66.6), culmen from base 12.3–14.2 (13.0), tarsus 16.5–17.8 (17.2) mm.

Females (20 from eastern Province of Panamá, Darién and San Blas), wing 64.6–73.8 (69.5), tail 59.0–68.0 (62.6), culmen from base 12.2–13.5 (12.9), tarsus 16.0–17.7 (16.7) mm.

Holotype, male, wing 74.2, tail 67.4, culmen from base 14.2, tarsus 17.5 mm.

Range: Tropical lowlands; on the Pacific slope through eastern Province of Panamá from the Cerro Azul through Darién (except the southwest on the Río Jaqué); on the Caribbean side in eastern Colón, including the Chagres Valley back of Madden Lake, and San Blas,

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[3] *Glyphorhynchus spirurus sublestus* Peters, Bull. Mus. Comp. Zoöl., vol. 69, October 1929, p. 443. (Changuinola, Bocas del Toro, Panamá.)

extending in Colombia to the extreme northern tip of Chocó (Acandí, Río Cutí, eastern slope of Cerro Tacarcuna); ranging to 1450 meters in mountain areas.

Remarks: The Wedge-billed Woodcreeper is the most abundant species of its family through the Isthmus of Panamá, found in the more humid areas wherever there is forest cover. Three populations, differing slightly in color, inhabit the region.

Glyphorhynchus spirurus sublestus Peters, darker, more reddish brown above, darker on the lower surface, with the throat more cinnamon-buff, ranges through the lower levels of Costa Rica and western Panamá, on the western slope to the base of the volcano in Chiriquí, on the Caribbean side through the northern Canal Zone to Cerro Bruja in eastern Colón, where it intergrades with the paler *pallidulus.* At the eastern end of its range in northwestern Colombia the race *pallidulus* merges with another darker race *Glyphorhynchus spirurus subrufescens,* which is more olive, less reddish brown above, and more olive on the ventral surface than the race *sublestus.* It also is slightly smaller, with the wing in males 66.1 to 71.8 (average 69.0) mm., and in females 63.5 to 69.5 (average 66.2) mm. This form comes into southeastern Darién in the valley of the Río Jaqué. From there it ranges south along the Pacific slope of Colombia to the Department of Nariño, probably to northwestern Ecuador. Eastward it extends through the lower Atrato valley in northern Antioquia (Villa Artiaga) and northern Chocó. Another variant appears in the Sinú Valley in the Department of Córdoba and eastern Antioquia, recognized as *Glyphorhynchus spirurus integratus.* This group, paler above and below than *subrufescens,* with the throat paler buff (but darker than *pallidulus*), ranges through the departments of Bolívar to Santander and Norte de Santander into western Venezuela.

Etymology: The subspecific name for the race described above has been taken from the Latin adjective *pallidulus,* somewhat pale, from its lighter colors.

Specimens examined in comparisons: Glyphorhynchus spirurus sublestus, Costa Rica—La Vijagua, 3 ♂, 3 ♀; Pozo Azul, ♂; Río Matina, ♂; Bonilla, 2 ♀; Buenos Aires, ♀; Pacuare, ♀; Jiménez, ♂; Reventazón, ♂, ♀; Talamanca, ♂. Panamá—Chiriquí: El Volcán, 2 ♂; Santa Clara, ♀; Puerto Armuelles, ♀. Coclé: Río Guabal, ♂; El Uracillo, ♂. Canal Zone: Gatun, 3 ♂, 3 ♀; Lion Hill, ♂. Colón: Cerro Bruja, 2 ♀.

Glyphorhynchus spirurus subrufescens, Panamá—Darién: Jaqué, ♀; Río Jaqué, 2 ♀. Colombia—Antioquia: Hacienda Potreros, ♂; Villa Artiaga, 6 ♂, 3 ♀. Chocó: Río Jurubidá, 2 ♂, 4 ♀; Río Nuquí, ♂, 4 ♀. Valle: Punto Muchimbo, ♂. Nariño: La Guayacana, 2 ♂, 2 ♀. Córdoba: Socarré (Río Sinú), ♂, ♀; Quebrada Salvajín (Río Sinú), ♂, ♀.

Glyphorhynchus spirurus integratus, Colombia—Antioquia: El Pescado, ♂, ♀; Valdivia, ♂; Hacienda Belén, 3 ♂; El Real, 2 ♂; La Raya, 6 ♂, 5 ♀; Regeneración, 2 ♂. Bolívar: Volador, ♀. Santander: Hacienda Santana, 6 ♂, 5 ♀. Norte de Santander: Petrólea, ♀; Bellavista, 2 ♂.

Xenops rutilans incomptus new subspecies

Characters: Similar to *Xenops rutilans septentrionalis* Zimmer,[4] but smaller; pale streaks on lower surface, crown and back narrower; rump and upper tail coverts faintly darker.

Description: Holotype, Museum of Comparative Zoology No. 140709, ♂, from Cana, Cerro Pirre, Darién, Panamá, collected 31 July 1928, by R. R. Benson (original number 460). Crown and hindneck sooty brown, streaked narrowly with pale brownish buff; back and scapulars dull cinnamon-brown, with the upper back streaked narrowly with cinnamon-buff; rump, upper tail coverts and tail cinnamon-rufous; inner web of third and fourth rectrices from outside black; fifth rectrix lined centrally on inner web with dusky; wing coverts with outer webs like back, inner webs dusky; secondaries cinnamon-rufous with a concealed distal spot of black; primaries with inner webs black, outer webs cinnamon-rufous; lores, and a streak from center of eye back along side of crown, dull white; side of head dusky lined with dull white; a short, narrow streak of slightly elongated feathers on the lower margin of the side of the head at the back clear white; chin, throat and upper foreneck clear white; under surface pale grayish brown, washed faintly with cinnamon on lower abdomen and flanks; under tail coverts pale dull cinnamon; sides of foreneck, breast, upper abdomen and under tail coverts lined narrowly with dull white; axillars white; edge of wing, and inner under wing coverts dull white; rest cinnamon-buff.

Measurements: Male (holotype), wing 62.0, tail 41.2, culmen from base 12.9, tarsus 14.7 mm.

Female (one specimen), wing 62.7, tail 41.9, culmen from base 13.0, tarsus 15.0 mm.

Remarks: The two specimens on which this form is based, reported originally by Ludlow Griscom (1929, p. 171), were referred provisionally to the race *heterurus* of northern Colombia, but with recognition that they appeared to differ from the scanty material then available for comparison. From the series of *heterurus* now at hand they differ in smaller size, reduced streaking, definitely grayer under surface, and deeper cinnamon hue above, especially on the rump and upper tail coverts.

Etymology: The subspecific name is from the Latin adjective *incomptus*, in the sense of unadorned, from the reduction in markings compared to those of its near relatives.

Specimens examined in comparisons: Xenops rutilans septentrionalis, Panamá—Chiriquí, 4 ♂, 4 ♀.

Xenops rutilans heterurus, Colombia—Antioquia: Hacienda Zulaiba, ♂, ♀; Hacienda La Ilusión, Río Urrao, ♀; Hacienda Potreros, ♀. Cauca: Hacienda La Capilla, ♂, 2 ♀; Tijeras, Moscopán, ♀. Huila: La Candela, 2 ♂; Belén, 3 ♂. Santander: Hacienda Las Vegas, 3 ♀.

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[4] *Xenops rutilans septentrionalis* Zimmer, Proc. Biol. Soc. Washington, vol. 42, March 25, 1929, p. 82. (Guayabo, Costa Rica.)

Thamnophilus doliatus nesiotes new subspecies

Characters: Similar to *Thamnophilus doliatus nigricristatus* Lawrence,[5] but male darker; under surface with black bars heavier, and the white interspaces correspondingly reduced; female also darker; slightly larger.

Description: Holotype, USNM 471358, ♂, from Río Cacique, Isla del Rey, Archipiélago de las Perlas, Panamá, collected 27 January 1960, by Alexander Wetmore (original no. 23186). Forehead pale grayish white, streaked lightly with black; crown black, tipped lightly with white at the back (these paler markings partly concealed); hindneck black, streaked narrowly with white; back and scapulars black, barred with white (the light bars one-half or less as wide as the black ones); wings black, barred and spotted narrowly with white; tail black, marked narrowly with white on the outer edge of both webs; side of head black, lined with pale grayish white; throat and upper foreneck white, streaked rather narrowly with black; rest of under surface, including sides, flanks and under tail coverts, white barred with black, the barring narrower on the abdomen which thus appears whiter; under wing coverts white spotted lightly with black; inner webs of flight feathers barred widely with white.

Measurements: Males (11 from islas del Rey, Cañas and Pedro González), wing 70.3–74.8 (72.8), tail 53.8–58.8 (56.2), culmen from base 20.2–22.4 (21.4), tarsus 26.2–27.9 (27.1) mm.

Females (7 from islas del Rey and Pedro González), wing 69.4–73.6 (71.4), tail 53.4–57.7 (56.3), culmen from base 20.2–22.4 (21.4), tarsus 26.2–27.9 (27.1) mm.

Holotype, male, wing 72.5, tail 55.7, culmen from base 22.3, tarsus 27.5 mm.

Range: Archipiélago de las Perlas, Gulf of Panamá, Panamá, where recorded from islas Pedro González, del Rey, Víveros and Cañas.

Remarks: In field work in the archipelago I was interested to find that the Barred Antshrike was not present on Isla San José which is one of the larger land masses in the group, but isolated to the southwest, nor have I encountered it on the small islands Contadora, Saboga, Chapera, Santelmo and Bayoneta. Possibly lack of water supply may be a factor on these smaller islands as both Víveros and Cañas, where the bird is present, while small, have permanent springs.

Etymology: The name for this insular population is from the Greek *nesiotes*, an islander.

Specimens examined in comparisons: Thamnophilus doliatus pacificus, Nicaragua—Sucuya, 2 ♂, ♀; Chinandega, ♂ (type). Costa Rica—La Palma, ♂; Bebedero, 2 ♂, ♀; Pozo Azul, ♀; Bolsón, 4 ♂, 3 ♀; El General, 2 ♂, ♀. Panamá—Chiriquí: Divalá, ♂, 2 ♀; Concepción, ♂, ♀.

Thamnophilus doliatus nigricristatus, Panamá—Chiriquí: San Félix, ♀;

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[5] *Thamnophilus nigricristatus* Lawrence, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 107. (Lion Hill Station, Panama Railroad, Atlantic slope, Canal Zone, Panamá.)

Las Lajas, 2 ♂; Quebrada Piedra, ♀. Veraguas: Soná, 7 ♂, 4 ♀; Río de Jesús, ♂; Chitra, ♀. Coclé: Aguadulce, ♀; El Copé, ♂; El Potrero, 2 ♂, 5 ♀; Gago, 2 ♂, ♀; El Uracillo, ♂, ♀. Los Santos: Las Palmitas, 2 ♂, 3 ♀; Ensenado Venado, ♂, 2 ♀; Punta Mala, ♂; Pedasí, 2 ♂, 3 ♀; Tonosí, 2 ♂, 2 ♀; Los Santos, ♂. Herrera: Parita, 4 ♂, 3 ♀; La Cabuya, ♀; El Barrero, ♂, ♀. Western Province of Panamá: Nueva Gorgona, 3 ♂, ♀; Cerro Chame, ♂. Canal Zone: Farfan, ♀; Fort Clayton, ♂, ♀; Corozal, ♂, ♀; Pedro Miguel, ♂; Miraflores, ♀; Tabernilla, 2 ♂, 2 ♀; Frijoles, ♂, ♀; Bas Obispo, ♂, ♀; Río Indio, ♂; Lion Hill, ♂; Juan Mina, 2 ♂, 4 ♀. Eastern Province of Panamá: Panamá, 2 ♂, ♀; Río Abajo, ♀; Pacora, 2 ♂, 2 ♀; Chico, ♂, 2 ♀; Chepo, 2 ♂; El Llano, ♀; Cañita, ♂. Colombia—Antioquia: Necoclí, ♂, ♀. Córdoba: Tierra Alta, 2 ♂, 2 ♀; Socarré, ♂; Pueblo Nuevo, 2 ♂, ♀. Bolívar: Simití, 3 ♂; Santa Rosa, ♂, ♀; Río Viejo, 2 ♂, ♀; Colosó, ♂. Magdalena: La Gloria, ♂; Hacienda La Esperanza, 2 ♂, ♀; Codazzi, ♂. Guajira: La Cueva, 3 ♂; Los Gorros, ♂, ♀.

Oryzoborus crassirostris loftini new subspecies

Characters: Similar to *Oryzoborus crassirostris nuttingi* Ridgway,[6] but female distinctly darker, less rufescent brown on both upper and lower surface; slightly smaller, with bill somewhat more slender.

Description: Holotype, USNM 533762, ♀, from Almirante, Bocas del Toro, Panamá, collected by P. Kirmse and T. V. Heatley, 14 October 1967. Crown, hindneck, back and scapulars olive-brown, changing to bister on the lower rump and upper tail coverts; lesser wing coverts bister; wings otherwise dull fuscous-black, with the middle and greater coverts, secondaries and inner primaries edged with dull bister; tail fuscous-black; side of head somewhat duller than bister; under surface slightly darker than snuff-brown; flanks and under coverts bister; (a single aberrant pure white, albinistic feather on the center of the right side); axillars and outer wing coverts olive-brown; inner under wing coverts and edgings of primaries on underside dull grayish white. Bill, in life, very dark brown.

Measurements: Males (2 from Almirante), wing 67.2–67.4 (67.3), tail 58.7–60.7 (59.7), culmen from base 18.0–18.3 (18.1), transverse width of mandible at base 13.3–14.0 (13.6), tarsus 18.2–18.8 (18.5) mm.

Female (holotype, from Almirante), wing 65.0, tail 59.0, culmen from base 18.1, width of mandible at base 13.7, tarsus 18.2 mm.

Range: Known from Almirante, Bocas del Toro, near the western end of the Caribbean slope, Panamá.

Remarks: The first intimation of the presence of this small, large-billed finch in Panamá was a male found at Almirante 10 June 1965, caught in the edge of a closed mist net set by men capturing birds for banding under the direction of Dr. Pedro Galindo. As it was partly

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[6] *Oryzoborus nuttingi* Ridgway, Proc. U.S. Nat. Mus., vol. 6, April 26, 1884, p. 401. (Hacienda Los Sábalos, Río San Juan, Chontales, Nicaragua.)

decomposed, it could be preserved only in part as a flattened specimen. Those working with birds in the area were alerted to watch for the species, but others were not found until two years later. Two males and a female were netted on 13, 14 and 30 October 1967 by P. Kirmse, V. M. Kleen and T. V. Heatley, operating the banding station under the direction of Dr. Horace Loftin. The species has been known previously in Central America from the Caribbean slope in eastern Nicaragua and northern Costa Rica. In South America it is found from northwestern Colombia, Venezuela and Trinidad to western Ecuador, eastern Perú and southern Brazil. The South American populations are distinct in having white or partly white axillars and under wing coverts, and a small white wing speculum (varying in size) in males. In some males there is concealed white also on the base of the rectrices.

Measurements of *Oryzoborus crassirostris nuttingi* are as follows: Males (11 from Nicaragua, 1 from Costa Rica), wing 69.0–71.0 (69.8), tail 61.0–66.3 (62.9), culmen from base 18.0–19.1 (18.6), transverse width of mandible at base 13.9–15.7 (14.7), tarsus 18.3–20.1 (19.1) mm.

Females (5 specimens), wing 66.0–69.1 (67.2), tail 59.4–65.4 (60.4), culmen from base 18.0–19.7 (18.7), transverse width of mandible at base 13.7–14.6 (14.3), tarsus 14.3–15.9 (14.7) mm.

Etymology: This addition to the avifauna of Panamá is named for Dr. Horace Loftin, head of the Florida State University Center for Tropical Studies in the Canal Zone, in recognition of his interest in the fauna of the Republic.

Specimens examined in comparisons: Oryzoborus crassirostris nuttingi, Nicaragua—Greytown, 3 ♂, ♀; Río Escondido, ♀; Los Sabalos, Río San Juan, 7 ♂, 5 ♀.

Oryzoborus crassirostris crassirostris, Colombia—Córdoba: Tierra Alta, ♂; Socarré, ♀; Quebrada Salvajín, 2 ♂ im., 4 ♀. Antioquia: Tarazá, ♀; Hacienda Belén, ♂. Bolívar: La Raya, 4 ♂, ♀.

Additions to the List of Birds Recorded from Colombia

The following, based on collections in the U.S. National Museum, made in Colombia by M. A. Carriker, Jr., add to the list as published by R. Meyer de Schauensee in the second printing of his volume, The Birds of Colombia and adjacent areas of South and Central America, published originally in 1964.

Racquet-tailed Hummingbird, *Ocreatus underwoodi discifer* Heine. Carriker collected two adult, two immature males, and a female in forest between 1675 and 1980 meters elevation on the Sierra de Perijá, above Hiroca, Magdalena, from 17 April to 1 May 1942. He found the species again near Palo Gordo, Norte de Santander, where he secured two males on 14 and 22 November 1947. One of these was taken in the shade trees over coffee, the other in heavy forest. The race, described from the mountains near Mérida, Venezuela, ranges in that country to the intermediate levels on the eastern face of the Sierra de Perijá. It is no surprise therefore to find that it occurs also on the

Colombian slopes of the range. Males are similar to nominate *underwoodi.* The females differ from that race in having the chin and center of throat plain white, with the spotting restricted or absent also on the center of the breast. In *underwoodi* these areas are definitely spotted.

Striped-breasted Spinetail, *Synallaxis cinnamomea aveledoi* Phelps and Phelps, Jr.

As an addition to the races of this species in Colombia, Carriker collected two males and three females of *aveledoi* at Palo Gordo, Norte de Santander, from 14 to 23 November 1947. These are the first records for Colombia, their identity checked by comparison with the type in the American Museum of Natural History. The race, found from northwestern Zulia to Mérida and Táchira in adjacent western Venezuela, is plain warm brown above, less reddish than any of the other races, and also is more buffy, less cinnamon on the lower surface.

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A NEW SPECIES OF LARGE *DIPLOGLOSSUS* (SAURIA: ANGUIDAE) FROM HISPANIOLA

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The anguid lizards of the genus *Diploglossus* Wiegmann are widespread on the islands of the Greater Antilles. The number of species on each island, however, varies; Cuba has but a single species (*delasagra* Cocteau), and Puerto Rico likewise has but one galliwasp (*pleii* Duméril and Bibron). Jamaica and Hispaniola have a diversity of forms; the former island has (or had) six species (*occiduus* Shaw, *barbouri* Grant, *crusculus* Garman, *duquesneyi* Grant, *hewardi* Gray, *microblepharis* Underwood) and Hispaniola has five species (*costatus* Cope, *curtissi* Grant, *darlingtoni* Cochran, *sepsoides* Gray, *stenurus* Cope). Another species (*montisserrati* Underwood) is the sole representative of this genus in the Lesser Antilles where it occurs on Montserrat. In addition, *D. costatus* occurs on Navassa (between Hispaniola and Jamaica) and *D. crusculus* occurs on the Lesser Cayman Islands (Little Cayman and Cayman Brac).

Of these species, the least known is *D. occiduus*. Grant (1940:109) was not convinced that *D. occiduus* was extinct, but Cousens (1956:1) stated that this giant galliwasp had not been collected in over 100 years. Although *D. occiduus* had in early times been reported to live in swamps and to eat fish and fruit (and thus in its habits and habitats it may have been less conspicuous than other of its Jamaican congeners), it seems highly unlikely that the species still persists in Jamaica. I know of only three specimens in American collections; I have examined these lizards in the collection of the Museum of Zoology at the University of Michigan and the Museum of Comparative Zoology at Harvard University through the courtesy of Charles F. Walker and Ernest E. Williams. If for no other reason, *D. occiduus* is the most distinctive of the Antillean *Diploglossus* because of its very great size.

When I reviewed the galliwasps of the Hispaniolan *costatus* complex, I examined a specimen in the United States National Museum from Rivière Bar (= Rivière des Barres) in northern Haiti; this specimen was collected by W. L. Abbott in 1917 and had been assigned by Cochran (1941:250) to her all-inclusive "*Celestus costatus.*" In turn, in my review of this complex, I consider the lizard as *D. stenurus rugosus* (1964: 17) and commented upon its very large size (snout–vent length 230 mm) which far exceeded that of any other specimen of *D. stenurus* studied. The lizard is badly crushed about the head, and details of head scutellation (aside from the position of the angular subocular on both sides) cannot be determined. I had suspected that possibly this lizard represented still another distinct taxon from northern Haiti, a taxon related to the *costatus* complex (which includes *costatus*, *stenurus* and *curtissi*), but the condition of the single specimen, its faded pattern due to length of time in preservative, and the fact that there was but one animal made its description an improvident course.

Through the efforts of C. Rhea Warren, herpetological collections were made on Ile de la Tortue off the northern Haitian coast in 1968. The herpetofauna of this island has been very poorly known, and through the efforts of Mr. Warren and local natives, excellent collections including several unexpected forms have now been collected there. Among the lizards secured are three species of *Diploglossus*: *costatus*, *curtissi*, and two specimens of the giant form previously known from Rivière des Barres. The absence of *D. stenurus* or immature representatives of the giant species is remarkable, although neither *costatus* nor *curtissi* is apparently common in the vicinity of Palmiste, whence the recent collections have come. It is moreover remarkable that the Rivière des Barres lies on the Haitian coast immediately opposite Ile de la Tortue and just to the east of the town of St. Louis du Nord. The entire northern Haitian coast has been poorly represented by *D. stenurus* (despite many collections from Cap-Haïtien and its vicinity in recent years); this species has been reported from Bombardopolis on the Presqu'île du Nord Ouest on the west, and near Limbé and near Limonade to the east of the Rivière des Barres (one specimen from each of these three localities; Schwartz, 1964:18). However, additional material more recently collected by Richard Thomas shows that *D. stenurus* is fairly common near Limbé, and in the vicinity of Limonade, and inland from Anse à Margot, all settlements on the northern Haitian versant. Thomas's material is both crucial and critical as far as comparison of *D. stenurus* and the new species is concerned.

Examination of Thomas's excellent series of 26 *D. stenurus* from these localities shows that there is nothing distinctive in size as far as they are concerned. The largest specimen (Albert Schwartz Field Series [ASFS] V9957) is a male with a snout–vent length of 138 mm; this measurement lies within the known extremes of male *D. stenurus* (maximum size 172 mm snout–vent length in *D. s. stenurus*, the largest of the four subspecies). Patterned *D. stenurus* from northern Haiti have the back covered with closely appressed dark brown and fragmented herringbones; the largest *D. stenurus* from this region (ASFS V9957) shows a dissolution of this pattern to one of dark longitudinal lines, the lines lying on the center of each dorsal scale row. If such a pattern is the result of ontogenetic change in these northern Haitian *D. stenurus*, then the dorsal patterns of the very large specimens is characteristic only of them and not of merely large-sized *D. stenurus.*

This pattern achieves some importance, since there are no meristic scale characters which separate the large species from its smaller relatives. This, however, is not surprising; examination of the data from the *costatus* complex (Schwartz, 1964) shows that various scale counts have little or no significance in separating the species *stenurus*, *costatus* and *curtissi* from each other. For instance, ventrals scales between the mental and the vent range from 81 to 105 in *stenurus*, 77 to 100 in *costatus*, and 80 to 102 in *curtissi*; similarly, scales around the body at midbody are 37 to 45 in *stenurus*, 35 to 44 in *costatus*, and 33 to 42 in *curtissi.* More important is keeling of the dorsal body and caudal scales, and striation of the ventral scales. Of the three well-known species, *stenurus* has keeled dorsal body and caudal scales and smooth ventrals, whereas both *costatus* and *curtissi* have smooth dorsal body and caudal scales and striate ventrals. The new northern Haitian species has very strongly keeled dorsal body and caudal scales, and striate ventral scales, and thus differs in this combination of characters from all other members of its complex in Hispaniola. Differences between these Haitian specimens and the Jamaican *D. occiduus* will be pointed out below; despite the fact of large size in both *occiduus* and the new species, the former is much the larger and bulkier lizard, and there is no close resemblance or relationship between the two species.

Aside from examining specimens of other Hispaniolan species in the ASFS, I have borrowed two specimens of *D. occiduus* (UMMZ 53249, 53251) from the University of Michigan, and one from the Museum of Comparative Zoology (MCZ 74090); I acknowledge the cooperation of Charles F. Walker and Ernest E. Williams for the loans of such valuable material. C. Rhea Warren was instrumental in the collection of and my receipt of one individual of the new form. The second Warren lizard had been deposited in the living herpetological collection of the New York Zoological Society, under the curatorship of F. Wayne King. Dr. King very generously allowed me to preserve this remarkable lizard, and it has been placed in the collection of the American Museum of Natural History (AMNH). I have borrowed the Abbott specimen in the United States National Museum (USNM) through the cooperation of James A. Peters and George R. Zug. Mr. Warren's travels in Haiti were greatly facilitated by M. Ramah Théodore, Directeur Général Adjoint de l'Office Nationale du Tourisme et de Propagande. I am especially grateful to Dr. King for allowing me to preserve a lizard which might otherwise have afforded an unusual display. In honor of Mr. Warren, who was instrumental in securing two of the three known specimens, I name the new species

Diploglossus warreni new species

Holotype: AMNH 103215, an adult female, from Palmiste, Ile de la

Tortue, Département du Nord Ouest, Haiti, taken 27 January 1968 by natives for C. R. Warren. Original number ASFS V15082.

Paratypes: USNM 59435, an adult male, from Rivière des Barres, Dépt. du Nord Ouest, Haiti, 21 February 1917, W. L. Abbott; ASFS V15071, same locality as holotype, November 1968, natives for C. R. Warren.

Definition: A species of *Diploglossus* of the Hispaniolan *costatus* complex which differs from other members of that complex (*costatus*, *stenurus*, *curtissi*) in much larger size (male *warreni* to 230 mm snout–vent length; female *warreni* to 227 mm snout–vent length; largest male and female of three other species those of *stenurus* with maximally sized male 172 mm, female 143 mm), low number of ventral scales between mental and vent (84 to 92 in *warreni*, 77 to 106 in other members of the complex combined), dorsal trunk scales striate and with a strong median keel, dorsal caudal scales likewise striate and strongly keeled, ventral scales finely striate; dorsal pattern consisting of a series of medium dark grayish chevrons, more or less confluent medially (especially anteriorly) and extending the full length of the unregenerated portion of the tail, on a pale tan to yellow-tan ground, sides very pale gray, flecked with dark brown and with remnants of vertical bars corresponding to lateral ends of dorsal chevrons, postocular dark mask obsolete and only very faintly indicated, iris brown, and venter immaculate cream to very pale orange-tan.

Distribution: Known only from Ile de la Tortue and from the adjacent Haitian mainland in the Département du Nord Ouest.

Description of holotype: An adult female with snout–vent length of 218 mm, tail (regenerated for distal half) 111 mm; scales between mental and vent 92, scales around body at midbody 37, 11 chin shields, angular subocular between supralabials 6 and 7 on both sides; fourth toe lamellae 15, arm length 32 mm, head width 27.0 mm, head length 34.1 mm. Color in life dorsally yellow-tan (Pl. 14 K 6; all color designations from Maerz and Paul, 1950) with a series of about 16 widely opened darker brown (Pl. 15 C 9) chevrons from the neck to the groin, the anterior neck with a vague pair of broad paramedian lines, which extend to just above the forelimb insertion and are concolor with the dorsal chevrons and obviously a part of that pattern sequence; about 6 chevrons between the groin and the regenerated portion of the tail; head scales tan, immaculate; sides pale gray, flecked with brown especially in the regions where a very vague series of vertical tannish lateral bars corresponds to the position of the lateral ends of the dorsal chevrons; both fore- and hindlimbs yellowish tan with a brown reticulum which isolates islands of the paler ground color; postocular mask obsolete, represented only by a vague dusky area from the eye onto the temple; upper labials and chin pale gray, with some brownish suture-following pigment on the chin; venter pale orange-tan (Pl. 12 C 5), immaculate except for some dark gray blotches on the free edge of the anal flap; subcaudal scales concolor with those of venter; iris brown.

Variation: USNM 59435, an adult male, has the following measurements (in millimeters) and counts: snout–vent length 230, tail about 70, distal third regenerated; scales between mental and vent 84, scales around body at midbody 37, 9 chin shields, angular subocular between supralabials 6 and 7 on both sides; fourth toe lamellae 18, arm length 48; head too badly damaged for measurements but conspicuously swollen and enlarged in masseteric region; specimen badly discolored but dorsal crossbars or chevrons still barely visible and uncountable; venter completely immaculate. ASFS V15071, an adult female, has the following measurements and counts: snout–vent length 227, tail about 175, distal third regenerated; scales between mental and vent 88, scales around body at midbody 37, 11 chin shields, angular subocular between supralabials 7 and 8 on left side, between 6 and 7 on right side; fourth toe lamellae 15, arm length 50, head width 32.4, head length 40.7. Color in life medium brown above with a series of grayish brown chevronate elements, at times broken middorsally to give a middorsal reticulum, extending from nape onto unregenerated portion of the tail, about 18 chevrons between the nape and the groin, about 14 chevrons between the groin and the regenerated portion of the tail; head scales medium brown margined with dark brown along their posterior borders; sides gray, irregularly flecked with brown; limbs slightly darker gray, the forelimbs with an irregular brownish reticulum, the hindlimbs with each scale outlined with dark brown; postocular mask obsolete, represented by an area of irregularly darkened scales in the temporal region; upper labials grayish, margined with dark brown; venter cream to white, immaculate except for very pale gray sutures on the sublabials and throat scales, and irregular black blotches on the free edge of the anal flap; subcaudal scales with a pattern of dark brown lines radiating from the base of each scale to give a characteristic dark fan-shaped pattern.

Comparisons: *D. warreni* requires comparison only with *D. stenurus*, apparently its closest relative on Hispaniola, and with *D. occiduus* in Jamaica, the only Antillean species which is as large as or larger than *D. warreni*. Comparison with *occiduus*[1] is the more easily made (but I

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[1] Dr. Walker advised me that the smaller of the two UMMZ *D. occiduus* (UMMZ 53251) has been considered a representative of *Diploglossus hewardi*. The lizard may well be *hewardi*, but I consider it *occiduus*. Comparison of this specimen with a series of 22 *hewardi* suggests the following differences between them and the problematical UMMZ specimen. Half-jaw counts of position of the angular subocular in *hewardi* are regularly 6/7 or 7/8, with the latter category having the higher incidence (30). The UMMZ lizard has this scale between supralabials 8 and 9 unilaterally, apparently an *occiduus* character. The two giant *occiduus* have striate but unkeeled dorsal scales, weakly striate caudals, and smooth ventrals, whereas the series of *hewardi* has striate *and* strongly keeled dorsals, caudals striate or striate to very weakly keeled, and ventrals smooth to weakly striate. The absence of keels on the dorsals of UMMZ 53251 suggests that this specimen is an *occiduus*. There seem to be no differences in the head scutellation (other than the position of the angular subocular) useful in differentiating these two taxa; the ventral count of 121 in the problematical specimen is slightly higher than the 107

doubt that these two species are at all closely related); ventral scales in *occiduus* vary between 107 and 121, midbody scales are 49 and 50, the angular subocular lies between supralabials 8 and 9 (unilaterally in UMMZ 53251 and MCZ 74090), fourth toe lamellae vary between 16 and 23, the dorsal body and caudal scales are striate but not keeled, and the ventrals are smooth. UMMZ 53249, an adult male, has a snout–vent length of 305, head length 66.8, head width 55.5, and arm length of 69. Similar measurements on MCZ 74090, a female, are 256, 52.9, 40.5 and 57; both are very much larger and bulkier lizards than *D. warreni.* All specimens of *D. occiduus* are presently bleached, so that no data are available from them on color or pattern. Boulenger (1885:290) stated that *D. occiduus* was "Brownish above, with dark brown spots or cross bands." Structurally, *occiduus* differs most strikingly from *warreni* in that the former has striate dorsal body and caudal scales and smooth ventrals, whereas *warreni* has strongly keeled dorsal body and caudal scales and finely striate ventrals. The higher number of ventral scales and midbody scales in *occiduus* likewise separates the two species; the position of the angular subocular between supralabials 8 and 9 in *occiduus* differs from its position between 6 and 7 in *warreni.*

D. warreni differs from *D. stenurus* in several features. First, the strongly keeled dorsal body scales and the very strongly carinate caudal scales differ from the keeled condition in *stenurus.* Although these scales are keeled in *stenurus*, even in large adult individuals of the latter species the keels are much lower. This is most especially shown by the caudals in *warreni*; these scales have such high keels that the tail appears angulate on gross inspection. The ventral scales of *warreni* are finely striate, whereas these scales are smooth in *stenurus.* Secondly, the dorsal pattern, although reminiscent of that of *stenurus*, is distinctive. *D. stenurus, D. costatus* and *D. warreni* have a community of dorsal pattern elements; the pattern is composed basically of chevrons or (when these are widely opened) crossbars which extend from the nape to at least the base of the tail. In *costatus* the chevrons are fine and narrow, giving a herringbone pattern, whereas in *stenurus* the chevrons are fragmented and are made up of more or less isolated dark squares or rectangles arranged in a chevronate pattern (see Schwartz, 1964:15, figs. 1–4), which, however, lacks the clarity and diagrammatic distinctness of the *costatus* pattern. Both these species likewise have, in most subspecies, a pair of anterior paramedian nuchal lines, much better delineated in *D. stenurus* (especially in *D. s. alloeides* Schwartz)

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and 118 counts for the undisputed *occiduus* and within the range of that count in *hewardi* (113–135), but then very little is known about the variation of this character in *occiduus.* Midbody counts in the two large *occiduus* are 49 and 49–59 in *hewardi*; the smaller *occiduus* has a count of 50. I do not consider, nor did Cousens (*loc. cit.*), that *occiduus* and *hewardi* are conspecific. But immature *occiduus* may be difficult to separate from *hewardi* except for modal differences, and the same may well be true of juvenile *warreni* and *stenurus.*

than in *D. costatus.* The dorsal pattern of *D. warreni* likewise is basically chevronate, but the chevrons, since they are widely opened, are almost crossbars. Additionally, these bars are broad and entire (not fragmented as in *stenurus*) and may be joined medially at their apices in an irregular fashion. There is no indication of paramedian nuchal lines, although the holotype has dark paramedian blotches on the neck. Thus, although the species *warreni, stenurus* and *costatus* are all basically chevronate, the degree and quality of the dorsal markings varies with the species. Thirdly, *D. warreni* is by far the largest member of the *costatus* complex in Hispaniola. Maximally sized *stenurus* (males first, females second in each case) are 172 and 143, maximally sized *costatus* measure 127 and 116, and maximally sized *curtissi* 86 and 82. The male *warreni* has a snout–vent length of 230, the larger female 227; in these measurements *warreni* ranks second only to *occiduus* in the Antilles.

Scale count differences between *warreni* and *stenurus* are difficult to assess, since there are counts available on only three *warreni* in contrast to those from several hundred *stenurus.* However, the *warreni* counts of ventral and midbody scales fall toward the lower extremes of these counts in *D. stenurus*, and in the case of midbody scales, the counts of *warreni* (33–37) lie just below the counts for *stenurus* (37–45). Overlap of counts is of little significance in this group of galliwasps, since even such strikingly different species of *stenurus* and *curtissi* have almost identical extremes in ventral and midbody counts. It would be extremely pleasant if *warreni* differed quantitatively from *stenurus* in some meristic character, but such is not the case, at least in those counts which I have heretofore employed in differentiating members of this Hispaniolan complex.

One other characteristic separates *warreni* from *stenurus.* In the former, the subcaudal scales are very large and almost fanlike in aspect; this resemblance is further enhanced by the dark brown lines of pigment which may radiate from the base of each scale. Such radiations do not occur in *stenurus* and the ventral caudal scales are relatively (as well as actually) much smaller. Thus the subcaudals in *warreni* are much larger than are those in *stenurus.* Finally, the distinctly angulate appearance of the tail, due to the high median keels on the dorsal caudal scales, does not occur in *stenurus*; in the latter species, although the dorsal caudals are keeled, the keels are not so high and do not impart an angulate or longitudinally keeled aspect to the upper side of the tail.

Remarks: Despite the fact that I regard *D. warreni* as a species distinct from *D. stenurus*, nevertheless, the very fact that I previously considered the USNM paratype of *D. warreni* as a *stenurus* suggests the similarity between these two species. The age and condition of the USNM specimen, as pointed out above, prevented my assessment of its characteristics. Still, *D. stenurus* is unknown from Ile de la Tortue and from the northern Haitian coast in the immediate region of St. Louis du Nord-Rivière des Barres. Thus, there is a possibility that the specimens I consider *D. warreni* are either 1) merely very large *D. stenurus* or 2) represent a local very large subspecies of *D. stenurus*. Neither of these possibilities can be absolutely refuted. But the facts that large *stenurus* from adjacent areas show no approach to the dorsal pattern of *warreni* and that, of hundreds of *stenurus* studied from throughout Hispaniola, none begins to approach the very large size of *warreni* suggests that these lizards are related to, but not conspecific with, *D. stenurus*. The structural characteristics of *D. warreni*, in comparison with those of *D. stenurus*, of course also militate against the conspecificity of the two taxa. The compact known geographic distribution of *D. warreni* also suggests that this population is distinctive from *D. stenurus*.

There is another inductive line of reasoning for specific status of *D. warreni*. Etheridge (1965:99–100), while discussing the fossil lizards from a cave at Cerro de San Francisco near Bánica in San Rafael Province, República Dominicana, distinguished between two size-classes of fossil *Diploglossus* found in this cave: one group with a presumed snout–vent length of 120 to 130 mm (*costatus*) and another group with a presumed snout–vent length of about 210 to 250 mm ("*stenurus*"). Dr. Etheridge made the latter assignment at the time because of my as yet unpublished data on the maximum size of *D. stenurus*; this maximum size (230 mm) was of course based upon the USNM paratype of *D. warreni*. The presence in these deposits of the two size groups suggests that there were indeed two species present, one of which (*warreni*) is much the larger. *D. warreni* is not known today from the Bánica area.

The presence of apparent *warreni* fossils from the interior of the República Dominicana, and the known occurrence today of this species only along the northern Haitian littoral and on Ile de la Tortue suggest that the species was once more widely distributed, and that it persists today mainly along the northern Haitian coast and on Tortue. The absence of *D. stenurus* on Tortue is especially puzzling, but considering the apparent rarity of any species of *Diploglossus* on that island, it is possible that *stenurus* occurs there. Another possibility is that large *stenurus* is incapable of competing with even larger *warreni*, and that *stenurus* has not been able to establish itself on Tortue where *warreni* is a long-established species. If the Bánica fossils are correctly interpreted as *warreni*, the previously widespread distribution of that species and its present apparently circumscribed (and partially insular) range seems clearly to indicate that *warreni* is a relict species, persisting in small numbers in northern Haiti and on Ile de la Tortue.

Mr. Warren advises me that the vicinity of Palmiste is mesic, and that the region immediately about the Rivière des Barres is likewise mesic, sufficiently so to allow the growing of bananas and coffee very near the coast. Farther to the west at Port-de-Paix, the countryside is scrub-grown and arid. Of the lizards reported by Etheridge from the pre-Columbian strata at Cerro de San Francisco, none is a confirmed inhabitant of xeric areas (although *A. chrysolaema* is a xerophile in some parts of its range); several species (*Anolis ricordi, Anolis cybotes, Anolis chlorocyaneus, Leiocephalus personatus, Ameiva taeniura, Diploglossus costatus*) are inhabitants of cool, shaded, and relatively moist areas. Considering the habitat preference (so far as it can be known from the few specimens available) of living *D. warreni*, it seems possible that the region about Cerro de San Francisco was formerly mesic and forested.

In summary, it seems probable that *D. warreni* was once more widely distributed on Hispaniola, but that (because of stringent ecological requirements?) it has disappeared from much of its former range and persists only on the mesic northern Haitian coast and on Ile de la Tortue. Perhaps the presence of *D. warreni* on Tortue has prevented the success there of its largest congeneric relative, *D. stenurus*.

Underwood (1959:11) suggested that since the Jamaican *microblepharis* was related to Cuban-Puerto Rican *delasagra–pleii* it was most likely that this group of species, on the basis of geographical distribution of its known members, must have a Hispaniolan representative. I agree, but *D. warreni* is not that as yet unknown member. Rather, the relationships of *warreni* are clearly with the *stenurus–costatus–curtissi* series on Hispaniola, *warreni* representing the culmination of size in this complex. Similarly, *occiduus* in Jamaica seems to represent the culmination of a Jamaican series (*crusculus–hewardi–barbouri*) with *crusculus* the smallest member in the series. In both cases the series progresses from small short-limbed species to very large long-limbed species. As in the *costatus* complex, the basic Jamaican dorsal pattern is a series of fine and narrow, closely appressed chevrons, giving a herringbone pattern. I am less sure of this sequential series in Jamaica than in the *costatus* series in Hispaniola; for one reason, Underwood (*op. cit.*:13, table) indicated that *occiduus* is the only member with many scale organs on the dorsal scales whereas all other Jamaican galliwasps have the scale organs present on the dorsal scales but apparently they are not so numerous as in *occiduus*. If many scale organs is a more primitive condition than few-to-no scale organs, then on the basis of this character, *occiduus* would seem to be the primitive member of the Jamaican series, and the remainder of the Jamaican species are derived forms—a situation which, on the basis of size, seems unlikely. Thus, the series of Jamaican galliwasps does not demonstrate the clearly sequential evolutionary series that the Hispaniolan *costatus* group members show.

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PROCEEDINGS
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A NEW IDOTEID ISOPOD, *IDOTEA (PENTIDOTEA) KIRCHANSKII*, FROM CENTRAL CALIFORNIA (CRUSTACEA)

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In his monograph on the idoteid isopods of northern California, Menzies (1950) reduces the genus *Pentidotea* Richardson, 1905, to the rank of a subgenus of *Idotea*[1] Fabricius, 1798, and gives an account of the six species then known. The present paper describes a seventh species in this subgenus. It is the third species of *Idotea* (*Pentidotea*) associated with surf grass (*Phyllospadix scouleri*), the other two being *I.* (*P.*) *montereyensis* (Maloney) Menzies, 1950 and *I.* (*P.*) *aculeata* (Stafford) Menzies, 1950. The new idoteid was first discovered during the course of ecological investigations on *Idotea montereyensis* (Lee, 1967) living alongside it on *Phyllospadix*, but unlike the latter isopod, *Idotea kirchanskii* did not appear to occur elsewhere intertidally.

Genus *Idotea* Fabricius, 1798

Menzies (1950) gives an emended diagnosis of the genus as follows: "GENERIC DIAGNOSIS: Flagellum of second antennae multiarticulate. Maxillipeds with a palp composed of four or five articles. Epimera of all the segments (somites) of thorax (peraeon), with the exception of the first, distinctly separated from the somites. Abdomen (pleon) composed of three segments, with a suture line on either side at the base of the terminal segment, indicating perhaps another partly coalesced segment. Includes the subgenera *Idothea* and *Pentidotea*."

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[1] Many authors, including Richardson (1905) and Menzies (1950), spell the generic name "*Idothea*" but Fabricius' original spelling was "*Idotea*."

Subgenus *Pentidotea* (Richardson) Menzies, 1950

Maxillipedal palp with 5 articles rather than 4 as in the subgenus *Idotea.*

Idotea (Pentidotea) kirchanskii new species

Figures 1 and 2

Diagnosis: Body narrow, linear, compact. Color bright green with tips of appendages often red. Frontal process of head broadly triangulate with bluntly rounded apex, shorter than frontal lamina 1 of clypeus. Frontal lamina 1 prominent, broadly triangulate, wider and longer than frontal process and concealing frontal lamina 2 in dorsal view. Antenna 2 short, rarely extending past posterior margin of pereonite 2, with flagellum comprising 7–12 articles. Eyes round. Maxilliped with 1 coupling hook, rarely 2. Epimera distinctly separated on pereonites 2–7, but usually visible dorsally only on segments 5–7. Epimera of pereonite 7 triangular with acute posterior angles. Pleotelson with medial posterior margin convex, lacking apical tooth. Found on *Phyllospadix.*

Description: The following characters may be noted in addition to those given above.

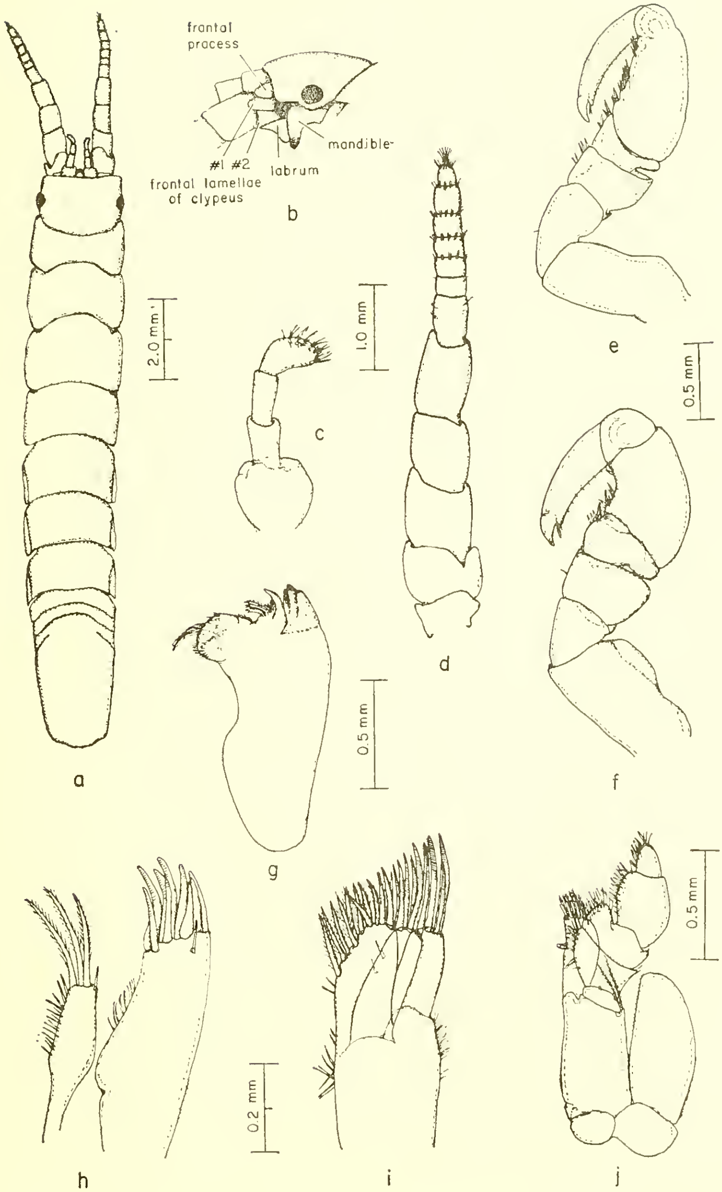
Holotype male (21 mm × 3.2 mm), allotype ovigerous female (15 mm × 2.8 mm). Paratypes: 5 males, 1 nonovigerous female, 8 ovigerous females. In type series, length/width ratios in six males range between 5.2 and 7.1, in the nonovigerous female, the ratio is 5.6; in nine ovigerous females, the range is 4.3–5.7 due to expansion in width at pereonites 1–3.

Head (Fig. 1, *a–b*) with supra-antennal line slightly concave, but median third of it often becomes convex. Anterolateral cephalic margin slightly flared, rounded. Eyes round (lateral view). Lateral margins slightly indented anterior to eyes. Frontal lamina 2 of clypeus broad and almost semicircular in frontal view.

Antenna 1 (Fig. 1, *c*) composed of 4 short articles, extending only to about two-thirds the length of third peduncular article of antenna 2. First article of antenna 1 stout, about as wide as long, and twice as broad as those following; articles 2–4 subequal in length; article 4 somewhat clavate and provided with stout apical and subapical setae (sensory?). Antenna 2 (Fig. 1, *d*) rarely extends past posterior margin of second pereonite. Peduncle of antenna 2 composed of 5 articles, the first small and barely visible dorsally; articles 2 and 3 larger and subequal; articles 4 and 5 narrower and each slightly longer than third article. Flagellum of antenna 2 consists of 7–12 articles (but juveniles may have

→

FIG. 1. *Idotea* (*Pentidotea*) *kirchanskii* new species. *a*, ♂ from Dillon Beach, dorsal view. *b*, head with left antennae and postmandibular mouthparts removed, side view. *c*, first antenna. *d*, second antenna. *e*, first pereopod. *f*, seventh pereopod. *g*, left mandible. *h*, first maxilla. *i*, second maxilla. *j*, maxilliped.


frontal process
#1 #2
frontal lamellae of clypeus
labrum
mandible
b
2.0 mm
a
1.0 mm
c
d
e
0.5 mm
f
0.5 mm
g
h
0.2 mm
i
0.5 mm
j

as few as 3 joints)—the first longest and often showing partial articulation; the last minute and semicircular in outline.

Mouthparts normal for genus (Fig. 1, *g–j*). Mandibles with heavily sclerotized incisive process and truncate molar process bearing a brush of setae. First maxilla has inner lamina with 3 long plumose setae and one short seta at apex, and outer lamina with stout apical spines, the inner slightly ctenate. Second maxilla trilobate, inner lobe fringed with long plumose setae, outer lobes with ctenate setae. Maxilliped has palp of 5 articles, and endite with 1 coupling hook (rarely 2).

Lateral thoracic margins subparallel, not sharply incised between segments. Posterior margin of first pereonite decidedly concave, that of second less so, that of third more or less straight, those of following segments medially convex.

Epimera of pereonites 2–4 do not extend the length of their segments, whereas those of segments 5–7 do. Epimera of pereonites 2 and 3 never visible from above, those of pereonite 4 sometimes visible dorsally, those on remaining three pereonites at least partially visible dorsally. Posterolateral edges of fifth and sixth segments somewhat rounded, edges of seventh form an acute angle. Sternal parts of coxal rings not fused medially leaving prominent medial groove. Coxal sockets deep.

Pereopod 1 (Fig. 1, *e*) bears row of stout conical setae along entire palmar margin of propodus; each seta complex with many fine filelike ridges facing palm and a filiform extension of its axis beyond bifid apex. Also one large complex seta and several smaller simple setae on distal edge of carpus. Dactylus with long curved unguis and accessory claw at base. Pereopod 7 (Fig. 1, *f*) with keel on external margin of basis, and a few stout, coarsely pectinate, spiniform setae at base of palmar margin of propodus and a few at distal margin of carpus.

Posterior margin of telson slightly convex, evenly rounded, lacking posterolateral angles, sometimes slightly produced in broad median lobe, but without apical tooth.

Penes (Fig. 2, *a*) double, short, flattened, bluntly tapered processes attached to sternite of seventh pereonite. Pleopod 1 (Fig. 2, *b*) with quadrate base bearing 8 stout coupling spines on medial distal border and two laminar rami each fringed with long plumose setae. Pleopod 2 of male (Fig. 2, *c*) bears long, slender appendix masculina extending along entire length of medial edge of endopod and beyond its distal edge, with rounded apex armed subapically with rows of spiny scales; both rami fringed with plumose setae. Posterior 3 pairs of pleopods also biramous, but show progressive reduction in marginal setation. Pleopod 3 (Fig. 2, *e*) has setae only on exopod and these are sparse compared to those of first and second pleopod, with plumose types limited to distal and distolateral margins. Pleopods 4 and 5 (Fig. 2, *f–g*) similar, with rami seemingly bare, but under magnification exopods show a sparse fringe of short, spinelike setae. Branches of pleopods 1 and 2 uniarticulate, but exopods of last 3 pairs show lateral and medial partial sutures connected by fine transverse lines making them biarticulate.

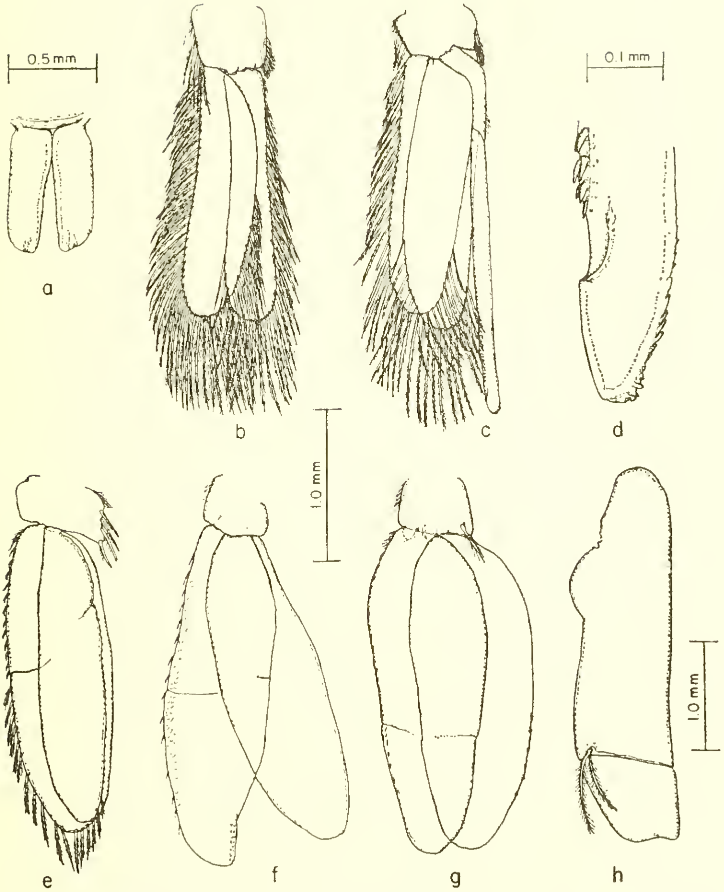


FIG. 2. *Idotea* (*Pentidotea*) *kirchanskii* new species, ♂ pleonal appendages. *a*, penes. *b*, first pleopod. *c*, second pleopod. *d*, tip of appendix masculina. *e*, third pleopod. *f*, fourth pleopod. *g*, fifth pleopod (exopod somewhat flattened). *h*, uropod.

Uropod (Fig. 2, *h*) uniramous with 3 plumose setae at outer distal angle of basal joint.

Localities: CALIFORNIA: Monterey County, Pebble Beach, 17 Mile Drive at Seal Rock, intertidal on *Phyllospadix* (6 ♂♂, 10 ♀♀ [9 ovigerous]), 14 May 1968, W. L. Lee (type-locality); Marin County, Dillon Beach, Second Sled Road, intertidal on *Phyllospadix* (10 ♂♂, 7 ♀♀ [2 ovigerous]), 18 June 1962, W. L. Lee. Additionally, this isopod has

TABLE 1. Similarities between *Idotea kirchanskii* and *I. aculeata.*

1. Body linear, sides subparallel.
2. Frontal process widely angulate and shorter than frontal lamina 1, with blunt, evenly rounded apex. In ovigerous females of *I. aculeata,* Menzies (op. cit.) notes that the apex is often somewhat concave, a variation not found in *I. kirchanskii.*
3. Frontal lamina 1 prominent, broadly triangulate, wider than frontal process and extending forward beyond it in dorsal view.
4. Eyes round.
5. Single coupling hook on maxilliped.
6. First pleonite with wide lateral borders.
7. Posterolateral margin of epimeron of seventh pereonite acute.
8. Posterolateral angles of pleotelson rounded.

been collected intertidally on many occasions at Dillon Beach, Marin Co.; and in Monterey Co., at Pacific Grove and Pebble Beach and in various localities between Carmel and Rocky Point. It has only been found on *Phyllospadix scouleri* and invariably it is the same green color as that plant.

Disposition of material: Types are deposited in the Smithsonian Institution. Holotype—USNM 125205, allotype—USNM 125206, paratypes—USNM 125207. Other material has been placed in the collections of the authors and the California Academy of Sciences, Golden Gate Park, San Francisco.

Etymology: The species is named in honor of Mr. James Kirchanski in recognition of his contribution to education in central California.

Distribution: The known geographical range of *Idotea kirchanskii* extends south from Dillon Beach, Marin County to Rocky Point, Monterey County, California. Its distribution within this range is imperfectly known, but it appears to be more abundant in the southern portion. Relatively few specimens were found at Dillon Beach where *I. montereyensis* is the dominant species on surf grass. At Rocky Point, however, *I. kirchanskii* is abundant and almost completely replaces *I. montereyensis.*

The range of *Idotea kirchanskii* overlaps the northern end of the distribution of its closest relative, *Idotea aculeata,* which is found from Dillon Beach, Marin County, south to La Jolla, San Diego County, California (Menzies, 1950). George and Strömberg (1968), however, report *I. aculeata* from San Juan Archipelago, Washington, a locality far north of its previously known range. *I. aculeata,* according to Menzies, is a major component of the isopod fauna south of Point Conception—a major breakpoint at about 34½° N latitude which separates the temperate marine biota of northern California from the transitional warm temperate biota of southern California. It is possible that some reports of *I. aculeata* north of Point Conception may be *I. kirchanskii* as the two species are quite similar (see Table 1).

TABLE 2. Differences between *Idotea kirchanskii* and *I. aculeata.*

	I. kirchanskii	*I. aculeata*
1. Body	Compact, pereonites without lateral incisions between them.	Not compact, lateral thoracic margins incised, especially between pereonites 1–4.
2. Color	Always green.	Mostly pink or red.
3. Head	Eyes bulge at lateral margins. Frontal process not concave.	Lateral margins not bulged. Frontal process in ovigerous females often concave.
4. Antennae 2	Short, barely reaching posterior margin of pereonite 2.	Longer, reaching almost to posterior margin of pereonite 4.
5. Pereonite 3	Posterior margin more or less straight.	Posterior margin concave.
6. Epimera	Dorsally visible only on pereonites 5–7.	Dorsally visible on pereonites 2–7.
7. Pleonites	Lateral margins curved inward anteriorly.	Lateral margins entirely straight.
8. Telson	Posterior margin without apical tooth.	Posterior margin with bluntly pointed median tooth.

Relationships: The fact that *Idotea kirchanskii* keys to *I. aculeata* in Menzies' (1950) monograph indicates a close morphological relationship between these two species. They differ significantly, however, in other respects. The similarities between the two species are shown in Table 1, the differences in Table 2.

A few specimens which have characters intermediate between *Idotea kirchanskii* and *I. montereyensis* have been found. *I. montereyensis* is also found on the same plant as the new species which suggests the possibility of some hybridization between them.

The separation of *I. aculeata* from other pentidoteans in Menzies' (1950) key is based on characteristics common to both *I. aculeata* and *I. kirchanskii*; however, with few modifications the key can be altered to conveniently include *I. kirchanskii.* The emended key is presented below:

KEY TO THE NORTHERN CALIFORNIA SPECIES OF THE SUBGENUS *PENTIDOTEA*

1\. Apex of frontal process entire. Maxilliped with one coupling hook. Eyes not markedly transversely elongate, length along body axis one-half or greater than one-half the width 2

— Apex of frontal process with a median notch 6

2\. Frontal process blunt or widely angulate, not extending beyond frontal lamina 1. Frontal lamina 1 triangulate in dorsal view 3

— A narow, pointed frontal process exceeds considerably the forward extent of a semicircular frontal lamina 1 5

3\. Posterolateral margin of epimeral plate of seventh peraeon somite evenly convex, not acute. Eyes somewhat pyriform .... *I.* (*P.*) *schmitti* Menzies

— Posterolateral margin of epimeral plate of seventh peraeon somite acute. Eyes reniform or oval 4

4\. First pleon somite with acute lateral borders. Eyes reniform .... *I.* (*P.*) *wosnesenskii* (Brandt) Menzies

— First pleon somite with wide lateral borders. Eyes circular 7

5\. Telson posterior margin deeply concave, posterolateral angles acute, each angle with a small but noticeable dorsal carina. Specimens usually found on eel grass (*Zostera* sp.) .... *I.* (*P.*) *resecata* (Stimpson)

— Telson posterior margin usually convex, with a small but distinct median tooth; when concave then only slightly so and lacking acute posterolateral angles and lacking any dorsal carina above each angle. Specimens usually found on surf grass (*Phyllospadix* sp.) .... *I.* (*P.*) *montereyensis* (Maloney)

6\. Maxilliped with two coupling hooks. Eyes transversely elongate .... *I.* (*P.*) *stenops* (Benedict)

— Maxilliped with one coupling hook. Eyes oval .... Some adult specimens of *I.* (*P.*) *aculeata* (Stafford)

7\. Segments distinctly separated laterally, lateral margins of cephalon entire, second antennae reaching almost to posterior margin of fourth thoracic segment, epimera noticeably visible dorsally on segments two through seven .... *I.* (*P.*) *aculeata* (Stafford)

— Segments not sharply separated laterally, lateral margin of cephalon indented anterior to the eyes, second antennae short, reaching almost to posterior margin of second thoracic segment, epimera noticeably visible dorsally only on segments five, six and seven .... *I.* (*P.*) *kirchanskii* Miller and Lee

Ecology: Little is known of the ecology of this species. It appears, however, to be restricted to one particular habitat, the green intertidal flowering plant, *Phyllospadix scouleri.* It is remarkably adapted for clinging to the wave-swept blades of this surf grass and accordingly is found on it even in rough water. Analysis of gut contents suggests that the animal feeds on both *Phyllospadix* and a wide variety of epiphytes found on the long narrow blades of the plant.

Initial investigations suggest that *Idotea kirchanskii* does not seem to change color in response to a change in the color of its substrate as does *I. montereyensis* (Lee, 1966a, 1966c), although superficial examination has revealed a pigmentary system similar to that found in the latter species (Lee, 1966a, 1966b).

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PELAGIC OSTRACODS (MYODOCOPA HALOCYPRIDIDAE) FROM THE NORTH ATLANTIC OFF BARBADOS[1]

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In connection with a study on primary productivity in the tropical North Atlantic off Barbados and in the Caribbean Sea off Jamaica, zooplankton samples were collected and the related hydrography and nutrient chemistry investigated by Beers, Steven and Lewis (1965, 1968) in a project carried out jointly by members of the staffs of the Bermuda Biological Station, the University of the West Indies in Jamaica, and the Bellairs Research Institute in St. James, Barbados. The zooplankton tows collected at the station off Barbados were stored at the Bermuda Biological Station, and these samples have been examined for pelagic ostracods. The majority of the zooplankton hauls were surface tows, collected to obtain an estimate of the standing crop of zooplankton, but between September 1963 and May 1964 samples were also collected at a depth of 400 m. Very few ostracods were found in the surface samples, but 26 species of Halocyprids were recorded from the six 400-m samples obtained in September, October, November 1963 and January, April and May 1964.

The Barbados station, at 15°12′N, 59°47.5′W, in 450 m of water, is eight miles west of the Bellairs Research Institute in St. James. The zooplankton tows were made with a half-meter diameter net of No. 8 nylon mesh, equipped with a flow-meter which recorded the distance towed in meters. The surface tows, which caught too few ostracods for further considera-

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[1] Contribution No. 480 from the Bermuda Biological Station.

tion, were of 10 minutes duration; the 400-m hauls were towed for 30 minutes. All the ostracods were removed, counted and identified from one-fourth of each 400-m sample. In the following listing of the species only those species will be described and figured that were not included in my report on the pelagic ostracods of the Sargasso Sea (Deevey, 1968). The species found at the station off Barbados, which were not taken in the Sargasso Sea, include *Fellia bicornis* (Müller), *Conchoecia echinata* Müller, *C. nasotuberculata* Müller, *C. parvidentata* Müller, and *Euconchoecia* sp.

Ostracods constituted at most 0.4 percent of the total numbers of organisms at the surface, but percentages ranged from 0.2 to 6.8 percent in the 400-m samples. The species of ostracods are listed in Table 1, which also gives the percentages of each species, based on the total numbers of ostracods. Highest numbers were found from November to May; few were present in September and October. Unidentifiable juvenile ostracods constituted 27–46 percent of the total numbers of ostracods. The most abundant species were all small, ranging 0.6–1.6 mm in length, and included *Archiconchoecia striata*, *Conchoecia curta*, *C. oblonga*, *C. procera*, and *C. spinirostris*. *Conchoecia acuminata*, *C. atlantica*, *C. elegans*, *C. parthenoda*, *C. porrecta* and *C. rotundata* were also relatively numerous and occurred in every sample. The commonest species at the Barbados station were also the most abundant in the Sargasso Sea (Deevey, 1968). One species, *C. imbricata*, which occurred year-round in the Sargasso Sea, was not taken at Barbados; other species including *C. atlantica*, *C. acuminata*, *C. bispinosa*, *C. elegans*, and *C. porrecta*, were more numerous at the Barbados station.

Data for temperature, salinity and nutrient chemistry were obtained from the surface down to 300 m, but not to 400 m, during the period studied. At 300 m the temperature range was 10.51–15.12°C, with a mean of 13.08°C, and the salinity varied between 35.1 and 35.9‰.

The samples were collected under Contract NONR 1135(05) from the Office of Naval Research. This study was supported partly by grant GB-2668 and partly by GB-6879, both from the National Science Foundation.

SUBORDER HALOCYPRIFORMES Skogsberg 1920
Family Halocyprididae Dana 1852
Subfamily Archiconchoecinae Poulsen 1969
Genus *Archiconchoecia* Müller 1894
Archiconchoecia striata Müller

Archiconchoecia striata G. W. Müller, 1894, p. 225, Pl. 6, Figs. 31–46, Pl. 8, Fig. 34; 1906a, p. 45, Pl. VII, Figs. 13–17; 1912, p. 56.
Archiconchoecia striata, G. B. Deevey, 1968, p. 23, Fig. 4.

This tiny species (males and females are 0.5–0.6 mm long) was one of the three most numerous ostracods, present in every sample, and constituted 2.4–17.3 percent (see Table 1) of the total numbers of ostracods.

Distribution: 36°N–37°S in the Atlantic, Indian, and Pacific Oceans and Mediterranean Sea.

Subfamily Euconchoecinae Poulsen 1969
Genus *Euconchoecia* Müller 1890
Euconchoecia chierchiae Müller

Euconchoecia chierchiae Müller, 1890, p. 277, Pl. XXVIII, Figs. 1–10.
Euconchoecia chierchiae, Skogsberg, 1920, p. 740, Figs. 148–151.
Euconchoecia chierchiae, Deevey, 1968, p. 116, Fig. 62.
Euconchoecia chierchiae, Poulsen, 1969, p. 38, Figs. 12–13.

This species was recorded in September and November 1963 and in January and April 1964 in small numbers.

Distribution: Atlantic, Pacific, and Indian Oceans between 40°N and 40°S.

Euconchoecia sp.
(Figure 1)

Three female specimens, differing from *E. chierchiae* females in appearance, were taken in the April 1964 sample. The shells (Fig. 1a–c) are 1.15, 1.17 and 1.2 mm long by 0.55 mm high, the height of the shell being around 47 percent of the length, and the greatest height just behind mid-length. There are no points at the posterodorsal corners of the shells, and the long point on the left rostrum, characteristic of *E. chierchiae* females, is also lacking. In *E. chierchiae* females from this station the depth of the shell is less, 38–42 percent of the length, the greatest height being just anterior to mid-length, there is a long spine at the posterodorsal corner of the right shell, and the left rostrum is produced into a sharp point.

The frontal organ is slim, undifferentiated, rounded at the tip, and reaches almost to the tip of the first antenna (Fig. 1d), which has distoventrally a cluster of 20–21 sensory filaments, all about the same length as the principal seta. The frontal organ differs from that of *E. chierchiae* in that it is rounded, not pointed nor bifid at the tip; also in *E. chierchiae* females the frontal organ reaches to the tip of the

TABLE 1. Percentages of ostracod species, based on total numbers of ostracods, from September 1963 to May 1964 in one-quarter of each 400-m sample. X indicates presence of species in one-quarter sample not counted.

	Sept.	Oct.	Nov.	Jan.	Apr.	May
Archiconchoecia striata	9.78	2.38	17.33	9.00	3.57	10.00
Euconchoecia chierchiae	X	—	1.93	0.56	1.78	—
Euconchoecia sp.	—	—	—	—	X	—
Halocypris brevirostris	—	—	X	0.56	4.16	1.04
Fellia bicornis	X	—	—	X	—	—
Conchoecia unid. larvae	42.60	46.40	40.00	34.90	27.40	37.50
C. acuminata	X	2.38	0.39	0.28	0.30	0.21
C. atlantica	1.77	X	1.93	2.53	5.95	0.42
C. bispinosa	0.89	X	X	X	—	1.04
C. concentrica	2.22	—	0.39	—	0.30	0.21
C. curta	15.53	15.45	1.93	18.00	12.20	15.20
C. daphnoides	X	—	X	0.56	X	0.21
C. echinata	—	X	—	1.68	0.60	1.67
C. elegans	3.11	1.19	1.16	1.68	0.89	1.46
C. magna	1.78	1.19	1.93	2.53	—	1.67
C. nasotuberculata	—	—	—	X	—	—
C. oblonga	5.78	5.96	6.55	4.22	10.10	10.00
C. parthenoda	1.33	X	6.94	2.25	2.38	3.96
C. parvidentata	X	—	—	—	—	—
C. porrecta	0.45	2.38	2.70	X	0.30	0.21
C. procera	10.20	13.10	7.33	9.57	22.00	10.20
C. rotundata	1.33	2.38	2.31	4.22	2.68	1.67
C. secernenda	0.89	—	1.93	1.96	0.30	0.21
C. spinifera	X	2.38	—	0.56	—	—
C. spinirostris	2.22	4.76	4.24	4.78	5.06	2.08
C. subarcuata	X	—	X	X	—	0.62
Conchoecia sp.	X	—	—	—	—	0.42

first antenna. The basal segment of the exopodite of the second antenna is approximately 44 percent the length of the shaft; the basal segment of the endopodite is approximately 25 percent shaft length, and bears dorsodistally two bristles, the shorter of which is slightly more than half as long as the longer (Fig. 1e). The distal segment of the endopodite has one long seta, which was broken on all three specimens, and two shorter setae or filaments, the longer one slightly more than twice as long as the shorter; in *E. chierchiae* females the longer filament is less than twice as long as the shorter one. In the morphology of the other appendages there appear to be no marked differences between these females and female *E. chierchiae*. The furca has seven claws, with a

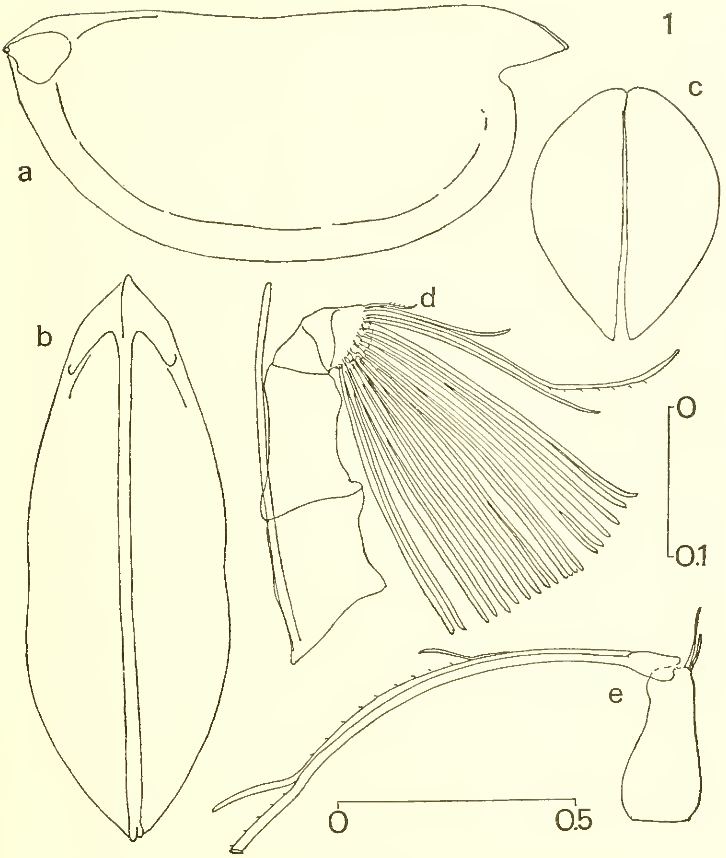

FIG. 1. Female *Euconchoecia* sp. a–c, Lateral, ventral and posterior views of shell. d, Frontal organ and first antenna. e, Endopodite of second antenna (long seta cut off). Scale at bottom for a–c, at right for d, e. Scales in mm.

pronounced knob between the first and second claws, and a tiny unpaired bristle behind the claws. The first several pairs of claws are less abruptly pointed than in *E. chierchiae.*

This species is very closely related to *E. chierchiae.* It is not named at this time, not only due to lack of more material including males, but also because a species of *Euconchoecia* lacking points at the posterodorsal corners is presently being described (Tseng, personal communication).

SUBFAMILY HALOCYPRINAE Poulsen 1969

Poulsen (1969) separated the genus *Halocypris* into three genera: *Halocypris*, *Halocypria*, and *Fellia*. Two species of two of these genera were found at the station off Barbados.

Genus *Halocypris* Dana 1852

Halocypris brevirostris (Dana)

Halocypris brevirostris, Skogsberg, 1920, p. 584, Figs. 112–115.
Halocypris brevirostris, Deevey, 1968, p. 19, Fig. 2a–f, 3c–e.
Halocypris brevirostris, Poulsen, 1969, p. 63.
For synonymy, see Skogsberg.

H. brevirostris was found from November to May, with highest percentages in April. This species has a wide range in size of mature individuals. According to Poulsen (1969) mature females vary in length from 1.1–2.1 mm, and males from 0.9–1.9 mm. This species occurs year-round in the Sargasso Sea (Deevey, 1968), where all the mature specimens were small, females being 1.1–1.3 mm, males 0.95–1.15 mm long. Mature females from the Barbados station were 1.6 mm, males 1.4 mm long.

Distribution: 60°N–40°S in the Atlantic, Pacific, and Indian Oceans. According to Poulsen, it occurs most frequently in the tropics.

Genus *Fellia* Poulsen 1969

Fellia bicornis (Müller)

(Figure 2)

Halocypris bicornis Müller, 1906a, p. 49, Pl. VIII, Figs. 8–12, 17; 1912, p. 58.
Halocypris taurina Vavra, 1906, p. 66, Pl. 7, Figs. 128–130, 131, 132a.
Fellia bicornis, Poulsen, 1969, p. 89, Fig. 38.

Poulsen has recently placed in a new genus, *Fellia*, two species that were formerly in the genus *Halocypris*, *F. cornuta* (Müller) and *F. bicornis* (Müller), with spines and/or rounded processes on the shells. Both these species occur in all oceans, mainly in tropical regions between 25°N and 25°S.

Ten specimens of *F. bicornis* were found at the Barbados station in September, January and February. Three juveniles were 0.6–0.7 mm long, four were 1.0–1.05 mm long, two were 1.4 mm long, and a mature female was 1.9 mm long by 1.55 mm high. Lateral, ventral and posterior views of the female shell, the frontal organ, first antenna, and the endopodite of the female second antenna are illustrated in Figure 2.

Distribution: Müller's specimens were found between 10°N and 10°S in the Atlantic and Indian Oceans. Poulsen's *Dana* specimens were collected from 45°N–8°S in the Atlantic, in the Indian-Indonesian region from 23°N–15°S, and in the Pacific from 5°–45°S. Very few specimens

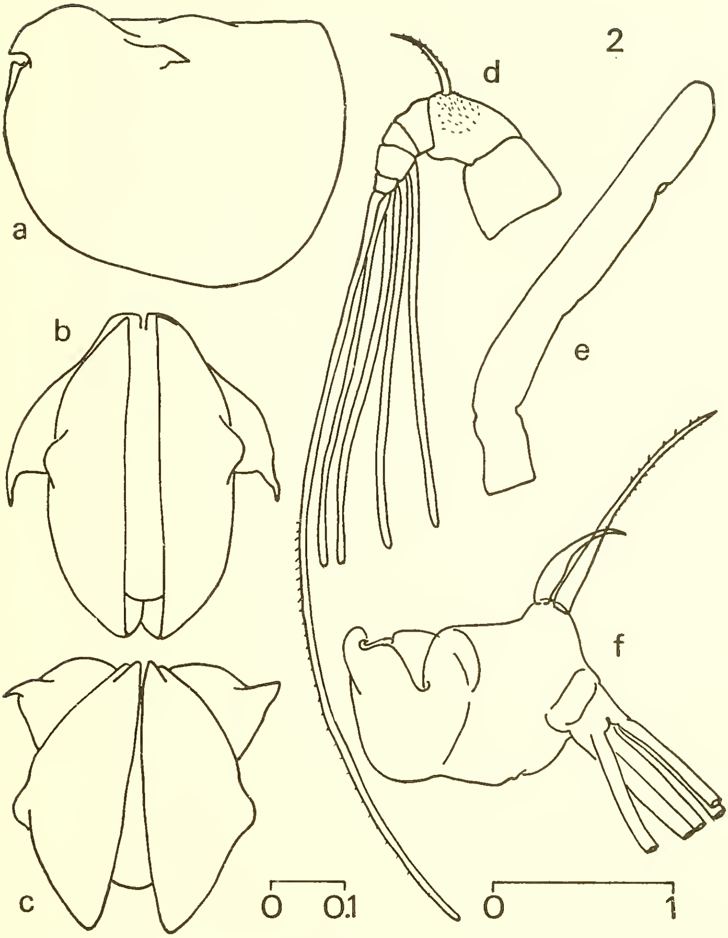

FIG. 2. Female *Fellia bicornis* (Müller). a–c, Lateral, ventral and posterior views of shell. d, First antenna. e, Frontal organ. f, Endopodite of second antenna. Scale at bottom right for a–c, at bottom center for d–f. Scales in mm.

were caught in the upper waters; most were taken over a depth range of 600–6,000 m, the majority from depths of 1,000–3,000 m.

SUBFAMILY CONCHOECINAE Müller 1906
Genus *Conchoecia* Dana 1849

The subfamily Conchoecinae, which originally included all the genera of Halocyprids except *Thaumatocypris*, is now, since Poulsen's (1969) revision, restricted to the genus *Conchoecia*. This genus includes many species that have been classified into more or less natural groups of closely related forms.

Spinifera Group

Three species which Müller (1906a) included in this group were taken at the Barbados station.

Conchoecia spinifera (Claus)

Paraconchoecia spinifera Claus, 1890, p. 14; 1891, p. 65, Pl. X, Figs. 1–7.
Conchoecia spinifera, Müller, 1906a, p. 56, Pl. IX, Figs. 1–10, 14, 15; 1912, p. 69.
Conchoecia spinifera, Deevey, 1968, p. 30, Figs. 8–9.

Specimens of this species were found only in September and October 1963 and in January 1964. *C. spinifera* was less numerous at the Barbados station than in the Sargasso Sea, where it was found year-round in the upper 500 m (Deevey, 1968).

Distribution: 52°N–35°S in the Atlantic, Indian, and Pacific Oceans.

Conchoecia oblonga (Claus)

Paraconchoecia oblonga Claus, 1890, p. 13; 1891, p. 63, Pl. VIII, Figs. 10–11, Pl. IX, Figs. 1–14.
Conchoecia oblonga, Müller, 1906a, p. 58, Pl. IX, Figs. 11–13, 16–25; 1912, p. 69.
Conchoecia oblonga, Skogsberg, 1920, p. 617, Fig. 116.
Conchoecia oblonga, Deevey, 1968, p. 33, Figs. 10, 11.

This was the largest of the dominant species and was found in every sample, constituting 4.2–10.1 percent of the total numbers of ostracods.

Distribution: 38°N–37°S in the Atlantic and Indian Oceans and Mediterranean Sea.

Conchoecia echinata Müller
(Figures 3, 4)

Conchoecia echinata Müller, 1906a, p. 61, Pl. X, Figs. 14–24; 1906b, p. 3.
Conchoecia notocera Vavra, 1906, p. 58, Pl. 6, Figs. 114–120.
Conchoecia echinata Müller, 1908, p. 67; 1912, p. 70.
Conchoecia echinata, Iles, 1953, p. 268.

Seven females, three males and a number of juvenile specimens of *C. echinata* were noted in October 1963 and January, February, April and May 1964. The females were 1.9–2.0 mm long, the males 1.65–1.7 mm long.

Description: Shell (Fig. 3a, d–g) similar in appearance to that of *C. oblonga*, but slightly larger, narrower anteriorly, greatest depth in the posterior half, with a sharp point at the posterodorsal corner of the right shell in both sexes. Height of male shell about half the length, of female shell 42–43 percent of length. The asymmetric glands are in the

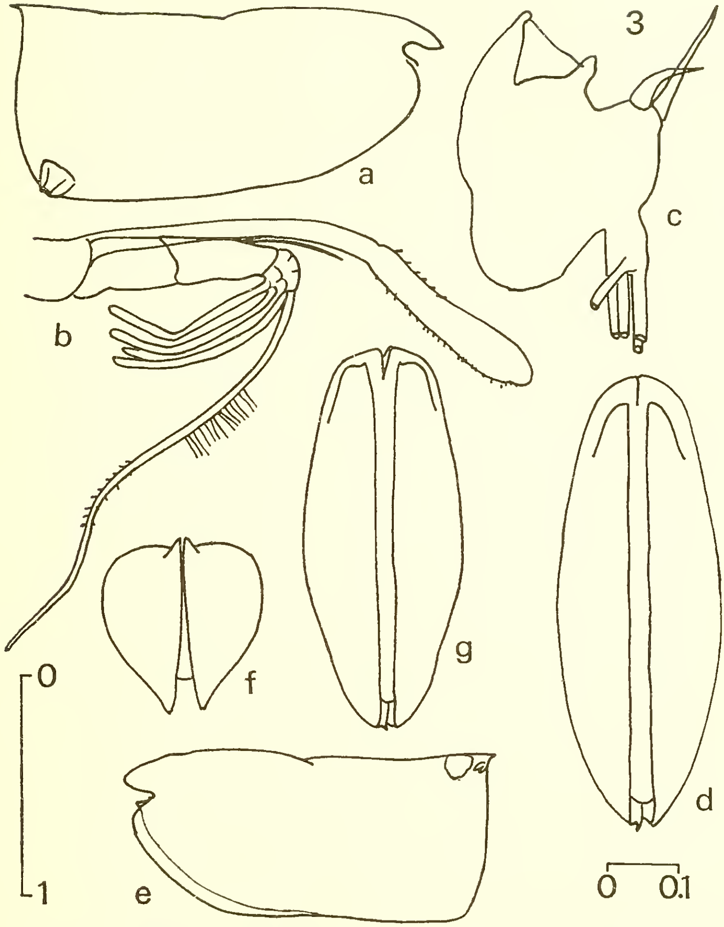

FIG. 3. *Conchoecia echinata* Müller. a, Lateral view of female shell. b, Female frontal organ and first antenna. c, Endopodite of female second antenna (setae and filaments cut off). d, Ventral view of female shell. e–g, Lateral, posterior, and ventral views of male shell. Scale at lower left for a, d–g; at lower right for b, c. Scales in mm.

usual location, the right one clearly defined at the posteroventral corner of the right shell. The female frontal organ (Fig. 3b) projects well beyond the tip of the first antenna, the capitulum covered with hairs on the proximal dorsal half and the ventral surface. The principal seta of the female first antenna has a row of long hairs anteriorly on the proximal

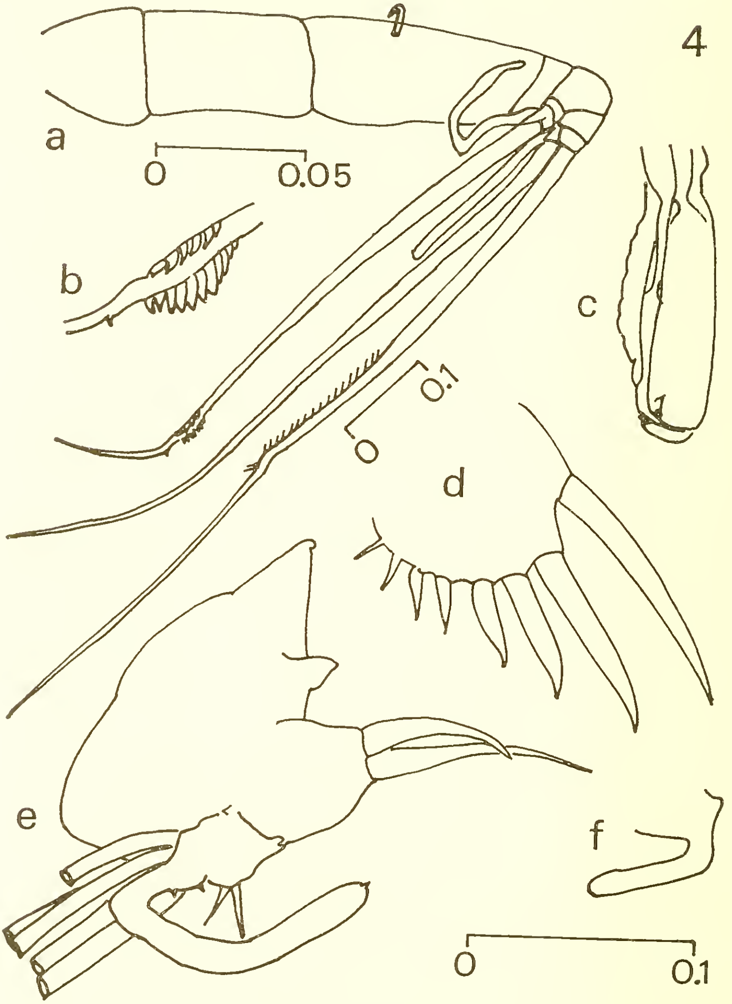

FIG. 4. Male *Conchoecia echinata* Müller. a, First antenna. b, Enlargement of portion of proximal secondary seta of first antenna. c, Penis. d, Furca. e, Endopodite of right second antenna (setae and filaments cut off). f, Left clasping organ. Scale at lower right for e, f; at center for a, c, d; at upper left for b. Scales in mm.

portion, as in other females of this group, and some spinules distally. The male principal seta (Fig. 4a) has 17–18 pairs (15, according to Müller) of thin teeth directed proximally and two directed distally at the distal end of the row of teeth. The distal secondary seta is bare, but the proximal seta has, three-quarters of the way down its length, a fan-shaped group of 6–10 spines (Fig. 4b), and more distally a tiny spine. The male right clasping organ is large and strongly curved, the left quite small (Fig. 4e, f). The claws on the furca (Fig. 4d) are almost straight, and this immediately distinguishes this species from *C. oblonga.*

Distribution: 31°N–29°S in the Atlantic, Indian, and Pacific Oceans.

Elegans Group

Conchoecia elegans Sars

Conchoecia elegans Sars, 1865, p. 117.
Conchoecia elegans, Skogsberg, 1920, p. 624, Figs. 117, 118.
Conchoecia elegans, Deevey, 1968, p. 40, Fig. 14.
For synonymy, see Skogsberg.

This species was present in all the 400-m samples, and was therefore somewhat more numerous at this station than in the Sargasso Sea (Deevey, 1968). As in the Sargasso Sea, all the mature specimens noted were small, females and males being 1.2–1.3 mm long. Skogsberg has discussed the extraordinary size range of this species, which is recorded to have a range of 1.0–2.25 mm in length of mature specimens.

Distribution: 79°58′N–55°S in the Atlantic and Indian Oceans. The smaller forms of this species have been recorded between 37°N and 24°S in the Atlantic.

Procera Group

Conchoecia procera Müller

Conchoecia procera Müller, 1894, p. 228, Pl. 6, Figs. 47, 48, 50–58; 1906a, p. 71, Pl. XIII, Figs. 37–47, Pl. XIV, Figs. 3–6; 1912, p. 72.
Conchoecia procera, Deevey, 1968, p. 45, Figs. 16, 17.

This was one of the dominant species at the Barbados station, and constituted 7.3–22 percent of the total numbers of ostracods (see Table 1). The females noted were 1.1–1.15 mm long, males 0.95–1.0 mm long.

Distribution: 32°N–37°S in the Atlantic and Indian Oceans and Mediterranean Sea.

Acuminata Group

Conchoecia acuminata (Claus)

Conchoecetta acuminata Claus, 1890, p. 16; 1891, p. 67, Pls. XIII, XIV.
Conchoecia acuminata, Müller, 1906a, p. 76, Pl. XV, Figs. 17–23; 1912, p. 74.
Conchoecia acuminata, Skogsberg, 1931, p. 9.
Conchoecia acuminata, Deevey, 1968, p. 48, Fig. 19.
For further synonymy, see Skogsberg.

This species was present in all 400-m samples. Males were 2.2–2.3 mm, females 2.9–3.15 mm long.

Distribution: 43°N–37°S in the Atlantic, Indian, and Pacific Oceans.

Rotundata Group
Conchoecia rotundata Müller

Conchoecia rotundata Müller, 1890, p. 275, Pl. XXVIII, Figs. 41–43, Pl. XXIX, Fig. 44.

Conchoecia rotundata, Deevey, 1968, p. 51, Fig. 20e–j; Fig. 21b, c, e, i–k; Fig. 22b–e.

C. rotundata was relatively numerous and was taken in every sample, constituting 1.7–4.2 percent of the total numbers of ostracods. Males were 0.85–1.1 mm, females 0.85–1.15 mm long.

Distribution: Tropical Pacific Ocean and 15–32°N in the Atlantic Ocean.

Conchoecia nasotuberculata Müller

(Figures 5, 6)

Conchoecia nasotuberculata Müller, 1906a, p. 83, Pl. XVIII, Figs. 25–30; 1908, p. 69; 1912, p. 76.

Conchoecia nasotuberculata, Iles, 1953, p. 269.

Only two specimens of this species, a female 0.8 mm long by 0.45 mm high and a male 0.8 mm long by 0.42 mm high, were taken in the January 1964 sample.

Description: In lateral view the female (Fig. 5a) and the male (Fig. 6a) shells are fairly similar in appearance, narrowed anteriorly, the anteroventral and posteroventral corners rounded, the height of the shell slightly greater than half the length. The left asymmetrical gland protrudes on the left rostrum (Fig. 5f), the right gland is a short distance below the posterodorsal corner. In ventral and posterior views the shells of the two sexes are differently shaped. In the male the shoulder vaults are broadly rounded, the width of the shell is greatest at about mid-length, and the shell tapers to the posterior end (Fig. 6b, c). The female shell (Fig. 5b, c) has symmetrically rounded bumps at approximately three-quarters of the shell length, which protrude in ventral and posterior views, and the rostrum is much narrower than the male's.

The capitulum of the frontal organ projects beyond the tip of the first antenna; the female's (Fig. 5d) is rounded, with hairs or spinules on the ventral surface, the male's (Fig. 6d) has relatively long spines ventrally over the proximal two-thirds of its length and is bent upwards at the tip. The female principal seta has only a few spinules on the posterior side of the distal half; the male principal seta has 11–12 pairs of thin sharp teeth directed proximally. The shapes of the male clasping organs are shown in Figure 6e–f.

Iles (1953) reported this species abundant at several stations in the Benguela Current between 22–29°S, and most numerous at depths of 250–500 m.

Distribution: 18°N–40°S in the Atlantic, Indian Ocean and Mediterranean Sea.

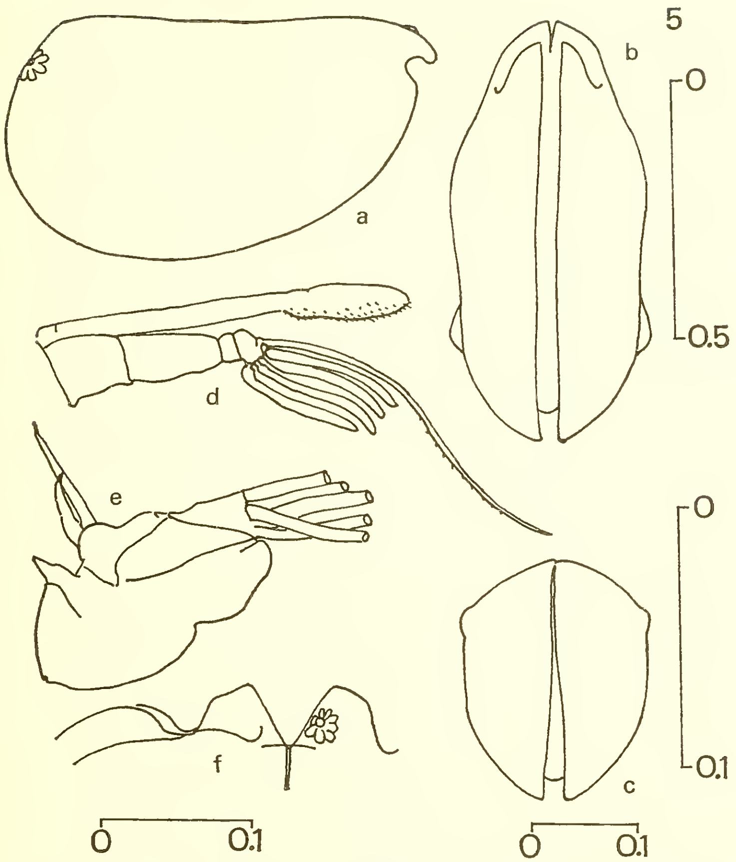

FIG. 5. Female *Conchoecia nasotuberculata* Müller. a–c, Lateral, ventral and posterior views of shell. d, Frontal organ and first antenna. e, Endopodite of second antenna (setae and filaments cut off). f, Inner view of rostrum. Scale at upper right for a–c; at lower right for e; at bottom right for f; at bottom left for d. Scales in mm.

Curta Group

Conchoecia curta Lubbock

Conchoecia curta, Müller 1906a, p. 86, Pl. XXX, Figs. 1–9; 1912, p. 77.
Conchoecia curta, Skogsberg, 1920, p. 661, Fig. 125.
Conchoecia curta, Deevey, 1968, p. 60, Fig. 26.
For synonymy, see Müller (1906a) and Skogsberg.

This was one of the most abundant species. Except in November, when it constituted only 1.9 percent of the total numbers of ostracods,

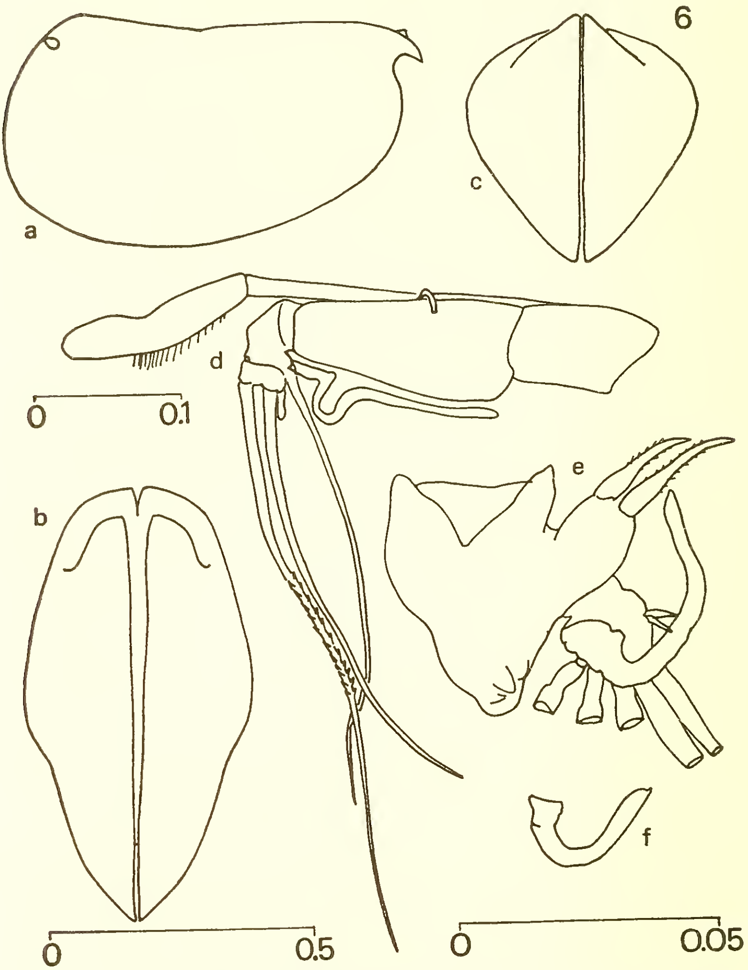

Fig. 6. Male *Conchoecia nasotuberculata* Müller. a–c, Lateral, ventral, and posterior views of shell. d, Frontal organ and first antenna. e, Endopodite of right second antenna (setae and filaments cut off). f, Left clasping organ. Scale at bottom left for a–c; at left center for d; at bottom right for e, f. Scales in mm.

percentages ranged from 12.2–18 percent (see Table 1). Females varied in length from 0.75–0.85 mm, males 0.75–0.8 mm. Some of the specimens had much more strongly arched shoulder vaults, but no other differences were noted.

Distribution: 42°N–37°S in the Atlantic, Indian, and Pacific Oceans and Mediterranean Sea.

Bispinosa Group

Conchoecia bispinosa Claus

Conchoecia bispinosa Claus, 1890, p. 10; 1891, p. 59, Pl. V, Figs. 1–10, Pl. VI, Fig. 1, Pl. VIII, Figs. 7, 8.
Conchoecia bispinosa, Skogsberg, 1920, p. 672, Fig. 128.
Conchoecia bispinosa, Deevey, 1968, p. 62, Figs. 27, 28.

This species was recorded from all but the April 1964 sample, and therefore was somewhat more abundant in these waters than in the Sargasso Sea, where specimens were taken only occasionally (Deevey, 1968). Females were 1.75–1.95 mm long, males 1.65–1.75 mm long.

Distribution: 42°N–29°S in the Atlantic Ocean.

Conchoecia secernenda Vavra

Conchoecia secernenda Vavra, 1906, p. 59, Pl. VI, Figs. 121–127.
Conchoecia secernenda, Deevey, 1968, p. 65, Figs. 29–31.

C. secernenda was present in every sample but one, and was almost as numerous at this station as in the Sargasso Sea, where it occurred year-round in the upper 500 m (Deevey, 1968).

Distribution: 37°N–7°S in the Atlantic Ocean.

Conchoecia atlantica (Lubbock)

Conchoecia atlantica, Müller, 1906a, p. 92, Pl. V, Figs. 6, 7, Pl. XIX, Figs. 17–28; 1912, p. 79.
Conchoecia atlantica, Rudyakov, 1962, p. 13, Fig. 9.
Conchoecia atlantica, Deevey, 1968, p. 69, Fig. 32.
For synonymy, see Müller (1906a).

C. atlantica occurred in every sample, and made up 6 percent of the total numbers of ostracods in April 1964. This is the largest species found at this station. Males were 3.4–3.45 mm long, females 3.6–3.65 mm long.

Distribution: 40°N–37°S in the Atlantic, Indian, and Pacific Oceans.

Magna Group

Conchoecia magna Claus

Conchoecia magna Claus, 1874a, p. 6, Pl. I, Fig. 6c, Pl. II, Figs. 16, 18; 1890, p. 8; 1891, p. 57, Pl. II, Figs. 1–9, Pl. III, Figs. 1, 2.
Conchoecia tetragona Sars, 1887, p. 254, Pl. XI, Figs. 5, 6, Pl. XIII, Figs. 5–9.
Conchoecia magna, Müller, 1894, p. 228, Pl. V, Figs. 7–12, 16–22, 27–31, 35–39, 45–52.
Conchoecia magna, Deevey, 1968, p. 77, Figs. 36, 37.

This species was present in all the samples except one.

Distribution: 52°N–55°S in the Atlantic, Indian, and Pacific Oceans and Mediterranean Sea.

Conchoecia subarcuata Claus

Conchoecia subarcuata Claus, 1890, p. 9; 1891, p. 58, Pl. III, Figs. 3–9, Pl. IV.
Conchoecia subarcuata, Müller, 1906a, p. 102, Pl. XXI, Figs. 10–16, 19; 1912, p. 83.
Conchoecia subarcuata, Skogsberg, 1920, p. 695.
Conchoecia subarcuata, Deevey, 1968, p. 86, Figs. 42, 43
For synonymy, see Skogsberg.

A few specimens of this species were taken in September, November, January and May. Females were 2.0–2.1 mm, males 1.8–1.85 mm long.

Distribution: 37°N–56°S in the Atlantic, Indian, and Pacific Oceans.

Conchoecia spinirostris Claus

Conchoecia spinirostris Claus, 1874, p. 6, Pl. I, Figs. 1, 6a, Pl. II, Figs. 11, 14, 15; 1890, p. 7; 1891, p. 56, Pl. I, Figs. 1–12.
Conchoecia spinirostris, Müller, 1894, p. 227, Pl. VI, Figs. 1–9, 13.
Conchoecia spinirostris, Skogsberg, 1920, p. 697, Fig. 134.
Conchoecia spinirostris, Deevey, p. 80, Figs. 38, 39.
For further synonymy, see Skogsberg.

This species was present in all the 400-m samples, constituting 2.1–5.1 percent of the total numbers of ostracods. It was also noted in the surface samples. It was less numerous at the Barbados station than in the Sargasso Sea, where it was probably the most abundant form in the upper 500 m (Deevey, 1968).

Distribution: 45°N–24°S in the Atlantic, the Mediterranean and 33°N in the Pacific.

Conchoecia porrecta Claus

Conchoecia porrecta Claus, 1890, p. 12; 1891, p. 61, Pl. VII, Figs. 1–13.
Conchoecia porrecta, Deevey, 1968, p. 83, Figs. 40, 41.

C. porrecta was present in every sample, in higher percentages in October and November, and therefore is a commoner species in the waters off Barbados than in the Sargasso Sea, where it occurred infrequently (Deevey, 1968). Males were 1.3–1.35 mm long, intermediate in size between *C. spinirostris* and *C. parthenoda* males, which they resemble in the shape of the shell. Females were 1.52–1.65 mm long and are similar in size and appearance to female *C. parthenoda*, but differ from the latter species in that the left asymmetrical gland does not protrude above the dorsal margin of the shell.

Distribution: 41°N–2°N in the Atlantic Ocean.

Conchoecia parthenoda Müller
(Figure 7)

Conchoecia parthenoda Müller, 1906a, p. 78, Pl. XVI, Figs. 24–29.
Conchoecia parthenoda, Deevey, 1968, p. 71, Figs. 33–35.

This species was originally placed in the *Obtusata* Group, before the male was described (Deevey, 1968). The male is similar in shape to all males of the *Magna* Group, and both males and females appear most closely related to *C. spinirostris* and *C. porrecta. Conchoecia parthenoda* was a common species at the Barbados station and was found in every sample, in higher percentages from November to May. Also during the period from November to May some specimens were present which differed in that the left asymmetrical gland was located farther forward on the dorsal margin. Most of these specimens were juveniles, but males 1.6 mm long were found in the January and May samples. One of these is illustrated in Figure 7. Aside from being slightly larger (males of *C. parthenoda* are 1.35–1.5 mm long), the armature of the principal seta (Fig. 7g) of these males had several more teeth: 8 pairs of closely set teeth distally, 6 pairs of alternating teeth, then 12 more widely spaced teeth proximally, making in profile 31–32 teeth. Also, the left asymmetrical gland was located farther forward on the dorsal margin, so that it was 23–24 percent of the total length from the posterodorsal corner; in the smaller *parthenoda* males the left asymmetrical gland is 14–16 percent of the total lengh from the posterodorsal corner.

Distribution: 37°N–30°S in the Atlantic and Indian Oceans.

Conchoecia parvidentata Müller
(Figure 8)

Conchoecia parvidentata Müller, 1906a, p. 100, Pl. XX, Figs. 11–13; 1908, p. 73; 1912, p. 83.
Conchoecia parvidentata, Skogsberg, 1920, p. 692, Fig. 132.

A single female of this species, 2.55 mm long by 1.23 mm high, was taken in September 1963.

Description: Shell narrower anteriorly, length slightly more than twice the height, greatest height in the posterior half, anteroventral and posteroventral corners rounded (Fig. 8a, b). The asymmetrical glands are in the usual location, but lateral corner glands are also present, the one on the right shell just dorsal to the right asymmetrical gland. This species lacks the gland cells beneath the rostral incisure, which are found in some members of the *Magna* Group, and this distinguishes this species from *C. lophura*, which is the same size but also has a group of gland cells on the ventral margin at the posteroventral corner of the left shell. The frontal organ extends well beyond the first antenna (Fig. 8c); the capitulum is large and bent downwards from the stem, covered with spines on the ventral surface and on the dorsal proximal third. The principal seta of the first antenna has many spinules distally on the

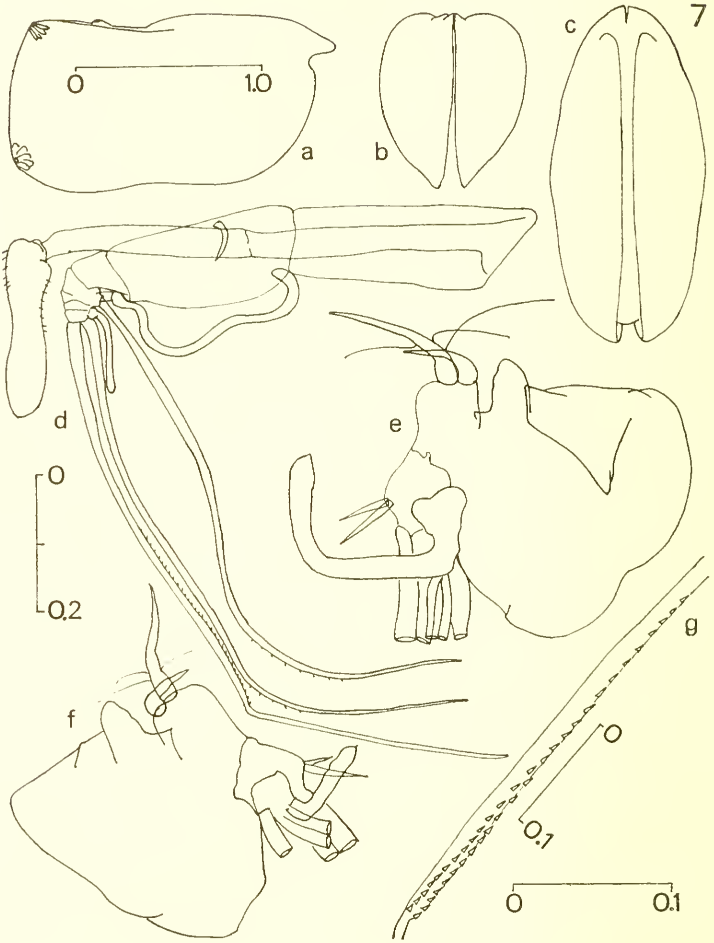

FIG. 7. Male *Conchoecia parthenoda* Müller, with left asymmetrical gland moved farther forward on the dorsal margin. a–c, Lateral, posterior and ventral views of shell. d, Frontal organ and first antenna. e and f, Endopodites of right and left second antennae (setae and filaments cut off). g, Armature of principal seta of first antenna. Scale on a for a–c; beside g for g; at left for d; at bottom right for e, f. Scales in mm.

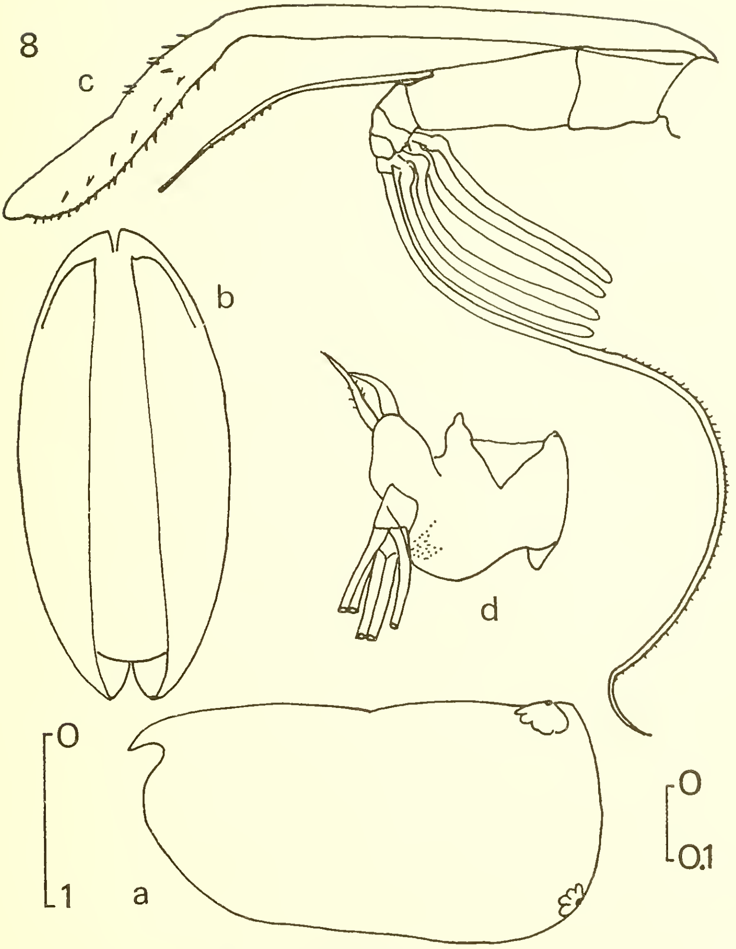

FIG. 8. Female *Conchoecia parvidentata* Müller. a, b, Lateral and ventral views of female shell. c, Frontal organ and first antenna. d, Endopodite of second antenna (setae and filaments cut off). Scale at lower left for a, b; at lower right for c, d. Scales in mm.

posterior surface. According to Skogsberg, the appendages are similar to those of *C. lophura.*

Apparently this species has been recorded only by Müller and Skogsberg, and Skogsberg's specimens were all females. Müller's (1906a) description of the male was brief; he described the armature of the principal seta as a long double row of small, fine, proximally directed

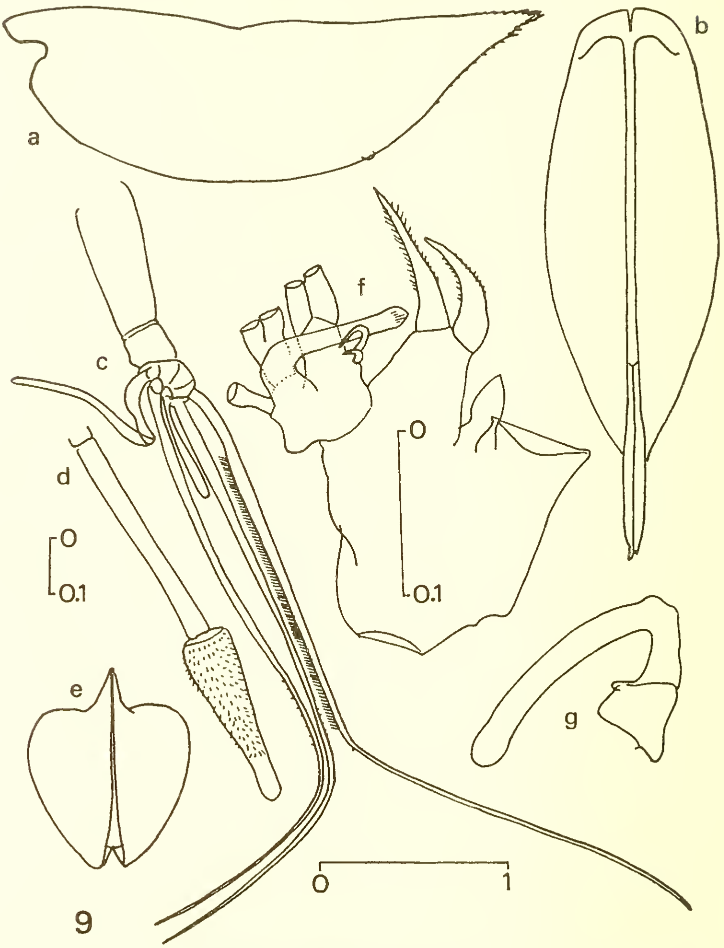

FIG. 9. Male *Conchoecia daphnoides* (Claus). a, b, e, Lateral, ventral, and posterior views of shell. c, First antenna. d, Ventral view of frontal organ. f, Endopodite of left second antenna (setae and filaments cut off). g, Right clasping organ. Scale at bottom center for a, b, e; at left for c, d; on f for f, g. Scales in mm.

teeth, thicker distally than proximally, and hard to distinguish. He noted that the longer bristle of the basal segment of the endopodite of the second antenna had strong spinules but lacked the long hairs characteristic of most males of the *Magna* Group. Müller gave the length of females as 2.5–2.7 mm, of males as 1.9–2.4 mm.

Distribution: 31°N–48°S in the Atlantic and Indian Oceans.

Daphnoides Group

Conchoecia daphnoides (Claus)

(Figure 9)

Conchoecilla daphnoides Claus, 1890, p. 17; 1891, p. 68, Pl. XV, Figs. 1–12.

Conchoecia daphnoides, Vavra, 1906, p. 45, Pl. III, Figs. 49–55.

Conchoecia daphnoides var. *typica* and var. *minor*, Müller, 1906a, p. 126, Pl. XXXI, Figs. 1–15.

Conchoecia daphnoides, Skogsberg, 1931, p. 20, Fig. V.

Conchoecia daphnoides, Deevey, 1968, p. 111, Fig. 60.

For further synonymy, see Skogsberg.

Specimens of *C. daphnoides* were taken in every sample but one. This species has a wide range in length of mature specimens, females being 4.2–5.9 mm and males 2.25–3.25 mm long. Although juvenile stages were present for most of the year in the upper 500 m of the Sargasso Sea (Deevey, 1968) no mature males were caught. One male, 2.8 mm long by 0.9 mm high, was taken in the January 1964 sample at the Barbados station.

Description of male: Shell elongate, but less so than female's, height approximately one-third length, ventral margin strongly rounded, shoulder vaults rounded (Fig. 9a, e), the right asymmetrical gland near the anteroventral corner beneath the rostrum, the left just below the posterodorsal corner of the left shell. Sculpture fairly striking, as illustrated by Müller (1906a, Pl. XXXI, Fig. 1). Three small lateral gland groups are present, two below the left asymmetrical gland, one near the posteroventral corner of the left shell. In ventral view (Fig. 9b) the rostrum is rounded, unlike the female's which is pointed with the point of the left rostrum extending well beyond the right. In a ventral view of the female shell the right posterodorsal corner projects well beyond the left; in the male the posterodorsal corners are of almost equal length, the right point slightly longer.

The male frontal organ bends up near the tip, most of the ventral surface covered with spines (Fig. 9d). The basal segments of the first antenna are relatively long and slim, and the principal seta is armed with a long row of approximately 140 pairs of thin fine teeth directed proximally, but no fine spines directed distally were present. The secondary setae have only a few spinules near the bend (Fig. 9c). On the basal segment of the endopodite of the second antenna the rounded portion that bears the two strong bristles is exceptionally large, the bristles are sharply bent and covered with spinules. The clasping organs are shown in Figure 9f, g.

Distribution: Atlantic (60°N–37°S), Pacific, and Indian Oceans.

The last two species found at the Barbados station have not been assigned to any group.

Conchoecia concentrica Müller
(Figures 10, 11a, b)

Conchoecia concentrica Müller, 1906b, p. 10, Pl. I, Figs. 1–9; 1912, p. 82.
?*Conchoecia pectinata* Leveau, 1966, p. 249, Pls. 1, 2.
Conchoecia concentrica, Deevey, 1968, p. 95, Figs. 48–50.

Juvenile specimens of *C. concentrica* were present in September and November 1963 and May 1964; one female 1.65 mm long was taken in April and one male 1.42 mm long in May 1964.

Müller described this species from three females and one male, and unfortunately did not figure the female shell. *Conchoecia concentrica* varies considerably in the sculpturing of the shell, presumably depending on the length of time since molting. The specimens found in the Sargasso Sea (Deevey, 1968) and at the Barbados station appear to differ from Müller's description only in that there is a tiny blunt point at the posterodorsal corner of the left shell instead of on the right. The shoulder vaults are swollen and extended laterally, as is evident in anterior or posterior view, and are blunt-edged in the male (Fig. 11b), but sharper-edged in immature specimens and some females (Fig. 10b, d, f), depending on the extent of the sculpturing. Müller remarked only "Schulterwulst stark vortretend, stumpfkantig." As noted previously (Deevey, 1968), the shoulder vaults of immature specimens and females "are relatively sharp-edged and may have projecting blunt spines (Fig. 10c–g), evidently prolongations of the sculpturing, which are proportionately larger in smaller individuals or may be lacking or broken off." The spines are usually broken off on mature females, so that in anterior or posterior view the shoulder vaults are blunt-edged (Fig. 10b). It is possible that the specimens described by Leveau (1966) as *Conchoecia pectinata* were immature *C. concentrica.* Stage IV individuals are 0.8–0.85 mm long, stage V specimens 1.1–1.3 mm long, the length range of Leveau's specimens. The blunt spines on the shoulder vaults of such immature specimens of *C. concentrica* (Fig. 10g) are as figured by Leveau (Pl. 1, Fig. 7) for *C. pectinata.* Leveau's figures indicate that he was describing immature specimens. His drawing of the furca of *C. pectinata*, for example, shows only 7 claws and an unpaired bristle on the furca. The number and lengths of the claws are similar in 1.1–1.3 mm long juveniles of *C. concentrica.*

In some respects *C. concentrica* resembles members of the *Bispinosa* Group. The capitulum of the male frontal organ is bent upwards and spined as in *C. bispinosa*; also the proximal secondary seta of the male first antenna has a pad or callous, such as is found in the *C. bispinosa* male. However, one of the two setae of the second segment of the endopodite of the male second antenna is not strikingly long, and the female lacks the extra bristle on this segment. *Conchoecia concentrica* differs also in having lateral corner glands near the posteroventral corners

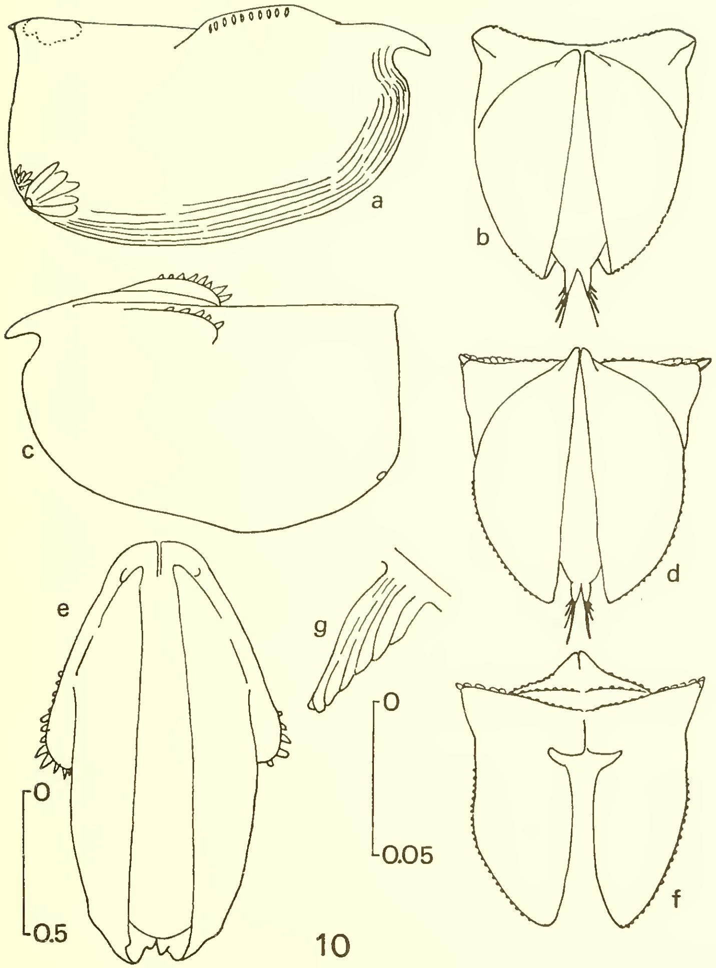

FIG. 10. Female *Conchoecia concentrica* Müller. a, b, Lateral and posterior views of a specimen from the Barbados station. c–f, Lateral, posterior, ventral and anterior views of specimen from the Sargasso Sea still retaining spines on shoulder vaults. g, Enlargement of spine. Scale at lower left for a–f; at lower center for g. Scales in mm.

of both shells. Skogsberg (1920) believed that *C. concentrica* might be related to *C. serrulata.*

Distribution: As previously known, the distribution was the Malay Archipelago and 38°N–32°N in the Atlantic Ocean; the Barbados specimens extend the range to 15°N.

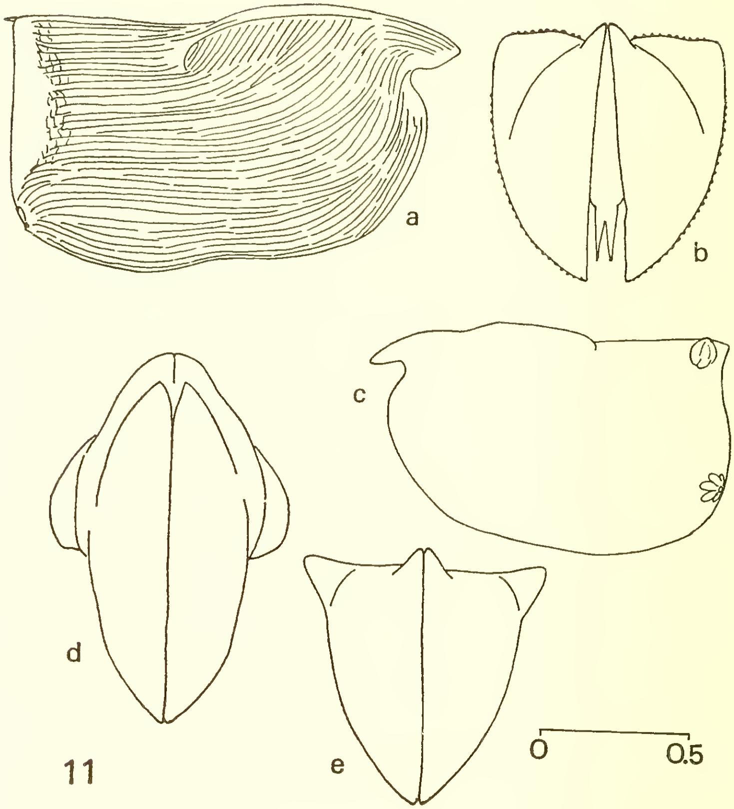

FIG. 11. a, b, Lateral and posterior views of male *Conchoecia concentrica* Müller. c–e, Lateral, ventral, and posterior views of juvenile *Conchoecia* sp. Scale for a–e, in mm.

Conchoecia sp.
(Figure 11c–e)

Conchoecia sp., Deevey, 1968, p. 114, Fig. 61.

Five juvenile specimens of a species not yet named due to lack of mature specimens were found in September 1963 and May 1964. These juveniles were 0.6, 1.15, 1.2, 1.6, and 1.65 mm long. This species resembles *C. concentrica* in the shape of the shell, but is larger at maturity and of slim build, whereas *C. concentrica* is a plump species, the body always filling the shell. The shell appears to lack sculpturing, but faint lines may be seen, running anteroposteriorly in a pattern similar to the sculpturing of the *C. concentrica* shell. The asymmetrical glands and lateral corner glands are situated as in *C. concentrica*. The posterodorsal corners of both shells are rather bluntly rounded and of equal size, neither the right nor the left shell produced into a definite point. Lateral, posterior, and ventral views of the 1.2 mm juvenile shell are shown in Figure 11c–e.

Distribution: 32°N–15°N in the Atlantic Ocean.

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A NEW SPECIES OF *EUPERA* (MOLLUSCA; PELECYPODA) FROM HAITI

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Museo Nacional de Historia Natural
Montevideo, Uruguay

The genus *Eupera* Bourguignat, 1854, is represented in the Greater Antilles by the following species: *E. cubensis* (Prime, 1865) from Cuba; *E. portoricensis* (Prime, 1863) and *E. parvula* (Prime, 1865) from Puerto Rico and *E. veatleyi* (C. B. Adams, 1849) from Jamaica, which to date has not been cited from Hispaniola.

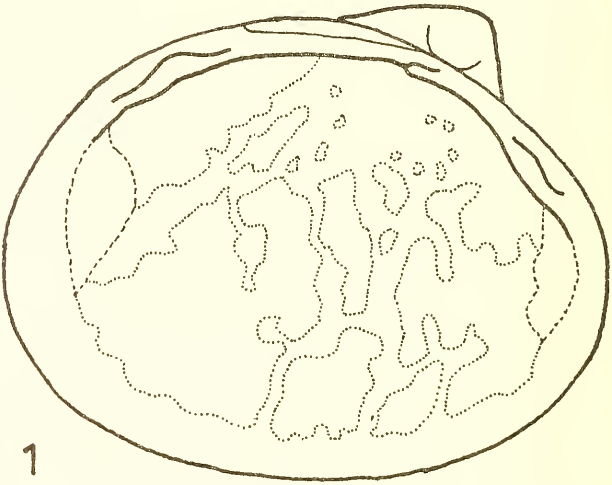
While recently checking material of this genus in the collections of the U.S. National Museum, I came across an undetermined lot consisting of a large number of isolated valves (possibly inarticulated when collected) found in the southwest of the island, near Los Cayes, Dept. du Sud, Haiti. Having studied this material, I arrived at the conclusion that it represented a new species, which I describe as follows:

Eupera haitiensis new species

Figures 1–3

Description: (Holotype, left valve). (Fig. 1). Shell of medium size for the genus; subovate, short and very deep for its size; margins smooth, slightly arched, united in a regular curve that does not present any particular characteristic. The anterior margin much shorter than the posterior; the inferior, the longest.

Umbo large, with a forward and inward projection and situated on a level with the first anterior third of the shell, while projecting conspicuously above the superior margin (Fig. 2). Cardinal tooth, small and simple. In its lateral aspect it has the appearance of a very small, short and straight lamella, obliquely located on the curved hinge, beneath and to the rear of the umbo. In its inferior aspect (Fig. 3), it has the appearance of a small, truncate cone, the anterior face of which continues slightly downwards, while the posterior, short side, terminates abruptly and almost vertically.



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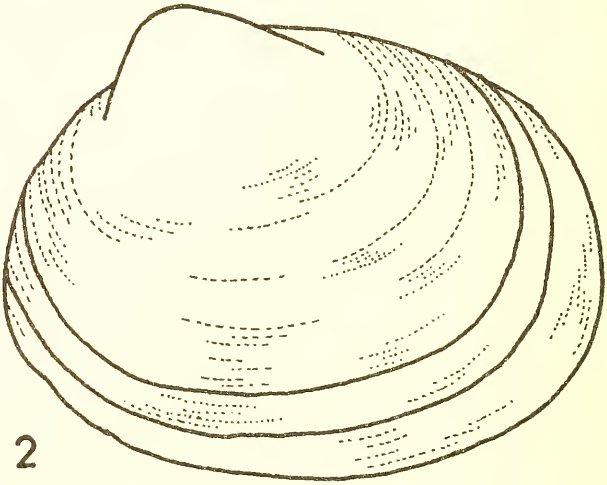

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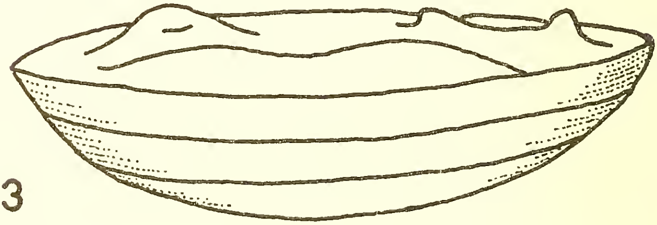

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This tooth is separated from the anterior margin by a small and not very deep parallel groove that engages the cardinal of the opposite valve.

On its anterior side an articular surface is present where the interior face of the right cardinal rests. Lateral teeth, simple; the anterior tooth with a short but robust base, appears from below as a higher cone than that of the cardinal. It is separated from the exterior margin by a small groove and presents on its superior and inferior faces a sharply defined articular surface.

The posterior lateral, lower and more extended, presents in its inferior aspect a conical profile, low but very regular. It, too, is separated from the external margin by an extended groove.

As in the other lateral, it presents on its superior and inferior faces a clearly defined articular surface.

The ligament, fine and elongate, extends from the umbo as far as the origin of the posterior lateral. It is limited inferiorly by a thin but quite perceptible ridge, parallel to the superior margin.

The internal surface, brilliant beyond the pallial line and in the impressions of the adductors, but opaque in the rest of the shell.

Color white, but splotchy, with characteristic purplish-brown spots, clotted and clustered, although limited in expansion by the pallial line.

The external surface, wanting in periostracum, presents a dullish white color with very fine concentric lines of growth alternating with larger, thick, rough and irregular ridges, of which it is possible to discern four.

Holotype: U.S.N.M. 404968. Left valve. Collected by C. R. Orcutt. Date: 17 May 1929

Type-Locality: O'Shell Sugar Plantation, near Los Cayes, Dept. du Sud, Haiti

Measurements: (in mm) 5.0 × 4.0

Paratypes: U.S.N.M. 679533. Same data as the holotype
M.N.H.N. Montevideo. 1328. Same data as the holotype
U.S.N.M. 440232. Los Cayes, Dept. du Sud, Haiti (Orcutt!)
U.S.N.M. 439871. Bizoton, Dept. de l'Ouest, Haiti (Orcutt!)

Remarks on Paratypes (Right Valve): Cardinal weaker. It appears as a small oblique fold that in its inferior aspect does not extend beyond the superior margin of the shell. On its inferior face, however, it presents a very small articular surface that is separated from the exterior margin by a shallow cavity.

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FIGS. 1–3. *Eupera haitiensis* n. sp. (Holotype, U.S.N.M. 404968). Fig. 1—Internal view. Fig. 2—External view. Fig. 3—The hinge.

The anterior laterals, though solid, are low and very short (the inferior the larger), and are separated from one another by a relatively deep cavity.

The posterior laterals (the inferior the larger) are also low but more extended than the anterior, and are separated by a narrow groove that is not so deep but longer than that of the anterior.

The inner faces of the laterals (both anterior and posterior) are finely granulate (as shown under magnification). The zones where the periostracum is still present are of a greenish-gray color and are not very brilliant. Over and above this, they exhibit the concentric lamellae already described in other species of the genus.

In some of the young specimens the periostracum presents a light-brownish color. Practically all the specimens show the thick and rough concentric ridges that were observed in the holotype; the number variable but as many as 15.

The depth of the valves and the strong teeth as compared with these features in other species of the genus is striking. The shape of the shell is remarkably constant in the whole lot.

Discussion: Compared with *E. cubensis*, the new species that we describe here may be easily distinguished by its different shape, characterized by its shorter posterior margin and more developed umbo.

In *E. cubensis*, the superior margin is higher posteriorly than the umbo, it being the highest part of the shell.

In *E. haitiensis*, on the other hand, the umbo is the highest part of the shell and definitely exceeds the superior margin. The cardinal tooth of the left valve is lower and more robust in *E. haitiensis*, while in *E. cubensis* it is higher and weaker. Nevertheless, the laterals are more elongated in this last species. The same occurs in the case of the other forms, *E. veatleyi*, *E. portoricensis* and *E. parvula*, of the area.

I may add that the position of the umbo is more central in *E. haitiensis* than in the other above-mentioned species. The same applies to *E. bahamensis* Clench, with which I have also compared *E. haitiensis*.

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A NEW CRAYFISH OF THE GENUS *FALLICAMBARUS* FROM TENNESSEE (DECAPODA, ASTACIDAE)

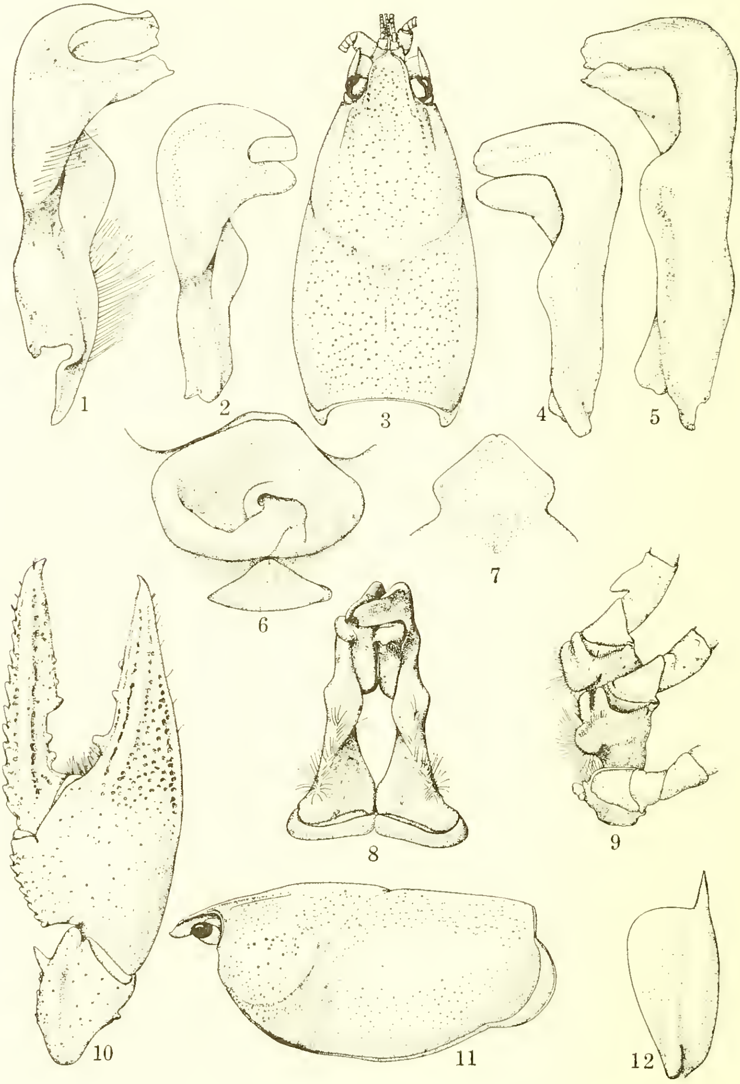
By Horton H. Hobbs, Jr. and Joseph F. Fitzpatrick, Jr.
Smithsonian Institution and
Randolph-Macon Woman's College

Among the many undescribed crayfishes known to occur in Tennessee, this new member of the burrowing genus *Fallicambarus* was dug from comparatively simple shallow burrows constructed in sandy soil near a small tributary to the Hatchie River in McNairy County. Its range lies along the edge of the boundary of that outlined for the genus by Hobbs (1969: 124), extending "from southern Ontario, Michigan and Illinois southward to Texas and across western Tennessee to southwestern Georgia; east of the Appalachians it extends from Maryland to South Carolina."

We are grateful to H. H. Hobbs III, Daniel J. Peters, and Dr. Jean E. Pugh for their assistance in obtaining the 24 specimens on which this description is based.

Fallicambarus hortoni new species

Diagnosis: Body pigmented, eyes well-developed. Rostrum depressed, acuminate, and devoid of marginal spines or tubercles. Areola obliterated or linear, its projected extent comprising 36.0 to 38.2 per cent of entire length of carapace. Cervical spines or tubercles lacking. Suborbital angle weak, obtuse. Postorbital ridges terminating cephalically with or without very small tubercles. Antennal scale 2.3 to 2.5 times longer than broad, broadest distal to midlength. Chela with two rows of tubercles on mesial surface of palm; lateral margin of chela costate and both fingers with well-defined longitudinal ridge on upper surface; dactyl with distinct emargination. First sinistral pleopod (Figs. 1, 5, 8) of first form male with corneous central projection recurved at approximately 90 degrees and strongly deflected dextrally, scarcely tapering distally, broadly truncate with subapical notch lacking, or perhaps represented by shallow emargination; non-corneous mesial process only slightly tapering



Figs. 1–12. *Fallicambarus hortoni* new species (pubescence removed from all structures illustrated except for Figs. 1, 8, 9, 10). 1, Mesial view of first pleopod of holotype. 2, Mesial view of first pleopod of morphotype. 3, Dorsal view of carapace of holotype. 4, Lateral view or first pleopod of morphotype. 5, lateral view of first pleopod of

distally, eminence on morphological cephalic border almost at tip of process and overlapping central projection laterally with small constricted distal portion extending slightly beyond tip of central projection. Annulus ventralis (Fig. 6) immovable, approximately 1.6 times broader than long, deeply excavate dextrally, and with conspicuous tongue sloping cephalosinistrally from elevated caudal wall. Color olive brown with irregular dark and light markings and sometimes with median longitudinal pale olive-tan stripe.

Holotypic Male, Form I: Body subovate, slightly compressed. Abdomen narrower than cephalothorax (11.0 and 12.6 mm). Carapace broader than depth at caudodorsal margin of cervical groove (12.6 and 10.8 mm). Areola linear and constituting 37.5 per cent of entire length of carapace; cephalic section of carapace 1.7 times longer than areola. Rostrum depressed, acuminate, excavate dorsally with converging thickened margins; marginal spines or tubercles lacking; upper surface with conspicuous, deep punctations, submarginal rows of setiferous punctations becoming progressively shallower toward apex; acumen slightly upturned and reaching slightly beyond base of ultimate podomere of peduncle of antennule; subrostral ridges visible in dorsal aspect almost to midlength of rostrum. Postorbital ridges strong, grooved dorsolaterally, and terminating cephalically without tubercles. Suborbital angle obtuse and weak. Branchiostegal spine reduced to angle. Carapace with many prominent setiferous punctations dorsally and dorsolaterally, but less dense cephalolaterally, and with setiferous squamous tubercles on lateral branchiostegal region, anteriormost forming row along caudoventral margin of cervical groove. Cervical spines or tubercles lacking. Abdomen longer than carapace (26.2 and 24.5 mm). Cephalic portion of telson with two strong spines in each caudolateral corner, mesial ones movable. Uropods with distolateral margin and distal end of submedian ridge of outer ramus with strong acute spines, that on ridge almost reaching distal margin of ramus; distal portion of proximal segment of inner ramus with row of strong acute spines; basal segment of uropods with strong mesiodistal acute spine overlapping base of outer ramus; smaller acute laterodistal spine also present.

Epistome (Fig. 7) about 1.5 times longer than broad, subtriangular, nearly plane, and bearing small apical notch and shallow caudomedian fovea. Antennules of usual form with well-developed small spine on mesioventral margin slightly distal to midlength. Antennae broken but probably reaching beyond midlength of abdomen. Antennal scale (Fig. 12) 2.3 times longer than broad, broadest distal to midlength with

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holotype. 6, Annulus ventralis of allotype. 7, Epistome of holotype. 8, Caudal view of first pleopods of paratypic male, form I. 9, Bases of third, fourth, and fifth pereiopods of holotype. 10, Dorsal view of distal podomeres of cheliped of holotype. 11, Lateral view of carapace of holotype. 12, Antennal scale of holotype.

widest lamellar area approximately 1.6 times width of thickened lateral portion, latter terminating in strong acute spine.

Right chela (Fig. 10) strongly depressed with palm inflated and bearing scattered punctations proximally, becoming more numerous distally, and particularly crowded and conspicuous at base of immovable finger. Inner margin of palm with mesial row of eight tubercles subtended dorsolaterally by row of eight with single tubercle immediately lateral to distal one in second-mentioned row. Ventral surface of palm with widely scattered setiferous punctations and with prominent tubercle at base of dactyl. Fingers only slightly gaping. Opposable margin of immovable finger with two prominent tubercles in proximal half and single row of minute denticles extending distally from distal tubercle; single large tubercle in proximal portion of distal half below row of denticles; upper surface with strong submedian ridge flanked by deep setiferous punctations, and less conspicuous ridge mesially; lateral margin of finger strongly costate, ridge extending proximally onto distal portion of palm; ventral surface with distinct row of setiferous punctations along lateral margin and heavily bearded in basal eighth of mesioventral portion. Opposable margin of dactyl distinctly excised, with two prominent tubercles in basal half of excision and one large tubercle at its distal end, latter tubercle followed distally by single row of minute denticles interrupted by two small tubercles; dorsal surface with strong submedian longitudinal ridge flanked by setiferous punctations, and six small tubercles flanking mesial row of punctations; mesial margin with row of 13 tubercles decreasing in size distally and extending almost entire length of dactyl.

Carpus of cheliped longer than broad with deep submedian longitudinal furrow; dorsal surface with scattered setiferous punctations; mesial surface with prominent acute spine slightly distal to midlength and with row of four much smaller spiniform tubercles proximal to it, latter flanked above and below by irregular cluster of small tubercles; ventral laterodistal and mesiodistal extremities with acute spines.

Merus of cheliped with upper surface sparsely punctate and bearing two obscure tubercles distally; mesial and lateral surfaces also sparsely punctate; ventral surface with mesial row of 15 heavy acute tubercles and lateral one of two acute tubercles in middle third. Ischium with single very small tubercle on mesial margin proximal to midlength.

Hooks on ischia of third pereiopods only (Fig. 9); hooks simple, extending proximally beyond distal margin of basis and not opposed by tubercle on latter. Coxa of fourth pereiopod with prominent longitudinally oriented furrow with conspicuous rounded elevation mesial to it and obliquely directed boss caudomesially, boss excavate anteroventrally. Coxa of fifth pereiopod with only slight caudomesial elevation.

Sternum between bases of third, fourth, and fifth pereiopods deep and with conspicuous setal mat extending mesioventrally and covering first pleopods.

First pleopods (Figs. 1, 5, 8) symmetrical basally but markedly asymmetrically disposed distally with central projection of sinistral member of pair directed caudodextrally across median line of body, displacing corresponding element of dextral pleopod laterally (Fig. 8). Pleopods reaching base of coxae of third pereiopods when abdomen is flexed and terminating in two parts bent caudally at approximately right angles to main axis of shaft of appendage (see diagnosis for description).

Morphotypic Male, Form II: Differs from holotype in following respects: rostrum with apical tubercle much reduced, not upturned, and not reaching base of ultimate podomere of peduncle of antennule; epistome subtriangular with rounded apex; right chela apparently regenerated but mesial margin of palm of left chela with most mesial row of only 7 tubercles; distal tubercle on opposable margin of immovable finger much reduced; mesial margin of dactyl with row of 12 tubercles and with row of 5 tubercles immediately lateral to it; carpus of chela not so distinctly longer than broad, and major spine on mesial surface surrounded by irregularly arranged tubercles; upper distal surface of merus with three small tubercles, ventrolateral margin with three spines; hooks on ischia of third pereiopods and ornamentation of coxa of fourth not so strongly developed.

First pleopod (Figs. 2, 4) with no corneus elements; central projection broadly rounded with faint indication of emarginations apically; mesial process also broadly rounded and directed somewhat laterally with eminence on morphological cephalic border much reduced; basal "segment" of pleopod delimited by suture.

Allotypic Female: Differs from holotype in following respects: abdomen and cephalothorax subequal in width; mesial row of six tubercles on inner margin of palm of chela subtended dorsolaterally by row of seven; opposable margin of dactyl with row of four tubercles distal to large tubercle at distal end of excision; mesial surface of dactyl with lateral row of only five tubercles; carpus with two spinous tubercles aligned between strong mesial spine and mesiodistal ventral spine; dorsal surface of merus with irregular row of five tubercles distally, ventromesial margin with row of 14 and ventrolateral margin with row of three.

Sternum between last three pairs of pereiopods deep. Annulus ventralis (Fig. 6) immovable but with distinct groove between it and sternum immediately cephalic to it, about 1.6 times broader than long, and with caudal margin markedly elevated (ventrally); deep sinus originating near median line caudal to midlength, extending approximately one-fourth width of annulus, and recurving rather suddenly caudodextrad to cut caudal margin just sinistral to median line; tongue sloping cephalosinistrally from caudal wall to dip below transverse portion of sinus; usual median trough displaced dextrally, extending caudodextrally from midcephalic margin of annulus to base of elevated caudodextral wall, becoming broader and deeper caudally. Sternite immediately caudal to annulus broadly triangular, about 2.4 times broader than long, not highly elevated but with highest portion centrally situated.

Type-locality: Low area along a roadside ditch leading into a small

Measurements: As follows (in mm):

	Holotype	Allotype	Morphotype
Carapace			
Height	10.8	10.7	7.6
Length	24.5	25.9	19.2
Width	12.6	12.5	9.3
Rostrum			
Length	6.4	6.0	4.5
Width	4.1	4.3	3.4
Areola length	9.2	9.6	7.1
Chela, right			
Length of outer margin	19.0	15.9	10.9
Length of inner margin of palm	4.7	4.5	2.9
Width of palm	7.9	7.0	5.1
Length of dactyl	13.1	11.0	7.8

tributary of Cypress Creek, 7.5 miles east of the Hardeman County line on State Route 57 (Hatchie River drainage), McNairy County, Tennessee. The animals were dug from burrows (see introductory paragraph), some of which were provided with chimneys similar to those constructed by *Cambarus d. diogenes* Girard, 1852. Vegetation in the area consisted of several species of grasses and Compositae and a member of the genus *Viola*. *Salix nigra* was along the ditch, and slightly more distant were trees belonging to the genera *Acer*, *Liquidambar*, and *Liriodendron*.

Disposition of Types: The holotypic male, form I, the morphotypic male, form II, and the allotypic female are deposited in the United States National Museum (nos. 129895, 129896, and 129897, respectively). Paratypes also located at the USNM include 3♂I, 3♂II, 12♀, and in the collection of the junior author are 1♂I, 1♀, and a damaged ♂II. All were collected from the type-locality on 20 May 1969 by those mentioned above and the authors.

Color Notes: Carapace and abdomen drab olive-brown with olive black and pale olive tan mottlings; branchiostegal areas fading ventrally. Some specimens with discreet pattern consisting of dorsomedian longitudinal light stripe extending from base of telson cephalically to cervical groove, flanked laterally by very dark irregularly margined dark stripes from telson to at least midlength of areola. Caudodorsal margin of pleura of abdomen with pale spot. Upper surface of distal podomeres of chelae very dark, somewhat paler below with tips of fingers reddish orange. Proximal podomeres of remaining pereiopods pale, merus and more distal podomeres dark, darker dorsally than ventrally. Lateral portions of cephalic section and most of caudal section of telson dark as are inner ramus and distal segment of outer ramus of uropods and mesiodistal end of uropodal peduncle.

Range and Crayfish Associates: Fallicambarus hortoni is known only from the type-locality. No other primary burrowing species were encountered in the immediate vicinity, but *Cambarus striatus* Hay, 1902, was collected from the adjacent creek as were *Procambarus ablusus* Penn, 1963, and an undescribed species of the genus *Orconectes.* Nearby localities yielded specimens of *C. d. diogenes* Girard, 1852, and what appears to be *C. d. ludovicianus* Faxon, 1914. Further collections in the area are needed to determine the precise degree of overlap (ecological and geographical) which exists between these primary burrowing crayfishes.

Variations: Little variation was observed in the type series beyond that usually encountered in a crayfish population. In one first form male, however, the branchiocardiac grooves are sharply arced so that the areola, although obliterated, is not linear, and one punctation is evident anterior and posterior to the obliterated portion.

Relationships: Fallicambarus hortoni is the first species to be assigned originally to the genus *Fallicambarus,* Hobbs, 1969. Of the eight species previously recognized, *F. hortoni* is probably more closely allied to *F. byersi* (Hobbs, 1941) and *F. oryktes* (Penn and Marlow, 1959) than to any of the others. The latter two occur in the lower coastal plain between the Choctawhatchee River, Florida and the Pontchartrain Basin in Louisiana. The kinship is most clearly seen in the similarities of the first pleopods and annulus ventralis. More distantly, it is related to *F. fodiens* (Cottle, 1863), *F. hedgpethi* (Hobbs, 1948), and *F. uhleri* (Faxon, 1884) which species occupy the northwestern, southwestern, and eastern limits of the range of the genus. The peculiar structure of the distal portion of the first pleopod of the first form male, however, readily distinguishes it from any other crayfish.

Etymology: We are pleased to name this crayfish in honor of Horton H. Hobbs III, who, in his work on the entocytherid ostracods associated with primary burrowing crayfishes, has added greatly to our knowledge of the ranges of many of the burrowing species.

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PROCEEDINGS
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FAMILIAL TAXA WITHIN THE CAPRELLIDEA (CRUSTACEA: AMPHIPODA)

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Historically the Caprellidea have been divided into two families, the Cyamidae (whale lice) and the Caprellidae (skeleton shrimps). Due primarily to the recent discovery of *Caprogammarus*, an intermediate form between the caprellidean and gammaridean stocks, questions have been raised about this classical division.

Vassilenko (1968) proposed a new family, Paracercopidae (invalid name), for the genus *Cercops* and the following four subfamilies for the remaining genera of Caprellidae:

Phtisicinae Vassilenko—*Phtisica, Paraproto, Protogeton, Protoplesius, Pseudoproto, Protomima, Metaproto.*

Dodecadinae Vassilenko—*Dodecas, Dodecasella, Caprellina, Hircella, Pseudocaprellina, Liriarchus, Aeginoides.*

Aeginellinae Vassilenko—*Aeginella, Aeginina, Thorina, Protellina, Proaeginina, Parvipalpus, Parvipalpina.*

Caprellinae Dana—*Aciconula, Caprella, Caprellinoides, Deutella, Eugastraulax, Eupariambus, Hemiaegina, Liropus, Luconacia, Mayerella, Metaprotella, Monoliropus, Noculacia, Orthoprotella, Paedaridium, Paracaprella, Paradeutella, Pariambus, Paraprotella, Pedoculina, Piperella, Proliropus, Propodalirius, Protella, Protellopsis, Pseudaeginella, Pseudolirius, Pseudoprotella, Triantella, Triliropus, Triperopus, Tritella.*

McCain (1968, pp. 107–112) discussed the relationship between the suborders Gammaridea and Caprellidea and stated that a revision of familial taxa is necessary in the Caprellidea but that the mouthparts of many Caprellidae were too poorly known to allow such a revision at that time. Since then, numerous species have been examined. The mandible shows several trends which roughly coincide with Vassilenko's conception of the subfamilies based primarily on degrees of pereopod reduction.

Four distinct groups of mandible types are evident in the Caprellidea as follows:

Group I. Mandible lacking molar, bearing numerous spines and accessory plates, and bearing a mandibular palp.

Group II. Mandible with molar, bearing 2 or 3 spines and a lacinia mobilis and incisor, and with a mandibular palp.

Group III. Mandible with molar, bearing 2 or 3 spines and a typical lacinia mobilis and incisor, and lacking a mandibular palp.

Group IV. Mandible without molar or palp.

Group I includes Vassilenko's concept of the Phtisicinae and Dodecadinae and Group II the Aeginellinae. The Caprellinae, however, appear to be a heterogeneous assemblage of mandible types.

McCain (1968, p. 3) stated that the mouthparts undoubtedly reflect feeding habits of caprellids and thereby, to some extent, their niche. Since we lack a fossil record of the Caprellidea, the choice of mandible types as conservative characters seems justified. Lacking other obvious conservative characters, the use of mandible types to characterize higher taxa should be much more valid than the use of reduced segmentation of vestigial appendages.

I, therefore, propose the following familial classification of the Caprellidea:

PHTISICIDAE VASSILENKO, 1968, emend.

Mandible lacking molar, with mandibular palp (Group I); pereopods 3–5 fully segmented or reduced; gills on pereonites 2–4, rarely 3–4; abdomen of single reduced article. Two subfamilies:

Phtisicinae Vassilenko, 1968, emend.

Pereopods 3–5 fully segmented, pereopod 5 rarely reduced. Nine genera: *Hemiproto, Metaproto, Paraproto, Phtisica, Protogeton, Protomima, Protoplesius, Pseudoproto, Pseudoprotomima.*

Dodecadinae Vassilenko, 1968, emend.

Pereopods 3–5 variably reduced, pereopod 5 of less than 4 articles except for 1 genus. Twelve genera: *Aeginoides, Caprellina, Caprellinoides, Dodecas, Dodecasella, ? Fallotritella, Hircella, Liriarchus, Peadaridium, Pereotripus, Prellicana, Pseudocaprellina.*

AEGINELLIDAE VASSILENKO, 1968, emend.

Mandible with molar and mandibular palp (Group II); pereopods 3–4 considerably reduced or absent, pereopod 5 occasionally reduced; gills on pereonites 3–4, 1 genus 2–4; abdomen of single reduced article. Two subfamilies:

Aeginellinae Vassilenko, 1968, emend.

Pereopods 3–4 absent, gills on pereonites 3–4 except 1 genus. Seven genera: *Aeginella, Aeginina, Parvipalpus, Proaeginina, Protellina, Pseudaeginella, Thorina.*

Protellinae new subfamily

Pereopods 3–4 absent or number of articles quite reduced, gills on pereonites 3–4. Sixteen genera: *Abyssicaprella, Deutella, Eupariambus, Liropus, Luconacia, Mayerella, Metaprotella, Monoliropus, Orthoprotella, Paraprotella, Parvipalpina, Protella, Protellopsis, Pseudoprotella, Triliropus, Tritella.*

CAPROGAMMARIDAE KUDRJASCHOV AND VASSILENKO, 1966, emend.

Mandible with molar and palp (Group II) or lacking molar (Group II, aberrant), pereopods 3–4 reduced to 1 or 2 articles, gills on pereonites 2–4 or 3–4, abdomen of numerous segments. Two genera: *Caprogammarus, Cercops.*

CAPRELLIDAE WHITE, 1847, emend.

Mandible with molar, lacking palp (Group III) except one genus with rudimentary palp; pereopods 3–4 quite reduced or absent; gills on pereonites 3–4; abdomen of single reduced article. Nine genera: *Caprella, Eugastraulax, Hemiaegina, Metacaprella, Paracaprella, Pariambus, Pedoculina, Propodalirius, Pseudolirius.*

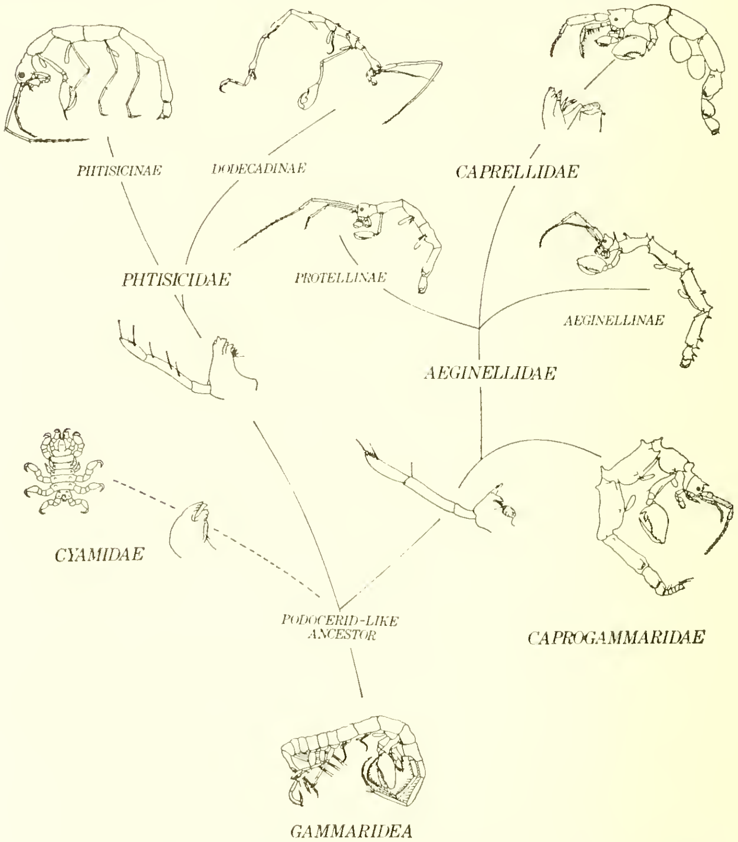

FIG. 1. Familial relationships in the suborder Caprellidea. (Posterior pereopods omitted except where taxonomically significant)

CYAMIDAE WHITE, 1847

Mandible without molar or palp (Group IV), pereopods 3–4 absent, gills on pereonites 3–4, abdomen of single reduced article. Five genera: *Cyamus*, *Isocyamus*, *Neocyamus*, *Platycyamus*, *Syncyamus*.

Incertae Sedis

Six genera: *Aciconula*, *Noculacia*, *Paradeutella*, *Proliropus*, *Triantella*, *Triperopus*. Mandibles of these six genera have not been described fully; however, all have a 3-segmented mandibular palp and appendages on pereonites 3–4. They, therefore, probably belong to the Protellinae of the Aeginellidae.

Two stocks are apparent within the Protellinae. Four genera bear reduced fifth pereopods, *Eupariambus*, *Liropus*, *Mayerella*, and *Parvipalpina*, while in most of the other genera they are fully segmented. These two stocks may ultimately be placed in separate subfamilies but their separation at this time seems unjustified because of the close similarity of their characters.

With the exception of *Fallotritella*, all Dodecadinae bear reduced fifth pereopods. The mandible of *Fallotritella* differs from that of other Phtisicidae in that the accessory plates are quite small, almost spinelike. It is possible that *Fallotritella* is an example of convergence of the subfamilies Protellinae and Dodecadinae based on the reduction of the molar on a typical Group II mandible.

The mandible of *Cercops* lacks a molar but in other respects resembles the Group II mandible, lacking the accessory plates found in the other genera which have no molar. Because of the segmentation of the abdomen, I have chosen to place it in the Caprogammaridae.

This system of classification shows several evolutionary lines within the Caprellidea. Postulating a podoceridlike ancestor (McCain, 1968) for the Caprellidea, 3 distinct lines emerge (Fig. 1). One line gives rise to the Cyamidae with quite reduced mouthparts, an absence of appendages on pereonites 3–4, and bearing gills only on pereonites 3–4. The Cyamidae are highly specialized parasites which led Barnard (1969, p. 21) to state that the cyamids comprise a fifth major group of Amphipoda. Their separation from the Caprellidea into a fifth suborder deserves consideration by a cyamid specialist. A second line gives rise to the Phtisicidae in which all members lack a mandibular molar and most have 3 pairs of gills. The third line passes through the Caprogammaridae which have large abdomens and typical mandibles reminiscent of the podocerids. Farther along this line are the Aeginellidae with reduced abdomens but typical mandibles. With the loss of the mandibular palp, the third line ends with the Caprellidae. The genus *Paracaprella* is intermediate between the Aeginellidae and the Caprellidae based on its rudimentary palp.

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PROCEEDINGS
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HATSCHEKIA PACIFICA NEW SPECIES (COPEPODA: CALIGOIDA) A PARASITE OF THE SAND BASS, *PARALEBRAX NEBULIFER* (GIARD)

By Roger F. Cressey
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As part of a survey of the copepods parasitic on the inshore fishes of La Jolla, California this paper describes a new species of *Hatschekia* contained in six collections from the gills of *Paralebrax nebulifer* (Giard).

All collections were made by Mr. Edmund Hobson and Mr. Lloyd Richards of the Tiburon Marine Laboratory, U. S. Bureau of Sport Fisheries and Wildlife.

All material has been deposited in the Smithsonian Institution, Division of Crustacea.

Hatschekia pacifica new species

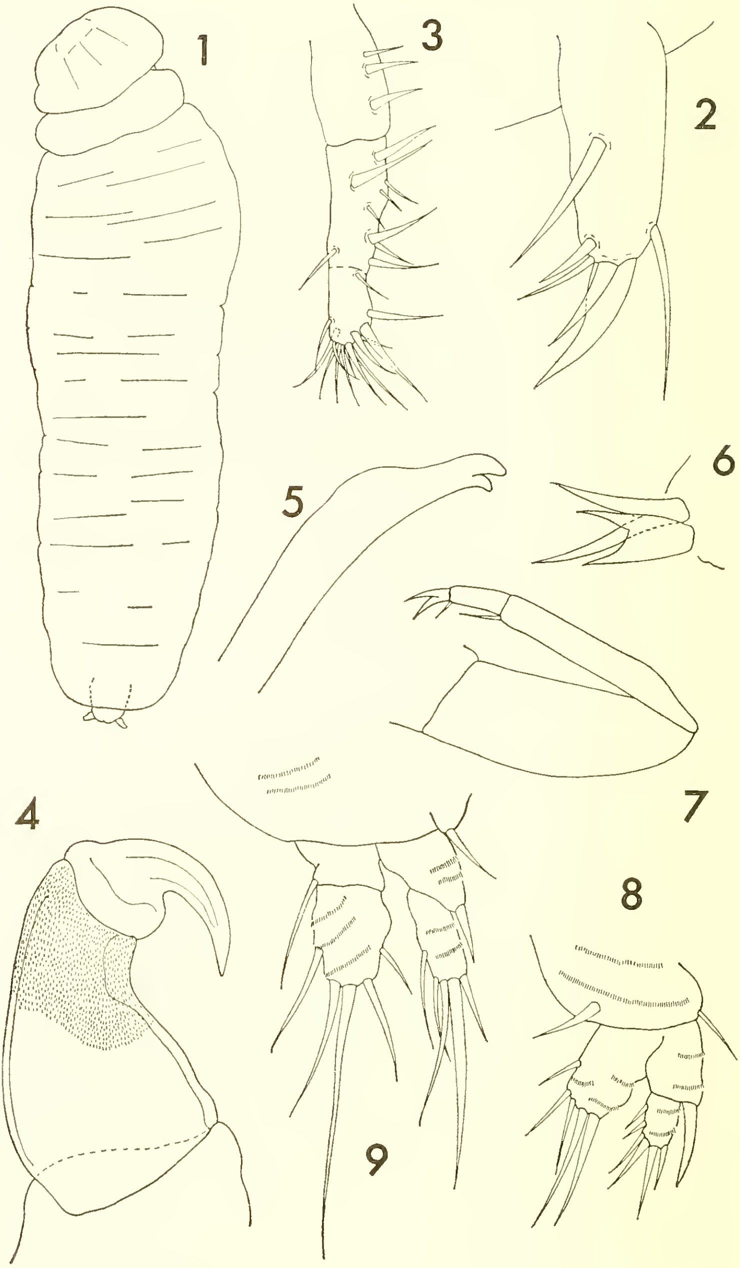
Figures 1–9

Material studied: Holotype ♀ (USNM 126976) and 67 paratype ♀♀ (USNM 126977) collected from the gills of *Paralebrax nebulifer* at La Jolla, California 2 October 1968. Five additional collections from the same host and locality were made on 22 July 1968 (2 ♀♀), 8 August 1968 (2 ♀♀), 24 September 1968 (5 ♀♀), 1 October 1968 (3 ♀♀), and 2 October 1968 (2 ♀♀).

Female: Body form as in figure 1. Total length 2.48 mm. Greatest width 0.6 mm. Cephalon comprises about one-eighth total length. Thoracic segment bearing first and second pairs of legs distinct.

Genital segment comprises approximately 75 percent of body length. Dorsal body surface without ornamentation. Posterior corners of genital segment smoothly rounded. Abdomen small and one-segmented. Caudal rami (fig. 2) small, about three times as long as wide, and bearing six setae, no ornamentation of the rami or setae could be seen under highest magnification.

First antenna (fig. 3) three-segmented; last two segments incompletely divided, all segments bearing naked setae as in the figure. Second antenna (fig. 4) in form of a stout claw, penultimate segment covered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with fine spinules on distal half. Mandible blade (fig. 5) narrowing abruptly at distal fourth and terminating as two teeth, entire structure lying within mouth cone. First and second maxillae (fig. 6) each consisting of two broad but weakly sclerotized setae; first maxilla setae short and furcalike. Maxilliped (fig. 7) 4-segmented, terminating as a bifid claw and with setae borne on the inner distal corners of the penultimate and antipenultimate segments.

First leg (fig. 8) biramose; exopod 2-segmented and armed as in the figure, endopod 1-segmented and bearing five setae: all segments with rows of spinules as indicated in the figure. Second leg (fig. 9) biramose; each ramus 2-segmented and armed as in the figure, rows of spinules on both exopod segments and the last endopod segment.

Egg strings uniseriate and generally about twice the length of the body, each string containing 50–75 eggs.

Male: Unknown.

Remarks: This new species differs from most of the known species of *Hatschekia* on the basis of the separation of the leg bearing segment from the cephalon. It seems most closely related to *H. conifera* Yamaguti but can be easily distinguished from it because of the processes present on the terminus of the genital segment of *conifera*; it can be further separated by the nature of the armature of the first and second legs, the setae of *pacificus* being much longer than in *conifera*.

This new species is only the third recorded from eastern Pacific waters. The other two are *conifera* by Cressey 1968 and *pinguis* Wilson 1908.

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FIGS. 1–9. *Hatschekia pacifica* new species, female: 1, dorsal view; 2, caudal ramus, ventral; 3, first antenna; 4, second antenna; 5, blade of mandible; 6, first and second maxilla; 7, maxilliped; 8, first leg; 9, second leg. All drawings except figure 5 drawn with the aid of a camera lucida —figure 5 freehand.

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A NOTE ON THE GENERIC NAMES *CYCLAGRAS* COPE AND *LEJOSOPHIS* JAN (REPTILIA: SERPENTES)

BY JAMES A. PETERS
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Hoge (1958: 221) recently reviewed the status of the generic name *Lejosophis* Jan, 1863, concluding that Dunn (1944: 70) was correct in using it to replace *Cyclagras* Cope, 1885. He presented a synonymy of the monotypic genus, using the name *Lejosophis* for it. Hoge's action was based on the statement by Dunn (1944: 70) that Boulenger (1894: 144), acting as first reviser, fixed the type-species of *Lejosophis* (spelled *Leiosophis* by Boulenger) as *Xenodon gigas* Duméril, and therefore *Lejosophis* and *Cyclagras* became objective synonyms, having the same type-species. If Dunn's interpretation is valid, there can be no question that *Lejosophis* is the correct name for the genus, and it would require a petition to the International Commission of Zoological Nomenclature to set it aside in favor of the long-established *Cyclagras*.

Dunn's action was interpretive in nature. When the British Museum Catalogues were published by Boulenger, he did not designate type-species in any manner. He clearly did not like tautonymic names, and I know of none coined by him in the Catalogues. A type-species by monotypy in Boulenger's work is obvious. A new genus described in his Catalogues and including several species must await a subsequent reviser for designation of a type, because there is never any clue as to his intent. One occasionally can take advantage of Boulenger's style in the Catalogues as a basis for considering an action as type-species designation, post facto. This, in fact, is what Dunn has done.

Boulenger (1894: 144) gives a synonymy of the genus *Cyclagras* which includes the following lines:

"*Xenodon*, part., Dum. and Bibr., Erp. Gén. vii. p. 753 (1854).

"*Leiosophis*, part., Jan, Arch. Zool. Anat. Phys. ii. 1863, p. 320.

"*Cyclagras*, part., Cope, Proc. Am. Philos. Soc. xxii. 1885, p. 185."

Since Boulenger then used the junior synonym *Cyclagras* for the single species included (*Xenodon gigas* Duméril), it is clear that he did not consider *Leiosophis* available for the taxon. By using *Cyclagras*, however, for a monotypic genus, Boulenger designated *gigas* as type-species of *Cyclagras*, through the exclusion of any other species, or by monotypy. Since Cope originally described *Cyclagras* as a substitute name for *Lejosophis*, Dunn extended the argument to include *Leiosophis*, and concluded that Boulenger simultaneously designated *gigas* as its type-species. Dunn's reasoning would be acceptable if this were the only place where *Leiosophis* was mentioned, but Boulenger (1894) again referred to the genus on p. 180, where the pertinent lines read:

"*Cosmiosophis*, Jan, Arch. Zool. Anat. Phys. ii. 1863, p. 289.

"*Leiosophis*, part., Jan, l.c. p. 320."

These citations are in the synonymy of *Urotheca* Bibron. The point here is that the two citations to *Leiosophis* are identical, and are both referred to as "part.," or partim, Boulenger's way of indicating that only some, not all, of the species assigned to the genus by the original author are included in the genus being discussed. Jan included two species in *Lejosophis* when he described it, *Xenodon gigas* Duméril and *Coluber bicinctus* Hermann. In Boulenger, the "*Leiosophis*, part." under *Cyclagras* refers to *gigas*, and the "*Leiosophis*, part." under *Urotheca* refers to *bicinctus*. It is clearly invalid to say one of these can be interpreted as a restriction of type-species while the other is ignored.

It is possible on other grounds to arrive at a type-species for *Leiosophis*. As pointed out above, Jan (1863) assigned two species to his new genus. In the Iconographie Générale des

Ophidiens (1881), however, he pointed out in his index that *gigas* was to be placed in genus *Xenodon* and figured it (Livr. 48, pl. 3, fig. 6) under the name *Xenodon gigas*. Thus, one could claim that Jan himself has designated *bicinctus* Hermann as the type-species of *Lejosophis* through the same "exclusion principle" followed by Boulenger in the case of *Cyclagras*. Jan vacillated in his treatment of the name *gigas*, because it was given as *Lejosophis gigas* on a different plate (Livr. 50, pl. 2, figs. 25–27). In his index, under *Lejosophis gigas*, he wrote "voy. *Xenodon gigas*." Under the genus *Xenodon* in the index, he wrote "........ [for *Xenodon*] (*Lejosophis*) *gigas* Dum. Bibr.," which makes it look like a subgenus! Jan did not refer to the second species, *Lejosophis bicinctus* Hermann, in the Iconographie.

Cope (1885: 185) rejected *Lejosophis* Jan, indicating that he felt that Jan had misspelled the name, and that, properly spelled, it would be *Liophis*, a preoccupied name (*Liophis* Wagler, 1830). Cope mentioned both *gigas* Duméril and *bicinctus* Hermann in his discussion, so he clearly intended to include both names in his *Cyclagras*, which he coined as a replacement name for *Lejosophis*. No type-species for *Cyclagras* was designated until Boulenger restricted the name to *gigas* Duméril, thus fixing that name as the type-species. It is possible to argue that *Cyclagras*, since it was proposed as a replacement name for *Lejosophis*, and must therefore take the same generotype, has as its type-species *bicinctus* Hermann, and would thus be a generic synonym of *Hydrodynastes* Fitzinger, 1843. This would require a new generic name for *gigas* Duméril, an action I consider unnecessary, superfluous, and a flouting of the basic concept of stability in zoological names.

If, however, herpetologists are willing to accept the interpretation that Jan removed the taxon *gigas* from *Lejosophis*, transferring it to *Xenodon*, and thus automatically designated *Coluber bicinctus* Hermann as type-species by monotypy, all problems are resolved. This interpretation will be followed in the Catalogue of Neotropical Squamata now being prepared by Braulio Orejas-Miranda and myself. There will be two genera recognized, as follows:

Hydrodynastes Fitzinger

1843 *Hydrodynastes* Fitzinger, Systema Reptilium: 25. Type-species: *Elaps Schrankii* Wagler, 1824 (= *Coluber bicinctus* Hermann), by original designation.

1863 *Lejosophis* Jan, Arch. Zool. Anat. Phys., 2: 320. Type-species: *Coluber bicinctus* Hermann, by subsequent monotypy. (See discussion above.)

1944 *Dugandia* Dunn, Caldasia, 3(11): 70. Type-species: *Coluber bicinctus* Hermann, by original designation.

CONTENT: A single species; *Hydrodynastes bicinctus* (Hermann).

Cyclagras Cope

1885 *Cyclagras* Cope, Proc. Amer. Phil. Soc., 22: 185. Type-species: *Xenodon gigas* Duméril, by subsequent monotypy (in Boulenger, Cat. Sn. Brit. Mus., 2, 1894, 144).

CONTENT: A single species; *Cyclagras gigas* Duméril.

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Vc 851–864 5 February 1970

PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

NEW ENTOCYTHERID OSTRACODS FROM TENNESSEE AND VIRGINIA

By Horton H. Hobbs, Jr. and Margaret Walton
Smithsonian Institution and
Mountain Lake Biological Station

Four new ostracods belonging to the genera *Ascetocythere* and *Dactylocythere* are described from the upper Tennessee and Cumberland drainage systems in Tennessee and Virginia.

In examining specimens of *Dactylocythere spinata* (see below), we observed, for the first time, an unpaired, heavily sclerotized spinelike prominence, here designated the *sternal spine*, which extends posteriorly along the ventromedian line of the body between the first pair of legs. Although this spine was first observed in *Dt. spinata*, it occurs, in various forms, in males of at least 10 of the 27 described members of the genus (see below) and is particularly well-disposed for illustration in a paratypic male of *Dt. xystroides* Hobbs and Walton, 1963: 460, from Hurricane Creek, southeast of Waverly, Humphreys County, Tennessee (see Figs. 1a, b).

The sternal spine (ss) appears to articulate anteriorly with a pair of long, slender, paramedian *ventral prongs* (vp) which extend anteriorly between the bases of the maxillae (mx) and mandibles (md), and to be supported dorsolaterally by the *posteroventral horns* (pvh) of paired λ-shaped apodemes, the *anteroventral horns* (avh) of which are continuous with the respective right and left ventral prongs. Each of the latter bears a prominence (mds) which supports the mandible and from which a slender, simple trabecula extends to the maxilla of the respective side. The *dorsal horn* (dh) of the apodeme bears an anterior spur which supports a complex trabecula extending from the proximal base of the maxilla to the base of the mandible.

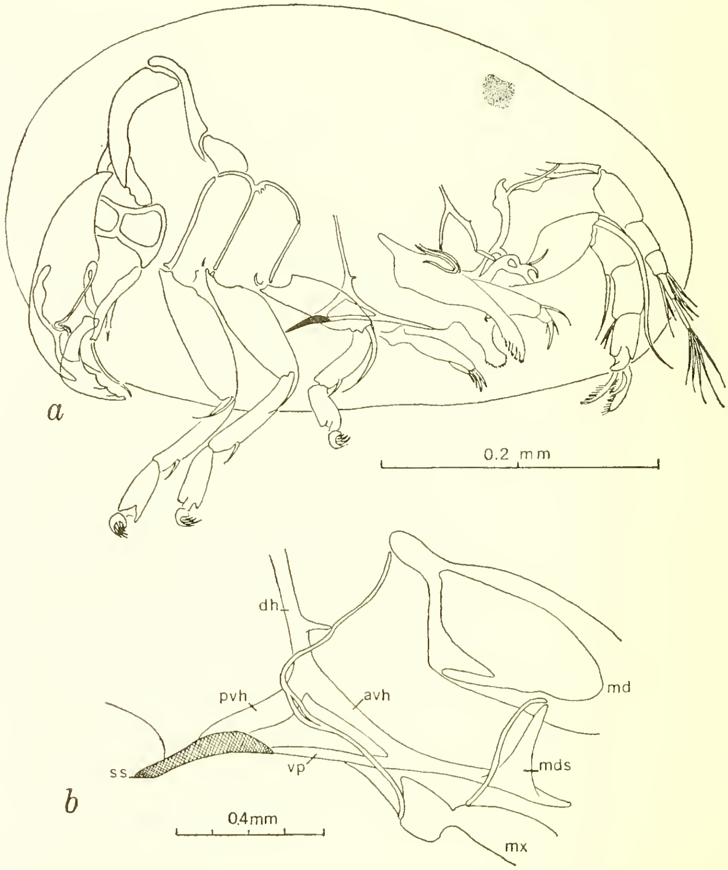


FIG. 1. *Dactylocythere xystroides.* a, Dextral view showing position of sternal spine (black); b, Apodeme and trabeculae associated with sternal spine. (See text for explanations of abbreviations.)

Rioja (1940 and 1941) made a careful study of the endoskeleton of *Ankylocythere heterodonta* (Rioja, 1940: 594) [= *Entocythere heterodonta*] but did not recognize most of the elements just described. Not only did we fail to find them in Rioja's species but we were also unable to identify them in certain species of the genus *Dactylocythere*, and only part of them were evident in others; thus, it is highly probable that if they are present in *Ank. heterodonta* and in the members of the genus *Dactylocythere* not listed below, they are not strongly sclerotized and consequently are not visible in available preparations.

Those species of *Dactylocythere* which possess sternal spines are: *Dt. amicula* Hart and Hart, 1966: 1; *Dt. brachystrix* Hobbs and Walton, 1966: 2; *Dt. chalaza* (Hobbs and Walton, 1962: 45); *Dt. chelomata* (Crawford, 1961: 242); *Dt. daphnioides* (Hobbs, 1955: 325); *Dt. exoura* Hart and Hart, 1966: 5; *Dt. pachysphyrata* Hobbs and Walton, 1966: 3; *Dt. runki* (Hobbs, 1955: 330); *Dt. spinata*, new species; and *Dt. xystroides* Hobbs and Walton, 1963a: 460.

Three of the remaining species of the genus—*Dt. jeanae* Hobbs, 1967: 6; *Dt. striophylax* (Crawford, 1959: 157); and *Dt. suteri* (Crawford, 1959: 162)—possess the paired λ-shaped apodemes and ventral prongs, and the posterior extremities of the latter are produced posteriorly into small lobes, but no remnant of the sternal spine has been observed in any of the three.

Those species of the genus which are not listed above appear not to have the λ-shaped apodemes, and the ventral prongs, if present, are not sclerotized in our specimens.

Acknowledgments: We wish to thank Raymond W. Bouchard, Perry C. and Virgie F. Holt for furnishing us with the specimens on which *Ascetocythere holti* and *Dactylocythere spinata* are based. For criticisms of the manuscript, we are indebted to Fenner A. Chace, Jr.

Ascetocythere holti new species
(Figures 2a, b, 3a, b)

Male: Eye pigmented. Shell (Fig. 2a) ovate in silhouette but slightly concave anteroventrally, greatest height slightly posterior to midlength. Submarginal setae anteriorly, posteriorly, and ventrally; those situated anteriorly progressively farther from margin dorsally; setae apparently absent dorsally.

Copulatory complex (Figs. 3a, b) with peniferum bearing three prominences extending from subterminal expansion: anterior process flattened, its length about half that of anteroposterior plane of distal portion of peniferum, and directed anteroventrally with distal portion deflected more ventrally; ventral process slightly heavier, subequal in length to ante-

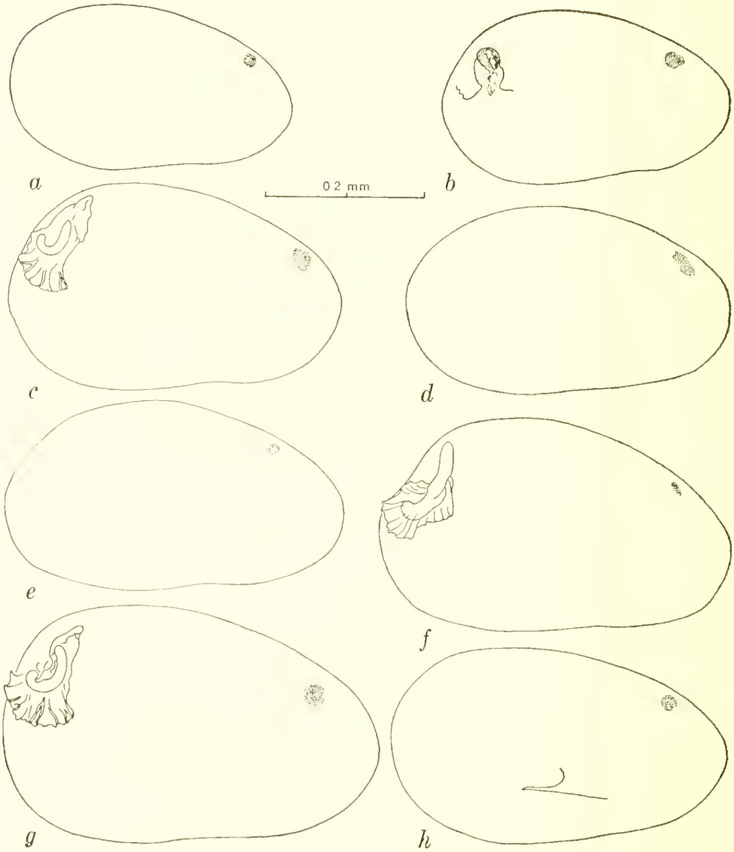


FIG. 2. Right valves of shells. a, d, e, h, Males; b, c, f, g, Females; a, b, *Ascetocythere holti* new species; c, d, *Dactylocythere enoploholca* new species; e, f, *Dactylocythere myura* new species; g, h, *Dactylocythere spinata* new species.

rior process, directed ventrally, and bearing fold along proximoposterior margin serving as penis guide; posterior process, situated immediately posterior to ventral process, slightly undulating, acute, about one-half as long as latter, and also directed ventrally. Penis complex long and extending ventrally along penis guides on posterior surface of ventral process. Clasping apparatus not clearly divisible into vertical and horizontal rami; internal border gently curved between broad base and tapering distal portion, and bearing two or three inconspicuous elevations along distal third (distal elevation acute, almost toothlike in some specimens); distal extremity with three anterodorsally directed denticles; external border also rounded with broadly oblique subangular bend; extensions of principal proximal and distal axes forming angle of approximately 105 degrees; height of distal extremity of tapering apparatus only approximately one-fourth anteroposterior diameter of base of apparatus. Dorsal finger comparatively stout and terminating in bifid seta extending posteroventrally; ventral finger moderately heavy, disposed somewhat subparallel to anterior margin of ventral portion of peniferum, with one subangular bend, and directed posteroventrally.

Triunguis Female: Eye pigmented. Shell (Fig. 2b) similar in shape to that of male but distinctly higher in posterior third; submarginal setae disposed as in male.

Genital complex consisting of sclerotized papilla surrounded by amorphous hyaline material (presumably the spermatophore) with dangling, irregularly shaped, delicate saclike membrane.

Measurements (in millimeters):

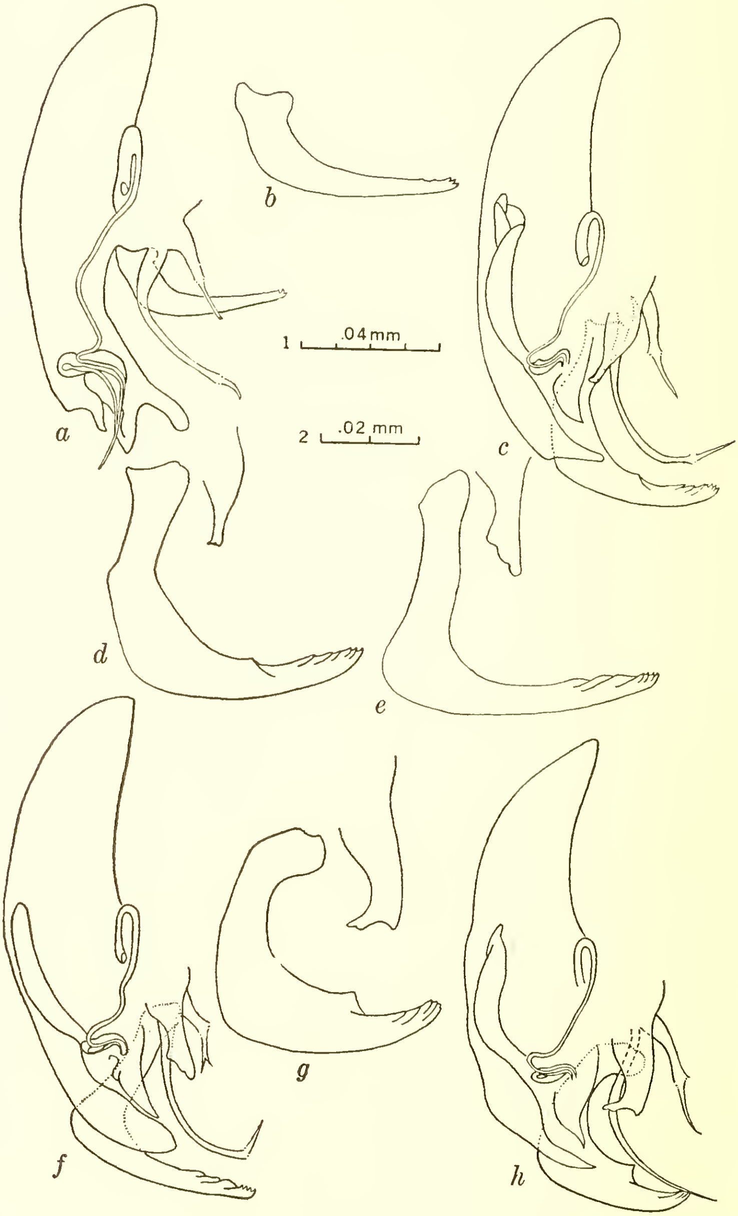
	Holotype	Males	Allotype	Females
Number of specimens		10		10
Length (range)	0.39	0.37–0.41	0.40	0.38–0.40
Average		0.39		0.39
Height (range)	0.22	0.21–0.24	0.24	0.24–0.25
Average		0.22		0.24

Type-locality: Stream, 8.3 miles west of junction of county roads 2451 and 3387 on latter, southeast of Oneida, Scott County, Tennessee.

Disposition of Types: The holotypic male and allotype are deposited in the National Museum of Natural History (Smithsonian Institution) no. 126974. Paratypes are in the collections of C. Willard Hart, Jr. (1 ♂, 1 ♀), H. H. Hobbs III (1 ♂, 1 ♀), and in the Smithsonian Institution (22 ♂, 3 ♀).

Hosts: Cambarus (Depressicambarus) sphenoides Hobbs, an unidentified crayfish related to *Cambarus (Jugicambarus) distans* Rhoades, and another related to *Cambarus (J.) obeyensis* Hobbs and Shoup.

Range and Entocytherid Associates: TENNESSEE (Cumberland River drainage system)—Anderson County: Tributary to New River, 4.4 miles E. of Shea, with no entocytherid associates. Campbell County: Small stream, 1.5 miles E. of Shea, with *Donnaldsoncythere tuberosa* (Hart and Hobbs, 1961: 182) and *Dactylocythere* sp.; Small stream, 9 miles S.W. of Caryville on road to Shea, with *Dn. tuberosa, Dt. spinata,* and *Entocythere* sp. Fentress County: Campbell Branch, 0.4 mile N.W. of junction of Tenn. Rte. 52 and unnumbered road near Armathwaite,


a
b
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1 .04 mm
2 .02 mm

with *Dn. tuberosa* and *Dactylocythere* sp. Morgan County: Mud Creek at Tenn. Rte. 52, with *Dn. tuberosa*; White Oak Creek on U.S. Hwy. 27 at Sunbright, with *Dn. tuberosa* and *Dt. spinata*. Scott County: Type-locality, with *Dn. tuberosa* and *Dt.* sp.; Bandy Creek W. of Leatherwood Fork, with *Dn. tuberosa, Dt. spinata*, and *Entocythere* sp.; Painted Rock Creek on Tenn. Rte. 63, E. of Huntsville, with *Dn. tuberosa*; Perkins Creek at U. S. Hwy. 27, N.E. of Winfield, with *Dn. tuberosa, Dactylocythere* sp., and *Entocythere* sp.

Relationships: Ascetocythere holti is a member of the Asceta Group of the genus and seems to have its closest affinities with *A. sclera* Hobbs and Hart, 1966: 42. It shares with all of the species of the group a clasping apparatus in which the major bend occurs proximal to its midlength, and with *A. sclera, A. didactylata* Hobbs and Hart, 1966: 43, and *A. batchi* Hobbs and Walton, 1968: 237, the absence of a flangelike process projecting from the ventral surface of the peniferum. It differs from *A. didactylata* in possessing three processes on the ventral portion of the peniferum, from *A. sclera* in having a much longer anterior process, an acute, undulating posterior process, and a subangular bend on the posteroventral margin of the peniferum, and from *A. batchi* in possessing a posterior process.

Etymology: It is a pleasure to name this species in honor of our good friend and colleague, Dr. Perry C. Holt, who has contributed numerous specimens of crayfishes and entocytherids to us.

Dactylocythere enoploholca new species
(Figures 2c, d, 3c, d)

Male: Eye pigmented, situated approximately one-eighth shell length from anterior margin. Shell (Fig. 2d) ovate with greatest height distinctly posterior to midlength. Submarginal setae present except dorsally between level of posterior margin of eye and that of dorsal portion of peniferum. Sternal spine lacking.

Copulatory complex (Figs. 3c, d) with finger guard broad at base and tapering to form narrow distal portion, ventral margin emarginate with posteriorly directed acute tip; peniferum moderately heavy with subtruncate ventral margin and posteroventral "heel"; accessory groove reaching level slightly dorsal to dorsal margin of spermatic loop, with its dorsalmost portion folded and possessing irregular margin; peniferal groove opening anteriorly, its apical width approximately two-thirds that

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Fig. 3. Copulatory complexes. a, c, f, h, Entire complexes drawn to scale 1; b, d, e, g, Finger guards and clasping apparati drawn to scale 2; a, b, *Ascetocythere holti* new species; c, d, *Dactylocythere enoploholca* new species; e, f, *Dactylocythere myura* new species; g, h, *Dactylocythere spinata* new species.

of diameter of vertical ramus of clasping apparatus above rounded shoulder (see below); penis somewhat L-shaped, situated in ventral fourth of peniferum; clasping apparatus, extending ventrally beyond ventral margin of peniferum, with two major bends, but not clearly divisible into vertical and horizontal rami and with major axes of extremities forming angle of approximately 70 degrees; external borders of both rami entire but that of vertical ramus with rounded shoulder at midlength (level of proximal bend); internal border of horizontal ramus with one large tooth near midlength and with three low elevations immediately proximal to three apical denticles. Both dorsal and ventral fingers moderately slender, latter more than twice length of former, gently curved from base and suddenly curved posteriorly at base of distal third.

Triunguis Female: Eye pigmented and situated as in male. Shell (Fig. 2c) distinctly larger than that of most males, more highly vaulted posteriorly, and with shallow ventral excavation anterior to midlength. Submarginal setae present except dorsally between level of eye and genital complex.

Genital complex consisting of prominent, but short, J-shaped rod and amiculum, latter protruding little, if at all, between valves.

Measurements (in millimeters):

	Holotype	Males	Allotype	Females
Number		10		10
Length (range)	0.46	0.44–0.49	0.47	0.46–0.55
Average		0.45		0.50
Height (range)	0.25	0.25–0.28	0.29	0.28–0.34
Average		0.27		0.30

Type-locality: South Fork of the Holston River at junction of state routes 600 and 762, Washington County, Virginia. This is the only locality in which this species is known to occur.

Disposition of Types: The holotypic male and allotype are deposited in the National Museum of Natural History (Smithsonian Institution) no. 126973. Paratypes are in the collections of C. Willard Hart, Jr. (1 ♂, 1 ♀), H. H. Hobbs III (1 ♂, 1 ♀), and in the Smithsonian Institution (3 ♂, 3 ♀).

Hosts: The type-series was obtained from a collection of *Cambarus* (*Hiaticambarus*) *longirostris* Faxon and *Cambarus* (*Puncticambarus*) sp.

Entocytherid Associate: Dactylocythere falcata (Hobbs and Walton, 1961: 379).

Relationships: Dactylocythere enoploholca has as its closest relatives *Dt. chalaza*, *Dt. pachysphyrata*, and *Dt. spinata.* In all four species, the accessory groove extends dorsally approximately to the level of the spermatic loop; the aperture of the peniferal groove is directed anteriorly; and the clasping apparatus is curved at almost the same angle and bears only one major tooth (two in *Dt. pachysphyrata*) on the internal border of the clasping apparatus. *Dactylocythere enoploholca* differs from the other three, however, in having a heel-like prominence on the posteroventral margin of the peniferum, a prominent rounded shoulder on the external border of the vertical ramus of the clasping apparatus, and in lacking a sternal spine.

Etymology: Enoplus (Greek) = armed, and *holkos* = furrow; so named because of the folded irregular dorsal extremity of the accessory groove of the peniferum of the male.

Dactylocythere myura new species
(Figures 2e, f, 3e, f)

Male: Eye pigmented, situated approximately one-fifth shell length from anterior margin. Shell (Fig. 2e) elongate ovate with greatest height at midlength. Submarginal setae present anteriorly, posteriorly, and ventrally, but none present dorsally between level of eye and dorsal portion of peniferum. Sternal spine lacking.

Copulatory complex (Figs. 3e, f) with finger guard rather heavy, its posterior margin concave and its oblique distal margin with three prominences of which anteriormost extending considerably farther ventrally than posterior one; peniferum moderately heavy with rounded ventral margin lacking tubercles, emarginations, or scallops; accessory groove reaching level of dorsal margin of spermatic loop with simple round dorsal extremity; peniferal groove opening anteriorly, its apical width narrow, no more than one-fourth least diameter of vertical ramus of clasping apparatus; penis L-shaped and situated at base of distal fourth of peniferum; clasping apparatus also L-shaped with vertical ramus slightly bowed anteriorly, extending ventrally beyond peniferum, clearly divisible into vertical and horizontal rami, and major axes forming angle of approximately 85 degrees; external borders of both rami and internal border of vertical ramus entire, that of vertical ramus lacking shoulder; internal border of horizontal ramus usually without teeth but with three low elevations distal to midlength (elevations occasionally subacute), and bearing three or four small dorsally directed denticles. Dorsal finger somewhat heavier than ventral and terminating in bifid tip; ventral finger gently curved throughout its length.

Triunguis Female: Eye pigmented and situated slightly more anteriorly than that of male. Shell (Fig. 2f), while scarcely longer than that of male, distinctly more highly vaulted with greatest height posterior to midlength, and with much steeper slope posterodorsally; ventral margin with only faintest indication of shallow excavation anterior to midlength. Submarginal setae distributed as in male.

Genital complex consisting of prominent, long J-shaped rod and long amiculum, latter sometimes slightly protruding between valves.

Measurements (in millimeters):

	Holotype	Males	Allotype	Females
Number		9		5
Length (range)	0.48	0.46–0.48	0.48	0.48
Average		0.47		0.48
Height (range)	0.27	0.25–0.27	0.29	0.27–0.29
Average		0.27		0.28

Type-locality: Burrows along bank of spring-fed stream, 3.5 miles southwest of Chilhowie in Washington County, Virginia (Holston River drainage system).

Disposition of Types: The holotypic male and allotype are deposited in the National Museum of Natural History (Smithsonian Institution) no. 126975. Paratypes are in the collections of C. Willard Hart, Jr. (1 ♂, 2 ♀), H. H. Hobbs III (1 ♂, 1 ♀), and in the Smithsonian Institution (4 ♂, 2 ♀).

Host: An undescribed crayfish closely allied to *Cambarus carolinus* Erichson.

Range and Entocytherid Associates: Dactylocythere myura is known from only one locality other than the type-locality, 1.0 mile southwest of Chilhowie off Interstate Hwy. 81, Smyth County, Virginia—only 2.5 miles from the type-locality and also in the Holston drainage system. In the type-locality, it was associated with *Donnaldsoncythere scalis* Hobbs and Walton, 1963b: 364, and in the Smyth County locality with *Dn. scalis* and *Ascetocythere hyperoche* Hobbs and Hart, 1966: 41.

Relationships: While *Dt. myura* is not obviously closely allied to any other species of the genus, the comparatively slender clasping apparatus and the finger guard with three lobes of which the anterior one extends farthest distally are somewhat like those found in *Dt. suteri.* It may be readily separated from the latter, however, by the more angular clasping apparatus which bears no more than one distinct tooth proximal to the apical denticles, and the distal margin of the finger guard is oblique rather than subtruncate. Its more distant relatives include *Dt. jeanae* and *Dt. striophylax*; in neither of these, however, is the finger guard distinctly trilobed distally.

Etymology: Myurus (Greek) = narrow; alluding to the narrow horizontal ramus of the clasping apparatus of the male.

Dactylocythere spinata new species
(Figures 2g, h, 3g, h)

Male: Eye pigmented, situated slightly more than one-fourth shell length from anterior margin. Shell (Fig. 2h) elongate ovate with greatest height some distance posterior to midlength. Marginal setae present anteriorly, posteriorly, and ventrally. Sternal spine prominent, long, directed posteriorly with apical portion only slightly bent ventrally.

Copulatory complex (Figs. 3g, h) with finger guard rather heavy, its posterior margin deeply convex anteriorly, and its ventral border excavate with anteroventral prominence decidedly smaller than bituberculate, posteroventrally directed posterior prominence, thus ventral margin with three prominences; peniferum moderately heavy with posterior margin slightly undulating, but nowhere angulate or with lobes, and terminating in anteriorly directed acute tip; peniferal groove, only slightly wider at apex than one-half least diameter of vertical ramus of clasping apparatus, and directed anteriorly; penis L-shaped and situated approximately at base of ventral fourth of peniferum; clasping apparatus clearly divisible into vertical and horizontal rami with major axes forming angle of approximately 80 degrees although vertical ramus with proximal portion bent anteriorly, almost paralleling horizontal ramus. External border of both rami and internal border of vertical ramus entire and external border of vertical ramus without conspicuous shoulder; internal border of horizontal ramus with single large tooth near midlength and two or three exceedingly low prominences immediately proximal to three small apical denticles; clasping apparatus thickest in region of junction of two rami, tapering slightly proximally and distally; portion of horizontal ramus distal to major tooth not nearly so thick as that proximal to it.

Triunguis Female: Eye pigmented and located slightly more anteriorly than that of male. Shell (Fig. 2g) much more highly vaulted posteriorly than in male, with greatest height some distance posterior to midlength and with posterior margin subtruncate; ventral margin with shallow excavation at about midlength. Submarginal setae disposed as in male. Genital complex consisting of prominent J-shaped rod and ruffled amiculum, frequently with small portion of latter slightly protruding posteriorly beyond margins of valves.

Measurements (in millimeters):

	Holotype	Males	Allotype	Females
Number		8		9
Length (range)	0.46	0.44–0.48	0.48	0.45–0.49
Average		0.46		0.47
Height (range)	0.27	0.27–0.29	0.30	0.28–0.32
Average		0.27		0.30

Type-locality: Small stream, 9.0 miles southwest of Caryville on county road to Shea, Campbell County, Tennessee (Cumberland River drainage system).

Disposition of Types: The holotypic male and allotype are deposited in the National Museum of Natural History (Smithsonian Institution), no. 126972. Paratypes are in the collections of C. Willard Hart, Jr. (1 ♂, 1 ♀), H. H. Hobbs III (1 ♂, 1 ♀) and in the Smithsonian Institution (7 ♂, 6 ♀).

Host: A crayfish tentatively identified as *Cambarus* (*J.*) *distans* Rhoades.

Range and Entocytherid Associates: TENNESSEE (Cumberland River drainage system)—Campbell County: Type-locality, with *As. holti, Donnaldsoncythere tuberosa*, and *Entocythere* sp. Fentress County: Laurel Fork, 9.7 miles N.E. of Jamestown on Tenn. Rte. 154, with *Dactylocythere* sp. Morgan County: White Oak Creek on U. S. Hwy. 27 at Sunbright, with *As. holti* and *Dn. tuberosa.* Scott County: Bandy Creek W. of Leatherwood Fork, with *As. holti, Dn. tuberosa*, and *Entocythere* sp.

Relationships: Dactylocythere spinata has its closest affinities with *Dt. chalaza* and its allies (see discussion of relationships of *Dt. enoploholca* above), and it is more similar to this species than to the other two. It differs from *Dt. pachysphyrata* in having only a single major tooth on the internal border of the horizontal ramus of the clasping apparatus, a bituberculate posteroventral prominence on the finger guard, and a sternal spine that is directed posteriorly rather than ventrally. In *Dt. chalaza*, the posteroventral prominence on the finger guard is not bituberculate, the guard is not strongly bowed anteriorly, and the sternal spine is directed posteroventrally rather than posteriorly. It differs from *Dt. enoploholca* in possessing a sternal spine and in lacking a heel-like prominence on the posteroventral margin of the peniferum.

Etymology: Spina (L.) = spine; referring to the long sternal spine of the male.

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NOTES ON THE WEST AMERICAN NEPHROPIDEAN LOBSTER, *NEPHROPSIS OCCIDENTALIS* FAXON

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This is the second in a series of planned reports on nephropid lobsters, with present emphasis on American species. In the first paper a striking new genus and species, *Nephropides caribaea*, was described from the Caribbean Sea (Manning, 1969). This report includes observations on the only West American lobster, *Nephropsis occidentalis* Faxon.

There has been a recent renewal of interest in the biology and systematics of marine nephropidean lobsters, particularly by those concerned with Indo-West Pacific species (Berry, 1969; Bruce, 1965, 1966a, 1966b, 1966c; Holthuis, 1964; and Yaldwyn, 1954). As pointed out by several students of the group, one aspect of the present interest is the availability in commercial quantities of some nephropids, especially species of the genus *Nephrops*.

A survey of American nephropids in the collections of the Division of Crustacea, National Museum of Natural History, Smithsonian Institution (USNM), revealed the presence of several lots of *N. occidentalis* from unrecorded localities. As far as I can determine, there are only three records of this species in the literature, the original description by Faxon (1893), which was supplemented by Faxon in 1895, and the extension of range from the west coast of Mexico to Chile by Bahamonde (1959). I take this opportunity to illustrate the pleopod and thoracic sternal region of a male. Preliminary studies indicate that these may provide important characters in the nephropids.

I thank Roger F. Cressey for comments on the manuscript. The illustrations are by my wife Lilly. The support of the

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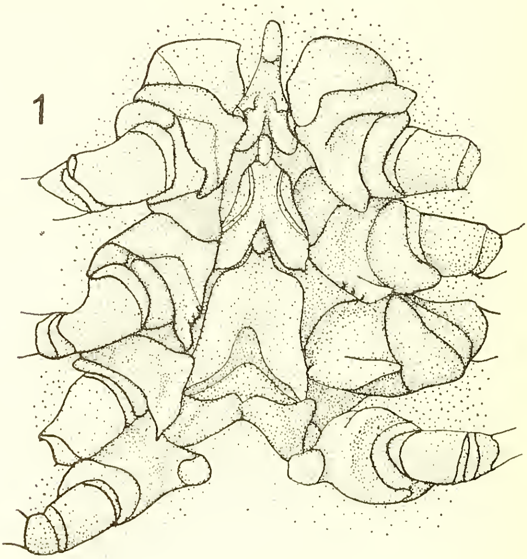

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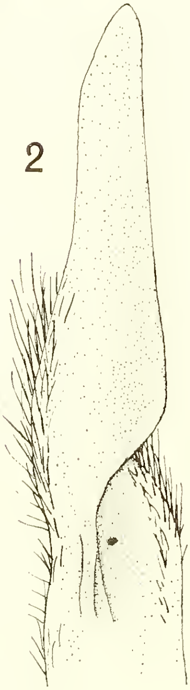

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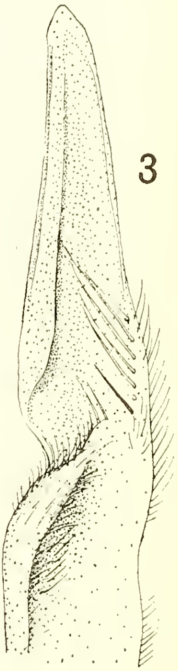

Smithsonian through its Research Awards Program is acknowledged.

Nephropsis occidentalis Faxon, 1893
(Figures 1–3)

Nephropsis occidentalis Faxon, 1893, p. 195; 1895, p. 127, pl. D, figs. 1 [color], 1a, 1b.—De Man, 1916, p. 97 [listed, table].—Bouvier, 1917, p. 20 [key].—Balss, 1927, p. 24 [table].—Bahamonde, 1959, p. 224, figs. 1–4.

Material: 1♂, 103 mm; off west coast of Baja California, Mexico; 27°38′45″N, 115°17′40″W; 525 fathoms; green mud, Globigerina; "Albatross" Station D 5688; 23 April 1911.—1♀, 101 mm; between Ballenas Bay and Santa Maria Bay, west coast of Baja California, Mexico; 25°31′15″N, 113°29′30″W; 645 fathoms; green mud, fine sand, Globigerina; "Albatross" Station D 5676; 17 March 1911.—1♂, 108 mm; off Cape San Lucas, Baja California, Mexico; 22°56′45″N, 109°50′15″W; 630 fathoms; coarse sand, green mud, gravel; "Albatross" Station D 5683; 20 April 1911.—2♂, 101–132 mm; near Trés Marias Islands, Mexico; 21°15′N, 106°23′W; 676 fathoms; gray sand, broken specks; "Albatross" Station 3424; 18 April 1891; syntypes; USNM 21082.—11♂, 51–113 mm; 16♀, 68–127 mm; off Acapulco, Mexico; 16°33′N, 99°52′30″W; 660 fathoms; brown sand, broken specks; "Albatross" Station 3418; 11 April 1891; syntypes; USNM 21081.—1♂, 81 mm; off Valparaiso, Chile; ca. 33°S; more than 300 fathoms; John Manning, collector.

Remarks: Relatively little can be added to Faxon's brief but excellent original description. The smaller specimens are less pubescent than the larger ones, and, in smaller specimens, the tubercles on the carapace, particularly those extending posteriorly from the rostrum, are comparatively sharper. The single Chilean specimen shows no marked differences when compared with Mexican specimens of the same size; however, the Chilean specimen apparently lacks a middorsal patch of small tubercles near the posterior border of the carapace which is visible in all of the Mexican specimens. Faxon (1895) commented on the inflated carapace in this species. The inflation of the branchial regions is particularly well marked in specimens longer than 100 mm.

Nephropsis occidentalis resembles five other species in the genus in having a middorsal carina on the second to fifth abdominal somites. It further resembles *N. aculeata* Smith, *N. carpenteri* Wood-Mason, and *N. rosea* Bate in having but one pair of lateral rostral spines. Of the other species with the middorsal carina on the abdomen, *N. ensirostris* Alcock lacks lateral rostral spines and *N. atlantica* Norman has two pairs.

←

FIGS. 1–3. *Nephropsis occidentalis* Faxon, male, 108 mm, "Albatross" Station D 5683: 1, ventral surface of thorax; 2, male pleopod in lateral view; 3, male pleopod in mesial view.

Nephropsis occidentalis differs from all species now known in the genus in having an erect dorsal spine on the telson near the anterior margin.

Of the American species of *Nephropsis*, *N. occidentalis* rather closely resembles *N. aculeata*; other than the dorsal spine on the telson and the projections at the bases of the walking legs discussed below, the two species are very similar. In *N. aculeata* the abdominal pleura are narrower and sharper, the chelae are more pubescent, and the body pubescence is not so well-developed.

Examination of the thoracic sternum of males of *N. occidentalis* revealed the presence of characters which may prove to be distinctive in members of the genus. The sternum of a male, 108 mm long, is shown in Figure 1. On the inner surface of the basal segment of the third pereiopod there is a spinous triangular projection which is recurved posteriorly. A similar, sharper projection at the base of the fourth leg is directed anteriorly. The process on the third pereiopod is directed ventrally, only slightly recurved, with smooth margins, in males 70 mm long. In males 90 mm long the apex is recurved posterolaterally, and at 108 to 113 mm the inner margin is tuberculate. The tubercles are comparatively much larger than those illustrated in the largest (132 mm) male examined. In *N. aculeata* this process on the third leg is larger than in *N. occidentalis* and the apex is subdivided into three or four prominent, sharp, posteriorly directed spines. This character needs to be surveyed throughout the genus.

Although the male pleopod (Figures 2, 3) has not been used as a specific character in this group I have included the illustrations here for future reference.

Nephropsis occidentalis is now known from localities off Mexico between western Baja California and Acapulco, and from off Chile, where it was first recorded by Bahamonde (1959). It has not yet been taken in the Panamanian region, but its absence there may reflect collecting effort rather than actual occurrence of the species. It apparently occurs on soft bottom in depths between 525 and 676 fathoms.

In his key to the species of *Nephropsis*, Bouvier (1917, p. 20) indicated that *N. occidentalis* was known from the Galapagos Islands and Iles Marion; these must be *lapsi* for Faxon's original records, both of which were from off Mexico.

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(New taxa indicated in **boldface**; n.c. = new combination)