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# PROCEEDINGS

# of the

# Biological Society of Washington

VOLUME 85
1972

WASHINGTON
PRINTED FOR THE SOCIETY

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ALLEN PRESS INC.
LAWRENCE, KANSAS 66044

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## Volume 85

# BIOLOGICAL SOCIETY OF WASHINGTON PROCEEDINGS

## 1044th Meeting—1 March 1972

The 1044th meeting and 93rd Annual Meeting of the Society was called to order by President Daniel Cohen at 2:35 p.m. in Room 43 of the National Museum of Natural History. Sixteen members were present.

The Minutes of the previous annual meeting were read by the Secretary and approved as read.

Victor Springer reported that the Finance Committee had found the Treasurer's book in order. Treasurer Maureen Downey read the Financial Report. A Motion to accept the reports was seconded and carried.

Secretary Isabel Canet reported on membership changes in the past year. Twenty-six new members and seven new subscribers had been added, one member died, and two members were lost by resignation.

Editor Paul Spangler reported that Volume 84 of the Proceedings consisted of 524 pages in 60 papers. A Motion to accept the report was seconded and passed.

James Peters, as Chairman of the Ad Hoc Committee on Back Accessions, reported that the articles are being organized by subject matter and a list of the items is being prepared.

Meredith Jones, as Chairman of the Ad Hoc Committee on the Panama Symposium, reported that 24 contributions, consisting of 294 manuscript pages, and 42 illustrations would be sent to Allen Press in March 1972.

Secretary Isabel Canet reported on the results of the elections; all candidates were elected.

President Daniel Cohen reported on Council activities in 1972. Two Council meetings were held. Contributions to the Panama Symposium were approved for publication. The Conservation Foundation had offered up to $3,000 to assist with the cost of publication of the Symposium papers. Richard H. Manville had been made an Emeritus member. The proposed budget for 1972 had been accepted. By vote of the Council members, a ruling was made that only members may publish in the Proceedings of the Society. An Ad Hoc Committee had been appointed to consider an economical method to bring the existence of a Subject Guide, Index to Authors of Proceedings, and List of previous authors prepared by John Miles to the members of the Society.

President Daniel Cohen then turned his gavel over to the incoming President, Roger F. Cressey, who moved that Daniel Cohen, Maureen Downey, and Isabel Canet be commended for having done an outstanding job. The Motion was unanimously approved.

The Meeting was adjourned at 2:50 p.m.

Isabel P. F. Canet
Secretary

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PROCEEDINGS
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# PHYTOPLANKTON COMPOSITION IN THE SOUTHEASTERN PACIFIC BETWEEN ECUADOR AND THE GALÁPAGOS ISLANDS (ARCHIPIÉLAGO DE COLÓN)

BY HAROLD G. MARSHALL[1]
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The western border of South America is exposed to the northward-moving Peru Current System. This flow is directed to the northwest off the coast of Ecuador, to contribute to the south equatorial current moving westward. The Galápagos Islands are situated along the northern border of this current system, approximately 816 km beyond the coast of Ecuador. Wyrtki (1967) has described an equatorial front that commonly exists between these locations, which separates the tropical surface waters north of this front, from the cooler and more saline equatorial surface waters to the south. Wyrtki presents this front as continuing westward to and beyond the Galápagos Islands.

Phytoplankton collections in the Peru Current System have indicated predominantly a diatom flora of *Chaetoceros*, *Rhizosolenia*, *Corethron*, *Synedra*, and *Planktoniella* species (Gunter, 1936; Hendy, 1937; Krasske, 1941). Mann (1907) described diatoms he found in dredgings off the Galápagos Islands. However, his findings are limited in scope, due to his preparation methods which resulted in a high loss of the more delicate diatoms. Hendy (1937) made collections of diatoms

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[1] The author thanks the Stanford Oceanographic Expedition Program for use of facilities aboard the R/V *Te Vega* during Cruise #19 supported by NSF grants GB6870 and GB6871.

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off Santa Elena and Cape Blanco, located north and south of the Gulf of Guayaquil. He noted counts consisting of up to 23 diatom species at the cooler and more shallow coastal stations off Cape Blanco (St. WS 708–714). The numbers of diatom species decreased seaward with only *Rhizosolenia alata*, *R. hebetata*, and *Licmophora lyngbyei* reported at a station 78 km off the coast. The phytoplankton composition off Santa Elena (St. WS 715) contained *Chaetoceros* as the most common of six diatom species present. This station was in warmer waters directly off the coast. Hendy did not include any of the phytoflagellates in his listings. Marshall (1970) described the phytoplankton composition along a transect extending north of the Gulf of Guayaquil to the Gulf of Panama. The phytoplankters were predominantly a warm-water flora along this tract, with diatoms in greater abundance in the near-shore stations and the phytoflagellates more numerous in open waters. West of the Galápagos Islands, equatorial phytoplankton has been described by Pavillard (1935), Graham and Bronikovsky (1944), Rampi (1952), Hasle (1959, 1960a, 1960b), and Semina (1960, 1962). Desrosieres (1969) reported macrophytoplankton composition along the equatorial Pacific, sampling from the Galápagos Islands westward. He noted a definite decrease in the amount of macroplankton and nutrients along this transect.

The major purpose of this paper is to present observations on the phytoplankton composition east of the Galápagos Islands to Ecuador, and to note the phytoplankton in the waters within the channels of this island complex.

## METHODS

Phytoplankton and hydrography data were obtained during Stanford Oceanographic Expedition #19 aboard the *Te Vega* in August 1968. Nansen water bottles were used to obtain water samples at the surface, 10, 30, 75, 100, 150, 200, and 300 meters at each of the open-water stations. In addition, surface water bucket samples were taken between the various islands, while aboard a ketch operated by Mr. Karl Angermeyer. In each case, a 500 ml water sample was preserved immediately with neutralized formalin for phytoplankton analysis. After a 3-week settling period, a 30–40 ml concentrate was obtained by siphoning. The concentrated samples were transferred to 50 ml settling cylinders for examination with a Zeiss inverted microscope (12.5 × ocular and 40 × objective, NA 0.65).

Gratitude is expressed to Mr. Thomas Malone for chemical analysis of water samples made aboard the *Te Vega*, and to Dr. Andrew McIntyre and Mr. J. A. Kostecki of the Lamont Geophysical Laboratory for preparation of EM grids and subsequent use of an electron microscope used in the identification of coccolithophores. Appreciation is also extended to Mr. Roger Perry and the staff of the Darwin Research Station for use of their facilities in Santa Cruz, Galápagos.

## Results and Discussion

*Open-Water Stations*: Five stations were located between Ecuador and the Galápagos Islands (Fig. 1). In contrast to hydro-stations located within the waterways of the island complex, these will be referred to as open-water stations. The greatest numbers and species diversity of phytoplankters occurred at station 91, located approximately 150 km west of Santa Elena, Ecuador. This station was located farther south (2° 29′ S lat.), had the coldest surface temperature (19.35°C), and highest surface salinity (34.85%), than the other three stations. A corresponding decrease in surface salinity and oxygen content was also recorded north of station 91. An apparent oceanic front was crossed proceeding northwest to stations 141 and 137, where surface temperatures were 24.50°C (1° 33″ S lat.) and 24.59°C (0°00′ lat.), respectively. The warmer surface waters at these stations overlaid a colder and more saline water mass. Temperature and salinity values varied slightly over the first 10 m of depth. However, the temperature drop between 10 and 30 m was over 5°C at each of these two stations (Table 1). Salinity values also decreased sharply with maximum salinity reached at approximately 75 m for both stations. A slightly lower thermocline appeared at stations 91 and 95 between 30 and 75 m. The oxygen values for

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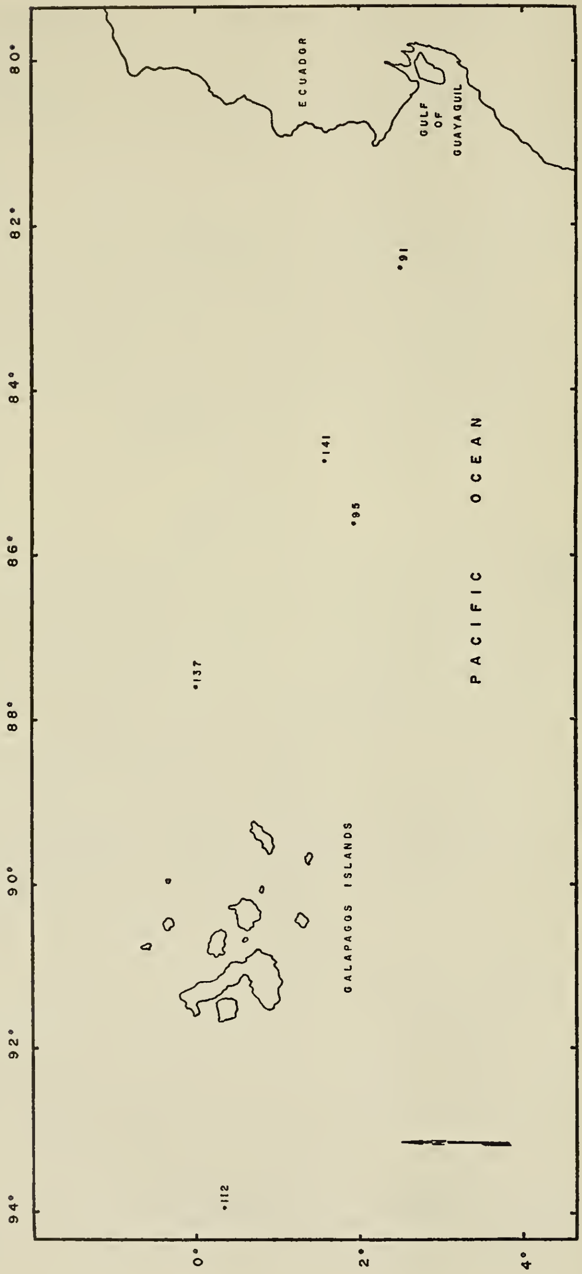

Fig. 1. The location of hydrostations east and west of the Galápagos Islands.

TABLE 1. Data obtained at open-water stations between Ecuador and the Galápagos Islands.

| Depth m | T °C | S ‰ | $O_2$ ml/l | $PO_4$-P µgA/l | $NO_3$-N µgA/l |
|---|---|---|---|---|---|
| I. Station 91. Location: 02° 29′ S, 82° 30′ W. Date: 8 August 1968 | | | | | |
| 0 | 19.35 | 34.85 | 5.30 | 1.0 | 10.8 |
| 10 | 19.36 | 34.85 | 5.23 | 0.8 | — |
| 30 | 19.30 | 34.89 | 5.14 | 0.8 | 18.6 |
| 75 | 16.19 | 35.04 | 2.31 | 1.4 | 13.4 |
| 100 | 15.38 | 35.00 | 1.99 | 1.5 | 40.0 |
| 150 | 14.81 | 34.99 | 1.76 | 1.6 | — |
| 200 | 14.18 | 34.97 | 1.65 | 1.6 | 26.5 |
| 300 | 13.30 | 34.94 | 0.31 | 2.3 | 45.5 |
| II. Station 95. Location: 01° 56′ S, 85° 37′ W. Date: 11 August 1968 | | | | | |
| 0 | 21.18 | 34.80 | 4.85 | 0.7 | 0.0 |
| 10 | 21.12 | 34.80 | 5.05 | 0.8 | 0.0 |
| 30 | 21.12 | 34.80 | 4.96 | 0.8 | 8.5 |
| 75 | 15.09 | 35.06 | 2.11 | 1.5 | 25.1 |
| 100 | 14.58 | 35.01 | 1.93 | 1.6 | 26.0 |
| 150 | 14.27 | 34.96 | 1.45 | 1.7 | 12.0 |
| 200 | 13.82 | 34.97 | 1.6 | 1.4 | 27.4 |
| 300 | 12.84 | 34.92 | 0.3 | 2.4 | 40.2 |
| III. Station 99.* Location: 01° 20′ S, 88° 56′ W. Date: 12 August 1968 | | | | | |
| 0 | 22.16 | 34.38 | 4.99 | 1.5 | 2.5 |
| 10 | 22.12 | 34.38 | 5.10 | – | 37.9 |
| 30 | 21.72 | 34.42 | 4.85 | 1.7 | 62.7 |
| 75 | 16.54 | 35.10 | 2.82 | 6.8 | 20.1 |
| 100 | — | — | – | – | — |
| 150 | 14.27 | 35.01 | 2.28 | 4.6 | 29.4 |
| 200 | 13.76 | 34.97 | 2.25 | – | 25.5 |
| 300 | 12.84 | 34.93 | 0.47 | 6.1 | 43.0 |
| IV. Station 137. Location: 00° 00′, 87° 37′ W. Date: 26 August 1968 | | | | | |
| 0 | 24.59 | 33.96 | 4.68 | | |
| 10 | 24.61 | 33.96 | 4.91 | | |
| 30 | 19.95 | — | 2.99 | | |
| 75 | 15.64 | 35.13 | 2.71 | | |
| 100 | 14.78 | 35.09 | 3.08 | | |
| 150 | 14.29 | 35.07 | 2.06 | | |
| 200 | 13.80 | 35.02 | 0.93 | | |
| 300 | 10.95 | 34.87 | 0.39 | | |

* Station 99 also listed as inter-island station 1.

TABLE 1. Continued.

| Depth m | T °C | S ‰ | $O_2$ ml/l | $PO_4$-P μgA/l | $NO_3$-N μgA/l |
|---|---|---|---|---|---|
| V. Station 141. Location: 01° 33′ S, 84° 52′ W. Date: 27 August 1968 | | | | | |
| 0 | 24.50 | 33.91 | 4.65 | | |
| 10 | 24.48 | 33.91 | 5.20 | | |
| 30 | 19.32 | 34.99 | 4.91 | | |
| 75 | 16.27 | 35.13 | 2.36 | | |
| 100 | 15.40 | 35.07 | 2.25 | | |
| 150 | 16.64 | 35.01 | 1.82 | | |
| 200 | 14.15 | 34.99 | 1.61 | | |
| 300 | 11.25 | 34.83 | 0.10 | | |

the upper 30 m at the open-water stations ranged from 2.99 ml/l at 30 m, station 137, to 5.30 ml/l from the surface at station 91. Values recorded below these depths decreased from 2.71 ml/l at 75 m (station 137) to 0.3 ml/l at 300 m (stations 91 and 95). The phosphate concentrations at stations 91 and 95 ranged in the upper 30 m between 0.7 and 1.0 μgA/l, with nitrates ranging from 0.0 to 8.5 μgA/l at station 95, and 10.8 to 18.6 μgA/l at station 91. Nutrient analysis at station 99, located 67 km east of the Galápagos Islands, showed higher values for both phosphate and nitrate concentrations. Over the upper 30 m, nitrates increased from 2.5 to 62.7 μgA/l with depth, with phosphates at 1.5 to 1.7 μgA/l.

Thirty-nine phytoplankters were identified at station 91 (0–300 m). The diatoms predominated in numbers, with *Chaetoceros decipiens*, *Coscinodiscus* spp., *Guinardia flaccida*, and *Rhizosolenia* spp. representing the majority of species. There were 29 diatom, nine pyrrhophycean, and one silicoflagellate species observed at this station. The numbers of total phytoplankton decreased, with fewer species of diatoms observed, at stations west and north of 91 (Table 4). This decline in numbers continued westward to the surface samples taken 67 km east of San Cristobal (station 99). In all of these later stations, both diatoms and dinoflagellates were represented, but there were no large numbers of any one species.

A wide vertical distribution of phytoplankters occurred only at station 91. Generally, the diatoms were common at all the

TABLE 2. Location of inter-island stations with surface water temperatures and dates of sampling.

| Station Number | Location | °C | Date |
|---|---|---|---|
| 1 | 1° 20′ S, 88° 56′ W | 22.2 | 12 August 1968 |
| 2 | 1° 06′ S, 89° 20′ W | 23.2 | 12 August 1968 |
| 3 | Wreck Bay | 22.4 | 24 August 1968 |
| 4 | Canal de Santa Fe | 22.4 | 16 August 1968 |
| 5 | Canal de Santa Cruz | 22.6 | 16 August 1968 |
| 6 | Barrington Cove | 23.4 | 16 August 1968 |
| 7 | Academy Bay | 24.6 | 16 August 1968 |
| 8 | Canal de Isabella | 22.4 | 18 August 1968 |
| 9 | Canal de Isabella | 22.5 | 19 August 1968 |
| 10 | Canal de Pinzon | 22.0 | 19 August 1968 |
| 11 | Canal de San Salvador | 23.0 | 19 August 1968 |
| 12 | Daphne-Baltra Canal | 22.2 | 22 August 1968 |
| 13 | Canal de Itabaca | 23.0 | 22 August 1968 |
| 14 | Canal de Itabaca | 23.2 | 22 August 1968 |
| 15 | Plaza-Santa Cruz Canal | 22.2 | 23 August 1968 |
| 16 | Sullivan Bay | 22.0 | 19 August 1968 |
| 17 | Sullivan Bay | 22.2 | 20 August 1968 |
| 18 | Canal de Marchena | 22.2 | 20 August 1968 |
| 19 | Canal de Pinta | 23.2 | 20 August 1968 |
| 20 | Canal de Pinta | 23.8 | 21 August 1968 |
| 21 | Santa Maria-Isabella Canal | 22.6 | 19 August 1968 |
| 22 | Tagus Cove | 21.7 | 17 August 1968 |
| 23 | Elizabeth Bay | 22.2 | 22 August 1968 |

depths sampled to 300 m. However, low counts were common in surface samples at each of the four stations. Concentrations were most abundant in depths to 100 m, then the numbers declined rapidly. The average oxygen values at the four open-water stations were 4.87, 2.56, 1.45, 0.27 ml/l respectively for the surface and approximate depths of 100, 200, and 300 m. Although several species were found restricted to depths above

TABLE 3. Data obtained from surface samples taken at stations 22 and 112.

| Station Number | Location | Date | T °C | S ‰ | $O_2$ ml/l | $PO_4$-P µgA/l | $NO_3$-N µgA/l |
|---|---|---|---|---|---|---|---|
| 22 | Tagus Cove | 18-8-68 | 21.70 | 34.95 | 5.57 | 0.3 | 0.3 |
| 112 | 0°17′N, 93°59′W | 16-8-68 | 21.86 | 34.58 | 4.19 | 1.0 | 1.2 |

TABLE 4.

| STATION | #91 | | | | | | | | #95 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEPTH (M) | 0 | 10 | 30 | 75 | 100 | 150 | 200 | 300 | 0 | 10 | 30 | 75 | 100 | 150 | 200 | 300 |
| *DIATOMS* | | | | | | | | | | | | | | | | |
| Asteromphalus hepaticus | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Bacteriastrum delicatulum | – | – | – | – | – | – | 2 | – | – | – | – | – | – | – | – | – |
| Chaetoceros sp. | – | – | – | – | – | 10 | – | 2 | – | – | – | – | – | – | – | – |
| Chaetoceros danicus | – | 6 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Chaetoceros decipiens | – | 18 | 16 | – | 22 | 88 | 48 | 8 | – | 6 | – | – | – | – | – | – |
| Chaetoceros didymus | – | – | – | 8 | – | – | – | – | – | – | – | – | – | – | – | – |
| Chaetoceros horridum | – | 6 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Chaetoceros peruvianus | 3 | – | – | – | – | – | – | – | 2 | – | 4 | – | – | – | – | – |
| Chaetoceros pseudocurvisetus | – | – | – | – | – | – | 12 | – | – | – | – | – | – | – | – | – |
| Coscinodiscus sp. | – | 126 | – | 10 | 12 | – | – | 2 | – | – | – | – | – | – | – | – |
| Coscinodiscus excentricus | – | 20 | – | 56 | 8 | – | – | – | – | – | – | – | – | – | – | – |
| Coscinodiscus nitidus | – | – | – | – | – | – | – | – | – | – | – | 4 | 2 | – | 2 | – |
| Guanardia flaccida | – | 154 | – | 16 | – | – | – | – | – | – | – | – | – | – | – | – |
| Navicula sp. | – | 2 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Nitzschia longissima | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Nitzschia pacifica | – | – | – | – | – | – | 12 | – | – | – | – | 20 | 6 | – | – | – |
| Nitzschia pungens atlantica | – | – | – | – | – | 4 | 14 | – | – | – | – | – | – | – | – | – |
| Planktoniella sol | – | 2 | 2 | 8 | – | 4 | 2 | – | 12 | 16 | 3 | – | – | – | – | – |
| Pleurosigma sp. | – | – | – | – | 2 | – | – | – | – | – | – | – | – | – | – | – |
| Pseudoeunotia doliolus | – | – | – | – | 32 | 2 | – | – | – | – | – | 8 | 4 | – | – | – |

Table 4. Continued.

| STATION | #91 | | | | | | | | #95 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEPTH (M) | 0 | 10 | 30 | 75 | 100 | 150 | 200 | 300 | 0 | 10 | 30 | 75 | 100 | 150 | 200 | 300 |
| *DIATOMS* | | | | | | | | | | | | | | | | |
| Rhizosolenia alata | 6 | 68 | 42 | 50 | 20 | 8 | 8 | 4 | – | 4 | 4 | 2 | 2 | 6 | – | – |
| Rhizosolenia calcar-avis | – | – | – | 4 | – | 2 | – | 4 | – | – | – | – | – | – | – | – |
| Rhizosolenia robusta | – | – | – | – | – | – | – | 2 | – | – | – | – | – | – | – | – |
| Rhizosolenia setigera | – | – | – | – | 8 | – | – | – | – | – | – | – | – | – | – | – |
| Rhizosolenia stolterfothii | – | 4 | – | – | 4 | – | – | – | – | – | – | – | – | – | – | – |
| Rhizosolenia styliformis | – | – | – | – | 4 | – | – | – | – | – | – | – | – | – | – | – |
| Stephanopyxis palmeriana | – | – | – | – | – | 6 | 2 | – | – | – | – | 4 | – | – | – | – |
| Stephanopyxis turris | – | – | – | 8 | 2 | – | – | – | – | – | – | – | – | – | – | – |
| Thalassiothrix curata | – | 8 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Thalassiothrix frauenfeldii | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Thalassiothrix mediterranea | – | 10 | – | 4 | – | – | – | – | – | – | – | – | – | – | – | – |
| Thalassionema delicatula | – | – | – | – | – | – | – | 2 | – | – | – | – | – | – | – | – |
| Thalassionema nitzschioides | – | – | – | 72 | 24 | – | 12 | – | – | – | – | – | – | – | – | – |
| Tropidoneis sp. | – | – | – | – | – | – | 2 | – | – | 6 | – | – | – | – | – | – |
| Total Diatoms | 9 | 424 | 60 | 236 | 138 | 124 | 114 | 24 | 14 | 32 | 11 | 38 | 14 | 6 | 2 | 0 |
| *PYRRHOPHYTA* | | | | | | | | | | | | | | | | |
| Amphisolenia globifera | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Ceratium breve | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Ceratium furca | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

Table 4. Continued.

| STATION | #91 | | | | | | | | #95 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEPTH (M) | 0 | 10 | 30 | 75 | 100 | 150 | 200 | 300 | 0 | 10 | 30 | 75 | 100 | 150 | 200 | 300 |
| *PYRRHOPHYTA* | | | | | | | | | | | | | | | | |
| Ceratium fusus | – | – | – | – | – | – | – | – | – | 2 | – | – | – | – | – | – |
| Ceratium pentagonium | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Ceratium tripos | – | 2 | – | – | – | – | – | – | – | 12 | – | – | – | – | – | – |
| Exuviella sp. | – | 2 | – | – | – | 8 | – | – | – | 12 | – | 12 | – | – | – | – |
| Gymnodinium sp. | – | – | – | – | – | – | 2 | – | – | 12 | – | – | – | – | – | – |
| Oxytoxum caudatum | – | – | – | – | 2 | – | – | – | – | – | – | – | – | – | – | – |
| Oxytoxum scolopax | – | – | – | 4 | – | – | – | – | – | – | – | – | – | 4 | – | – |
| Peridinium spp. | – | 6 | – | – | – | – | – | – | – | – | – | – | 2 | – | – | – |
| Phalacroma mucronatum | – | – | – | – | 2 | 2 | – | – | – | – | – | – | – | – | – | – |
| Podolampas palmipes | – | – | – | – | 6 | – | – | – | – | – | – | – | 6 | – | – | – |
| Prorocentrum sp. | – | – | – | 2 | – | – | – | – | – | – | – | – | – | – | – | – |
| Unidentified flagellates | – | 8 | – | 8 | – | – | – | – | – | – | – | – | – | – | – | – |
| Total Pyrrhophyta | 0 | 18 | 0 | 14 | 10 | 10 | 2 | 0 | 0 | 38 | 0 | 12 | 8 | 4 | 0 | 0 |

Table 4. Continued.

| STATION | #91 | | | | | | | | #95 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEPTH (M) | 0 | 10 | 30 | 75 | 100 | 150 | 200 | 300 | 0 | 10 | 30 | 75 | 100 | 150 | 200 | 300 |
| *SILICOFLAGELLATES* | | | | | | | | | | | | | | | | |
| Dictyocha deflandrei | – | – | – | – | 2 | – | – | – | – | – | – | – | – | – | – | – |
| Dictyocha fibula | – | – | – | – | – | – | – | – | – | 2 | – | – | – | – | – | – |
| Distephanus sp. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Distephanus speculum | – | – | – | – | – | – | – | – | – | 2 | – | – | – | – | – | – |
| Total Silicoflagellates | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL PHYTOPLANKTON | 9 | 442 | 60 | 25 | 150 | 134 | 116 | 24 | 14 | 74 | 11 | 50 | 22 | 10 | 2 | 0 |

Table 4. Continued.

| STATION | #137 | | | | | | | | #141 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEPTH (M) | 0 | 10 | 30 | 75 | 100 | 150 | 200 | 300 | 0 | 10 | 30 | 75 | 100 | 150 | 200 | 300 |
| *DIATOMS* | | | | | | | | | | | | | | | | |
| Asteromphalus hepaticus | – | – | – | – | – | – | – | – | – | – | – | – | – | 2 | 2 | – |
| Bacteriastrum delicatulum | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Chaetoceros sp. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Chaetoceros danicus | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Chaetoceros decipiens | – | – | – | – | – | – | – | – | – | 12 | – | – | – | – | – | – |
| Chaetoceros didymus | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Chaetoceros horridum | – | 8 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Chaetoceros peruvianus | – | 12 | – | – | – | – | – | 2 | – | – | – | – | – | – | – | – |
| Chaetoceros pseudocurvisetus | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Coscinodiscus sp. | – | – | – | – | – | – | – | – | – | 2 | – | 2 | 6 | – | – | – |
| Coscinodiscus excentricus | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Coscinodiscus nitidus | – | 2 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Guanardia flaccida | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Navicula sp. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Nitzschia longissima | – | 4 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Nitzschia pacifica | – | 12 | – | 12 | – | – | – | – | – | – | – | – | – | – | – | – |
| Nitzschia pungens atlantica | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Planktoniella sol | – | 4 | – | – | – | – | – | 4 | – | 2 | – | – | 4 | 2 | – | – |
| Pleurosigma sp. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |

Table 4. Continued.

| STATION | #137 | | | | | | | | #141 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEPTH (M) | 0 | 10 | 30 | 75 | 100 | 150 | 200 | 300 | 0 | 10 | 30 | 75 | 100 | 150 | 200 | 300 |
| *DIATOMS* | | | | | | | | | | | | | | | | |
| Pseudoeunotia doliolus | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Rhizosolenia alata | – | 6 | – | – | – | – | – | – | – | 4 | – | – | 2 | – | – | – |
| Rhizosolenia calcar-avis | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Rhizosolenia robusta | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Rhizosolenia setigera | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Rhizosolenia stolterfothii | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Rhizosolenia styliformis | – | 4 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Stephanopyxis palmeriana | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Stephanopyxis turris | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Thalassiothrix curata | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Thalassiothrix frauenfeldii | – | 6 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Thalassiothrix mediterranea | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Thalassionema delicatula | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Thalassionema nitzschioides | – | 16 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Tropidoneis sp. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Total Diatoms | 0 | 74 | 0 | 12 | 0 | 0 | 0 | 6 | 0 | 20 | 0 | 2 | 12 | 4 | 2 | 0 |
| *PYRRHOPHYTA* | | | | | | | | | | | | | | | | |
| Amphisolenia globifera | – | – | – | – | – | – | – | – | – | – | – | 2 | – | – | – | – |
| Ceratium breve | – | 2 | – | – | – | – | 2 | – | – | – | – | – | 2 | – | – | – |

TABLE 4. Continued.

| STATION | #137 | | | | | | | | #141 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEPTH (M) | 0 | 10 | 30 | 75 | 100 | 150 | 200 | 300 | 0 | 10 | 30 | 75 | 100 | 150 | 200 | 300 |
| *PYRRHOPHYTA* | | | | | | | | | | | | | | | | |
| Ceratium furca | – | – | – | – | – | – | – | – | – | – | – | – | 2 | – | – | – |
| Ceratium fusus | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Ceratium pentagonium | – | – | – | – | – | – | – | – | 2 | – | – | – | – | – | – | – |
| Ceratium tripos | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Exuviella sp. | – | 4 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Gymnodinium sp. | – | 6 | – | – | – | – | – | – | 4 | – | – | – | – | – | – | – |
| Oxytoxum caudatum | – | – | – | – | – | – | – | – | – | – | – | 2 | – | – | – | – |
| Oxytoxum scolopax | – | 12 | – | – | – | – | – | – | 10 | – | – | – | – | – | – | – |
| Peridinium spp. | – | 8 | – | – | – | – | – | – | 2 | – | – | – | – | – | – | – |
| Phalacroma mucronatum | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Podolampas palmipes | – | – | 2 | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Prorocentrum sp. | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Unidentified flagellates | – | – | – | – | – | – | – | – | 12 | – | – | – | – | – | – | – |
| Total Pyrrhophyta | 0 | 32 | 2 | 0 | 0 | 0 | 2 | 0 | 30 | 0 | 0 | 4 | 4 | 0 | 0 | 0 |

TABLE 4. Continued.

| STATION | #137 | | | | | | | | #141 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEPTH (M) | 0 | 10 | 30 | 75 | 100 | 150 | 200 | 300 | 0 | 10 | 30 | 75 | 100 | 150 | 200 | 300 |
| *SILICOFLAGELLATES* | | | | | | | | | | | | | | | | |
| Dictyocha deflandrei | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Dichtyocha fibula | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Distephanus sp. | – | – | – | – | – | 0 | 2 | – | – | – | 2 | – | – | – | – | – |
| Distephanus speculum | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Total Silicoflagellates | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| TOTAL PHYTOPLANKTON | 0 | 106 | 2 | 12 | 0 | 0 | 4 | 6 | 30 | 20 | 2 | 6 | 16 | 4 | 2 | 0 |

or below 100 m, the limited number of vertical samples prevent general statements about the species spatial distribution. *Rhizosolenia alata* and *Planktoniella sol*, and *Oxytoxum scolopax* were found at all four open-water stations. Silicoflagellates were noted in low concentrations at each station, with their presence rare, but more common at the lower depths. There were only slight changes in the phytoflagellates observed at these stations, with the largest numbers of total cells found at station 95.

The surface phosphate and nitrate concentrations at these stations are below values reported by Desrosieres (1969) directly west of the Galápagos. Sampling along the equator from east to west, he noted a decrease in phosphate and nitrates content accompanied by a temperature rise and decline in the standing crop. High nutrient values were reported in the Peru Current and waters east and west of the Galápagos Islands by Forsbergh and Joseph (1964). Holmes et al. (1957) further reviewed the primary production of the tropical eastern Pacific and showed chlorophyl data and zooplankton volumes support the presence of high productivity off northwest South America to and west of the Galápagos Islands.

*Station #112. (0° 17′ N lat. 93° 59′ W long.)*: Located 225 km west of Fernandina Island, only a surface sample was taken at this most western station of the present collections. The phytoplankton consisted mainly of the diatoms *Nitzschia delicatissima, N. pacifica, Planktoniella sol, Rhizosolenia alata,* and *Thalassionema delicatula.* The common phytoflagellates were *Ceratium paradoxides, Oxytoxum scolopax, Peridinium* sp., and the lone silicoflagellate was *Mesocena* sp. A variety of copepods, nauplii, and tintinnids were also abundant. *R. alata* and *R. bergonii* were both common. *R. bergonii* was also prominent within the waters of the island complex, but was not found east of the Galápagos Islands.

Although limited to a surface sample at station 112, the total numbers of species and total phytoplankton, were greater here than any of the other surface stations located east of the Galápagos Islands. This sample also included large numbers of coccolithophores. The cold-water form of *Emiliania huxleyi* (*Coccolithus huxleyi*) and *Gephyrocapsa oceanica* were most common. The other coccolithophores at this station were *Cyclococcolithus leptoporus*, *Umbellosphaera irregularis*, and *Discosphaera tubifera*.

Nitrate and phosphate concentrations of 1.0 and 1.2 μgA/l at this station were higher than surface values obtained at open-water stations east of the Galápagos Islands. However, these concentrations were below those obtained by Desrosieres (1969), yet support his conclusions of enriched waters and high phytoplankton density immediately west of the Galápagos Islands. Unfortunately, nutrient values were not obtained at other depths in the photic zone at station 112. Desrosieres noted at his station (#3) closest to the Galápagos, that the dominant species were *Rhizosolenia bergonii*, *Planktoniella sol*, *Pseudoeunotia doliolus*, *Coscinodiscus* sp., *Ceratium agaricum* and *C. furca*. These species, with the exception of *P. doliolus* which was found at stations 91 and 95 and *C. agaricum*, which was not observed, correspond closely to the most abundant species found at station 112. Pavillard (1935), who had his station No. 2 located more to the southwest (2° S long. 94° W), observed the diatoms *Coscinodiscus* spp., *P. sol*, *R. bergonii*, *Asteromphalus elegans*, *A. heptactis*, and 16 phytoflagellate species. An increase in the ratio of the phytoflagellates to the diatoms apparently is characteristic westward in the open ocean along the equator (Hasle 1959, Semina 1962).

*Inter-island stations:* Surface water samples were taken at 23 stations in the waterways and bays among the islands and are referred to as inter-island stations (Fig. 2). Station locations and surface water temperatures are given in Table 2. Temperatures was taken at mid-day, and ranged from 21.7°C in Tagus Cove, on the west coast of Isabela, to 24.6°C in Academy Bay at Santa Cruz. The currents in the open waters were constantly strong, flowing northwest at 1–2¾ knots.

The lowest concentrations of phytoplankters occurred in the waters bordering the southern fringe of the island complex (stations 1–8, 21). Total counts for these stations ranged from 24 to 326 cells per liter (Table 5). This was the only area where *Biddulphia laevis*, *Licmophora abbreviata* and *Melosira jurgesii* were common. Other diatoms and the pyrrhophyta

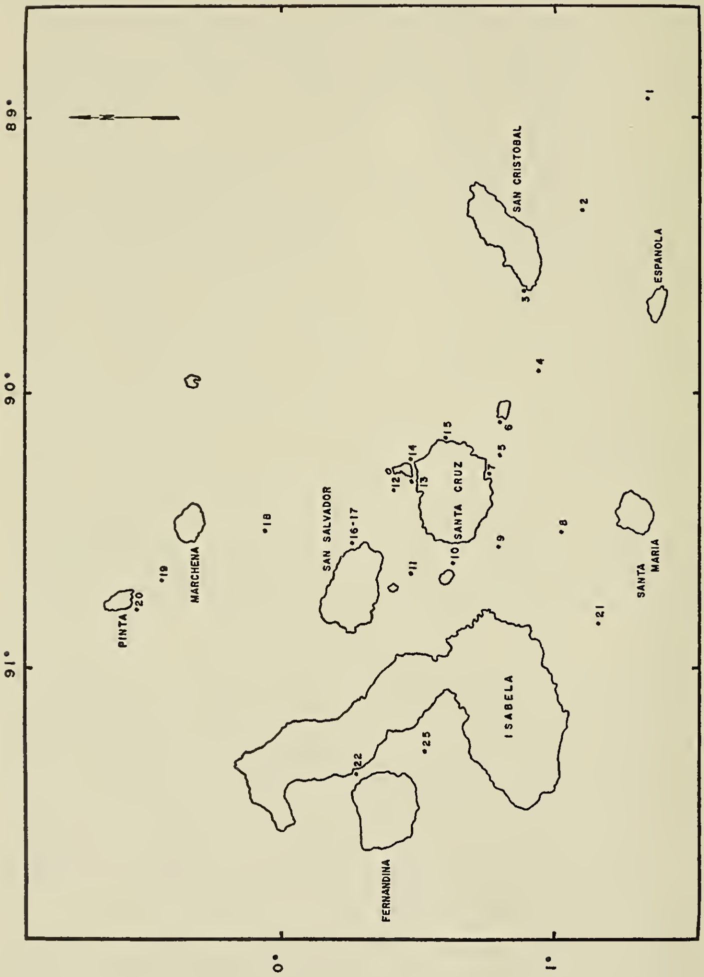

Fig. 2. The Galápagos Islands with the location of hydrostations, numbers 1 through 23.

TABLE 5. Phytoplankton composition from surface samples at 23 stations between the Galápagos Islands and at Station 112. Values refer to number of cells per liter.

| | STATIONS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| *DIATOMS* | | | | | | | | | | | | |
| Asteromphalus heptactis | – | – | – | – | – | – | – | – | – | – | – | – |
| Asterolampra marylandica | – | – | – | – | – | – | – | – | – | – | – | – |
| Biddulphia sp. | – | – | – | – | – | 4 | – | – | – | – | – | – |
| Biddulphia laevis | – | – | – | 8 | 12 | – | 44 | – | – | – | – | – |
| Cerataulina bergonii | – | – | – | – | – | – | – | – | – | – | – | 96 |
| Chaetoceros atlanticus neopolitana | – | – | – | – | – | – | – | – | – | – | 48 | – |
| Chaetoceros coarctatus | – | – | – | – | – | – | – | – | – | – | – | – |
| Chaetoceros curvisetus | – | – | – | – | – | – | – | – | – | – | – | 3200 |
| Chaetoceros danicus | – | – | – | – | – | – | – | – | – | – | – | – |
| Chaetoceros decipiens | 10 | 8 | – | – | – | – | – | – | – | – | – | 64 |
| Chaetoceros didymus | – | – | – | – | – | – | – | – | – | – | – | – |
| Chaetoceros peruvianus | 6 | 4 | – | 2 | – | – | – | – | 2 | 4 | 15 | 12 |
| Chaetoceros sp. | – | – | – | – | – | – | – | – | – | – | – | – |
| Coscinodiscus sp. | 4 | 2 | 2 | – | – | – | – | – | – | – | – | – |
| Coscinodiscus excentricus | – | – | – | – | – | – | – | – | – | – | – | – |
| Coscinodiscus lineatus | – | – | – | – | – | – | – | – | 6 | – | – | – |
| Corethron sp. | – | – | – | – | – | – | – | – | – | – | – | – |
| Eucampia cornuta | – | – | – | – | – | – | – | – | – | – | – | – |

Table 5. Continued.

| | STATIONS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| *DIATOMS* | | | | | | | | | | | | |
| Grammatophora marina | – | – | – | – | – | – | 2 | – | – | – | – | – |
| Hemiaulus hauckii | – | – | – | – | – | – | – | – | – | – | – | – |
| Licmophora abbreviata | – | – | – | 12 | 16 | 4 | 74 | – | 4 | – | – | – |
| Licmophora ehrenbergin | – | – | – | – | – | – | – | – | – | – | – | – |
| Melosira jurgensii | – | – | – | 10 | 4 | 8 | 76 | – | – | – | – | – |
| Navicula sp. | – | – | – | – | – | 1 | – | – | – | – | – | – |
| Nitzschia bicapita | – | – | – | – | – | 6 | 6 | – | – | – | – | – |
| Nitzschia delicatissima | – | – | – | – | – | 8 | 4 | – | 192 | 120 | 18 | 4760 |
| Nitzschia longissima | – | – | – | – | – | 8 | 8 | – | – | – | – | – |
| Nitzschia kolacyekii | – | – | – | – | – | – | 8 | – | – | – | – | – |
| Nitzschia pacifica | – | – | – | – | – | – | 12 | – | – | – | 28 | – |
| Nitzschia pungens atlantica | – | – | – | – | – | – | – | – | – | – | – | 3240 |
| Plagiogramma vanheurckii | – | – | – | – | – | 24 | – | – | – | – | – | – |
| Planktoniella sol | 4 | 4 | – | 8 | 4 | – | 2 | 4 | – | 6 | 10 | 4 |
| Pleurosigma sp. | – | – | – | – | – | 4 | – | – | – | – | – | 2 |
| Rhizosolenia alata | 4 | 2 | 4 | 8 | 2 | – | – | 2 | – | – | 64 | 12 |
| Rhizosolenia bergonii | – | – | – | – | – | – | – | – | 26 | 14 | 28 | – |
| Rhizosolenia calcar-avis | – | – | – | – | – | – | – | – | – | – | – | 6 |
| Rhizosolenia hebetata semispina | – | – | – | – | – | – | – | – | – | – | – | – |

Table 5. Continued.

| | STATIONS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| *DIATOMS* | | | | | | | | | | | | |
| Rhizosolenia imbricata | – | – | – | – | – | – | – | – | – | – | – | – |
| Rhizosolenia stolterfothii | – | – | – | – | – | – | – | – | – | – | – | – |
| Rhizosolenia styliformis | – | – | – | – | – | – | – | – | – | – | – | – |
| Thalassiothrix frauenfeldii | – | – | – | – | – | – | 16 | 12 | 14 | 12 | 48 | 28 |
| Thalassiothrix mediterranea | – | – | – | – | – | – | – | – | – | – | – | 68 |
| Thalassionema elegans | – | – | 6 | – | – | – | – | – | – | – | – | 18 |
| Thalassionema delicatula | – | – | – | 10 | – | – | – | – | – | – | 68 | 42 |
| Thalassionema nitzschioides | 6 | – | – | – | – | – | 8 | – | – | – | – | – |
| Thalassiosira oestruppii | – | – | – | – | – | – | – | – | 40 | 8 | – | – |
| Tropidoneis sp. | – | – | – | 2 | – | – | 34 | 8 | 10 | 12 | 18 | 8 |
| Unidentified diatoms | – | – | – | 8 | – | – | | | | | | |
| Total Diatoms | 34 | 20 | 12 | 68 | 38 | 67 | 294 | 26 | 244 | 176 | 345 | 11560 |
| *PYRRHOPHYTA* | | | | | | | | | | | | |
| Amphisolenia sp. | – | – | – | – | – | 2 | – | – | – | – | – | – |
| Ceratium declinatum | – | – | – | 2 | – | – | – | – | – | – | – | – |
| Ceratium furca | – | – | – | – | – | – | – | – | 8 | – | – | – |
| Ceratium massiliense | – | – | – | – | – | – | – | – | – | – | – | – |

TABLE 5. Continued.

| | STATIONS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| *PYRRHOPHYTA* | | | | | | | | | | | | |
| Ceratium paradoxides | – | – | – | 2 | – | – | – | – | – | – | – | – |
| Ceratium trichoceros | – | – | – | – | – | – | – | – | 2 | – | – | – |
| Ceratium tripos | 2 | – | – | – | – | – | – | – | – | – | – | – |
| Danasphaera indica | – | – | – | 2 | – | – | – | – | – | – | – | – |
| Dinophysis acuminata | – | – | – | – | – | – | – | – | – | – | – | – |
| Exuviella sp. | – | – | – | – | – | – | – | – | – | – | – | – |
| Glenodinium dankum | – | – | – | – | – | – | – | – | – | – | – | – |
| Gonyaulax kofoidi | – | – | – | – | – | – | – | – | 2 | – | – | – |
| Gymnodinium sp. | – | – | – | – | – | – | – | – | – | – | – | 2 |
| Gymnodinium oceanicum | – | – | 2 | – | – | – | – | – | – | – | – | – |
| Gyrodinium sp. | – | – | – | – | – | – | – | – | – | – | – | – |
| Murrayella spinosa | – | – | – | – | – | – | – | – | – | – | – | – |
| Oxytoxum scolopax | – | – | 2 | 2 | – | – | – | – | 6 | – | – | 4 |
| Peridinium spp. | – | – | – | – | – | 6 | – | – | 12 | – | 2 | – |
| Peridinium globulus | – | – | – | – | – | – | – | – | – | – | – | – |
| Peridinium solidcorne | – | – | – | – | – | – | – | – | – | – | – | 4 |
| Phalacroma sp. | – | – | – | – | – | – | – | – | – | – | – | – |
| Phalacroma mucronatum | – | – | – | – | – | – | – | – | – | – | – | – |

TABLE 5. Continued.

| | STATIONS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| *PYRRHOPHYTA* | | | | | | | | | | | | |
| Podolampas bipes | – | – | – | – | – | – | – | – | – | – | 2 | – |
| Podolampas palmipes | – | – | – | 2 | – | – | – | – | – | – | – | – |
| Podolampas sp. | – | – | 4 | – | – | – | – | – | – | – | – | 4 |
| Prorocentrum sp. | – | – | – | – | – | – | | | | | | |
| Total Pyrrhophyta | 2 | 0 | 8 | 10 | 0 | 8 | 0 | 0 | 30 | 0 | 4 | 12 |
| *SILICOFLAGELLATES* | | | | | | | | | | | | |
| Dictyocha fibula | 2 | 4 | 4 | 2 | – | – | – | – | – | – | 2 | – |
| Distephanus speculum | – | – | – | – | – | – | – | – | – | – | – | – |
| Distephanus speculum octonarius | – | – | 4 | 12 | – | – | – | – | – | – | – | – |
| Mesocena sp. | – | – | – | – | – | 2 | – | – | – | – | – | – |
| Mesocena polymorpha biseptenaria | – | – | – | – | – | – | – | – | 2 | – | 4 | – |
| Total Silicoflagellates | 4 | 4 | 8 | 14 | 0 | 2 | 0 | 0 | 2 | 0 | 6 | 0 |
| TOTAL PHYTOPLANKTON | 40 | 24 | 28 | 92 | 38 | 77 | 294 | 26 | 326 | 176 | 355 | 11572 |

TABLE 5. Continued.

| | STATIONS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 112 |
| *DIATOMS* | | | | | | | | | | | | |
| Asteromphalus heptactis | – | – | – | – | – | – | – | – | 4 | – | – | – |
| Asterolampra marylandica | – | – | – | – | – | – | – | – | – | 12 | – | – |
| Biddulphia sp. | – | – | – | – | – | – | – | – | – | – | – | – |
| Biddulphia laevis | – | – | – | – | – | – | – | – | – | – | – | – |
| Cerataulina bergonii | 702 | 120 | 52 | 148 | – | 24 | 8 | 12 | – | – | – | – |
| Chaetoceros atlanticus neopolitana | – | 32 | – | – | – | – | – | – | – | – | – | – |
| Chaetoceros coarctatus | – | – | 6 | – | – | – | – | – | – | – | – | – |
| Chaetoceros curvisetus | 1594 | – | 6 | 2160 | – | 24 | 4 | – | – | – | – | – |
| Chaetoceros danicus | 780 | – | – | – | – | – | – | – | – | – | – | – |
| Chaetoceros decipiens | 40 | – | 420 | 180 | 358 | 4 | 22 | 10 | 16 | – | – | – |
| Cheaetoceros didymus | – | – | – | – | 8 | – | – | – | – | – | – | – |
| Chaetoceros peruvianus | – | – | – | – | 4 | 2 | 4 | – | 8 | 16 | – | – |
| Chaetoceros sp. | – | 24 | 24 | – | – | – | – | – | – | – | – | – |
| Coscinodiscus sp. | 56 | – | – | – | – | – | – | – | 2 | 8 | 2 | – |
| Coscinodiscus excentricus | 4 | – | – | – | – | – | – | – | – | – | 2 | 2 |
| Coscinodiscus lineatus | – | – | – | – | 4 | – | – | – | – | – | – | – |
| Corethron sp. | – | – | – | – | 2 | – | – | – | – | – | – | – |
| Eucampia cornuta | – | – | – | – | – | – | – | – | – | – | – | – |
| Grammatophora marina | 4 | – | – | – | – | – | 24 | 36 | – | – | – | – |

Table 5. Continued.

| | STATIONS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 112 |
| *DIATOMS* | | | | | | | | | | | | |
| Hemiaulus hauckii | 8 | – | – | – | 4 | – | – | – | – | – | – | – |
| Licmophora abbreviata | – | – | – | – | – | – | – | – | – | – | – | – |
| Licmophora ehrenbergin | – | – | – | – | 2 | – | – | – | – | – | – | – |
| Melosira jurgensii | – | 4 | – | – | – | – | – | – | – | – | – | – |
| Navicula sp. | – | – | – | – | – | – | – | – | – | – | – | – |
| Nitzschia bicapita | – | – | – | – | – | – | – | – | – | – | – | – |
| Nitzschia delicatissima | – | – | 6 | – | – | – | – | – | – | – | – | – |
| Nitzschia longissima | 2620 | 5280 | 120 | 9640 | 646 | 92 | 840 | 1280 | 120 | 588 | 22640 | 154 |
| Nitzschia kolacyekii | – | – | – | – | 2 | – | – | – | – | – | – | – |
| Nitzschia pacifica | – | – | – | – | – | – | – | – | – | – | – | – |
| Nitzschia pungens atlantica | 864 | – | 20 | 5240 | 244 | 32 | 46 | 58 | – | – | – | 32 |
| Plagiogramma vanheurckii | – | – | – | – | – | – | – | – | – | – | – | – |
| Planktoniella sol | – | – | – | – | – | – | – | – | – | – | – | – |
| Pleurosigma sp. | 6 | 4 | 16 | 10 | 6 | – | 4 | – | 8 | – | 4 | 20 |
| Rhizosolenia alata | – | – | – | – | – | – | – | – | – | – | – | – |
| Rhizosolenia bergonii | 8 | 10 | 28 | 44 | 40 | 14 | 26 | 54 | 16 | 8 | – | 28 |
| Rhizosolenia calcar-avis | 2 | – | 2 | 8 | 62 | 8 | – | – | 4 | – | – | 20 |
| Rhizosolenia hebetata semispina | 2 | – | 12 | 10 | – | 8 | – | – | – | – | – | – |
| Rhizosolenia imbricata | – | – | – | – | 52 | – | – | – | – | – | – | – |

Table 5. Continued.

| | STATIONS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 112 |
| *DIATOMS* | | | | | | | | | | | | |
| Rhizosolenia stolterfothii | – | – | – | – | 10 | – | – | – | – | – | – | – |
| Rhizosolenia styliformis | – | – | – | – | 32 | – | – | – | – | – | – | – |
| Thalassiothrix frauenfeldii | – | – | – | – | 8 | – | – | – | – | – | – | – |
| Thalassiothrix mediterranea | 30 | 14 | 192 | 12 | 40 | 84 | – | 12 | – | 16 | – | – |
| Thalassionema elegans | – | – | – | – | 12 | – | – | – | – | – | – | – |
| Thalassionema delicatula | – | – | – | – | – | – | – | – | – | – | – | – |
| Thalassionema nitzschioides | – | – | 64 | 32 | 144 | 54 | 46 | 122 | 8 | – | – | 20 |
| Thalassiosira oestruppii | – | – | 80 | 48 | 46 | 24 | – | – | – | – | – | – |
| Tropidoneis sp. | – | – | 28 | 52 | 4 | 50 | – | – | – | 396 | 10380 | – |
| Unidentified diatoms | 50 | – | 56 | 48 | – | 64 | 18 | 24 | 14 | 6 | 40 | 8 |
| Total Diatoms | 6818 | 5484 | 1130 | 17638 | 1730 | 484 | 1042 | 1608 | 200 | 1050 | 33044 | 284 |
| *PYRRHOPHYTA* | | | | | | | | | | | | |
| Amphisolenia sp. | – | – | – | – | – | – | – | – | – | – | – | – |
| Ceratium declinatum | – | – | – | – | – | – | – | – | – | – | – | – |
| Ceratium furca | – | 16 | – | – | – | – | – | – | 2 | – | 180 | – |
| Ceratium massiliense | – | – | – | – | – | – | 2 | 2 | – | – | – | 6 |
| Ceratium paradoxides | – | – | – | – | – | – | – | – | – | – | – | – |

Table 5. Continued.

| | STATIONS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 112 |
| *PYRRHOPHYTA* | | | | | | | | | | | | |
| Ceratium trichoceros | – | – | – | – | – | – | – | – | – | – | – | – |
| Ceratium tripos | – | – | – | – | – | 2 | – | – | 4 | – | – | – |
| Danasphaera indica | – | – | – | – | – | – | – | – | – | – | – | – |
| Dinophysis acuminata | – | – | – | 16 | 2 | – | – | – | – | 2 | 56 | – |
| Exuviella sp. | – | 8 | 2 | – | – | – | – | – | – | – | – | – |
| Glenodinium dankum | 78 | – | – | – | – | – | – | – | – | – | – | – |
| Gonyaulax kofoidi | – | – | – | – | – | – | – | – | – | 20 | 760 | – |
| Gymnodinium sp. | – | – | – | 12 | 4 | – | – | – | – | – | – | – |
| Gymnodinium oceanicum | 212 | – | – | – | – | – | – | – | – | 28 | 1740 | – |
| Gyrodinium sp. | 4 | – | – | – | – | – | – | – | – | 8 | – | – |
| Murrayella spinosa | – | – | – | – | – | – | – | – | – | 16 | – | – |
| Oxytoxum scolopax | – | – | – | – | – | – | – | – | 6 | 2 | 40 | 2 |
| Peridinium spp. | 12 | 32 | – | 28 | 4 | – | – | – | 4 | 8 | 4 | 4 |
| Peridinium globulus | – | – | – | – | – | – | – | – | – | – | 5220 | – |
| Peridinium solidcorne | – | – | 4 | – | – | – | – | – | – | – | 2 | – |
| Phalacroma sp. | – | – | – | – | – | – | – | 2 | – | – | – | – |
| Phalacroma mucronatum | – | – | – | – | – | – | – | – | – | 2 | – | – |
| Podolampas bipes | – | – | – | – | – | – | – | – | – | – | – | – |

Table 5. Continued.

| | STATIONS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 112 |
| PYRRHOPHYTA | | | | | | | | | | | | |
| Podolampas palmipes | – | – | – | – | – | – | – | – | 2 | 4 | – | – |
| Podolampas sp. | – | – | – | – | – | – | – | – | – | 10 | – | – |
| Prorocentrum sp. | – | – | – | 2 | – | – | – | – | – | 100 | – | – |
| Total Pyrrhophyta | 306 | 56 | 6 | 58 | 10 | 2 | 2 | 4 | 18 | 200 | 8002 | 12 |
| *SILICOFLAGELLATES* | | | | | | | | | | | | |
| Dictyocha fibula | – | – | 2 | 6 | 2 | – | – | – | 4 | – | 20 | – |
| Distephanus speculum | – | – | 2 | – | – | – | – | – | – | – | – | – |
| Distephanus speculum octonarius | – | – | – | – | – | – | – | – | – | 2 | – | – |
| Mesocena sp. | – | – | 2 | 44 | – | 6 | – | 6 | 8 | – | – | 8 |
| Mesocena polymorpha biseptenaria | – | – | – | – | – | | | | | | | |
| Total Silicoflagellates | 0 | 0 | 6 | 50 | 2 | 6 | 0 | 6 | 12 | 2 | 20 | 8 |
| TOTAL PHYTOPLANKTON | 7124 | 5540 | 1142 | 17746 | 1742 | 492 | 1044 | 1618 | 230 | 1252 | 41066 | 304 |

were in low numbers. However, in contrast to their scarcity in the open-water stations, the silicoflagellates (*Dictyocha fibula* and *Distephanus speculum octonarius*) were found at five of the nine inter-island stations. There were greater numbers of phytoplankters at the more northern stations (Nos. 18–20), where totals ranged from 492 to 1,618 cells per liter. This increase was augmented primarily by the diatoms which were dominated by *N. delicatissima.* The numbers of pyrrhophyceans and silicoflagellates were low. The pyrrhophyceans were numerous in the Canal de Itabaca and Sullivans Bay (stations 13 and 16). In the former, *Gymnodinium oceanicum* totaled 212 cells/l and *Glenodinium dankum* 78 cells/l. Total phytoplankton counts reached 17,746 cells/l in Sullivans Bays with *Chaetoceros curvisetus, N. delicatissima,* and *N. pacifica* the most numerous species. The largest concentration of silicoflagellates was also found at this station. Six *D. fibula* and 44 *Mesocena* sp. were observed. The four pyrrhophyceans at this station were *Dinophysis acuminata, Gymnodinium* sp., *Peridinium* sp., and *Prorocentrum* sp. The greatest diversity of pyrrhophyceans occurred in Tagus Cove (station 22) where 11 species were noted, but not in large numbers. The diatoms occurred in highest numbers at this station, with the silicoflagellates represented by only *Distephanus speculum.* The largest concentration of phytoplankton at any of the stations was at Elizabeth Bay (station 23). Cell counts reached 41,066 cells per liter, of which 80% were diatoms. The most numerous diatoms were *N. delicatissima* and *T. oestruppii,* having counts of 22,640 and 10,380 cells/l respectively. The most numerous pyrrhophyceans were *Gymnodinium oceanicum* and *Peridinium globulus.*

The most common of the 47 diatom species noted in the inter-island waters were *Cerataulina bergonii, Chaetoceros decipiens, Chaetoceros peruvianus, N. delicatissima, N. pacifica, P. sol, R. alata, R. bergonii, Thalassiothrix frauenfeldii, Thalassionema delicatula, T. nitzschioides, T. oestruppii,* and *Tropidoneis* sp. There were 24 diatoms limited to the inter-island waterways and bays, and 21 diatoms observed at both the inter-island and open-sea stations (Tables 6–8). This latter group was mainly composed of the genera *Chaetoceros, Cos-*

TABLE 6. Phytoplankton observed at only inter-island stations.

| Diatoms | Pyrrhophyceans | Coccolithophorids | Silicoflagellates |
|---|---|---|---|
| Asterolampra marylandica | Amphisolenia sp. | Gephyrocapsa ericsonii | Distephanus speculum |
| Biddulphia sp. | Ceratium declinatum | | Distephanus speculum octonarius |
| Biddulphia laevis | Ceratium massiliense | | Mesocena sp. |
| Cerataulina bergonii | Ceratium paradoxides | | Mesocena polymorpha biseptenaria |
| Chaetoceros atlantica neopolitana | Ceratium trichoceros | | |
| Chaetoceros coarctatus | Danasphaera indica | | |
| Chaetoceros curvisetus | Dinophysis acuminata | | |
| Coscinodiscus lineatus | Glenodinium dankum | | |
| Corethron sp. | Gonyaulax kofoidi | | |
| Eucampia cornuta | Gymnodinium oceanicum | | |
| Grammatophora marina | Gyrodinium sp. | | |
| Hemiaulus hauckii | Murrayella spinosa | | |
| Licomophora abbreviata | Peridinium globulus | | |
| Licomophora ehrenbergin | Peridinium solidcorne | | |
| Melosira jurgensii | Phalacroma sp. | | |
| Nitzschia bicapita | Podolampas bipes | | |
| Nitzschia delicatissima | Podolampas sp. | | |
| Nitzschia kolacyekii | | | |
| Plagiogramma vanheurckii | | | |
| Rhizosolenia bergonii | | | |
| Rhizosolenia hebetata semispina | | | |
| Rhizosolenia imbricata | | | |
| Thalassionema elegans | | | |
| Thalassionema oestruppii | | | |

TABLE 7. Phytoplankton observed at only open-sea stations east of the Galápagos Islands.

| Diatoms | Pyrrhophyceans | Coccolithophorids | Silicoflagellates |
|---|---|---|---|
| Bacteriastrum delicatulum | Amphisolenia globifera | Acanthoica acanthifera | Dictyocha deflandrei |
| Chaetoceros horridum | Ceratium breve | Acanthoica quattrospina | Distephanus sp. |
| Chaetoceros pseudocurvisetus | Ceratium fusus | Anoplosolenia brasiliensis | |
| Coscinodiscus nitidus | Ceratium pentagonium | Anthosphaera robusta | |
| Guinardia flaccida | Oxytoxum caudatum | Discolithus antillarum | |
| Pseudoeunotia doliolus | | Gephyrocapsa caribbeanica | |
| Rhizosolenia robusta | | Ophiaster hydroideus | |
| Rhizosolenia setigera | | Syracosphaera pulchra | |
| Stephanopyxis palmeriana | | Umbilicosphaera mirabilis | |
| Stephanopyxis turris | | | |
| Thalassiothrix curata | | | |

Table 8. Phytoplankton observed at both open-sea stations and inter-island stations.

| Diatoms | Pyrrhophyceans | Coccolithophorids | Silicoflagellates |
|---|---|---|---|
| Chaetoceros danicus | Ceratium furca | Cyclococcolithus leptoporus | Dictyocha fibula |
| Chaetoceros decipiens | Ceratium tripos | Emiliania huxleyi | |
| Chaetoceros didymus | Evuviaella sp. | Gephyrocapsa oceanica | |
| Chaetoceros peruvianus | Gymnodinium sp. | Syracosphaera tuberculata | |
| Chaetoceros sp. | Oxytoxum scolopax | Umbellosphaera irregularis | |
| Coscinodiscus excentricus | Peridinium sp. | | |
| Navicula sp. | Phalacroma mucronatum | | |
| Nitzschia sp. | Podolampas palmipes | | |
| Nitzschia longissima | Prorocentrum sp. | | |
| Nitzschia pacifica | | | |
| Nitzschia pungens atlantica | | | |
| Planktoniella sol | | | |
| Pleurosigma sp. | | | |
| Rhizosolenia alata | | | |
| Rhizosolenia calcar-avis | | | |
| Rhizosolenia stolterfothii | | | |
| Rhizosolenia styliformis | | | |
| Thalassiothrix frauenfeldii | | | |
| Thalassiothrix mediterranea | | | |
| Thalassionema delicatula | | | |
| Thalassionema nitzschioides | | | |
| Tropidoneis sp. | | | |

*cinodiscus*, *Nitzschia*, *Rhizosolenia*, *Thalassiothrix*, and *Thalassionema*. There were no diatoms found exclusively at the most western collection site, station 112. However, the six diatoms at this station were also found between Ecuador and the Galápagos and within the island waterways. These diatoms were *C. excentricus*, *N. pacifica*, *P. sol*, *R. alata*, *T. delicatula*, and *Tropidoneis* sp. Eleven diatom species were found limited to the open-water stations east of the Galápagos. None of these was found in large numbers.

There were small numbers of pyrrhophyceans in the open-water stations east and west of the Galápagos Islands. Generally they were most common in the samples taken between 10 and 30 m. Of the 31 pyrrhophyceans identified, five species were observed only at the open-sea stations east of the islands and 19 were limited to the inter-island stations. Another nine species were common to both of these areas. *Ceratium massiliense* and *Phalacroma* sp. were found only in the most northern stations (19 and 20) between Pinta and Marchena. Semina (1962) mentions *C. massiliense* as one of the common species along the 174° W meridian in the central Pacific waters, yet it was not noted by Desrosieres (1969). In contrast, the species *Ceratium declinatum*, *C. paradoxides*, *C. trichoceros*, *Danasphaera indica* were found mainly in waters that flowed along the southern margin of the islands. Species limited in appearance to the protected bays were *Amphisolenia* sp., *Dinophysis acuminata*, and *Peridinium globulus*. Only in Elizabeth Bay did any of these species reach large concentrations (*P. globulus*: 5220 cells/l), and in Tagus Cove, where 11 pyrrhophycean species were observed in the sample. The silicoflagellates occurred in 15 of 23 surface samples within the island complex, and at station 112. They were present but rare in the four open-water stations east of the Galápagos. *Dictyocha fibula* was common in the island waters, and was the only silicoflagellate that occurred at both open-water stations and among the islands. *D. deflandrei* and *Distephanus* sp. were observed only at the open-water stations. *Distephanus speculum*, *D. speculum octonarius*, *Mesocena* sp., and *M. polymorpha biseptenaria* were not found beyond the inter-island stations.

Although total counts were not made for the coccolithophorids, relative abundance is noted for open-water and inter-island stations in Table 9. A total of 16 species were identified with *Emiliania huxleyi* ubiquitous and most abundant. This species occurred in cold- and warm-water forms at all but one station. There were no warm-water forms at station 91. The coccolithophorids observed at these stations were at temperatures that correspond closely to the ranges given by McIntyre et al. (in press). However, the cold-water form of *Emiliania huxleyi*, they describe as characteristic for sub-polar waters, remained dominant northward in the Peru Current System, but in reduced percentages in most of the equatorial stations. The cold-water form of *Emiliania huxleyi* was found exclusively at station 91, with a ratio to the warm-water form of 9:1 at station 95, and averaging 5:1 at stations north of the oceanic front and among the islands. Within these waters occurred coccolithophorids with wide temperature tolerances (*Emiliania huxleyi*, *Cyclococcolithus leptoporus*, and *Gephyrocapsa oceanica*), mixed with tropical (*Umbellosphaera irregularis*), the more sub-tropical (*Discosphaera tubifera*) and the sub-polar (*E. huxleyi*—cold-water form) species. It should also be noted that the cold-water form of *Emiliania huxleyi* was still dominant at station 112, located 225 km west of the Galápagos, where the surface waters were 21.86°C. The persistence of these phytoplankters more characteristic to the colder waters into these equatorial areas is significant in their role as indicator species, and possibly reflects wider temperature tolerances to their life processes.

Fifteen of the 16 coccolithophorids were observed at the open water stations, nine species in inter-island channels, with eight common to both areas. The species most frequently noted were *Emiliania huxleyi*, *Cyclococcolithus leptoporus*, and *Gephyrocapsa oceanica*. All other coccolithophorids were in low numbers. These three correspond to dominants mentioned by Hasle (1959, 1960a) in equatorial Pacific collections made west of the Galápagos. Hasle also indicated *C. fragilis* as abundant, but I did not observe this species.

The phytoplankton described above represent a mixture of

Table 9. Occurrence of coccolithophorids at open-water and inter-island (1–23) stations. The more abundant species for the stations are indicated, in order of abundance by A, B, and C. X indicates presence. *Emiliania huxleyi* is listed separately for the cold-water and warm-water form.

| | 91 | 95 | 137 | 141 | 112 | 1–23 |
|---|---|---|---|---|---|---|
| Acanthoica acanthifera | | | X | X | | |
| Acanthoica quattrospina | | | X | | | |
| Anoplosolenia brasiliensis | | X | | X | | |
| Anthosphaera robusta | | | | X | | |
| Cyclococcolithus leptoporus | | X | X | X | X | B |
| Discolithus antillarum | | | | X | | |
| Discolithus tubifera | | | | | X | X |
| Emiliania huxleyi (cold) | A | A | X | A | B | A |
| Emiliania huxleyi (warm) | | B | X | X | | |
| Gephyrocapsa caribbeanica | X | | | X | | |
| Gephyrocapsa ericsonii | | | | | | X |
| Gephyrocapsa oceanica | B | X | A | X | A | C |
| Ophiaster hydroideus | | C | X | X | | X |
| Syracosphaera pulchra | | | | X | | |
| Syracosphaera tuberculata | | X | | | | X |
| Umbellosphaera irregularis | | | | | X | |
| Umbilicosphaera mirabilis | | | | X | | |

oceanic and neritic species from both tropical, sub-tropical, and equatorial water masses. The Peru Current System dominated by *Chaetoceros* and *Rhizosolenia* species, travels into this equatorial region marked by changing temperature and salinity values. The location of the hydrostations and the Galápagos Islands are approximately along the border separating these major water masses. Large numbers of diatoms predominated at stations close to land and in the protected bays of the island complex. Generally, at stations distant from land or in the more southern or eastern rim of the Galápagos, the diatoms were in lower concentrations, with the phytoflagellates common, but seldom in high numbers. No doubt if the coccolithophorids had been included in the numerical counts of total phytoflagellates, the overall concentrations would be much greater for these samples.

More extensive investigation would be required to offer explanations for several of the distribution patterns presented in the present survey. The study has initiated the problem of distinguishing species distribution that may be considered rational from those which appear to be irrational. The species changes at the four open-water stations between Ecuador and the Galápagos Islands appear to be predominantly rational, especially when matched against temperature and salinity changes. However, within the inter-island complex, there exists larger amounts of plankton near certain islands than elsewhere. The disparity between the distribution of a number of species at one station and the excessive abundance of one or two at an adjoining station constitute features that overshadow the north-south pattern of change within the island complex.

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4.0613

Vol. 85, No. 2, pp. 39–48 30 August 1972

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# SUPPLEMENTARY DATA ON THE MORPHOLOGY OF *NEONESIDEA* AND REMARKS ON THE SYSTEMATIC POSITION OF THE FAMILY BAIRDIIDAE (OSTRACODA: PODOCOPIDA)

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During recent years studies on the morphology of ostracodes advanced very much. However the details of the antennae (especially their chaetotaxy), of the mandibular gnathobasis, the lower lip, and the male copulatory organ were not studied thoroughly. I remarked in several notes (Danielopol 1968, 1969a, 1969b, 1970) that many minute details of these limbs are very constant and can be used for the systematics of different groups of Podocopids.

The morphology and systematics of Recent bairdiids progressed during recent years thanks to the contributions of Kornicker (1961) and Maddocks (1969).

Through the kindness of Dr. Louis S. Kornicker, I had the opportunity to study a small collection of bairdiids of the National Museum of Natural History, Smithsonian Institution. I was especially interested in the minute details of the limbs I mentioned above. According to these observations I shall present several remarks on the systematic position of the family Bairdiidae.

G. W. Müller (1894), Alm (1916) and, recently, Hartmann (1963) and McKenzie (1968) showed that the Bairdiidae are closely related to the Cytheridae. McKenzie (1968) considered that these two families represent one suborder Podocopina,

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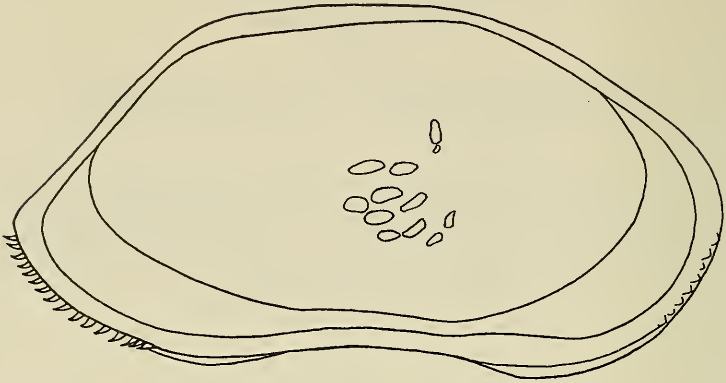

FIG. 1. *Neonesidea* sp., male USNM 98553. Right valve, externolateral aspect.

while the families Saipanettidae, Cyprididae and Darwinulidae belong to another suborder Metacopina.

Sars (1923), Schweier (1940), Sylvester-Bradley (1961), and, recently, Gründel (1967) considered the Bairdiidae related to the Cyprididae. The last author proposed a new suborder Bairdiocopina to include the bairdiids, cypridids and ?darwinulids.

A quite opposite opinion was developed by Skogsberg (1920) who considered the families Cytheridae, Bairdiidae, and Darwinulidae as belonging to a single group (named by him Cypriformes, but which is a junior synonym of the suborder Podocopa Sars 1866.).

Van Morkhoven (1962), suggested that the family Bairdiidae has an intermediary position between the Cyprididae and the Cytheridae.

The morphological features of the limbs I shall discuss here represent new data to confirm the last two opinions.

The material was collected in the South Pacific Ocean, near Ifalik Atoll (Carolina Islands); USNM nos. 98546, 98549, 98550, 98552, 98553, and consists of *Neonesidea* sp. and *N. schulzi ifalikensis.* I studied the limbs of two males of *Neonesidea* sp. (USNM 98553) and two females of *N. schulzi ifalikensis* (USNM 98549).

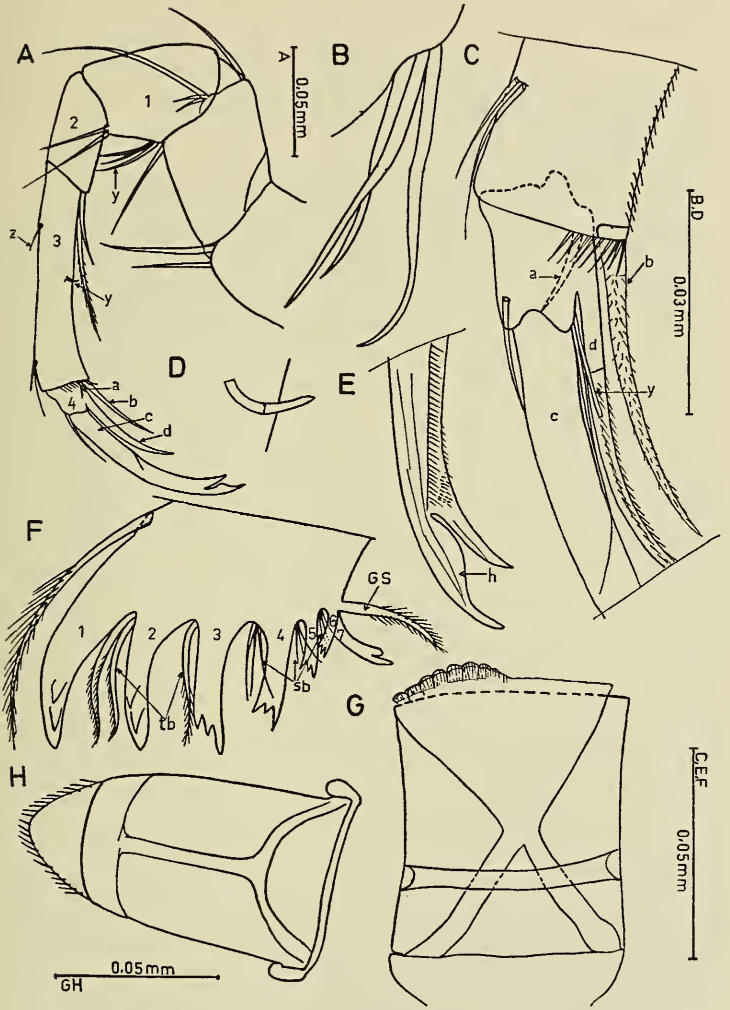

FIG. 2. *Neonesidea* sp., male, specimen no. 1, USNM 98553. A-E- second antenna. A, general aspect; B, "Y" bristle of the first endopodial segment; C, distal third of the endopod; D, "Y" bristle of the third endopodial segment; E, distal third of the central claw "C"; F, mandibular gnathobasis; G, the oesophagean masticatory organ; H, lower lip.

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The limbs were stained in glycerine mixed with blue-methylene and then mounted in the same medium between two cover glasses. This method allowed me to examine the stained limbs on both sides. Definitive preparata were made in gelatinous glycerine.

### MORPHOLOGY OF *NEONESIDEA SCHULZI IFALIKENSIS* AND *NEONESIDEA* SP.

*Chaetotaxy of the antennal endopod*: (Fig. 2, A–E). First segment bearing three posteroproximal setae that I (1970) named "Y" setae. The distal part of these setae is much more quickly stained than the two other bristles inserted on the posterodistal margin of this segment. I suppose that the "Y" setae are chemoreceptors as they are stained in the same way as the aesthetascs of Cyprididae and Darwinulidae. Third segment bearing posteromedially a short bristle. Its distal part is strongly stained like the "Y" setae of the first segment, so that I named it "Y" bristle too. Maddocks (1969) figured such a bristle when describing *Bythocypris mozambiquensis.* Posterodistally there are two bristles, one short and slender (a) the other long, strong, and hairy (b). On the anterior side of this segment there are three slender bristles, i.e., an anteroproximal one (z) and two anterodistal ones. The last segment bears two distal doubly serrate claws and three bristles. The male of *Neonesidea* has on the central claw (c) a distal hook (h). This is one of the most peculiar features of the genus *Neonesidea,* which differs strongly from the other bairdiids. This claw is surrounded by three slender bristles (two on the posterior side and one on the anterior side). One of them is a "Y" bristle. The female of *Neonesidea schulzi ifalikensis* has the central distal claw without hook. The slender second distal claw (d), is fused to the segment, the fusion of this claw being one of the characteristics of the subfamily Bairdiinae (Maddocks, 1969). Both species of *Neonesidea* examined have doubly serrated claws, contrary to Maddock's opinion (1969), who considers that the genus *Neonesidea* has the "fused claw smooth." The same number of claws and bristles of the distal two antennal segments as mentioned above for *Neonesidea* species was figured by Maddocks (1969) when describing the following species: *Neonesidea cracenticlavula, Paranesidea* sp. (S.F. Bairdiinae), *Bythocypris spiriscutica* and *Bythocypris eltanina* (S.F. Bythocypridinae). It seems that this is a peculiarity of the family Bairdiidae.

*Mandibular gnathobasis*: (Fig. 2, F). Represented by seven teeth, several interdental bristles and a posterior guide seta (GS). All teeth except the last one, have three cusps. The first four anterior teeth are well developed, the last three are smaller and slender. In the first and second (anterior) interdental space, there are three long bristles of "tooth brush" type (tb) bristles, two in the first space and one in the second space; in the other three interdental spaces there are two or

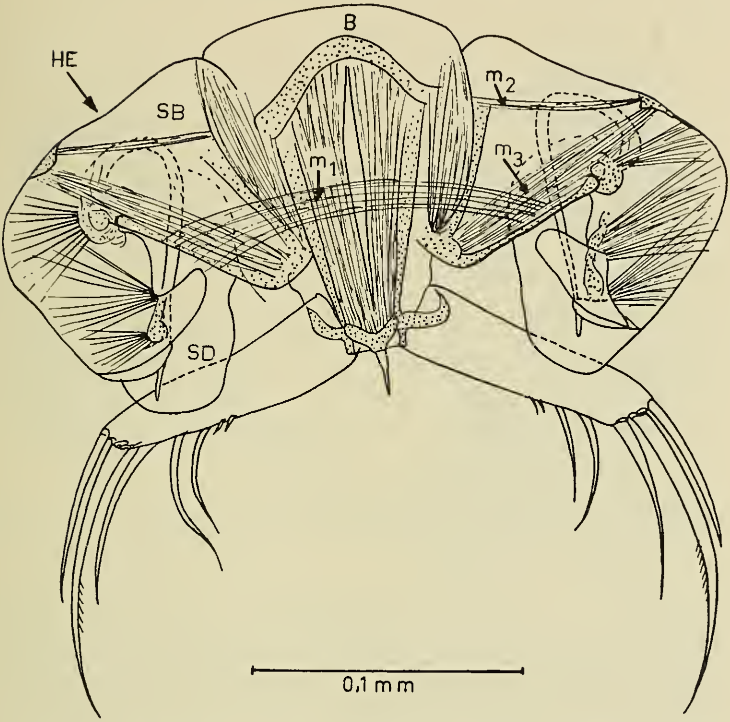

FIG. 3. *Neonesidea* sp., male, specimen no. 2 USNM 98553. Copulatory organ and furca.

three small spiky bristles (sb). Very probably the general shape of the mandibular gnathobasis as described here is proper for many bairdiids (see for instance the figures of Maddocks (1969) for the mandibular gnathobasis of *Bairdia* (*Bairdiopilata*) *alcionicola* and *Neonesidea pateriformis* (S.F. Bairdiinae) and *Bythocypris mozambiquensis* (S.F. Bythocypridinae)).

*Lower lip*: (Fig. 2, H). The outer surface of this limb has a groove with fringed margins. There are no dentiferous rakelike organs.

*Oesophagean masticatory organ*: (Fig. 2, G). A thorough study of this organ was published by G. W. Müller (1894). It seems that this strong organ sets off the lack of dentiferous rakelike organs. The oesophagean masticatory organ is certainly the most original feature of the Bairdiidae.

*Male copulatory organ of Neonesidea sp.*: (Fig. 3–5). Formed by two hemipenes (he) fused by their basal part to the posteroventral part

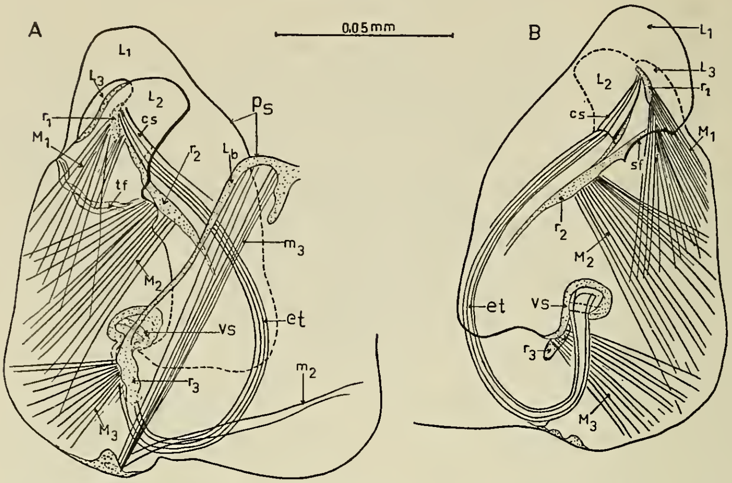

FIG. 4. *Neonesidea* sp., male, specimen no. 1, USNM 98553. Distal part of the hemipenis. A, lateral aspect; B, medial aspect.

of the body (B) (Fig. 3). The hemipenis (Fig. 4) has a peniferum or penial shield (ps) (called in French, Danielopol, 1969b "gaine penienne") inside of which there are: the vas deferens, a membranous tube; the seminal vesicle (vs); the ejaculatory tube (et), which has a sclerotized sleeve (I named this tube in French (1969b) "tube copulateur"); a concial sleeve (cs) which seems to belong to the peniferum; the erector muscles (m and M), and several sclerotized strips (r).

Every hemipenis (Fig. 3) has a basal side (SB) and a distal side (SD). Laterally seen (Fig. 3) the basal side of the hemipenis has a triangular shape. The lateral shield of this side (Fig. 4, A) has a lobe (Lb) which joins the ejaculatory tube. Within the basal part of the peniferum there are three muscles that I named "$m_1$", "$m_2$", "$m_3$" (Fig. 3). The position of the muscle "$m_1$" is transversal, joining the two hemipenes. The "$m_2$" has a transvero-oblique position. The "$m_3$" has a longitudinal position (Fig. 4, A).

On the distal side (Fig. 4, A, B) the peniferum has the medial shield with a largely rounded lobe "$L_1$"; its dorsal margin is slightly bent. The lobe "$L_1$" has, ventrally (Fig. 4, B) a sigmoid fold (sf). The lateral shield of the peniferum (Fig. 4, A), much more slender than the medial shield, has a distal digitiform lobe ($L_2$); the dorsal margin of this lobe joins the basal part of the ejaculatory tube; this lobe has a transversal fold (tf); the lobe "$L_2$" can be more or less retracted inside the peniferum. Between the lobes "$L_1$" and "$L_2$" there is a smaller one, named lobe "$L_3$" (Fig. 5, A).

Inside the peniferum there are several sclerotized strips. The most

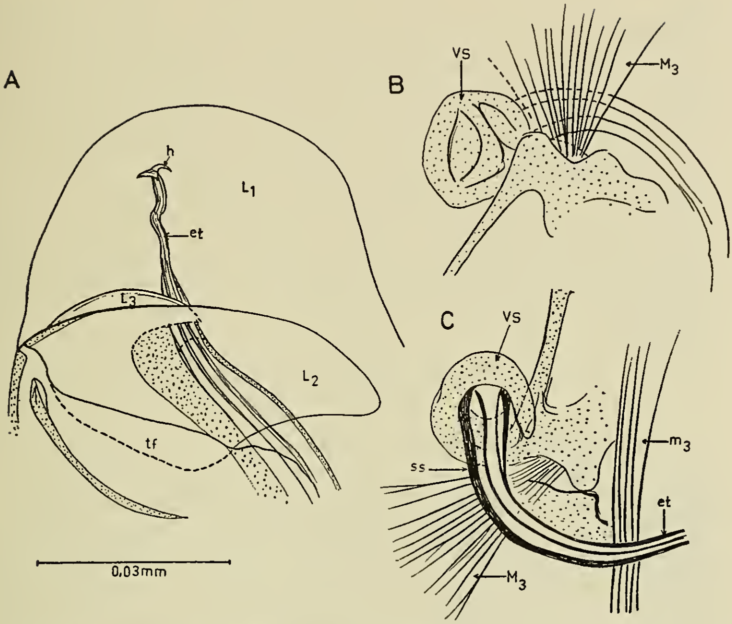

FIG. 5. *Neonesidea* sp., male, specimen no. 2, USNM 98553. Details of the male copulatory organ. A, the lobes $L_1$-$L_3$ and the ejaculatory tube. B and C, vesica seminis and the ejaculatory tube; B, medial aspect; C, lateral aspect.

important are named "$r_1$", "$r_2$", "$r_3$"; on these three strips the erector muscles, "$M_1$", "$M_2$", "$M_3$" are inserted (Fig. 4, A, B). The membranous "vas deferens" ends in a globular strongly sclerotized cavity (vs) (Figs. 4, A, B and 5, B, C). G. W. Müller (1894) named it "vesica seminis." In my opinion this is homologous with the "labyrinth" of the Cyprididae (see Danielopol, 1969b). The "vesica seminis" (Fig. 5, C) is prolonged by the ejaculatory tube (et), which has a strong sclerotized sleeve (ss). The proximal part of this tube is larger than the distal part which is narrow, slender, and ends with three small hooks (h) (Fig. 5, A). The distal part of the ejaculatory tube slips into a groove made by the "$r_2$" strip and a fold of the medial shield. The distal third of the ejaculatory tube is covered by a conical sleeve (cs) which seems to be a fold of the medial shield.

## THE SYSTEMATIC POSITION OF THE FAMILY BAIRDIIDAE

The general shape of the antennae (i.e., the reduced chaetotaxy, the presence of only one or two distal claws, the third very elongated endopodial segment), the three pairs of legs, having an undifferentiated endopod suggest that the Bairdiidae are related to the family Cytheridae. In contrast to these two families, the Cyprididae and Darwinulidae have: a richer antennal chaetotaxy of the last two segments, represented by five or six strong claws, the second and third endopodial segments of the antenna generally shorter than those of the cytherids and bairdiids, the three pairs of legs differentiated (the first pair generally becomes a maxillipede; the second one is a walking leg; and the third one, sometimes losing the ambulatory function, becomes a cleaning leg). Apparently these differences led McKenzie (1968) to divide the order Podocopida into two suborders, Podocopina (for the Cytheridae and the Bairdiidae) and Metacopina (for Saipanettidae, Darwinulidae and Cyprididae).

In the Bairdiidae the central muscle scar area shows a subcircular group of four to 10 scars often placed irregularly (Fig. 1). The pattern of the central muscles scars of the subfamily Bairdiinae are like in the Cyprididae, Macrocypridinae. The Bythocyridinae, a second subfamily of Bairdiidae, has a pattern which can be compared with those of the Cyprididae, Candoninae or Pontocypridinae and even with the Terrestricytheridae Schornikov, 1969. Mainly due to these similitudes Gründel (1967) proposed to include the Bairdiidae, Cyprididae, and Darwinulidae in a special suborder Bairdiocopina and the family Cytheridae (which have a single row of central muscle scars and a very diversified and sometimes complicated hinge) in another suborder, Cytherocopina, both belonging to the order Podocopida.

The morphological data presented above suggest the following: 1. The antennal "Y" bristles of the first endopodial segment of the bairdiids are like the aesthetascs of Cyprididae, Macrocypridinae (Danielopol, 1971a); they can be homologized also with the "Y" aesthetascs of the Darwinulidae (Danielopol, 1970). The "Y" bristles of the third and fourth endopodial segment of the antenna of bairdiids could be homologous with the aesthetascs "$Y_2$" and "$Y_3$" of the Darwinulidae and Cyprididae (Danielopol, 1970). The chaetotaxy of the distal third, of the third endopodial segment of the antenna of bairdiids, i.e., four bristles, two anterior and two posterior, can be homologized to the distal claws of the third endopodial segment of the Cyprididae and Darwinulidae; the anterior proximal bristle "z" of the bairdiids is in my opinion homologous with bristle "z" of the Darwinulidae and Cyprididae (Danielopol, 1970). The chaetotaxy of the distal antennal segment of bairdiids represented by two claws and three slender bristles (one of these bristles being a "Y" bristle) are like the chaetotaxy of some Cyprididae, see for instance the subfamily Candoninae or Cypridinae. 2. The presence of seven mandibular teeth and three "tooth brush" bristles is another similitude with most of the Cyprididae (Danielopol, 1970) and Cytheridae (Danielopol, 1969a). 3. The male copulatory organ has the general structure we find in some cytherids like the Enthocytheridae, (Danielopol, 1971b) or some Cyprididae like the Pontocypridinae (Danielopol in litt.), i.e., a peniferum with distal lobes, a vesica seminis, a sclerotized ejaculatory tube, several erective muscles, etc. 4. The lack of dentiferous rakelike organs and the development of the mandibular gnathobasis with four well-developed teeth and three small ones are some of the most remarkable characters of the family Bairdiidae.

If we also now take into account some well-known facts like the presence of the "brush-shaped organ" and the presence of the exopodite (or traces of this appendage) on the legs of different groups of Bairdiidae, Cytheridae and Cyprididae, one may conclude that the family Bairdiidae is not much closer to the Cytheridae than to the Darwinulidae or Cyprididae. In my opinion the Cytheridae, Bairdiidae, Saipanettidae, Terrestricytheridae, Darwinulidae, and Cyprididae represent six independent phylogenetic lines belonging to a single group. One can name this group suborder Podocopa Sars 1866.

## ACKNOWLEDGMENTS

I express my thanks to Dr. L. S. Kornicker for the loan of the bairdiids. Part of this contribution was completed during a stay at the Geological Institute of the University of Stockholm. I am grateful to the Svenska Institute and the University of Stockholm for the financial support and working facilities. I thank Professor I. Hessland, Head of the Geological Institute, for his comprehension concerning my work during the stay in his institution as well as for much advice that he kindly provided me.

I am much indebted to Dr. Fr. Adamaczack (Geological Institute, Stockholm) for much useful information about fossil platycopids and metacopids.

I thank Dr. R. Maddocks (Houston University), Dr. K. McKenzie (British Museum, London) and Dr. L. Botoşăneanu (Institute of Speology "E. G. Racovitza") for reading the manuscript of this paper. Dr. Maddocks provided me with several specimens of a new species of *Saipanetta* which is here gratefully acknowledged.

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Vol. 85, No. 3, pp. 49–56 30 August 1972

# PROCEEDINGS
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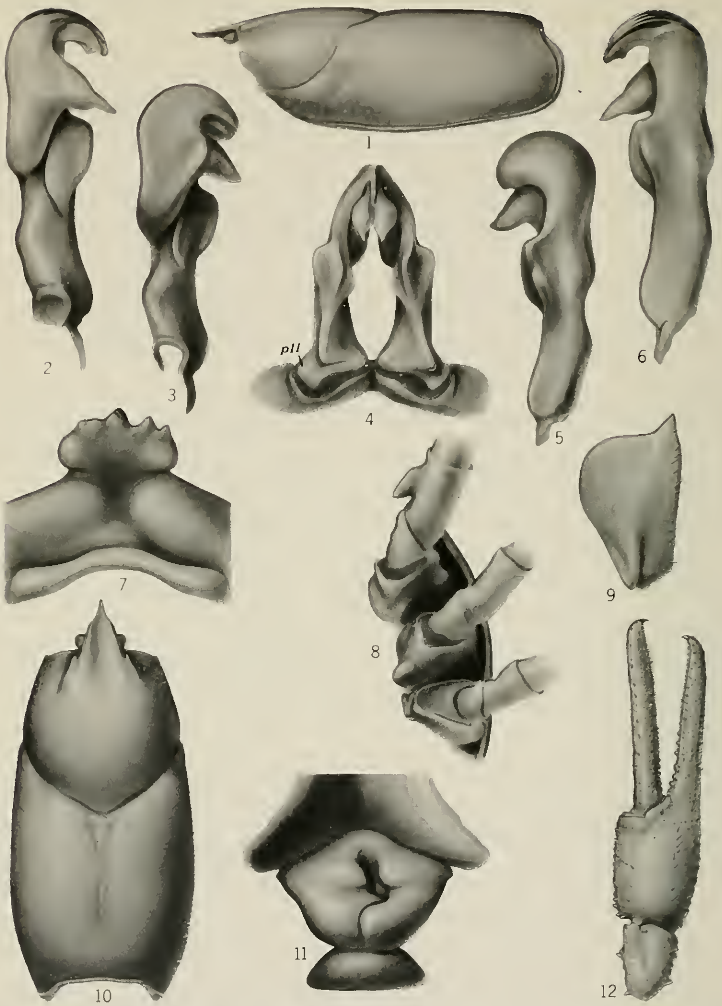
## A NEW TROGLOBITIC CRAYFISH FROM OKLAHOMA (DECAPODA: ASTACIDAE)

By Horton H. Hobbs, Jr. and Martha R. Cooper
*Smithsonian Institution, Washington, D.C. 20560*

With the discovery of *Cambarus* (*Jugicambarus*) *tartarus*, new species, in the subterranean waters of northeastern Oklahoma by Jeffrey H. Black, four members of the subgenus are known to have become adapted to a spelean existence. One of these, *C.* (*J.*) *cryptodytes* Hobbs (1941: 110) is found in the panhandle of Florida and southwestern Georgia, and three inhabit the Ozark region: *C.* (*J.*) *setosus* Faxon (1889: 237) in southwestern Missouri, *C.* (*J.*) *zophonastes* Hobbs and Bedinger (1964: 11) in north-central Arkansas, and *C.* (*J.*) *tartarus.*

The only specimens of the new species that are available are the primary types. Surprising to us is the fact that these specimens are not conspecific with those cited by Hobbs and Barr (1960: 27) and Bedinger and Hobbs (1965: 94) from other localities in the same drainage (Spavinaw Creek) in Delaware and Mayes counties. Unfortunately, first form males from these localities ("cave between Spavinaw and Jay [=Twin Cave], Delaware Co., and Spring Creek, 5 mi. S. of Locust Grove, Mayes Co.") are not available and specific determinations of them and of a second form male from Twin Cave, collected by Mr. Black, cannot be made.

We are most grateful to Mr. Black for both the specimens and his interest. We also thank Fenner A. Chace, Jr., and Raymond B. Manning for their criticisms of the manuscript and Carolyn B. Gast for the illustrations.



FIGS. 1–12. *Cambarus* (*Jugicambarus*) *tartarus.* 1, Lateral view of carapace of holotype. 2, Mesial view of first pleopod of holotype. 3, Mesial view of first pleopod of morphotype. 4, Caudal view of first pair of pleopods of holotype. 5, Lateral view of first pleopod of morphotype. 6, Lateral view of first pleopod of holotype. 7, Epistome of holotype. 8, Bases of third, fourth, and fifth pereiopods of holotype. 9, Antennal scale of holotype. 10, Dorsal view of carapace of holotype. 11, Annulus ventralis and adjacent sternal elements of allotype. 12, Dorsal view of distal podomeres of cheliped of holotype.

### **Cambarus (Jugicambarus) tartarus** new species

*Diagnosis*: Body and eyes without pigment, latter reduced, subcylindrical. Body and chelipeds bearing conspicuous stiff setae. Rostrum with or without small marginal tubercles, sometimes tapering to apex without distinct angle at base of acumen. Areola 15.5 to 17.5 times longer than wide, and comprising 44.3 to 46.4 percent of entire length of carapace (51.5 to 52.2 percent of postorbital length), with two punctations across narrowest part. Cervical spines absent; suborbital angle obsolete; postorbital ridges degenerate but with small apical tubercles. Antennal scale approximately 1.6 times longer than broad, broadest distal to midlength. Chela with rectangular palm bearing 2 sublinear arrangements of 8 and 10 tubercles along mesial surface of palm; longitudinal ridges on fingers poorly developed. Hooks on ischia of third pereiopods distinctly compressed. First pleopod of first form male with central projection short, broad, bladelike, strongly recurved with distal portion directed toward base of appendage, and having distinct terminal notch; mesial process with broad base, not greatly inflated, its distal third tapering and projecting approximately 120 degrees to shaft of appendage; proximolateral lobe (Fig. 4, *pll*) distinctly delimited from major portion of shaft by conspicuous groove. Annulus ventralis symmetrical with caudal portion somewhat movable; cephalic third membranous and bearing deep, broad median trough. First pleopods lacking in female.

*Holotypic male, form I*: Body subovate, strongly depressed (Figs. 1, 10). Abdomen narrower than thorax (11.4 and 14.6 mm). Greatest width of carapace greater than depth at caudodorsal margin of cervical groove (14.6 and 10.0 mm). Areola very narrow, 15.5 times longer than wide, with 2 punctations across narrowest part, latter located one-third of areola length from caudal end; length of areola 45.5 percent of entire length of carapace (52.2 percent of postorbital length). Rostrum with somewhat thickened, elevated borders, lacking marginal spines or tubercles, and converging to base of acumen; latter reaching base of ultimate podomere of antennule and terminating in corneous, acute, slightly upturned tip; upper surface concave and punctate; thickened margins flanked by rows of deep punctations, some of which supporting stiff, hairlike setae. Subrostral ridges weakly developed but evident in dorsal aspect to base of acumen. Postorbital ridges almost rudimentary with conspicuous setiferous punctations, terminating cephalically in small, weakly cornified, subacute tubercles. Suborbital angle absent; branchiostegal spine almost obsolete. Cervical spine absent and tubercles in area not conspicuously larger than those on branchiostegite. Carapace punctate dorsally, granulate laterally, punctations and granules bearing setae, many of latter erect.

Abdomen slightly shorter than carapace (28.5 and 30.4 mm); pleura comparatively short and rounded ventrally. Cephalic section of telson with 2 spines in each caudolateral corner. Proximal podomere of uropod without spines or prominent tubercle; mesial ramus with moderately well-developed dorsomedian keel terminating in small distal spine situated distinctly proximal to distal margin of ramus.

Cephalic lobe of epistome (Fig. 7) much broader than long, asymmetrical, with conspicuous cephalomedian prominence, bearing tubercle at dextral base; cephalosinistral border with 2 tuberculiform projections, and cephalodextral with 2 distinctly less prominent ones; basal portion of epistome with broad anteromedian fovea and with lateral areas, posterior to renal aperture, verrucose. Basal segment of antennule with small median spine on ventral surface slightly beyond base of distal third. Antennae reaching far beyond telson. Antennal scale (Fig. 9) conspicuously broad, broadest distal to midlength; thickened lateral portion terminating in short, broad, subacute, corneous-tipped tubercle, projecting slightly beyond tip of rostrum.

Right chela (Fig. 12) almost 4 times as long as wide, slightly depressed, with rectangular inflated palm; mesial margin of palm with 2 irregular rows of 8 to 10 tubercles, flanked by additional ones; ventrodistal surface of palm with longitudinal row of 3 submedian tubercles increasing in size distally; lateral margin with row of low tubercles along basal half, otherwise punctate; all punctations and tubercles on palm and fingers supporting long stiff setae. Opposable margin of fixed finger with 2 rows of tubercles: dorsal row with 5 along proximal fourth and 5 minute ones in distal half; ventral row of 5 in proximal half, largely filling gap between two segments of dorsal row; tubercles of lower row and those in distal segment of upper row corneous tipped, those in upper row acute; single longitudinal row of minute denticles extending entire length of finger between dorsal and ventral rows of tubercles. Opposable margin of dactyl with single row of 21 tubercles along proximal four-fifths of finger, interspersed by single row of minute denticles; tubercles distal to sixth from base, corneous and acute; median longitudinal ridges on dorsal and ventral surfaces of both fingers almost obsolete; nonopposable surfaces of both fingers with sublinearly arranged setiferous punctations.

Carpus longer than broad (8.0 and 5.5 mm) with deep, oblique furrow on upper surface; mesial face with group of 4 tubercles, one of which larger than others; ventromesial surface with row of 3 tubercles, progressively larger distally, distal tubercle with acute corneous tip; distal ventrolateral margin with corneous tubercle on articular condyle; lateral surface tuberculate proximally, podomere otherwise with setiferous punctations.

Upper surface of merus with proximal four-fifths tuberculate; mesial surface tuberculate ventrally, somewhat polished dorsally; lateral surface punctate; ventral surface with lateral row of 9 tubercles, mesial row of 13, and a few tubercles lateral and mesial to both rows. Ischium with 2 tubercles ventrally and row of 10 small tubercles dorsally.

Hooks present on ischia of third pereiopods only (Fig. 8); hooks strongly compressed and scarcely reaching basioischial articulation. Coxae of fourth pereiopods with moderately prominent, rounded boss; coxae of fifth pereiopods without prominences. For measurements see Table 1.

First pleopods (Figs. 2, 4, 6) reaching caudal portion of coxae of third pereiopods when abdomen flexed. See Diagnosis for description.

*Allotypic female*: Differing from holotype in following respects: rostrum with small marginal tubercles at base of acumen, latter reaching midlength of ultimate podomere of antennule; upper rostral surface less concave; proximal podomere of uropod with mesial lobe bearing acute corneous tip. Cephalic lobe of epistome with median prominence reduced and cephalic border otherwise slightly undulate; basal portion of epistome with lateral areas very weakly verrucose. Thickened lateral portion of antennal scale more spiniform distally. Right chela with ventral surface of palm bearing single prominent spine at base of dactyl; opposable margin of fixed finger with single row of 10 tubercles (fourth from base largest) on proximal two-thirds of finger, and single prominent, corneous, subacute tubercle situated below row and between seventh and eighth tubercles from base; opposable margin of dactyl with row of 15 corneous tubercles, becoming progressively more flattened and acute toward distal end of row; ridges on fingers more pronounced. Carpus of cheliped with distalmost tubercle on ventromesial surface greatly enlarged basally, as also ventrolateral condyle; few accessory tubercles situated mesially and laterally on ventral surface. Ventral surface of merus with lateral row of 9 tubercles and mesial of 15, with 3 tubercles forming row between distalmost members of two rows. Ischium with 4 very low tubercles ventrally, and dorsal row of tubercles scarcely evident. First pleopods absent but vestigial sockets represented by 2 subovate, membranous areas on first abdominal sternite. For measurements, see Table 1.

Annulus ventralis (Fig. 11) shallowly embedded in sternum, fused with latter cephalically but posterior part rather freely movable; outline symmetrical. Cephalic third membranous with deep submedian excavation inclined sinistrally to near midlength; tongue projecting posterosinistrally from right half of transverse ridge; sinus originating on cephalic side of tongue approximately on median line, extending sinistrally and making hairpin turn across median line, then continuing caudally to cut elevated caudal wall of annulus. Sclerite immediately caudal to annulus subspindle-shaped in outline with ventral surface domelike.

*Morphotypic male, form II*: Cephalic region abnormal due to past injury. Differing from holotype in following respects: uropod with mesial lobe of proximal podomere spiniform apically. Cephalic lobe of epistome almost symmetrical, with 2 pairs of lateral projections flanking median projection; basal portion of epistome with broad, shallow excavation replacing fovea and with lateral areas very weakly verrucose.

TABLE 1. Measurements (mm) of *Cambarus* (*J.*) *tartarus*

| | Holotype | Allotype | Morphotype |
|---|---|---|---|
| Carapace: | | | |
| Entire length | 30.4 | 23.7 | 23.5* |
| Postorbital length | 26.5 | 20.4 | 21.0 |
| Width | 14.6 | 11.5 | 11.9 |
| Height | 10.0 | 8.2 | 8.5 |
| Areola: | | | |
| Width | 0.9 | 0.6 | 0.7 |
| Length | 13.8 | 10.5 | 10.9 |
| Rostrum: | | | |
| Width | 3.5 | 3.2 | 3.1 |
| Length | 4.3 | 4.0 | 3.6* |
| Chela: | | | |
| Length, palm inner margin | 10.5 | 8.4 | 10.1 |
| Palm width | 8.6 | 6.0 | 7.0 |
| Length, hand outer margin | 31.9 | 22.2 | 28.2 |
| Dactyl length | 20.6 | 13.0 | 16.8 |

* Acumen injured.

Palm of chela with only 2 tubercles on ventral surface, proximal one very small; opposable margin of fixed finger with single row of 13 tubercles (fourth from base largest) and single large tubercle ventral to row situated between eighth and ninth tubercles from base; opposable margin of dactyl with row of 19 tubercles. Right carpus with few accessory tubercles situated mesially and laterally on ventral surface; ventral surface of merus with lateral row of 13 tubercles and mesial row of 18; dorsal and ventral margins of ischium with row of 4 small tubercles on each. Hooks on ischia of third pereiopods and boss on coxae of fourth pereiopods reduced. For measurements, see Table 1.

First pleopod (Figs. 3, 5) reaching coxa of third pereiopod when abdomen flexed, with central projection much heavier and less strongly recurved, exhibiting only trace of subapical notch; mesial process less attenuate and more bulbiform; proximolateral lobe almost as distinct as in holotype.

*Type-Locality*: Stansberry-January Cave System, 4 miles north of Colcord (T.21N, R.22E, Sec. 11), Delaware County, Oklahoma, in the Spavinaw Creek drainage of the Arkansas River Basin. Mr. Black informed us that the holotype was collected on 11 April 1971 from the "upper end of cave where stream gets quite small and narrow," about 1 mile inside the cave. The allotype and morphotype were collected on

11 July 1970 from a very small stream over 2,000 feet from the Stansberry entrance. Specimens of *Orconectes neglectus neglectus* (Faxon, 1885: 142) were found in the large stream as far as 2,000 feet inside the entrance.

*Disposition of Types*: The holotypic male, form 1 (no. 131951), the allotypic female (no. 131411), and the morphotypic male, form II (no. 132754) are deposited in the National Museum of Natural History, Smithsonian Institution. No other specimens are known.

*Relationships*: *Cambarus* (*Jugicambarus*) *tartarus* shares more characters with *C.* (*J.*) *setosus* and *C.* (*J.*) *zophonastes* than with any other crayfishes. Although the most conspicuous resemblances are those common to many troglobitic crayfishes, there are more fundamental similarities, especially in the annulus ventralis, the epistome, and the markedly well-developed setae on the chelipeds and carapace. Its epigean relatives include the stream-dwelling members of the subgenus occurring on the Cumberland Plateau, Highland Rim, and southern Appalachians. Of these, only *C.* (*J.*) *conasaugaensis* Hobbs and Hobbs (1962: 41), *C.* (*J.*) *distans* Rhoades (1944: 136), and *C.* (*J.*) *parvoculus* Hobbs and Shoup (1947: 142) have retained the primitive subapical notch of the central projection of the first pleopod of the male, a feature that is well developed in *C.* (*J.*) *tartarus* and *C.* (*J.*) *cryptodytes*, and less so in *C.* (*J.*) *setosus*.

The albinistic *Cambarus* (*J.*) *tartarus* may be distinguished from other troglobitic members of the subgenus as follows: from *C.* (*J.*) *cryptodytes* by its much narrower areola, more than 10 times longer than broad; and from *C.* (*J.*) *setosus* and *C.* (*J.*) *zophonastes* by the short, strongly recurved central projection of the first pleopod that in the first form male bears a well-defined subapical notch.

*Etymology*: Tartarus, L.—the infernal regions; so named because of its subterranean mode of life.

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Vol. 85, No. 4, pp. 57–62 30 August 1972

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# A KEY TO THE CRASSULUS GROUP OF *APHODIUS* WITH DESCRIPTIONS OF NEW SPECIES FROM TEXAS AND MARYLAND (COLEOPTERA: SCARABAEIDAE: APHODIINAE)

By Oscar L. Cartwright
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In 1957, I described three new species and presented a key to the species in the crassulus group of American *Aphodius*, Coleopterists' Bulletin, 11: 55–61. Two additional species are described below and placed in a revised key. All of the species are found in and under deer droppings in shady woods.

## Key to Species

1. Clypeus with two triangular teeth or angulations ........ 2
Clypeus with four equal, spiniform, slightly recurved teeth; Texas ........ *bottimeri* Cartwright
2. Elytral intervals concave, especially at the shoulders: New Jersey ........ *odocoilus* Robinson
Elytral intervals flat or convex ........ 3
3. Terminal abdominal sternum with a distinct concavity; mountains of North and South Carolina ........ *brimleyi* Cartwright
Terminal abdominal sternum without concavity ........ 4
4. Elytral striae noticeably wider over apical declivity ........ 5
Elytral striae not noticeably wider over apical declivity ........ 6
5. Elytral intervals very moderately convex on disc, strongly convex over apical declivity; South Carolina, Georgia, Florida ........ *crassulus* Horn
Elytral intervals flat on disc, only moderately convex over apical declivity; Maryland ........ *silvanicus* new species
6. Clypeal margin slightly angulate outside of the very sharp, very distinct teeth (Fig. 1), a small species 3.3 to 3.7 mm; Mexico ........ *spiniclypeus* Hinton
Clypeal margin not angulate outside the clypeal teeth (Fig. 3) ........ 7

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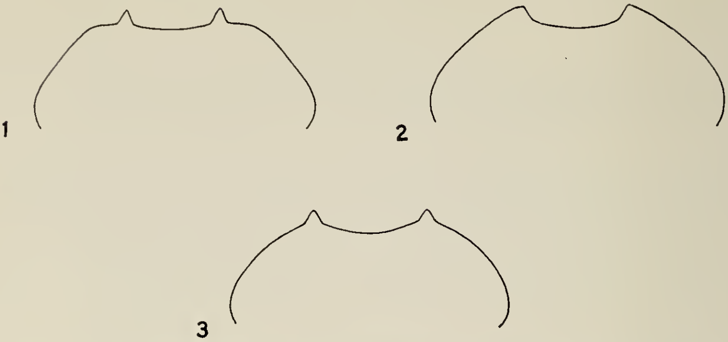
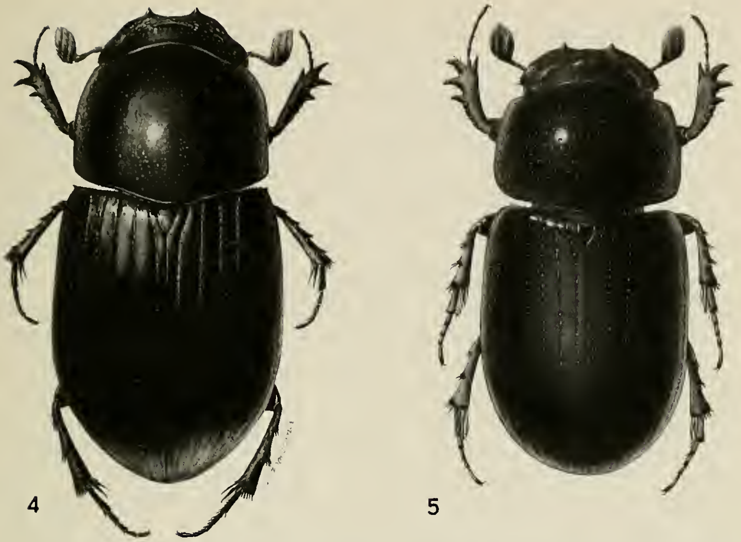


Figs. 1–3. *Aphodius spiniclypeus* Hinton, clypeal margin; *Aphodius crassuloides* Fall, clypeal margin; *Aphodius texensis* new species, clypeal margin.

7. Clypeus with small, rounded, well-separated tubercles, otherwise relatively smooth ........ 8
   Clypeus strongly rugose-punctate ........ 9
8. Basal tooth of anterior tibia slightly nearer base than apex; antennae light colored; strial punctures and crenations of elytral intervals not or scarcely evident over apical declivity; first four striae subparallel, only slightly converging at apex; South Carolina, Florida ........ *windsori* Cartwright
   Basal tooth of anterior tibia nearer apex than base; antennae fuscous; strial punctures of elytra very slightly larger and more noticeable over apical declivity than on disc; South Carolina to Texas ........ *lodingi* Cartwright
9. Elytra relatively short, four-fifths as wide as long; pronotal punctures relatively coarse, dense at sides and in anterior angles where they are separated by less than the diameter of the fine punctures, often some merging together; Texas ........ *abusus* Fall
   Elytra longer, three-fourths as wide as long, pronotal punctures more widely separated in anterior angles ........ 10
10. Apex of elytra always alutaceous; Oklahoma, North Dakota ........ *pseudabusus* Cartwright
   Apex of elytra not alutaceous ........ 11
11. Clypeal teeth with clypeal margin forming outer side of the tooth, joining the tooth at tip rather than base (Fig. 2); New Mexico, Arizona ........ *crassuloides* Fall
   Clypeal teeth set off from margin as complete, distinct, triangular teeth (Fig. 3); small species, 2.9 to 4.1 mm; Texas ........ *texensis* new species



FIGS. 4–5. *Aphodius silvanicus* new species; *Aphodius texensis* new species.

### **Aphodius silvanicus** new species

Figure 4

*Holotype male*: USNM No. 71962. Length 4.8 mm, width 2.3 mm. Shining black, strongly convex, elongate oval. Clypeal margin feebly reflexed, widely, moderately emarginate anteriorly between two strong, sharp, triangular teeth, sides feebly sinuate; genae obtusely rounded. Clypeal surface shining, punctate-tuberculate, gradually less roughened and noticeably alutaceous to frontal suture where the punctures are very shallow, alutaceous within and separated by their own diameter or less. Three weak tubercles on the frontal suture, front with wide band of moderate punctures, separated generally by less than their diameters. Pronotum strongly convex, length 1.5 mm, width at posterior angles, 2.0 mm, sides and base finely margined, all angles obtusely rounded, base sinuate; surface punctate throughout, punctures nearly uniform in size on disc where separated by one or two times their diameters, gradually much closer and discernably of two sizes outward to sides. Elytra very convex, length 2.8 mm, width 2.3 mm, striae rather wide and deep, strial punctures deep, very slightly crenating sides of intervals, separated by four times their diameters on disc, striae gradually wider over apical declivity and the punctures tend to disappear. Intervals flat, with scattered very fine punctures on disc, weakly convex over apical declivity. Mesosternum weakly convex between the coxae. Metasternum with fine to moderate scattered punctures, at least some of them very finely setigerous. Abdominal sterna finely, closely, shallowly, setigerously punctate; sterna otherwise alutaceous with posterior edge very narrowly smooth and shining. The posterior of three anterior tibial teeth nearer apex than base, anterior face of tibia smooth, impunctate; first tarsal segment shorter than the second. Middle and hind femora finely, closely punctate. Posterior tibial fringe with short equal setae, first tarsal segment slightly longer than long spur, equal to following three combined.

*Allotype*: Length 4.5 mm, width 2.3 mm. The pronotum has a narrow impunctate midline but I noticed no other difference.

*Type-locality*: Shelltown, Somerset County, Maryland. Holotype and one paratype collected under deer droppings, 11 April 1965 by E. J. Ford, Jr. Allotype and one paratype same locality, 29 April 1969, under deer droppings, by Robert Gordon.

*Remarks*: *Aphodius silvanicus* is very similar to *A. crassulus* Horn but differs in the slightly finer pronotal punctures and the much less disparity in size of punctures over lateral areas of the pronotum. The elytral intervals over the disc are flat to very slightly concave and only moderately convex over the apical declivity, while in *crassulus* the intervals are moderately convex on the disc to very strongly convex over the declivity.

### **Aphodius texensis** new species

Figure 5

*Holotype male*: USNM No. 71963. Length 3.7 mm, width 1.9 mm. Shining; pronotum brownish black, convex, elongate oval; head and elytra dark reddish brown. Clypeal margin finely reflexed, medially widely, weakly emarginate between strong, sharp, triangular teeth, sides weakly arcuate; genae very obtusely rounded, not prominent; clypeal surface generally roughly, closely, moderately punctate, an obscure transverse median ridge, the punctures less numerous above the ridge. Three low tubercles, the middle one binodose, on frontal suture. Front with transverse band of very moderate punctures separated by one or more times their diameters. Pronotum convex; length 1.2 mm, width 1.5 mm; lateral and basal margins finely margined; anterior angles rounded; posterior angles very obtusely rounded; sides weakly arcuate; base very slightly sinuate; surface quite uniformly punctate; punctures on disc very moderate, separated by one to three times their diameters, laterally much closer and distinctly of two sizes, the larger punctures up to twice the diameter of the smaller. Elytra convex; length 2.3 mm, width 1.9 mm; striae rather fine, not deep; strial punctures crenating sides of intervals, separated by about four times their diameters; intervals nearly flat on disc with a row of very fine punctures along each side; striae not noticeably wider over apical declivity and the intervals here only weakly convex. Mesosternum weakly convex between the coxae.

Metasternum vaguely longitudinally depressed medially, scattered fine punctures separated by one or more times their diameters. Abdominal sterna noticeably hairy, the very fine hair from very fine punctures, surface otherwise finely alutaceous. Foretibiae with three teeth, the upper about midway between base and apex; face of tibia smooth; first tarsal segment shorter than the second. Middle and hind femora with scattered very fine punctures. Posterior tibiae with fringe of short equal setae; first tarsal segment shorter than long spur, shorter than three following segments combined.

*Allotype*: Length 3.9 mm, width 1.9 mm. I was unable to determine sex without dissection. Allotype and 28 paratypes vary from 2.9 mm to 4.1 mm. In some the transverse clypeal ridge is more distinct as are the three frontal sutural tubercles, with the middle tubercle more or less binodose. I found no other variation.

*Type-locality*: Kerrville, Texas, 20 September 1951, O. L. Cartwright.

*Paratype data*: Allotype and 3, collected with holotype; 1, Kerrville, 27 March 1906, F. C. Pratt; 1, Kerrville, 30 May 1906, F. C. Pratt; 1, Kerrville, 28 September 1948, L. J. Bottimer; 1, Camp Stanley, Texas, 16 March 1953, L. J. Bottimer; 17, Junction, Kimble County, Texas, 29, 30 March 1967, A. and M. E. Blanchard; 2, Texas, Belfrage, M. Robinson Collection; 1, Texas, M. Robinson Collection; 1, New Braunfels, Texas, 11 May 1910, F. C. Pratt, M. Robinson Collection; 1, Las Vegas H S, New Mexico, 14 August, Barber and Schwarz Coll.

*Remarks*: *Aphodius texensis* is close to *A. crassuloides* Fall but averages smaller in length with the clypeal teeth projecting as distinct triangles. In *A. crassuloides* the clypeal margin forms the outside of the tooth. It does not join the tooth at base but forms an almost straight line to the tip of the tooth, Figure 2.

Illustrations were drawn by Mrs. Elsie Froeschner. Dissections of the type-specimens were made by Dr. Paul J. Spangler.

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Vol. 85, No. 5, pp. 63–70 30 August 1972

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# A NEW SUBSPECIES OF SANDHILL CRANE FROM MISSISSIPPI

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A very small resident group of sandhill cranes (*Grus canadensis*) is barely surviving in southern Mississippi. This is a remnant of a larger and more extensively distributed population of these cranes which formerly occurred along the Gulf Coastal Plain of Louisiana, Mississippi, and Alabama (Walkinshaw, 1949; Valentine and Noble, 1970).

The former status of these birds is very poorly documented, but it is probable that they always occurred in fairly widely separated pockets of suitable habitat and never in very large numbers. Breeding has been recorded for southern Louisiana by Cooke (1914), Figgins (1923), McIlhenny (1943), and Lowery (1960); for Mississippi by E. A. McIlhenny (1938), Turcotte (1947), Walkinshaw (1949), Valentine (1963), and Valentine and Noble (1970); and for Alabama by Howell (1928) and Imhof (1962).

Apparently the only place where the sandhill crane breeds on the Gulf Coast west of Florida at present is in Mississippi. There are no recent records of occurrence of these birds during the breeding season in other parts of the known former breeding range or elsewhere in that region. However, the Mississippi population has received particular attention in recent years under the stimulus of the endangered species program of the Fish and Wildlife Service. Reports by Valentine (1963) and Valentine and Noble (1970) give informative accounts of the status of these birds. These authors report that the Mississippi sandhill crane population, estimated

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as between 38 and 40 birds, is confined to Jackson County, generally between the Pascagoula River on the east and the Jackson-Harrison County line on the west; U.S. Highway 90 on the south and Bluff Creek on the north. The breeding grounds are near Ocean Springs and Fontainebleau and are divided into seven rather distinct nesting areas (Valentine and Noble, 1970).

The nesting habitat is described by Walkinshaw (1949), Valentine (1963), and Valentine and Noble (1970) as wet areas in semiopen pine flats. It would appear that, although savannalike in aspect, breeding areas have more trees than is usually the case with sandhill cranes (Walkinshaw, 1949). In fact, the habitat of these birds is so different from the usual wide open environment of sandhill cranes that Valentine and Noble suggest that this population should be considered a distinct ecotype.

It has been generally assumed that the Gulf Coast breeding sandhill cranes were of the same subspecies as those in Florida, *Grus canadensis pratensis.* However, as Hellmayr and Conover (1942, footnote) point out, the Gulf Coast breeding sandhills have never been critically studied and have been placed with *pratensis* only for "geographical reasons." The fact is they could not have been studied to determine their correct subspecific status since it appears that no adult specimens have ever been preserved (Walkinshaw, 1949, and personal communication).

In the course of the above mentioned endangered species program, eggs were taken beginning in 1965 from the nests of the Mississippi sandhill crane population for the purpose of propagation in captivity. This has resulted in the rearing at the Patuxent Wildlife Research Center, Laurel, Maryland, of eight Mississippi birds to adult plumage stage by 1971. One of these died on 15 September 1971, and became specimen 564841 in the National Museum of Natural History, Smithsonian Institution. Meanwhile, sandhill cranes were also reared from eggs taken in southern Florida, Okefenokee Swamp, Georgia, and Oregon.

Although slight differences were noted among individuals in the downy stage, as soon as the first of the Mississippi cranes acquired its contour feathers, a color much darker than that of those reared from eggs taken in Florida was apparent. This dark color has been consistent in all others of this population reared subsequently and has been noticed by all persons who have viewed them critically. Subsequent to this discovery, the very dark appearance of the sandhill crane photographed beside its nest in Mississippi and shown in Figure 2, Plate 14, in Walkinshaw's (1949) monograph was noted, and Walkinshaw (personal communication) verified this condition in Mississippi cranes which he had observed.

On 19 October 1970, I made a detailed comparison of seven living, adult plumaged sandhill cranes hatched from eggs taken in Mississippi with an equal number originating in southern Florida, two from Okefenokee Swamp, Georgia, and examples of greater sandhills originating at Malheur National Wildlife Refuge, Oregon. This time of year was selected because all birds were in freshly molted plumage. These birds were intermingled in the same pen and observations were made by walking among them and examining the plumage at close range.

There was no difficulty whatever in distinguishing the Mississippi birds from all others at a glance. Compared with the south Florida and Oregon birds, they were very much darker on back, wings, neck, sides of head and breast. In these respects, the Florida birds were very similar in color to the greater sandhills (*Grus canadensis tabida*) from Oregon and to lesser sandhills (*G. c. canadensis*) taken as migrants in New Mexico. The dark color of the neck and ear patches of the Mississippi birds had the effect of making the white cheeks stand out more distinctly in contrast than was the case in cranes from other regions.

The two Okefenokee Swamp cranes appeared slightly darker than the examples from south Florida but were not nearly as dark as those from Mississippi. The significance of this is that the Okefenokee specimens represent a breeding area very close to the type-locality of *pratensis* restricted by Harper (1942) to Bronson, Levy County, Florida. Thus, the Okefenokee birds almost certainly are representative of the same population

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that breeds near the locality in northern Florida where Bartram (1791) described his "Great Savanna Crane" that was the basis of the formal diagnosis of *pratensis* (Meyer, 1794). Since migrant cranes from breeding populations in the central northern United States (*tabida*) are known to winter in northern Florida together with resident birds (Walkinshaw, 1960; Williams, 1970), it might not have been possible to determine which one Bartram was looking at when he provided the basis for the name *pratensis*, if he had not mentioned nesting. However, in the description of his exploration of the "Alachua Savanna" he mentioned seeing these cranes with nests and eggs. This definitely identifies his "Great Savanna Crane" with the breeding population of that area and therefore it seems certain that the name *G. c. pratensis* applies to the resident population of Florida and not the migrant birds from the north.

The differences between the birds originating in south Florida and those from Okefenokee Swamp, viewed side by side in the crane pen, were so slight that it seems justifiable to consider them the same subspecies, *Grus canadensis pratensis*. The seven specimens from Mississippi-taken eggs, however, were quite different, being consistently much darker than the Florida and Okefenokee birds. Also, they were darker than examples of greater sandhill cranes (*tabida*) and lesser sandhill cranes (*canadensis*) living in nearby pens and also specimens of the Canadian sandhill crane (*rowani*) and Cuban sandhill crane (*nesiotes*) in the National Museum of Natural History. The darker coloration considered a distinguishing characteristic of *pratensis* as compared with *tabida* (Peters, 1925) was not obvious with living birds, although it was noted in comparison of museum specimens of Great Basin breeding *tabida* and Florida *pratensis*.

So far, it has not been possible to determine the sex of the living cranes at Patuxent and thus segregate their measurements accordingly. However, comparisons of the range of measurements of the Mississippi birds of both sexes combined with the ranges known for breeding populations of previously described subspecies are indicative of major differences in overall size or in proportions. These ranges of measurements (in mm) are as follows.

Mississippi (8 live captive birds hatched from Mississippi eggs). Wing (chord), 470–493; bill (from posterior end of nostril), 82–91; tarsus, 216–258.

Florida, *pratensis* (28 live captive birds hatched from southern Florida eggs). Wing (chord) 451–506; bill (from posterior end of nostril) 82–103; tarsus, 218–274.

Greater, *tabida* (20 live captive birds hatched from Oregon eggs). Wing (chord), 479–550; bill (from posterior end of nostril), 86–111; tarsus, 215–260.

Canadian, *rowani* (10 breeding season specimens, from Walkinshaw, 1965) Wing (chord), 456–524; bill (from posterior end of nostril), 73–88; tarsus, 205–239.

Lesser, *canadensis* (50 breeding season specimens, from Walkinshaw, 1965) Wing (chord), 420–503; bill (from posterior end of nostril), 63–76; tarsus, 162–210.

From comparison of these measurements it would appear that Florida and Mississippi sandhills are quite similar in size and proportions. They both have tarsi as long or longer than greater sandhills from Oregon but are smaller in other dimensions. Measurements of lesser sandhill cranes (*canadensis*) showed them to be smaller in all respects than either Florida or Mississippi birds, particularly in bill and tarsus length. The Canadian sandhill (*rowani*) appears to have a shorter bill and tarsus but a similar or possibly longer wing than the Florida and Mississippi populations. The size of the Cuban subspecies (*nesiotes*), except for a longer bill, is apparently about the same size as the lesser sandhill according to measurements by Todd (1916) and so is definitely smaller than either Florida or Mississippi populations in wing and tarsus.

The difference in the Mississippi breeding population of sandhill cranes from all others of this species warrants its description as a distinct subspecies which may be known as:

### **Grus canadensis pulla** new subspecies

### Mississippi Sandhill Crane

*Type*: Adult ♀ USNM No. 564841 in the National Museum of Natural History. Hatched 15 May 1969, from egg taken 7 May 1969, about

7 miles northwest of Fontainebleau, Jackson County, Mississippi. Reared at Patuxent Wildlife Research Center, Laurel, Maryland, leg band No. 49, wing tag No. 207. Died 15 September 1971, as result of leg injury. Measurements: wing, primaries broken—unmeasurable; bill (from posterior end of nostril to tip), 91 mm; tarsus, 251 mm, middle toe (without claw), 72 mm. Plumage: worn nuptial, just beginning to molt to fresh autumn; back (worn feathers) sepia to clove brown, (fresh feathers) iron gray to dark mouse gray; breast (worn feathers) brownish olive, (fresh feathers) deep mouse gray; dorsal side of neck (worn feathers) deep neutral gray.

*Subspecific characters*: Similar in size to *G. c. pratensis* that breeds from southern Georgia south to southern Florida but colored portions of plumage much darker throughout. It is the darkest colored of all populations of *Grus canadensis*. From the greater sandhill crane, *G. c. tabida*, breeding in Oregon, Idaho, and Michigan, it differs on the basis of both smaller size (except tarsus) and darker color. From the Arctic breeding lesser sandhill crane, *G. c. canadensis*, the new Mississippi subspecies can be distinguished by larger size in all dimensions and darker color. From the breeding sandhills of the boreal forest region of western Canada, *G. c. rowani*, Mississippi birds can be distinguished particularly by longer tarsi and darker color. From the Cuban sandhill crane, *G. c. nesiotes*, they differ in larger size in all respects except bill length and in having darker colored plumage.

*Geographical distribution*: Jackson County, Mississippi, near Ocean Springs and Fontainebleau between the Pascagoula River on the east and Jackson-Harrison County line on the west; U.S. Highway 90 on the south and Bluff Creek on the north.

*Examples of G. c. pulla examined*: Eight in adult plumage at Patuxent Wildlife Research Center, Laurel, Maryland, hatched from eggs taken in Jackson County, Mississippi, by Jacob M. Valentine, Jr.: wing tag No. 86, hatched 3 May 1966; No. 110 hatched 3 May 1965; No. 87, hatched 16 May 1966; No. 184, hatched 26 May 1967; No. 215, hatched 4 June 1969; No. 212, hatched 16 May 1969; No. 207 (type specimen USNM 564841) hatched 15 May 1969; No. 341, hatched 30 May 1970.

Immature ♀, USNM 531663, hatched 18 May 1967, from egg taken in Jackson County, Mississippi, by Jacob M. Valentine, Jr. Died Patuxent Wildlife Research Center, Laurel, Maryland, 7 January 1968.

Downy young, sex ?, USNM 530210, hatched from egg taken 4 May 1966, in Jackson County, Mississippi, by Jacob M. Valentine, Jr., died in aviary of John Lynch, Lafayette, Louisiana, 6 July 1966.

Downy young, ♀, USNM 532029, hatched from egg taken 30 May 1968, in Jackson County, Mississippi, by Jacob M. Valentine, Jr.; died at Patuxent Wildlife Research Center, Laurel, Maryland, 12 June 1968.

Downy young, ♂?, Museum of Zoology, University of Michigan 104976, collected Ocean Springs, Mississippi, 20 April 1940, on day of hatching, by Lawrence Walkinshaw; weight 93.4 grams.

Downy young, sex?, Museum of Zoology, Louisiana State University, 2009, collected "Lake Misere, Cameron Parish, Louisiana," 7 April 1938, by E. A. McIlhenny, 3 days old. A note on the label says: "this specimen almost certainly came from southern Mississippi where E. A. McIhenny studied nesting sandhill cranes in the spring of 1938. See Auk 55, 1938: 598–602 - GHL."

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Vol. 85, No. 6, pp. 71–76 30 August 1972

PROCEEDINGS
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# A NEW SPECIES OF *PHASCOLION* (SIPUNCULA) FROM THE WESTERN NORTH ATLANTIC

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In Cutler (1967) a subpopulation of *Phascolion* was briefly mentioned as being distinct from *P. strombi* but was neither completely described nor named. At that time it was not absolutely certain whether this entity merited the rank of a new and distinct species. Subsequent study and consultation with Dr. V. V. Murina have convinced us that this is a unique, new form. Additional material has been included and a more complete description follows.

The specimens came from collections made by Sanders, Hessler, and Hampson (1965) and by the authors utilizing the R/V *Eastward.* These latter collections were made possible through participation in the Duke University Cooperative Oceanographic Program which is supported by N.S.F. Grant No. GS-8189.

### **Phascolion microspheroidi** new species

*Diagnosis*: A very small *Phascolion* lacking holdfasts and tentacles, commonly found in pteropod and scaphopod shells on the Continental Slope off Eastern North America.

*Description*: The 286 specimens are from 18 stations. These worms range from 1 to 4 mm in length and from 0.5 to 1.5 mm in diameter. They are translucent, thin-skinned with light brown pigmentation, and usually spherical. The introvert is smooth and almost equal in length to the trunk (Fig. 1A).

The introvert hooks are single-pointed and range from 0.04 to 0.056 mm high (Fig. 1B). On six specimens with fully extended introverts, tentacles were lacking but fleshy lobes were present. The trunk lacks attachment papillae with holdfasts. Two types of papillae are present.

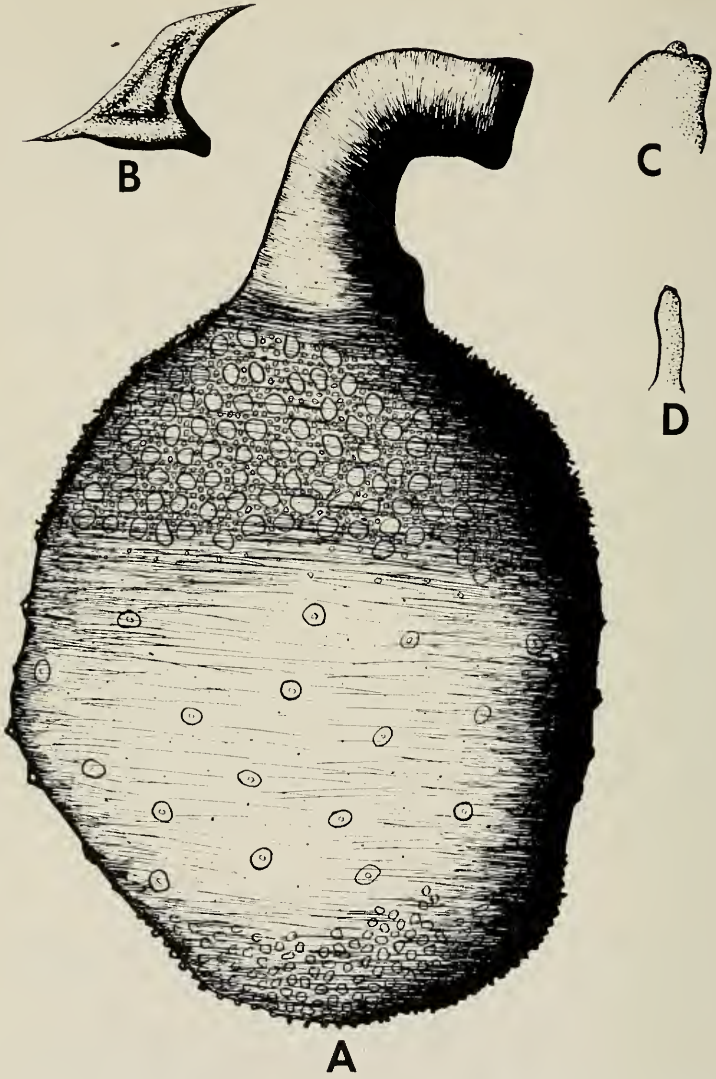

FIG. 1. External features of *Phascolion microspheroidi*. A. Whole animal with partially extended introvert (trunk 1–4 mm); B. hook (0.04–0.056 mm high); C. and D. papillae.

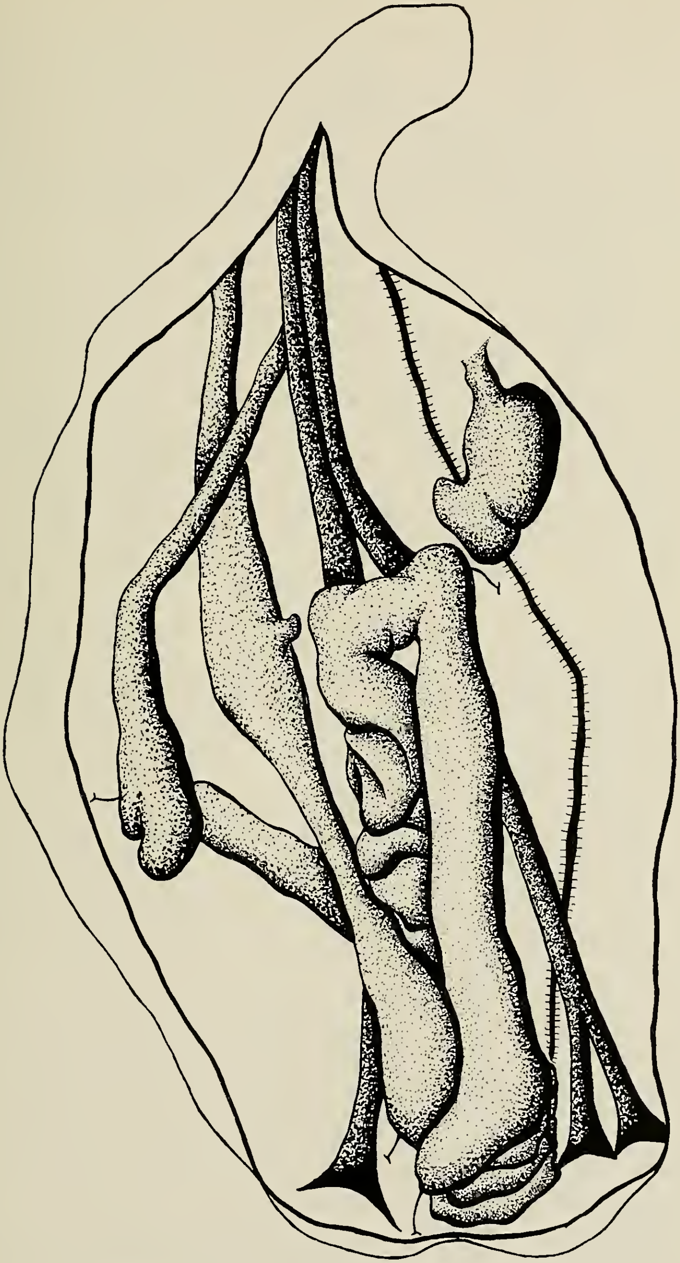

Fig. 2. Internal view of *Phascolion microspheroidi.*

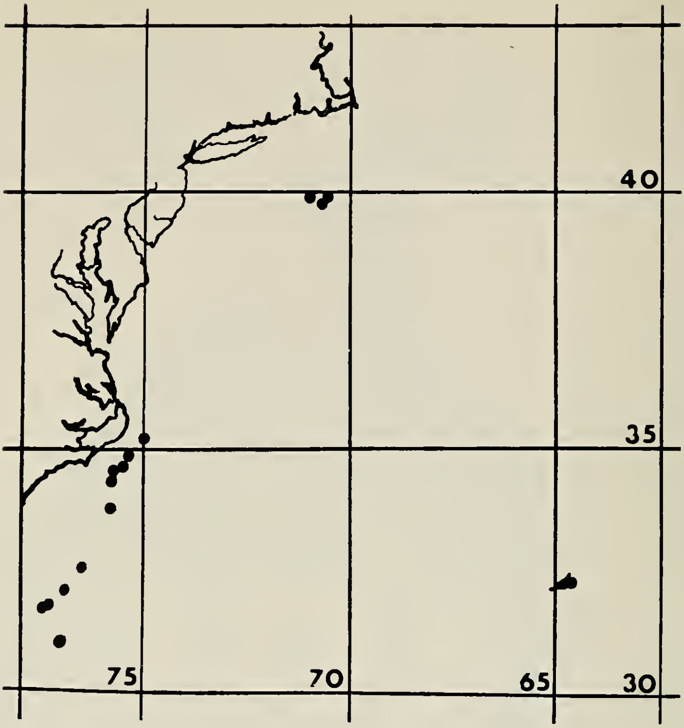

FIG. 3. Distribution of *Phascolion microspheroidi.*

The more common ones are small and oval shaped with a nipplelike tip (Fig. IC). They are sparse in the middle of the trunk and more dense at the base of the introvert. The second type of paplliae is slender, columnar, or spinelike, and found at the posterior end of the trunk as well as with the other papillae at the anterior. These range in height from 0.03 to 0.08 mm (Fig. 1D).

The beginning of the intestine is attached by a fixing muscle to the right midtrunk region. It continues posteriorly in three to six coils, loops forward where it is attached by a fixing muscle on the left side, and recourses in another loop which is attached to the end of the trunk by two fixing muscles. It then continues forward with a rectal diverticulum and a wing muscle present. The anus is slightly anterior to the nephridiopore. The single nephridium is unilobed and partially attached by a mesentery to the body wall (Fig. 2).

The two retractor muscles are of equal size and thickness. The ventral one originates by two roots at the end of the trunk to the right of the ventral nerve cord. The dorsal retractor originates at the end of the trunk from one root which sometimes has a tendency to break apart into several distinct strands.

*Remarks*: The only other member of this genus which occurs in the same location is *P. strombi*. Externally these two differ in the nature of papillae and tentacles. *P. strombi* has well-developed tentacles and attachment papillae, both of which are lacking in *P. microspheroidi*. In the genus *Phascolion*, the only other species having two retractor muscles of equal strength, hooks present, attachment papillae absent, and lacking tentacles is *P. beklemischevi* (Murina, 1964). *P. beklemischevi* differs, however, by having hooks with a blunt lobe at their tip.

*Distribution*: This species was found between 487 and 1,700 m on the Continental Slope of the east coast of the United States between 31°49′ and 39°57′ north latitude, with one small specimen on the Bermuda Slope (Fig. 3). The sediment is silt and sand; although this may not be important as the animal is usually found sheltered in pteropod and scaphopod shells resting on the surface of the sediment. The temperature ranges from 3.5 to 6°C.

*Holotype*: USNM 44754; Location, 39°49′N, 70°41′W; Depth, 1,102 m; Collected 6 July 1964 by Sanders, Hessler and Hampson, station number 87.

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Vol. 85, No. 7, pp. 77–108 30 August 1972

PROCEEDINGS
OF THE
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# CLASSIFICATION OF THE OVIPENNIS AND TRIFARIA GROUPS OF *NEBRIA* LATREILLE (COLEOPTERA: CARABIDAE: NEBRIINI)

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This study of western high altitude *Nebria* began with our discovery of a new form on Circleville Mountain in southern Utah. This new form is related to *Nebria trifaria* LeConte, and because we are opposed in principle to publication of isolated descriptions of new taxa (Ball and Erwin, 1969), we surveyed the trifaria group of species in seeking more information about the relationships of this new form. In turn, this led us to reexamine Lindroth's (1961) study of North American *Nebria*, which further led us to examine other *Nebria* species groups occurring in the mountains of western United States. Our data on two of these groups are presented here.

On the basis of more extensive material than was available to Lindroth, we have slightly rearranged his groups; revised part of his key to accommodate our new forms; and we have provided illustrations of diagnostic characteristics not illustrated by him.

## Material

We examined 719 adult specimens of the ovipennis and trifaria groups. The number of specimens of each taxon is given with the respective descriptions. We have also seen numerous additional specimens of *Nebria* representing species not reported on here, which helped in our understanding of the genus in North America.

The following letter code denotes museums or private collections whose material we examined: CAS—California Academy of Sciences,

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San Francisco, California 94118; DHKa—David H. Kavanaugh, GRNo—Gerald R. Noonan, and UASM—Strickland Museum, Department of Entomology, University of Alberta, Edmonton 7, Alberta, Canada; MCZ—Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts 02138; USNM—National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560; OUCO—Ohio State University, Columbus, Ohio 43210; SJSC—San Jose State College, San Jose, California 95114; TLEr—personal collection of senior author; UCD—University of California, Davis, California 95616; UCR—University of California, Riverside, California 92502.

## METHODS

These have been described in detail previously (Ball and Erwin, 1969; Erwin, 1970).

We define subspecies as geographically (or temporally) isolated populations within a species that differ taxonomically from other such populations (but which are potentially capable of interbreeding with these other subspecies). The evidence for meeting the criteria is derived from morphological and distributional data, only.

An exclamation point (!) is used here to indicate type-specimens seen by us.

The only measurement presented is total length. This was made with an ocular micrometer in a Wild binocular microscope. At the magnification used, one unit equalled 0.07 mm.

## NOTES ABOUT THE STRUCTURE OF THE FEMALE REPRODUCTIVE SYSTEM

Females for study should be killed and preserved in a histological fixative, such as Bouin's solution. Our observations, however, were of museum specimens known to have been killed in cyanide or ethyl acetate fumes. Thus, the observations are tentative and must be confirmed with material especially prepared for study of lightly sclerotized tissue.

The bursa copulatrix of a nebriine female (Fig. 36) is a large, saclike structure diverted anterodorsally from the common oviduct. This sac has a characteristic shape which differs from species group to species group.

Among females of the trifaria and ovipennis groups and *N. paradisi* Darlington, the spermathecal duct arises from the dorsal surface of the bursa (Fig. 36), and extends to the lanceolate-shaped spermathecal reservoir. Near the origin of the duct, the membrane of the bursa is various, differing among groups of species, interspecifically and intraspecifically. In females of *N. hudsonica,* the bursal sclerite and spermatheca are located ventrally.

Females of *N. purpurata* and *N. trifaria* exhibit a sclerite on the dorsal surface of the bursa, near the point of origin of the spermatheca. This sclerite varies in form both among and within population samples of *N. trifaria*, but the intrapopulation variation is slight compared to the amount of interpopulation difference.

## Taxonomy

### *Nebria* Latreille

*Nebria* Latreille, 1802: 89. Type-species.—*Carabus brevicollis* Fabricius, 1792: 150. (See Lindroth, 1961: 60 for nomenclatorial remarks about the type species.)

*Diagnostic characteristics*: Head with one supraorbital seta over each eye; scrobe of mandible unisetose; stipes and mentum without spiniform setae; mentum with tooth broadly truncate or bifid; anterior coxae uniperforate-separate, open behind; anterior tibia anisochaetous-sulcate; middle coxae disjunct-confluent; hind coxae conjunct-confluent, lateral margin or "wing" vertical; elytra each with short scutellar stria and nine complete striae; male genitalia with unarmed internal sac (sac shape various) and glabrous unequal parameres; styli of ovipositor each with bisetigerous ventral puncture; bursa copulatrix various (Figs. 36–41); proventriculus internally with four large, coarse teeth (Fig. 22), each with two external projections alternated with four rows of dense brushes; (Figs. 21, 22); proventricular teeth of two types, one with broad smooth concavity, three more linearly convex, without smooth areas. Size medium to large (length 7.5–17.0 mm, from Lindroth, 1961).

### Revised Portion of Lindroth's Key to the North American Species of *Nebria* (1961).

(to be inserted at couplet number 19, replacing 19–27:
page numbers given below refer to this paper)

19. Pronotum without posterior lateral seta; with deep furrow inside hind angle (Fig. 9) ............ *N. kincaidi* Schwarz, p. 85.
Pronotum with lateral setigerous puncture just in front of hind angle ............ 20.

20. Hind coxa at base (except in *hudsonica* and, individually in *paradisi*) and sterna III-V plurisetose (not all three sterna in some specimens of *paradisi*) ............ 21.
Hind coxa and sterna III-V (except for asymmetrical anomalies) unisetose ............ Couplet 36 in Lindroth

21. Humeri narrow, sloped; elytra broadest in apical half, basal setigerous puncture (between striae one and two) absent in most specimens; wings reduced, with or without bare suggestion of reflexed apex ............ 22a.
Humeri prominent; elytra rather parallel-sided; basal setigerous puncture present; wings with complete reflexed apex ............ Couplet 28 in Lindroth

22a. Abdominal sternum II with setae between hind coxae ............ 23a.
Abdominal sternum II without setae between hind coxae ............ 24a.

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23a. Tarsal articles short and robust (Fig. 4); scape of antenna swollen, widest about middle ______ *N. ovipennis* LeConte, p. 81.
Tarsal articles long and narrow (Fig. 5); scape of antenna narrower, widest apically ______ *N. spatulata* Van Dyke, p. 83.

24a. Metasternum subequal to or longer than diameter of middle coxa (Fig. 7). Elytra ellipsiform, widened only slightly from humeri to basal third. Wing rudiment with suggestion of reflexed apex ______ 25a.
Metasternum shorter than diameter of middle coxa (Fig. 6). Elytra oviform. Wing rudiment without trace of reflexed apex ______ 30a.

25a. Pronotum with sides widely reflexed (Fig. 8); lateral bead effaced at anterior angle. Scape of antenna swollen apically. Head, pronotum and elytra broad ______ 26a.
Sides of pronotum not or barely reflexed (Fig. 2); lateral bead clearly engraved at anterior angle (Fig. 2). Antennal scape almost cylindrical. Head, pronotum and elytra narrow ______ *N. purpurata* LeConte, p. 89.

26a. Elytron with intervals 3, 5 and 7 strongly catenate. Dorsal surface piceous, not metallic. Median lobe with apical portion as in Figures 26, 28, 29 ______ 27a.
Elytral intervals 3, 5 and 7 with few catenations, interval 5 of some males not catenate. Dorsal surface shiny, elytra violaceous metallic. Median lobe with apical portion as in Figure 27; known only from Circleville Mt. of southern Utah ______ *N. trifaria piute* new subspecies, p. 95.

27a. Male median lobe with apical portion as in Figure 26; locality, mountains of central Utah, southern Wyoming or eastern Nevada (Fig. 42) ______ *N. trifaria trifaria* LeConte, p. 93.
Apex of median lobe and range not as above ______ 28a.

28a. Median lobe with apical portion as in Figure 29; locality, Rocky Mountains of southern Colorado and eastern Utah (Fig. 42) ______ *N. trifaria catenata* Casey, p. 97.
Apex of median lobe and range not as above ______ 29a.

29a. Median lobe with apical portion as in Figure 28; locality, Rocky Mountains of southern Wyoming, northern and central Colorado (Fig. 42) ______ *N. trifaria coloradensis* Van Dyke, p. 96.
Median lobe with apical portion as in Figure 25; locality, Grand Teton Mountains, Wyoming (Fig. 42) ______ *N. trifaria tetonensis* new subspecies, p. 95.

30a. Mentum with tooth broadly truncate. Tarsus with articles short and robust (Fig. 4), especially in male; (median lobe of *ingens* Horn as in Fig. 33) ______ "ingens Group."
Mental tooth bifid. Tarsus with articles long and narrow (Fig. 5) ______ 31a.

31a. Elytra piceous to black, each with intervals 3, 5 and 7 catenate. Abdominal sterna III-V with group of setigerous punctures laterally at base ........................ *N. vandykei* Bänninger, p. 87.
Elytra violaceous, metallic, without catenate intervals. Abdominal sterna without lateral setae; male median lobe as in Figure 35 ................................ *N. paradisi* Darlington, p. 81.

### The ovipennis Group

The diagnostic characteristics of this group are as follows. Elytra with narrow humeri, elytral intervals not or weakly catenate; hind wings extremely reduced; sterna III-V with apical setae only; median lobe of male genitalia with pouch in right side; bursa copulatrix without sclerites.

Originally included in this group by Lindroth (1961) were the three species described below plus *Nebria paradisi* Darlington. The latter species is removed on the grounds that males lack the pouch of the median lobe, and hence there is no evidence that *N. paradisi* is related to the other three species. Its true relationships must await further studies.

### *Nebria ovipennis* LeConte

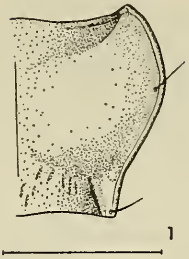
Figures 1, 4, 12, 15, 18, 42

*Nebria ovipennis* LeConte, 1878: 477. Type-locality.—Sierra Nevada, California, as originally given by LeConte, but here restricted to Chipmunk Flat, Tuolumne County, California, on the basis that the range is restricted to the southern Sierra Nevada. Type a male!, MCZ No. 648.

*Diagnostic characteristics*: Body dark rufous to piceous, without metallic luster, appendages rufous. Microsculpture of entire dorsal surface isodiametric. Antenna with scape short, robust, widest about middle. Tooth of mentum broadly truncate or bifid. Head and pronotum very broad, pronotum wider than one elytron, sides narrowly reflexed, anterior and posterior angles produced, posterior angles acute. Elytra oviform, interval 7 partially catenate or not. Middle coxa with longitudinal diameter much greater than length of metasternum behind middle coxa. Tarsus with articles short and robust, especially in male (Fig. 4). Male median lobe with long broad pouch on right side (Figs. 15 and 18). Stylus of female ovipositor as in Figure 36. Total length 10.9–12.1 mm. Material dissected: three males, one female.

*Geographical distribution*: The members of this species are in the Sierra Nevada of California, ranging from Tulare County in the south to at least Placer County in the north (Fig. 42). We have studied 19 specimens from the following localities.

California: alpine county: Ebbetts Pass 8,730′ 25 June (MCZ); Gin, July (NMNH). placer county: (NMNH). tulare county:



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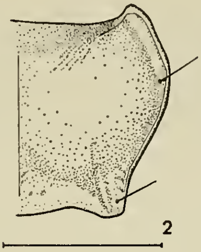

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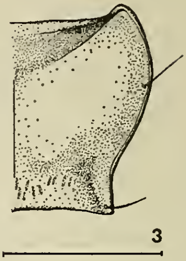

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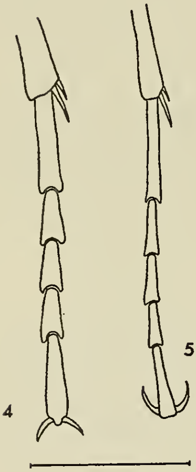

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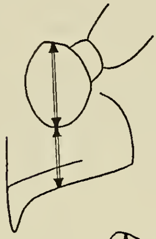

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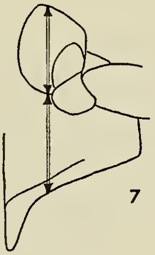

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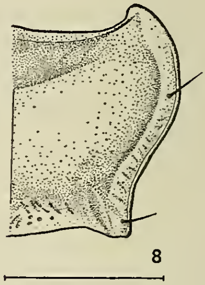

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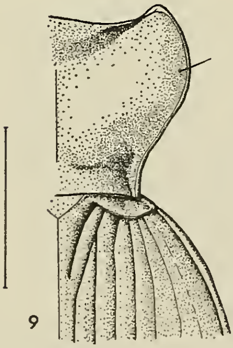

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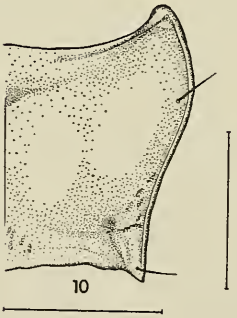

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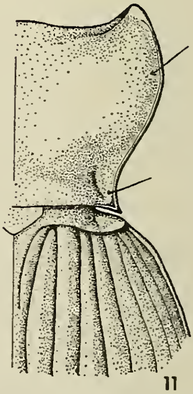

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Figs. 1–3, 8 and 10. Pronotum, right dorsal aspect. 1. *Nebria ovipennis* LeC., female, Lake Elizabeth, California. 2. *Nebria purpurata* LeC., female, Canyon of the Big Blue, Colorado. 3. *Nebria spatulata*

Franklin Lake, 8 September (MCZ); Mount Silliman, 10,000′, September (CAS). TUOLUMNE COUNTY: Chipmunk Flat, 9 August (UCR); Lake Elizabeth 11,000′, 6 August (CAS); above Lundy, 9,000–11,000′, 9 July (USNM); Sonora Pass, 9,626′, 27 July (GRNo); Tuolumne Meadows, 27 July (CAS, MCZ).

One specimen is labelled Eugene, Oregon (MCZ). We doubt the authenticity of this record.

### *Nebria spatulata* Van Dyke

Figures 3, 5, 13, 16, 19, 42

*Nebria spatulata* Van Dyke, 1925: 119. Type-locality.—Franklin Lake, California. Type a female!, No. 1625 (CAS).

*Diagnostic characteristics*: Color of body rufous to dark piceous, appendages rufous. Microsculpture of dorsum well developed, meshes slightly transverse. Dorsal surface shiny. Antenna with scape elongate, narrow, widened apically. Pronotum narrow, as wide as single elytron; sides narrowly reflexed; anterior and posterior angles produced, latter acute. Elytra ellipsiform, humeri more pronounced than in *ovipennis* specimens. Middle coxa with longitudinal diameter subequal to or slightly greater than length of metasternum behind middle coxa (Fig. 6). Median lobe of male as in Figures 16 and 19, pouch narrower than in *ovipennis* males. Ovipositor of female with stylus as in Figure 36. Total length 11.0–12.4 mm. Material dissected: three males, one female.

*Geographical distribution*: Members of this species are known from the southern part of the Sierra Nevada of California, from Tulare County to Tuolumne County (Fig. 42). We have seen 14 specimens from the following localities.

CALIFORNIA: FRESNO COUNTY: Brewer Lake, 22 September (CAS). MADERA COUNTY: Mount Lyell, 11,000′, 27 August (CAS). TULARE

←

Van Dyke, female, Mt. Lyell, California. 8. *Nebria trifaria tetonensis* n. ssp., female, Cascade Canyon, Wyoming. 10. *Nebria vandykei* Bänninger, female, Mt. Rainier, Washington.

FIGS. 4 and 5. Tarsi of posterior left leg, dorsal aspect, setae not shown. 4. *Nebria ovipennis* LeC., male, Ebbetts Pass, California. 5. *Nebria spatulata* Van Dyke, male, Mt. Lyell, California.

FIGS. 6 and 7. Diagrammatic illustration of metasternum and middle coxa. 6. Metasternum subequal to middle coxa. 7. Metasternum longer than middle coxa.

FIGS. 9 and 11. Pronotum, right dorsal aspect and humeral portion of right elytron. 9. *Nebria kincaidi* Schwarz, male, Seven Lakes Basin, Washington. 11. *Nebria paradisi* Darlington, female, Mt. Rainier, Washington.

FIGS. 12–14. Right and left parameres of male genitalia, ventral aspect. 12. *Nebria ovipennis* LeC. 13. *Nebria spatulata* Van Dyke, Mt. Lyell,

COUNTY: Franklin Lake, 8 September (MCZ); Mount Silliman, 10,000′, 3 August (CAS). TUOLUMNE COUNTY: Chipmunk Flat, 9 August (UCR); Tioga Pass, 10,000′, 24 August (CAS).

### *Nebria kincaidi* Schwarz

Figures 9, 14, 17, 20, 42

*Nebria kincaidi* Schwarz, 1900: 525. Type-locality.—Farragut Bay, Alaska. Type a male!, No. 56138 (USNM).

*Nebria columbiana* Casey, 1913: 48. Type-locality.—Inverness, British Columbia. Type a male!, No. 46848 (USNM).—Lindroth, 1961: 88.

*Diagnostic characteristics*: Color of body dark piceous to black, elytra (also head and pronotum of some specimens) vividly metallic purple with green-coppery luster. Microsculpture of dorsal surface with lines finely impressed, meshes transverse. Antenna with scape moderately robust, slightly swollen toward apex. Head and pronotum narrow, pronotum slightly wider than one elytron, sides moderately reflexed and narrowed behind to slightly acute hind angles, anterior angles produced, surface convex. Elytra oviform, intervals variously catenate, basal margin at humerus strongly sinuate. Middle coxa with longitudinal diameter greater than length of metasternum just behind middle coxa. Male genitalia (Figs. 14, 17, 20) with median lobe with small narrow pouch in right side. Ovipositor with stylus as in Figure 36. Length 11.2–11.5 mm. Material dissected: three males, one female.

*Geographical distribution*: According to Lindroth (1961), these beetles range from northern Oregon to southern Alaska. See this refer-

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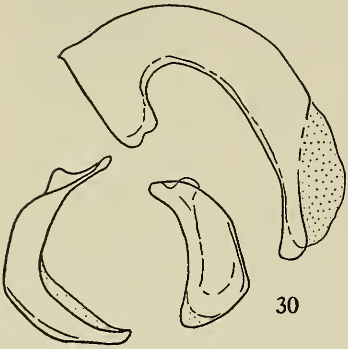
California. 14. *Nebria kincaidi* Schwarz.

FIGS. 15–17. Median lobe of male genitalia, left lateral aspect. 15. *Nebria ovipennis* LeC. 16. *Nebria spatulata* Van Dyke, Mt. Lyell, California. 17. *Nebria kincaidi* Schwarz.

FIGS. 18–20. Median lobe of male genitalia, apex, ventral aspect. 18. *Nebria ovipennis* LeC. 19. *Nebria spatulata* Van Dyke, Mt. Lyell, California. 20. *Nebria kincaidi* Schwarz.

FIGS. 21–22. Proventriculus of *Nebria trifaria piute* n. ssp. 21. Lateral aspect. 22. Internal aspect after dissection.

FIGS. 23–29. Apex of median lobe of male genitalia, right lateral aspect. 23. *Nebria vandykei* Bänninger, Paradise Park, Washington. 24. *Nebria purpurata* LeC., Leavenworth, Colorado. 25. *Nebria trifaria tetonensis* n. ssp., Cascade Canyon, Wyoming. 26. *Nebria t. trifaria* LeC., Alta, Utah. 27. *Nebria trifaria piute* n. ssp., Circleville Mt., Utah. 28. *Nebria trifaria coloradensis* Van Dyke, Broadmoor, Colorado. 29. *Nebria trifaria catenata* Casey, North Creek, Utah.



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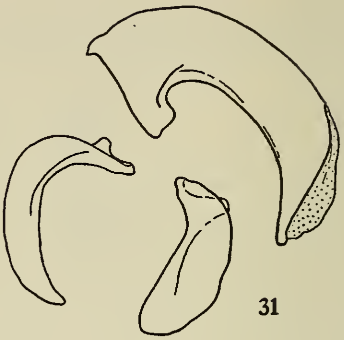

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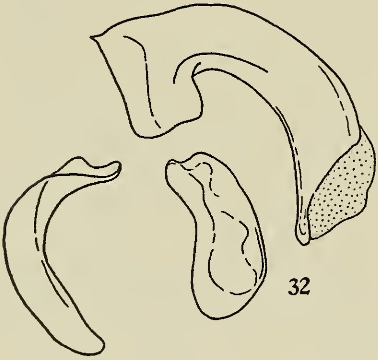

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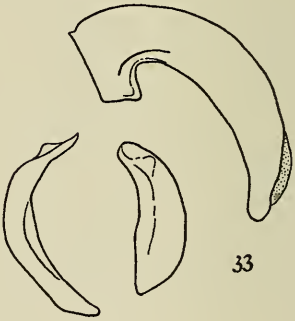

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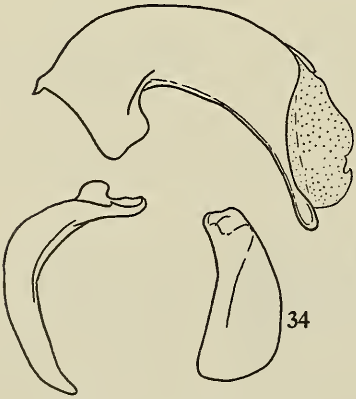

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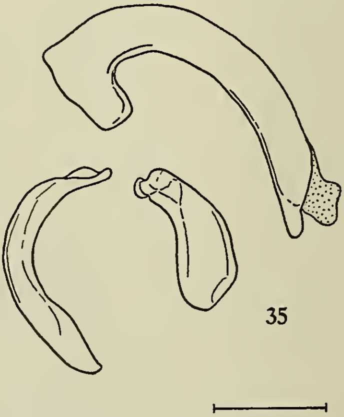

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ence for locality data. We have also seen specimens from the Olympic Peninsula, Washington, and from Mount Rainier.

### THE TRIFARIA GROUP

The diagnostic characteristics of this group are as follows. Elytra with narrow humeri, intervals 3 and 7 catenate; hind wings reduced; abdominal sterna III-V each with group of setae laterally at base in addition to two or more apical setae; median lobe of male genitalia with apical portion more or less extended; bursa copulatrix with or without large dorsal median sclerite.

### *Nebria vandykei* Bänninger

Figures 10, 23, 30, 42

*Nebria vandykei* Bänninger, 1928: 5. Type-locality.—Mount Rainier, Washington. Holotype presumably in Bänninger collection, Zürich.

*Diagnostic characteristics*: Color of body and appendages dark piceous to black, without metallic luster. Microsculpture of dorsal surface of fine lines, meshes slightly transverse, dorsal surface rather shiny. Scape of antenna swollen, longer than in *trifaria*. Pronotum as in Figure 10, wider than single elytron, sides widely reflexed, anterior and posterior angles very prominent and acute, base coarsely punctate. Elytra ellipsiform, catenations numerous, interval 5 of left elytron of males with five to seven ($N = 7$, mean 5.71), of females with four to six ($N = 11$, mean 5.27). Hind wings without apical reflexed portions, more reduced than those of *trifaria*. Middle coxa with longitudinal diameter about equal to length of metasternum just behind middle coxa. Median lobe of male with apical portion short and very broad (Fig. 23). Female ovipositor with stylus as in Figure 36. Bursa copulatrix without sclerites. Length 13.3–15.5 mm. Material dissected: six males, two females.

*Geographical distribution*: Members of this species are known from mountains of the Cascades system in Oregon and Washington (Fig. 42). We have seen 26 specimens from the following localities.

OREGON: CLACKAMAS COUNTY: Mount Hood, Sand Creek, 7 July (CAS). WASHINGTON: PIERCE COUNTY: Mount Rainier, 13 July (MCZ, USNM); Paradise Park, 6,000′, Mount Rainier, 15 July (CAS); Paradise River, 5,500′, Mount Rainier, 18 July (CAS).

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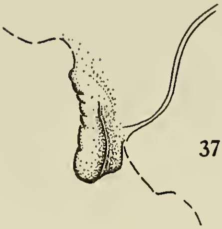
FIGS. 30–35. Male genitalia; parameres, ventral aspect, median lobe, left lateral aspect. 30. *Nebria vandykei* Bänninger. 31. *Nebria purpurata* LeC. 32. *Nebria t. trifaria* LeC. 33. *Nebria ingens* Horn. 34. *Nebria trifaria piute* n. ssp., Circleville Mt., Utah. 35. *Nebria paradisi* Darlington.



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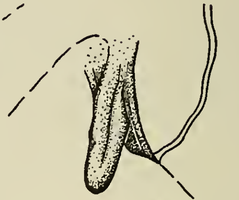

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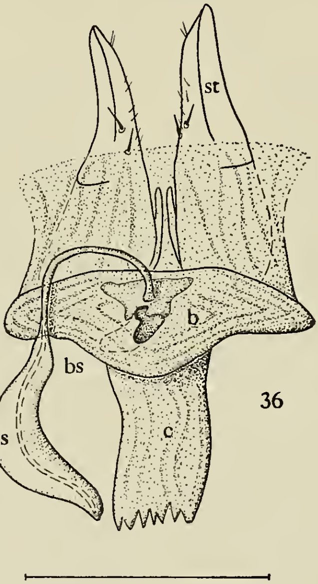

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Fig. 36. Female genitalia of *Nebria trifaria coloradensis* Van Dyke, Longs Peak, Colorado. Symbols: c = common oviduct, b = bursal sac, s = spermathecal reservoir, st = stylus, bs = bursal sclerite.

Figs. 37–41. *Bursal sclerite*, lateral aspect. 37. *Nebria t. trifaria* LeC., Alta, Utah. 38. *Nebria trifaria piute* n. ssp., Circleville Mt., Utah. 39. *Nebria trifaria catenata* Casey, Montrose, Colorado. 40. *Nebria purpurata* LeC., Ouray, Colorado. 41. *Nebria trifaria coloradensis* Van Dyke, Long's Peak, Colorado.

### *Nebria purpurata* LeConte

Figures 2, 24, 31, 40, 42

*Nebria purpurata* LeConte, 1878: 477. Type-locality.—Leavenworth Valley, Colorado. Type a male!, No. 649, MCZ.

*Nebria mobilis* Casey, 1913: 50. Type-locality.—Colorado. Type a female! No. 46850, USNM.—Lindroth, 1961: 86.

*Diagnostic characteristics*: Color of body and appendages excluding elytra, dark piceous to black, elytra vividly metallic purple, blue or green. Microsculpture as in *N. vandykei.* Pronotum as in Figure 2, narrow, sides narrowly reflexed, anterior angles moderately produced, posterior angles about right. Elytra with sides nearly parallel, catenations few, interval 5 of left elytron without or with one to three catenations (males, N = 25, mean 0.80; females, N = 26, mean 0.50). Length of metasternum as in *N. vandykei.* Median lobe of male as in Figure 31, apical portion very short, width average. Female ovipositor with stylus as in Figure 36. Bursa copulatrix with dorsal sclerite dome-shaped, smooth. Material dissected: five males, two females.

*Geographical distribution*: Members of this species are known to us from the Rocky Mountains of Colorado; from Rocky Mountain National Park in the north, to Silverton in the south (Figs. 42 and 43). Lindroth (1961: 86) reports specimens from Idaho and Montana, based on literature records, but David H. Kavanaugh informed us that these specimens are members of *N. gebleri* Dejean. We have seen 134 specimens, from the following localities.

Colorado: boulder county: Ouzel Falls, 24 July (DHKa). clear creek county: Georgetown, 8,300′–8,600′, 15–26 July (MCZ); Leavenworth Valley, above Georgetown, 9,000′–10,000′, June (MCZ, USNM); Silver Plume, 9,000′–10,000′, 15–26 June (MCZ, USNM). gunnison county: Canyon of Big Blue, 8,500′, 5–6 July (MCZ, USNM). lake county: Lake Creek, 7 miles west of Twin Lakes, 16–23 August (DHKa). mineral county: North Creede, 9,500′, 8 July (MCZ); 2 miles west of Wolf Creek Pass, 29 August (DHKa); 4 miles west of South Fork of Rio Grande (DHKa). ouray county: Ouray, 9,000′, July (USNM). park county: N. Fork South Platte River, near Hoosier Pass, 11,500′, 12 July (DHKa). pitkin county: Lake Creek, 11,200′ (DHKa). san juan county: Silverton, 9,800′, June (USNM); valley of Upper San Juan, 7,000′–10,500′, 13–15 August (USNM). summit county: Blue Lakes, 10.0 miles south of Breckenridge, 11,483′, 12–19 July (DHKa, TLEr); Monte Cristo Creek, 11,000′, 12 July (DHKa); Quanday Peak, 12,500′, 19 July (DHKa). rocky mountain national park: Fall River, 8,600′, 18 August (UASM).

### *Nebria trifaria* LeConte

*Nebria trifaria* LeConte, 1878: 478. Type-locality.—American Fork Canyon, Utah. Type-specimen a female!, No. 651, MCZ.

*Diagnostic characteristics*: Color of body and appendages dark piceous to black, not or slightly metallic. Microsculpture of dorsal surface with lines moderately coarse, meshes slightly transverse, elytra slightly dull. Antenna with scape robust, swollen apically, hind edge straight. Pronotum as in Figure 8, wider than elytron, sides widely reflexed, anterior angles strongly produced, base coarsely punctate. Elytra oviform, intervals 3 and 7 variously catenate, interval 5 catenate or not (see below for details). Length of metasternum as in *N. vandykei.* Male genitalia with apical portion of median lobe various, but longer than in *N. purpurata* and narrower than in *N. vandykei* (Figs. 24–29, and see below for details). Stylus of female ovipositor as in Figure 36. Bursa with dorsal sclerite, variously formed (Figs. 37–41, and see below for details.)

*Geographical distribution*: The range of this species extends from the Grand Teton Mountains of Wyoming southward to southern Colorado, and from the front range of the Rockies to northeastern Nevada. (See Figs. 42 and 43.)

*Variation patterns*: The following characteristics exhibit geographical variation: color; number of catenations in elytral interval 5; form and proportions of the male median lobe; and form of the bursal sclerite of females. The variation pattern of each characteristic is described below.

Variation in color: The dorsal surface is black in all specimens except those from Circleville Mountain (No. 6). The elytra of the latter specimens are dull purple.

Catenations in elytral interval 5: Data for population samples from 14 areas are provided in Table 1. Each area is numbered, and the position of the area is indicated by the appropriate number in Figure 43. The number of catenations was determined for the left elytron, only. The range is from zero to seven among males and from zero to eight among females. For males, both extremes are exhibited by the Mount Linnaeus sample (No. 14). On average, more northern specimens have higher numbers than have more southern specimens. Thus, northern samples tend to have higher mean values than have the southern samples.

In more detail, highest mean values are exhibited by the Wyoming samples. The lowest mean values are in samples from southwestern Utah, next lowest in samples from southeastern Utah (No. 14), and samples with intermediate mean values are in Colorado and northern Utah. The mean differences are slight among samples from areas other than southwestern Utah, and variation is probably clinal from north to south. The southwestern Utah samples differ markedly from their more northern counterparts (0.9 to 5.1 ♂♂, 2.6 to 5.4 ♀♀), and a step-cline is probably the mode of the variation pattern between the former and latter groups of samples.

Another way to analyze the data is to examine the ratio of means of males and females of each sample (Table 1). The ratios are near unity, except for the Circleville (No. 6) sample, in which the value for the ratio is 0.35, and the Montrose sample (No. 12) in which the value is

TABLE 1. Data on variation among population samples of *Nebria trifaria* in number of catenations of interval 5 of left elytron.

| Locality | Map reference number | Males | | | Females | | | Ratio of means: Males/females |
|---|---|---|---|---|---|---|---|---|
| | | N | Range | Mean | N | Range | Mean | |
| Tetons National Park, Wyo., 9,600′–10,200′ | 1 | 9 | 5–7 | 5.7 | 9 | 4–8 | 5.6 | 1.02 |
| Mt. Timpanogos, Utah, 9,000′ | 2 | 23 | 4–7 | 5.1 | 17 | 4–7 | 5.4 | 0.94 |
| Wasatch Mountains, Utah | 3 | 15 | 3–6 | 4.6 | 10 | 3–8 | 5.3 | 0.87 |
| Bluebell Knoll, Utah, 9,500′–10,000′ (1) | 4 | 18 | 0–3 | 1.2 | 9 | 0–3 | 1.3 | 0.91 |
| (2) | | 9 | 0–3 | 1.6 | 8 | 0–3 | 1.1 | 1.48 |
| Cedar Breaks, Utah, 10,500′ | 5 | 11 | 0–5 | 2.5 | 22 | 0–5 | 2.8 | 0.89 |
| Circleville Mountain, Utah, 9,700′ | 6 | 14 | 0–4 | 0.9 | 18 | 0–4 | 2.6 | 0.35 |
| Snowy Range Pass, Wyoming, 12,500′ | 7 | 5 | 5–7 | 5.6 | 3 | 4–5 | 4.3 | 1.29 |
| Long's Peak, Colorado, 11,000′ | 8 | 14 | 2–6 | 4.4 | 7 | 3–6 | 4.4 | 1.00 |
| Lefthand Creek, Colorado | 9 | 15 | 3–7 | 4.8 | 15 | 3–6 | 4.6 | 1.04 |
| Leavenworth Valley, Colorado, 10,000′–11,000′ | 10 | 4 | 3–5 | 4.0 | 5 | 2–7 | 5.0 | 0.96 |
| Pike's Peak, Colorado | 11 | 4 | 3–5 | 4.2 | 14 | 3–6 | 4.6 | 0.93 |
| vic. Montrose, Colorado, 9,000′–10,000′ | 12 | 8 | 2–6 | 4.5 | 4 | 2–3 | 2.5 | 1.80 |
| Wolf Creek Pass, Colorado, 11,500′ | 13 | 7 | 4–5 | 4.6 | 9 | 3–5 | 4.0 | 1.14 |
| North Creek, Abajo Mts., Utah, 8,200′ | 14 | 16 | 3–6 | 4.2 | 3 | 3–5 | 4.0 | 1.06 |
| Abajo Mountains, Utah, 8,200′ | 14 | 10 | 3–6 | 4.2 | 6 | 2–5 | 3.3 | 1.27 |
| Mount Linnaeus, Utah, 10,000′ (1) | 14 | 29 | 0–6 | 3.2 | 31 | 0–6 | 3.7 | 0.86 |
| (2) | 14 | 30 | 0–7 | 3.6 | 27 | 0–5 | 3.6 | 1.00 |
| Abajo Mountains, Utah, 11,000′ | 14 | 5 | 0–4 | 3.1 | 12 | 0–5 | 3.1 | 1.00 |

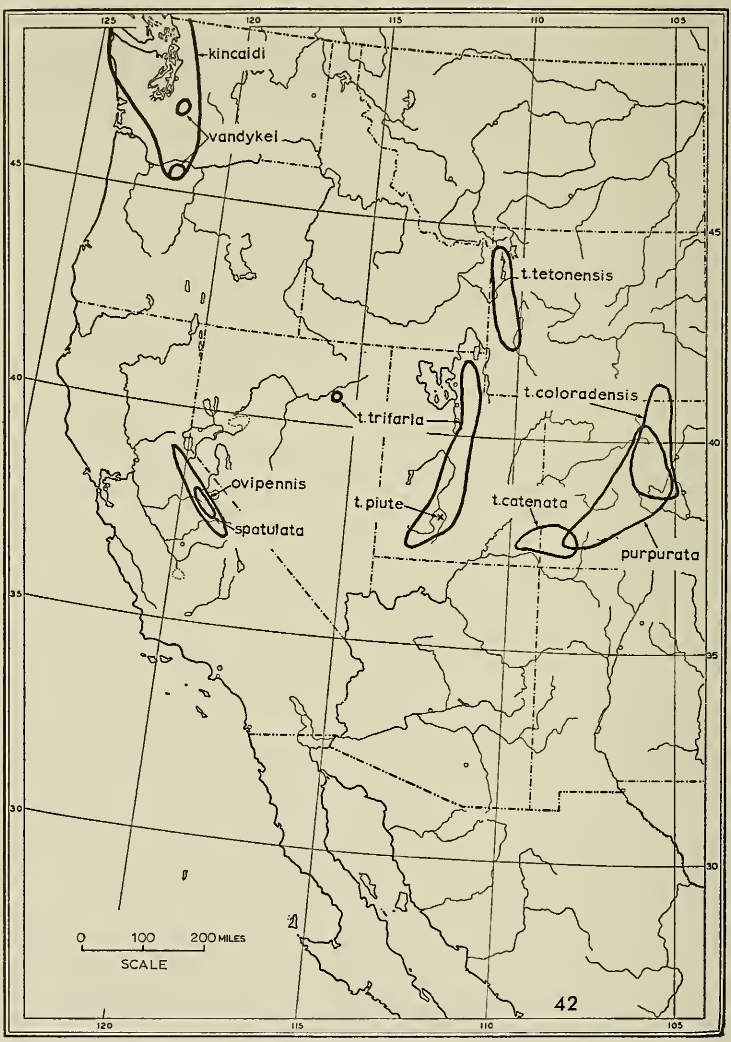

Fig. 42. Distributional area maps of each species of the trifaria and ovipennis groups.

1.80. The females of the latter sample are few, and the abnormally high value may be a result of sampling error. The Circleville sample, however, is large, and this difference is probably of some significance.

In summary, clinal variation seems to be the pattern, with a step-cline between the southwestern Utah samples and the others, and among the former group the Circleville sample is outstanding in its markedly deviant ratio of males/females mean value.

Variation in form and proportions of the apical portion of the male median lobe: Intrapopulation variation in this characteristic is slight but sufficient to prevent its use as a characteristic of specific value. The apical portion is shorter among specimens from western Utah, except for the Circleville Mountain sample. It is longer among specimens of the remaining samples (Figs. 27, 28, 29). The apical portion is arcuate dorsad among males from eastern Utah and western Colorado, but straight among the remaining males. It is narrower among the Colorado specimens, and narrowest among males from western Colorado and eastern Utah.

In summary, the variation pattern seems to be in the form of a four-step morphocline, with one extreme represented by the western Utah samples (excluding the Circleville sample), the other extreme represented by the western Colorado and southeastern Utah samples, and the two intermediate steps represented by Circleville, Wyoming, and northern Colorado samples.

Variation in form of the bursal sclerite: Among the females from northwestern Wyoming, the bursal sclerite is a flattened plate with shallow convolutions. Among the remaining females, this sclerite is pouch-shaped, more convoluted and various in form (Figs. 37, 38, 39, 41).

Summary: Overall, the variation pattern is discordant and consequently complex. The four geographically discrete groups are distinguished more or less clearly from one another, by characteristics of at least one sex. In addition, the southwestern Utah group of samples is the most heterogeneous, and it is reasonable to recognize two groups: one, the Circleville Mountain sample; and two, the remaining samples. Because of their geographical discreteness and slight but constant morphological differences, and in spite of the discordant variation pattern, these groups are ranked as subspecies, and are defined below.

### *Nebria trifaria trifaria* LeConte

Figures 26, 32, 37, 42, 43

*Diagnostic characteristics*: Elytra dark piceous to black, number of catenations of elytral interval 5 about same for males and females of same population. Median lobe with apical portion short, wide, straight (Fig. 26). Bursal sclerite pouch-shaped, form various (Fig. 37). Length 12.0–13.7 mm. Material dissected: 27 males, nine females.

*Geographical distribution*: Members of this subspecies are known from the mountain systems of central Utah from Cedar Breaks National Monument in the south, to White Pine Lake near Logan, in the north. Lindroth (1961) and Hatch (1953) reported specimens from Idaho, but we have not seen them. However, we have seen one specimen

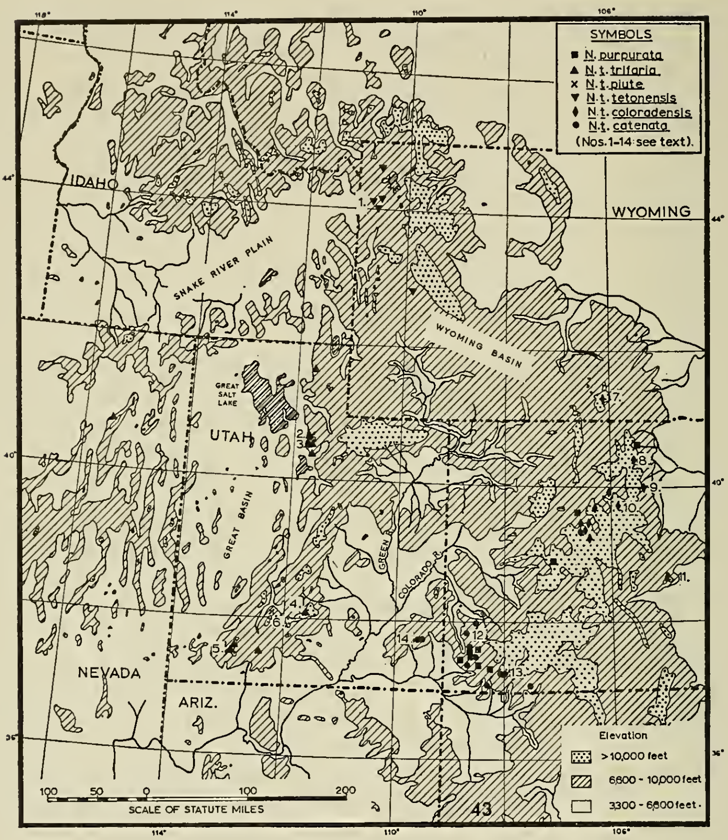

Fig. 43. Distributional area maps (by symbols) of each subspecies of *Nebria trifaria* and of *N. purpurata*, in relation to elevation. Numbers refer to Table 1.

from northeastern Nevada. (See Fig. 42.) We have studied 215 specimens from the following localities.

Nevada: elko county: Lamoille Canyon, 7,300′ (GRNo). Utah: cache county: Logan, White Pine Lake, 8,000′ 15 July (CAS). iron county: Cedar Breaks, 10,500′, 17 July, 2 August (CAS); Cedar Breaks Nat. Mon., 30 July (ONCO); The Mammoth, top Parowan Mountains, 10,000′, 11–22 July (MCZ). kane county: Long Valley Junction, September (CAS). salt lake county: Alta, 30 June (USNM). utah county: American Fork Canyon, 9,500′, 2–3 August (MCZ); Aspen Grove, Provo Canyon, 20 August (CAS); Glacier Lake, Timpanogos, 9,000′, 7–9 July (MCZ); Mount Timpanogos, 9,000′, 5 July (CAS, USNM); North Fork, Provo Canyon, 9 July, August (CAS, USNM). WAYNE COUNTY: Bluebell Knoll, 22.0 miles south of Teasdale, 9,500′–10,000′, 17 July (DHKa, TLEr). COUNTY UNKNOWN: City Creek Canyon (USNM); Wasatch Mountains, July (CAS).

We suspect that this subspecies will be found in the Uinta Mountains of northeastern Utah, and the Sawtooth Range of southern Idaho.

### **Nebria trifaria tetonensis** new subspecies

Figures 8, 25, 42, 43

*Type-locality*: South Fork of Cascade Canyon, 10,000′, Teton National Park, Wyoming.

*Type-specimens*: The holotype male and allotype are in USNM. Both were collected at the type-locality by J. Gordon Edwards and Alice Edwards on 22 July 1960. Thirteen paratypes collected on the same day at the same locality are deposited as follows: CAS—2; DHKa—2; USNM—2; SJSC—5; UASM—2.

*Diagnostic characteristics*: As in *trifaria* sensu stricto, except apical portion of male median lobe slightly more elongate. Bursal sclerite a flattened plate, with shallow convolutions. Material dissected: seven males, seven females.

*Collecting notes*: The specimens collected by the Edwards were found at night on snow, actively preying on cold, immobilized insects. One specimen is labeled "carrying live scarab, acc. No. 6269."

*Geographical distribution*: Members of this subspecies are known from the northwestern mountains of Wyoming from Yellowstone in the north, to Fremont Lake in the south (Figs. 42 and 43). We have seen 23 specimens from the following localities.

WYOMING: PARK COUNTY: Yellowstone, 7,000′–10,000′, 1–19 September (MCZ). SUBLETTE COUNTY: Fremont Lake, 25 July (CAS). TETON COUNTY: Grand Teton Park, July (CAS); head of Leigh Canyon, 9,700′ 11 July (SJSC); South Fork of Cascade Canyon, 10,050–10,200′, 22 July (SJSC); Sunset Lake, Alaska Basin, 9,650′, 29 July (SJSC).

The actual range of this subspecies is probably more extensive than our data show. The outlying mountain peaks in the vicinity of the Tetons are poorly collected, and the higher ones probably harbor populations of this subspecies. In addition, the area between the known ranges of this subspecies and that of *N. trifaria trifaria* is yet to be explored.

### **Nebria trifaria piute** new subspecies

Figures 21, 22, 27, 34, 38, 42, 43

*Type-locality*: Circleville Mountain, La Baron Lake, 9,700′, 15.9 miles west of Junction, Beaver County, Utah.

*Type-specimens*: The holotype male and allotype are in USNM. Both were collected at the type-locality on 17 September 1967, Ball, Erwin and Leech. Twenty-eight paratypes, collected on the same day at the same locality, are deposited as follows: CAS—3; DHKa—3; MCZ—3; USNM—3; TLEr—3; UASM—13.

*Diagnostic characteristics*: As in *trifaria* sensu stricto, except color of elytra violaceous, antennal scape with hind edge slightly more arcuate, catenations of elytra much reduced, especially among males, median lobe with apical portion slightly longer (Fig. 27). Bursal sclerite as in Figure 38. Length 12.8–14.0 mm. Material dissected: six males, three females.

*Geographical distribution*: Members of this subspecies are known from the type-locality, only. (See Figures 42 and 43.)

### *Nebria trifaria coloradensis* Van Dyke, New Combination

Figures 28, 36, 41, 42, 43

*Nebria coloradensis* Van Dyke, 1943: 19. Type-locality.—Twin Lakes, Lake County, Colorado. Type-specimen a male!, No. 5298, CAS.
*Nebria catenata*; Lindroth, 1961: 84 (in part).

*Diagnostic characteristics*: As in *trifaria* sensu stricto, except apical portion of male median lobe slightly more elongate and slightly more slender (Fig. 28). Bursal sclerite as in Figure 36. Length 12.3–14.0 mm. Material dissected: eight males, four females.

Geographical distribution: Members of this subspecies are known from the Rocky Mountains of southern Wyoming and Colorado, from the Snowy Range of Wyoming to Broadmoor Gold Camp in Colorado. We have seen 128 specimens from the following localities.

COLORADO: BOULDER COUNTY: Long's Peak, 10,000′–11,000′, 2 July (CAS); 5.0 miles east of Ward, Lefthand Creek, 20 July (DHKa). CLEAR CREEK COUNTY: Leavenworth Valley, above Georgetown, 10,000′–11,000′, June (CAS, MCZ, USNM); Silver Plume, 9,000′–10,000′, 15 June (CAS, MCZ); Summit Lake, Mount Evans, 13,000′, 24 July (CAS). EAGLE COUNTY: Redcliff (USNM). EL PASO COUNTY: 9.0 miles east of Broadmoor Gold Camp Road, 2 August (DHKa); Pike's Peak (DHKa). LAKE COUNTY: Leadville, 10,000′–11,000′, 7 July (MCZ, USNM). MESA COUNTY: (USNM). PARK COUNTY: Alma, Mount Bross, 11,500′, 23 July (CAS); Kenosha Pass, 10,000′, 23 July (CAS). SUMMIT COUNTY: 10.0 miles south of Breckenridge, Blue Lakes, 11,400′, 19 July (TLEr). WYOMING: ALBANY COUNTY: Snowy Range Pass, 12,500′, above tree line, June (UASM). CARBON COUNTY: 30.0 miles east of Saratoga, Silver Lake, 10,400′, 22 July (TLEr).

The only area north of the Snowy Range in southeastern Wyoming of an elevation sufficiently high to provide a habitat suitable for the members of this subspecies is Elk Mountain (11,156′) in Carbon County. One of us (TLE) has been on top of that isolated peak during the optimal collecting season, but no specimens of *N. trifaria* were found. Specimens of another as yet undescribed species of *Nebria* were very common, however.

### *Nebria trifaria catenata* Casey, New Combination

Figures 29, 39, 42, 43

*Nebria catenata* Casey, 1913: 49. Type-locality.—Colorado, as originally given by Casey, but here restricted to the San Juan Mountains of southwestern Colorado. Type-specimen a female!, No. 46849, USNM.
*Nebria catenata*; Lindroth, 1961: 84 (in part).

*Diagnostic characteristics*: As in *trifaria* sensu stricto, but apical portion of male median lobe elongate, narrow and arcuate dorsad (Fig. 29). Bursal sclerite pouch-shaped, form various (Fig. 39). Length 12.3–13.7 mm. Specimens dissected: 29 males, eight females.

*Geographical distribution*: Members of this subspecies are known from the mountain systems of southwestern Colorado south of the Gunnison-Saguache area and in the higher mountains of southeastern Utah (Figs. 42 and 43). We have seen 217 specimens from the following localities.

Colorado: conejos county: Valley of Upper San Juan, 7,000′–10,000′, 13–15 August (MCZ). dolores county: Vicinity of Rico, 8,500–10,000 , 19–22 July (MCZ). gunnison county: Canyon of Big Blue, 8,500′, 5–6 July (MCZ). la plata county: Vicinity of Durango, 5,500–7,000′, 23 July (MCZ). mineral county: Wolf Creek Pass, 11,500′, 17 June (CAS); 2.0 miles west of Wolf Creek Pass, 29 August (DHKa). montrose county: Vicinity of Montrose, 9,000′–10,000′, 9–10 July (MCZ). ouray county: Ouray, 7,500–8,000′, 1–15 July (CAS, USNM); above Ouray, 9,000′–10,000′, July (CAS, USNM). san miguel county: South Fork San Miguel, 8,500′, 14–15 July (MCZ, USNM). county unknown: La Plata Mountains, 11,000′–12,000′, 19 July (MCZ). Utah: san juan county: Monticello, 20 July (MCZ). Abajo Mountains, 8,500 and 11,000′, July (UASM), Mount Linnaeus, ca 10,000′, 18 July (DHKa, TLEr), North Creek, 5.0 miles west of Monticello, 8,200′, 18 July (DHKa, TLEr), Spring Creek, 7.0 miles west of Monticello, ca. 8,000′, 18 July (DHKa, TLEr).

According to our maps, there are continuous high mountains along a narrow corridor at the continental divide in Colorado (Saguache County). We have not seen specimens from anywhere near this area, but we suspect that it provides suitable habitats, and furthermore, that this area will be important for gamma-level studies of this subspecies and its sister group, *N. trifaria coloradensis*.

## Evolutionary Considerations

We discuss below the sister-group relationships and zoogeography of the taxa of the *Nebria trifaria* group. The data available at present are not sufficient to extend the discussion to other western species groups of *Nebria*.

*Phylogenetic relationships*: A phylogenetic classification of the characteristics of the taxa included in the trifaria group is presented in Table 2. Each characteristic is represented by a letter: capital for apomorphic

TABLE 2. Distribution and evolutionary classification of selected character states among the taxa of the *Nebria trifaria* species group

| Characteristics | *vandykei* | *purpurata* | *t. tetonensis* | *t. trifaria* | *t. piute* | *t. coloradensis* | *t. catenata* |
|---|---|---|---|---|---|---|---|
| A. Color of Elytra | | | | | | | |
| a. black | | | | | | | |
| A. purple | a | A | a | a | A | a | a |
| B. Antenna: Scape | | | | | | | |
| b. cylindrical | | | | | | | |
| B. swollen | B | b | B | B | B | B | B |
| C. Pronotum: Sides | | | | | | | |
| c. narrowly reflexed | | | | | | | |
| C. broadly reflexed | C | c | C | C | C | C | C |
| D. Pronotum: Angles | | | | | | | |
| d. moderately produced | | | | | | | |
| D. strongly produced | D | d | D | D | D | D | D |
| E. Elytra: Sides | | | | | | | |
| e. parallel | | | | | | | |
| E. rounded | E | e | E | E | E | E | E |
| F. Hind Wings | | | | | | | |
| f. apical portion reflexed | | | | | | | |
| F. apex not reflexed | F | f | f | f | f | f | f |

Table 2 (continued)

| Characteristics | *vandykei* | *purpurata* | *t. tetonensis* | *t. trifaria* | *t. piute* | *t. coloradensis* | *t. catenata* |
|---|---|---|---|---|---|---|---|
| G. Male Median Lobe | | | | | | | |
| g. very short—broad—straight | | | | | | | |
| G. short—very broad—straight | | | | | | | |
| G′ short—broad—straight | | | | | | | |
| G″ longer—broad—straight | | | | | | | |
| G‴ longest—broad—straight | | | | | | | |
| G⁗ longest—narrow—arcuate | G | g | G″ | G′ | G″ | G‴ | G⁗ |
| H. Female Bursal Sclerite | | | | | | | |
| h. absent | | | | | | | |
| H. dome-shaped | | | | | | | |
| H′ flat; shallow convolutions | | | | | | | |
| H″ pouch-shaped, convoluted | h | H | H′ | H″ | H″ | H″ | H″ |

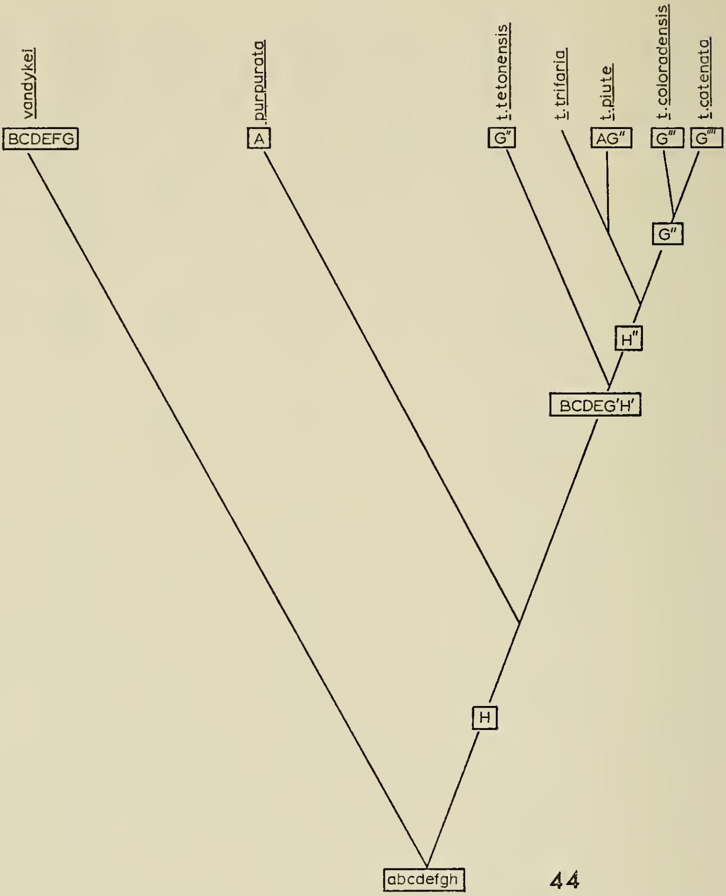

FIG. 44. Hypothetical phylogeny of trifaria group; explanation in text and Table 2.

states, lower case for the plesiomorphic state. These letters are used in the phylogenetic diagram (Fig. 44). The states judged to be plesiomorphic are those which are more widespread in *Nebria* or in other groups of Carabidae than are their respective alternative states; or those which cannot be derived from their respective alternative states in the trifaria group (for example, longer hind wings).

The form of the apical portion of the male median lobe exhibits a number of states which together comprise a morphocline or transformation series. The "very short-broad-straight" condition (Fig. 33) is most widespread among the members of *Nebria*, so it regarded as the most plesiomorphic. The state "short-very broad-straight" (Fig. 23) represents evolution in one direction; and the sequence "short-broad-straight" (Fig. 23), "longer-broad-straight" (Fig. 24), "longest-broad-straight" (Fig. 28) and "longest-narrow-arcuate" (Fig. 29) represents evolution in another direction.

A second morphocline involves the bursal sclerite of the female genitalia. This sclerite is lacking from the bursae of females of *N. vandykei* and females of other species of *Nebria* (for example, those of metallica, paradisi and ovipennis groups). Therefore, this character state is regarded as plesiomorphic. Among females of *N. purpurata*, the bursal sclerite is simple in structure, and in females of *N. trifaria* it is more complex. It is assumed that the *purpurata* condition is more primitive than the *trifaria* condition. Thus the morphocline is: absent; present-simple; present-complex.

A third morphocline involves the number of catenations of elytral interval 5: high, intermediate and low mean values for population samples. It is not clear which of these character states is the more plesiomorphic. Consequently, this characteristic is excluded from the phylogenetic analysis.

The distribution of the character states forms a complex pattern. In external characteristics (form of antennal scape, pronotum and elytra) *N. purpurata* is plesiomorphic, whereas *N. vandykei* and *N. trifaria* exhibit the apomorphic states of these characteristics. In color, *N. purpurata* and *N. t. piute* are apomorphic, whereas the remaining subspecies of *N. trifaria* and *N. vandykei* are plesiomorphic. One plesiomorphic state is shared by *N. purpurata* and *N. trifaria*: size of hind wings. In summary, then, the external characteristics suggest this sequence of taxa: *purpurata-trifaria-vandykei.*

The sequence of the character states of the male median lobe is generally consistent with the external character sequence, except that the evolutionary tendencies in *N. trifaria* and *N. vandykei* are divergent with respect to width.

The sequence of the character states of the female bursal sclerite is incongruous with the sequence of external characteristics. The morphocline is: *vandykei-purpurata-trifaria.*

In summary, the different characters suggest two different systems of relationships. However, there was a single phylogeny, only. The question is, which of the above systems (if either) approximates more closely the true phylogeny? If the sequence indicated by external characteristics is accepted, the loss of the bursal sclerite from *N. vandykei* is required and must be accounted for. If the sequence indicated by the bursal sclerite is accepted, then the apomorphic similarities shared by *N. trifaria* and *N. vandykei* must be accounted for by assuming convergent evolution.

To us, the second alternative seems more likely to be correct. The similarities in external characteristics seem rather simple. They are of the sort which have evolved independently many times among many groups of carabids. On the other hand, it seems unlikely to us that a complex structure, such as the bursal sclerite, would be lost rapidly after having once developed—and this would be required if the first alternative were accepted. Further, the sequence of the median lobe can be rationalized with the bursal sequence if it is assumed that the form of the apical portion of the median lobe of ancestral males of the trifaria group was like that of *N. purpurata*, that this was modified in one direction in the *N. vandykei* line, retained unmodified in the *purpurata-trifaria* ancestral stock, and then modified in a different direction in the *N. trifaria* line. In any event, the male genitalia of *N. purpurata* and *N. trifaria* seem more like one another than either is like the genitalia of *N. vandykei*, and this suggests a relatively more isolated position for the last-named species. These views are summarized in Figure 44.

*Zoogeography*: The purpose of this section is to interpret the geographical relationships of the extant species of the *N. trifaria* group in terms of present and past climate and topography, in an attempt to explain the present distribution pattern. We accept for purposes of this study that ". . . most contemporary subspecies have differentiated in late Pleistocene time; otherwise, the frequent correspondence seems inexplicable of their ranges with current topographical and ecological features which stem from late Pleistocene events" (Findley and Anderson, 1956). We also accept the assumption that these groups of *Nebria* are cool- or cold-adapted and have been for a long time. This assumption is based on the present distribution, habitat preference, and rearing studies of the Nebriini as a whole; hence cool/cold-adaptedness is judged to be plesiomorphic in Nebriini.

This species group is confined to the mountains of western North America and can be classified in the terminology of Weber (1965) as a sub-element of the cordilleran group of coincident patterns. Actually the distribution of this species group does not coincide exactly with any of the patterns of plant distribution described by Weber, but it is most like his "Central Rocky Mountain-Pacific Northwest sub-element." Probably the ancestor of the *N. trifaria* group evolved in western North America and almost certainly, still earlier ancestors entered the Nearctic Region from Asia, via the Bering land bridge, probably during late Tertiary time. If this is correct, then the *N. trifaria* group can be regarded as a member of the montane Boreal-Asiatic element. Thus, the history of this group is likely to be the same as the history of the vegetational component of this latter element. At present, this is not a very important consideration, for the history of the plants is not well understood. However, it is likely that the history of the vegetational component will be clarified before that of the animal component. As this is achieved, the history of the animal component will be clarified, by analogy.

The species of the trifaria group are represented on tundra (alpine zone) or in coniferous forests of the montane and subalpine zones (for descriptions of these in the eastern Rockies, see Marr (1967) and Blake (1945)). Members of *N. vandykei* and *N. purpurata* are restricted to stream margins, whereas of *N. trifaria* are found both along stream margins and in forests at some distance from open water, or on tundra. The range of each species is discontinuous, and allopatry rather than sympatry is the rule. The most primitive species, *N. vandykei*, is known only from two high peaks in the Cascade Mountains. Five-hundred miles to the east, in the Rocky Mountains of western Wyoming, the northernmost population of *N. trifaria* is encountered, and several hundred miles southeastward in the Southern Rockies (that portion of the Cordillera south of the Wyoming deserts (Weber, 1965)), populations of *N. purpurata* are found (Figs. 42 and 43). The range of *N. purpurata* overlaps that of two subspecies of *N. trifaria*: *t. coloradensis* and *t. catenata.*

The subspecies of *N. trifaria* are more or less widely isolated from each other (Fig. 42). Gaps of 100 to 200 miles separate the nearest known localities for adjacent members of different subspecies (except *t. piute*, which is only 40 or so miles from the nearest populations of *t. trifaria*). Within the range of each subspecies are more or less extensive gaps, some of which are simply the result of lack of sampling. Other gaps are the result of absence of suitable habitats.

Lowland river basins and deserts evidently do not provide suitable habitats for members of the trifaria group, and are barriers to dispersal. The major barriers are the Colorado River and Green River basins; the high desert basins of Wyoming associated with the Green River (Scott, 1965, Fig. 1); the Snake River Plain; the Great Salt Lake desert; the Columbia River basin and associated Palouse country of eastern Washington and Oregon. Kelson (1951) and Findley and Anderson (1956) discuss the importance of some of these barriers to dispersal of boreal or cool-adapted mammals. Barriers of lesser extent are the lower slopes of high peaks within any one mountain system: for instance, within the Wasatch Mountains. Although these areas restrict dispersal of the members of the trifaria group at present, at least some of the barriers were less effective in the past. During the glacial stages of the Pleistocene, the generally cooler and wetter climate plus alpine glaciers, caused a shift downward of several thousand feet of the life zones. Roberts (1970), for example, suggests that the late glacial vegetation at 5,000 feet in southeastern Wyoming was Transition-Canadian Zone open forest. Thus populations of Rocky Mountain species presently confined to the upper slopes, would have been on the lower slopes and in the adjacent valleys during glacial time. The distribution of the populations of *N. trifaria* may have been continuous at the 6,000 or 7,000 foot level, throughout the mountain systems of Wyoming, southern Idaho, northern Nevada, Utah, Colorado and eastern New Mexico.

It is not difficult to imagine that the range of *N. trifaria* was once more extensive than it is at present. It is also apparent that *N. vandykei* had a more extensive range than it has now, but it is surprising that the species seems not to be represented to the east, in the Rocky Mountains of Idaho. Similarily, the species *N. purpurata* seems to be confined to the Southern Rocky Mountains in Colorado, whereas it might be expected to have a distribution pattern more like that of *N. trifaria.* Of course, these species may have been more widespread during full glacial stages, but failed to attain ranges sufficiently extensive to occupy the high country adjacent to their present ranges. Alternatively, they may have occupied adjacent mountain ranges, with the peripheral populations dying out in post-Wisconsin time. For example, post-Pleistocene extinctions of local montane populations of *Marmota flaviventris* Audubon and Bachman were postulated to explain present-day absence of this species from the isolated mountain ranges of New Mexico (Harris, 1970: 24).

The history of dispersal of the *Nebria trifaria* group was probably a series of range expansions during favorable periods followed by range restriction and extinction of local populations during unfavorable times. Probably during periods of range restriction, isolation of populations occurred, and differentiation took place.

The morphological data seem to indicate this sequence of relationships: *vandykei-purpurata-trifaria* (Fig. 44). On the other hand, distributional data suggest a different sequence: *vandykei-trifaria-purpurata.* We interpret the geographical proximity of *N. vandykei* and *N. trifaria* to be secondary. Interpretation of the distribution pattern in terms of the evolutionary one suggests that the ancestral *trifaria-purpurata* population was eliminated from the northern Rockies, but survived in the southern Rockies, followed by pre-Wisconsin dispersal from a southern center, with isolation and subsequent differentiation of the isolates: an ecologically more broadly tolerant *N. trifaria,* and an ecologically more restricted *purpurata.* The area of origin of *N. trifaria* cannot be specified exactly, but it was probably to the west of Colorado.

During the Wisconsin glacial period, *N. trifaria* became widespread and underwent minor, probably clinal, differentiation. In post-Wisconsin time, the range of this species became disrupted. As the climate warmed, the glacial ice melted and the beetles withdrew from lower to higher elevations. Probably the sequence of range interruption was as follows. First, the northern Wyoming populations were cut off as desert conditions developed (or returned) in the lowlands of the southern part of the state. Second, the Utah populations became isolated from the Colorado ones by downcutting of the Green River Canyon (Kelson, 1951). Third, the populations of the Wasatch Mountains became isolated from one another, and since then, *N. t. piute* has differentiated from the other populations. At the same time, the Abajo Mountains populations became isolated from the Colorado ones. Finally, the range of the Colorado populations became divided (as the available data suggest), or the extent of contact was reduced by reduction of favorable habitats. (The high areas between the known ranges of *N. t. coloradensis* and *N. t. catenata* suggest that suitable habitats exist therein, and the gap in distribution is apparent rather than real.)

Except for the most recent part of this evolutionary sequence, the events cannot be accurately timed. It seems reasonable to believe that the present-day distribution of *N. trifaria* is a reflection of Wisconsin and post-glacial events. The slight differences among the geographical isolates suggest a short period of isolation, and the present-day barriers to dispersal were almost certainly not effective during the Wisconsin period. This isolation must be recent, the diagnostic characteristics of the subspecies probably reflecting nothing more than interruption of formerly clinal variation, overlain by slight additional differentiation in isolation. (To support our contention that slight but significant differentiation is likely to be of relatively recent origin, we cite the study of *Mimulus guttatus* DC., by Lindsay and Vickery (1966). They demonstrated that slight geographical differentiation of the Utah populations of this species occurred within the past 4,000 years.) Because of the very narrow geographical range of the subspecies *N. t. piute* and its marked similarity to adjacent populations and absence of indications of clinal variation in its diagnostic characteristics, differentiation almost certainly occurred in post-glacial time, after the isolation of this population from the geographically adjacent ones had taken place. If this were not so, then one would expect to see clinal variation among geographically adjacent populations in the characteristics used to distinguish the subspecies.

It is tempting to suggest that the entire evolution of the extant species of the *N. trifaria* group took place during the latter part of the Pleistocene, with alternating waves of dispersal/range expansion and range contraction/differentiation coinciding with alternating episodes of cooler glacial stages and warmer interglacial ones. However, available fossil evidence for carabids suggests that rate of change requires more time than available during the glacial-interglacial portions of the Pleistocene (see, for example, Matthews, 1968, and Hopkins et al. (1971)). Therefore, the initial dispersal and speciation of the group probably took place prior to the Pleistocene, but the present pattern only became established rather recently, certainly post-Pleistocene.

*Conclusion*: Although we have used the subspecies category here based solely on distributional and morphological criteria (in the Mayr sense, 1963, 1970) without data from studies in population dynamics, life histories, and genetic capabilities, we feel justified in doing so. Our reasons can be summarized with a statement made by Darlington (1970) at a symposium in Puerto Rico on "Adaptive Aspects of Insular Evolution," "practical revisions . . . allows me to pick out and emphasize special cases which look exciting for future work . . . but they require also, especially, detailed study in the field of the insects' ecology, adaptations, and behavior. My role is to present cases like these as problems for the future."

## ACKNOWLEDGMENTS

The following made available to us material in their possession or care: J. Gordon Edwards, David H. Kavanaugh, Hugh B. Leech, Gerald R. Noonan and C. A. Triplehorn. We received assistance from LaVerne Erwin and Arthur Borkent (Edmonton, Alberta) in examination of the specimens. Our colleagues, David H. Kavanaugh and Donald R. Whitehead, discussed with us the problems of ranking taxa and working out their relationships, and the manuscript was improved by taking account of their views. John S. Scott (Department of Entomology, University of Alberta) prepared the final draft of the maps and phylogenetic diagram, and LaVerne Erwin typed the manuscript. We also acknowledge with thanks the assistance we received from Robin E. Leech (Entomology Research Institute, Ottawa, Ontario) for his assistance in collecting the type-series of *Nebria trifaria piute*.

This paper is, in part, a by-product of a project supported by a grant from the National Science Foundation (GB-3312), held by the junior author.

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Vol. 85, No. 8, pp. 109–130 30 August 1972

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# COMMENTS ON THE ECHINOID GENUS *ENCOPE*, AND A NEW SUBGENUS

Corrected copy
T.F.P.

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Two species of the sand dollar *Encope* occur in the coastal waters of eastern Mexico and the United States from the northern tip of the Yucatan Peninsula to Cape Hatteras. They are *Encope michelini* L. Agassiz and *Encope aberrans* Martens. A third species *E. emarginata* (Leske) is restricted to Caribbean and Atlantic coastal waters south of the Yucatan Peninsula. Unfortunately A. Agassiz (1872, p. 126) considered *E. aberrans* a junior synonym of *E. michelini*. This and a typographical error in one of his plate explanations has led to misidentifications of *Encope* specimens collected from Cape Hatteras to the Yucatan Peninsula.

The misidentifications were generally as follows: 1. Specimens of both *E. michelini* and *E. aberrans* were identified as *E. michelini*. 2. Specimens of *E. michelini* were identified as *E. emarginata* and specimens of *E. aberrans* were identified as *E. michelini*. 3. Specimens of *E. michelini* and *E. aberrans* were both identified as *E. emarginata*.

The following distinctive features from the original descriptions and illustrations clearly delineate the three species.

*E. emarginata*: The original figures (Leske 1778, Pl. 50, Figs. 5, 6) show a completely closed notch forming a lunule in ambulacrum V. The other four notches are closed but a fine line in the drawing indicates that a complete bridging at the notch openings has not occurred. Leske compared this species with *Echinodiscus sexiesperforatus* Leske (1778, Pl. 50, Figs. 3, 4) and states that it differs in that the holes reach

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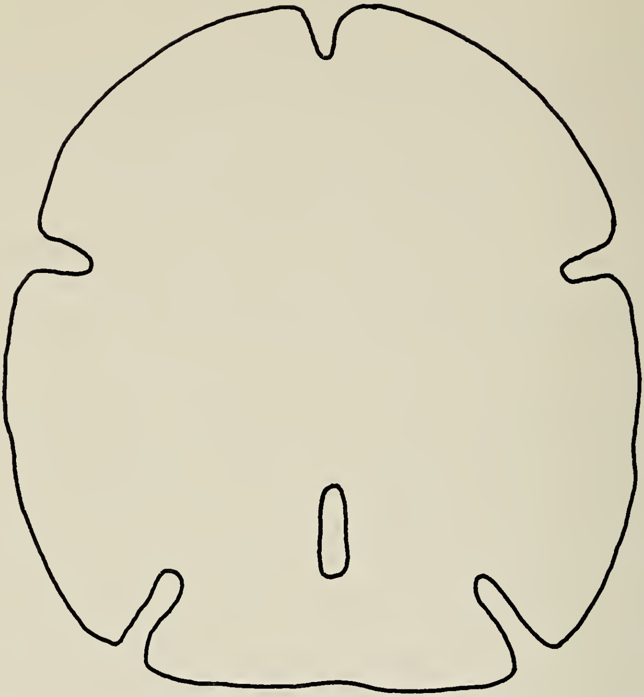

FIG. 1. Tracing of the original figure of *Encope michelini* L. Agassiz (1841, Plate 6a, Fig. 9). Note the uniform notches. Figure reduced by one-third.

to the very margin thus forming five incisions. Leske does not mention the position of the apex of the test.

Leske reported that the specimen was sent from the island of Bourbon (now Reunion) to the Reamur Museum. This locality must be in error as the genus *Encope* is restricted to the coastal waters of the Americas. In fact no echinoid species with a closed odd posterior interambulacral lunule is known to occur in the Indian Ocean.

*E. michelini*: L. Agassiz (1841, p. 58) stated that the notches are medium deep, uniform, the posterior ones slightly deeper than the anterior three with no tendency to close. The apex of the test is between the apical system and the posterior

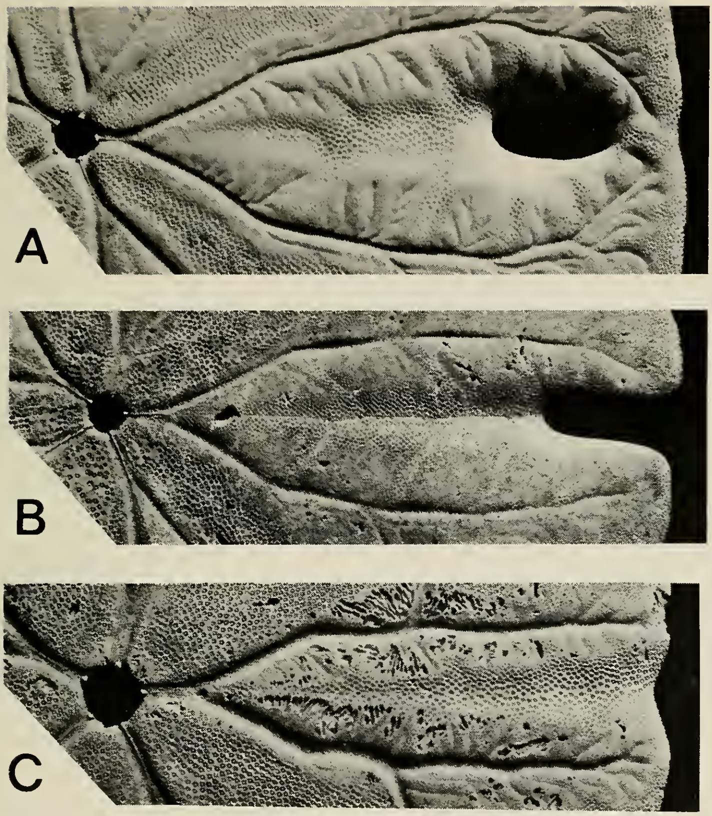

FIG. 2. A comparison of the notches; ambulacral midline depression; food groove shape, depth, and width; and peristome size. A. *Encope emarginata* length 125.4 mm, USNM 8421, × 1.5. B. *Encope* ~~*emarginata*~~ michelini length 115 mm, USNM 170549, × 1.5. C. *Encope aberrans* length 114 mm, USNM 170548, × 1.5. All views are of the adoral surface of Ambulacra IV.

interambulacral lunule. A tracing of the original adapical view is shown in Figure 1.

*E. aberrans*: The odd and paired anterior notches are only slight indentations (schwache Einkerbungen). Posterior paired notches are short (kurze Einschnitte). The odd posterior lunule is about as long as the depth of a posterior notch, and is anterior to the tips of the posterior ambulacral petals.

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FIG. 3. Profile of right side of *Encope emarginata* (Leske), length 125.4 mm, Sabanilla, Columbia, USNM 8421.

*E. aberrans* is distinct from *E. michelini* and *E. emarginata* by its weak development of notches. The posterior notches are short (kurze Einschnitte), the anterior ones mere indentations (blosse Einkerbungen).

The differences between the three species are described in Table I.

*E. aberrans* is distinct from *E. michelini* as there are no mature specimens with an intermediate condition between the deep notches of *E. michelini* and the slight indentations of *E. aberrans.* There is a marked difference between the ratio of peristome diameter to specimen length in these two species. The food grooves of *E. aberrans* are relatively wider, deeper, and more angular than those of *E. michelini* (Figs. 2B, C, 7, 10). There is a deep depression in each ambulacrum between the two main branches of the food grooves in *E. michelini.* The corresponding depressions on *E. aberrans* are very shallow.

Populations of the two species commonly do not mix. I have been informed by I. E. Gray, Duke University Marine Laboratory (personal communication, 1971) that dredge hauls off North Carolina with a large number of *Encope* specimens usually contain one species, either *E. michelini* or *E. aberrans.* When the two species are collected together one of them occurs in small numbers. I found the same kind of distribution in the *Encope* collections in the National Museum of Natural History.

I believe the two species prefer a bottom sediment of different particle size. The differences in food groove depth and width, peristome size, and adoral ambulacral midline depression all indicate that the two species are adapted to a different feeding condition. It is known that the distribution of some sand dollars is strongly related to sea floor particle

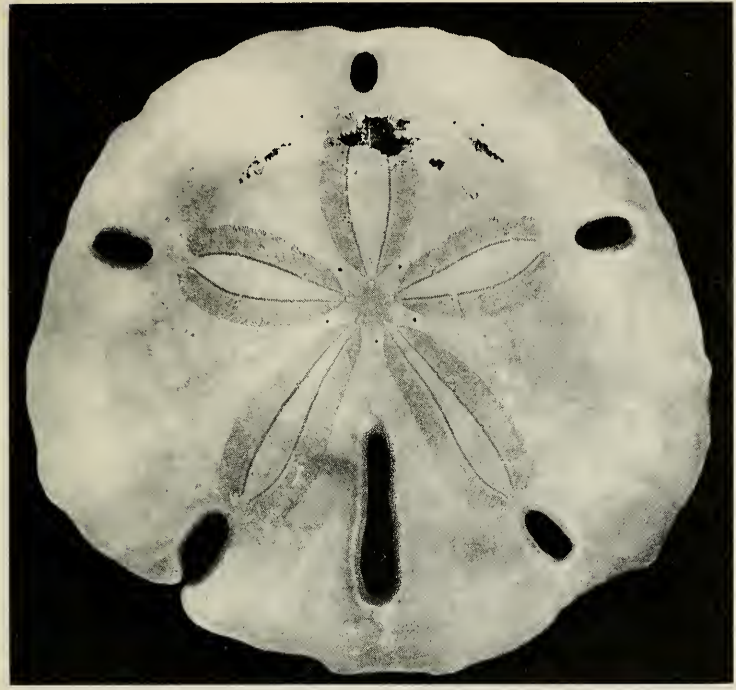

FIG. 4. Adapical view of *Encope emarginata* (Leske), same (same specimen as Fig. 3).

size as shown by Stanley and James (1971) for the distribution of *Echinarachnius parma.*

Features of *E. emarginata* which make it distinct from both *E. michelini* and *E. aberrans* are:

1. Two ambulacral plates and the first pair of post basicoronal interambulacral plates are in contact with the the periproct. Rarely only one plate of the first interambulacral pair is in contact with the posterior portion of the periproct. Durham (1955) emphasized the taxonomic importance of the adoral plate arrangement in in the clypeasteroid echinoids.
2. The five ambulacral notches close or have a strong tendency to close forming lunules (Figs. 2A, 4).
3. The apex of the test is a long flattened area extending

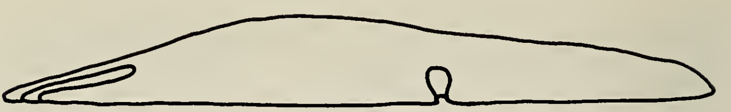

FIG. 5. Profile of right side of *Encope michelini* A. Agassiz, length 112.6 mm, USNM 174444.

from anterior to the apical system to the posterior odd lunule. The highest point is commonly anterior to the apical system (Fig. 3).

Lütken (1864, p. 43) considered *E. michelini* and other eastern American Recent *Encope* echinoids junior synonyms of *E. emarginata*. Although most subsequent authors are in agreement on South and Central American species, they do not agree that *E. michelini* is only a local variety of *E. emarginata* (see A. Agassiz 1872, p. 329).

I believe Alexander Agassiz overlooked several significant differences between *E. michelini* and *E. aberrans* when he considered *E. aberrans* a junior synonym of *E. michelini* (A. Agassiz 1872, p. 126). He presented no reasons for his action in the redescription of *E. michelini* (A. Agassiz 1872, p. 329).

Agassiz' only illustration of an *E. michelini* specimen is Plate 12d, figure 1 (A. Agassiz 1872), but a typographical error in the plate explanation incorrectly identifies it as *E. emarginata*. His reference to this figure in the text is correct. His other illustrations of *E. michelini* (Pl. 12b, Fig. 4; Pl. 12c, Figs. 3, 4) are all of specimens of *E. aberrans*.

A. Agassiz reported *E. emarginata* from South Carolina to Rio de Janeiro (A. Agassiz 1872, p. 233). I have been unable to find any specimens from the Gulf of Mexico or in the Atlantic waters of the United States. I do not believe it occurs in this region. Clark (1914, p. 74) also doubted the occurrence of *E. emarginata* in the coastal waters of the United States.

Mortensen (1948, p. 441) concurred with A. Agassiz' (1872) opinion. In his description of *E. michelini* Mortensen described the anterior notches as small indentations in the margin of the test; a diagnostic feature of *E. aberrans*. He had one

Fig. 6. Adapical view of *Encope michelini* L. Agassiz (same specimen as Figs. 5, 7).

specimen of *E. michelini* on hand from Charlotte Harbor, Florida, similar to Agassiz' figured specimen (A. Agassiz 1872, Pl. 12d, Fig. 1). Mortensen recognized it as *E. michelini* and commented on its rather deep marginal slits, but did not discuss the differences in the margin due to his lack of specimens for study. He overlooked differences on the adoral surface (see Diagnoses) and continued to recognize *E. aberrans* as a junior synonym of *E. michelini.*

W. Berry (1941) compared fossil and Recent specimens identified as *E. michelini.* The fossil specimens (Pl. 63, Figs. 1, 3, 7; Pl. 64, Figs. 1–6; Pl. 65, Figs. 1, 2) are here identified as *E. michelini.* The Recent specimens from Albatross Station 2609 (Pl. 63, Figs. 2, 5, 8) are specimens of *E. aberrans.* I have not tried to identify the juvenile specimens (Pl. 63,

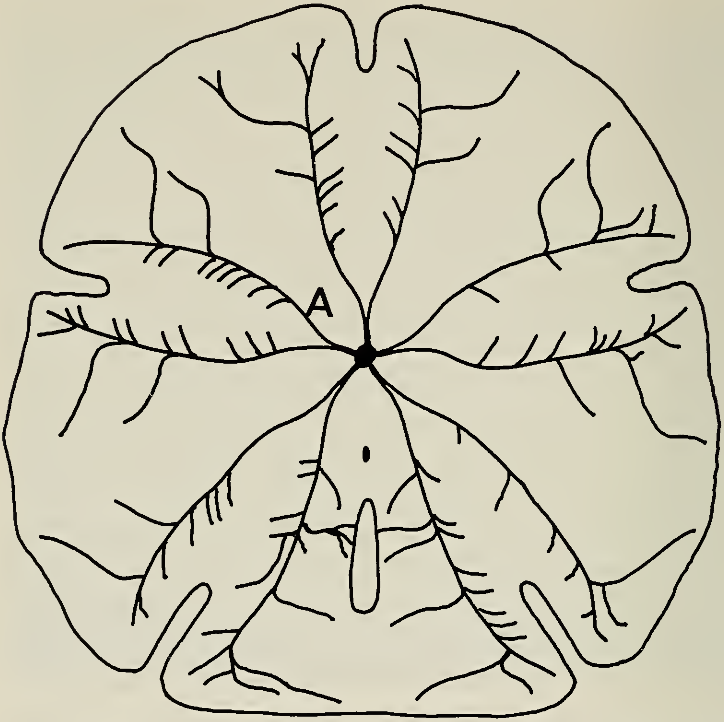

FIG. 7. Adoral view of *Encope michelini* L. Agassiz, length 112.6 mm; note the narrow curving food grooves and small peristome, USNM 174444.

Figs. 4, 6; Pl. 65, Figs. 3, 4, 6). The food groove and peristome size differences of the two *Encope* species are well illustrated by the two side-by-side photographs (Pl. 63, Figs. 7, 8).

Cooke (1942, p. 20, Pl. 3, Figs. 14, 15) reported finding fossil specimens of *E. emarginata* in the Carolinas. These specimens [*Mellita carolinana* (Ravenel)] are strikingly similar to but are not *E. emarginata* (see material examined under *E. emarginata* and the section on *Encope* posterior plate arrangement).

Cooke recognized that two distinct *Encope* species inhabited the coastal waters of the United States and occurred as fossils. Specimens of *E. michelini* he identified as *E. emarginata*

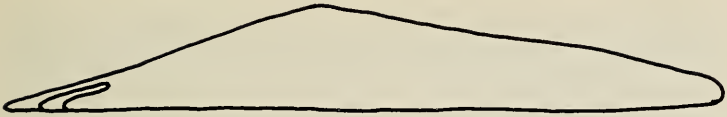

FIG. 8. Profile of right side of *Encope aberrans* Martens, length 113.1 mm, Tampa Bay, Florida, USNM 174443.

(Cooke 1959, Pl. 17, Fig. 5; Pl. 18, Fig. 1) and specimens of *E. aberrans* he identified as *E. michelini* (Cooke 1959, Pl. 18, Figs. 2, 3). Figuratively, although not literally, he was placing *E. michelini* in synonymy with *E. emarginata* and recognizing *E. aberrans* as a distinct species, because in his opinion all the features of *E. michelini* as described by L. Agassiz (1841, p. 58) were attributable to *E. emarginata.* The diagnostic features of *E. aberrans* (Martens 1867, p. 112) are the ones he retained for *E. michelini.* Cooke's opinion strengthened the widespread belief that *E. emarginata* occurred in the coastal waters of the United States.

Cooke (1961, p. 17, Pl. 6, Figs. 5, 6; Pl. 7, Fig. 5) reported fossil specimens of *E. michelini* from the Miocene of Venezuela. These are specimens of *E. aberrans.*

An unusual fossil population of *E. aberrans* was found and reported by Kier (1963, p. 33, Pl. 5, Fig. 1; Pl. 6, Figs. 3, 4; Text-figs. 25–30). I believe this population has more variation than expected in a normal population. The posterior interambulacral lunule size ranges from about the smallest normal size for *Encope aberrans* to complete lack of a lunule. The subspecies designation *E. michelini imperforate* Kier was due to the common opinion of many workers that specimens of *E. michelini* were *E. emarginata* and specimens of *E. aberrans* were *E. michelini.* It is evident that two species have commonly been recognized in the United States and its coastal waters.

Cerame-Vivas and Gray (1966, p. 263) reported collecting specimens of *E. emarginata* off the coast of North Carolina. Gray kindly sent specimens for me to examine, and they proved to be specimens of *E. michelini* and *E. aberrans.* Although he referred both species to *E. emarginata,* Gray (personal com-

Fig. 9. Adapical view of *Encope aberrans* Martens (same specimen as Figs. 8, 10).

munication, 1971) has informed me that he believes two species of *Encope* occur off the North Carolina coast.

*Definition of terms*: In the following diagnoses the terms large, medium, and small are used to indicate the relative size of a feature as compared to its equivalent on the other two of the three species.

### *Encope emarginata* (Leske) 1778

Figures 2A, 3, 4; Tables I, II.

*Echinodiscus emarginatus* Leske 1778, p. 136; Pl. 50, Figs. 5, 6.

*Encope emarginata* Agassiz, L. 1841, p. 47; Pl. 10, Figs. 1–6.—Agassiz, A. 1872, p. 325; Pl. 12b, Figs. 1–3; Pl. 12d, Figs. 2, 3 (not Pl. 12d, Fig. 1).—Durham 1955, p. 97; Fig. 17D. For additional synonymy see Mortensen 1948, p. 438.

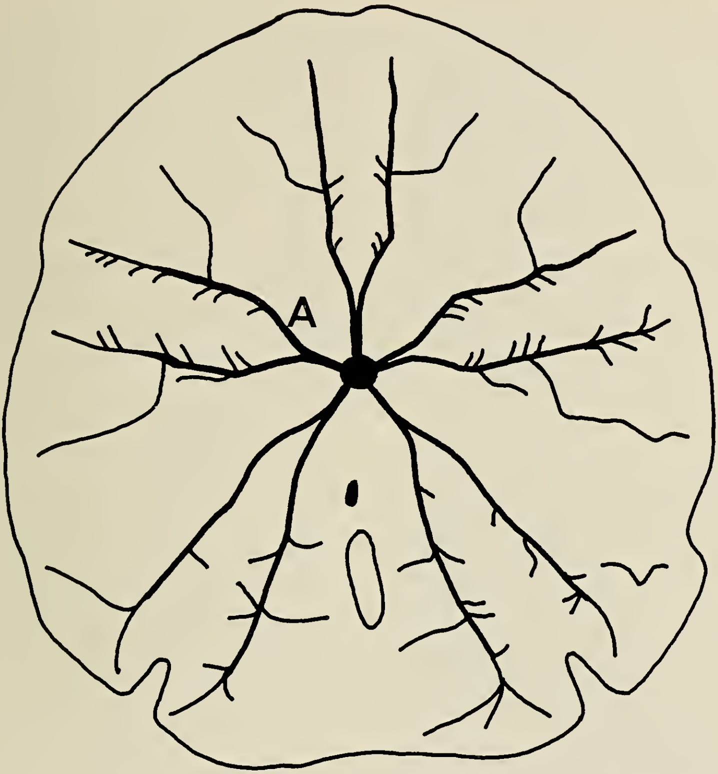

Fig. 10. Adoral view of *Encope aberrans* Martens, length 113.1 mm, note wide angular food grooves, large peristome, and slight indentations insead of notches in the margins of ambulacra II, III and IV. "A" is the point where food groove was measured on 10 specimens; USNM 174443.

*Diagnosis*: The adoral surface of the test is flat. Height is approximately 10 percent of the length. A long flattened area extends lengthwise across the apical system (Fig. 3) with the highest point commonly anterior to the apical system although on some specimens it is at a thick anterior edge of the posterior odd lunule. The large posterior interambulacral lunule is approximately 21 percent of specimen length. The five notches are nearly uniform, commonly closed to form lunules (Figs. 2A, 4). Open notches show a strong tendency to close (see left posterior notch, Fig. 4). The food grooves turn in gentle curves and are of medium width. There is a medium deep depression

TABLE I. Distinctive features of *E. emarginata*, *E. michelini*, and *E. aberrans*.

| | *E. emarginata* | *E. michelini* | *E. aberrans* |
|---|---|---|---|
| Ambulacral notches. | Closed, forming lunules or a very strong tendency to close (Figs. 2A, 4). | The three anterior deep, no tendency to close, posterior two deeper than the three anterior ones, posterior two have a slight tendency to close (Figs. 1, 2B, 6, 7). | The three anterior only slight indentations of the margin, depth of posterior two approximately equal to 1/12 specimen length (Figs. 2C, 9, 10). |
| Apex of the test. | A broad flattened zone extending from anterior of apical system to the posterior odd lunule, commonly with the highest point anterior of the apical system (Fig. 3). | Between the apical system and the posterior lunule (Fig. 5). | Between the apical system and the posterior lunule (Fig. 8). |
| Peristome (comparative). | Intermediate (Fig. 2A). | Small (Figs. 2B, 7). | Large (Figs. 2C, 10). |

Table I (continued)

| | *E. emarginata* | *E. michelini* | *E. aberrans* |
|---|---|---|---|
| Food grooves (comparative). | Intermediate width and depth, curving turns (Fig. 2A). | Narrow, shallow curving turns (Figs. 2B, 7). | Wide, deep, angular turns (Figs. 2C, 10). |
| Depth of adoral ambulacral midline depression. | Intermediate (Fig. 2A). | Deep (Fig. 2B). | Shallow (Fig. 2C). |
| Plates in contact with periproct. | Two ambulacral plates and first pair of post basicoronal interambulacral plates. | First pair of post basicoronal interambulacral plates. | First pair of post basicoronal interambulacral plates. |
| Posterior interambulacral lunule. | Large (Fig. 4). Distal end of posterior petals align at about midpoint of lunule. | Medium (Figs. 1, 6). Distal end of posterior petals align at about midpoint of lunule. | Small (Fig. 9). Distal end of posterior petals align with posterior edge of lunule. |

Table II. Statistics based on measurements of ten mature specimens of each species. Measurements are in millimeters. Standard deviation (S.D.) and variation coefficient (V.C.) are based on the means of the ratio: measured value/~~wave-~~length.

| | *E. emarginata* | *E. michelini* | *E. aberrans* |
|---|---|---|---|
| Length: | | | |
| Greatest | 140.7 | 117.2 | 143.3 |
| Least | 124.8 | 89.7 | 103.7 |
| Mean | 135.2 | 106.3 | 125.0 |
| Width: | | | |
| Greatest | 149.2 | 115.2 | 140.7 |
| Least | 128.8 | 90.7 | 98.9 |
| Mean | 138.1 | 104.0 | 120.8 |
| S.D. | .032 | .030 | .016 |
| V.C. | 3.18 | 3.06 | 1.67 |
| Height: | | | |
| Greatest | 16.4 | 13.1 | 21.2 |
| Least | 13.3 | 8.3 | 15.1 |
| Mean | 14.4 | 10.7 | 18.2 |
| S.D. | .006 | .007 | .014 |
| V.C. | 4.44 | 8.79 | 10.09 |
| Distance between peristome and periproct: | | | |
| Greatest | 16.0 | 10.9 | 23.6 |
| Least | 12.7 | 7.8 | 13.6 |
| Mean | 14.0 | 9.7 | 18.2 |
| S.D. | .008 | .005 | .015 |
| V.C. | 8.54 | 6.03 | 10.44 |
| Width of food groove: | | | |
| Greatest | 1.00 | .70 | 1.8 |
| Least | .70 | .40 | 1.2 |
| Mean | .84 | .51 | 1.4 |
| S.D. | .0005 | .0008 | .001 |
| V.C. | 8.80 | 16.13 | 9.76 |
| Depth of posterior paired notches: | | | |
| Greatest | 28.1 | 21.8 | 13.7 |
| Least | 17.6 | 15.4 | 4.7 |
| Mean | 23.6 | 18.5 | 9.4 |
| S.D. | .021 | .008 | .023 |
| V.C. | 12.03 | 5.12 | 30.49 |

TABLE II (continued).

| | *E. emarginata* | *E. michelini* | *E. aberrans* |
|---|---|---|---|
| Depth of anterior paired notches: | | | |
| Greatest | 21.4 | 14.2 | 4.40 |
| Least | 16.8 | 9.7 | 2.00 |
| Mean | 19.4 | 11.9 | 2.81 |
| S.D. | .007 | .007 | .005 |
| V.C. | 5.30 | 6.53 | 24.62 |
| Depth of anterior odd notch: | | | |
| Greatest | 16.5 | 11.8 | 3.00 |
| Least | 13.7 | 8.4 | .90 |
| Mean | 14.9 | 10.0 | 1.83 |
| S.D. | .005 | .005 | .005 |
| V.C. | 5.31 | 5.87 | 33.89 |
| Length of interambulacral lunule: | | | |
| Greatest | 38.7 | 15.9 | 11.6 |
| Least | 17.8 | 10.1 | 8.1 |
| Mean | 28.9 | 12.8 | 9.6 |
| S.D. | .045 | .016 | .0001 |
| V.C. | 21.48 | 13.22 | 14.82 |

in the ambulacral midline between the food grooves (Fig. 2A). The peristome is medium size. The periproct is almost completely enclosed by two ambulacral plates (Ia2 and Vb2). The first pair of posterior post basicoronal plates makes contact at the posterior edge of the periproct.

*Material examined*: Collections of Recent specimens at the National Museum of Natural History, USNM 8421, Sabanilla, Columbia; USNM E8102, Columbia; USNM E7862, USNM E533, USNM E539, Brazil; USNM E4695, Isle of Love; R. Chesher Collection, Caribbean coast of Panama, USNM uncatalogued; University of California, 33792, Locality A-4882, Desterro (now Florianapolis), Brazil (Durham 1955, p. 97, Fig. 17D).

The late Miocene specimens reported (Cooke, 1942) as *E. emarginata* have the interambulacral plates surrounding the periproct as in the genus *Mellita*. Approximately one-quarter of the specimens have five genital pores instead of four. These specimens are not considered *E. emarginata*: USNM 166525 (Cooke 1942, Pl. 3, Figs. 14, 15), large collection USGS locality 17733 Intercoastal Waterway, South Carolina, USNM uncatalogued.

*Distribution*: Caribbean coast of Central and South America, Atlantic coast of Brazil. Depth approximately 20–70 fathoms (based on USNM collections).

### *Encope michelini* L. Agassiz 1841

Figures 1, 2B, 5, 6, 7; Tables I, II.

*Encope michelini* Agassiz L. 1841, p. 58; Pl. 6a, Figs. 9, 10.—Agassiz, A. 1872, p. 330 (in part), Pl. 12d, Fig. 1 (not Pl. 12c, Figs. 3, 4; Pl. 12b, Fig. 4. These are *E. aberrans.*).—Mortensen 1948, p. 442 (in part), portion referring to a specimen from Charlotte Harbor only.—Caso 1961; Fig. 113.—Kier and Grant 1965, p. 33 (in part); Pl. 5, Fig. 7; Pl. 6, Figs. 9, 10; Pl. 7, Figs. 1–8; Pl. 15, Fig. 7; Text-fig. 7.

*Encope emarginata* Cooke 1959, p. 49; Pl. 17, Fig. 5; Pl. 18, Fig. 1 (not Pl. 18, Figs. 2, 3. These are *E. aberrans.*).

*Diagnosis:* The adoral surface of the test is flat. Height is approximately 11 percent of specimen length. The apex of the test (Fig. 5) is between the apical system and the posterior lunule. The medium sized lunule opening is approximately 12 percent of specimen length. Notches are open, deep and uniform. The posterior notches are a little deeper than the three anterior ones. None of the notches close to form lunules but the two posterior ones are slightly narrowed at the openings (Figs. 1, 6). I examined one fossil specimen (USNM 174698) in which the posterior notches were closed by a slight bridging across the opening. Berry (1941, Pl. 64, Fig. 6) illustrated a fossil with the right posterior notch closed in similar fashion. These are uncommon occurrences.

I have not seen any Recent specimens with closed notches. On Recent specimens that I observed with very narrow anterior notches the sides of the openings were parallel with no tendency to close. Food groves (Figs. 2B, 7) are shallow, very narrow, and turn in gentle curves toward the peristome. A deep depression extends down the ambulacral midline from each notch. The peristome (Figs. 2B, 7) is small. The periproct is entirely enclosed by the first posterior pair of post basicoronal interambulacral plates. These plates extend into the posterior lunule. The series of plates in interambulacrum 5 is uninterrupted by ambulacral plates. It is interrupted in *E. emarginata.* I consider this an important diagnostic feature distinguishing this species from *E. emarginata.*

Juvenile specimens of *E. emarginata,* with notches not yet closed to form lunules, superficially resemble specimens of *E. michelini.* A juvenile specimen of *E. emarginata* 73.7 mm in length figured by Durham (1955, p. 97, Fig. 17D) has a marginal outline very similar to specimens of *E. michelini,* but note that two ambulacral plates (Ia2 and Vb2) and the first pair of posterior interambulacral plates are in contact with the periproct. This specimen was incorrectly reported from the Gulf of Mexico, but was collected off Desterro (now Florianopolis), Brazil.

Prior to the development of the three anterior notches, juvenile specimens of *E. michelini* have a marginal outline similar to specimens of *E. aberrans*, but the small peristome in *E. michelini* can be used to distinguish between these two species except in the case of very small specimens.

*Material examined*: Collections at the National Museum of Natural History, USNM 174444, 12 miles southeast of Sapelo Island, Georgia; USNM 562282 (fossil), South Carolina figured as *E. emarginata* (Cooke 1959, Pl. 17, Fig. 6; Pl. 18, Fig. 11); USNM 174698 (fossil), South Carolina, large collection USNM uncatalogued Sister Rock, Florida Keys; Duke University Eastward Cruise E-33-67, Station 7702.

*Distribution*: Cape Hatteras, North Carolina, to northeastern coast of Florida, Florida Keys, Florida and Texas Gulf Coasts, northern coast of Yucatan Peninsula. Depth 6 to 90 meters (based on USNM collections).

### *Encope aberrans* Martens 1867

Figures 2C, 8, 9, 10; Tables I, II.

*Encope aberrans* Martens 1867, p. 112.

*Encope michelini* A. Agassiz 1872, p. 330 (in part); Pl. 12b, Fig. 4; Pl. 12c, Figs. 3, 4 (not Pl. 12c, Fig. 1).—Berry 1941 (in part); Pl. 63, Figs. 2, 5, 8 (not Pl. 63, Figs. 1, 3, 7; Pl. 64, Figs. 1–6; Pl. 65, Figs. 1, 2).—Mortensen 1948 (description in part), p. 442 (only the portion describing the indentations of the margin and the vortex of the test).—Cooke 1959, Pl. 18, Figs. 2, 3.—Cooke 1961, p. 17; Pl. 6, Figs. 5, 6; Pl. 7, Fig. 5.

*Encope michelini imperforata* Kier 1963, p. 35; Pl. 5, Fig. 1; Pl. 6, Figs. 3, 4; Text-figs. 25–30.

*Diagnosis*: The adoral surface of the test is flat. Height is approximately 15 percent of the length. The apex of the test is situated between the apical system and the small posterior interambulacral lunule (Fig. 8). The small lunule opening is approximately 8 percent of the length of the specimen (Fig. 9). Notches of the posterior paired ambulacra are small. Depth is approximately 7 percent of specimen length. There is no tendency for the notches to close. Notches of the anterior odd and paired ambulacra are very shallow to slight indentations (Figs. 2C, 9). Some fossil specimens have slightly deeper V-shaped notches and indentations than found on Recent specimens. Food grooves (Figs. 2C, 10) are deep and very wide, even prominent with spines in place. The turns of the food grooves are very angular. There is a very shallow depression in the ambulacral midline between the food grooves. The peristome is large (Figs. 2C, 10), very noticeably larger than in specimens of *E. michelini*. The periproct is completely enclosed by the first posterior pair of post basicoronal interambulacral plates. These plates extend into the small posterior lunule. The series of plates in interambulacrum 5 is uninterrupted as in *E. michelini.*

*Type-locality*: Campeche Bay, Mexico.

*Material examined*: Collections of Recent specimens at the National Museum of Natural History, USNM 12940, Albatross Station 2609; USNM 174443, Tampa Bay, Florida; USNM 562283, Gulf of Mexico, two miles off Longboat Key, Florida, figured as *E. michelini* (Cooke 1959, Pl. 18, Figs. 2, 3); USNM uncatalogued collection dredged off South Carolina; Duke University specimen, Eastward Cruise E-25-66, Station 4941; fossil specimen from the Miocene of Venezuela, USNM 638631 figured as *E. michelini* (Cooke 1961, Pl. 6, Figs. 5, 6; Pl. 7, Fig. 5); specimens figured as *E. michelini imperforata* Kier (1963, p. 33; Pl. 5, Fig. 1; Pl. 6, Figs. 3, 4; Text-figs. 25–30); USNM 648169, USNM 648167 (Holotype), USNM 648170, USNM 648168, USNM 648171, USNM 648172, and 10 USNM uncatalogued specimens.

*Conclusions*: A detailed examination of collections indicates that *E. emarginata* does not occur off the Atlantic and Gulf coasts of the United States. A study of the adoral food gathering surface on specimens of *E. michelini* and *E. aberrans* indicates distinct differences in food groove width, depth and shape, and peristome size. Populations of the two species tend to inhabit separate zones even when geographically in close proximity to each other. A study of the variation in marginal indentations, notches, and posterior interambulacral lunules indicates a wide separation between these two species. As a result I believe *E. aberrans* is a distinct species from *E. michelini* and henceforth should not be considered by echinoid workers as a junior synonym of *E. michelini.*

## Posterior Plate Arrangement

After completing the foregoing study I checked the interambulacrum 5 plate arrangement of other available *Encope* species to determine which had post basicoronal interambulacral plates in contact with the basicoronal interambulacral plate (continuous series), and which had post basicoronal ambulacral plates Ia2 and Vb2 interrupting the series (interrupted series). See Durham 1955, p. 174, figures 16a, 17c, d.

Species with a continuous series [*Encope* (*Encope*) L. Agassiz]:

- *E. aberrans* Martens
- *E. grandis* L. Agassiz (periproct in contact with basicoronal plate)
- *E. michelini* L. Agassiz
- *E. tamiamiensis* Mansfield (fossil)
- *E. platytata* Jackson (fossil)

Species with an interrupted series [*Encope* (**Echinadesma**) new subgenus]:

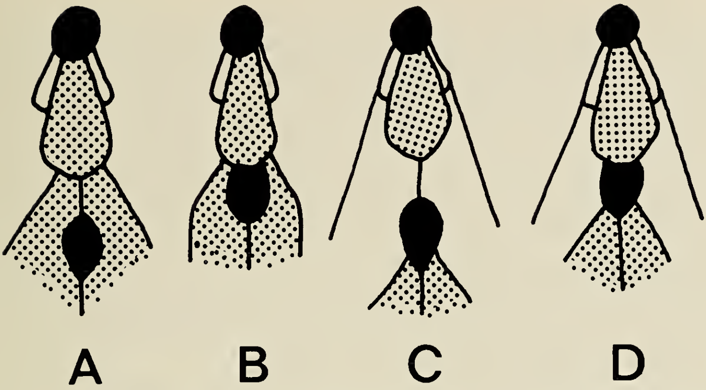

FIG. 11. Continuous and interrupted series of posterior interambulacral plates occurring in *Encope* echinoids. A. Continuous series with only the first pair of post basicoronal plates in contact with the periproct. B. Continuous series, periproct in contact with basicoronal plate and first pair of post basicoronal plates. C. Interrupted series, ambulacral plates Ia2 and Vb2 and first pair of post basicoronal interambulacral plates in contact with periproct. D. Interrupted series, periproct in in contact with basicoronal plate, ambulacral plates Ia2 and Vb2, and first pair of post basicoronal interambulacral plates. A and B illustrate the plate arrangement in the subgenus *Encope* (*Encope*) L. Agassiz. C and D are of the new subgenus *Encope* (*Echinadesma*).

*E. emarginata* (Leske) (including *E. valenciennesii* L. Agassiz)
*E. micropora* L. Agassiz (including *E. californica* Verrill and *E. irregularis* H. Clark)
*E. perspectiva* L. Agassiz (periproct in contact with basicoronal plate)
*E. wetmorei* A. Clark (periproct in contact with basicoronal plate)
*E. secoensis* Cooke (fossil).

*Conclusions*: The genus *Encope* has two basic interambulacrum 5 plate series arrangements, continuous and interrupted. Both arrangements occur in fossil and Recent species, and in Recent Atlantic and Pacific species. Each group has species with the periproct in contact with the basicoronal plate, therefore there are four general patterns of plates surrounding the periproct (Fig. 11).

The continuous series in interambulacrum 5 is the more primitive form, but the periproct has migrated toward and made contact with the basicoronal plate in species with the interrupted and continuous series indicating parallel evolution. All *Encope* species with interambulacrum 5 interrupted by ambulacral plates Ia2 and Vb2 (Fig.

11C, d) are assigned to the new subgenus *Encope* (*Echinadesma*) with *Encope* (*Echinadesma*) *micropora* L. Agassiz designated the type-species. The name *Echinadesma*, derived from Echin[os]: Gr. spiny a: Gr. not desm[os]: Gr. linked, indicates the lack of a continuous series of plates in interambulacrum 5. All *Encope* species with a continuous series of plates in ambulacrum 5 (Fig. 11A, B) are assigned to the subgenus *Encope* (*Encope*) L. Agassiz with *Encope* (*Encope*) *grandis* L. Agassiz the type species by original designation. I believe the genus *Mellita* evolved from the continuous interambulacrum 5 stock of *Encope*. *Mellita carolinana* (Ravenel) from the upper Miocene of South Carolina probably is very close to the base of the *Mellita* stock. It has the massive calcite test of *Encope*, approximately 25 percent of the specimens have five genital pores but the periproct is inserted well into the basicoronal plate.

*Material examined*: *E.* (*Encope*) *aberrans* USNM 170549, dredged off South Carolina; USNM 638631 Miocene of Venezuela; *E.* (*Encope*) *grandis* USNM E7455 Bahia Adair, Lower California; *E.* (*Encope*) *michelini* USNM 174698, Pleistocene, near Myrtle Beach, South Carolina; USNM uncatalogued, large collection from west of Sister Rock, Florida Keys; *E.* (*Encope*) *tamiamiensis*, USNM 648141, Miocene, Florida; *E.* (*Encope*) *platytata* Jackson (holotype), USNM 324455, Miocene, Canal Zone; *E.* (*Echinadesma*) *emarginata*, USNM 8421, Sabanilla, Columbia; University of California, 33792, locality A-4882 Desterro (now Florianapolis), Brazil; *E.* (*Echinadesma*) *valenciennesii*, USNM 3607, Cumana, Venezuela; *E.* (*Echinadesma*) *micropora*, USNM E1396, Salinas Bay, Nicaragua; *E.* (*Echinadesma*) *californica*, USNM 33206, Galapagos Islands; USNM 10010 La Paz, Mexico; *E.* (*Echinadesma*) *irregularis* H. Clark, USNM E8837, Peru; *E.* (*Echinadesma*) *wetmorei*, USNM E7165, Petatlan Bay, Guerrero, Mexico; *E.* (*Echinadesma*) *perspectiva*, USNM E5635, Lower California; *E.* (*Echinadesma*) *secoensis*, USNM 649218, USNM 649219 (paratypes), Pliocene, Venezuela.

## Acknowledgments

I thank Carol Wagner Allison, University of Alaska, for calling my attention to Marten's description of *E. aberrans*; Astrid Witmer, Freie Universität, Berlin, for translating Marten's description; Porter M. Kier for encouraging me to publish these findings and for reviewing the manuscript; J. Wyatt Durham for reviewing the manuscript and the loan of a specimen; David Pawson for constructive criticism of the manuscript; Keith Serafy, University of Maine, who checked the National Collection to determine the distribution of the *Encope* species; I. E. Gray, Duke University Marine Laboratory, for comments on *Encope* distribution and the loan of specimens; and Donna Copeland for typing the manuscript.

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Vol. 85, No. 9, pp. 131–138 30 August 1972

PROCEEDINGS
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# THE NOMENCLATURE OF *PIPILO ABERTI* BAIRD (AVES: FRINGILLIDAE)

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*Pipilo aberti*, or Abert's Towhee, was described from an apparently dataless and now lost specimen from the collection of Lt. James W. Abert, for whom the species is named (Baird, 1852). For over a century the type-locality was assumed to be in the eastern part of the species' range, and probably in New Mexico. Recently, Phillips (1962) rejected this assessment and instead designated the type-locality in the western reaches of the range, in the vicinity of Gila Bend, Maricopa County, Arizona. With this shift Phillips renamed the eastern race as *P. a. vorhiesi* Phillips (type-locality: ca. 15 km south of Tucson, Arizona), and made *P. a. dumeticolus* van Rossem (type-locality: 3 miles northwest of Calexico, Imperial County, California) a synonym of the newly nominate western race. Although Phillips' proposals have been accepted by Paynter (1970: 179), a further examination of them and other details is desirable.

One of Phillips' bases for rejecting an eastern type-locality for *P. aberti* is his assertion that Baird's original description fits the western rather than the eastern race of the species. There are two races of *P. aberti*, a paler and redder western form and a darker and grayer eastern form. While not extremely well marked, the two are nevertheless sufficiently distinct for formal recognition as subspecies. (Some question exists over the geographic limits of the two, but Phillips with

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better material is probably correct in extending the Colorado Valley race eastward along the Gila River to central Arizona.) Phillips (ibid.: 364) assigns the type to the western population on the basis that the original description ". . . . *hace hincapié en el dorso moreno-oriniento del tipo, que no destacaba de los lados del cuello o de las partes inferiores.*" (i.e., ". . . . lays emphasis on the type's rusty-brown dorsum, which is not set off from the sides of the neck or the underparts."). What Baird (1852: 325) actually said was "colour above. . . . a nearly uniform rusty-brown, *or* (italics mine) olive, . . .; beneath, and on the sides of the neck, the colour is much like that of the back, [but] with a stronger tinge of ferruginous, . . . . which becomes very decided about the lower tail coverts." Phillips' interpretation of Baird's statements is of a uniformly rusty-brown bird (which would suggest western *P. aberti*), but as can be seen from above this assessment is not accurate. The color of the upperparts of the type was given by Baird as rusty-brown *or* olive, which is ambiguous because the two hues are not generally considered to be very similar. I think this ambiguity, or at least lack of clarity, invalidates any claim that the type of *P. aberti* is assignable to subspecies level on the basis of dorsal coloration. Furthermore, Baird *does* imply contrast between the upperparts and the lower parts (including the sides of the neck), contrary to Phillips. Rather than arguing that this would more likely refer the type to the eastern race, however, I would simply contend that the original description does not allow one to single out either race.

The ambiguity or lack of clarity in the original description is not the only factor which undermines its value in assessing the subspecific identity of the type. For example, not only is color variation subtle in this species, but it is subject to various post-mortem changes as reviewers since van Rossem (1946) have been aware. The condition of the type is not precisely known, but the bird had suffered some mutilation (Baird 1852: 325) and may well have been unsatisfactory for determination of subspecific identity. In the catalog of the United States National Museum it bore the notation: "was in mounted series in 1863 and was marked as 'bad' and to be replaced."

These facts do not evoke confidence in the finer points of Baird's description, and there is at least a suggestion that the type may have been a mounted bird (and thus subject to fading, soiling, etc.) at the time he examined it. When one considers the above factors, plus our lack of knowledge of the age, sex, and plumage wear of the type, the task of identifying Abert's specimen to a given population becomes one of extreme speculation. In fact, based on the present evidence, it would appear impossible to justify such a determination, and therefore Phillips' (1962) assessment is rejected. Thus the question of designating a type-locality of *P. aberti* must rest on grounds other than Baird's original description. This being the case, the matter would then hinge mainly on a satisfactory reconstruction of the possible origin of the type.

Phillips (1962), as well as Davis (1951), expressed doubt that Lt. Abert himself had collected the type of *P. aberti*, and judging from his itinerary (Cooke, *in* Bailey 1928: 17–18) they probably are correct. Abert was never in the present range of the species, the closest approach being in the Rio Grande Valley at Valverde, Socorro County, New Mexico. That point is about 110 miles northeast of the nearest population of *P. aberti*, in the Gila Valley of New Mexico. Of course, it is possible that the type was a stray, as Cooke (ibid.: 718) suggests, but Abert (1882) made no mention of the species among those seen in New Mexico in 1846–47. Davis (1951) suggested that Abert may have received the bird from members of a U. S. Army expedition that entered the Gila Valley in October 1846. Abert was to have been a member of that expedition, but illness prevented him from joining it (Cooke, ibid.: 17). He did follow it as far as south of Valverde, however, and would certainly have been in the path of men turning back to Santa Fe from the Gila Valley in the autumn of 1846.

Phillips (1962), partly because of his opinion on the subspecific allocation of the type, suggests another possible origin of the specimen. He mentions that Col. John J. Abert also provided specimens to the United States National Museum, and from their localities it seems that he was better traveled than Lt. Abert, including probably to Mazatlán, Sinaloa, Mex-

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ico, and perhaps Hawaii. Had Col. Abert, or someone he knew, traveled to Mazatlán, Phillips surmises that he would have passed through southern Arizona. This hypothetical traveler would probably have stopped at the villages of the Pima Indians near the present Gila Bend, where *P. aberti* would have been less shy and more vulnerable to casual collecting. There, Phillips thinks that the specimen of the species could have been collected and subsequently found its way to Baird.

Discounting the subspecific allocation of the type of *P. aberti*, Phillips' basis for designating the type-locality as to Pima villages rests mainly on his supposition that the species must have been taken where it was presumably most available. There are numerous species which have been described from vagrants or at least from parts of their range where they were not the most common, so that availability alone cannot be the deciding criterion. We have no evidence that Col. Abert, who was the father of Lt. Abert, did indeed enter southern Arizona or knew anyone who did. The specimens from Mazatlán could just as well have been taken by a maritime as an overland traveler. Since they were not cataloged (as were Lt. Abert's birds) at the United States National Museum until 1859, there is no assurance that they have a bearing on *P. aberti*, described 7 years earlier. On the other hand, Baird (1852: 308) specifically stated that the small collection containing *P. aberti* was procured by Lt. Abert, although it was Col. Abert who permitted Baird to examine and publish on the material. The implication is that Col. Abert turned the specimens over to Baird with the belief that his son had taken them in New Mexico and that they were relevant to Baird's report. Incidentally, had Baird been correct in his assumption that Lt. Abert himself discovered *P. aberti* (which we may now doubt), the type-locality would have to be in the present boundaries of New Mexico and not in the larger area that included Arizona.

If one assumes that the type of *P. aberti* was acquired by Lt. Abert rather than his father and that Lt. Abert himself did not collect it, a probable source, as already mentioned, would have been the U. S. Army expedition to the Gila Valley.

Members of that expedition included both W. H. Emory and A. R. Johnston, who made biological notes on the trip, collected plants, and made scientific drawings (Emory, 1848). They entered the Gila Valley on 20 October 1846 and were thus among the very first naturalists to penetrate the range of *P. aberti.* They are not definitely known to have taken birds, but they made ornithological observations and the collection of occasional avian specimens would not have been unexpected. Such specimens may have later found their way into the hands of Lt. Abert, including not only the type of *P. aberti* but also two other species reported in his collection by Baird (1852), but not mentioned by Abert (1882): *Lophortyx gambelii* and *Zenaida asiatica.* Both Emory and Johnston mention the former as being numerous on the first date of entry into the Gila Valley, and it is conceivable that the specimen was taken then. The specimen of *Zenaida asiatica* would more likely have come from farther west, but H. W. Henshaw (1874) reported taking one in the New Mexico portion of the Gila Valley on 28 October 1873, so that one cannot entirely discount the possibility of Emory's expedition having taken it there.

Of course, even if one accepts this suggested origin of the type of *P. aberti*, there is no way of conclusively establishing where it was taken. The expedition followed the length of the Gila River in moving westward, thus crossing the ranges of both races of the species (including at the Pima villages). On the other hand, there is no reason to assume that the two naturalists would have been unable to collect *P. aberti* in the eastern parts of its range, even in the face of its shyness there. Frank Stephens (Stevens [sic], 1878) was to find the bird common in the Gila Valley of New Mexico in 1876, and there is no reason to think it was less numerous or less detectable 30 years earlier by Emory's party. In fact, one might be tempted to choose an eastern origin of the type on the assumption that the earlier in the autumn of 1846 the specimen of *P. aberti* was taken, the more likely it is to have been sent back to Lt. Abert. There are, however, more compelling reasons for accepting an eastern type locality.

We are faced with two theories regarding the geographic origin of the type of *P. aberti*, but on the basis of evidence summarized above I feel that neither is clearly superior to the other. Acceptance of this assessment means that the choice of one over the other rests on other bases. Considering the interest of preserving nomenclatural stability within *P. aberti*, the traditional concept of an eastern origin of the type is obviously the better choice. Workers accepted this concept for 110 years, including van Rossem, the first reviser and describer of subspecies (1946), and Davis, the second and most thorough reviser (1951). Van Rossem tacitly accepted the assessment of the general type-locality by such workers as Baird (1852) and Cooke (*in* Bailey, 1928) as New Mexico (and perhaps in the Rio Grande Valley). Davis concurred with the general area being New Mexico, but suggested the Gila Valley (possibly near Cliff or Redrock) as the probable source without formally designating such. Because Phillips (1952) has produced no compelling evidence for overturning the traditional concept and the earlier name *P. a. dumeticolus*, I feel that his proposed type-locality of Gila Bend, Arizona, should be rejected. In its stead I am designating as the type-locality the first place at which the Emory expedition entered the range of *P. aberti*: the Gila Valley at the mouth of Mangas Creek, ca. 7 miles south of Cliff, Grant County, New Mexico. *P. a. vorhiesi* Phillips thus becomes a synonym of the nominate race, as Tucson birds are similar to those of New Mexico.

Early drafts of this paper were read and commented on by John Davis, Eugene Eisenmann, and Allan R. Phillips, to whom I tender my thanks. I appreciate the use of collections and library facilities of the National Museum of Natural History, Smithsonian Institution, and the Academy of Natural Sciences of Philadelphia.

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Vol. 85, No. 10, pp. 139–146 30 August 1972

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OF THE
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# A NEW GENUS AND TWO NEW SPECIES OF MADICOLOUS BEETLES FROM VENEZUELA (COLEOPTERA: HYDROPHILIDAE)[1]

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Among those beetles that have become adapted to an aquatic existence, the majority are found in typical lentic habitats, e.g., puddles, water-filled ditches, pools, ponds, and lakes. However, some beetles have become adapted to more specialized aquatic niches and belong to the madicolous faunas. Madicolous habitats may appear to be unrewarding and even unlikely places to find aquatic insects for collectors familiar with the rich variety of taxa frequently found in lentic habitats. However, minor and atypical habitats will not be overlooked if one applies the rule that aquatic insects may occur wherever water occurs. Madicoles living in streamside niches have been studied as part of complete stream surveys and are, therefore, reasonably well known. Those forms living in hygropetric habitats unassociated with streams are less well known and it is in these microhabitats where rare and new taxa often may be found. The new taxa described below were found in madicolous habitats in the mountains of northwestern Venezuela.

## Hydrobiini

### **Notionotus** new genus

Head with clypeus expanded and shelflike in front of eyes and feebly emarginate along anterior margin. Eyes viewed from above somewhat reniform. Antenna 8 segmented; 2 basal, 2 intermediates, 1 cupule and 3 club segments. Maxillary palpus short, robust, and 4 segmented; basal

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[1] This study was made possible by Smithsonian Institution Grant No. Sg 063310.

segment very short; second segment longest, as long as ultimate and penultimate combined; ultimate segment about twice as long as penultimate. Prosternum longitudinally carinate on midline, acutely angulate at apex. Prosternal process distinctly produced posteriorly, distinctly separating front coxae, apex concave for articulation with mesosternal protuberance. Elytra convex; shining; finely, sparsely punctate; narrowly margined laterally; without sutural striae; epipleura almost vertical. Mesosternum with prominent triangular protuberance on same plane as metasternum. Metasternum with apex broad between middle coxae, and merging with prominent triangular protuberance of mesosternum. Front and middle femora moderately densely punctate and pubescent beneath on basal three-fourths. Hind femur sparsely punctate and finely pubescent beneath; pubescence absent from hind margin and distal fifth.

*Type of the genus*: *Notionotus rosalesi* new species. Gender: masculine.

*Etymology*: *Notionotus* from notios, G.—wet, plus notos, G.—back; in reference to the usual condition under which these beetles have been found, i.e., creeping around on a rocky or leafy substrate beneath a thin film of slowly flowing water.

The new genus described above belongs to the tribe Hydrobiini and superficially resembles the genera *Paracymus* and *Anacaena*. However, *Notionotus* may be distinguished from both *Paracymus* and *Anacaena* immediately by the absence of a sutural stria on each elytron. In addition, *Notionotus* differs from *Paracymus* by the presence of a distinct mesosternal protuberance extending between the procoxae on the same plane as the metasternum and the absence of a median, longitudinal carina on the first abdominal sternum. *Paracymus* has a distinct longitudinal carina behind the anterior $\wedge$-shaped protuberance of the mesosternum and most species have a median, longitudinal carina on the first abdominal sternum. *Notionotus* also differs from *Anacaena* by the presence of a distinct prosternal carina. In d'Orchymont's (1942) key to the tribe Hydrobiini, *Notionotus* keys to the subtribe Hydrobiae. In his key to the genera in the Hydrobiae, *Notionotus* keys to couplet 16 because it lacks a sutural stria, has eight segments in the antenna, the eyes viewed from above are somewhat reniform and the maxillary palpi are short and robust. From *Oocyclus* and *Beralitra*, which d'Orchymont separated in couplet 16, the new genus may be distinguished readily by the following couplets.[2]

1. Apex of metasternum broad between middle coxae and extending on the same plane onto the prominent triangular protuberance of the mesosternum; elytra shining and with a few fine, widely spaced punctures on surface; length 1.73–1.97 mm;

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[2] Couplets modified from d'Orchymont's (1942) key.

South America ........................................ *Notionotus* Spangler

Apex of metasternum very narrow between middle coxae, almost laminate, then meeting the elliptical or ovoid protuberance of mesosternum; elytra shining or not, but with numerous coarse punctures and frequently with tufts of golden setae spaced regularly along striae or serial rows of punctures; length 2.95–6.52 mm ........................................ 2

2. Elytral suture not raised posteriorly; form more or less hemispherical; eyes seen from above approaching each other posteriorly; Central and South America, Ceylon, and Sumatra ........................................ *Oocyclus* Sharp

Elytral suture raised posteriorly; form depressed with the elytra more or less dilate-explanate on the sides; elytral epipleura horizontal posteriorly, developed to the sutural angle; South America ........................................ *Beralitra* d'Orchymont

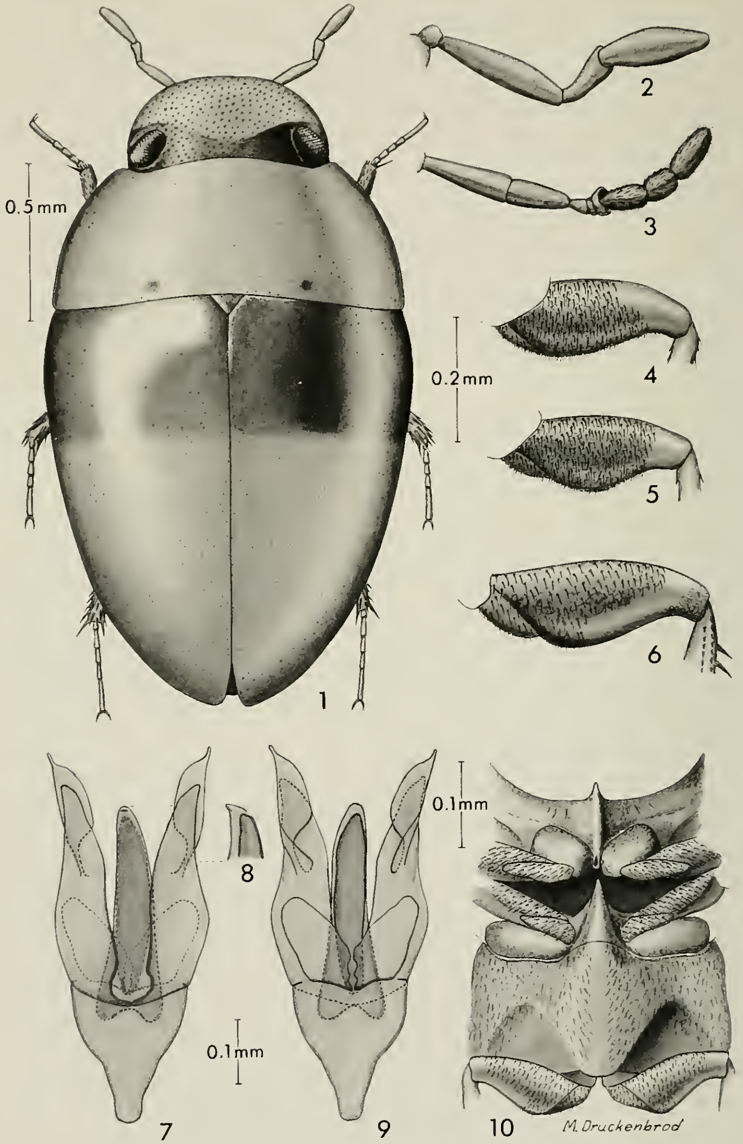
**Notionotus rosalesi** new species

Figures 1–10

*Holotype male*: Length 1.92 mm, greatest width 1.10 mm at midlength. Color of head mostly testaceous, reddish brown medially and along basal margin of head. Pronotum testaceous except two small black spots along hind margin and separated about one-third the width of hind margin. Scutellum testaceous. Elytra testaceous except a dark reddish-brown band across basal third. Mouthparts, antennae, and legs mostly testaceous; underside of head darker reddish brown; prosternum testaceous but carina darker; mesosternum and anterior half of metasternum dark reddish brown; posterior half of metasternum testaceous. Abdominal sterna dark reddish brown.

Head shining; with fine, widely spaced punctures over surface, punctures separated by about 5 times their width. Clypeus greatly expanded and shelflike in front of eyes, covering much of labrum; finely alutaceous along anterior margin. Labrum finely alutaceous over entire surface and shallowly emarginate medially. Ventral surface of head finely alutaceous behind eyes and in gular region; mentum smooth except for fine, sparse punctures. Antenna 8 segmented; 2 basals, 2 intermediates, 1 cupule and 3 club segments; club segments darkest. Maxillary palpus 4 segmented; basal segment very short; second segment longest, almost as long as ultimate and penultimate segments combined; ultimate segment about twice as long as penultimate segment. Labial palpus small; 3 segmented; first segment short, about half as long as second segment; second segment about two-thirds as long as ultimate segment, with 1 long yellow seta on apicodorsal angle; ultimate segment broadest, swollen dorsoventrally, with 1 long yellow seta at apicoventral angle.

Pronotum almost 3 times as wide as long; punctures finer than on head and very sparse; narrowly margined laterally; anterolateral and posterolateral angles rounded. Prosternum longitudinally carinate on



FIGS. 1–10. *Notionotus rosalesi* new genus, new species, ♂ holotype: 1. habitus, dv; 2. maxillary palpus, vv; 3. antenna, vv; 4. profemur, vv; 5. mesofemur, vv; 6. metafemur, vv; 7. genitalia, dv; 8. median lobe

midline, acutely angulate at apex. Prosternal process distinctly produced posteriorly, distinctly separating front coxae; apex concave for articulation with mesosternal protuberance.

Elytra convex, narrowly margined laterally; widest slightly before midlength; surface with very fine, sparse punctures similar to pronotum. Sutural stria absent. Scutellum a small equal-sided triangle. Epipleura almost vertical.

Mesosternum finely alutaceous, with prominent triangular posteromedial protuberance on same plane as metasternum. Metasternum smooth and impunctate on swollen medial region but finely alutaceous laterally; apex broad between middle coxae and extending on same plane onto the prominent triangular protuberance of mesosternum. Abdominal sterna finely alutaceous and moderately densely covered with short yellowish pubescence.

Front and middle legs with femora finely, densely punctate and densely pubescent on basal four-fifths. Hind femur smooth except for fine, sparse, seta-bearing punctures on basal four-fifths (Fig. 6); apical fifth finely alutaceous. Trochanter densely pubescent. Tarsal formula 5–5–5. Foreleg with segments 1 to 4 about equal in length; fifth segment about as long as segments 1 to 4 combined. Midleg with first, second, and third segments subequal; fourth segment shortest, about one-third as long as fifth segment; fifth segment slightly shorter than second, third, and fourth segments combined. Hindleg with basal segment short, about as long as fourth segment; second and third segments about equal in length; fourth segment slightly less than half as long as fifth segment; fifth segment about as long as third and fourth segments combined.

Genitalia as illustrated (Figs. 7, 8, 9).

*Allotype*: Similar to male except mentum slightly less punctate.

*Variations*: The specimens vary in size as follows. Male: length, 1.73 to 1.92 mm (avg. 1.82 mm); width, 1.80 to 2.00 mm (avg. 1.60 mm). Female: length, 1.73 to 1.97 mm (avg. 1.82 mm); width, 1.80 to 2.05 mm (avg. 1.88 mm). In addition to size difference, four specimens have a row of fine, indistinct punctures near suture. On two other specimens these punctures are coarse and distinct.

*Type-data*: Holotype male, Venezuela: Aragua: Rancho Grande (10 km S), 14 February 1969, Paul and Phyllis Spangler. USNM Type 71950, deposited in the National Museum of Natural History, Smithsonian Institution. Allotype, same data as holotype. Paratypes: same data as holotype, 2♀♀. Aragua: Rancho Grande, (15 km N), 20 February 1969, 1♂. Barinas: Barinitas, (24 km NW), 23 February 1969. All specimens were collected by Paul and Phyllis Spangler.

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apex, lv; 9. genitalia, vv; 10. pro-, meso-, metasterna, vv. (vv = ventral view; dv = dorsal view; lv = lateral view.)

*Etymology*: I take great pleasure in dedicating this new species to my friend Dr. Carlos J. Rosales, professor at the Universidad Central, Maracay, Venezuela. Dr. Rosales and his associates kindly arranged for us to use the facilities at Rancho Grande where we found the new genus and species described above. He also led us on a delightful 5-day field excursion to the state of Barinas where we found the second new species described below.

*Habitat*: The type-specimens were found in a small spring brook 10 km south of Rancho Grande at approximately 1,300 feet elevation. Specimens were collected from a small pool on the north side of and adjacent to Highway 3. The pool was in bedrock and the bottom was covered with rotting leaves. The paratype from 15 km north of Rancho Grande was found below a small dam built across a spring brook also at approximately 1,300 feet elevation. This specimen was found beneath leaves in a seepage area below the dam. The paratype from 24 km northwest of Barinitas was found beneath a leaf in water seeping over a rock outcrop exposed by a road cut.

### **Notionotus liparus** new species

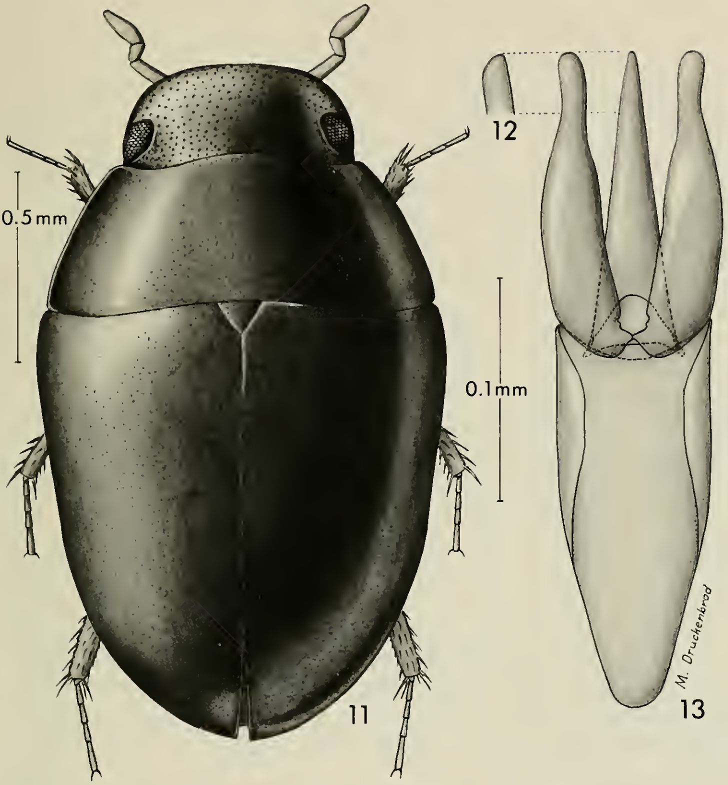
Figures 11, 12, 13

*Notionotus liparus* may be distinguished from *N. rosalesi* immediately by its piceous color (Fig. 11), and distinctively different genitalia (Fig. 13).

*Holotype male*: Length 1.65 mm, greatest width 1.00 mm at midlength. Color above piceous except lateral and anterior margins of pronotum and sides of elytra dark reddish brown. Ventral surface of head, mouthparts, prosternum, epipleura, and legs reddish brown. Mesosternum, metasternum, and abdominal sterna piceous.

Head shining, with fine punctures separated by about 2 times their width. Clypeus greatly expanded and shelflike in front of eyes, covering much of labrum; feebly emarginate along anterior margin. Labrum smooth except for a few fine punctures; shallowly emarginate medially. Ventral surface of head finely alutaceous behind eyes and in gular region; mentum smooth except for a few coarse punctures. Antenna 8 segmented; 2 basals, 2 intermediates, 1 cupule, and 3 club segments. Maxillary palpus 4 segmented; basal segment very short; second segment longest, about three-fourths as long as third and fourth segments combined; penultimate segment angulate basally and swollen apically; ultimate segment almost twice as long as penultimate segment and swollen. Labial palpus small; 3 segmented; first segment short, about half as long as second segment; second segment about two-thirds as long as ultimate segment, with 1 long yellow seta on apicodorsal angle; ultimate segment broadest, compressed laterally, swollen dorsoventrally, with 1 long yellow seta at apicoventral angle.

Pronotum about 3 times as wide as long; punctures finer than on head and very sparse; narrowly margined laterally; anterolateral and postero-



FIGS. 11–13. *Notionotus liparus* new species, ♂ holotype: 11. habitus, dv; 12. median lobe apex, lv; 13. genitalia, dv. (dv = dorsal view; lv = lateral view.)

lateral angles rounded. Prosternum longitudinally carinate on midline, acutely angulate at apex. Prosternal process distinctly produced posteriorly, distinctly separating front coxae, apex concave for articulation with mesosternal protuberance.

Elytra convex, narrowly margined laterally; widest slightly before midlength; surface with very fine, sparse punctures similar to pronotum. Sutural stria absent. Scutellum a small equal-sided triangle. Epipleura almost vertical.

Mesosternum finely alutaceous, with prominent triangular posteromedial protuberance. Metasternum smooth and impunctate on swollen medial region but finely alutaceous laterally; apex broad between middle coxae then narrowing and extending on same plane onto the prominent triangular protuberance of mesosternum. Abdominal sterna finely alutaceous and moderately densely covered with short yellowish pubescence.

Front and middle legs with femora finely, densely punctate and densely pubescent on basal four-fifths. Hind femur smooth except for fine, very sparse, seta-bearing punctures on basal four-fifths, apical fifth alutaceous; seta-bearing punctures denser alongside pubescent trochanter. Tarsal formula 5–5–5. Foreleg with segments 1 to 4 about equal in length; last segment about as long as segments 1 to 4 combined. Midleg with first, second, and third segments subequal; fourth segment shortest, about one-third as long as fifth segment; fifth segment slightly shorter than second, third, and fourth segments combined. Hindleg with basal segment short, about as long as fourth segment; second and third segments about equal in length; fourth segment slightly less than half as long as last segment; last segment about as long as third and fourth segments combined.

Genitalia as illustrated (Figs. 12, 13).

*Allotype*: Similar to male except mentum is more sparsely punctate.

*Variations*: The specimens vary in size as follows. Male: length, 1.65 to 1.90 mm (avg. 1.76 mm); width, 0.90 to 1.15 mm (avg. 1.05 mm). Female: length, 1.80 to 1.85 mm (avg. 1.82 mm); width, 1.05 to 1.15 mm (avg. 1.11 mm).

*Type-data*: Holotype male, Venezuela: Barinas: Barinitas (24 km NW), 23 February 1969, Paul and Phyllis Spangler. USNM Type 71951, deposited in the National Museum of Natural History, Smithsonian Institution. Allotype, same data as holotype. Paratypes: same data as holotype, 3♂♂, 2♀♀. Merida: Santo Domingo (12 km SE), 24 February 1969, 10♂♂, 4♀♀. All specimens were collected by Paul and Phyllis Spangler.

*Etymology*: *liparus* from liparos, G.—shiny; in reference to the shiny appearance of the beetle.

*Habitat*: These specimens, like *N. rosalesi*, are madicoles and were found on the wet surface of rocks, in crevices, and on leaves in spring seepage areas in road cuts. The specimens from 24 km northwest of Barinitas were collected at approximately 2,000 feet. The specimens from 12 km southeast of Santo Domingo were found at approximately 6,000 feet beside a roadside shrine.

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Vol. 85, No. 11, pp. 147–150 30 August 1972

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# A NEW SPECIES OF *ANOROPALLENE* (PYCNOGONIDA) FROM THE HAWAIIAN ISLANDS

By C. Allan Child
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A single pycnogonid specimen has been found among miscellaneous material collected by the U.S. Fisheries Steamer *Albatross* some 70 years ago. Since this unrecorded specimen appears undescribed and was collected from an area where few collections of any kind have been made since the time of the *Albatross*, I will describe the specimen in this note rather than wait in hope that more material will be found. The label accompanying the specimen is hardly legible and appears to read "Alb. 3464 May 22 44 fms." The latter data is incorrect for station 3464, but agrees exactly with station 3964. Assuming that a hastily written number nine can look like a number four, I treat the specimen as having come, in fact, from station 3964.

The manuscript has been reviewed by Dr. Joel W. Hedgpeth, and I gratefully acknowledge his comments. The specimen is deposited in the collections of the National Museum of Natural History, Smithsonian Institution.

Callipallenidae
*Anoropallene* Stock, 1956
**Anoropallene laysani** new species

*Material examined*: Holotype, male; WSW of Laysan Island, Hawaiian Islands, in 80 meters; 25°50′N., 171°50′W.; 22 May 1902. *Albatross* station 3964. USNM no. 138139.

*Description*: Trunk completely segmented, lateral processes separated by about half their diameter, each slightly longer than wide, bearing a pair of dorsolateral spine-bearing tubercles shorter than diameter of processes. Trunk and leg sutures with dark thin pigmentation line. Neck short, abruptly constricted immediately anterior to oviger im-

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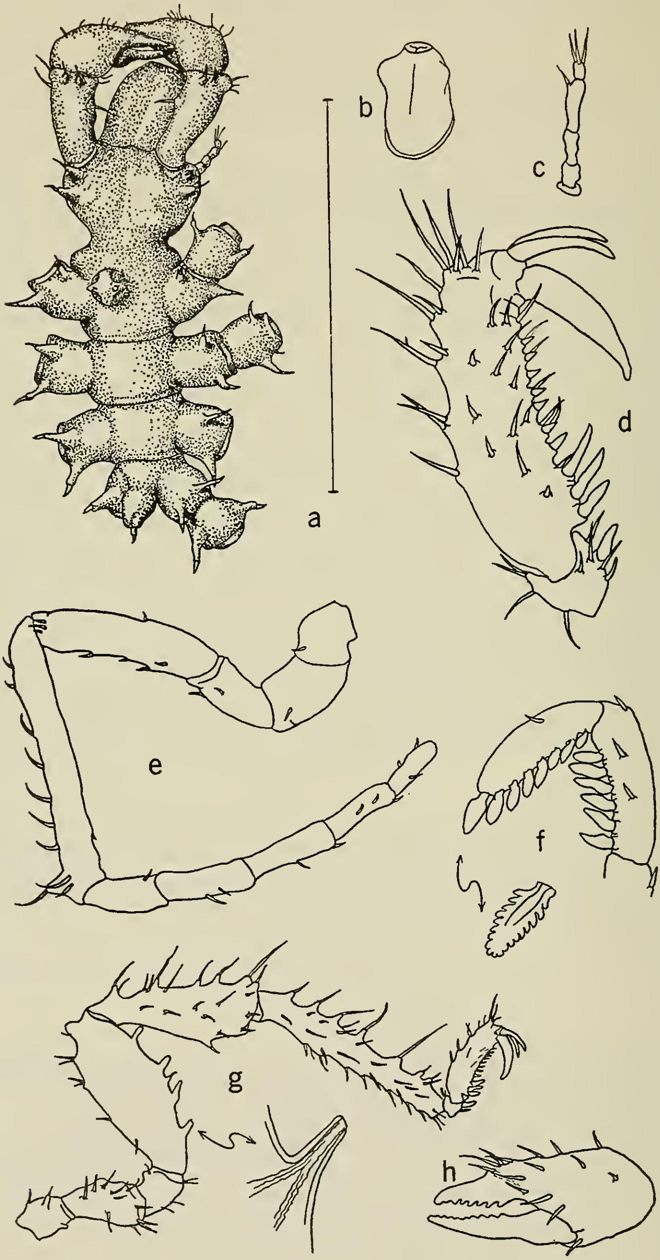
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plantation, bearing two pairs of spine-bearing tubercles on crop posterior to chelifore bases. Ocular tubercle between first lateral processes and posterior to oviger implantation, capped with two tiny lateral tubercles. Eyes slightly pigmented. Abdomen short, reaching tip of fourth lateral processes, unarmed, with bulge above basal constriction. Proboscis cylindrical with ventrolateral bulges near tip.

Chelifores two-jointed, scape with six to eight lateral and distal setae. Chelae large, well developed, with fringe of setae on back of palms. Fingers with fine blunt serrations.

Palpi four-jointed, slightly more than half probosis length. First and second joints subequal, third almost twice first two and bearing a distal seta, fourth a tiny oval, bearing three setae longer than joint.

Oviger 10-jointed, second, third, and sixth joints subequal, fourth over twice their length, fifth the longest, bearing broad conical tubercle distally, armed with single seta. Four terminal joints slightly longer than sixth, each armed with denticulate spines in the formula 8 – 7 – 6 – 8, without terminal claw. All joints with one to seven small setae, fifth with row of setae equal to or less than joint diameter.

Legs robust, very spinose, first coxae with two dorsolateral tubercles bearing setae, second coxae one and one-half times first, bearing 12–14 strong setae, third coxae with several ventral and distal setae. Femora swollen, with seven to nine dorsal setae and single median ventral seta and four ventral femoral cement glands. Cement glands thin, pointing slightly anteriorly, each less than half joint diameter. First tibiae slightly shorter than femora, second tibiae one and one-fourth times the first, each bearing dorsal row of spine-bearing tubercles, lateral rows of setae, and scattered ventral setae. Tarsus small, U-shaped, armed with single broad ventral spine and nine or 10 setae. Propodus without heel, armed with three broad proximal sole spines and seven or eight short thick distal sole spines, a fringe of lateral setae and 12 or more dorsal and distal setae. Terminal claw robust, less than half propodal length, auxiliaries slightly over half terminal claw length.

*Measurements* (in mm): Length of trunk (anterior end of crop to tip of abdomen) 2.08. Width of trunk (across second lateral processes), 1.12. Length of abdomen, 0.34. Length of proboscis (ventrally), 0.94. Third leg: Coxa 1, 0.38; Coxa 2, 0.60; Coxa 3, 0.40; Femur, 1.41; Tibia 1, 1.32; Tibia 2, 1.63; Tarsus, 0.13; Propodus, 0.69; Claw, 0.31.

*Distribution*: Type-locality: WSW of Laysan Island, Hawaiian Islands. Depth range: 80 meters.

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Fig. 1. *Anoropallene laysani* new species. a. Dorsal view of trunk (line = 2 mm); b. ventral proboscis; c. palp; d. tarsus and propodus; e. oviger (denticulate spines omitted); f. terminal oviger joints with enlargement of ultimate spine; g. third leg with enlargement of proximal femoral cement gland; h. chela.

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*Remarks*: This specimen does not agree exactly with the diagnosis of *Anoropallene* given by Stock (1956, p. 46). The diagnosis of *Anoropallene* and its parent genus *Oropallene* places primary distinction on the presence or absence of a terminal oviger claw and propodal auxiliary claws. In *Anoropallene*, including *A. crenispina, heterodenta, and palpida*, there are no auxiliaries and no terminal oviger claw. In *Oropallene*, including *O. dimorpha, minor, ovigerosetosa*, and *polaris*, auxiliaries and the terminal oviger claw are present. This leaves *Anoropallene valida*, placed uneasily in the genus by Stock (1956), and the present species, both of which seem to be intermediate between the two genera in not having a terminal oviger claw, but having auxiliary claws. Based on the diagnoses, possibly a third genus is needed to include the two latter species even though it is agreed (Stock, loc cit; Clark, 1963, p. 21) that the presence or absence of a terminal oviger claw may have more taxonomic importance than the presence or absence of auxiliary claws. As with a number of other pycnogonid genera which are based on a single specimen or only a few individuals, it seems best to await more specimens of this *Oropallene—Anoropallene* complex before splitting the group further, if indeed it becomes necessary.

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Vol. 85, No. 12, pp. 151–162 30 August 1972

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# A NEW CRAYFISH FROM THE TALLAPOOSA RIVER IN GEORGIA (DECAPODA: ASTACIDAE)

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The new species described herein is known from only two localities, both in the upper Tallapoosa River in Haralson County, Georgia, where it occurs syntopically with one of its closest relatives, *Cambarus* (*Depressicambarus*) *halli* Hobbs (1968: 269). On the basis of the limited available data, it appears that the new species is restricted to riffle areas of the stream, whereas, *C.* (*D.*) *halli* is predominantly a denizen of the stream litter and tangled roots of the shoreline trees and shrubs. The two are remarkably similar in coloration and general mien, but fundamental differences, at least some of which are listed below, do exist between them.

We thank all of those who assisted in collecting the specimens on which the new species is based. We are also grateful to Fenner A. Chace, Jr., and Martha R. Cooper for their criticisms of the manuscript and to Carolyn B. Gast for the illustrations.

## **Cambarus (Depressicambarus) englishi** new species

Figure 1

*Diagnosis*: Body pigmented, eyes moderately large and well developed. Rostrum usually with marginal spines or tubercles, sometimes tapering without interruption to apex of acumen. Areola 4.2 to 4.9 times longer than wide and comprising 33.2 to 38.0 percent of entire length of carapace

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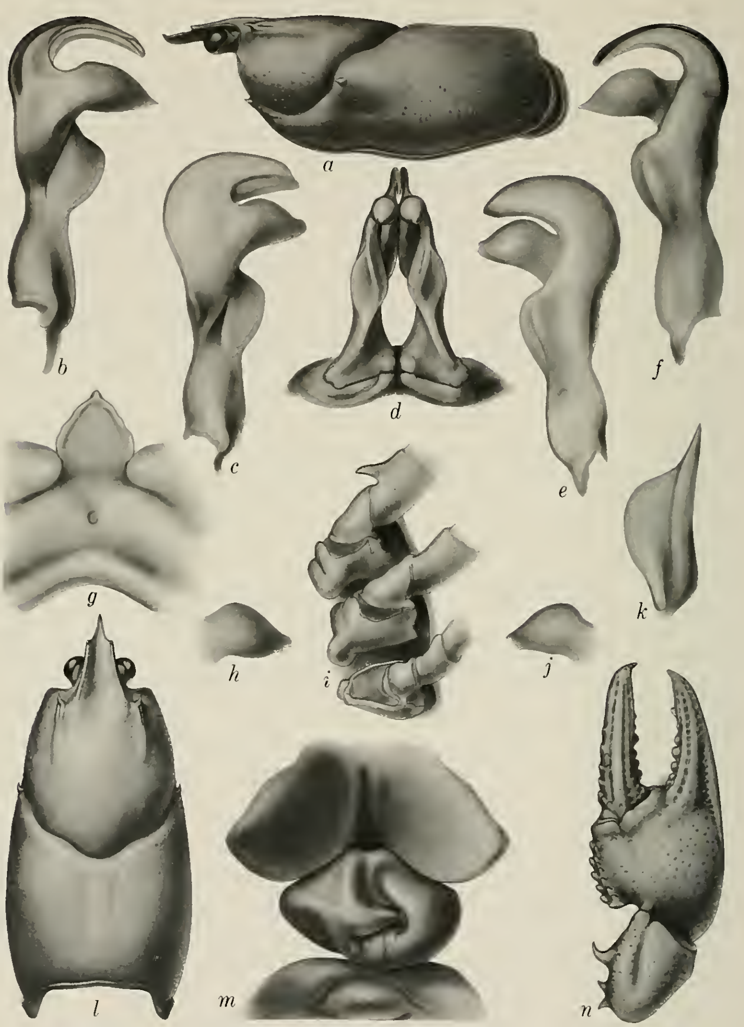

FIG. 1. *Cambarus* (*Depressicambarus*) *englishi* new species (pubescence removed from all structures illustrated). *a*, Lateral view of carapace of holotype; *b*, Mesial view of first pleopod of paratypic male, form I; *c*, Mesial view of first pleopod of morphotype; *d*, Caudal view of first pleopods of holotype; *e*, Lateral view of first pleopod of morphotype; *f*, Lateral view of first pleopod of paratypic male, form I; *g*, Epistome of holotype; *h*, Mesial view of left mesial process of holotype; *i*, Basal podomeres of third, fourth, and fifth pereiopods of holotype;

(41.3 to 46.7 percent of postorbital length), with four to six punctations across narrowest part. Cervical spines present. Suborbital angle almost obsolete, broadly rounded. Postorbital ridges with cephalic spines or tubercles. Antennal scale approximately 2.8 times longer than broad, lamellar portion evenly rounded, broadest about midlength. Chela with two rows of tubercles along mesial surface of palm, with mesialmost row typically bearing six or seven; lateral margin costate, and both fingers with well-defined longitudinal ridges dorsally. First pleopod (Fig. 1*b*, *d*, *f*, *h*, *j*,) of first form male with central projection long, narrow, tapering, and recurved at angle of approximately 110 degrees and lacking subterminal notch; mesial process with distinct gap between bulbiform portion and shaft of appendage, either tapering distally to acute tip or truncate with two or three small acute prominences. Annulus ventralis (Fig. 1*m*) distinctly asymmetrical with cephalic membranous portion bearing deep median trough, and with caudal portion slightly movable.

*Holotypic Male, Form I*: Body subovate, depressed (Fig. 1*a*, *l*). Abdomen narrower than thorax (12.1 and 14.5 mm); greatest width of carapace greater than depth at caudodorsal margin of cervical groove (14.5 and 11.0 mm). Areola broad, 4 times longer than wide, with four punctations across narrowest part; length of areola 35.4 percent of entire length of carapace (43.0 percent of postorbital length). Rostrum with thickened, elevated, slightly concave borders bearing corneous marginal tubercles at base of long acumen, latter reaching distal extremity of antennular peduncle and terminating in corneous, acute, slightly upturned tip; dorsal surface of rostrum concave with scattered punctations anteriorly, and larger, more crowded ones basally; usual submarginal row of setiferous punctations extending from base almost

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*j*, Mesial view of right mesial process of holotype; *k*, Antennal scale of holotype; *l*, Dorsal view of carapace of holotype; *m*, Annulus ventralis of allotype; *n*, Dorsal view of distal podomeres of cheliped of holotype.

to tip of acumen. Subrostral ridges moderately well developed and evident in dorsal aspect to base of marginal tubercles of rostrum. Postorbital ridges moderately strong, grooved dorsolaterally, and terminating cephalically in acute spines. Suborbital angle obsolete. Branchiostegal spine moderately large and acute. Cervical spine acute and flanked caudodorsally by three tubercles. Carapace punctate dorsally, and granulate laterally; granules somewhat larger in hepatic region and in cephaloventral portion of branchiostegites.

Abdomen slightly shorter than carapace (28.5 and 29.1 mm); pleura moderately long, second through fifth with caudoventral angles. Cephalic section of telson with three spines in each caudolateral corner; caudal section subtriangular. Proximal podomere of uropod with two distal spines, mesial one larger; mesial ramus with poorly developed dorsal keel terminating in distal spine, tip of which almost reaching distal margin of ramus.

Cephalomedian lobe of epistome (Fig. 1g) subtriangular, its base and altitude subequal in length, and with slightly thickened, weakly crenulate, elevated (ventrally) cephalolateral margin; basal portion with prominent cephalomedian fovea. Ventral surface of proximal segment of antennule with prominent spine at base of distal fourth. Antennae reaching third abdominal tergum. Antennal scale (Fig. 1*k*) about 2.8 times longer than broad, with considerable portion of mesial and lateral margins subparallel; thickened lateral portion terminating in strong acute spine extending anteriorly to or slightly beyond level of tip of rostrum. Third maxillipeds moderately setose, but lateral half of ventral surface of ischium with few setae mesial to sublateral row.

Right chela (Fig. 1*n*) about twice as long as broad, depressed with inflated palm; mesial margin of palm with row of six prominent tubercles subtended dorsolaterally by row of seven smaller ones; dorsal surface of palm mostly punctate but with few small tubercles mesiodistally; lateral surface rounded proximally and with basal portion of costa extending onto fixed finger; ventral surface punctate and with one prominent tubercle on distal margin at base of dactyl, another proximolateral to distal tubercle, and row of three extending between latter tubercle and two on fixed finger. Opposable margin of fixed finger with row of six knoblike tubercles along proximal three-fifths of finger, fourth from base largest, and another large tubercle on lower level at base of distal third; single row of minute denticles distal to fifth tubercle from base, interrupted only by sixth tubercle of row; dorsal surface of fixed finger somewhat impressed proximolaterally and bearing prominent submedian ridge and smaller ridge mesially with punctations in impression and flanking ridges and lateral costa of finger; ventral surface of finger with two previously mentioned tubercles proximomesially, otherwise punctate. Opposable margin of dactyl with row of seven knoblike tubercles along proximal three-fourths, fourth from base largest, and row of minute denticles extending distally from fifth, interrupted only by sixth and seventh tubercle of row; dorsal surface of finger with prominent median longitudinal ridge and less prominent, more lateral one; mesial margin with row of six tubercles decreasing in size distally, row flanked on each side by two additional tubercles proximally.

Carpus longer than broad (8.9 and 6.7 mm) with deep, oblique furrow dorsally; dorsal surface otherwise with row of four squamous tubercles mesially, elsewhere punctate; mesial surface with large procurved spine near midlength and smaller one proximally; ventral surface with large submedian distal spine and smaller one on laterodistal articular condyle; remainder of ventral surface and lateral surface punctate. Merus with two prominent spines on dorsal subdistal surface; mesioventral margin with row of eight spines and lateroventral margin with row of two proximal tubercles and two more-distal spines; distal ventrolateral extremity with small corneous spine; podomere otherwise sparsely punctate. Ventral margin of ischium with row of five small tubercles.

Hooks on ischia of third pereiopods only (Fig. 1*i*); hooks simple and overreaching basioischial articulation. Coxae of fourth pereiopods with rounded caudomesial boss; coxae

Table 1. Measurements (mm) of *Cambarus* (*D.*) *englishi.*

| | Holotype | Allotype | Morphotype |
|---|---|---|---|
| Carapace: | | | |
| Height | 11.0 | 13.0 | 13.1 |
| Width | 14.5 | 18.5 | 18.0 |
| Length | 29.1 | 36.5 | 34.3 |
| Postorbital length | 23.3 | 30.2 | 28.6 |
| Areola: | | | |
| Width | 2.5 | 2.9 | 2.9 |
| Length | 10.0 | 13.0 | 12.7 |
| Rostrum: | | | |
| Width | 4.2 | 5.0 | 5.1 |
| Length | 6.9 | 7.6 | 7.2 |
| Left Chela: | | | |
| Length of mesial margin of palm | 6.9 | 8.6 | 7.0 |
| Width of palm | 10.3 | 13.6 | 11.0 |
| Length of lateral margin of propodus | 21.0 | 27.1 | 23.5 |
| Length of dactyl | 12.8 | 17.0 | 15.6 |

of fifth pereiopods with boss almost obsolete. For measurements, see Table 1.

First pleopods (Fig. 1*b*, *d*, *f*, *h*, *j*) reaching coxae of third pereiopods when abdomen flexed. As described in diagnosis except mesial process less attenuate distally and bearing two or three small apical projections on left and right pleopods, respectively.

*Allotypic Female*: Differing from holotype in following respects: acumen reaching midlength of ultimate podomere of antennular peduncle, much exceeded by distal spine on antennal scale; areola more sparsely punctate; cephalic section of telson with two spines in each caudolateral corner; ventral surface of palm of chela with two spiniform tubercles proximal to marginal tubercle at base of dactyl; opposable margin of fixed finger of chela with row of seven knoblike tubercles along proximal two-thirds, fifth from base largest; merus of cheliped with additional spiniform tubercle on ventral surface situated ventromesial to large spine on mesial surface. See Table 1 for measurements.

Annulus ventralis (Fig. 1*m*) moderately deeply embedded in sternum, only slightly movable and with cephalic half pliable, almost membranous. Outline somewhat asymmetrical, produced much farther caudally on left than on right; cephalic half with deep median longitudinal furrow inclined caudally to left; right transverse ridge near midlength forming tongue disappearing beneath inflated dextrocaudal wall; sinus originating in longitudinal furrow along cephalic margin of tongue and disappearing under left wall, then reappearing on caudosinistral margin of tongue, following latter caudodextrally across median line, there making sharp turn caudosinistrally and finally cutting caudal margin of annulus slightly dextral to median line. Median sclerite immediately caudal to annulus elliptical. First pleopods uniramous and extending to midlength of annulus when abdomen flexed.

*Morphotypic Male, Form II*: Differing from holotype in following respects: rostrum with marginal tubercles reduced to very small corneous knobs, apex of acumen not quite reaching midlength of distal podomere of antennular peduncle; antenna reaching caudally to sixth abdominal tergum; branchiostegal spines reduced to small tubercles; cephalic section of telson with only two spines in each caudolateral corner; palm of chela with dorsomesial row of only five tubercles; opposable margin of fixed finger of chela with row of five tubercles and tubercle beyond row almost in line with proximal row; proximal five tubercles in row on opposable margin of dactyl subequal in size; ventromesial row of spines on merus of cheliped consisting of only six on right chela; hooks on ischia of third pereiopods reduced in size and length, and boss on coxa of fourth pereiopod slightly smaller and less conspicuous. See Table 1 for measurements.

First pleopod (Fig. 1*c*, *e*) with both terminal elements much heavier and approximating one another more closely than in holotype; apex of mesial process subtruncate.

*Color Notes*: Cephalic portion of carapace brownish olive dorsally with cream-tan markings over origins of gastric muscles; hepatic area greenish blue, fading ventrally to bluish cream; rostral margins, postorbital and suborbital ridges orange; tubercles in hepatic area and cephalic margin ventral to orbit cream. Thoracic area with areola straw-brown, dorsal portions of branchiostegites orange tan fading ventrally to bluish cream and studded with small pale tubercles; caudal ridge on carapace pinkish cream with narrow, almost black band immediately cephalic to ridge; band, except on dorsolateral area of branchiostegite, fading rapidly anteriorly, there more gradually. Dorsal surface of first abdominal segment mostly pinkish cream with one broad or two narrow blackish transverse bands cephalically; remaining abdominal terga and pleura blackish with narrow pinkish cream transverse band along caudal margin of each, band continuing on ventral margin of pleura and expanding on cephalic side of latter. Telson and uropods blackish dorsally and pale bluish green bordered in tan ventrally. Chela olive green dorsally with orange to cream-orange tubercles, lateral costa, and distal portions of fingers; latter with yellowish orange (corneous) tips. Carpus brownish olive dorsally with orange-cream tubercles and spines; dorsodistal part of merus dark olive with orange-cream spines. All podomeres fading ventrally to pinkish or bluish cream. Remaining pereiopods with podomeres distal to ischium pale olive dorsally, carpus darkest with other podomeres fading gradually toward proximal and distal ends of appendages; all podomeres fading ventrally.

*Size*: The largest specimen available is a female having a carapace length of 39.2 mm. The largest and smallest first form males have corresponding lengths of 36.4 and 29.1 mm.

*Type-locality*: Tallapoosa River, in riffle area immediately downstream from City of Tallapoosa water intake, 1 mile north of Tallapoosa, Haralson County, Georgia, a few hundred yards east of bridge on State Route 100. There the River is some 40 feet wide, and in the riffle area only 1 or 2 feet in depth. The bed of the riffle consists of moderately large stones, partially embedded in sand, that support a luxuriant growth of *Podostemum ceratophyllum.* At low-water stages, the water is almost clear, but, frequently, following rains it becomes reddish orange in color, due to the heavy load of clay and silt, and attains a depth of more than 4 feet. Four crayfishes frequent this segment of the stream, with *C.* (*D.*)

*englishi* dominating the riffle and *C.* (*D.*) *halli* the litter and root mats of plants growing along the banks. Far less abundant are *Procambarus* (*Pennides*) *spiculifer* (LeConte, 1856: 401) and *Cambarus* (*D.*) *latimanus* (LeConte, 1856: 402).

*Types*: The holotypic male, form I, allotypic female, and morphotypic male, form II (Nos. 131700, 131701, and 132519, respectively) are deposited, together with the paratypes (8♂I, 6♀, 9 juv. ♂, and 10 juv. ♀), in the National Museum of Natural History, Smithsonian Institution.

*Range and Specimens Examined: Cambarus* (*D.*) *englishi* is known from only two localities, on the Tallapoosa River in Haralson County, Georgia. One juvenile male and two juvenile females, not included in the type-series, were taken from the River, 2.5 miles west of Tallapoosa by Max W. Walker and E. T. Hall, Jr. on 3 September 1969. The remaining specimens constituting the type-series were collected at the type-locality by T. A. English, Jr., R. F. Holbrook, E. T. Hall, Jr., and H. H. Hobbs, Jr., (3 September 1969; 13 October 1969; and 23 September 1971).

*Variations*: Among the more conspicuous variations occurring in *C.* (*D.*) *englishi* is the presence or absence of marginal tubercles or spines on the rostrum. All of the young individuals, as well as some of the largest, have well-developed spines, but in several adults there is not a trace of a tubercle and scarcely any interruption of the margins between the basal portion of the rostrum and the acumen. The areola varies from 4.2 to 4.9 times longer than wide and comprises from 33.2 to 38.0 (average 35.4) percent of the total length of the carapace; only two specimens, however, have areolae constituting less than 34 percent and two others as much as 37 percent.

The row of tubercles on the mesial surface of the palm of the chela varies from five to eight, with seven the usual number; only one individual has eight on one chela and another has five on one member of the pair. The tubercle on the ventral surface of the palm, at the base of the dactyl, may be simple, essentially bifid, or absent, and there are one to three proximal to it. The number of tubercles along the fixed finger and dactyl ranges from five to eight and seven to eight, respectively. The two spines on the mesial surface of the carpus are present in all except one specimen in which the proximal one is lacking, and, in one individual, there are two additional small tubercles. The ventral surface of the carpus always has the two tubercles as described for the holotype, and an occasional third tubercle is present as in the allotype. The dorsal surface of the merus of all of the specimens except one, in which there are three, bears two spiniform tubercles; the ventromesial row consists of seven to nine tubercles and the ventrolateral of two to seven.

The mesial process of the first pleopod of the first form male may be somewhat more inflated than those illustrated in Figure 1*b*, *d*, *f*, *h*, and *j*, but the distal extremities do not exceed the limits indicated in the figure. The cephalic portion of the annulus ventralis is consistently membranous, but in all except three of the females, the tongue is directed dextrally. See Table 1 for measurements.

*Relationships*: Among the closest relatives of *Cambarus* (*Depressicambarus*) *englishi* is the syntopic *C.* (*D.*) *halli*. The two were collected from the same segment of the Tallapoosa River at the type-locality, and their coloration and general conformation are so markedly similar that when first examined, they were believed to be conspecific. Other close relatives include *C.* (*D.*) *jordani* Faxon (1884: 119) from the Coosa River system and *C.* (*D.*) *obstipus* Hall (1959: 221) from the Black Warrior drainage. It differs from all three in the more distally situated tumescence of the mesial process of the first pleopod of the first form male. In addition, it may be distinguished from *C.* (*D.*) *halli* by the more gently curved and entire (lacking a subapical notch) central projection of the first pleopod, usually in possessing a narrower, longer, and less densely punctate areola, and distinctly thickened rostral margins that are at least slightly concave. It differs from *C.* (*D.*) *obstipus* in having a much longer, more strongly recurved central projection of the first pleopod and a broader, usually shorter areola. Characters that serve to separate *C.* (*D.*) *englishi* from *C.* (*D.*) *jordani* include the longer, slenderer, and less strongly recurved central projection of the first pleopod, and the more spiniform conditions of most of the tubercles on the carapace and chelipeds.

*Life History Notes*: First form males have been collected in September and October, and inasmuch as those that were taken on 23 September 1971 were encrusted, it may be concluded that they had not molted for a number of months, which suggests, in turn, that the breeding season extends through the summer months. Seemingly paradoxically, among the specimens collected in September and October 1969, all of the adult males had recently molted to first form! Only one second form male, the morphotype, has been obtained, and that specimen, taken on 23 September 1971, was also encrusted.

*Etymology*: This crayfish is named in honor of Teddy A. English, Jr., our mutual friend and frequent companion on collecting trips in Georgia.

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Vol. 85, No. 13, pp. 163–178 30 August 1972

PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

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# PUPA OF *NEOMOCHTHERUS ANGUSTIPENNIS* (HINE), WITH NOTES ON FEEDING HABITS OF ROBBER FLIES AND A REVIEW OF PUBLICATIONS ON MORPHOLOGY OF IMMATURE STAGES (DIPTERA: ASILIDAE)

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## Feeding Habits

Robber flies are one of the most taxonomically diverse and numerically abundant groups of Diptera. As far as known, the adults and some (possibly all) larvae are predators of other insects, especially phytophagous forms. Some adult asilids attack beneficial insects such as honey bees and other Hymenoptera, and some prey on harmful species, such as locusts, grasshoppers, and chafer-beetles. Although these common flies appear to be significant elements of the ecosystem and of practical importance to agriculture, surprisingly little is known about the behavior of the adults. Even less is known about the immature stages.

In addition to many isolated, single-specimen observations of prey, extensive lists of prey of adult Asilidae have been presented (among others) by Adamovic (1964) and Hobby (1930, 1933) in Europe, Bromley (1930) and Fattig (1945) in North America, Carrera and Vulcano (1961) in South America, Cuthbertson (1937) in Africa, and Iwata and Nagatomi (1962) in Japan. No adult asilids are known to be monopha-

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gous or even oligophagous. Whereas some robber flies are opportunistic predators and attack most of the abundant, slow-flying, appropriately sized and conspicuous species available (Powell and Stage, 1962), others have more limited prey preferences (Linsley, 1960; Lavigne and Holland, 1969). Apparently many species have hunting zones restricted to certain parts of the habitat (Adamovic, 1963; Lehr, 1969; Zinov'eva, 1959). As is true of most other groups of entomophagous insects, there is little quantitative data on the impact of adult robber flies on populations of their prey.

The most extensive study of the biology of Asilidae (Melin, 1923) includes much information on various aspects of all stages, especially the adults, but little specific data on the critical issues of the food and feeding behavior of the larvae. From the fragmentary data of many earlier authors (but not including the important information of Felt, 1918, and Davis, 1919) and from his own mainly circumstantial evidence, Melin concluded that asilid larvae are principally phytophagous. This opinion, made without knowledge of the complete life cycle of any species, has been repeated in many subsequent general discussions of the biology of Asilidae.

Since Melin's paper, conclusive studies of the feeding habits of larvae belonging to the genera *Hyperechia*, *Mallophora*, and *Promachus* have appeared. Adults of *Hyperechia* are well known as striking mimics of *Xylocopa* bees in the Old World Tropics, and at least the mature larvae of several species of *Hyperechia* are predators of the larvae and pupae of the xylocopid models (Poulton, 1924; Tsacas, et al., 1970). The complete development of the larvae of only three of the 5,000 known species of Asilidae (*Promachus yesonicus* Bigot, *Mallophora media* Clements and Bennett, and *M. ruficauda* (Wiedemann)) has been studied. The larvae of *Promachus yesonicus* are free-living predators of the larvae of Scarabaeidae, especially of *Anomala* spp., in Japan (Kinoshita, 1940). The larvae of *Mallophora media* were reared from larvae of a scarabaeid (*Barybas insulanus* Moser) in Trinidad by Clements and Bennett (1969). The young larva is an ectoparasite and remains in place with its anterior end buried in the integument of the grub. During later larval life it may remain with the original host or it may live free in the soil. The young larva of *M. ruficauda* is an ectoparasite of *Archohileurus vervex* (Burmeister) (Scarabaeidae); it remains with the host larva and consumes it as it matures (Copello, 1927, 1942). Less detailed reports of the behavior of the larvae of *M. ruficauda* are found in the papers of Crouzel (1965) and De Gavotto (1964).

Other reports on the food and feeding habits of asilid larvae not included in Melin's 1923 review or published subsequently are summarized below. Most of these also indicate that the larvae of Asilidae are predaceous. Felt (1918) reported that larvae of *Promachus fitchii* Osten Sacken are efficient natural enemies of larvae of *Phyllophaga fusca* (Froelich (Scarabaeidae) in New York. Davis (1919) observed free-living larvae of *Promachus vertebratus* (Say) feeding on white grubs in Wisconsin and Michigan, and he cited unpublished reports of other asilid larvae feeding on scarabaeid larvae. Irwin-Smith (1923) kept first-instar larvae of an Australian species, *Neoaratus hercules* Wiedemann, alive for more than 25 days but the larvae did not feed on, '. . . pieces of Scarabaeidae larvae . . ." or on earthworms or scraps of meat. Champlain and Knull (1923) reared adults from larvae and pupae of *Andrenosoma fulvicauda* (Say) found in pupal cells of *Chrysobothris femorata* (Olivier) (Buprestidae) in *Quercus* sp. in Pennsylvania. Osterberger (1930) reared larvae of *Triorla interrupta* (Macquart) on larvae of *Eutheola rugiceps* (LeConte) (Scarabaeidae) in Louisiana. Osterberger stated that, "The feeding (Pl. 24, fig. 1) was accomplished by the larva attaching itself to the white grub in a tender, unprotected region just back of the head. There it remained until all the body juices were sapped. . . ." Reinhard (1938) was unable to induce newly hatched larvae of *Efferia aestuans* (L.) to feed on small *Phyllophaga* grubs or on ant larvae in Illinois. Ritcher (1940) found over 40 larvae of *Diogmites discolor* Loew attacking pupae or in pupal cells containing shrivelled skins of pupae of five species of *Phyllophaga* in Kentucky. Fattig (1944) stated that, "From hundreds

FIG. 1. Larva of *Mallophora* sp. on larva of *Phyllophaga* sp.

of white grubs brought in with the larva of some insect attached . . . ," he reared the following in Georgia: *Asilus virginicus* Banks, "*Deromyia winthemi* Wiedemann," *Diogmites discolor* Loew, *D. ternatus* Loew, *Efferia aestuans* (L.), *E. pogonias* (Wiedemann), "*Erax barbatus* Fabricius," "*Erax interruptus* (L.)," "*Proctacanthus brevipennis* Wiedemann," *P. longus* (Wiedemann), *P. rufus* Williston, *Promachus rufipes* (Fabricius), and *Tolmerus notatus* Wiedemann. Stower, et al., (1958) found larvae of *Scylaticus* sp. in egg-pods of *Schistocerca gregaria* (Forskål) in Eritrea. Greathead (1963) recorded larvae of *Scylaticus* sp., *Stenopogon* sp., and *Trichardis* sp. from egg-pods of *S. gregaria* in East Africa. Daniels (1966) found larvae (1–1.5 inches long) of an unidentified species of Asilidae in soil with larvae of *Phyllophaga koehleriana* (Saylor) in Texas: the asilid larvae killed and ate the scarabaeid larvae during laboratory rearings. Ecipenko (1967) collected a larva of *Eutolmus rufibarbis* Meigen, ". . . that was sucking out a larva of the beetle *Maladera japonica* Motschulsky [Scarabaeidae] through a puncture in the head capsule." During laboratory rearings, Ecipenko saw a larva of *E. rufibarbis* kill and eat a larva of *Machimus* sp. (Asilidae), and he also observed cannibalism in a culture of *E. rufibarbis.* Weinberg (1968) obtained hatching of eggs of *Dysmachus fuscipennis* (Meigen) in Romania. The larvae lived for 11 days in containers of different kinds of soil. Weinberg did not state that the larvae fed, although she did mention that some of the larvae molted to the second instar.

The sites and manner of attachment of young *Mallophora* larvae are very similar to those of the larvae of certain tiphiid wasps that are also ectoparasites of scarabaeid larvae. The presence of a pair of bristles on each thoracic segment and of four pairs of elongate, fine bristles on the last body segment and the absence of lateral abdominal spiracles readily distinguish asilid larvae from tiphiid larvae. Figure 1 shows a larva of *Phyllophaga* sp. (Scarabaeidae) (determined by D. M. Anderson) parasitized by young asilid larvae, possibly of the genus *Mallophora.* Several scarabaeid larvae infested in this manner were sent to the Systematic Entomology Laboratory, USDA, for determination by L. Castenada, Salvadorian Coffee Research Institute, San Salvador. The specimens were collected during September 1968, at El Sunza, Dept. Sonsonate, San Salvador. The asilid larvae closely match the description of *Mallophora media* (Clements and Bennett, 1969) and *M. ruficauda* (Copello, 1927, 1942). Mr. A. N. Clements (personal communication), who has seen the specimens, agrees that they are Asilidae, possibly of the genus *Mallophora.* There are seven specimens of *Mallophora ruficauda* in the National Museum of Natural History, Smithsonian Institution, pinned with pupal skins and labeled as follows: 1♂, So. Amer. Par. Labo., Uruguay, near Montevideo, No. 1013, XII.22, H. L. Parker col., Host, Scarabaeidae. 2♀, as above except 1♀ XII. 20, P. A. Berry col. and 1♀ XII.26, P. A. Berry col. 1♀, So. Amer. Paras. Lab., Montevideo, No. 561.9, XII.21, Host, Scarabaeidae, Parker and Silveira. 1♀, as above except No. 5618. 1♀, So. Amer. Paras. Lab., Seriano, Uruguay, No. 6262, XII.17, in soil, Silveira. 1♀ Canelones, Uruguay, pred. Scarabaeidae, 16.I.1942, 561.11, Lot No. 42–8967, H. L. Parker.

## MORPHOLOGY OF IMMATURE STAGES

Only about 2 percent of the approximately 5,000 world species of Asilidae are known in any immature stage. Of some 400 total genera, there is information on the immature stages of only 41. Of the 856 species and 82 genera known from North America, immature stages of only 25 and 12, respectively, have been described. Papers on the morphology and biology of immature stages of Asilidae, published to 1918, were listed by Irwin-Smith (1923). Hennig (1952) summarized descriptive data on the immature stages of 64 species in 30 genera. Information on the morphology of immature stages that has been published since Hennig's and Irwin-Smith's summaries (and earlier papers not included by them) is listed in Table 1.

## PUPA OF *NEOMOCHTHERUS ANGUSTIPENNIS* (HINE) AND FEATURES OF THE ADULTS

*Neomochtherus* Osten-Sacken is a typical example of the paucity of information available on the immature stages of Asilidae. In his revision of the genera of Asilidae of the world, Hull (1962) listed 49 species belonging to this genus. The Old World fauna has been studied intensively recently by Tsacas (1968, 1969), who treated 120 Palearctic and Ethiopian species. Apparently only the first-instar larva and pupa of *N. perplexus* Becker (= *N. hungaricus rossicus* Engel?) (Zinov'eva, 1959) and the egg of *N. kivuensis* Tsacas (Tsacas, 1969) have been described. In the Smithsonian Institution there is a male of the rare *N. angustipennis* (Hine) pinned with a pupal skin, which is described below.

### *Neomochtherus angustipennis* (Hine)

Pupa, Figures 2-5.

Greatest length, 14.0 mm; greatest width of thorax, 3.5 mm; greatest width of abdomen, 3.5 mm, tapering to 1.5 mm at greatest width of last abdominal segment. Subshining straw-yellow, spines and processes glistening reddish brown. Head with a pair of terminal anterior antennal

Table 1. Recently published descriptions and figures of the immature stages of Asilidae.

| | | | |
|---|---|---|---|
| | | LEPTOGASTRINAE | |
| *Leptogaster cylindrica* De Geer | E, IL, P[1] | Kazakhstan, U.S.S.R. | Zinov'eva, 1959 |
| *Leptogaster salvia* Martin | E | Wyoming, U.S.A. | Lavigne, 1963 |
| | | LAPHRIINAE | |
| *Andrenosoma atra* Séguy | P | France | Musso, 1967 |
| *Andrenosom bayardi* Séguy | P | France | Musso, 1967 |
| *Andrenosoma fulvicauda* (Say) | L | Ohio, U.S.A. | Peterson, 1957 |
| *Hyperechia bomboides* (Loew) | L, P | Senegal | Tsacas, et al., 1970 |
| *Laphria* sp. | L | Ohio, U.S.A. | Peterson, 1957 |
| *Laphria flava* L. | L | England | Brindle, 1962 |
| *Laphria gilva* L. | E | Germany | Wichmann, 1956 |
| *Laphria gilva* L. | E | South Dakota, U.S.A. | Schmid, 1969 |
| *Laphria gilva* L. | L | England | Brindle, 1962 |
| *Laphria gilva* L. | P | France | Quentin, 1948 |
| | | DASYPOGONINAE | |
| ?*Dioctria oelandica* (L.) | L | Westmoreland, England | Brindle, 1969 |
| *Dioctria rufipes* (De Geer) | L | England | Brindle, 1962 |
| *Dioctria rufipes* (De Geer) | L, P | Cheshire, England | Brindle, 1968 |
| *Diogmites angustipennis* Loew | E | Wyoming, U.S.A. | Lavigne and Holland, 1969 |
| *Diogmites basalis* (Walker) (as *Deromyia umbrina* Loew) | E | Indiana, U.S.A. | Davis, 1919 |
| *Diogmites discolor* Loew | L, P | Kentucky, U.S.A. | Ritcher, 1940 |

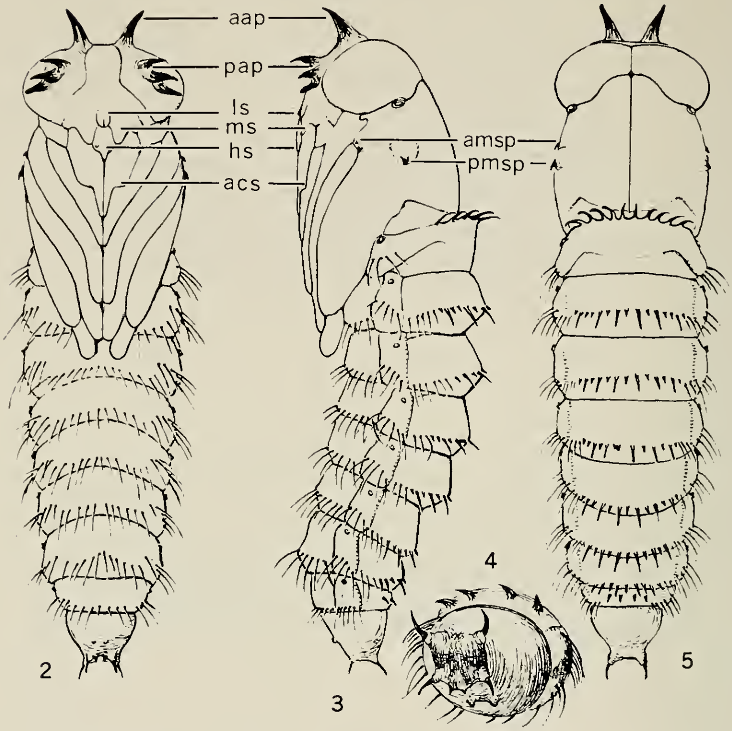
[1] E = egg, L = Mature larva only, unless otherwise indicated, P = pupa.

TABLE 1 (Continued)

| | | | |
|---|---|---|---|
| *Leptarthrus brevirostris* Meigen | P | Sussex, England | Parmenter, 1952 |
| *Leptarthrus brevirostris* Meigen | E | Surrey, England | Stubbs, 1970 |
| *Pritchardia hirtipes* (Macquart) | E | Chile | Artigas, 1970 |
| *Scylaticus* sp. | L, P | East Africa | Greathead, 1963 |
| *Stenopogon coyote* Bromley | E | Wyoming, U.S.A. | Lavigne, 1963 |
| | | ASILINAE | |
| *Apoclea helvipes* Loew | E, IL | Kazakhstan, U.S.S.R. | Zinov'eva, 1959 |
| *Astochia caspica* Hermann | E, IL | Kazakhstan, U.S.S.R. | Zinov'eva, 1959 |
| *Dysmachus* sp. | L | Germany | Brauns, 1954a |
| *Dysmachus fuscipennis* (Meigen) | E, I, II L | Rumania | Weinberg, 1968 |
| ?*Dysmachus trigonus* Meigen | P | Germany | Brauns, 1954b |
| *Echthistus rufinervis* Meigen | E, IL, P | Kazakhstan, U.S.S.R. | Zinov'eva, 1959 |
| *Eccritosia rubriventris* (Macquart) | P | Chile | Artigas, 1970 |
| *Efferia helene* (Bromley) (as *E. bicaudata* (Hine)) | E | Wyoming, U.S.A. | Lavigne, 1964 |
| " " | E | Wyoming, U.S.A. | Lavigne and Holland, 1969 |
| *Efferia pallidula* (Hine) | E | Wyoming, U.S.A. | Lavigne and Holland, 1969 |
| *Efferia staminea* (Williston) | E | Wyoming, U.S.A. | Lavigne and Holland, 1969 |
| *Eremisca vernalis* Zinov'eva | E, L | Kazakhstan, U.S.S.R. | Zinov'eva, 1959 |
| *Eutolmus implacidus* Loew | E | Kazakhstan, U.S.S.R. | Lehr, 1962 |
| *Eutolmus rufibarbus* Meigen | L, P | Khabarovsk Region, U.S.S.R. | Ecipenko, 1967 |

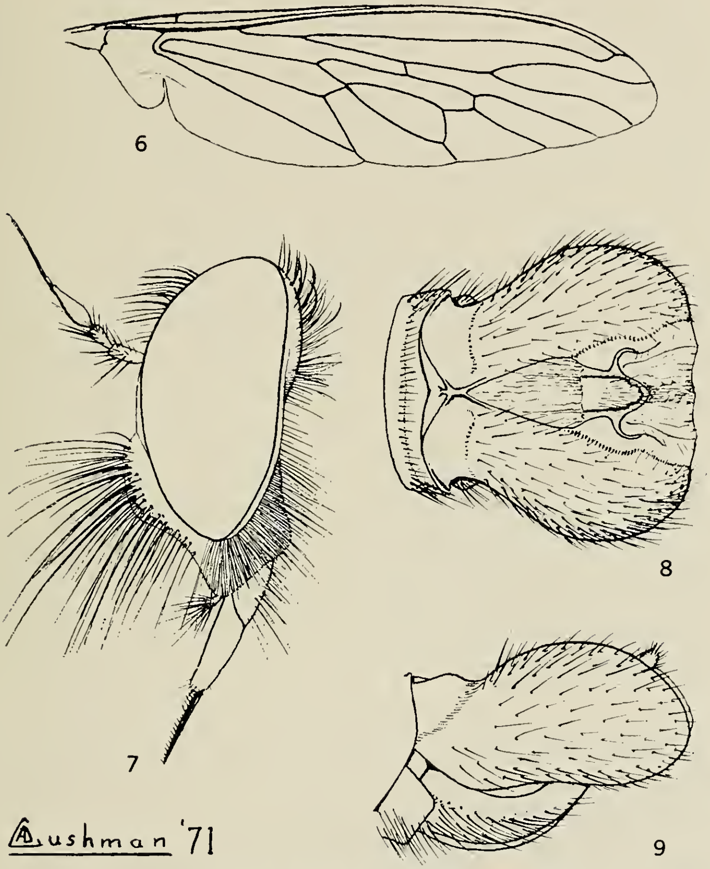
Table 1. (Continued)

| | | | |
|---|---|---|---|
| | | ASILINAE | |
| *Machimus atricapillus* Fallén | P | Kazakhstan, U.S.S.R. | Zinov'eva, 1959 |
| *Machimus gonatistes* Zeller | E, L, P | Kazakhstan, U.S.S.R. | Zinov'eva, 1959 |
| *Mallophora media* Clements and Bennett | I–IV L, P | Trinidad, West Indies | Clements and Bennett, 1969 |
| *Mallophora ruficauda* (Wiedemann) | E, I–IV L, P | Argentina | Copello, 1927, 1942 |
| *Mallophorina frustra* Pritchard | E | Arizona, U.S.A. | Cole and Pritchard, 1964 |
| *Mallophorina pulchra* Pritchard | E | Arizona, U.S.A. | Cole and Pritchard, 1964 |
| *Promachus bastardii* (Macquart) | L | Michigan, U.S.A. | Peterson, 1957 |
| *Promachus dimidiatus* (Curran) | E | Wyoming, U.S.A. | Lavigne and Holland, 1969 |
| *Promachus leontochlaenus* Loew | E | Kazakhstan, U.S.S.R. | Lehr, 1958 |
| *Promachus vertebratus* (Say) | L, P | U.S.A. | Davis, 1919 |
| *Promachus* sp., prob. *vertebratus* (Say) | L | Ohio, U.S.A. | Peterson, 1957 |
| *Neomochtherus kivuensis* Tsacas | E | Lake Kivu, Congo | Tsacas, 1969 |
| *Neomochtherus perplexus* Becker (= *N. hungaricus rossicus* Engel ?) | E, IL, P | Kazakhstan, U.S.S.R. | Zinov'eva, 1959 |
| *Philonicus albiceps* (Meigen) | L | England | Brindle, 1962 |
| *Satanas gigas* Eversmann | E, IL, P | Kazakhstan, U.S.S.R. | Zinov'eva, 1959 |
| *Triorla interrupta* (Macquart) (as *Erax maculatus* Macquart) | L | U.S.A. | Davis, 1919 |
| *Triorla interrupta* (Macquart) (as *Erax interruptus* Macquart) | L, P | Louisiana, U.S.A. | Osterberger, 1930 |



FIGS. 2–5. *Neomochtherus angustipennis* (Hine); pupal skin: 2, ventral view; 3, lateral view; 4, posterolateral view of last abdominal segment; 5, dorsal view. aap, anterior antennal process; acs, anterior coxal sheath; amsp, anterior mesothoracic spines; hs, hypopharyngeal sheath; ls, labral sheath; ms, maxillary sheath; pap, posterior antennal process; pmsp, posterior mesothoracic spine.

processes (aap) not joined at base and a group of 3 basally fused posterior antennal processes (pap) located ventrolaterally on either side, the 2 outermost processes fused basally for a greater distance and thus appearing shorter than the innermost process. Outermost process rounded apically, the 2 innermost processes acute. Labral sheath (ls) with a slight keel apically that is rugulose on either side. Hypopharyngeal sheath (hs) with a minute tubercle on either side. Maxillary (ms) and anterior coxal sheaths (acs) entirely smooth. Paired prothoracic spiracles elongate-oval, surrounded by a ring of thickened cuticle basally, situated midlaterally at anterior margin of thorax. A pair of anterior mesothoracic spines (amsp), 1 short and blunt, the other long and sharply curved,



Figs. 6–9. *Neomochtherus angustipennis* (Hine): 6, Wing; 7, Head; 8, Male terminalia, dorsal view; 9, Same, lateral view.

on either side of thorax above bases of sheaths of second pair of legs. A short, dull posterior mesothoracic spine (pmsp) on tubercle at base of each wing sheath. No rugulose area on thorax above wing sheaths. Sheaths of third pair of legs reaching slightly beyond middle of abdominal segment 3. First abdominal segment with a transverse row of 10 long, subequal, apically recurved spines dorsally along anterior margin and 4 yellowish bristles behind lateral spiracle, venter obscured. Second segment with a median transverse row of alternate long and short, straight spines dorsally, a short row of 4 or 5 bristles dorsolaterally, 4 to 7 bristles behind the lateral spiracle, and a mesally interrupted row of bristles ventrally. Third through seventh abdominal segments similar, each with spines and bristles dorsally as on second segment, 5 or 6 bristles laterally, and complete ventral transverse row of bristles. Abdominal segment 8 (last segment) composed of a ringlike anterior portion with 4 subequal spines dorsally, 6 or 7 bristles laterally, and 12 bristles ventrally. Tapered posterior portion with a pair of long dorsolateral processes, a pair of shorter ventrolateral processes, and a pair of short ventromedian processes. A pair of low tubercles midventrally on posterior part of segment 8.

The specimen is labeled, "Barcroft, Va., VIII.1.34, emerged VIII.13. 34, pupa in surface soil under pine tree, J. C. Bridwell."

The adult compares exactly with Hine's (1909) description and figures, and with a male cotype from St. Elmo, Virginia, collected by F. C. Pratt, September 13 (USNM Type Number 12648). There is an additional adult in the Smithsonian Institution, a male, from Camp Peary, Virginia, July 1943, R. M. and G. E. Bohart. The Catalog of North American Diptera (Stone, et al., 1965) also records the species from North Carolina.

This species was described in the genus *Asilus* L. by Hine (1909), listed under *Asilus* in the North American Catalog, and under *Neomochtherus* by Hull (1962). Except for the rather well-developed facial gibbosity, *N. angustipennis* has the characters of the genus as discussed by Hull (1962) and Tsacas (1963, 1968). The only figures of this species that have been published are Hine's (1909) rather superficial drawings of the male terminalia; the head, wing, and male terminalia are shown here in Figures 6–9.

## ACKNOWLEDGMENTS

Figure 1 was prepared by V. Krantz, Smithsonian Institution Photographic Services, and Figures 2–9 were prepared by A. D. Cushman, Systematic Entomology Laboratory, USDA.

I am very grateful to the following colleagues who read the manuscript and offered many suggestions for its improvement: A. N. Clements, Woodstock Agricultural Research Centre; R. J. Lavigne, University of Wyoming; H. Oldroyd, British Museum (N. H.); and L. Tsacas, Museum National d'Histoire Naturelle, Paris.

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Vol. 85, No. 14, pp. 179–190 30 August 1972

PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

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# A NEW HETEROMYID RODENT FROM THE EARLY OLIGOCENE OF NATRONA COUNTY, WYOMING

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In the Frick Collection, Department of Vertebrate Paleontology, The American Museum of Natural History, are several hundred fossil rodent specimens from the early Oligocene deposits of the Flagstaff Rim area, Natrona County, Wyoming. Among these is a single specimen, consisting of the rostrum and parts of both lower jaws, that compares most favorably with *Meliakrouniomys wilsoni* Harris and Wood, 1969, and is described below as a new species of that genus. Harris and Wood (1969) assigned *Meliakrouniomys* to the Eomyidae and suggested that it was "an eomyid on the way to becoming a heteromyid" (1969, p. 5). Additional features are preserved in the new species and on the basis of these the genus is transferred to the Heteromyidae.

For the opportunity to study the collection that includes this new form, I thank Dr. Malcolm C. McKenna, Frick Curator, Department of Vertebrate Paleontology, The American Museum of Natural History. The specimen was collected in 1958 by a Frick Laboratory field expedition under the joint leadership of Mr. Morris F. Skinner and Mr. Ted Galusha, both of whom I thank for the excellent stratigraphic and geographic documentation. I thank Dr. Mary R. Dawson of the Carnegie Museum, Pittsburgh, and Dr. Robert W. Wilson of the Museum of Geology, South Dakota School of Mines and Technology, for critically reading the manuscript and offering helpful suggestions; this does not necessarily imply that they concur with all of my interpretations and conclusions, for which

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I alone am responsible. The illustrations are by Miss Jennifer Perrott.

The abbreviation FAM, used as a prefix to the specimen catalog number, stands for Frick American Mammals, Department of Vertebrate Paleontology, The American Museum of Natural History.

## HETEROMYIDAE ALLEN AND CHAPMAN, 1893

### *Meliakrouniomys* Harris and Wood, 1969

### **Meliakrouniomys skinneri**[1] new species

Figures 1 and 2

*Type*: FAM 79300, rostrum, partial left mandibular ramus with $P_4$-$M_3$, and fragment of right mandibular ramus with $P_4$-$M_1$. There can be little doubt that the three fragments belong to one individual. They were found together where they had weathered from one broken nodule, which probably originally contained the remainder of the skull and mandible.

*Type-locality and horizon*: From the divide area between the South Fork of Lone Tree Gulch and the Central Fork of Blue Gulch, in the SE ¼, Sect. 27, T. 31 N., R. 83 W., Natrona County, Wyoming. From about 30 feet (9 meters) below ash G, or about 405 feet (123 meters) above the base of the generalized zonation section which has a total thickness of about 720 feet (219 meters), all of Chadronian (early Oligocene) strata. The section will be published in a report on the stratigraphy of the Flagstaff Rim area.

*Diagnosis*: Slightly smaller than the genotypic and only previously known species, *M. wilsoni* (Table 1). Lower premolar with anterior cingulum (lacking in *M. wilsoni*) and without posterior cingulum (present in *M. wilsoni*). Hypoconid of $M_1$ and $M_2$ without anterior arm seen in *M. wilsoni*. Hypoconulids of $M_1$ and $M_2$ barely indicated.

*Description*: In the only known specimen of *Meliakrouniomys skinneri*, the skull is broken at the level of the premolar alveoli and the part posterior to this is missing. The anterior part of the skull, however, exhibits many important characters that contribute to our fund of knowledge about the genus.

The rostrum is deep and laterally compressed, not appreciably wider dorsally than ventrally. In dorsal view, the lateral profiles of the rostrum are slightly convex and taper anteriorly (Fig. 1B). The nasal bones are long and slender, the posterior part having nearly parallel sides. Anteriorly, the nasals are expanded laterally, carried downward onto

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[1] The specific term is for Mr. Morris F. Skinner, whose Frick Laboratory field parties have made extensive collections from the Flagstaff Rim area.

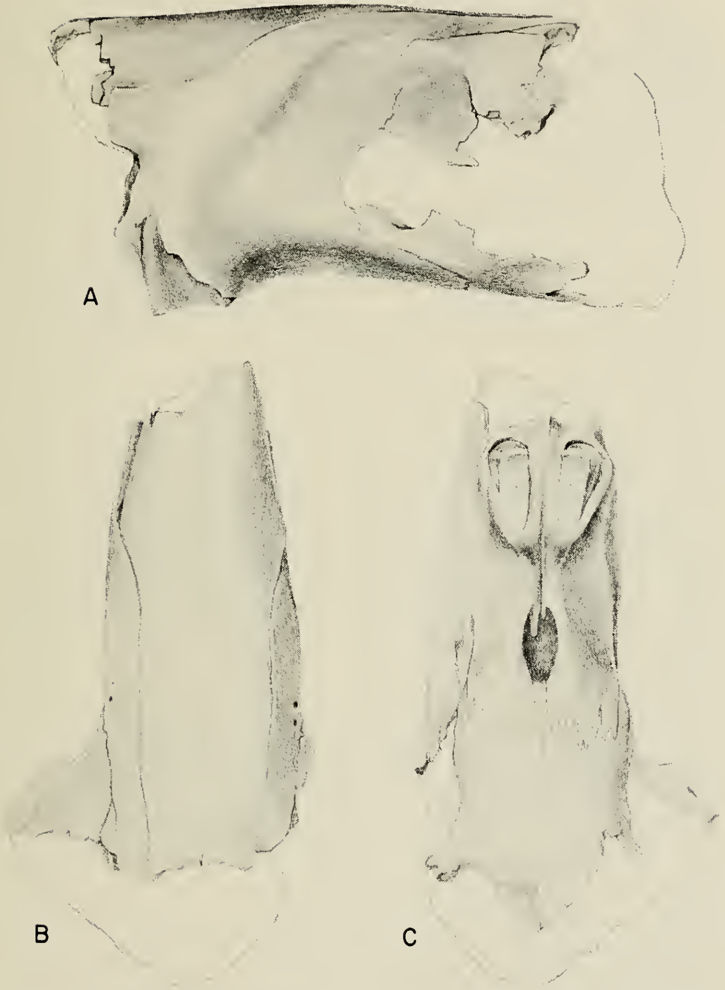

Fig. 1. *Meliakrouniomys skinneri*, rostrum of type, FAM 79300. A, left lateral view. B, dorsal view. C, ventral view. All approximately ×4.

the sides of the snout, and extend forward beyond the premaxillaries (Figs. 1A and 1B). The posterior limit of the nasals cannot be determined because it is not certain that the skull is broken at the naso-frontal suture. The nasals did extend backward beyond the

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upper limit of the zygomatic plate, at least to the level of the orbit. In lateral view, the dorsal profile of the snout is slightly convex. The ventral profile is nearly straight, sloping gently upward, to a point just anterior to the incisive foramina, and then becomes concave and slopes downward just behind the incisors.

The maxillary bones are damaged on both sides, but the dorsal part of the zygomatic plate is preserved on the left side (Fig. 1A and 1B). The plate, though incomplete, was apparently of typical heteromyid form, inclined and excavated on the anteroventral surface for origin of the masseteric musculature. A low crest continues anteriorly from the anterodorsal edge of the zygomatic plate and then turns downward, nearly following the curvature of the incisor almost to its alveolus. This low crest apparently defines the edge of the area of origin of the masseteric musculature. The ventral border of the infraorbital foramen is preserved on both sides. The position of the foramen is typical of heteromyids, far ahead of the zygomatic plate, just behind the maxillary-premaxillary suture. Due to breakage, the full size of the foramen cannot be determined, but the parts preserved indicate that it was relatively large; it can also be determined that it opened anterolaterally into a depression or sulcus. The origin for the masseter lateralis superficialis is a slightly depressed, elliptical, rugose area just posteroventral to the infraorbital foramen. This compares more favorably with that of most geomyoids rather than that of eomyids, and, incidentally, *Heliscomys*, which have a prominent tubercle for origin of this muscle.

The premaxillary bones have narrow dorsal processes that extend backward between the maxillaries and nasals, at least to the point where the skull is broken. Anteriorly, each premaxillary has a small process produced forward beneath the extended nasals. These processes, along with the nasals, form a somewhat tubular nares.

The ventral part of the rostrum is narrow between the incisors and the incisive foramina. Posterior to the incisive foramina the ventral part is much broader and bulbous, similar to that of some of the Recent heteromyids. The zigzag course of the premaxillary-maxillary suture is so clearly shown in the figures that any attempt to describe it in words would be redundant.

The only upper teeth present are the incisors, and these are broken off almost level with the alveoli. In cross section, they are very narrow, the anteroposterior dimension being about three times the transverse. The anterior surface is rounded. The enamel reaches about one-fourth the way around the lateral surface. The pulp cavity is a thin slit.

Compared with the eomyid *Paradjidaumo*, described by Wilson (1949a), the rostrum and upper incisors of *Meliakrouniomys* are more laterally compressed; the masseteric plate extends farther dorsally to very near the dorsal profile of the rostrum; the anterior border of the infraorbital foramen is closer to the maxillary-premaxillary suture;

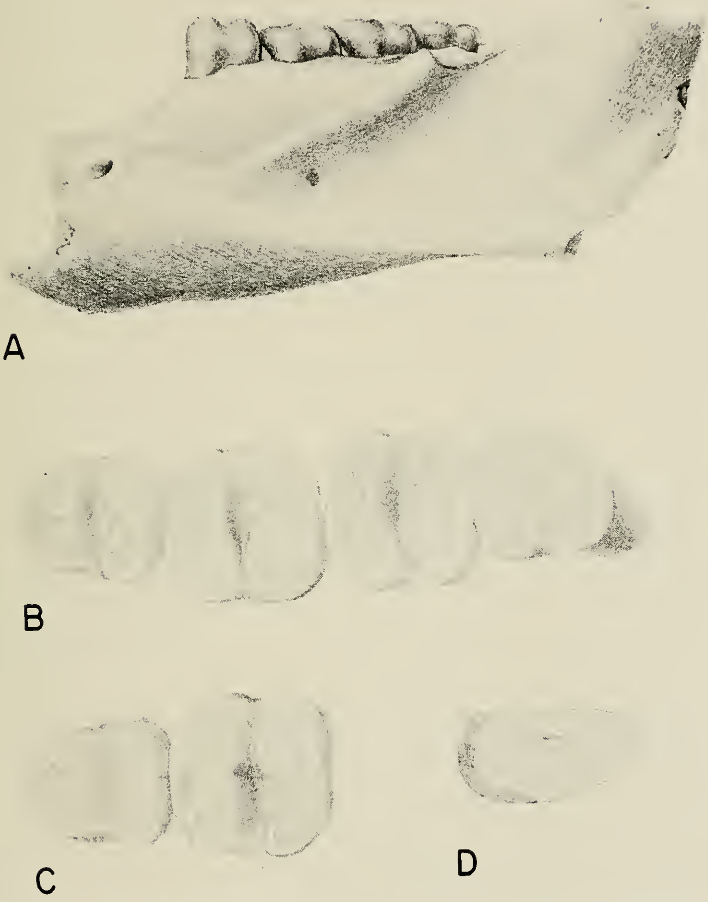

Fig. 2. *Meliakrouniomys skinneri*, mandibular ramus and dentitions of type, FAM 79300. A, left mandibular ramus, lateral view, approximately × 6. B, occlusal view of left $P_4$-$M_3$, approximately × 12. C, occlusal view of right $P_4$-$M_1$, approximately × 12. D, cross-sectional view of left $I_1$, approximately × 12.

the nasals and dorsal wings of the premaxillaries extend farther posteriorly; the area of origin of the masseter lateralis superficialis is slightly depressed and flat rather than being a tubercle.

The morphology of the mandible of *M. skinneri* is much like that of *M. wilsoni*, except that in the new species the jaw is a little deeper anteriorly, the ventral border more convex, and the ventral masseteric ridge extends slightly farther forward. Breakage precludes determination of the actual length of the diastema, but if the incisor were restored beyond its point of breakage, it would allow the observation that the diastema was relatively long. The dorsal border is only slightly depressed between $P_4$ and the incisor. The mental foramen is high on the side of the jaw, just anterior to the masseteric fossa, and well ahead of $P_4$. The masseteric fossa is large and well defined. The dorsal and ventral masseteric ridges meet beneath the anterior part of $P_4$. The ventral ridge is very strong, the dorsal ridge quite weak but more distinct than that of *Heliscomys* and later heteromyids. The ventral ridge is carried forward, beyond its junction with the dorsal ridge, as a flat, sharply defined, elliptical shelf that extends well forward of $P_4$, ending at the level of, and just behind, the mental foramen. Posteriorly, the ventral masseteric ridge descends to the lower border of the jaw. The front edge of the ascending ramus flares outward to accommodate the root of the incisor.

The lower incisor is narrow; in cross section it is about twice as long as wide. The anterior surface is rounded. The enamel extends nearly half way around the lateral surface, as it does in *M. wilsoni.* The pulp cavity is a narrow slit.

The permanent lower premolar of *M. skinneri* has a distinct anterior cingulum that descends from the anterior surface of the protoconid and crosses the front of the tooth to merge with the anterior surface of the metaconid. This feature is missing in *M. wilsoni.* The anterior half of $P_4$ is narrower than the posterior half. The metaconid is a little larger than the protoconid. The two cusps are joined at their posterior margins. The hypoconid and entoconid of $P_4$ are both transversely elongate and are joined into a continuous loph, though when unworn would have been separate cusps. The protoconid and hypoconid, as well as the metaconid and entoconid, are joined basally by low crests so that the transverse valley is actually a very shallow basin. There is no evidence of the small posterior cingulum seen in $P_4$ of *M. wilsoni.*

The first two molars of *M. skinneri* are so nearly identical that one description will apply to both. These two teeth are quadrate in outline, slightly longer (anteroposteriorly) than wide (transversely), and basically bilophate. The four main cusps are distinct, but have been joined by wear into two transverse lophs. Each tooth has an anterior cingulum that descends from the anterior surface of the protoconid and extends nearly to the lingual margin of the tooth, longer and more strongly developed than that of *M. wilsoni.* The hypoconulid, if present at all, is no more than a raised part of the posterior cingulum. The posterior cingulum, at the present stage of wear, is very indistinct, but was apparently a low shelf posterior to the entoconid. The inner cusps of the molars are more anteroposteriorly compressed and are higher than the outer cusps. The hypoconids appear to be expanded

TABLE 1. Measurements (in millimeters) of type of *Meliakrouniomys skinneri* compared with similar measurements of type of *M. wilsoni* (measurements of *M. wilsoni* from Harris and Wood, 1969, p. 6).

| | *M. skinneri* | *M. wilsoni* |
|---|---|---|
| Left $I^1$, anteroposterior | 2.75 | — |
| transverse | 1.00 | — |
| Diastema, right $I^1$–$P^4$ alveolus | 10.50 | — |
| Left $P_4$–$M_3$, anteroposterior | 6.60 | 7.15 |
| Left $I_1$, anteroposterior | 1.95 | 2.16 |
| transverse | 1.00 | 0.95 |
| Left $P_4$, anteroposterior | 1.55 | 1.70 |
| metalophid transverse | 1.27 | 1.31 |
| hypolophid transverse | 1.45 | 1.63 |
| Left $M_1$, anteroposterior | 1.65 | 1.89 |
| metalophid transverse | 1.77 | 1.87 |
| hypolophid transverse | 1.80 | 1.98 |
| Left $M_2$, anteroposterior | 1.60 | 1.83 |
| metalophid transverse | 1.80 | 1.98 |
| hypolophid transverse | 1.70 | 1.95 |
| Left $M_3$, anteroposterior | 1.48 | 1.71 |
| metalophid transverse | 1.55 | 1.73 |
| hypolophid transverse | 1.25 | 1.42 |
| Depth of left ramus below $P_4$ | 4.70 | — |

toward the center of the basins but do not really have anterior arms like those of *M. wilsoni.* The transverse valleys are slightly deeper in the center than at the buccal and lingual margins.

The posterior part of $M_3$ is narrower than the anterior part. The anterior cingulum connects to the anterolingual part of the protoconid and extends nearly to the lingual margin of the tooth as in the other two molars. The protoconid and metaconid are joined into a continuous loph, also similar to the other molars. $M_3$ is so worn that the hypoconid and entoconid are fused into a loph, with only a shallow indentation in the posterolingual margin to indicate the division between these two cusps. If this indentation indicates the approximate limits of the two cusps, the entoconid was considerably smaller then the protoconid. $M_3$ apparently had no posterior cingulum: if it did, it has been completely obliterated by wear.

*Discussion:* On the basis of radiometric dates from the type area of *Meliakrouniomys skinneri* (Evernden et al., 1964) and from the type area of *M. wilsoni* (Wilson et al., 1968), the two species are of nearly equivalent age. Most of the other elements of the Ash Springs local fauna, which includes *M. wilsoni* (Wilson et al., 1968, p. 596), correspond, at least at the generic level, with forms associated with

*M. skinneri*, and also indicate close temporal equivalence. It is at least certain that both are Chadronian, and, at least in my opinion, equally certain that neither is earliest Chadronian. Both species are certainly younger than the Yoder fauna of eastern Wyoming.

*Meliakrouniomys skinneri* and *M. wilsoni* are similar except for minor details and are clearly closely related. The more distant relationships of the genus are, however, not so apparent. Harris and Wood (1969, p. 6) commented that the jaw of *M. wilsoni* "is closer to those of heteromyids than to those of eomyids." The tooth pattern of *Meliakrouniomys* is much simpler than that of eomyids, but Harris and Wood (1969, p. 5) postulated that it had been derived from that of an eomyid by loss of the mesoconid and ectolophid and reduction of anterior and posterior cingula. They assigned the genus to the Eomyidae and considered it to be transitional between the Eomyidae and Heteromyidae. Additional features of the snout of the new species (*M. wilsoni* is known only from a lower jaw) indicate that the genus has the typical heteromyid zygomasseteric structure, and, although the dentition is less characteristically heteromyid, it is transferred to the Heteromyidae on the basis of the following features: bilophate cheek teeth; very narrow and deep snout, not appreciably wider dorsally than ventrally; narrow incisors; nasals extending forward beyond premaxillaries; zygomatic plate inclined and reaching nearly to the dorsal profile of the snout; infraorbital foramen far ahead of the zygomatic plate; nasals and premaxillaries both extending backward beyond the upper part of the zygomatic plate; masseteric fossa of mandible extending anterior to $P_4$; mental foramen high on side of jaw and well ahead of $P_4$; mandible small relative to size of skull.

The rostrum of *M. skinneri* compares very well in most features with that of the medial Oligocene heteromyid *Heliscomys tenuiceps* Galbreath, 1948. The principal differences are that in *H. tenuiceps* the premaxillary forms the anterointernal border of the infraorbital foramen, and the ventral part of the rostrum is relatively broader anterior to the incisive foramina than it is in *M. skinneri*. The mandible of *H. tenuiceps* is not known, but it is known in other species of *Heliscomys*, and is similar to that of *Meliakrouniomys*. The masseteric fossa of *Heliscomys* terminates beneath $P_4$, but the ventral ridge is carried forward as a heavy shelf to a point just behind the mental foramen (Black, 1965, p. 43). The ventral ridge is stronger than the dorsal ridge, and the mental foramen is high on the mandible.

The lower premolar of *Meliakrouniomys* is not aberrant for that of a heteromyid. It is similar in general form and differs only in details from that of *Proheteromys*, particularly *P. parvus* (see Wood, 1935, p. 84, fig. 5). The lower premolars of other later heteromyids, for example *Mookomys*, *Perognathus*, and *Diprionomys*, also have a general resemblance to that of *Meliakrouniomys* in the spatial arrangements of the four primary cusps, though they differ from *Meliakrouniomys*, and from each other, in the presence or absence of cingula, accessory cuspules, and crests. A general similarity is also seen in the $P_4$ of the entoptychine geomyid *Pleurolicis leptophrys* (see Wood, 1936b, p. 6, fig. 6).

*Meliakrouniomys* lacks the buccal cingula and stylids on the lower molars that seem to be so characteristic of most of the later heteromyids. Stylids developed from the buccal cingula in *Heliscomys*, for example, are nearly as large as the primary cusps. Though Harris and Wood (1969) assigned *Meliakrouniomys* to the Eomyidae, and considered *Heliscomys* to be descended from an eomyid, they commented (p. 5) that *Meliakrouniomys* seems perhaps too far advanced to be ancestral to *Heliscomys*, in the large size of the protoconid of $P_4$, and in the fact that the cusps of the teeth are not isolated, rounded tubercles, as they are in *Heliscomys*. There is some evidence (Wilson, 1949b, pp. 114–115) that the cusp pattern of *Heliscomys* does not represent the primitive heteromyid pattern. It seems more likely that the $P_4$ of *Heliscomys* has undergone cusp reduction, rather than the premolar pattern of all later heteromyids having been derived from that of *Heliscomys* by addition of the protoconid.

The medial Oligocene heteromyids *Apletotomeus* Reeder, 1960, and *Akmaiomys* Reeder, 1960, seem to have a combination of features seen in *Meliakrouniomys* and the later heteromyids. Both of these genera approach *Meliakrouniomys* in the basically quadricuspate, bilophate cheek teeth with anterior and posterior cingula. These two genera, unlike *Meliakrouniomys*, have buccal cingula on the lower molars. The cingula are shelflike, and, although stylids are present, they are not so prominent and do not participate in loph development as they do in most species of *Heliscomys* and later heteromyids such as *Proheteromys*, *Peridiomys*, and *Diprionomys*. The later heteromyids also lack the anterior and posterior cingula that are seen in *Meliakrouniomys*, *Apletotomeus*, and *Akmaiomys*.

The lower dentition of *Heliscomys tenuiceps* is not known. The upper dentition differs from that of other species of the genus in having essentially undivided internal cingula with no distinct styles. The lower molars would probably be much like those of *Apletotomeus* and *Akmaiomys*, and it is possible that one of these forms, which are known only from lower dentitions, represents the lower dentition of *H. tenuiceps*. Reeder stated (1960, p. 513) of *Apletotomeus crassus* that "this species represents the largest mammal yet described, the dentition of which resembles that of *Heliscomys*." He makes no mention, however, of *H. tenuiceps* Galbreath, 1948, the largest described species of *Heliscomys*. The anteroposterior crown length of $P^4$-$M^3$ of *H. tenuiceps* is 3.75 mm (Galbreath, 1948, p. 294). The anteroposterior length of $P_4$-$M_3$ of *Apletotomeus crassus*, obtained by adding the lengths of the four teeth of the type given by Reeder (1960, p. 516), is 3.65 mm. $P_4$ and $M_1$ of *Akmaiomys incohatus* are even smaller. Galbreath (1948, p. 293) noted that the upper teeth of heteromyids rarely exceed the lower teeth in length. If a similar relationship is assumed to exist in the genera here in question, *H. tenuiceps* is the largest of the three, though all are very nearly the same size. *Apletotomeus* sp. (Reeder, 1960, p. 517) and the type of *Akmaiomys incohatus* are both from the Cedar Creek Member of the Brule Formation of northeast Colorado, as is the type of *Heliscomys tenuiceps*. Though it cannot be determined until upper and lower dentitions have been found in association, it is a distinct possibility that one of the forms known only from lower dentitions is a synonym of *H. tenuiceps*, of which only the upper dentition is known.

Earlier forms that show a general similarity to *Meliakrouniomys* are *Griphomys* Wilson, 1940, and *Floresomys* Fries, Hibbard, and Dunkle, 1955.

*Griphomys*, from the late Eocene Sespe Formation, was assigned to ?Geomyoidea by Wilson (1940). The teeth of this genus are composed of essentially four cusps with an anterior cingulum, the cusps joining into transverse lophs with wear. The masseteric fossa extends to beneath $P_4$, and the mental foramen is high on the side of the mandible.

*Floresomys* was assigned by Fries, Hibbard, and Dunkle (1955, p. 16) to the Sciuravinae (since elevated to Sciuravidae) on the basis of distinct cusp development and reduction of conules. The authors noted, however, that it is distinct from other known genera of Sciuravidae in the presence of the broad, deep valleys separating the paracone and protocone from the metacone and hypocone, and the metaconid and protoconid from the entoconid and hypoconid. The primary cusps merge into two transverse lophs as the teeth are worn. There is no mesoconid nor mesostylid. Anterior and posterior cingula are present on the molars. The masseteric fossa ends beneath $M_1$. The age of *Floresomys* is uncertain; it is possibly late Eocene or early Oligocene. Fries, Hibbard, and Dunkle (1955, p. 24) remarked that the dentition of *Floresomys* is reminiscent of the Heteromyidae, but added that the shortness of the diastema and construction of $M^3$ rule out the relationship unless *Floresomys* was very early in the development of the Geomyoidea.

The dentition of *Meliakrouniomys* does not, in my opinion, indicate greater affinities to the eomyids than it does to some of the sciuravids, particularly *Sciuravus powayensis* Wilson, 1940, in which the lophs are strengthened and the masseteric muscle scar of the mandible is farther forward than in other species of *Sciuravus*. The sciuravid *Taxymys* also has more strongly bilophate cheek teeth, and some specimens have a pattern of four more or less isolated cusps, both these features being an approach to the geomyoid plan (Wilson, 1949b, p. 98). Comment has already been made on the resemblances of *Meliakrouniomys* to the supposed sciuravid *Floresomys*.

In summary, *Meliakrouniomys* is characteristically a heteromyid in its zygomasseteric structure, and, although the dentition is less typically that of a heteromyid, the similarity here is closer than to any of the Eomyidae. Addition of a buccal cingulum to the lower dentitions of

*Meliakrouniomys* would result in a form similar to *Apletotomeus* and *Akmaiomys*, and reduction of the posterior and anterior cingula would increase the similarity to later heteromyids. Although it is possible that *Meliakrouniomys* is derived from an eomyid, similarities are also seen in the sciuravids *Floresomys* and *Sciuravus powayensis* and in the ? geomyoid *Griphomys*. Material of all the discussed forms does not exist in sufficient quantity or quality to justify establishing lines of descent, but it is believed that some special relationships exist.

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Vol. 85, No. 15, pp. 191–204 30 August 1972

PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

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# A NEW EASTERN PACIFIC WORMFISH, *MICRODESMUS KNAPPI* (PISCES:MICRODESMIDAE)

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There are 16 recognized species of wormfishes described from low temperate and tropical waters of the Western Hemisphere. One of these, *Microdesmus lanceolatus* Dawson, is known only from the holotype dredged at a depth of 37 meters (m) but the remainder most commonly occur in estuarine, coral reef and tidepool habitats at depths of less than 3 m. The majority of estuarine forms burrow in sand and mud substrates of low energy beaches and mangrove swamps. I here describe an unusual new estuarine species from a beachrock habitat on the Pacific coast of Colombia.

Reported specimens, obtained through personal collections and the Smithsonian Oceanographic Sorting Center (SOSC), have been deposited in the following institutions: Academy of Natural Sciences of Philadelphia (ANSP); California Academy of Sciences (CAS); Gulf Coast Research Laboratory Museum (GCRL); School of Marine and Atmospheric Sciences, University of Miami (UMML); National Museum of Natural History, Smithsonian Institution (USNM). Head length is measured from tip of lower jaw to articular base of the dorsalmost pectoral fin-ray, eye diameter is that of the pigmented area only, body depth is measured at anal fin origin, caudal fin length is the distance between posterior margin of hypural vertebra and tip of longest caudal ray. Measurements, taken with needlepoint dial caliper or ocular micrometer, are in millimeters (mm); proportions are shown as percentages of stan-

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dard length (SL) or head length (HL); all fin-rays are counted separately.

Appreciation is expressed to Dr. Constantine Tapias for expediting my work in Colombia and to Srs. O. Arroyo, O. Barona, and M. Estevez for assistance in the field. I thank Dr. R. R. Priddy, Millsaps College, for prompt examination of a beachrock sample from the type-locality and Dr. V. G. Springer (USNM) for critical review of the manuscript. Drawings are by Harry L. Moore, Jr. This study was supported in part by National Science Foundation Grant GB-15295.

### **Microdesmus knappi** new species

Figure 1

*Holotype*: USNM 206506 (54.5 mm SL); Colombia, Valle del Cauca, Bahia de Buenaventura, off Punta la Guida, approx. 03°51′00″N, 77°10′00″W (H. O. Chart 1786); ichthyocide; 8 Oct. 1969; Sta. No. LK 69–42; L. W. Knapp.

*Paratypes*: USNM 206507 (1, 58.9 mm SL), GCRL 7816 (1, 56.4 mm SL, cleared, stained, and partly dissected); Bahia de Buenaventura, rocky point S of La Bocana, approx. 03°50′51″N, 77°09′55″W; 0–0.6 m; ichthyocide; 1 Nov. 1970; Sta. No. LK 70–19; L. K. Knapp, W. R. Taylor and M. Estevez. ANSP 117497 (1, 52.6 mm SL), CAS 13979 (1, 49.7 mm SL), GCRL 7817 (4, 52.4–61.0 mm SL), UMML 29864 (1, 51.6 mm SL), USNM 206508 (1, 49.9 mm SL); Bahia de Buenaventura, Punta la Guida, approx. 03°50′54″N, 77°10′00″W; from holes in beachrock; ichthyocide; 20 Nov. 1971; C. E. Dawson, O. Arroyo and M. Estevez.

*Diagnosis*: Pectoral rays 11; anal fin-rays 23–25; head breadth 57–64 percent of head length, broadly rounded in front; eye obscured, lacking a distinct orbital margin; lips fleshy, plicate, united to form a prominent, free dermal flap at angle of gape; teeth uniserial, incisiform; scales inconspicuous, well separated, sparse on head; body and head finely freckled, without distinct stripes, bars or blotches; proximal pterygiophore of 1st dorsal spine usually inserted between 4th and 5th neural spines; abdominal vertebrae more numerous than caudal vertebrae.

*Description*: Dorsal fin XVI–XVIII, 28–30, total dorsal fin elements 45–47; anal fin 23–25; pectoral fin 11; pelvic fin 1, 3; segmented caudal fin-rays 17; vertebrae $27-28+20-21=47-48$. See Tables 1 and 2 for proportional measurements and counts.

Body moderately elongate, depth at anal fin origin averages about 8 percent of SL, tapers little posteriad but narrows to about 6 percent of SL at caudal peduncle; slender, breadth at anal fin origin about 38

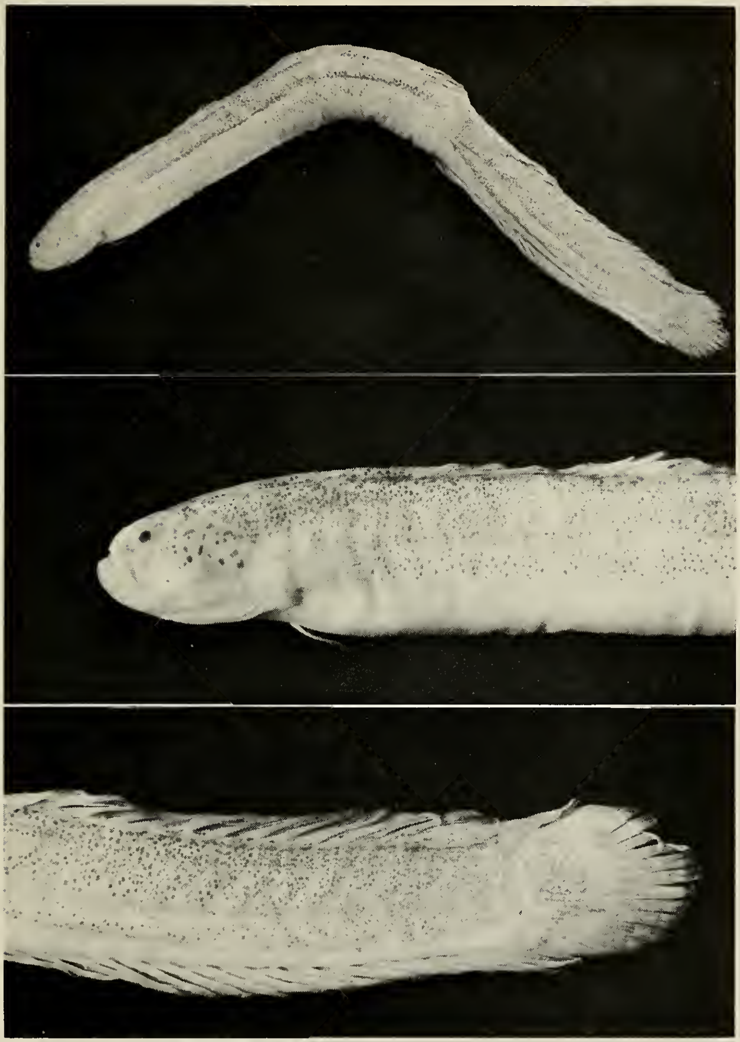

Fig. 1. *Microdesmus knappi* USNM 206506; holotype; 54.5 mm SL.

percent of HL, greatest breadth (about 64 percent of HL in holotype) at opercles; caudal fin short, broadly rounded, greatest depth about 20 percent greater than body depth, united to posteriormost dorsal and anal fin-rays, without a well-defined peduncle; holotype with 15 branched caudal rays and a simple segmented ray above and below, cleared para-

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TABLE 1. Measurements of *Microdesmus knappi* in millimeters (mm) and in percent of standard length (SL) or head length (HL).

| | Holotype (mm) USNM 206506 | Paratypes (mm) | | | Percent SL or HL* | | |
|---|---|---|---|---|---|---|---|
| | | N | Range | x̄ | N | Range | x̄ |
| Standard length | 54.5 | 10 | 49.7–61.0 | 54.7 | | | |
| Caudal fin length | 4.6 | 9 | 4.1– 5.0 | 4.6 | 10 | 8.0– 9.0 | 8.4 |
| Least caudal peduncle depth | 3.1 | 10 | 2.8– 3.5 | 3.2 | 11 | 5.3– 6.4 | 5.8 |
| Depth at anal fin origin | 4.0 | 10 | 3.7– 4.7 | 4.2 | 11 | 6.4– 8.5 | 7.6 |
| Predorsal length (to tip of lower jaw) | 8.7 | 10 | 7.7–10.0 | 8.6 | 11 | 14.4–17.7 | 15.8 |
| Preanal length | 33.7 | 10 | 32.7–39.0 | 35.5 | 11 | 61.8–66.2 | 64.7 |
| Pectoral fin length | 2.6 | 9 | 2.4– 3.1 | 2.8 | 10 | 4.2– 5.6 | 4.9 |
| Pelvic fin length | 1.8 | 10 | 1.6– 2.1 | 1.8 | 11 | 2.7– 3.8 | 3.2 |
| Pelvic insertion to anal fin origin | 28.6 | 10 | 27.0–33.3 | 30.0 | 11 | 52.4–56.8 | 54.6 |
| Head length | 5.2 | 9 | 5.0– 5.6 | 5.3 | 10 | 8.9–10.4 | 9.7 |
| Eye diameter* | 0.4 | 9 | 0.4– 0.5 | 0.4 | 10 | 7.1–10.0 | 8.0 |
| Preorbital length* | 0.8 | 8 | 0.9– 1.1 | 1.0 | 9 | 15.3–20.0 | 18.1 |
| Anterior margin of eye to tip of lower jaw* | 1.2 | 9 | 1.3– 1.7 | 1.5 | 10 | 23.0–30.3 | 27.5 |
| Postorbital length* | 3.6 | 9 | 3.1– 3.6 | 3.4 | 10 | 60.7–69.2 | 64.5 |
| Interorbital width* | 0.8 | 9 | 0.7– 1.0 | 0.8 | 10 | 13.4–17.8 | 15.5 |
| Head breadth* | 3.0 | 10 | 3.1– 3.6 | 3.3 | 10 | 57.6–64.2 | 60.7 |
| Tip of lower jaw to posterior angle of gape* | 1.1 | 8 | 0.8– 1.5 | 1.2 | 9 | 15.0–26.7 | 21.3 |

TABLE 2. Meristic data from holotype and paratypes of *Microdesmus knappi.*

| | Holotype USNM 206506 | Paratypes | | |
|---|---|---|---|---|
| | | N | Range | Mode |
| No. of dorsal spines | 17 | 10 | 16–18 | 17 |
| No. of dorsal segmented rays | 30 | 10 | 28–30 | 29 |
| Total dorsal fin elements | 47 | 10 | 45–47 | 46 |
| No. of anal fin-rays | 25 | 10 | 23–25 | 25 |
| No. of pectoral fin-rays | 11 (2) | 16 | | 11 |
| No. of abdominal vertebrae* | 27 | 10 | 27–28 | 27 |
| No. of caudal vertebrae | 21 | 10 | 20–21 | 20 |
| Total vertebrae | 48 | 10 | 47–48 | 48 |
| Anal fin origin beneath interspace between dorsal fin elements | 25/26 | 10 | 24/25–25/26 | |

* Vertebral counts from radiographs.

type similar but 4 simple procurrent elements are visible above and below the segmented rays. Predorsum curves slightly ventrad toward head, length averages about 16 percent of SL; predorsum broad and more or less flat, with a distinct median longitudinal depression from dorsal fin origin to nape. Head length about 10 percent of SL; head broad, not distinctly narrowed in front, depth somewhat less than body depth; interorbital slightly convex, its width more than twice eye diameter; posterior naris dorsolateral, diameter contained about three times in eye, located in a short fleshy tubule less than one narial diameter removed from anterodorsal margin of eye; anterior nares, about ⅓ diameter of posterior, open anteroventrad at tips of distinct, fleshy, tubiform prominences that overhang upper lip (Fig. 2); snout depressed ventrad between narial ridges, the anteromedian profile variously V-shaped as viewed from above, frequently with a minute fleshy lobe on midline. Lips prominent, fleshy, plicate, continuous across symphyses, lower lip slightly emarginate beneath anterior nares; lips united laterally, forming a free dermal flap (0.5 mm long × 0.3 mm wide in holotype) which, in undamaged preserved material, extends outward at about 45° from angle of gape; a distinct groove, concealed by swollen lips, extends from base of anterior narial prominence around angle of gape and along side of lower jaw to near vertical from tip of overhanging narial tube; gape short, its posterior angle (beneath lips and dermal flap) fails to reach vertical from anterior margin of eye, most frequently falls short of vertical from posterior naris. Eye small, dorsolateral, distinguishable only as a dark pigmented area through the skin, without an obvious iris and lacking a definite orbital margin. Teeth uniserial, strong and incisiform in cleared and stained paratype (Fig. 3); 10 slightly recurved teeth on dentary, posteriormost 3 about half as long as anterior teeth; premaxilla

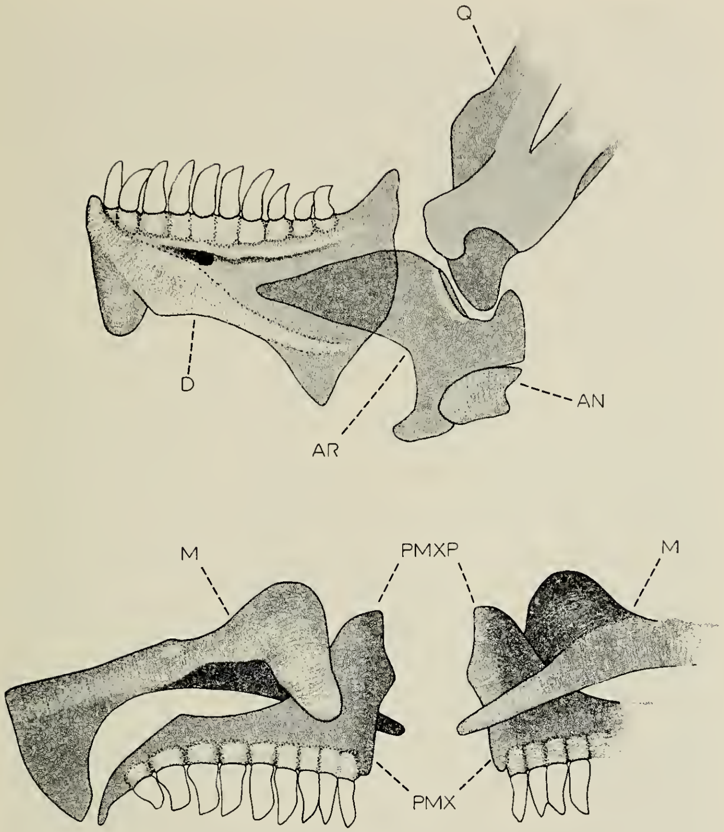

Fig. 3. (Top). Lateral view of lower jaw of *Microdesmus knappi.* (Bottom). Maxilla and premaxilla; inner aspect (left), outer (right). AN: retroarticular; AR: articular; D: dentary; M: maxilla; PMX: premaxilla; PMXP: premaxillary pedicel; Q: quadrate.

with 2 relatively straight, slender teeth anteriad, and with 7 somewhat recurved, broader teeth behind, the last 4 of which gradually shorten posteriad; tongue broadly rounded. Gill opening restricted, distance between upper and lower points of origin less than width of pectoral fin

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Fig. 2. Semidiagrammatic delineation of anterior head of *Microdesmus knappi*; lateral aspect above, dorsal below. Anterior naris opens at tip of narial prominence overhanging upper lip.

FIG. 4. Left gill opening of holotype of *Microdesmus knappi.* Upper point of origin near base of 4th (counting dorsad) pectoral ray; lower point of origin on pectoral fin base and below lowermost pectoral fin-ray.

base, not continued to isthmus, variable both bilaterally and between individuals; bilateral morphology of holotype, one paratype and right and left sides, respectively, of two other paratypes as illustrated (Fig. 4); gill openings somewhat more tubiform in remainder of type series; gill opening extremes range from upper and lower points of origin approximated near base of 3rd (counting dorsad) pectoral fin-ray, to where lower point is well removed and united somewhat posteriad to a narrow dermal expansion along anteroventral margin of pectoral fin.

Dorsal spines flexible, equally spaced; 1st spine averages about 30 percent shorter than 4th, 2nd and 3rd successively longer than 1st, remaining dorsal fin elements of more or less equal length; all dorsal fin elements bound by a continuous membrane; dorsal fin originates ⅓ to ⅔ of pectoral fin length behind vertical from tip of adpressed pectoral fin; 1st segmented dorsal ray branched in all specimens; anal fin height about 20 percent less than that of dorsal at vertical from 5th anal fin-ray, 1st and 2nd anal rays about 20 percent shorter than remainder; 1st anal ray branched in holotype and three paratypes, apparently simple in other specimens; terminal dorsal and anal fin-rays typically included within dermal envelope of caudal fin, usually without a distinctly separate membranous connection to caudal fin; terminal rays difficult to see without transmitted light, easily overlooked; last dorsal fin-ray branched, last anal ray simple in cleared specimen. Pectoral fin narrowly rounded, 6th–8th rays (counting ventrad) longest, uppermost and lowermost minute; holotype with 3 simple rays above, 7 branched rays and simple ray below; pelvic fins separate, with minute outer spine and 3 simple segmented rays, innermost ray about 38 percent longer than 2nd ray and 58 percent longer than outermost. Scales embedded, separated, most closely spaced, but seldom touching, along myomeric impressions; maximum observed scale diameter in cleared paratype 0.2 mm, about 14 scales fall on vertical between anal fin origin and dorsal fin base; a few scales present on cheek, opercle and between nape and interorbital, 1 or 2 scales just before pelvic fin insertion, remainder of head and chest apparently naked; scales most abundant on upper sides and predorsum (to nape), smaller and more widely spaced ventrad, midventral surface of abdomen apparently naked; caudal fin with 2 or 3 irregular scale rows proximad, other fins and pectoral fin base naked.

Usually 1 well-ossified predorsal interneural between 3rd and 4th neural spines and first proximal pterygiophore inserted between 4th and 5th; 2 paratypes (GCRL 7816; GCRL 7817, 57.8 mm) have 2 predorsal interneurals with the 1st proximal pterygiophore inserted between the 5th and 6th neural spines; distal pterygiophores begin immediately behind 1st segmented dorsal ray and behind 2nd anal fin-ray; ossified frontals fail to reach mesethmoid and lateral ethmoid; suspensorium, jaws and cranium well ossified; basihyal very short, broadly triangular, slightly emarginate in front; abdominal neural spines strong, rather broad, often distally truncate, usually shorter than centrum length; prezygopophyses low, not distinctly elevated; pleural ribs articulate with centra of 1st and 2nd vertebrae, subsequently articulate with parapophyses; epipleurals begin at 3rd vertebra. Last dorsal and anal fin elements lack pterygiophores, their bases are approximated to that of the respective penultimate ray; last dorsal proximal pterygiophore inserted between neural spines of 5th and 6th pre-ural centra, terminal anal proximal pterygiophore is between the 4th and 5th.

Ground color in alcohol pale tan; without dark bars, stripes or prominent blotches. Upper body of holotype shaded with a dense scattering of dark tan to brown melanophores, which gradually disperse and vanish ventrad; venter and narrow band above anal fin immaculate (Fig. 1); top of head to interorbital, cheeks and opercles above line from angle of gape to upper pectoral angle with scattered melanophores that become sparse ventrad; a few melanophores on outer surface of narial prominences but interorbital and remainder of snout immaculate; lips and oral flaps pale, a small patch of melanophores on tip of lower jaw, eye black, remainder of head immaculate; dorsal fin mainly pale with a few tan melanophores along some fin-rays; caudal fin base densely speckled with brown, tan streaks line most segmented rays, distal margin pale; remaining fins immaculate. Peritoneum (one specimen examined) pale ventrally, speckled with jet black melanophores above.

Aside from minor variations in melanophore density or shade of brown, preserved coloration is similar in all paratypes. Life coloration of specimens from LK 70–19 was recorded by Dr. Knapp as "reddish-brown color like that of earthworms"; all of my specimens were bright pink to red and finely speckled with darker points in areas now occupied by brownish melanophores.

Branched dorsal and anal fin-rays, the expected adult complement of 15 branched caudal rays, and evidence of developing gonads in some specimens indicate that the type-specimens are adult or near adult fish.

*Etymology*: I name this species for the collector of the holotype, Dr. Leslie W. Knapp, in recognition of his diligence and expertise in the field and in acknowledgment for many valuable specimens and personal courtesies provided.

*Comparisons*: Although distinguished from all known wormfishes by having the least number of anal fin-rays and caudal vertebrae, free oral flaps, and uniserial dentition, *Microdesmus knappi* exhibits similarities in one or more characters with a number of species or species groups. *Clarkichthys bilineatus* (Clark) shares the modal count of 11 pectoral rays, but its boldly striped coloration, biserial dentition, 28–31 anal rays, and differences in head and dorsal fin morphology preclude confusion with *Microdesmus knappi.* The relatively short body, broadly rounded caudal fin, and frequently tubiform gill openings are suggestive of *Cerdale ionthas* Jordan and Gilbert, which may have as few as 27 anal fin-rays and 22 caudal vertebrae. *Cerdale*, however, has more caudal than abdominal vertebrae and differs in gross morphology, dentition,

TABLE 3. Range of vertebral counts in species of *Microdesmus* with more abdominal than caudal vertebrae.

| | N | Abdominal vertebrae | Caudal vertebrae | Total vertebrae |
|---|---|---|---|---|
| *M. carri* | 160 | 36–39 | 29–34 | 66–71 |
| *M. suttkusi* | 50 | 35–37 | 30–32 | 66–69 |
| *M. retropinnis* | 70 | 31–33 | 26–29 | 57–61 |
| *M. knappi* | 11 | 27–28 | 20–21 | 47–48 |

squamation, and in having modal counts of 14 pectoral rays (Dawson, Ms.).

There are four microdesmids with more caudal than abdominal vertebrae (Table 3). Number of abdominal vertebrae is a conservative character in wormfishes, the typical range of three centra being exceeded in only one fish among several hundred specimens examined, and these four species represent a distinctive group within the catchall genus *Microdesmus*. Reid's (1936) treatment of Atlantic and eastern Pacific wormfishes as an open-ended continuum is inadequate and not in accord with evidence now at hand. This matter will be more fully treated in a subsequent report, but certain intra-group comparisons are warranted here.

The recently described geminate species *M. carri* and *M. suttkusi* (Gilbert, 1966) are slender, elongate forms with 11–14 pectoral rays, relatively large and unrestricted gill openings and dentition triserial in part. They are most readily separated from *M. knappi* by their total dorsal fin-ray counts of 66–72. *Microdesmus retropinnis* Jordan and Gilbert has partly triserial dentition and slender form, but its pectoral rays are modally 10 and the gill openings, though somewhat variable, are always more restricted than those of *carri* and *suttkusi* and generally similar to that illustrated for *M. knappi*. Numbers of dorsal spines and total dorsal fin elements overlap those of *knappi*, but *M. retropinnis* is marked with distinctive bars and stripes, and the anal fin, which originates beneath the 16th–22nd dorsal fin elements, has 28–32 rays.

*Habitat*: The holotype and paratypes taken by Dr. Knapp were swimming at the surface. He had the distinct impression that these fish came from a beachrock area, about a meter distant from the actual point of collection, rather than from the immediately surrounding sandy-mud and boulder bottom. I visited the same area on a falling tide in late 1971 and was able to confirm Knapp's impressions and determine the apparent micro-habitat of *M. knappi*. I initially poisoned open water flushing the base of high beachrock at Punta la Guida as well as several shallow rock and sand tidepools on the gently sloping beach immediately east of the point; salinity and temperature of open surface water were 15.0 ‰ and 29.5 °C. One *Cerdale ionthas* and about 40 *Microdesmus retropinnis* were obtained, but no *M. knappi* were seen during about 2

Fig. 5. Beachrock habitat of *Microdesmus knappi* during collection of paratypes on low incoming tide, 20 Nov. 1971. All specimens taken at waist to shoulder heights and from holes in rock face (Srs. M. Estevez, left, and O. Arroyo).

hours of intensive search. Shortly after low tide, I poured poison directly on the beachrock, some 2 meters above its base, and the poison was allowed to flow slowly down the almost vertical face of the beachrock. Soon, the first *M. knappi* was seen trying to escape from one of the many small holes and canals riddling the eroded rock, and eight specimens were collected within 30 minutes. All were taken at waist to shoulder heights above the rock base, and well above existing tide level (Fig. 5). Specimens were taken with considerable difficulty as they squirmed through interconnecting canals in the rock, and it was often necessary to break off pieces of the soft rock in order to secure a particular fish. The only other organisms taken from the canals were two small stomatopods (identified as *Gonodactylus festai* Nobili by Dr. R. B. Manning, USNM) and one *Microdesmus retropinnis.* The beachrock formation extends more than 30 m along the Punta la Guida shore, but collecting efforts were restricted to less than a fifth of this distance.

Dr. R. R. Priddy examined a sample of the beachrock and information from his report is abstracted as follows: a dark gray marine or brackish-water sandstone composed of poorly and incompletely cemented, well sorted, fine quartz sand; cementing material is 90 percent clay and 10 percent limonite; riddled with sub-rounded, unoriented, sinuous holes 50–250 mm deep and 20–150 mm across; burrowing animals honey-combed the deposit before lithification and the mucous lining and filling of holes was removed as modern waves eroded the exposed beachrock. I have no information on the extent or frequency of this type of formation in western Colombian waters, but I have not seen similar sedimentary facies during several years of Pacific shore collecting from México to Panamá.

Frayed caudal and pectoral fins in several fish and occasional unilateral loss of an oral flap, possibly resulting from abrasion, suggests that *M. knappi* is a more or less permanent resident of the beachrock habitat. Apparent absence of this species from nearby, but entirely different environments, during 1971 collecting provides supporting evidence for this conclusion. Mean tide range at Buenaventura is 3.12 m (U.S. Dept. Commerce, 1970) and beachrock levels occupied by *M. knappi* are without active water exchange during several hours of each tide cycle. These fish evidently survive in the small quantity of water retained within the rock, and intriguing eco-physiological problems dealing with temperature variation and rapid salinity changes accompanying not infrequent rainstorms remain to be investigated.

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Vol. 85, No. 16, pp. 205–222 30 August 1972

PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

# FIRST RECORDS OF JUVENILE GIANT SQUID, *ARCHITEUTHIS* (CEPHALOPODA: OEGOPSIDA)

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The literature on cephalopods contains numerous records of individuals of the giant squid *Architeuthis* (see review in Clarke, 1966), the sole genus in the Architeuthidae. Most reports, of course, stress the large size of specimens, including the total length (a measure otherwise little used in cephalopod descriptions). Larvae and juveniles of *Architeuthis*, however, have remained unknown during the century following the original zoological recognition of the genus by Japetus Steenstrup (1857, et seq.).

Two juvenile specimens of *Architeuthis*, representing separate species, were discovered in the collections of the Institute of Marine Sciences, University of Miami during studies on pelagic Cephalopoda. One specimen, 57 mm in mantle length (ML), was taken from the stomach of a fish, *Alepisaurus ferox* (cf.), captured off Camara de Lobos, Madeira Island, Atlantic Ocean. The second specimen (45 mm ML) also was taken from the stomach of a fish, very probably *Alepisaurus* (fide W. Klawe, personal communication), captured by the R/V *Shoyo Maru* in the eastern Pacific off Chile. These specimens represent the smallest known individuals of *Architeuthis*; they are one order of magnitude smaller than the smallest previously reported specimen, an individual of *A. physeteris* of 460 mm ML (Joubin, 1900). Iwai (1956) reported *Architeuthis* specimens of 92 and 104 mm ML, but both of these specimens are demonstrated in this paper to be misidentifications.

This report describes and compares the two juvenile *Architeuthis* specimens, establishes the first record of the genus from the eastern Pacific Ocean, and provides a brief discussion of certain aspects of their biology and phylogeny.

The authors acknowledge the following persons and institutions: Witek Klawe, Inter-American Tropical Tuna Commission, provided the *Shoyo Maru* specimen and traced down information concerning its capture; G. E. Maul supplied the specimen and information from Madeira; John Fitch, California Fish and Game Department, examined the stomach contents; Robert H. Gibbs, Jr., Smithsonian Institution, examined the stomach contents and provided information about the vertical distribution of *Alepisaurus*; G. L. Voss, Institute of Marine Sciences, Miami, provided the opportunity to study the material and information about an unreported *Architeuthis* specimen in his collections; Constance Stolen McSweeny, Molly Dwyer and Carolyn Gast rendered the illustrations; Mrs. McSweeny also discovered the second specimen in the I. M. S. collections; M. J. Sweeney prepared the distribution chart. The manuscript was read and valued comments given by F. A. Aldrich and C. C. Lu, Marine Sciences Research Laboratory of Memorial University, St. John's, Newfoundland and by G. L. Voss. We are most grateful to these people for their aid.

## DESCRIPTIONS

Because of the chaotic state of the systematics of *Architeuthis*, in which until recently nearly every specimen found was named a new species, we will not attempt to assign specific names to our specimens. Table 1 presents the measurements and indices of both specimens.

*Atlantic Specimen*: *Architeuthis* sp. A. Camara de Lobos, Madeira; 18 February 1961; Stomach of *Alepisaurus ferox*, No. 18123; G. E. Maul; 57 mm ML. Figures 1a, 1b, 1c, 2, 3, 4, 5a.

Mantle very long, slender; tapers posteriorly to pointed tip; mantle wall thick, muscular; marginal lobes distinct (Fig. 1a). Mantle and pen terminate together as a pointed tip an-

TABLE 1. Measurements (mm) and indices of juvenile *Architeuthis*.[a]

| | Measurements | | | Indices | |
|---|---|---|---|---|---|
| | 18123 | Fish 17 | | 18123 | Fish 17 |
| Sex | F | M | Sex | F | M |
| ML | 57 | 45 | ML | 57 | 45 |
| MW | 12 | 8 | MWI | 21 | 18 |
| FL | 20 | 14 | FLI | 35 | 31 |
| FW | 15 | 11 | FWI | 26 | 24 |
| HL | 17 | 11 | HLI | 30 | 24 |
| HW | 11 | 9 | HWI | 19 | 20 |
| Gill L | 16 | 14 | GLI | 28 | 31 |
| | L | L | | | |
| Arms I | 47 | 20 | ALI I | 83 | 44 |
| II | 59 | 27 | II | 103 | 60 |
| III | 58 | 27 | III | 102 | 60 |
| IV | 58 | 28 | IV | 102 | 62 |
| Tent. L | 90 | 33 | TLI | 158 | 73 |
| Club L. | 25 | 14 | CLI | 44 | 31 |
| Suck. | | | Suck. | | |
| Diam. I | 0.96 | 0.72 | Ind. I | .017 | .016 |
| II | 1.04 | 0.88 | II | .018 | .020 |
| III | 0.96 | 0.80 | III | .017 | .018 |
| IV | 0.64 | 0.56 | IV | .011 | .012 |
| Club Suck. | | | Club Suck. Ind. | | |
| Diam. (manus) | | | | | |
| medial | 0.96 | 0.56 | medial | .017 | .012 |
| marginal | 0.40 | 0.24 | marginal | .007 | .0053 |

[a] Indices expressed as % of ML × 100. Sucker measurements based on size of largest sucker on each arm or club.

terior to posterior border of fins; only a weak rod of fibrous tissue extends to tip of fins. Fins small (35% of ML), longer than wide, narrow anteriorly, broadest in posterior half, broadly rounded terminally; fins a broad paddle-blade shape in outline. Fins thick, muscular basally; thin, fragile marginally (difference, however, not as great as in adult). Free anterior lobes absent; lobe insertions broadly separated (Fig. 5a).

Funnel short, muscular; extends anteriorly to level of posterior border of bulbus of eye. Funnel locking-cartilage simple, straight, long, narrow; cartilage narrowest, bluntly pointed anteriorly, broadly rounded posteriorly; entire margin thin, almost membranous; groove deep, narrow anteriorly, shallow,

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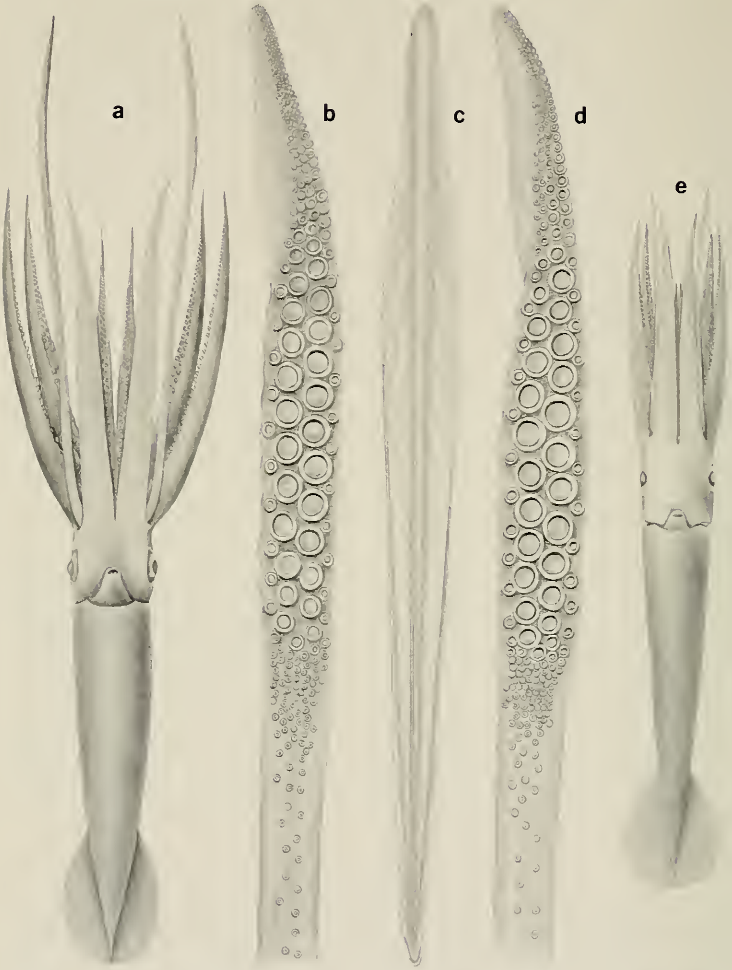

FIG. 1. a-c: Atlantic specimen, 57 mm ML (54 mm ventral ML). a. Ventral view of whole specimen. b. Left tentacular club. c. Gladius. d, e: Pacific specimen, 45 mm ML (43 mm ventral ML). d. Left tentacular club. e. Ventral view of whole specimen.

broad at posterior tip. Groove slightly undercut along medial surface. Mantle locking-cartilage long, robust anteriorly; it tapers and narrows posteriorly; ridge distinctly overhung along medial border. Dorsal part of funnel organ missing; ventral pad damaged, broadly pointed anteriorly, long, tapered posteriorly. Funnel valve broad, crescent shaped.

Head rounded in cross section; eyes prominent, large; eye openings circular; sinus broad, indistinct. Tissue along posterior border of eye opening distinctly thickened, crescent shaped. Surface of bulbus of eye covered with silvery-gold iridescent tissue. Silvery-white fibrous tissue covers mantle, head, and aboral surfaces of arms but is completely lacking from posterior margin of head where a low nuchal crest occurs. Funnel groove short, deep; distinct lateral edges extend posteriorly and dorsally from groove to form nuchal fold. "Olfactory" papilla a thumblike flap on posteroventral section of nuchal fold. Nuchal cartilage narrow posteriorly, broad, rounded anteriorly; groove on raised median ridge narrow, deep.

Arms extremely long (arms II–IV about equal to ML), robust, muscular, attenuate (Fig. 1a); arm formula IV = III = II > I. Distal half of arms I–III strongly compressed in cross section. Protective membranes low, weak on all arms. Broadly bilobed trabeculae, each with bases in common with broad, expanded base of sucker stalk (Fig. 2). Aboral surface of arms I–IV with sharply defined band of silvery fibrous tissue. Suckers biserial, very numerous, 40 on proximal half of left III (measured from basal-most sucker); rings lacking due to damage by digestion. Suckers attain maximum size at about the third to fourth pair; suckers gradually decrease in size distally becoming minute toward arm tips; arm tips with minute sucker-precursor knobs only. Suckers on arms IV very numerous (64 on proximal half) and very small (Table 1).

Tentacles very long (nearly 1½ times ML), robust; clubs long, broad (Fig. 1b). Proximal-most sucker on tentacular stalk originates about 10 mm from base; about 6–7 mm separate the 3–4 widely spaced single suckers that occur along proximal stalk; they occur on alternating sides of the tentacular midline; knobs that are paired with the tentacular stalk suckers and carpal suckers in adults are not developed at this size; therefore, these suckers occur singly. Suckers progressively closer together distally and, proximal to the 14th single sucker

FIG. 2. Atlantic specimen; lateral view of section of right arm III.

at about ⅔ the length (right tentacle stalk), they become biserial for 4 pairs; suckers then increase in number and become clustered in carpal area where 6–7 small suckers (maximum) occur in a transverse line across the carpal area just proximal to manus (approximately 100 suckers in carpal area). Suckers on manus tetraserial; 26–28 enlarged suckers (13–14 pairs) in medial 2 rows, those in ventromedial row slightly larger. Medial suckers 2½ times larger in diameter than marginal suckers. Dactylus long, attenuate; suckers tetraserial (in about 34 transverse rows), those in ventral row proximally about 2–3 times the diameter of those in dorsal row; difference diminishes distally and all suckers are about equal sized (minute) near tip. Terminal group of suckers at tip lacking. Protective membranes weak; trabeculae bilobed; lateral sucker stalks arise from bases of trabeculae between lobes (Fig. 3). Swimming keel along entire length of manus and dactylus narrow.

Buccal membrane with 7 lappets; connectives attached to dorsal borders of arms I, II, and IV and to ventral borders of III (DDVD).

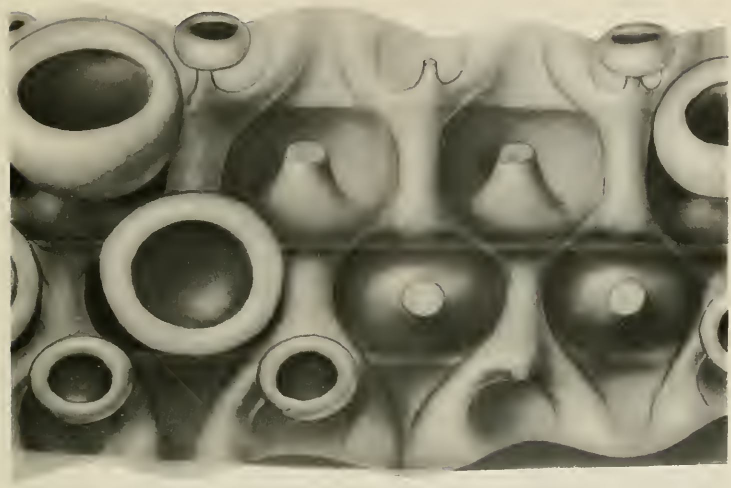

FIG. 3. Atlantic specimen; oral view of section of left tentacular club. Some suckers removed to show bilobed trabeculae and lateral sucker stalk bases (somewhat diagrammatic; sucker rings lacking).

Beaks are illustrated in Figure 4. Dorsal mandible with strong, acutely pointed rostrum, strong and well-defined jaw angle. Ventral mandible with short, blunt rostrum, broad, rounded wings and distinct jaw angle. Measurements (mm), as defined by Clarke (1962), are as follows:

| Upper beak | | Lower beak | |
|---|---|---|---|
| 1. length of rostrum | 1.2 | 1. length of rostrum | 1.0 |
| 2. hood length | 4.5 | 2. hood length | 2.0 |
| 3. crest length | 5.8 | 3. crest length | 3.5 |
| 4. wing length | 1.7 | 4. wing length | 2.5 |
| 5. width of rostrum | 0.7 | 5. rostral gap | 2.2 |

Radula with 7 transverse rows of teeth. Rachidian tricuspid with moderately long, bluntly pointed medial cusp, 2 low bluntly pointed lateral cusps. First lateral bicuspid with short, straight, blunt, medial cusp and blunt lateral cusp. Second lateral moderately long, curved; no lateral cusps. Third lateral very long, curved, pointed; no lateral cusps. Marginal plates single, oval.

Gladius long, slender (Fig. 1c). Vane thin, narrow; reaches

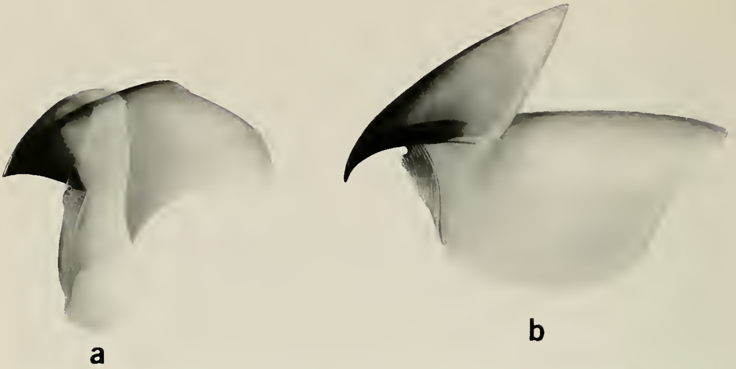

Fig. 4. Atlantic specimen. a. Ventral mandible. b. Dorsal mandible.

maximum width anteriorly shortly after its origin; vane and rhachis taper gradually to pointed terminus; no distinct conus; thickened lateral rib arises at midpoint of vane and extends posteriorly, passing medial to lateral edge. Free portion of rhachis short, narrow; remaining portion of rhachis moderately thick, sharply convex dorsally, broadly concave ventrally in cross section.

Viscera: Gills long, bases situated just anterior to midpoint of mantle; about 50 pairs of gill lamellae. Pancreas short, connects anteriorly to large liver. Ink sac large with long duct; both sac and duct covered with silvery-gold iridescent tissue. Sexual organs undeveloped.

*Pacific Specimen*: *Architeuthis* sp. B. 19°51′S, 95°09′W off Chile, South America; R/V *Shoyo Maru* Cruise 13, Fish Station 17, 17 December 1963; Stomach of fish (probably *Alepisaurus*); W. L. Klawe and E. D. Forsbergh; 45 mm ML. Figures 1d, 1e, 5b.

Mantle, long, slender, thick, muscular; tapers gradually from anterior margin to pointed tip; marginal lobes small, distinct (Fig. 1e). Muscular portion of mantle terminates posteriorly at tip of pen; only a slender cone of muscular tissue extends to posterior border of fins. Fins small (31% of ML), slightly longer than wide, widest posterior to midpoint, broadly rounded posteriorly, oblong (paddle-blade shape) in outline. Free anterior lobes absent; insertions broadly spaced (Fig. 5b).

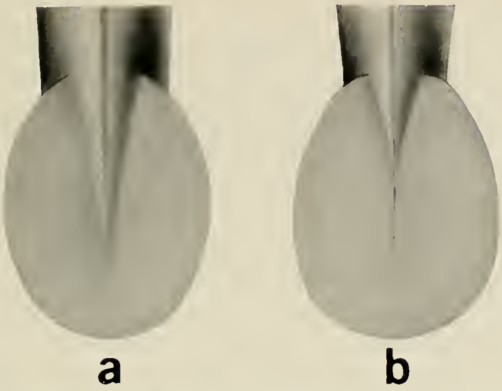

FIG. 5. Dorsal view of fins. a. Atlantic specimen. b. Pacific specimen.

Funnel short, muscular; anterior end reaches just past level of posterior edges of eyes. Funnel locking-cartilage long, straight (a slight medial curvature anteriorly), narrow; cartilage narrowest and pointed anteriorly, broadest and rounded posteriorly. Groove straight, deep; shallow and broad posteriorly; medial edge undercut. Mantle locking-cartilage straight, tapers posteriorly to termination; ridge with distinct medial overhang. Funnel organ damaged; dorsal pad an inverted V-shape, very long; limbs extend posteriorly onto funnel retractor muscles. Anterior portions of limbs constricted and raised into ridges or low flaps. Small anterior papilla present at apex. Ventral pads large, nearly oval with posterior portion slightly narrower. Funnel valve broadly U-shaped.

Head cylindrical in cross section, slightly broader than mantle width; eyes large, openings circular, sinus broad, very ill-defined. Lateral surfaces of eyes bear silvery-bronze iridescent tissue. Posteriorly the eyelid incorporates a distinct crescent-shaped tissue that is thicker than adjacent head tissue. A thick layer of white iridescent fibrous tissue covers mantle, head, and aboral surfaces of arms; tissue terminates abruptly around posterior margin of head, forming a very distinct but unelevated nuchal crest. Funnel groove deep, sharply delimited; posterior margin of groove continues as a thin nuchal fold that extends dorsally on posterolateral surface of head until level with dorsal edges of lenses of eyes. Nuchal fold bears short, broad "olfactory" papilla on posteroventral portion. Nuchal cartilage broad anteriorly, narrow posteriorly; median ridge contains a deep central groove.

Arms moderately long (arms II–IV about 60% of ML), very muscular, robust (Fig. 1e); arm formula IV = III = II > I. Distal half of arms II–III somewhat flattened dorsoventrally in cross section. Trabeculate protective membranes low, weak on arms I–IV; trabeculae bilobed. Outer integument of arms entirely lacking; aboral surfaces covered with well-defined bands of silvery fibrous tissue. However, no trace of aboral keels on arms I–III. Thick lateral keels present on arms IV. Suckers biserial on all arms; 30 suckers on proximal half of left III. Suckers extremely small near arm tips, represented only by small knobs (sucker precursors) at the tips. Sucker rings destroyed. Suckers of ventral arms much smaller than those of other arms (Table 1) and very numerous (57 on proximal half).

Tentacles short, moderately slender; clubs elongate, slender (but expanded) (Fig. 1d). Proximal-most sucker on tentacular stalk originates 3 mm from base; second sucker 2 mm distal to first on alternate side of midline; 8 additional alternating single suckers occur along stalk progressively closer to each other until, at about the ⅔ point on the stalk, suckers become truly biserial for 8 pairs (16 suckers). Distal to the pairs, suckers increase to about 7–8 in an irregular transverse series forming a carpal cluster with at least 64 suckers. Suckers on manus and dactylus tetraserial;. 13 transverse rows on manus, 32 transverse rows on dactylus (right club). Terminal grouping of suckers absent from tip of dactylus. Suckers of medial 2 rows on manus enlarged to about twice the size of suckers of marginal rows. At about midpoint of dactylus, suckers of ventral 2 rows are nearly equal in size, the ventral-most suckers slightly larger; suckers of the dorsal medial row are much smaller, and suckers of the dorsal marginal row are minute. All suckers about equal in size near tip of dactylus. Trabeculate protective membrane along carpus and manus relatively low and weak. Bilobed trabeculae share common base with marginal sucker stalks along manus. A low keel extends from proximal end of manus to distal tip of club.

Buccal membrane contains 7 lappets; connectives attach to dorsal borders of arms I, II and IV and to ventral borders of arms III (DDVD).

Beaks, radula and gladius were not removed for examination.

Viscera: Gills very long with bases situated well posteriorly in mantle cavity (posterior to the midpoint of mantle); about 55 pairs of gill lamellae. Pancreas long, slender, extends forward to a relatively small liver. Ink sac small, with long duct; ink sac and duct covered with a gold or silvery iridescent tissue. Sexual organs undeveloped.

## DISCUSSION

*Comparisons*: Table 1 lists the measurements and indices of the two juvenile specimens of *Architeuthis*. The data indicate that differences in some body proportions exist. These differences are great enough that they cannot be accounted for by ontogenetic differences between the specimens which differ only slightly in size. The most striking difference occurs in the lengths of the arms. The Atlantic specimen has arm lengths that are nearly as long as the mantle (arm I) or are equivalent in length to the mantle (arms II–IV). The Pacific specimen has proportionately much shorter arms, the longest of which (arms II–IV) are only 60% of the length of the mantle.

Although tentacle measurements are notoriously variable in cephalopods, the differences here are so great that they must be significant: the Atlantic specimen has long tentacles half again as long as the mantle, while the Pacific specimen has short tentacles that measure only three-quarters the length of the mantle. Clubs also exhibit differences in length, although not so striking; those of the Atlantic specimen are longer.

Although the arm suckers on both species appear to be of comparable size, the large and small manal suckers on the clubs of the Atlantic specimen are proportionately larger than those on the Pacific specimen.

Sucker arrangement on the tentacular stalk differs markedly between the two species. In the Atlantic specimen the proximal-most sucker originates more distally than that of the Pacific specimen; the unpaired stalk suckers are fewer (3–4 suckers) and more widely spaced (6–7 mm) in the Atlantic form than in the Pacific form (10 suckers; 2 mm and less). Suckers in the carpal region of the Atlantic specimen are more numerous than in the Pacific specimen (approximately 100 vs. 65, respectively).

Suckers may be more numerous on arms III of the Atlantic specimen (40 on proximal half of III vs. 30 in Pacific specimen). Both specimens, however, were still in the process of adding suckers to their arms as the arm tips were studded with numerous knoblike precursors of suckers.

Some differences in viscera are noted. The Atlantic specimen, in comparison to the Pacific specimen, has: slightly shorter gills with slightly fewer lamellae, a shorter pancreas, a a larger liver, and a larger ink sac.

Robson (1933) has shown that dentition of arm and club suckers in *Architeuthis* frequently is of specific value, but the sucker rings of both of the present specimens have been destroyed by the digestive juices of their captors, or by the original fixatives (formalin). Dell (1970, p. 32) reported that a specimen from New Zealand lacked sucker rings entirely and suggested that the species may not possess horny rings on the arm suckers. In our experience, we feel this is untenable and suggest that the sucker rings of Dell's specimen were dissolved after immersion in formalin. C. C. Lu (personal communication) reports similar degradation of sucker rings in *Architeuthis* from Newfoundland after preservation in formalin.

The differences described here demonstrate that the Atlantic and Pacific specimens belong to separate species. Twenty nominal species have been described in *Architeuthis* (Clarke, 1966); certainly many of these are synonyms. Because the state of systematics of *Architeuthis* is currently in utter confusion, it is impossible to determine how many of these are valid species (see Dell, 1970 for brief discussion). In addition, it is impossible to relate the juvenile specimens described here to any of the named species because of their small size and imperfect condition. It is interesting to note, however, that the juveniles are in general form strikingly similar to adults, although differences do exist, for instance in the relative proportions of the arms and tentacles and in the configuration of the tail. At least some of the arms and the tentacles of the juvenile specimens appear to be proportionately shorter than in adults; this is particularly so in the Pacific specimen. In adults the mantle extends posterior to the fins as a short, stout tail and the borders of the fins curve posteriorly along the tail. In juveniles no tail exists; the muscular portion of the mantle terminates anterior to the posterior borders of the fins; the bases of the fins are joined posteriorly along the midline and are supported by a turgid conical extension from the mantle which probably develops into the tail of the adult.

The distinctive structure of *Architeuthis* beaks is recognizable even in the small specimens (Fig. 4). Therefore, it should be possible to identify specimens of the genus *Architeuthis* of nearly any developmental stage from beaks that are commonly found in the stomachs of many marine predatory fish and mammals.

*Distribution*: Clarke (1966) has presented a chart of localities from which specimens of *Architeuthis* have been recorded. The chart is reproduced here as Figure 6 with the addition of the localities of our juvenile specimens and recent records of *Architeuthis* from Newfoundland (Aldrich, 1968) and New Zealand (Dell, 1970). The juvenile from the Pacific off Chile, South America, represents the first known record of the genus from the eastern Pacific Ocean. Previous Pacific records of the genus originate only from the far western Pacific waters of Japan and New Zealand (see Dell, 1970, for recent record in New Zealand and for summary of New Zealand strandings). The Atlantic specimen was taken from off Madeira Island, an area from which *Architeuthis* has been recorded on a number of occasions.

*Depth Distribution*: Both specimens of *Architeuthis* were

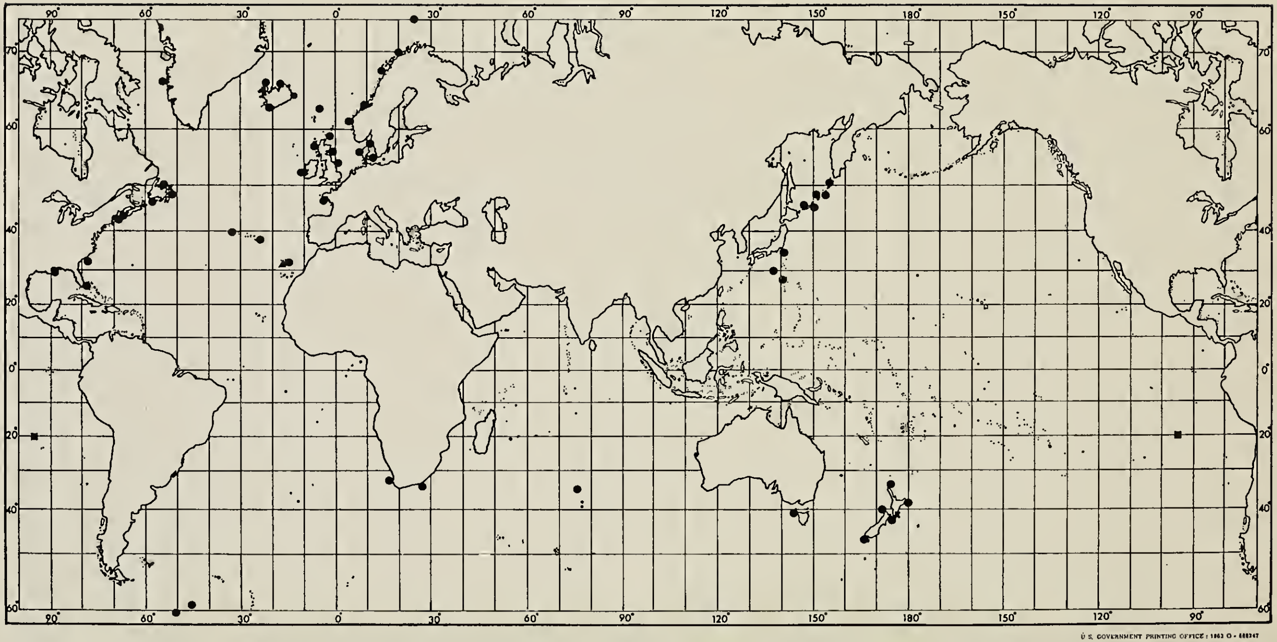

FIG. 6. Locality records of *Architeuthis* (redrawn after Clarke, 1966, fig. 2). Locations of captures of juvenile specimens reported here indicated by the solid triangle (Atlantic) and the solid square (Pacific). Additional records from New Zealand (Dell, 1970) and Newfoundland (Aldrich, 1968) indicated by **x**'s.

taken as stomach contents from the fish, *Alepisaurus*, species of which feed on a wide variety of oceanic fishes and invertebrates (Haedrich, 1964; Haedrich and Nielsen, 1966). It was hoped that a knowledge of the feeding habits and depth distribution of *Alepisaurus* would shed light on the possible depth layer inhabited by juvenile *Architeuthis.*

Although the *Alepisaurus* specimen in the Pacific was captured on a long-line somewhere between 80 and 150 m, Haedrich and Nielsen (1966) pointed out that *Alepisaurus* must feed over a broad range of depths on members of a particular "high-seas community," since both epipelagic and deep-living species of fishes are found in their stomachs, while some other common middepth species are excluded.

The Atlantic specimen was taken from the stomach of an *Alepisaurus ferox* which was caught on a tuna long-line set to 50 to 150 m over deep water off Camara de Lobos, Madeira (G. E. Maul, personal communication). Rees and Maul (1956, pp. 278–279) recorded 18 species of cephalopods as stomach contents of *A. ferox*, caught at depths down to 200 m off Madeira. None of these species is a restricted deep-sea form, and all occur in the upper 200–300 m either as permanent residents, nocturnal visitors, or during early stages of development. Rancurel (1970, p. 82), in a report on cephalopods taken from stomachs of *A. ferox* in the southwestern Pacific, concluded that the hunting area of the predator is rarely deeper than 300 m.

Although neither of these studies is conclusive, they do suggest that our specimens of *Architeuthis* probably were devoured in the upper few hundred meters. Whether these species are vertical migrators or residents at these depths is uncertain. Their muscular appearance and the presence of reflecting layers on the head, body and arms strongly suggest that they occur no deeper than the lower mesopelagic zone during the day.

*Spawning*: Although nothing is known of the spawning areas of any member of the family Architeuthidae, the small size of the present specimens suggests that they were spawned in the nearby region of their localities of capture in tropical or warm temperate waters.

*Stomach Contents*: The Atlantic specimen contained a large quantity of food in a greatly distended stomach, which occupied the entire posterior mantle cavity. The stomach contents consisted almost entirely of amorphic material and a few small bony fragments from the skeletal remains of small fishes; all fragments were otherwise unidentifiable (J. E. Fitch, R. H. Gibbs, Jr., personal communication).

The stomach of the Pacific specimen was empty.

*Size*: The two specimens described here, a female of 57 mm ML from the Atlantic and a male of 45 mm ML from the Pacific, represent the smallest known specimens of *Architeuthis*. Heretofore, the smallest specimen was the holotype of *A. physeteris* (Joubin, 1900) of which only the mantle, with a length of 460 mm, was known. A second relatively small specimen of *A. physeteris* was a mature male with a mantle length of 612 mm (Voss, 1956). A small mature male of 664 mm ML was taken floating at the surface off the east coast of Florida (Voss, personal communication). Knudsen (1957) described a mature male of *Architeuthis* sp. with a mantle length of 1,010 mm.

Iwai (1956) identified as *Architeuthis* two specimens with mantle lengths of 92 and 104 mm taken from the "digestive canal" of a sperm whale captured off the Borrin Islands south of Japan. Our examination of the descriptive notes and particularly of the illustrations, however, leaves no doubt that the identification is incorrect. The features of the mantle, fins, tentacles, clubs and arms are entirely nonarchiteuthid in nature. Some nonarchiteuthid characters of Iwai's specimens are: the mantle is too broad for its length; the fins are too long, too broad and too angular; the clubs have "five" rows of suckers, no carpal cluster, and no paired suckers occur on tentacular stalk; the arms are too short; the rhachis of the gladius is too long, and the vane is too broad. Although positive identification is difficult to establish, the specimens appear to be members of the Psychroteuthidae, a little-known family of oceanic squid, previously known only from Antarctic waters.

*Familial Relationships*: Young and Roper (1968) aligned the Architeuthidae with a number of other families that shared straight funnel locking-cartilages and buccal connectives that attach to the dorsal borders of arms IV. These families are: Lycoteuthidae, Enoploteuthidae, Histioteuthidae, Psychroteuthidae, Neoteuthidae (= Alluroteuthidae) and Bathyteuthidae.

A striking similarity exists in the structure of the tentacular clubs between *Architeuthis* and *Alluroteuthis* (family Neoteuthidae); both have enlarged medial suckers on the manus and numerous small suckers on the carpus. An important difference, however, exists: in *Alluroteuthis* only the suckers along the dorsal margin of the carpus are paired with knobs and participate in tentacular locking, while in *Architeuthis* all of the carpal suckers are paired with knobs. A second similarity exists between these two families: members of both lack free anterior fin lobes. This is an unusual feature and would have considerable significance were it not for the fact that the posterior fin lobes are free in the Neoteuthidae (also an unusual feature), but they are united in the Architeuthidae (Fig. 5). Although these similarities exist between the two families, a strong case cannot be made for their close relationship. However, the similarities between the Architeuthidae and Neoteuthidae, though weak, are stronger than those between the Architeuthidae and any other family listed above. Therefore, we feel that the closest relatives of the giant squid belong to the family Neoteuthidae, members of which are small, generally deep-living species.

Note: Since this paper went to press, recent additional records of *Architeuthis* in the eastern Pacific have come to our attention: Iverson, I. L. K. (1971; California Fish and Game, Fish Bulletin 152) listed one specimen (beaks?) from the stomach of an albacore (*Thunnus alalunga*); C. H. Fiscus & D. Rice (personal communication, in ms.) discovered beaks of *Architeuthis* in stomachs of sperm whales taken off California.

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Vol. 85, No. 17, pp. 223–248 30 August 1972

PROCEEDINGS
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# STUDIES OF NEOTROPICAL CADDISFLIES, XIV: ON A COLLECTION FROM NORTHERN ARGENTINA

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During a recent trip to South America I was fortunate to be able to spend from 30 March to 9 April 1971, collecting in the Provinces of Santa Fe and Misiones, Argentina, two areas of particular concern to me. The first, Santa Fe, is type-locality for many species described by Navas, and topotypical collections are necessary in order to establish the identity of many of these species. The Province of Misiones is of interest in relation to the adjacent province of Santa Catarina, Brazil, whose fauna is fairly well known and rather distinctive.

Collections of caddisflies were made at two sites in Santa Fe using an ultraviolet light. The first site overlooked the Río Salado from the property of the Instituto Nacional de Limnologiá in Santo Tomé. This river, several tens of meters in width, is rather slow-flowing with silt and sand banks, and generally with floating marginal vegetation. The second site was a few kilometers east of Santa Fe on the road to Paraná where it crosses several small bridges marked Ao. Saladillo, numbers 1, 2, and 3. The collection was made at bridge number 2, where the drainage consists of a small riffle area just above the road, and shallow, weed-filled ponds above and below the riffle.

The collections from Misiones were made in or near Puerto Rico which is about midway between Posadas and Iguazú near the Río Paraná. The collections from Puerto Rico were made at an ultraviolet light overlooking the Río Paraná at either the small "naval station" or the "fishing club" near town. The river here is rather swift, although very broad and silty,

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and apparently flows over some submerged ledges. The site at Capioví is about 15 kilometers south of Puerto Rico at the small falls near town. The shallow stream, about 1–2 meters wide is milky in appearance and flows over bedrock, boulders, and gravel. It is dammed just above the falls, with most of the flow diverted through a sawmill, thus reducing the falls to hardly more than a trickle. Most of the caddisflies were attracted to the ultraviolet light operated beside the falls, but a few additional specimens were beaten from vegetation overhanging the stream. The stream at Mbopicua is the first major drainage south of Puerto Rico. It is approximately the same size as the one at Capioví, but has a much lower gradient. It alternates between gravel riffles and long pools. The light was operated on the old bridge over the stream, and the larval collections were made from the rubble just below the new bridge.

As a result of these collections, it has been possible to identify a number of poorly known species. However, of greater interest has been the elucidation of several zoogeographic patterns. The first pattern is associated with the larger lowland rivers and covers most of eastern South America, at least. Many of the species of the genera *Cyrnellus*, *Nyctiophylax*, *Leptonema*, *Neoleptonema*, *Leptocella*, *Oecetis*, and *Brachysetodes* have rather extensive distributions at least in the Paraná basin, often over most of lowland South America, and sometimes Central America as well. These species were generally collected at Santa Fe and Puerto Rico.

The second pattern is one of a much more restricted distribution that includes the low mountains of Misiones and adjacent Brazil. This fauna, which is much better known from Brazil, includes a number of endemics of rather isolated taxonomic position. The species *Atopsyche longipennis, Mexitrichia albolineata, M. teutonia, M. unota, Chimarra brasiliana, Abtrichia antennata*, and *Smicridea* (*R.*) *weidneri* which I include in this fauna were generally collected at the small streams of Misiones (Capioví and Mbopicua). The distribution of the remaining species is not yet well enough known to permit a suggestion of their distributional patterns.

I express my appreciation to Dr. Raúl A. Ringuelet and Dr. Ricardo A. Ronderos of the Universidad Nacional de La Plata for their help in Buenos Aires and in arranging for the trip to Santa Fe. Dr. A. A. Bonetto and the entire staff of the Instituto Nacional de Limnología were extremely cordial and helpful during our stay in Santa Fe. Prof. Dr. Herbert Weidner very kindly arranged for the loan of the types of *Rhyacophylax brasilianus* from the Hamburg Museum. I am especially grateful to my wife for all the time she spent helping with the collections, both day and night.

Unless otherwise stated, all collections herein reported were made in Argentina by Carol M. and Oliver S. Flint, Jr.

## RHYACOPHILIDAE

### *Atopsyche* Banks, 1905

### *Atopsyche longipennis* (Ulmer)

*Psilochorema longipenne* Ulmer, 1905a:110.
*Atopsyche longipennis* (Ulmer).—Ulmer, 1907b:205.—Ross & King, 1952: 202.

Originally described from Santa Catarina in Brazil and previously known only from this province, the presence of *A. longipennis* is here recorded from Argentina for the first time.

*Material*: Prov. Misiones, Mbopicua, 6–7 April 1971, 1♂ metamorphotype, 1♀. Puerto Rico, 4–8 April 1971, 1♀.

## GLOSSOSOMATIDAE

### *Mexitrichia* Mosely, 1937

### *Mexitrichia albolineata* (Ulmer)

*Mortoniella* species Ulmer, 1906:98.
*Mortoniella albolineata* Ulmer, 1907a:44.
*Mexitrichia albolineata* (Ulmer).—Flint, 1966:2.

The discovery of specimens agreeing with the type of this species and other specimens agreeing with *M. teutonia* Mosely in the same collection, makes me conclude that the two are valid species, albeit closely related, not synonyms as earlier stated (Flint, 1966:2–3). The differences pointed out in 1966 are just those that distinguish the two species in these collections. The lectotype of the species is from Santa Catarina, Brazil. *M. albolineata* was subsequently recorded from Rio de Janeiro, Brazil, and Salta, Argentina. These records, however, should be held in abeyance until the presence of the species is confirmed by examination of the genitalia of males from these localities.

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*Material*: Prov. Misiones, Puerto Rico, 4–8 April 1971, 1♂. Capioví, 5 April 1971, 1♂.

### *Mexitrichia teutonia* Mosely, RESURRECTED SPECIES

*Mexitrichia teutonia* Mosely, 1939:223.—Flint, 1963:474.

As pointed out above, I am resurrecting *M. teutonia* Mosely. The species was described from Santa Catarina, Brazil, and recorded from Minas Gerais, Brazil. Larvae and male metamorphotypes of the species were taken at Mbopicua.

*Material*: Prov. Misiones, Puerto Rico, 4–8 April 1971, 8♂. Mbopicua, 6–7 April 1971, 18♂, 1♂, 2♀ metamorphotypes, larvae and pupae. Capioví, 5 April 1971, 6♂.

### *Mexitrichia unota* Mosely

*Mexitrichia unota* Mosely, 1939:223.

This species was described from Santa Catarina, Brazil, and is here recorded from Argentina for the first time.

*Material*: Prov. Misiones, Capioví, 5 April 1971, 1♂. Puerto Rico, 4–8 April 1971, 1♂.

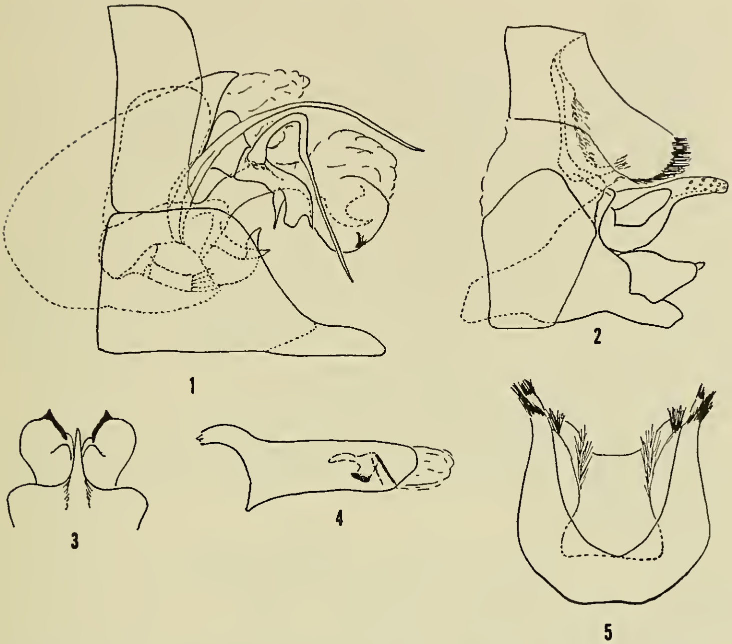
### *Protoptila* Banks, 1904

### **Protoptila misionensis** new species

Figure 1

This species, the first of the genus known from Argentina, is related to the Mexican species *P. guata* Mosely and *P. spangleri* Flint, both of which have the lateral margin of the ninth segment produced into a long process, and the dorsal margin of the tenth tergum similarly produced. From both of these species, *P. misionensis* is to be recognized by the more elongate eighth sternum, and the differently shaped tenth tergum and aedeagus.

*Adult*: Length of forewing, 3 mm. Color in alcohol, pale brown. Sixth sternum with a short, pointed, mesal process. Male genitalia: Eighth sternum broadly produced posteriad, narrowly divided apicomesally for half length. Ninth segment produced and rounded anterolaterally, barely produced posteroventrally; posterolateral margin developed into a long slender process curving over tenth tergum and aedeagus. Tenth tergum with a small basal segment on each side; apical segment slightly elongate, apex divided into 3 ventrally directed teeth; basodorsally bearing a long, slender process which is first directed laterad, then mesad, and finally posteroventrally, becoming contiguous to apex of aedeagus. Aedeagus with a mesal, basodorsal lobe; a pair of ventral rodlike appendages; posteroventrally with 2 pairs of appendages, lateralmost swordlike, directed posteriad, mesal pair with tips pointed and upturned; a narrow central tube, apically developed



Figs. 1–5. *Protoptila misionensis* n.sp.: 1, genitalia, lateral. *Chimarra parana* n.sp.: 2, genitalia, lateral; 3, ninth sternum and claspers, ventral; 4, aedeagus, lateral; 5, eighth tergum, posterodorsal.

into a short, broad, troughlike section with posterior margin bearing a small tooth ventrolaterally, membranous dorsally, and with an internal spine.

*Material:* Holotype, male: Argentina, Prov. Misiones, Mbopicua, near Puerto Rico, 6–7 April 1971, C.M. & O.S.Flint, Jr. USNM Type 72158.

## PHILOPOTAMIDAE

### *Chimarra* Stephens, 1829

### **Chimarra (Curgia) parana** new species

Figures 2–5

This species is closely related to *C. brasiliana* (Ulmer) from which it may be distinguished by the many small golden spots on the forewing and golden hair on the head. In *C. brasiliana* these hairs are silvery and the forewings are marked with fewer, larger spots. The male genitalia are also very similar in the two species, but the central portion of the eighth tergum in *C. parana* possesses two pairs of brushes rather than one, the tenth tergum is narrow apically and directed posteriad, and the claspers are more elongate.

*Adult*: Length of forewing, 5–7 mm. Color generally dark brown; head with golden hairs; forewing with dark brown hair with numerous small spots of golden hair. Fifth sternum with a round, dark, anterolateral mark. Male genitalia: Eighth tergum with posterolateral arms broad, apices bearing brushes of specialized setae; posteromesal face nearly vertical, bearing on lateral margins 2 pairs of brushes, dorsalmost linear and rather diffuse, ventralmost on a short process and rather dense. Ninth segment produced anteroventrally, with an elongate posteromesal process. Tenth tergum hoodlike; apex narrow, directed posteriad, with many sensillae. Cercus large, clavate. Clasper small, slightly elongate, with a small apicomesal tooth. Aedeagus with a pair of small spines and a rod and ring assembly.

*Material*: Holotype, male: Argentina, Prov. Misiones, Puerto Rico, 4–8 April 1971, C.M. & O.S.Flint, Jr. USNM Type 72159. Paratypes: Same data, 15♂, 11♀. Mbopicua, 6–7 April 1971, 29♂, 37♀. Capioví, 5 April 1971, 3♀.

### *Chimarra* (*Curgia*) *Brasiliana* (Ulmer)

*Chimarrha brasiliana* Ulmer, 1905a:96.
*Chimarra brasiliana* (Ulmer).—Fischer, 1961:58.—Flint, 1966:3.

I hesitate to record the presence of this species in Argentina for the first time when the record is based on females only. However, the examples are in agreement with Brazilian specimens in coloration and in all characters of the genitalia, whose differences from the preceding species are very minute.

*Material*: Prov. Misiones, Puerto Rico, 4–8 April 1971, 2♀.

## PSYCHOMYIIDAE

### *Polyplectropus* Ulmer, 1905a

### *Polyplectropus elongatus* (Yamamoto)

*Polycentropus elongatus* Yamamoto, 1966:909.
*Polyplectropus elongatus* (Yamamoto).—Flint, 1968:21.

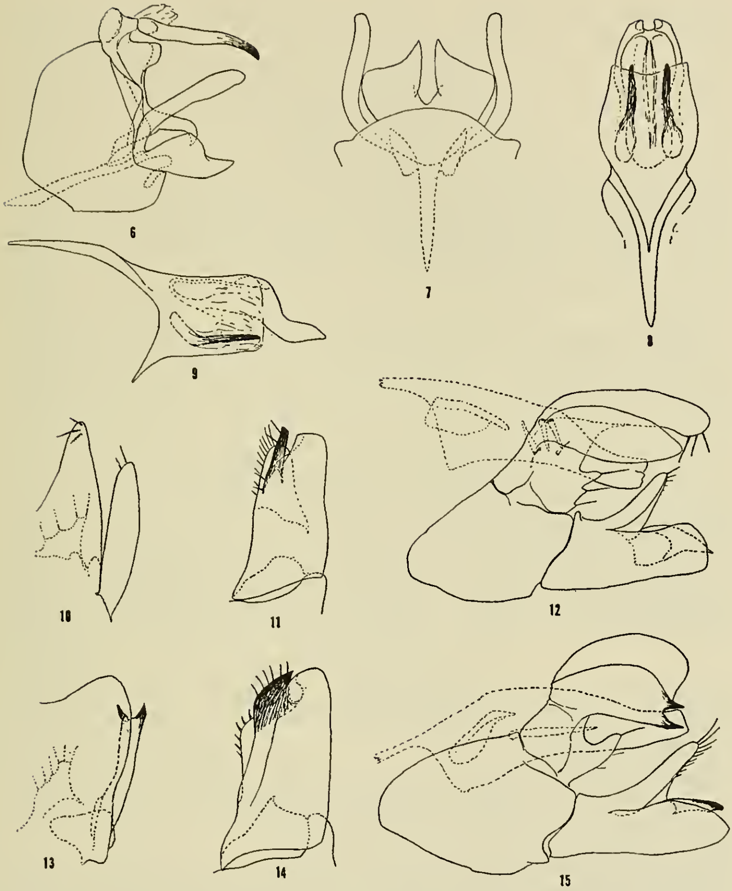
This species was recently described from Iguazú, Argentina. Its presence a short distance downstream is hardly surprising.

*Material*: Prov. Misiones, Puerto Rico, 4–8 April 1971, 1♂.

### **Polyplectropus hamulus** new species

Figures 6–9

This species is close to *P. banksianus* Flint which is known from the central Amazon. From *banksianus*, *hamulus* may be recognized by the long, narrow, ventromesal lobe of the cercus; by the shorter, straighter



Figs. 6–15. *Polyplectropus hamulus* n.sp.: 6, genitalia, lateral; 7, ninth sternum and claspers, ventral; 8, aedeagus, dorsal; 9, aedeagus, lateral. *Cernotina medioloba* n.sp.: 10, lobe of tenth tergum and cercus, dorsal; 11, clasper, ventral; 12, genitalia, lateral. *C. chelifera* n.sp.: 13, lobe of tenth tergum and cercus, dorsal; 14, clasper, ventral; 15, genitalia, lateral.

spines of the aedeagus; and the blunt apices of the apicolateral arms of the aedeagus.

*Adult*: Length of forewing, 5–6 mm. Color generally grey; antennae, legs, and venter yellowish; head with white hairs frontally; forewing with costal margin dark, remainder of wing irregularly mottled with light grey. Male genitalia: Ninth sternum broad, anterior margin produced into a broad, truncate lobe. Tenth tergum membranous. Cercus composed of a dark-tipped dorsomesal, spinelike lobe which is slightly arcuate in dorsal aspect; dorsolateral lobe small and truncate; ventromesal lobe narrow, elongate, with tip produced into a decurved hook. Clasper with dorsolateral lobe long, slender, and terete; ventromesal lobe scoopshaped, short with an apicomesal point. Aedeagus with a tubular collar and long basodorsal straps; apicoventrally with a pair of long, nearly straight spines arising from enlarged bases, apicodorsally with a sclerotized structure whose lateral arms are in dorsal view sharply angled mesad and whose tips are truncate and almost touching.

*Material*: Holotype, male: Argentina, Prov. Misiones, Puerto Rico, 4–8 April 1971, C.M. & O.S.Flint, Jr. USNM Type 72160. Paratypes: Same data, 3♂.

### *Nyctiophylax* Brauer, 1865

### *Nyctiophylax neotropicalis* Flint

*Nyctiophylax neotropicalis* Flint, 1971:28.

This small, black species which appears to be widespread over South America, is now known from Argentina, Brazil, and Colombia.

*Material*: Prov. Misiones, Puerto Rico, 4–8 April 1971, 6♂, 500♀.

### *Cyrnellus* Banks, 1913a

### *Cyrnellus bifidus* Flint

*Cyrnellus bifidus* Flint, 1971:32.

*Cyrnellus bifidus* was described from several localities in the central Amazon basin. In addition to the two males taken at Arroyo Saladillo, many females were collected from both localities in Santa Fe, but cannot be determined to species at this time.

*Material*: Prov. Santa Fe, Arroyo Saladillo, near Santa Fe, 2 April 1971, 2♂.

### *Cyrnellus arotron* Flint

*Cyrnellus arotron* Flint, 1971:32.

Similarly to the preceding species, *C. arotron* was described from the Amazon basin and is now recorded from the upper Río Paraná.

*Material*: Prov. Misiones, Puerto Rico, 4–8 April 1971, 16♂.

### *Cyrnellus mammillatus* Flint

*Cyrnellus mammillatus* Flint, 1971:30.

This species is common in the Amazon basin of Brazil, and is here recorded from Misiones, Argentina.

*Material*: Prov. Misiones, Puerto Rico, 4–8 April 1971, 1♂. Capioví, 5 April 1971, 5♂.

### *Cernotina* Ross, 1938

### **Cernotina medioloba** new species

Figures 10–12

This species is clearly related to *C. subapicalis* Flint which is widely distributed in the Amazon basin. It differs most noticeably in the shape of the claspers, especially their basodorsal lobe which is not displaced into a subapical position, and the apicomesal lobe which is long and slender.

*Material*: Length of forewing, 3.5–4.5 mm. Color generally fuscous; antennae and bases of legs cream-colored, hairs on middle of head and thorax white; forewing fuscous with a narrow white band along posterior margin. Male genitalia: Ninth segment slightly produced and rounded anteriorly. Tenth tergum membranous, bilobed, each lobe with several stout apicoventral setae. Cercus 2-lobed: dorsolateral lobe elongate, tip rounded; ventromesal lobe broad, halves united mesally, slightly produced dorsolaterally, with a row of enlarged setae along posterior margin. Clasper with basodorsal lobe large, erect, with a row of enlarged setae along mesal margin; apicomesal lobe elongate, slender, well separated from body of clasper, with several enlarged setae. Aedeagus tubular, tip constricted, with 4 small internal spines, and a basal sclerite, Y-shaped in dorsal aspect.

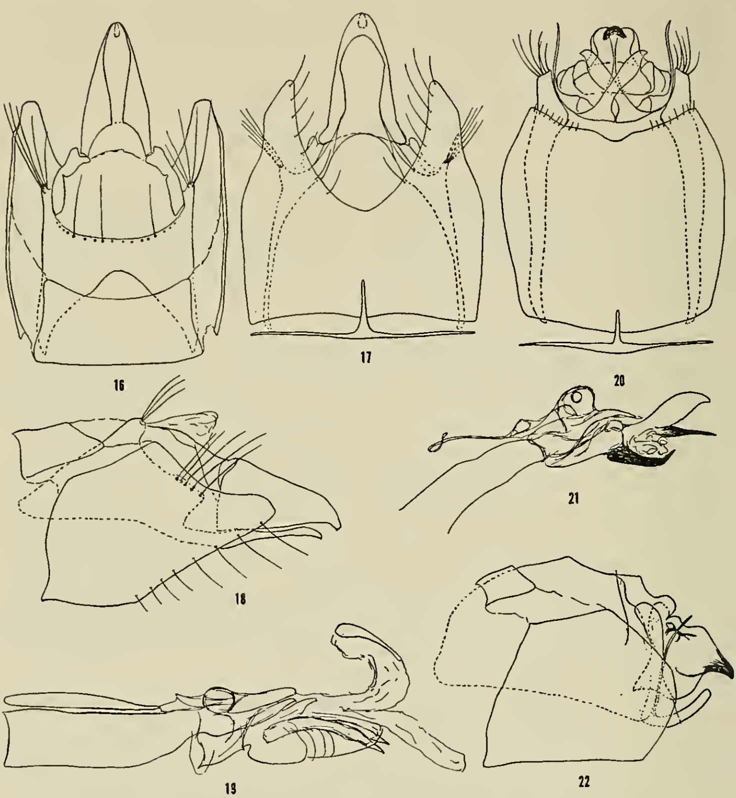
*Material*: Holotype, male: Argentina, Prov. Santa Fe, Arroyo Saladillo, near Santa Fe, 2 April 1971, C.M. & O.S.Flint, Jr. USNM Type 72161. Paratypes: Same data, 6♀.

### **Cernotina chelifera** new species

Figures 13–15

This species is also related to *C. subapicalis* Flint. From this species, *chelifera* may be recognized by the bifid apex of the dorsolateral lobe of the cercus and its partial union with the tenth tergum.

*Adult*: Length of forewing, 3.5–4 mm. Color light brown; white hairs mesally on head and thorax; forewing pale brown with a paler band along posterior margin. Male genitalia: Ninth segment produced anterolaterally. Tenth tergum short, shallowly divided apicomesally, ventrolaterally fused to dorsolateral lobe of cercus. Cercus with dorsolateral lobe fused to ventrolateral margin of tenth tergum, apex produced into 2 short, black spines; ventromesal lobes narrowly united mesally, dorsolateral angles produced, posterior margin with enlarged setae. Clasper with basodorsal lobe large, with a mesal row of enlarged setae; apicomesal lobe broad, apex pointed. Aedeagus with apex constricted, with an elongate internal spine, and a basal sclerite Y-shaped in dorsal aspect.



Figs. 16–22. *Betrichia argentinica* n.sp.: 16, genitalia, dorsal; 17, genitalia, ventral; 18, genitalia, lateral; 19, aedeagus, lateral. *Abtrichia antennata* Mosely: 20, genitalia, ventral; 21, aedeagus, lateral; 22, genitalia, lateral.

*Material*: Holotype, male: Argentina, Prov. Misiones, Capioví, 5 April 1971, C.M. & O.S.Flint, Jr. USNM Type 72162. Paratypes: Same data, 1♂, 1♀.

## HYDROPTILIDAE

### *Betrichia* Mosely, 1939

### **Betrichia argentinica** new species

Figures 16–19

This species, on the basis of genital structure, is closely related to the type-species, *B. zilbra* Mosely, yet it differs in possessing 3 rather than 2 well-developed ocelli. The genitalia of *argentinica* differ in having the posterior margin of the eighth sternum deeply cleft, in having the subgenital plate broad and surpassing the claspers, and in having a pair of elongate spines in the aedeagus.

*Adult*: Length of forewing, 3 mm. Color fuscous, head and thorax covered with green hairs; forewing mottled green and fuscous. Head and antennae simple; ocelli 3. Spurs: 1,3,4. Seventh sternum with a slender apicomesal process. Male genitalia: Eighth sternum produced posterolaterally; in ventral aspect broadly and deeply divided, posterior margin with a row of stout setae. Ninth segment with anterolateral angle produced into a blunt point; posterolateral margin with a row of enlarged setae borne on a low shoulder. Subgenital plate open dorsally, broad basally, tapering to a slightly hooked apex. Claspers united mesally, elongate, thin in lateral aspect, slightly shorter than subgenital plate. Aedeagus with typical basal tube, basal loop, and midlength complex; apex with basolateral plates, a pair of elongate basal spines, and membranous apical lobes, one of which bears on upper surface a darkened, sclerotized region.

*Material*: Holotype, male: Argentina, Prov. Misiones, Capioví, 5 April 1971, C.M. & O.S.Flint, Jr. USNM Type 72163.

## *Abtrichia* Mosely, 1939

### *Abtrichia antennata* Mosely

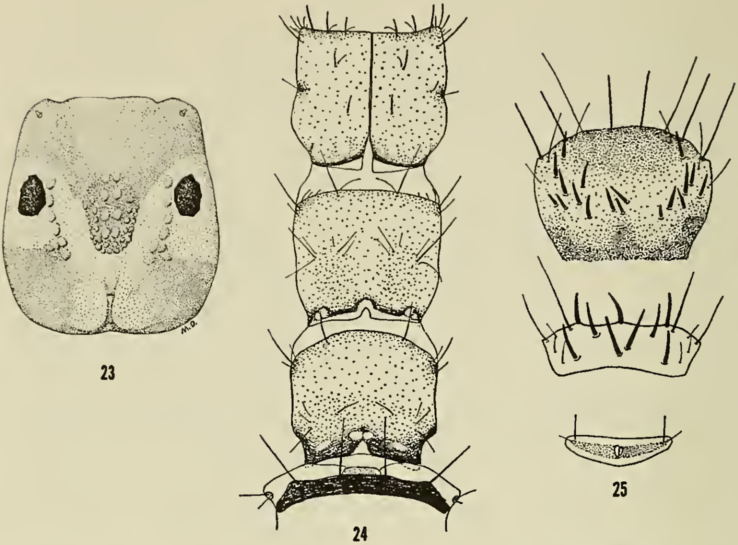
Figures 20–25

*Abtrichia antennata* Mosely, 1939:227.

This species was described from Santa Catarina in Brazil and not recorded since. I have a long series from the type-locality, Nova Teutônia, and have compared the genitalia of these with that of the male metamorphotype collected in Argentina. The figures of the male genitalia were prepared from the Brazilian example, and those of the larva from the Argentinian. The adult is not further described here as the original figures and descriptions, supplemented by the new figures are adequate for its identification.

The cases of the immature stages were found tightly attached to rocks in riffle areas at Mbopicua. These larvae are most similar to those of *Zumatrichia antilliensis* Flint. The larvae of *antennata* may be recognized by the papillae on their head which are lacking on the larvae of the few species of *Zumatrichia* that are known.

*Larva*: Length to 4 mm. Sclerites pale yellow, marked with brown. Stem of frontoclypeal suture well marked, arms obsolete. Anterior margin of frontoclypeus truncate; posteromesally with rows of papillae. A row of papillae mesad of each eye. Pronotum with anterior margin darkened; divided mesally. Femora with spikelike setae dorsally. Abdomen with nine tergites: first transverse with 2 pairs of erect setae; tergites 2–7 much smaller, with a pair of central pores and a pair of



FIGS. 23–25. *Abtrichia antennata* Mosely: 23, larval head, anterior (drawn by Mr. Michael Drunckenbrod); 24, larval thoracic nota and first abdominal tergum, dorsal; 25, larval ninth, eighth, and seventh tergites, dorsal.

erect setae; eighth tergite large, transverse, with numerous large, black setae, 3 of which are borne from posterior margin; ninth tergite slightly broader than long with many large, black setae. Segments 1 and 8 each with a small seta-bearing lateral sclerite; segments 2–7 with 2 pairs of such sclerites. Anal claw with dorsal seta small and pale. Abdomen with segments 5–7 greatly enlarged at maturity.

*Case*: Length to 5 mm, width 2 mm. Silken, oval, domed. Larval case with a small circular opening at each end and open ventrally. Pupal case with openings closed with silk.

*Material*: Prov. Misiones, Mbopicua, 6–7 April 1971, 2♂ metamorphotypes, many larvae and pupae.

### HYDROPSYCHIDAE

#### *Leptonema* Guerin-Meneville, 1843

#### *Leptonema columbianum* Ulmer

*Leptonema columbianum* Ulmer, 1905a:61.—Navas, 1917:404; 1930: 132.—Mosely, 1933:13.

The species, originally described from Colombia, was recorded from Santa Fe by Navas, and is also recorded from Ecuador, Bolivia, Paraguay, and Brazil. This identification is based, in the absence of males, on the dilated tibia and tarsus of the midleg in the female.

*Material*: Prov. Santa Fe, Arroyo Saladillo, near Santa Fe, 2 April 1971, 4♀.

### *Leptonema crassum* Ulmer

*Leptonema crassum* Ulmer, 1905a:58.—Mosely 1933:12.

This large, brownish species was originally described from Brazil, but is widely distributed over South and Central America. The following is the first record for Argentina.

*Material*: Prov. Misiones, Puerto Rico, 4–8 April 1971, 2♂, 3♀.

### *Leptonema dissimile* Mosely

*Leptonema dissimile* Mosely, 1933:43.

Originally described from Bolivia, the species is now recorded from Argentina. The genitalia of these males agree perfectly with the figures and description of the genitalia of the type. The females have a yellow cellule on the first anal vein of the hindwing, as does the female of a pair taken in copula in Surinam.

*Material*: Prov. Misiones, Mbopicua, 6–7 April 1971, 2♂, 2♀.

## Neoleptonema Ulmer, 1907c

### *Neoleptonema aspersum* Ulmer

*Neoleptonema aspersum* Ulmer, 1907c:61.—Mosely, 1931:170.

This species, although not reported from Argentina previously, is apparently widespread in South America being known from Brazil and Guyana. The males in this series are much larger than the females.

*Material*: Prov. Misiones, Puerto Rico, 4–8 April 1971, 2♂, 8♀.

## *Synoestropsis* Ulmer, 1905a

### *Synoestropsis pedicillata* Ulmer

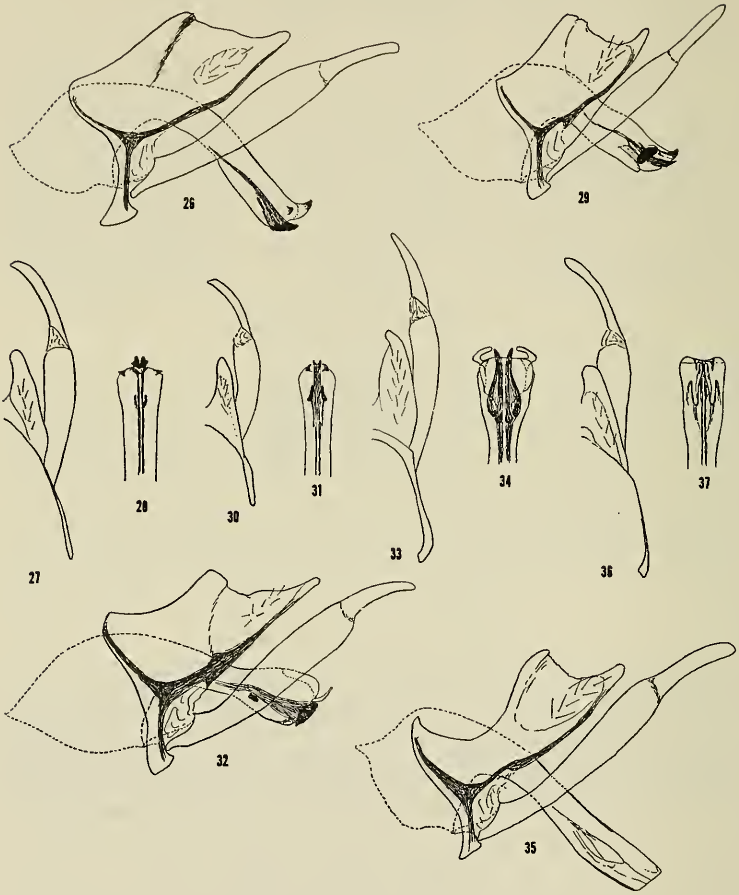
*Synoestropsis pedicillata* Ulmer, 1905a:43; 1913:392.—Flint, 1966:8.

Ulmer recorded the presence of this species in Argentina; the types were from Santa Catarina, Brazil.

*Material*: Prov. Misiones, Puerto Rico, 4–8 April 1971, 1♀.

## *Smicridea* McLachlan, 1871

All the species encountered on this trip belong to the subgenus *Rhyacophylax* Müller. This subgenus lacks the two pairs of internal reticulate sacs in the subapical abdominal segments of the male.



Figs. 26–37. *Smicridea argentina* (Navas): 26, genitalia, lateral; 27, lobe of tenth tergum and clasper, dorsal; 28, tip of aedeagus, dorsal. S. *discalis* n.sp.: 29, genitalia, lateral; 30, lobe of tenth tergum and clasper, dorsal; 31, tip of aedeagus, dorsal. S. *appendiculata* n.sp.: 32, genitalia, lateral; 33, lobe of tenth tergum and clasper, dorsal; 34, tip of aedeagus, dorsal. S. *weidneri* n.sp.: 35, genitalia, lateral; 36, lobe of tenth tergum and clasper, dorsal; 37, tip of aedeagus, dorsal.

### *Smicridea* (*R.*) *argentina* (Navas), NEW COMBINATION

Figures 26–28

*Badallus argentinus* Navas, 1918:21.
*Rhyacophylax argentinus* (Navas).—Navas, 1920c:42.—Schmid, 1949: 341.

Navas described the species under the name of *Badallus argentinus* from Santa Fe, Argentina, and later recorded it from Paraguay and Peru. Subsequent records, however, must be viewed with caution considering the large number of superficially similar species in the genus. The examples here recorded agree in characters of size, coloration, and genitalia with the type as redescribed by Schmid.

New figures of the male genitalia are presented to facilitate comparison with the other species herein described. The three dorsal points at the tip of the aedeagus are diagnostic.

*Material:* Prov. Santa Fe, Río Salado, Santo Tomé, 30–31 Mar. 1971, 8♂, 33♀.

### **Smicridea (R.) discalis** new species

Figures 29–31

This species is closely related to S. *argentina*, as is shown by the similarity in coloration and the presence of small points at the apex of the aedeagus. S. *discalis* may be recognized by the presence of only 2 apicodorsal points on the aedeagus, and the presence of a pair of internal, ovoid plates subapically on the internal sclerite of the aedeagus.

*Adult:* Length of forewing, 4 mm. Width of eye middorsally not quite ⅓ that of interocular distance. Color brown; with darker transverse bands at anastomosis and at midlength of apical cells, latter bordered inwardly by a paler band, indication of darker spots in cells M and 3A. Abdomen without internal sacs. Male genitalia: Ninth segment with anterolateral margin only slightly produced. Tenth tergum deeply divided apicomesally; tergite in lateral aspect gradually narrowed apicad, in dorsal aspect with apex directed posteriad, rounded. Clasper with basal segment long, slightly inflated apicad; apical segment tapering to a blunt point. Aedeagus with basal section enlarged, at right angles to axis of stem which is barely longer than basal section; apex with a pair of dorsolateral points, with an elongate internal sclerite bearing an ovoid plate subapically in lateral aspect.

*Material:* Holotype, male: Argentina, Prov. Misiones, Puerto Rico, 4–8 April 1971, C.M. & O.S.Flint, Jr. USNM Type 72164. Paratypes: Same data, 10♂, 14♀.

### **Smicridea (R.) appendiculata** new species

Figures 32–34

Although this species is quite different from the others described in the subgenus, it may be compared to the *columbiana* group. From all described species it differs in possessing a pair of apicodorsal appendages and a dorsal depression at the tip of the aedeagus. The color of the forewing, bright yellowish brown with three transverse fuscous bands, is also distinctive.

*Adult*: Length of forewing, 5 mm. Width of eye middorsally about ⅓ that of interocular distance. General color bright yellowish; forewing with 3 distinct, narrow, transverse fuscous bands, outermost midway of apical cells, second along anastomosis, third very near wing base, with dark spots in cells M and 3A. Abdomen without internal reticulate sacs. Male genitalia: Ninth segment with anterior margin produced into a broad, round lobe. Tenth tergum divided apicomesally; tergite in lateral aspect with a narrow apex, in dorsal with narrow apical portion angled mesad. Clasper with basal segment long, barely enlarged apicad; apical segment tapering to a blunt point. Aedeagus with base greatly enlarged, angled to axis of stem, apical section slightly enlarged; apex with a pair of slender, dorsal appendages, dorsal surface bearing a thin carina for some distance on each side, with internal sclerite considerably widened apically, in dorsal aspect with 2 halves pointed and slightly divergent apically.

*Material*: Holotype, male: Argentina, Prov. Santa Fe, Arroyo Saladillo, near Santa Fe, 2 April 1971, C.M. & O.S.Flint, Jr. USNM Type 72165. Paratypes: Same data, 1♂. Río Salado, Santo Tomé, 30–31 Mar. 1971, 3♀. Prov. Misiones, Puerto Rico, 4–8 April 1971, 2♂.

### **Smicridea (R.) weidneri** new species

Figures 35–37

*Rhyacophylax brasilianus* (nec. Ulmer).—Flint, 1966, p. 8.

I recently have been able to study additional type material of the species S. (*R.*) *brasiliana* (Ulm.) that is in the Ulmer collection now at the Zoologischen Staatsinstituts und Zoologischen Museums Hamburg. It is apparent that two species were mixed in the original series, the true *brasiliana* and a second closely related species which I illustrated in 1966 and which I am here describing as new. H. Weidner in 1964 published a paper, unknown to me in 1966, listing the caddisfly types in the Hamburg Museum collection. His statement under *Rhyacophylax brasilianus* on page 95 "Brasilien, Sta. Catharina, ♂, Holotype (von Ulmer selbst bezeichnet)" I consider to be a lectotype designation. As this designation precedes mine of 1966, the latter is clearly invalid, and the concept of the species rests with the specimen designated by Weidner.

The species *brasiliana* is closely related to *weidneri*, but differs in being slightly larger and more obscurely marked. Genitalically *brasiliana* bears a pair of small, serrate, lateral processes near the tip of the aedeagus, has slightly different internal sclerites in the aedeagus, together with a more heavily sclerotized ventral margin of the tenth tergum.

*Adult:* Length of forewing, 5 mm. Width of eye middorsally slightly more than ½ that of interocular distance. General color yellowish, female with pale areas more infuscate; forewing with 3 distinct transverse bands, outermost midway of apical cells, beyond which the wingtip is slightly infuscate and basad of which there is a pale band, second along anastomosis, and third near wing base, dark spot in cell M. Abdomen without internal sacs. Male genitalia: Ninth segment with anterior margin produced in an upturned, pointed lobe. Tenth tergum divided apicomesally; tergite in lateral aspect with a narrow apex and in dorsal with tip rounded. Clasper with basal segment long, slightly inflated apicad; apical segment bluntly pointed. Aedeagus with base greatly enlarged, angled to axis of stem which is long and slender; apex without processes, with internal sclerites bearing an indistinct lateral structure.

*Material:* Holotype, male: Argentina, Prov. Misiones, Capioví, 5 April 1971, C.M. & O.S.Flint, Jr. USNM Type 72173. Paratypes: Same data, 3♂, 13♀. Mbopicua, 6–7 April 1971, 1♂, 3♀. Other: Brazil, S. Catarina, Luderwaldt, 1♂ (Hamburg Museum, from type series of *brasiliana*).

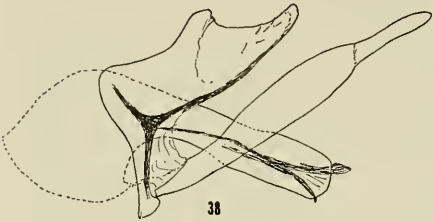
### **Smicridea (R.) pallidivittata** new species

Figures 38–40

This and the following species are probably related as indicated by coloration, slightly enlarged eyes, and lack of appendages on the aedeagus. However, *pallidivittata* may be recognized by its larger size and structure of the internal sclerites of the aedeagus.

*Adult:* Length of forewing, 4 mm. Width of eye middorsally not quite ⅓ that of interocular distance. Color brownish black; forewing with a transverse pale band at midlength of apical cells. Abdomen without internal sacs. Male genitalia: Ninth segment with anterolateral margin produced into a large rounded lobe. Tenth tergum deeply and broadly divided apicomesally; tergite narrowed apically and directed dorsomesally. Clasper with basal segment long, slightly inflated apicad; apical segment with tip rounded. Aedeagus with basal section enlarged, angled at right angles to axis of stem; apex with lateral surfaces slightly produced, internal sclerite consisting of a dorsal complex which in dorsal aspect has a clear central region, and a ventral complex whose tip is bifid with halves flared.

*Material:* Holotype, male: Argentina, Prov. Misiones, Capioví, 5



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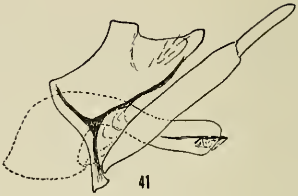

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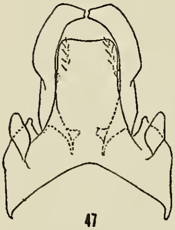

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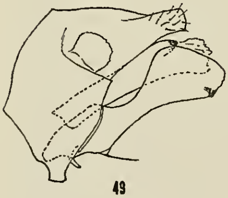

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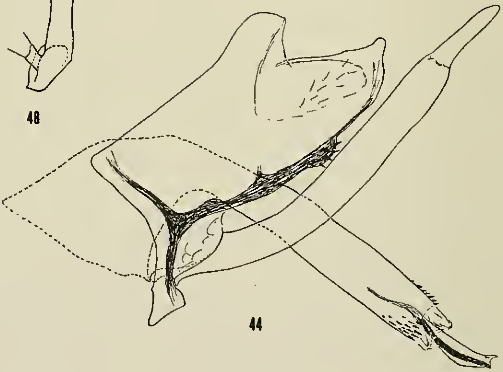

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April 1971, C.M. & O.S.Flint, Jr. USNM Type 72166. Paratypes: Same data, 12♂, 75♀. Mbopicua, 6–7 April 1971, 8♂, 38♀.

### **Smicridea (R.) minima** new species

Figures 41–43

This is one of the smallest species of the genus yet described. In addition to its size, the structure of the internal parts of the aedeagus, especially the parenthesis-like internal plates are distinctive.

*Adult*: Length of forewing, 2.5–3 mm. Width of eye middorsally not quite ⅓ that of interocular distance. Color fuscous, females greyer; forewing with a transverse, pale band at midlength of apical cells. Abdomen without internal sacs. Male genitalia: Ninth segment with anterolateral margin slightly produced; dorsal bridge rather broad. Tenth tergum divided apicomesally; tergite tapering to a rounded, narrow apex. Clasper with basal segment elongate, parallel-sided; apical segment tapering to a blunt point. Aedeagus with basal section moderately enlarged, angled to axis of stem which is bent at midlength; apex evenly rounded, internal sclerite elongate, and in dorsal aspect with a pair of parenthesis-like lateral plates.

*Material*: Holotype, male: Argentina, Prov. Misiones, Puerto Rico, 4–8 April 1971, C.M. & O.S.Flint, Jr. USNM Type 72167. Paratypes: Same data, 59♂, 75♀. Argentina-Paraguay, Alto Paraná River, 18–23 Jan. 1920, Cornell Univ. Exp., lot 569 sub 158, 9♂, 2♀.

### **Smicridea (R.) spinulosa** new species

Figures 44–46

This species is a member of the *magna* group, most closely related to S. *peruviana* (Martynov). From the latter, *spinulosa* differs in possessing a spinose lobe from the ventrolateral margin of the tenth tergum, in lacking a process from the ninth sternum, and in lacking the pair of small dorsal processes at the apex of the aedeagus.

*Adult*: Length of forewing, 7 mm. Width of eye middorsally not quite ⅓ that of interocular distance. Color bright yellowish, females with pale areas much darker; forewing with a dark, scalloped band

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Figs. 38–49. *Smicridea pallidivittata* n.sp.: 38, genitalia, lateral; 39, lobe of tenth tergum and clasper, dorsal; 40, tip of aedeagus, dorsal. S. *minima* n.sp.: 41, genitalia, lateral; 42, lobe of tenth tergum and clasper, dorsal; 43, tip of aedeagus, dorsal. S. *spinulosa* n.sp.: 44, genitalia, lateral; 45, lobe of tenth tergum and clasper, dorsal; 46, tip of aedeagus, dorsal. *Cochliopsyche opalescens* n.sp.: 47, genitalia, dorsal; 48, clasper, ventral; 49, genitalia, dorsal.

at midlength of apical cells beyond which the wing is more infuscate, crossveins of anastomosis dark, with small spots in cells M and 3A. Abdomen without internal sacs. Male genitalia: Ninth segment with anterolateral margin moderately produced. Tenth tergum with apicomesal division well developed; tergite in lateral aspect broad, with a small apicodorsal lobe, in dorsal aspect with an apical lobe angled slightly mesad; ventrolateral margin with a small sclerotized lobe bearing several small spines. Clasper with basal segment long, of uniform diameter; apical segment with apex rounded. Aedeagus with basal section moderately enlarged and angled to axis of stem which is long and slender; apex with a few spicules on dorsal margin and a few more elongate spicules lateroventrally, internal sclerite long, slender (everted in type).

*Material*: Holotype, male: Argentina, Prov. Misiones, Puerto Rico, 4–8 April 1971, C.M. & O.S.Flint, Jr. USNM Type 72168. Paratypes: Same data, 5♂, 3♀. Mbopicua, 6–7 April 1971, 14♂, 34♀. Capioví, 5 April 1971, 2♀.

## Leptoceridae

### *Leptocella* Banks, 1899

### *Leptocella flavofasciata* Ulmer

*Leptocella flavofasciata* Ulmer, 1907a:18.—Flint, 1966:9.
*Leptocella sparsa* Banks, 1920:353.—Flint, 1966:9.

This very pretty species was described from Brazil, but its synonym, *sparsa*, was described from Misiones, Argentina. It is easily recognized by its coloration; a photograph of the forewing is to be found in Flint, 1966, plate 2E.

*Material*: Prov. Misiones, Capioví, 5 April 1971, 1♀.

### *Leptocella separata* Banks

*Leptocella separata* Banks, 1920:353.—Flint, 1967:22.

This species is also easily recognized by the color pattern of the forewing, which is well shown in plate 1G of Flint, 1967. It was previously known from Santa Catarina, and Rio de Janeiro, Brazil.

*Material*: Prov. Misiones, Capioví, 5 April 1971, 1♂, 2♀. Mbopicua, 6–7 April 1971, 8♀.

### *Leptocella punctata* Ulmer

*Leptocella punctata* Ulmer, 1905b:75.—Flint, 1966:9.
*Leptocella fenestrata* Banks, 1913b:237.—Flint, 1966:9.
*Leptocella ambitiosa* Navas, 1933:118.—Schmid, 1949:386.—Flint, 1966: 9.

This is a common and widespread species over much of South and Central America. It has been recorded from Argentina, Brazil, Bolivia, Ecuador, and Panama. It is somewhat variable in the degree to which the brown marks on the forewings are outlined with darker brown. In these specimens from Argentina there is almost no outlining of these marks.

*Material*: Prov. Misiones, Puerto Rico, 4–8 April 1971, 3♂, 6♀.

### *Leptocella nigricapilla* Navas

*Leptocella nigricapilla* Navas, 1920d:68.—Schmid, 1949:389.
*Leptocella ornata* Navas, 1933:119 [NEW SYNONYMY].

Navas described *nigricapilla* from the Río Paraguay, Paraguay, and later described *ornata* from Santa Fe, providing a rather good figure of the color pattern of the forewing of the latter. On the basis of these new collections it is clear that *ornata* is the female of *nigricapilla*, and *ornata* is hereby synonymized. In the same 1933 paper Navas described *ditata* from Piquete, Santa Fe, which might well be a rather badly rubbed example of *nigricapilla* or *flavofasciata*. Until it is possible to study the type, however, it is impossible to be certain of its exact identity.

*Material*: Prov. Santa Fe, Río Salado, Santo Tomé, 30–31 Mar. 1971, 2♂, 12♀.

### *Leptocella bruchi* Navas

*Leptocella bruchi* Navas, 1920d:66.

I have been able to study the type of *bruchi*, which is in the Museum of Natural History "Bernardino Rivadavia" in Buenos Aires, and have collected a long series in the Prov. Buenos Aires. It is in appearance quite similar to *L. muelleri* Ulmer from southern Brazil. The latter has the black dashes along the longitudinal veins of the forewing continuous from base to apex, whereas in *bruchi* the dashes are lacking in the middle of the wing.

*Material*: Prov. Santa Fe, Río Salado, Santo Tomé, 30–31 Mar. 1971, 1♀.

### *Leptocella muhni* Navas

*Leptocella muhni* Navas, 1916a:68.—Schmid, 1949:388.
*Leptocella fulvocapilla* Navas, 1922:399 [NEW SYNONYMY].

The species was described from Santa Fe, and appears to be widespread over South America. I was able to study the male type of *L. fulvocapilla* Navas at the Museum "Bernardino Rivadavia" in Buenos Aires. This is the same species as *muhni*, and it is herewith synonymized.

*Material*: Prov. Santa Fe, Río Salado, Santo Tomé, 30–31 Mar. 1971, 2♂, 5♀. Prov. Misiones, Puerto Rico, 4–8 April 1971, 14♂, 8♀. Capioví, 5 April 1971, 1♂. Mbopicua, 6–7 April 1971, 7♂, 12♀.

### *Leptocella splendida* Navas

*Leptocella splendida* Navas, 1917:403.

The species was described from Santa Fe and later recorded from Bolivia. It is a small and strikingly colored species which is identified on the basis of the original description and examples determined as such by Nathan Banks.

*Material:* Prov. Misiones, Puerto Rico, 4–8 April 1971, 1♀.

## *Brachysetodes* Schmid, 1955

### *Brachysetodes duodecimpunctatus* (Navas) NEW COMBINATION

*Setodes duodecimpunctata* Navas, 1916b:33.

I am transferring this species, which seems to be common over much of South America, to *Brachysetodes* with which it agrees in venation and to a lesser degree, genital pattern.

*Material:* Prov. Misiones, Puerto Rico, 4–8 April 1971, 3♂, 16♀. Capioví, 5 April 1971, 4♂, 14♀. Mbopicua, 6–7 April 1971, 1♂.

## *Oecetis* McLachlan, 1877

### *Oecetis excisa* Ulmer

*Oecetis excisa* Ulmer, 1907a:15.

*Oecetis mutila* Navas, 1918:22.—Schmid, 1949:382.

*Oecetis castilleja* Navas, 1920a:134.—Schmid, 1949:381 [NEW SYNONYMY].

*Oecetis muhnia* Navas, 1920b:28 [NEW SYNONYMY].

This species is frequently encountered in collections from the Paraná Basin and adjacent areas. It was described from Santa Fe, and it or its synonyms have been recorded from Bolivia and Paraguay. Navas described *O. mutila*, *O. castilleja*, and *O. muhnia* all from Santa Fe. Schmid, after studying the type, synonymized *mutila*, and suggested that *castilleja* might be a synonym. I have studied a male determined by Navas as *castilleja* and it is *excisa* also. The original figures and descriptions also leave no room for doubt but that all three are *excisa*, and they are herewith synonymized. *O. apicata* Navas from Santiago del Estero also appears to be the same, but until its type is found or other topotypic collections are made. I prefer to keep its status open. Rather surprisingly we did not collect this species in Santa Fe.

*Material:* Prov. Misiones, Puerto Rico, 4–8 April 1971, 4♀. Capioví, 5 April 1971, 2♂, 3♀. Mbopicua, 6–7 April 1971, 6♀.

### *Oecetis amazonica* (Banks)

*Oectina amazonica* Banks, 1924:447.

*Oecetis amazonica* (Banks).—Fischer, 1966:109.—Flint, 1967:22.

Banks described *amazonica* from Manaus, Brazil, and recorded it from Peru and Piedra Blanca, Argentina. At Santa Fe we collected this species, but not *excisa* which has been collected there on previous occasions.

*Material*: Prov. Santa Fe, Río Salado, Santo Tomé, 30–31 Mar. 1971, 1♀. Arroyo Saladillo, near Santa Fe, 2 April 1971, 2♂.

### *Oecetis punctipennis* (Ulmer)

*Pseudosetodes punctipennis* Ulmer, 1905b:77.
*Oecetina parishi* Banks, 1915:631.—Flint, 1966:10.
*Oecetis bridarollina* Navas, 1933:116 [NEW SYNONYMY].
*Oecetis punctipennis* (Ulmer).—Flint, 1966:10.

Known from Brazil and Guyana, this species is apparently widespread over South America. Navas' original description of *O. bridarollina* from Santa Fe, Argentina, accompanied by a good figure of its coloration, is sufficient to show that it is the same as *punctipennis* with which it is now synonymized.

*Material*: Prov. Misiones, Puerto Rico, 4–8 April 1971, 1♂.

## HELICOPSYCHIDAE

### *Cochliopsyche* Müller, 1885

### **Cochliopsyche opalescens** new species

Figures 47–49

This species is very closely related to *C. clara* (Ulmer), known from Santa Catarina, Brazil. *C. opalescens* differs in possessing a mesal process from the sixth sternum in addition to small differences in the genitalia, especially in the claspers which lack the pair of small points dorsally in the expanded apical portion and which have a longer narrowed basal section.

*Adult*: Length of forewing, male 5.5 mm, female 4.5 mm. General color brown; head and thorax dorsally with pale brown hairs; forewing covered with fuscous hairs, with scattered, small, silvery spots especially on veins. Abdomen of male with second through fifth sterna with large clear lateral areas surrounded by sclerotized margins, second and third segment with darkened posterolateral patches, hairs on sterna arising from large, clear tubercles; sixth sternum with a mesal pointed process about half as long as sternum. Male genitalia: Ninth segment very narrow ventrally, widened laterally from both anterior and posterior margins, dorsally grading imperceptibly into tenth tergum. Tenth tergum a simple elongate lobe, slightly indented apicomesally. Cercus broader than long. Clasper with a distinct, terete, basal section widening into a broad apical flap with 2 small teeth apicoventrally; with a small basomesal flap with 1 or 2 enlarged setae. Aedeagus tubular, elongate, membranous apically, with a small internal sclerite.

*Material*: Holotype, male: Argentina, Prov. Misiones, Puerto Rico, 4–8 April 1971, C.M. & O.S.Flint, Jr. USNM Type 72169. Paratypes: Same data, 1♂, 3♀.

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Vol. 85, No. 18, pp. 249–254 30 August 1972

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# *CITHADIUS CYATHURAE*, A NEW GENUS AND SPECIES OF TACHIDIIDAE (COPEPODA: HARPACTICOIDA) ASSOCIATED WITH THE ESTUARINE ISOPOD, *CYATHURA POLITA*

By Thomas E. Bowman
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While examining populations of the estuarine isopod *Cyathura polita* that he had collected at the Chesapeake Bay Center for Environmental Studies, John W. Vogel noticed a harpacticoid copepod in his preserved samples of this isopod. The copepod occurred so regularly that it seemed likely that its association with the isopod was not accidental. Observations on living specimens (see below) supported this supposition.

I am grateful to Mr. Vogel for his discovery of the copepod, a new genus and species which is described below, and for carefully selecting and preserving the specimens on which the description is based.

## TACHIDIIDAE

### Tachidiinae

Lang (1948) divided the family Tachidiidae into three subfamilies, Euterpininae, Thomsonulinae, and Microarthridioninae. The last, which contains *Microarthridion* and the type-genus of the family, *Tachidius*, is the nominate subfamily, and must be named *Tachidiinae.*

### **Cithadius** new genus

*Diagnosis*: ♀ antenna 1 7-merous. Exopod of antenna 2 1-merous, with 4 setae. Endopod of leg 1 not longer than exopod. Legs 2–3 not sexually dimorphic; rami subequal; 1st segment of exopod and endopod not reduced, with seta on medial margin. Leg 4 much reduced; rami 2-merous. Leg 5 in both sexes a broad undivided plate.

*Type-species*: *Cithadius cyathurae* new species.

*Etymology*: An anagram of *Tachidius*. Gender, masculine.

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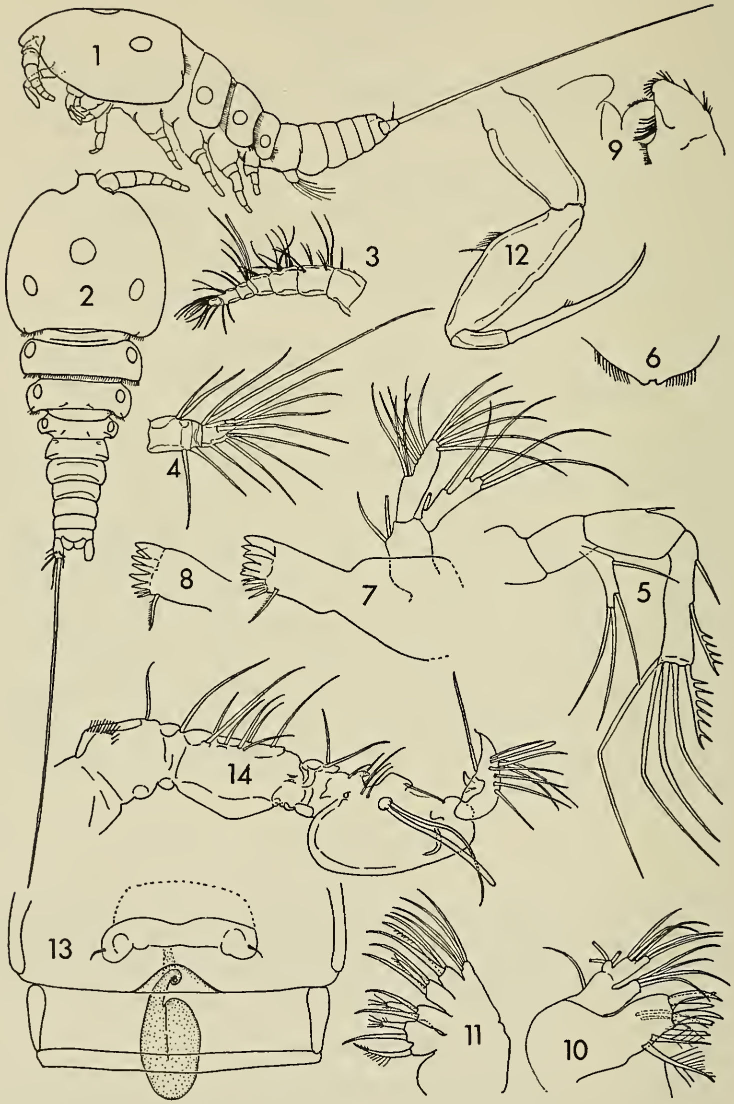

FIGS. 1–14. *Cithadius cyathurae.* 1–13, ♀: 1, lateral view. 2, dorsal view. 3, left 1st antenna. 4, right 1st antenna, distal segments. 5, 2nd antenna. 6, labrum. 7, mandible. 8, gnathal lobe of mandible from different specimen. 9, hypopharynx. 10, 1st maxilla. 11, 2nd maxilla. 12, maxilliped. 13, genital field. 14, ♂ 1st antenna.

### **Cithadius cyathurae** new species

Figures 1–23

*Diagnosis*: With the characters of the genus.

*Additional description*: Length of ♀ 0.54–0.58 mm, of ♂ 0.48–0.50 mm. Nuchal organ and lateral discs present on cephalothorax; lateral discs on pedigerous segments 2–4. Rostrum broad. Posterolateral margins of cephalothorax and pedigerous segments 2–4 and dorsal margin of pedigerous segment 2 fringed with fine setae. Genital field as in Figure 13; ♀ leg 6 represented by a single seta. Urosomites 4–5 each with row of spines along posteroventral margin. Anal operculum margin smooth.

Caudal ramus about ⅓ longer than width at base, with 4 apical setae. Innermost apical seta slender, shorter than ramus; next-to-innermost seta very robust, about ⅞ as long as body; next-to-outermost seta slender, about twice as long as ramus; outermost seta slender, about ¼ longer than ramus; dorsal setae 2. Lateral seta inserted slightly distal to midlength of lateral margin.

♀ antenna 1 composed of 7 segments bearing 1, 8, 7, 4, 2, 4, and 10 setae; segment 4 with long esthete. ♂ antenna 1 forming a powerful claw with a complex pattern of sclerotization and setation which I did not fully elucidate; not all of the setae are shown in my illustration (Fig. 14).

Antenna 2 slender; endopod 2-merous, distal segment with 3 marginal spines, 1 simple others ctenate, and 4 apical setae flexed at their midlengths; exopod 1-merous, with 4 setae. Mandibular palp with 1-merous exopod and endopod; basis with 2 setae; endopod with 5 setae; exopod with notch at midlength, armed with 7 marginal and 6 apical setae. Maxilla 1 with 6 spines and 4 setae on arthrite; coxa with 4 inner setae and 1 epipodal seta; basis and endopod not clearly separate, bearing total of 5 setae; exopod with 3 setae. Maxilla 2 with 5 inner lobes bearing 3, 3, 3, 3, and 4 setae. Maxilliped rather slender, 4-merous, prehensile; 2nd and 4th segments with a few setae as shown in Figure 12.

Legs 1–3 with armature of setae and spines identical with that given by Gurney (1932) for *Tachidius discipes* and *T. incisipes.* Leg 3 may have 1 or 2 inner setae on 2nd exopod segment; in one ♀ left leg had 2 setae, right leg 1 seta. Leg 4 much smaller than others; rami 2-merous; 1st segment of exopod with 1 outer spine, 2nd segment with 1 outer spine, 2 terminal and 1 subterminal setae; 1st segment of endopod unarmed, 2nd segment with 3 terminal setae. Leg 5 bearing 7 setae arranged as in Figures 20–21, identical in both sexes except smaller in ♂. Leg 6 of ♂ with 2 long terminal setae and a shorter outer seta.

*Types*: Holotype ♀ (USNM 139193), allotype (USNM 139194) and 38 ♀ and 4 ♂ paratypes (USNM 139195), collected with *Cyathura polita* by John W. Vogel, 29 April 1968, at Fox Creek, Rhode River estuary, Chesapeake Bay Center for Environmental Studies.

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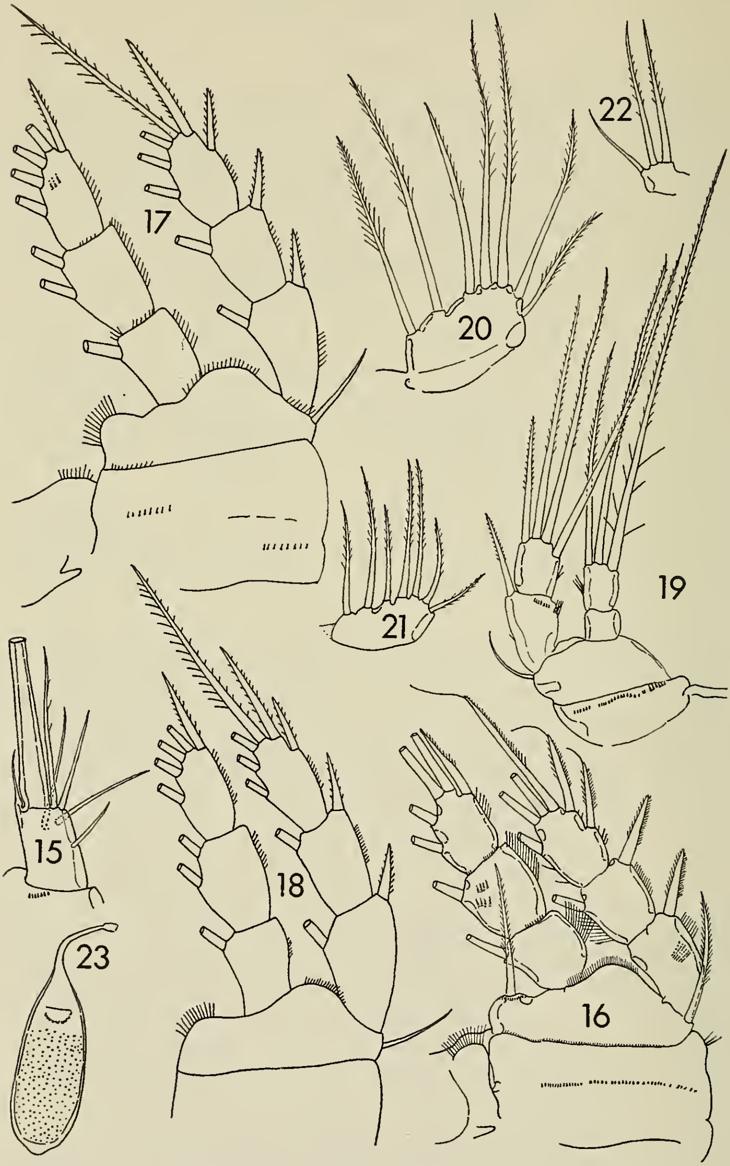

FIGS. 15–23. *Cithadius cyathurae.* 15–20, ♀: 15, caudal ramus, ventral. 16, leg 1. 17, leg 2. 18, leg 3. 19, leg 4. 20, leg 5. 21–23, ♂: 21, leg 5. 22, leg 6. 23, spermatophore.

*Etymology*: The specific name refers to the isopod with which it is associated.

*Relationships*: *Cithadius* shares many characters with the two genera of Tachidiinae, *Tachidius* and *Microarthridion*, as defined by Lang (1948), but can be immediately distinguished by its unique 4th legs, as well as by the 1-merous exopod of antenna 2. The discovery of *Cithadius* necessitates expanding the definitions of the family Tachidiidae and the subfamily Tachidiinae to include these characteristics.

*Natural history*: A few observations were made on living specimens of *Cyathura polita* together with *Cithadius*. The *Cyathura* paid no observable attention to the copepod, which moved over the body of the host with facility. Favorite sites seemed to be the telson and the articulations between the segments of the posterior pereopods, but other parts of the body were visited, including the ventral surface of the pereon.

The consistent occurrence of *Cithadius* in Vogel's collections of *Cyathura*, together with its observed behavior suggests that the natural habitat of *Cithadius* is the body surface of *Cyathura*. The biology of *Cyathura polita* has been studied intensively by Burbanck (1961, 1963, 1967) and its distribution is well known. It occurs in estuaries from the Sheepscot River, near Boothbay Harbor, Maine, to Lake Pontchartrain, Louisiana. It seems unlikely that *Cithadius* is limited to the Chesapeake Bay, and its distribution will probably be found to approximate that of *Cyathura polita*. Harpacticoid copepods have been reported as associates of other crustaceans, for example, spider crabs (Jakubisiak, 1932), land crabs (Humes, 1941), hermit crabs (Humes and Ho, 1969a, 1969b), lobsters (Humes, 1953), and crayfishes (Bowman, Prins, and Morris, 1968); among the isopods they are known to be associated only with the gribble, *Limnoria* (Stephensen, 1936; Coull and Lindgren, 1969).

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Vol. 85, No. 19, pp. 255–264 30 August 1972

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# CONTRIBUTION TO THE POLYCHAETOUS STUDY OF THE TULEAR REGION (SW OF MADAGASCAR)

## IV. *STHENELANELLA CORALLICOLA* NEW SPECIES (SIGALIONIDAE)

By Bernard A. Thomassin
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In the study of some Aphroditidae (sensu lato) from the coral sands of the Tuléar region (Thomassin, 1970), I referred some sigalionid polychaetes to *Sthenelanella uniformis* Moore (1910), originally described from California, the one validly described species at that time. Subsequent to the writing of the manuscript, Pettibone (1969) revised the genus *Sthenelanella* Moore, 1910, and synonymized with it the genus *Euleanira* Horst, 1916, represented by a single species, *E. ehlersi* Horst (1916, 1917), originally described from Indonesia (Madura Strait, *Siboga* station 2). The latter species recently was reported by Day (1967) from Natal, South Africa, by Gallardo (1968) from Nha Trang Bay, South Vietnam, and by Gibbs (1971) from New Georgia, Solomon Islands.

In light of the revision by Pettibone, I reexamined my specimens from Tuléar and found that they showed some characters in common with S. *ehlersi* and some with S. *uniformis* but differed in other respects from both species. At my request, Dr. M. H. Pettibone examined some of my Tuléar specimens and concluded that they comprised a new species. She very kindly left it to me to describe. I thank her for this and for her suggestions and help. The manuscript benefited also from the suggestions of Prof. J. -M Pérès, Dr. L. Laubier, and Dr. M. L. Jones.

The types are deposited in the Museum National d'Histoire

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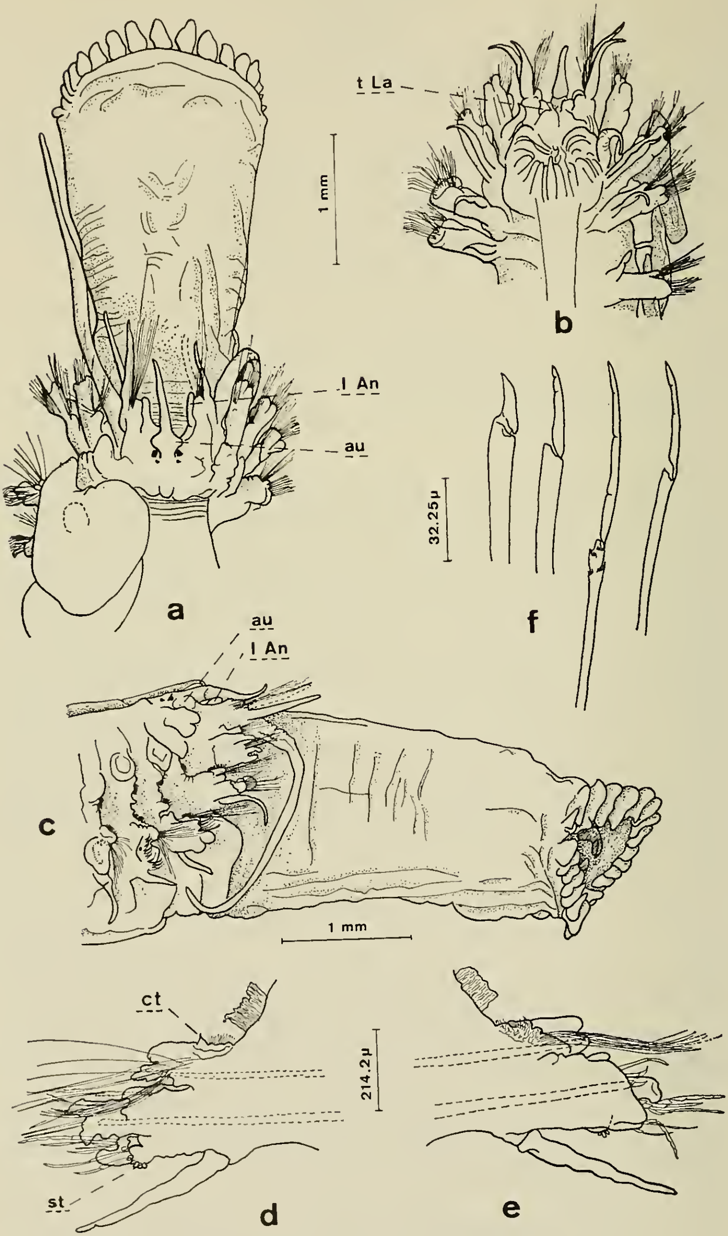
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## SIGALIONIDAE

### *Sthenelanella* Moore, 1910

Synonym: *Euleanira* Horst, 1916.

### **Sthenelanella corallicola** new species

Figures 1–3

*Sthenelanella uniformis*—Thomassin, 1970, p. 64, fig. 10a-i, 4f. Not Moore, 1910.

*Material examined*: MADAGASCAR, Tuléar, coral reef flat of the Great Reef (Grand Récif), collected by B. Thomassin at 11 stations from July 1965 to January 1966—holotype and 30 paratypes : stations 2, 56, 62, 64, 66, 76, 108, 110—8 paratypes (BT) : station 52—7 paratypes (BMNH ZB1971: 32–39); station 80—6 paratypes (USNM 43175); station 113—holotype and 9 paratypes (MNHNP A465).

*Description*: Body elongate, linear, depressed, tapering posteriorly. Length more than 30 mm (all specimens incomplete), width about 3 mm, including parapodia, segments more than 91. Elytra numerous pairs, on segments 2, 4, 5, 7, alternate segments to 25, continuing on all segments. Elytra delicate, transparent, smooth, not completely covering middorsum; first pair rounded, with numerous cylindrical micropapillae on anterior border, tips of papillae with 1–2 sensory hairs (Fig. 2a); following elytra subreniform to subcordiform, with submarginal fringe of papillae along lateral borders (Fig. 2b). Elytral pigmentation generally lacking; few anterior elytra sometimes with light brown pigmentation.

Prostomium rounded, fused with first or tentacular segment (Fig. 1a-c). Ceratophore of median antenna with small lateral auricles (or basal lappets) and short, tapered style. Lateral antennae very short, oval, fused to inner dorsal bases of tentacular parapodia. Palps long, slender, tapered, emerging ventral to tentacular parapodia and extending to

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FIG. 1. *Sthenelanella corallicola* (paratypes, from Station 25) : a, Anterior end, dorsal view, pharynx fully extended, elytra on segments II and IV removed, right dorsal tentacular cirrus missing (dotted); b, anterior end, ventral view, palps not shown; c, anterior end, lateral view; d, parapodium from segment II, anterior view; e, same, posterior view; f, neurosetae from same. (au, auricle; ct, ctenidia; 1 An, lateral antenna; st, stylodes or papillae; t La, tentacular lamella.)

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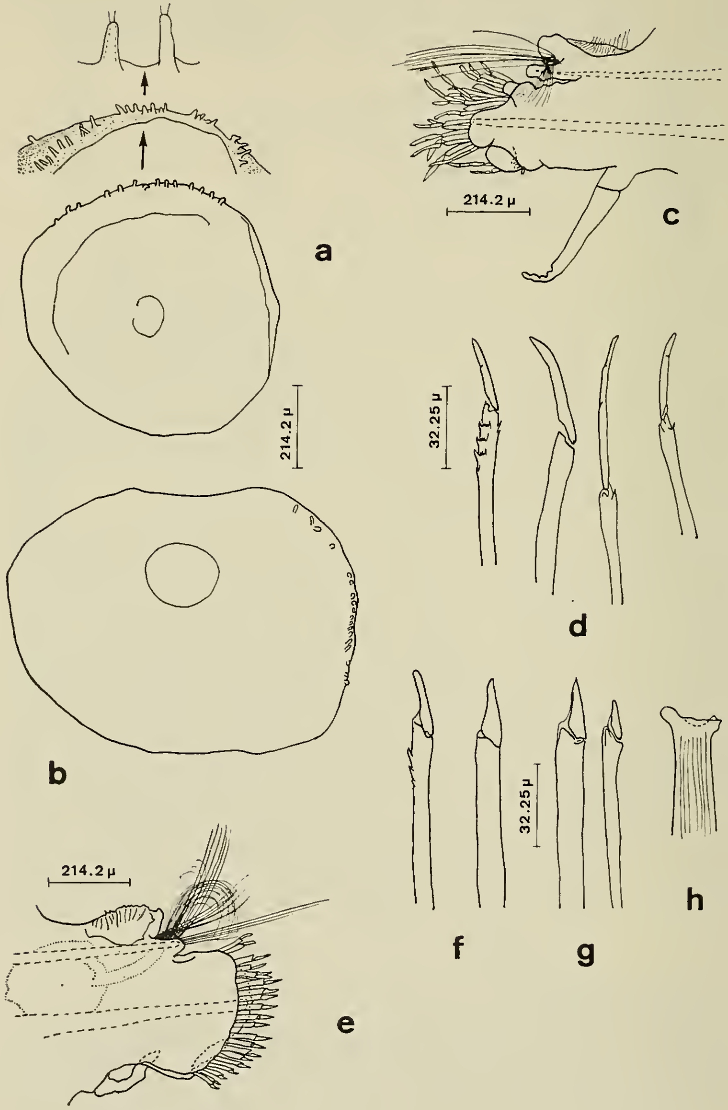
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about segment 7 (6–9). Eyes two pairs, brown, each pair closely approximated, situated on slightly raised ocular areas lateral to ceratophore of median antenna, anterior pair about twice as large as posterior pair, partly hidden by auricles. Each tentacular parapodium uniramous, with single aciculum, 2 bundles of capillary notosetae, pair of tentacular cirri similar to median antenna, ventral one slightly shorter than dorsal one, and small elongate-conical tentacular lamella medial to base of tentacular cirri; without dorsal ctenidium.

Parapodia of segments II–IV directed anteriorly; buccal segment (II) with ventral buccal cirri longer than following ventral cirri, similar to ventral tentacular cirri; segment III with conical dorsal tubercles (without dorsal cirri; without extra ctenidia; Figs. 1a-e, 2c). Presetal neuropodial acicular lobes bilobed, with micropapillae (5–6) on distal borders; posterior lobe ending in curved line ventrally. Neurosetae all compound, differing markedly from those of following segments, of several kinds (Figs. 1f, 2d): upper ones with spinous rows (4–8), and blades short to longer, showing 1–4 pseudoarticulations, and entire, slightly hooked tips; middle ones slightly stouter, with smooth stems and short, slightly hooked blades with entire tips; lower ones slender, stems with few spinous rows (2–3), and blades showing 2–4 pseudoarticulations and slender bifid tips, secondary tooth very delicate.

Branchiae short, conical, lateral to dorsal tubercles and elytrophores from segment II on. Parapodia (except I) biramous, with rami closely united; ciliated notopodial ctenidia 3 per parapodium, 1 dorsal to notopodium, and 2 in concave area between notopodium and branchia (Figs. 2e, 3a-d). Notopodia bulbous, with projecting acicular lobes on lower sides; notosetae forming loose spreading bundles. All notosetae of anterior region simple, slender, spinous, tapering to capillary tips. Beginning about segment 16 (15–20), additional long, undulating, silky, threadlike notosetae, formed from notopodial spinning glands, emerging from posterior sides of notopodia and extending far beyond usual type of notosetae. Neuropodia larger than notopodia, with subconical presetal acicular lobes, distal part truncate and slightly bilobed in region of tip of neuroaciculum (latter with cup-shaped tip, Fig. 2h), with series of micropapillae on anteroventral part; shorter truncate postsetal lobes. Neurosetae all compound, with blades short and simple; numerous middle ones stouter, with smooth stems and blades tapered to pointed tips (some

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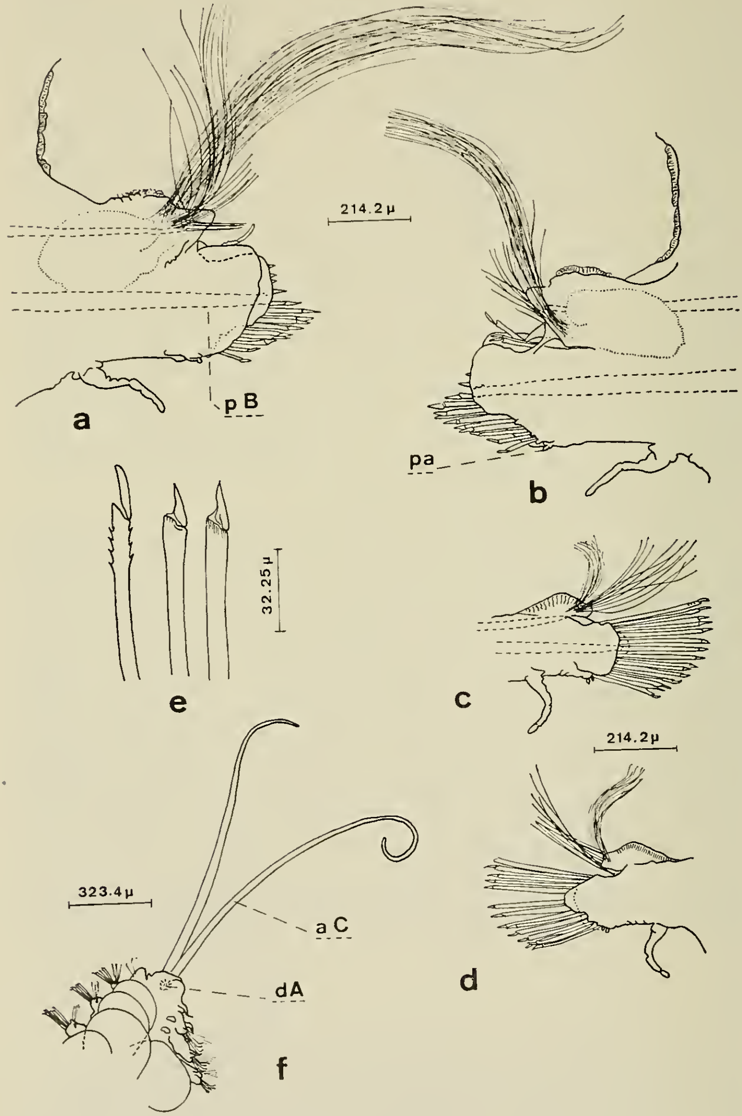
FIG. 2. *Sthenelanella corallicola* (paratypes, from Stations 52, 113) : a, First elytron, detail showing fringe of anterior papillae; b, middle elytron (about segment 25); c, parapodium from segment III, anterior view; d, neurosetae from same; e, parapodium from segment 20, posterior view; f, neurosetae from same; g, neurosetae from segment 26; h, tip of neuroaciculum from same.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with blades more or less fused to stems); few upper and lower neurosetae more slender, stems with few faint spinous rows and blades slightly curved, with blunt tips (Figs. 2f, g; 3e). Ventral cirri subulate, with small bulbous lobes on outer basal sides and distal articles.

Pygidium with dorsal anus and pair of long anal cirri (Fig. 3f). Extended pharynx elongate, about five times prostomial length (Fig. 1a, c), with 2 pairs of interlocking jaws and about 13 pairs of foliaceous, axe-shaped papillae (13–18 dorsal, 14–16 ventral). Tube up to 8 cm long, tough, fibrous, formed of several layers with bits of embedded coral sand, of greater diameter than animal and forming loose-fitting structure.

*Biology*: *Sthenelanella corallicola* is found intertidally and subtidally in coarse sands with some silt, occupying the coral-head ridges with interdigitating sand gullies, in the coarse sand banks on the inner margin of the reef flat, along the lagoon (or postrecifal channel), and in coarse and medium sand on the inner slope of the reef (3 to 6 meters depth, in the lagoon). Medium granular size: $\overline{P_{16}} = 2.30 \pm 0.35$ mm, $\overline{Q_1} = 1.92 \pm 0.29$ mm, $\overline{M} = 1.22 \pm 0.13$ mm, $\overline{Q_3} = 0.77 \pm 0.13$ mm, $\overline{P_{84}} = 0.63 \pm 0.09$ mm, $\overline{\Delta\Upsilon} = 0.50 \pm 0.04$. The sigalionids form fibrous tubes covered by mucus and embedded vertically in the substrate.

*Remarks*: *Sthenelanella corallicola* shows some characters in common with *S. uniformis* and some with *S. ehlersi*, as indicated in Table 1.

It was of interest to determine if the two additional records of *Euleanira ehlersi* from Natal, South Africa (shallow and deep, to 500 meters) by Day (1967), and from Nha Trang, South Vietnam (shallow, sandy-muddy bottoms) by Gallardo (1968) refer rather to *S. corallicola* or to some undescribed species of *Sthenelanella.*

Professor J. H. Day very kindly lent me one of his specimens for comparison. It agrees with *S. ehlersi* in most respects, including the following: first pair of elytra round, with few scattered sensory papillae on anterior border; second and posterior elytra subreniform; middle elytra with two deep lateral notches, without papillae; elytra on all segments from 25 on (not segment 21, as indicated by Day); dorsal bases of tentacular parapodia with pair of small ctenidia; parapodia of segment III without dorsal cirri, with pair of ventral knobs. The fine hairy setae of the notopodia are extra long, similar to those of *S. corallicola* and *S.*

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FIG. 3. *Sthenelanella corallicola* (paratypes, from Stations 52, 62, 113) : a, Parapodium from segment 26, anterior view; b, same, posterior view, notopodial hairy setae cut off; c, parapodium from far posterior region, anterior view; d, same, posterior view; e, neurosetae from same; f, posterior end, dorsal view, some elytra removed. (aC, anal cirrus; pa, papillae; pB, posterior bract; dA, dorsal anus).

TABLE 1. Comparison of three species of *Sthenelanella* Moore (= *Euleanira* Horst).

| | *S. uniformis* Moore, 1910 (Syn.: *S. atypica* Berkeley & Berkeley, 1941) | *S. corallicola* n. sp. | *S. ehlersi* (Horst, 1916) |
|---|---|---|---|
| Type-locality: | Southern California | Madagascar (Tuléar) | Indonésia (Madura Strait) |
| Elytra on all segments from: | *27 on | 25 on | 25 on |
| Pigmentation of anterior elytra: | mottled | colorless or light brown | transversely banded |
| Lateral margins of middle and posterior elytra: | entire; smooth or with scattered micropapillae | entire; with row of submarginal micropapillae | *deeply sinuous; without papillae |
| Oval ctenidia on dorsal bases of tentacular parapodia (I): | absent | absent | *present |
| Paired dorsal oval ctenidia between segments II and III: | *present | absent | absent |

* Differs from two species. (Underlines = characters in common for two species.)

TABLE 1. (Continued).

| | *S. uniformis* Moore, 1910 (Syn.: *S. atypica* Berkeley & Berkeley, 1941) | *S. corallicola* n. sp. | *S. ehlersi* (Horst, 1916) |
|---|---|---|---|
| Neuropodia: | subequal rounded presetal acicular and postsetal lobes; without micropapillae | *longer subconical presetal acicular lobes, truncate and slightly bilobed distally, with micropapillae on anteroventral part; shorter truncate postsetal lobes | subequal rounded presetal acicular and postsetal lobes; without micropapillae (except on anterior few neuropodia) |
| Neurosetae: | *tips of blades of upper ones blunt; rest conical | tips of blades of upper and lower ones blunt; middle ones conical, pointed | tips of upper and lower ones blunt; middle ones conical, pointed |

*uniformis.* Some of the neurosetae have short conical pointed blades, similar to those of *S. corallicola.* My observations agree with Day's identification.

An attempt was made to obtain some of Gallardo's specimens from South Vietnam, now deposited in the Allan Hancock Foundation, without success. The small cushionlike branchiae on the notopodia were referred to as dorsal cirri by Gallardo. Spinning glands were present from about segment 9. It may be pointed out that the segment at which feltage setae first appear is perhaps somewhat variable within a species. The elytra were not described. The figures of the neurosetae resemble those of *S. corallicola.*

Recently, Gibbs (1971) reported two specimens of *Sthenelanella ehlersi,* without additional morphological remarks, from the mud and silty sands (18–24 m depth) of the Marovo lagoon, New Georgia, Solomon Islands.

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Vol. 85, No. 20, pp. 265–270 30 August 1972

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# *THERODAMAS DAWSONI*, A NEW SPECIES OF PARASITIC COPEPOD (CYCLOPOIDA: ERGASILIDAE) FROM THE WEST COAST OF PANAMA

By Roger Cressey
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A single female specimen of this new species was sent to me by Mr. C. E. Dawson of the Gulf Coast Research Laboratory. The copepod attached to the base of the pectoral fin of a stargazer, *Dactyloscopus thysannotus*, was collected by Dawson at Chiriqui, Panama, 21 June 1971. I am indebted to the collector for sending me this unusual copepod.

## **Therodamas dawsoni** new species

*Material studied*: Holotype female (USNM 141308).

*Female*: Body form as in Figure 1. Holotype measurements: total length, 2.17 mm; length of head to posterior margin of neck, 0.56 mm; width of head at area of lobes, 0.42 mm; width of neck, 0.31 mm; length of genital segment and abdomen, 0.30 mm; width of genital segment, 0.32 mm; length of abdomen, 0.09 mm; width of abdomen, 0.16 mm.

Anterior part of head (Fig. 2) with lateral lobes posterior to second antenna at junction of necklike area. Neck of specimen studied appearing somewhat contracted. Posterior part of head behind neck expanding to form broad shoulders with no obvious demarcation separating head from thorax. Thoracic segments weakly divided. Genital segment (Fig. 3) with 2 transverse rows of short hairs on ventral surface, surface with scutelike divisions. Abdomen (Fig. 3) bilobed with deep post median incision. Caudal ramus (Fig. 4) on lateral edge of abdomen, bearing 4 terminal setae as indicated in figure.

First antenna (Fig. 5) 5-segmented, each segment bearing several long setae; terminal setae obscured in specimen studied and exact number could not be determined. Second antenna (Fig. 6) a stout claw; basal segment with broad spine near inner midmargin; claw with small seta near base; tip blunt in holotype antenna. Mouthparts (Fig. 7) very

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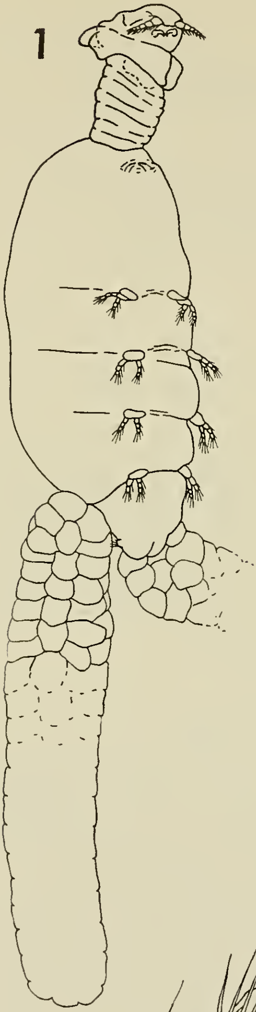

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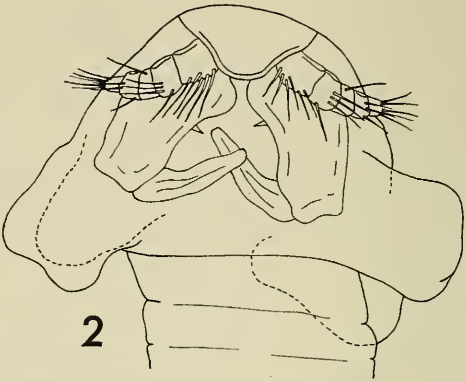

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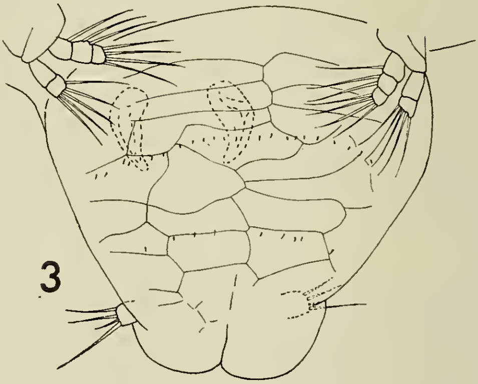

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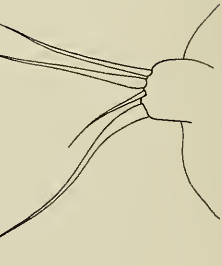

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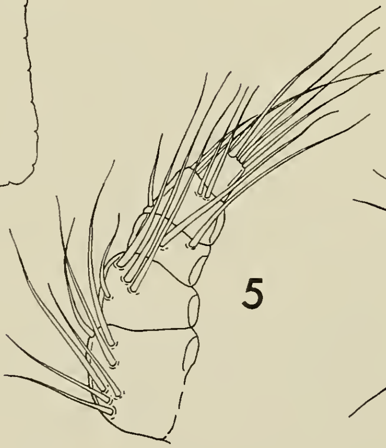

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small, separated from rest of head appendages by long neck. First maxilla simple lobe with 2 setae. Second maxilla 2-segmented, terminal segment with several setae in comblike arrangement. Maxilliped absent.

Legs 1–4 biramose. Leg 1 (Fig. 8) rami 3-segmented, segmentation of endopod weak; exopod terminal segment with one outer spine and 6 terminal setae, endopod terminal segment with 2 outer spines and 4 terminal setae, all setae with short plumosities, all spines with spinules along outer edge. Leg 2 (Fig. 9) rami 3-segmented; exopod terminal segment with 6 setae, endopod terminal segment with 5 setae, setae sparsely plumose. Leg 3 as in leg 2. Leg 4 (Fig. 10) exopod 2-segmented, terminal segment with 5 setae; endopod 3-segmented, terminal segment with 4 setae.

Spine and seta formula of legs 1–4 as follows (Roman numerals refer to spines, Arabic numerals to setae):

| | leg 1 | | leg 2 | | leg 3 | | leg 4 | |
|---|---|---|---|---|---|---|---|---|
| | exo | end | exo | end | exo | end | exo | end |
| Seg. 1 | I:0 | 0:1 | I:0 | 0:1 | I:0 | 0:1 | 0:0 | 0:1 |
| Seg. 2 | 0:0 | 0:1 | 0:1 | 0:2 | 0:1 | 0:2 | 5 | 0:2 |
| Seg. 3 | I:6 | II:4 | 6 | 5 | 6 | 5 | | 4 |

Legs 5 and 6 absent.

Egg sacs as long as body containing 50–75 eggs.

*Male*: Unknown.

*Remarks*: In 1863 Krøyer described a new species of copepod parasitic on *Serranus* sp. from the Danish West Indies. This species, *Therodamas serrani*, represented a new genus. Wilson, in 1917, determined that Krøyer's species belonged to the family Lernaeidae based on Krøyer's description. Thomsen, in 1949, collected additional specimens of *T. serranus* from *"Tachyurus barbus"* and a new species, *T. sphyricephalus*, from the same host from Uruguay. Thomsen reassigned the genus to the family Ergasilidae. Based on my examination of the new species described here I agree with Thomsen that the genus *Therodamas* is not a lernaeid and the morphology of the appendages is typical ergasilid. The striking modification of the cephalon with the necklike separation of the anterior cephalic appendages from the mouthparts certainly is unique to ergasilids and may in the future warrant separating this genus from other ergasilids at the subfamily level.

*Therodamas dawsoni* can be separated from the other two species by the following characters. In the new species the anterior portion of the head including the neck comprises only about one-fourth of the total

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←

FIGS. 1–5. *Therodamas dawsoni* new species, female: 1, ventral; 2, anterior portion of head, ventral; 3, genital segment and abdomen, ventral; 4, caudal ramus, ventral; 5, first antenna.

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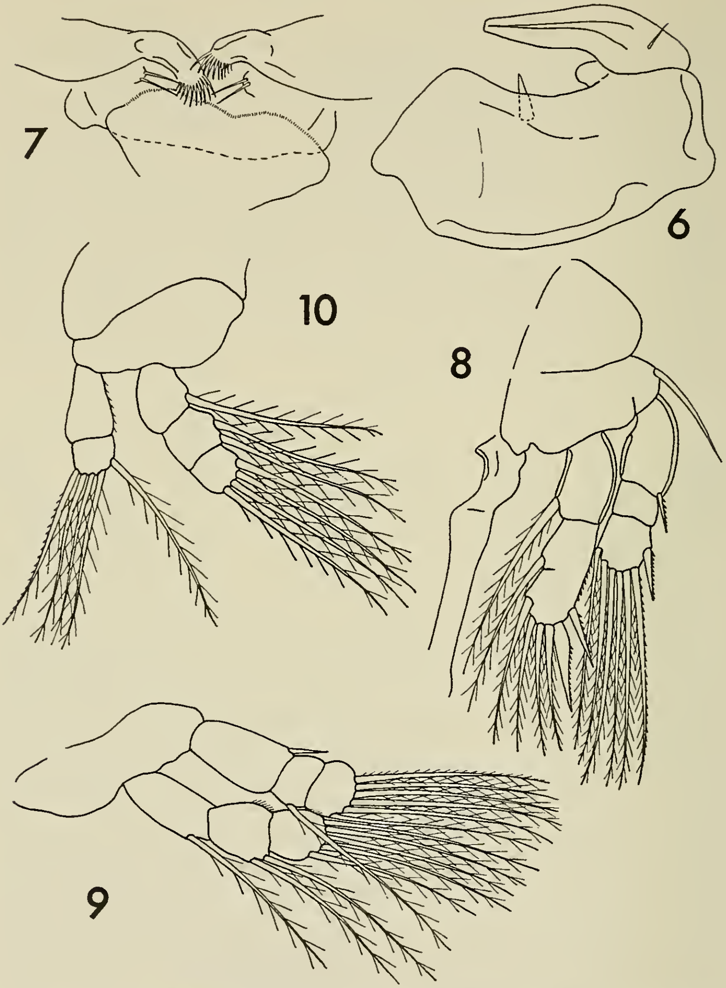

Figs. 6–10. *Therodamas dawsoni* new species, female: 6, second antenna; 7, oral; 8, leg 1; 9, leg 2; 10, leg 4.

body length. Even if not contracted I doubt that it would reach one-half of the body length as it does in the other two species. The spine and seta formula of the new species differs from the other two in that there are more setae present on the last ramal segment of the new species (Thomsen indicates that the legs of his new species are armed as in *T. serranus*). The egg sacs of *T. dawsoni* are equal to the total body length, whereas in *T. sphyricephalus* they are considerably shorter. I was advised by Mr. Dawson that over 2,000 specimens of the host fish were examined and only the single parasite found. This indicates either the copepod is very rare or that *D. thysannotus* is not the preferred host.

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Vol. 85, No. 21, pp. 271–278 30 August 1972

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# THREE NEW STOMATOPOD CRUSTACEANS OF THE FAMILY LYSIOSQUILLIDAE FROM THE EASTERN PACIFIC REGION

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The three new species described below include a new *Coronida* from Cocos Island and two new species of *Nannosquilla*; a key to the Eastern Pacific species of *Nannosquilla* is presented. The *Coronida* is of particular interest in that it represents an Indo-West Pacific element in the eastern Pacific stomatopod fauna.

All of the specimens reported below have been deposited in the Division of Crustacea, National Museum of Natural History, Smithsonian Institution (USNM).

Terms and measurements have been described in detail in an earlier paper (Manning, 1969). The illustrations are by my wife Lilly.

### **Coronida cocosiana** new species

Figure 1

*Holotype*: ♂, TL 20 mm; Cocos Island, Costa Rica; divers at anchorage; 26 April 1941; USNM 139518.

*Diagnosis*: Antennular peduncle more than two-thirds carapace length. Cornea (Figs. 1*a*, *b*) bilobed, set almost transversely on stalk. Ocular scales subquadrate, separate. Rostral plate (Fig. 1*a*) broader than long, rounded anteriorly. Antennal protopod with 1 ventral papilla. Dactylus of raptorial claw (Fig. 1*c*) with 4 teeth, outer margin of dactylus inflated basally. Mandibular palp and 5 epipods present. Anterior 4 abdominal somites unarmed, smooth. Posterior half of fifth abdominal somite covered with rounded tubercles; 3 sharp carinae, dorsalmost shortest, present laterally on fifth somite. Sixth abdominal somite (Fig. 1*e*) completely covered with raised, rounded tubercles, posterior margin with row of blunt spines; lateral margin of sixth somite forming entire carina terminating posteriorly in small spine. Telson (Fig. 1*e*)

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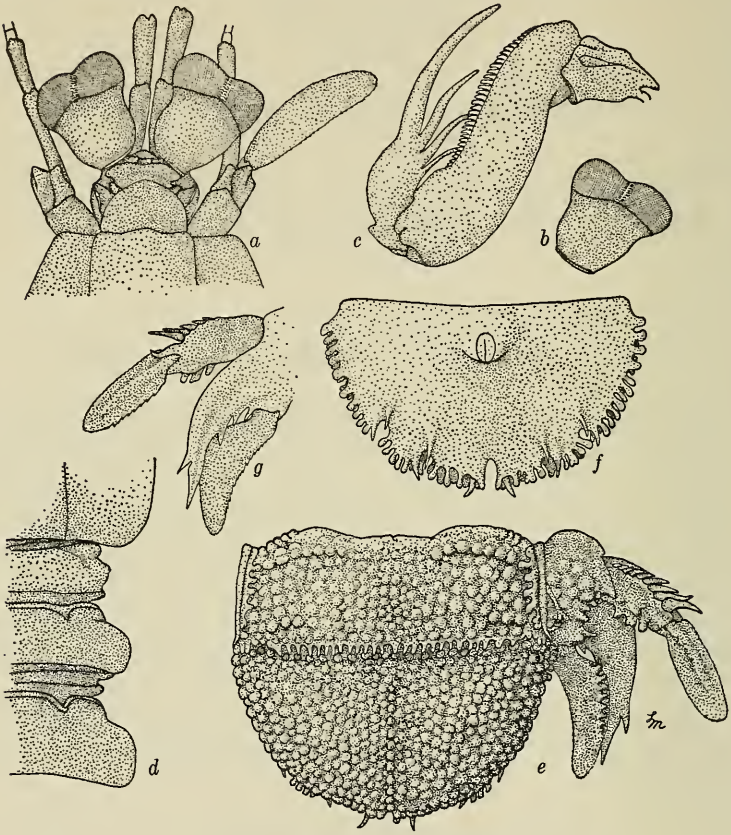

FIG. 1. *Coronida cocosiana* new species, male holotype, TL 20 mm: *a*, anterior portion of body; *b*, eye; *c*, carpus, propodus, and dactylus of raptorial claw; *d*, lateral processes of fifth, sixth, and seventh thoracic somites; *e*, sixth abdominal somite, telson, and uropod, dorsal view; *f*, telson, ventral view; *g*, uropod, ventral view. (Setae omitted.)

broader than long, broadly rounded posteriorly, surface covered with raised, rounded tubercles; posterior margin of telson with rounded projections and with 3 pairs of teeth, inner movable, lateral 2 pairs fixed, each flanked mesially by slender denticle; ventral surface of telson (Fig 1*f*) unarmed. Dorsal surface of uropod (Fig. 1*e*) irregularly tuberculate; proximal segment of exopod tuberculate dorsally, with 9 or 10 movable spines on outer margin and 4 stiff setae on inner distal margin, ventral surface with long, sinuous, sharp projection at articulation with distal segment; endopod with row of erect tubercles dorsally; basal prolongation

(Fig. 1*g*) with inner distal spine longer than outer, and with 3 smaller spines on inner margin.

*Measurements*: Male holotype, total length 20 mm. Other measurements, in mm: carapace length 3.7; cornea width 1.2; rostral plate length 0.7, width 1.0; fifth abdominal somite width 4.0; telson length 2.7, width 4.1.

*Remarks*: *Coronida cocosiana* resembles the Indo-West Pacific *C. trachura* (Von Martens, 1881) in basic facies, but differs from that species in several features. The rostral plate is rounded rather than angled anteriorly, the dorsal tubercles on the posterior two abdominal somites and telson are rounded rather than stellate, and the ventral surface of the telson is unarmed. The new species differs from *C. armata* (Leach, 1817) (see Holthuis, 1967, for synonymy), reported from the Galapagos Islands by Schmitt (1940) as *C. bradyi*, in having rounded rather than spinous projections on the posterior portion of the body, and the ventral surface of the telson is not ornamented with denticles as in *C. armata.*

*Coronida cocosiana* probably represents another Indo-West Pacific element in the Eastern Pacific stomatopod fauna—it clearly is more related to *C. trachura* than to the Eastern Atlantic-Eastern Pacific *C. armata.* This is the third stomatopod reported from the Eastern Pacific with Indo-West Pacific rather than Atlantic affinities; the other two species are *Pseudosquilla adiastalta* Manning, 1964 and *Lysiosquilla panamica* Manning, 1971.

*Etymology*: The specific name is derived from the type-locality.

### **Nannosquilla galapagensis** new species

Figure 2

*Holotype*: ♀, TL 22 mm; Black Beach Anchorage, Charles Island, Galapagos Islands; 15 fathoms; Fred E. Lewis, collector; 7 March 1938; USNM 139519.

*Paratypes*: 2♀, TL 21–23 mm; data as for holotype; USNM 139520.

*Diagnosis*: Cornea (Fig. 2*a*) subglobular, set slightly obliquely on stalk. Rostral plate (Fig. 2*a*) subquadrate, lateral margins convex, slightly divergent, anterior margins converging on obtusely pointed apex. Dactylus of raptorial claw with 13–15 teeth. Mandibular palp absent; 4 epipods present. Abdomen flattened, smooth, unarmed except for sharp posterolateral projections on sixth somite (Fig. 2*b*). Telson (Figs. 2*b*, *c*) broader than long, smooth dorsally, false eave with low, inconspicuous median and submedian projections, lateral teeth not visible in dorsal view; marginal armature of telson comprising, on each side of midline: 8 or 9 submedian denticles, 1 movable submedian tooth, and 4 and 5 fixed lateral denticles and teeth. Uropod (Figs. 2*b*, *d*) with 2 stiff setae on inner margin of proximal segment of exopod and 4 or 5 spines on outer margin; inner spine of basal prolongation of uropod much longer than outer.

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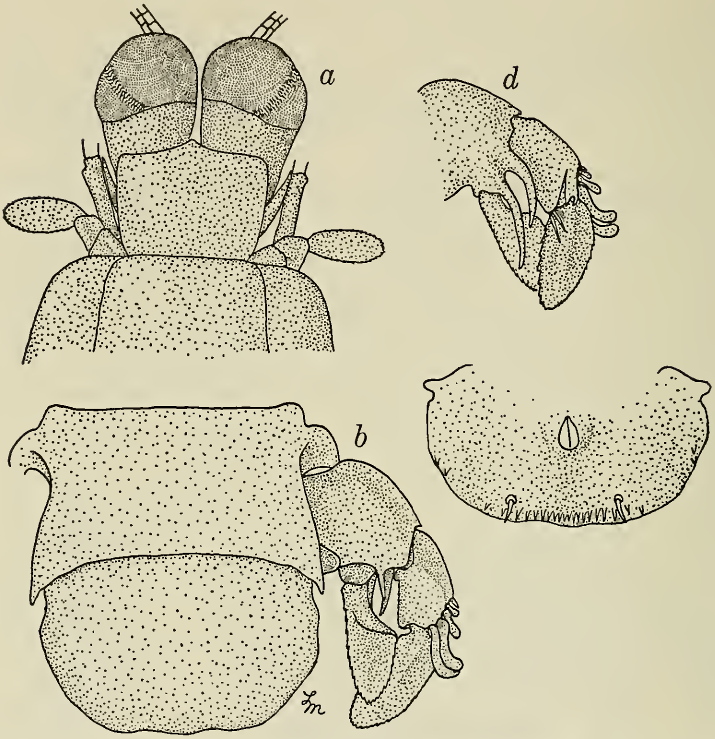

FIG. 2. *Nannosquilla galapagensis* new species, female holotype, TL 22 mm; *a*, anterior portion of body; *b*, sixth abdominal somite, telson, and uropod, dorsal view; *c*, telson, ventral view; *d*, uropod, ventral view. (Setae omitted.)

*Measurements*: Females only known, TL 21–23 mm. Other measurements, in mm, of female holotype: carapace length 3.1; cornea width 1.1; rostral plate length 1.1, width 1.4; fifth abdominal somite width 3.0; telson length 1.7, width 2.5.

*Remarks*: *Nannosquilla galapagensis* is very similar to *N. decemspinosa* (Rathbun, 1910), which is known from a few localities in the eastern Pacific between Costa Rica and Peru, but differs in having more teeth on the dactylus of the claw, 13–15 rather than 11, in having 4–5 rather than 3 fixed lateral denticles and teeth on the telson, and in having a minute lateral tooth on the telson which is not visible in dorsal view. The fixed lateral teeth and denticles in *N. galapagensis* are much smaller than those found in *N. decemspinosa.*

The Eastern Pacific species of *Nannosquilla* may be distinguished by using the key given below.

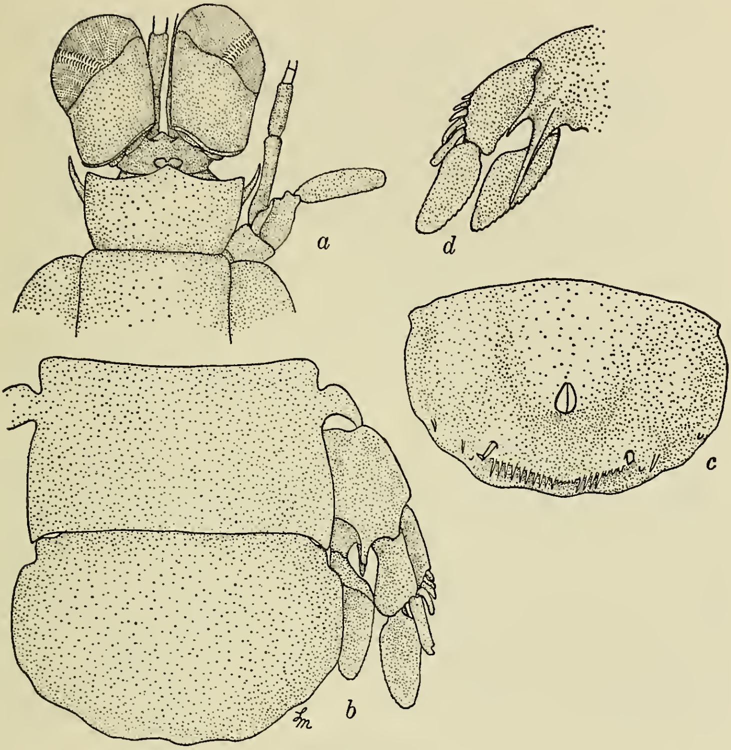

FIG. 3. *Nannosquilla similis* new species, female holotype, TL ca. 25 mm: *a*, anterior portion of body; *b*, sixth abdominal somite, telson, and uropod, dorsal view; *c*, telson, ventral view; *d*, uropod, ventral view. (Setae omitted.)

*Etymology*: The specific name is derived from the type-locality, the Galapagos Islands.

### **Nannosquilla similis** new species

Figure 3

*Holotype*: Broken ♀, TL about 25 mm; north end of Albemarle Island, Galapagos Islands (near Allan Hancock Foundation station 145-34, 6–7 fathoms); from stomach of sand bass, Manter no. G88; 12 January 1934; USNM 139521.

*Diagnosis*: Cornea (Fig. 3*a*) subglobular, set obliquely on stalk. Rostral plate (Fig. 3*a*) rectangular, width twice greatest length, rounded laterally, anterior margins bilaterally concave forming obtusely pointed median apex. Dactylus of raptorial claw with 17 teeth. Mandibular palp absent; 4 epipods present. Abdomen flattened, smooth, unarmed, posterolateral angles of sixth somite bluntly pointed (Fig. 3*b*). Telson (Figs. 3*b*, *c*) broader than long, smooth dorsally, false eave with low median projection, margins irregular, marginal teeth not visible in dorsal view; marginal armature of telson comprising, on each side of midline; 10 or 11 submedian denticles, 1 movable submedian tooth, and 3 small fixed lateral denticles, lateral teeth represented by obtuse lobes. Uropod (Figs. 3*b*, *d*) with 5 movable, spatulate spines on outer margin of proximal segment of exopod, stiff setae on inner margin not discernible; inner spine of basal prolongation of uropod much longer than outer.

*Measurements*: Female holotype, only known specimen, TL about 25 mm. Other measurements, in mm: carapace length 3.7; cornea width 1.4; rostral plate length 0.9, width 1.8; fifth abdominal somite width 4.1; telson length 2.3, width 3.6.

*Remarks*: *Nannosquilla similis* resembles *N. chilensis* (Dahl, 1954) and differs from the other species of the genus from the Eastern Pacific region in having a broad, rectangular rostral plate and in having 17 teeth on the dactylus of the raptorial claw. It differs from *N. chilensis* in having the inner spine of the basal prolongation of the uropod longer than the outer and in lacking posterolateral spines or sharp projections on the sixth abdominal somite. These species may be distinguished in the key to Eastern Pacific species given below.

*Etymology*: The specific name is from the Latin and alludes to the similarity of this species to *N. chilensis.*

## DISCUSSION

The two new species of *Nannosquilla* described here bring to six the number of species known from the Eastern Pacific region. All but one are tropical; *N. chilensis* is a south temperate species which has not been collected north of 40° South Latitude. The Eastern Pacific species may be distinguished by the following key.

1. Rostral plate subrectangular in shape, width about twice greatest length ........ 2
   Rostral plate subquadrate in shape, width and length subequal or width slightly greater ........ 3
2. Sixth abdominal somite with spinous posterolateral projections. Spines of basal prolongation of uropod subequal in length (Dactylus of raptorial claw with 12–17 teeth) ........ *N. chilensis* (Dahl, 1954); Chile.
   Sixth abdominal somite with bluntly pointed posterolateral projections. Inner spine of basal prolongation of uropod longer than outer (Dactylus of raptorial claw with 17 teeth) ........ *N. similis* new species.

3. Spines of basal prolongation of uropod subequal in length. False eave of telson with median and 6 pairs of lateral projections. (Dactylus of raptorial claw with 8 teeth) ........ N. *californiensis* (Manning, 1961); Gulf of California.
   Inner spine of basal prolongation longer than outer. False eave of telson with less than 6 pairs of lateral projections ........ 4
4. False eave of telson with median and 4 pairs of lateral projections. Posterolateral angles of sixth abdominal somite produced into long, slender spines (Dactylus of raptorial claw with 10–14 teeth) ........ N. *anomala* Manning, 1967; California.
   False eave of telson not markedly subdivided laterally (but small lateral tooth may be visible dorsally). Posterolateral angles of sixth abdominal somite not produced into long, slender spine ........ 5
5. Marginal armature of telson including 3 pairs of fixed teeth, or denticles, lateralmost visible in dorsal view. Dactylus of raptorial claw with 11 teeth ........ N. *decemspinosa* (Rathbun, 1910); Costa Rica and Peru.
   Marginal armature of telson including 4–5 pairs of fixed teeth or denticles, none visible in dorsal view. Dactylus of raptorial claw with 13–15 teeth ........ N. *galapagensis* new species.

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Vol. 85, No. 22, pp. 279–286 30 August 1972

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# DESCRIPTIONS OF FEMALES OF FOUR SPECIES OF *CHEUMATOPSYCHE* FROM THE SOUTHERN UNITED STATES (HYDROPSYCHIDAE, TRICHOPTERA)[1]

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Of the 34 species of *Cheumatopsyche* described from North America, only 19 of them have had the females associated with the males. Associated females for four additional species are described here. These females were collected during an ecological study of the Savannah River and were subsequently associated with the males.

All four of these females will key out at couplet 14 in Ross's (1944) key in The Caddis Flies or Trichoptera of Illinois. Diagnostic characters for separating these species from each other and/or from other closely related species are given at the end of each description. The length quoted in the descriptions is from the front margin of the head to the tip of the folded wings. Specimens drawn are deposited in the University of Georgia insect collection.

I thank Dr. J. B. Wallace, Mr. F. F. Sherberger and Mr. J. C. Morse for collecting much of the material, Dr. H. H. Ross for supervising the study and Mr. K. G. A. Hamilton for assisting with the illustrations.

### *Cheumatopsyche geora* Denning

Figures 1, 5

*Cheumatopsyche geora* Denning, 1948:400. Holotype: male from Georgia.

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[1] This research was supported by Grant No. 18050 from the Federal Water Quality Administration, U. S. Department of Interior.

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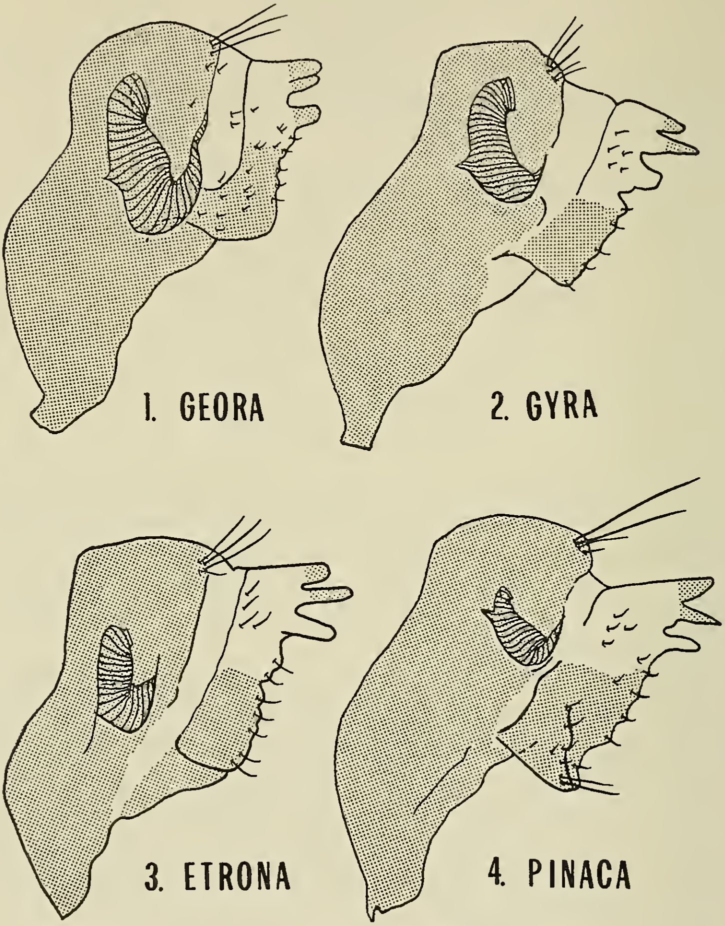

Figs. 1–4. Lateral aspect of the female genitalia of *Cheumatopsyche* species.

*Female:* Length 8.0 mm. Color and general appearance as for male except legs with femora yellowish brown, dark marks near base of femora; antennae uniformly brown with no dorsal V-markings.

Eighth tergum with ventroanterior corner triangular; secondary suture distinct for one-third of tergum, directed caudad; ventrocaudal angle broad, blunt; setae sparse; caudal margin shallowly concave. Pleurosternum with caudal end narrowed; setae sparse. Caudal margin of eighth sternum sinuate, slightly indented near posterocaudal corner, with numerous marginal and submarginal setae. Ninth and tenth terga as in Figures 1 and 5. Clasper receptacle of ninth tergum erect, large, about one-third as long as tergum; ventral margin forming large rounded lobe that extends below posteroventral corner of tergum; posterior corner upturned and extended dorsad as long tail, higher than anterior corner; sclerotized ridge may extend anteriad from anterior corner; posterior edge of receptacle bulging slightly at midpoint, extent of bulge variable; distal portion long, two-thirds as long as receptacle, tip angled slightly posteriad producing small hood which is angled slightly mesad and contains large inner opening. In dorsal view, receptacle about one-fourth as wide as tergum; distal portion a U-shaped projection directed dorsad; apical hood level, directed posteriad and slightly mesad; anterior corner continued anteriad as long tail. Posterior edge of outer opening U-shaped; inner opening at tip of receptacle, directed posteriad and slightly mesad; membranous incision at midline extending about one-half of length of sclerotized dorsum, parallel-sided. Processes of tenth tergum short, subequal in length; apices diverging greatly in dorsal view. Ninth sternal plate enlarged distally, covering most of lateral aspect of fused ninth and tenth sterna; tenth sternal plate blunt distally; ventral and dorsal margins appressed.

*Material examined*: Females were collected with numerous males at the following locations: SOUTH CAROLINA: MCCORMICK CO., Rocky Cr., 2 mi. NE McCormick, 2 May 1970, A. Gordon and F. Sherberger, 6M, 6F; OCONEE CO., Chauga R., Whetstone, 17 April 1969, J. Morse, 6M, 36F. An additional 88 specimens were examined from: GEORGIA: STEPHENS CO., Tugaloo R., Panther Cr.; HABERSHAM CO., Cascade Branch of Broad R. SOUTH CAROLINA: OCONEE CO., Little Longnose Cr.; MCCORMICK CO., Rocky Cr.

*C. geora* most closely resembles *C. gyra* and *C. oxa*. As do *C. gyra* and *C. oxa*, *C. geora* has a lateral invagination that is erect, large and that has a wide inner opening. However, *C. geora* can be distinguished from *C. gyra* by the inner opening lacking a flange, the bulging posterior wall of the receptacle and the ventral margin extending ventrad and posteriad to cover the posteroventral corner of the ninth segment. Although both *C. geora* and *C. oxa* have the ventral margin covering the posteroventral corner of the ninth segment, *C. geora* differs in the bulging posterior wall, rounded ventral margin and dorsal extension of the posterior corner of the ventral margin. In dorsal view, *C. geora*'s chimney is directed caudad and the lower portion of the pocket lacks the hooklike extension that is found in *C. oxa*.

## *Cheumatopsyche pinaca* Ross

Figures 4, 8

*Cheumatopsyche pinaca* Ross, 1941:82–83. Holotype: male from Georgia.

*Female*: Length 6.5 mm. Color and general appearance same as male except front wings may have definite clear areas in anal region.

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Ventroanterior corner of eighth tergum triangular; secondary suture extended caudad for one-fourth of tergum; ventrocaudal angle of eighth tergum moderately rounded, directed ventrad, setae sparse; caudal margin shallowly concave, coming to a small point at the midline. Caudal portion of pleurosternum expanded slightly, margin with few setae. Intersegmental membrane between tergum and pleurosternum produced into wide blunt lobe that is directed laterad and curved ventrad. Caudal margin of eighth sternum straight; at dorsocaudal angle, margin produced into thumblike lobe; setae sparse, more numerous at margin. Ninth and tenth terga as in Figures 4 and 8. Clasper receptacle small, one-sixth as long as tergum, situated near midpoint of tenth tergum; ventral margin produced as rounded lobe, anterior corner higher than posterior corner which curves dorsad as a tail. Distal portion of receptacle short, twisted mesad very slightly; tip produced posteriad forming short trumpet; inner opening directed dorsad and with edge produced as rim. In dorsal view, receptacle small, one-sixth as wide as tergum, angled towards meson; trumpet appears as small U-shaped projection with apical flange; remainder of distal portion narrow, necklike; anterior corner extended anteriad as a tail. Inner opening directed posteriad and slightly mesad; outer opening visible as three-quarters circle; membranous area broadly ovate. Posterior edge of tenth tergum notched widely just above caudoventral corner; middle processes longest, pointed apically; in dorsal view, dorsal processes with contiguous bases, diverging apices. Ninth and tenth sternal plates indistinct; ventral and dorsal margins appressed.

*Material examined*: Females were collected with numerous males at the following locations: GEORGIA: RABUN CO., Tallulah R., 11 August 1969, J. Wallace, 84 M, 258F; FRANKLIN CO., Nails Cr., 4 August 1969, A. Gordon and R. Woodall, 101M, 56F; MADISON-OGLETHORPE CO. LINES, Broad R., 5 August 1969, J. Wallace, 3M, 37F; RICHMOND CO., Savannah R., 3 October 1969, J. Wallace, 20M, 129F; EFFINGHAM CO., 15 May 1970, J. Wallace and F. Sherberger, 38M, 7F. SOUTH CAROLINA: OCONEE CO., Little R., 7 August 1969, J. Wallace and F. Sherberger, 5M, 13F; same except Yellow Branch, 7 August 1969, J. Wallace and F. Sherberger, 6M, 5F. An additional 321 specimens were examined from: GEORGIA: RABUN CO., Chattooga R., Becky Branch, Coleman R.; HABERSHAM CO., Panther Cr.; STEPHENS CO., Cool Springs, Panther Cr.; BURKE CO., Briar Cr. SOUTH CAROLINA: MCCORMICK CO., Rocky Cr.; ALLENDALE CO., Brier Cr. NORTH CAROLINA: MACON CO., Chattooga R., stream in Horsecove Valley; TRANSYLVANIA-JACKSON CO. LINES, Whitewater R.

*C. pinaca* most closely resembles *C. gyra*, but may be distinguished from this species by the small size of the invagination relative to the size of the ninth tergum, the small size of the chimney, the anterior corner lying slightly above the posterior corner, the slightly wider posterior corner of the ventral margin and the inner opening being small and directed more dorsad than caudad.

### *Cheumatopsyche etrona* Ross

Figures 3, 7

*Cheumatopsyche etrona* Ross, 1941:80–81. Holotype: male from Georgia.

*Female*: Length 5.5 mm. Color and general appearance same as male except tibiae and tarsi of hind legs may be yellowish brown; clear areas near base of front wings may be absent.

Ventroanterior corner of eighth tergum triangular, corner and secondary suture extended caudad for one-third of tergum; caudal margin shallowly concave; ventrocaudal angle rounded, directed caudad; setae on margin sparse. Dorsocaudal angle of pleurosternum truncate, directed dorsad; setae on caudal margin sparse. Eighth sternum with caudal margin broadly V-shaped; setae sparse. Ninth and tenth terga as in Figures 3 and 7. In lateral view, clasper receptacle moderately large, one-fourth as long as tergum, situated about middle of ninth tergum; ventral margin forming rounded lobe, anterior edge of lobe straight, angled dorsad to anterior corner; posterior corner curved upward, higher than anterior corner. Anterior edge of receptacle very straight, descending almost at a right angle from top and extending beyond ventral margin as sclerotized ridge delimiting clasper groove. Posterior edge with slight bulge at midpoint, extent of bulge variable. Distal portion twisted very slightly mesad and with dorsocaudal corner produced as rim around inner opening. In dorsal view, receptacle one-fourth as wide as tergum; outline somewhat ovate, shouldered distally, constricted proximally. Outer opening expanded distally, edges apparently merging with receptacle walls at proximal constriction; inner opening located distally and directed posteriad. Narrow membranous area at midline extended full length of tergum. Tenth tergum short; posterior edge notched at midpoint. Dorsal and ventral processes blunt; middle processes longest; dorsal processes contiguous in dorsal view. Ninth sternal plate expanded distally, occupying nearly entire lateral aspect of fused ninth and tenth sterna; tenth sternal plate acute distally.

*Material examined*: Females were collected with numerous males at the following locations: GEORGIA: RABUN CO., Chattooga R. at Georgia-South Carolina state lines on Ga. rt. 28, 7 June 1969, J. Wallace, 17M, 35F; same except on U.S. rt. 76, 11 August 1969, J. Wallace, 138M, 4200F; STEPHENS CO., Panther Cr. above Toccoa, 13 June 1969, J. Wallace, 46M, 59F; same except 10 July 1969, 221M, 117F. An additional 3,000 specimens were examined from: GEORGIA: RABUN CO., Tallulah R., Chattooga R.; HABERSHAM CO., Panther Cr.; STEPHENS CO., Tugaloo R., Panther Cr. SOUTH CAROLINA: OCONEE CO., E. Fork Chattooga R., Little R., Chauga R. NORTH CAROLINA: MACON CO., Chattooga R.

*C. etrona* is easily distinguished from the other three species by the central location and very straight anterior wall of the lateral invagination and the ventral margin extending below, but not covering, the posteroventral corner of the ninth segment and a very small flanged inner opening which is directed caudad. *C. etrona* may be confused with *C. speciosa* for both have erect and very straight-sided receptacles. However, unlike *C. speciosa*, *C. etrona* has the anterior corner extending below the posterior corner, the inner opening flanged and directed caudad, not mesad and, in dorsal view, the top of the chimney imparting a humpbacked appearance to the receptacle.

### *Cheumatopsyche gyra* Ross

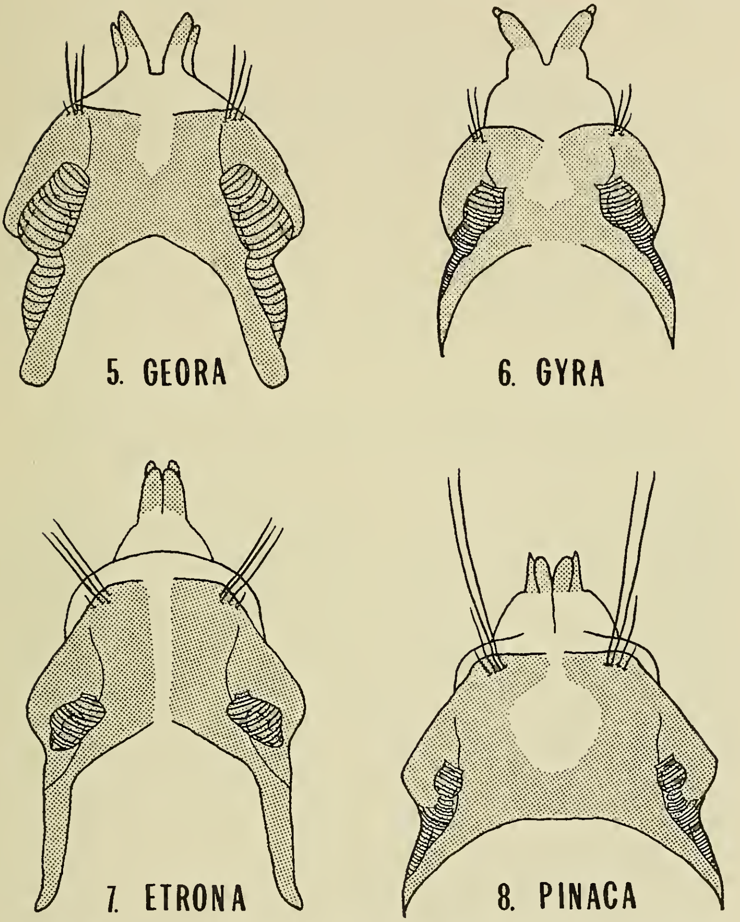
Figures 2, 6

*Cheumatopsyche gyra* Ross, 1938:154. Holotype: male from North Carolina.

*Female*: Length 7.0 mm. Color and general appearance same as male except basal four segments of antenna may be lighter with dorsal V-markings.

Eighth tergum with ventroanterior corner triangular; secondary suture extended caudad about one-third of tergum; caudal margin shallowly concave; ventrocaudal angle rounded; setae short, sparse. Pleurosternum narrowed caudally; setae sparse and short. Caudal margin of eighth sternum slightly convex with few scattered setae. Ninth and tenth terga as in Figures 2 and 6. Clasper receptacle erect, large, about one-third as long as ninth tergum; ventral margin forming large rounded lobe with posterior corner upturned and level with anterior corner; distal portion of receptacle long, one-half of receptacle length; tip produced posteriad as a hood and twisted slightly mesad; inner opening directed posteriad and with edge produced as rim. In dorsal view, clasper receptacle large, about one-third as wide as ninth tergum; angled towards meson; hood portion bulbous and with apical flange; anterior corner extended anteriad as long tail. Inner opening apical and directed posteriad; distal portion of outer opening visible as three-quarters circle in tip of receptacle; membranous area at midline bell-shaped. Posterior edge of tenth tergum acutely notched below ventral process; middle processes moderately acute and long; dorsal and ventral processes subequal in length, blunt. In dorsal view, dorsal processes separate at bases, apices widely diverging. Ninth sternal plate expanded distally, covering most of lateral aspect of fused ninth and tenth sterna; tenth sternal plate acute apically; ventral and dorsal margins appressed.

*Material examined*: Females were collected with males at the following locations: GEORGIA: RABUN CO., Chattooga R. at forest service road 646, 17 May 1969, J. Wallace, 4M, 3F; same except at S. C. rt. 28, 11 August 1969, J. Morse, mating pair. NORTH CAROLINA: TRANSYLVANIA-JACKSON CO. LINES, Whitewater R., 11 June 1969, J. Wallace and F. Sherberger, 1M, 5F. SOUTH CAROLINA: OCONEE CO., Chauga R., 14 August 1969, J. Wallace and T. Harris, 1M, 1F. An additional 100 specimens were examined from: GEORGIA: RABUN CO., Chattooga R.



5. GEORA

6. GYRA

7. ETRONA

8. PINACA

Figs. 5–8. Dorsal aspect of the female genitalia of *Cheumatopsyche* species.

South Carolina: oconee co., E. Fork Chattooga R. North Carolina: macon co., Chattooga R., Glen Falls.

*C. gyra* resembles *C. aphanta* very closely, but can be distinguished from this species by the ventral margin of the pocket not extending beyond the posteroventral corner of the ninth segment.

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Vol. 85, No. 23, pp. 287–296 30 August 1972

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# NATURAL HISTORY OF PLUMMERS ISLAND, MARYLAND[1]

## XXI. Infestation of the lichen *Parmelia baltimorensis* Gyel. & For. by *Hypogastrura packardi* Folsom (Collembola)

By Mason E. Hale, Jr.
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Lichens, long-lived symbiotic associations of lichenizable fungi and algae, appear to have effective means of resisting attacks by pathogenic microorganisms. This resistance has been attributed, at least in part, to the antibiotic activity of phenolic acids that are secreted extracellularly by many species. Snails and slugs, however, have often been seen feeding on and destroying lichen colonies (Coker, 1967; Peake & James, 1967). The paucity of reports in botanical literature on damage by insects, on the other hand, would seem to imply that lichens are relatively immune to these otherwise destructive pests. The best documented studies, as far as I have determined, are concerned with psocids (Broadhead & Thornton, 1955; Broadhead, 1958; Laundon, 1971) but mites have also been mentioned (Sowter, 1971).

I am now able to report a case history of infestation by an insect of *Parmelia baltimorensis* Gyel. & For. (a close segregate of the pan-temperate *P. caperata* (L.) Ach.), a very common foliose lichen on rocks at Plummers Island. Beginning in August 1970, I noted a small amount of frass on the surface of

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[1] The preceding number in this series was published as a Special Publication of the Washington Biologists' Field Club, 1968, 44 pp. Publication costs of the present number have been defrayed by the Washington Biologists' Field Club to promote its primary objective of research on the fauna and flora of Plummers Island and adjacent areas.

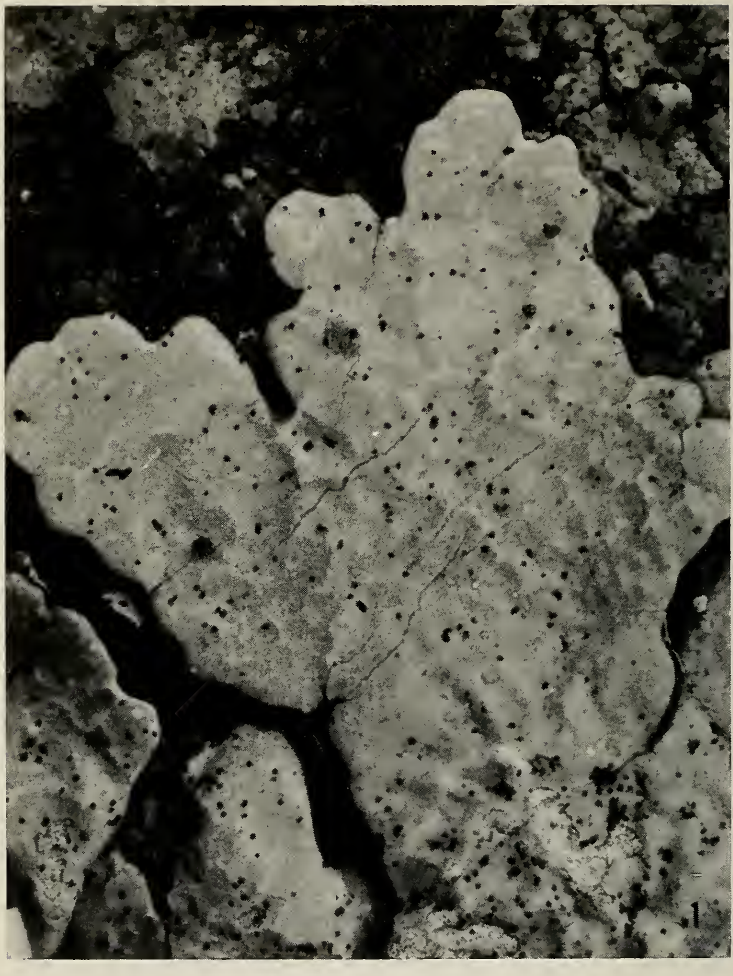

Fig. 1. Close-up of a single lobe of *Parmelia baltimorensis* taken on 13 September 1970, showing frass and initial stage of infestation. Scale as in Fig. 2.

colonies being photographed for growth studies (Hale, 1970) but not significantly more than had been observed in the past. Between late August and early November, however, the upper cortex and most of the algal layer of this species were chewed away completely on specimens covering the rocky

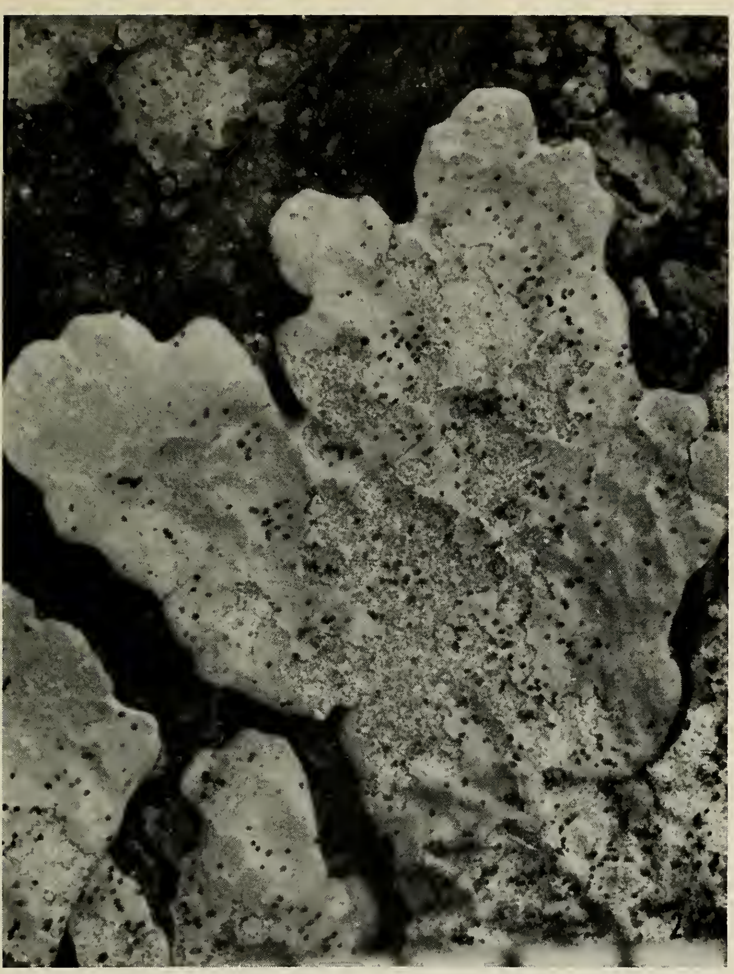

Fig. 2. Close-up of the lobe in Fig. 1 taken on 4 October 1970, showing cortical areas chewed away. Scale at bottom in mm.

ledges west of the cabin (Figs. 1–3). Damage was observed at some distance because the colonies turned dull whitish yellow in contrast to the normal darker greenish yellow.

A thorough inspection of the rocky areas in November showed that thousands of springtails were present just under the turf mat surrounding the lichen-covered rocks (Fig. 4).

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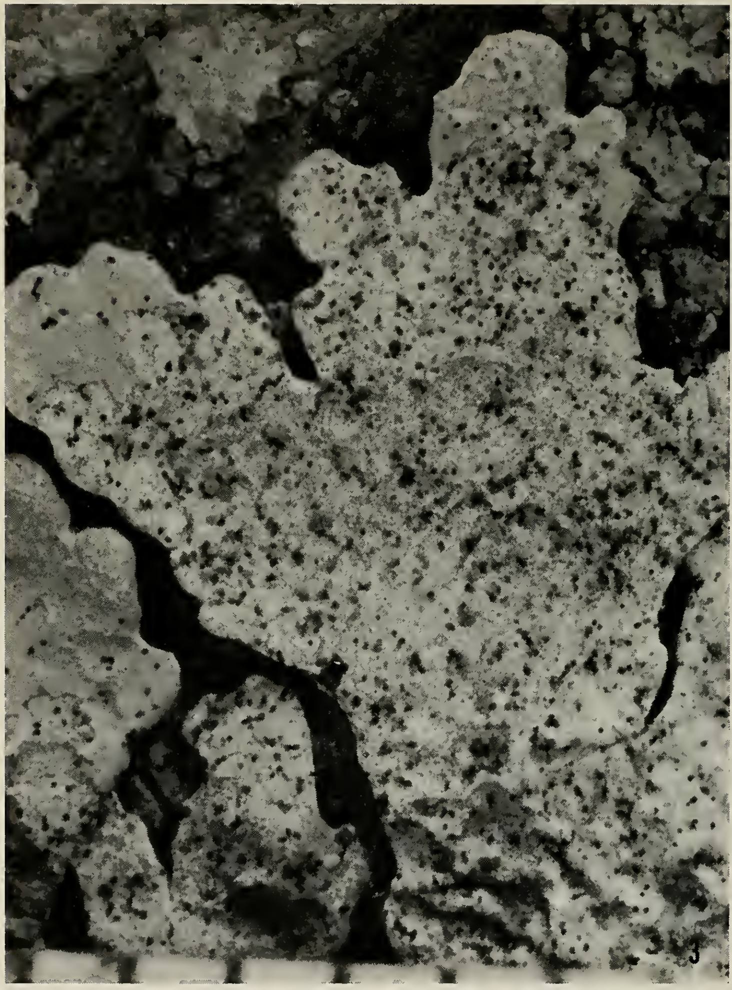


FIG. 3. Close-up of the lobe in Fig. 1 taken on 3 December 1970, showing the lobe surface destroyed except for small areas at the tips. Scale at bottom in mm.

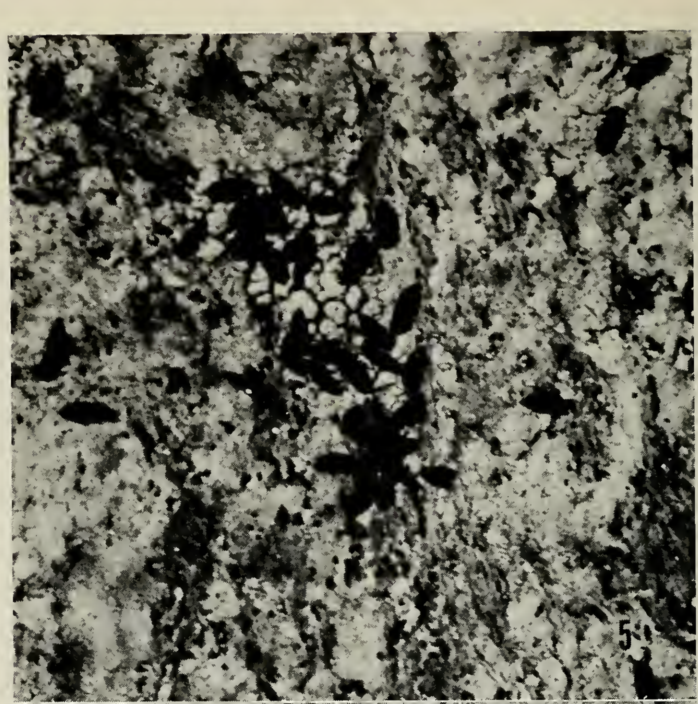
They were not seen feeding during the daytime in the fall but in the following spring (1971) they came out during the day (Figs. 5, 6). Living specimens were brought into the laboratory and reared by Dr. Dale Habeck. They fed on

FIG. 4. Turf mat bordering a rock outcrop covered with *Parmelia baltimorensis.*

lichen samples and produced frass identical to that on the lichens in nature, although the frass was so compact and thoroughly digested that no intact algae or hyphae were seen under a microscope. The insect was identified as *Hypogastrura packardi* Folsom, a species that appears to be widespread in eastern United States.

The springtails stopped active feeding by early November 1970 and the lichens were not attacked again during the winter. The insects overwinter in the turf mats bordering the rocks, but emerge on almost any day, even in January at temperatures near freezing. Additional minor damage was done in May 1971 (Fig. 6) but by June the springtails once again retreated to the turf mats and did not attack the plants during the second summer and fall.

The insects fed on the upper cortex and part of the algal layers, leaving the medulla largely untouched. Protocetraric acid, the main acid component of *P. baltimorensis*, occurs abundantly as crystals encrusting the medullary hyphae and may



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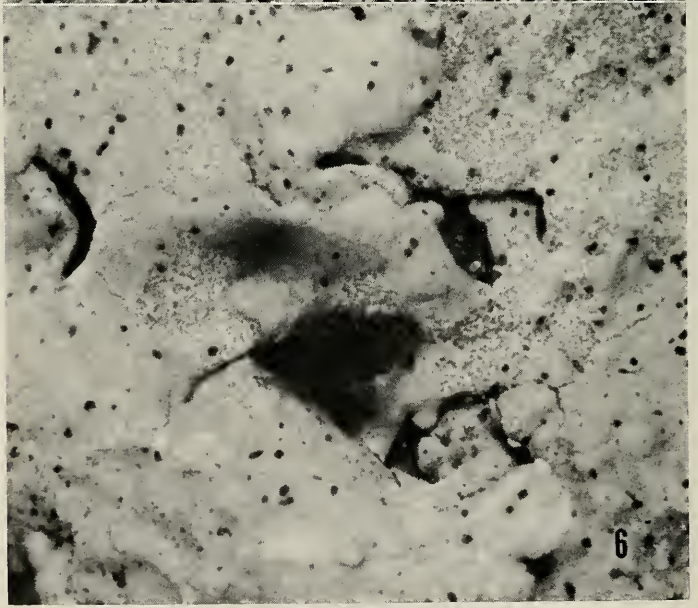

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have discouraged the springtails from eating more of the thallus. In any event large areas in the central part of the lichen colonies soon disintegrated and fell away (Fig. 7). Juvenile thalli disappeared over the winter. In all cases, a band along the lobe margins about 1 mm wide was left untouched. It is noteworthy that as long as the main thallus retained a foothold on the rock the lobe continued nearly normal growth through the summer of 1971. This is good evidence that lateral transport of nutrients across a thallus plays little if any role in lichen metabolism.

Thalli that survived the insect infestation and continued to grow also regenerated the cortical areas that had been chewed away by midsummer. I have no good photographs of this but these new surfaces, though quite rugose, were indistinguishable from unaffected surfaces. The total effect of the infestation, however, was a loss of at least 50% of the lichen colony area covering the rocks.

Why the springtails did such conspicuous damage to this lichen in the fall of 1970 is unknown. The same or nearby quadrats photographed continuously since 1965 had previously shown no comparable damage. The main weather correlation is the lack of rainfall from late August through October 1970. The summer of 1971 was exceptionally wet, and while springtails could be found in the turf mats, no infestation occurred during the wet period from May 1971 through December 1971.

I thank Dr. W. L. Culberson for lists of literature relating to destruction of lichens by animals and David L. Wray for identifying the collembolan.

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FIGS. 5 and 6. 5. Masses of springtails feeding on *Lecanora* sp. in May 1971 (about 10 ×). 6. Single individual of *Hypogastrura packardi* feeding on *Parmelia baltimorensis* (about 20 ×).

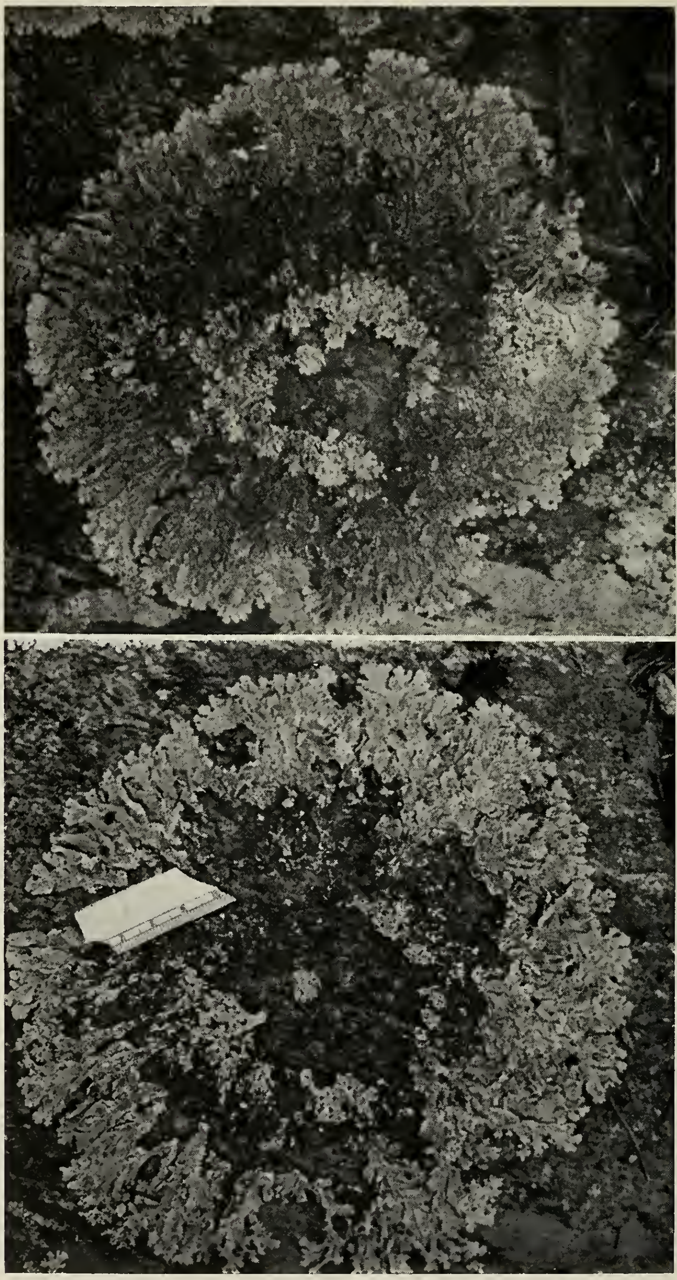

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Fig. 7. Changes in a colony of *Parmelia baltimorensis* over the period 4 October 1970 (top) to 1 May 1971 (bottom). Centimeter ruler in lower photograph.

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Vol. 85, No. 24, pp. 297–308 30 August 1972

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# NOTES ON SOME STOMATOPOD CRUSTACEANS FROM PERÚ

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In 1910, M. J. Rathbun recorded three species of stomatopods from Peruvian waters: *Cloridopsis dubia* (H. Milne-Edwards), *Pseudosquillopsis lessonii* (Guérin), and *Nannosquilla decemspinosa* (Rathbun). The same three species were reported by Schmitt (1940) in a detailed review of the Eastern Pacific stomatopods. More recently, marine investigations in Peruvian waters have shown that several other species also occur there. Two new species have been described from specimens taken off Perú (Manning, 1970) and additional records have been given by several authors (Del Solar, 1968, 1970; Del Solar and Alamo, 1970; Del Solar et al., 1970; Fonseca, 1970; and Del Solar and Mistakidis, 1971). In all, 13 species have been recorded from Perú.

Two other species are recorded below, one representing a new genus and species, based on material collected by Dr. Enrique M. Del Solar. In addition, the first postlarva of *Hemisquilla ensigera* is reported. I am indebted to Dr. Del Solar for making this material available for study.

I take this opportunity to correct the name of a species which I named in 1970 in honor of Dr. Del Solar, *Eurysquilla solari*. As Dr. Del Solar pointed out to me (in litt.), the specific name should be *delsolari* [EMENDATION].

Terms and measurements used in the descriptive accounts have been explained in detail in an earlier paper (Manning, 1969a). All of the material has been deposited in the Division of Crustacea, National Museum of Natural History, Smith-

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sonian Institution (USNM). The illustrations are by my wife Lilly.

### *Hemisquilla ensigera ensigera* (Owen, 1832)

Figure 1

*Hemisquilla stylifera*.—Schmitt, 1940, p. 182, figure 18a [other references].

*Hemisquilla ensigera*.—Manning, 1963a, p. 315.

*Hemisquilla ensigera ensigera*.—Stephenson, 1967, p. 16.—Del Solar et al., 1970, p. 36.—Fonseca, 1970, p. 79.—Del Solar, 1970, p. 47.

*Hemisquilla ensiger*.—Fonseca, 1970, p. 79, figure 193.

*Material*: 1♀ postlarva, TL 29.5 mm; Mancora Bank, Perú; 140 meters; trawl; 11 January 1971; E. M. Del Solar; USNM 139516.

*Diagnosis*: Cornea bilobed, smaller secondary lobe visible in dorsal view. Antennular peduncle ⅔ carapace length. Antennal scale ovate, more than half as long as carapace. Rostral plate triangular, length and width subequal, apex rounded. Carapace unarmed, lacking carinae; gastric grooves and lateral portions of cervical groove visible. Mandibular palp and 5 epipods present. Dactylus of raptorial claw slender, unarmed, external margin with strong proximal notch; superior margin of propodus tuberculate proximally, with 2 proximal spinules. Lateral processes of sixth and seventh thoracic somites rounded. Abdominal somites unarmed, not carinate dorsally; sixth somite with ventrolateral spine anterior to articulation of uropod. Telson with 3 longitudinal ridges on dorsal surface, median terminating in a blunt lobe, and 3 pairs of marginal teeth, submedians widely separate, with movable apices; denticles: 27 submedian, 2 intermediate (inner on rounded lobe), 1 lateral. Basal segment of uropod unarmed; proximal segment of exopod with 5 movable spines, distalmost extending about to midlength of distal segment; basal prolongation of uropod with stronger inner spine and broad, rounded lobe between spines.

*Color*: Completely faded.

*Measurements*: Only specimen examined, female postlarva, total length 29.5 mm; other measurements, in mm: carapace length ca 5.6; eye length 1.9; rostral plate length 2.8, width 2.7; fifth abdominal somite width 6.2; telson length 3.8, width 6.1.

*Remarks*: The postlarva of *H. e. ensigera* resembles adults in basic facies, but differs in having a bilobed eye, a more conspicuous lobe on the dactylus of the raptorial claw, lower dorsal carinae and numerous submedian denticles on the telson, a more prominent outer spine on the basal prolongation of the uropod, and in lacking a median keel on the eighth thoracic somite and longitudinal carinae on the sixth abdominal somite. In spite of these differences, the postlarva is clearly identifiable as that of a *Hemisquilla*.

There are numerous differences between the postlarva of *Hemisquilla*

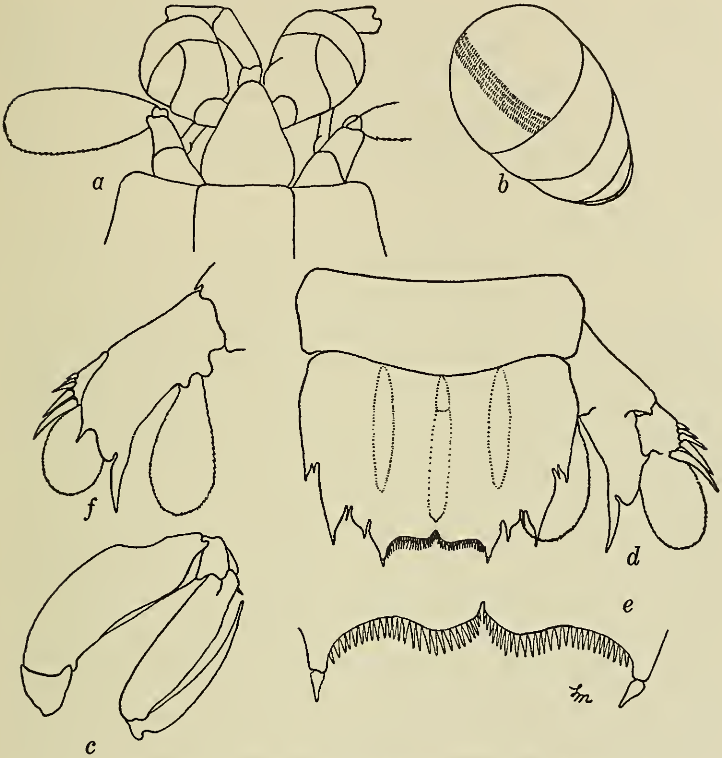

FIG. 1. *Hemisquilla ensigera ensigera* (Owen), female postlarva, TL 29.5 mm: *a*, anterior portion of body; *b*, eye, enlarged; *c*, raptorial claw; *d*, sixth abdominal somite, telson, and uropod; *e*, submedian margin of telson, enlarged; *f*, uropod, ventral view. (Setae omitted.)

and that of species in other genera in the Gonodactylidae such as *Parasquilla*, *Pseudosquilla*, and *Pseudosquillopsis*; as adults, representatives of these other genera also are large gonodactylids, although none attains the size of *Hemisquilla*, and as adults all have three teeth on the dactylus of the raptorial claw (Manning, 1963b). The postlarva of *Hemisquilla* differs from those of *Parasquilla* and *Pseudosquillopsis* in lacking teeth on the claw and in having only two spines rather than three on the basal prolongation of the uropod; the bilobed eyes of the postlarva of *Hemisquilla* are very different from the trilobed eyes found in representatives of the other two genera (Manning, 1969b). The postlarva of *Hemisquilla* differs from that of *Pseudosquilla* (see Bigelow, 1931) in that the shape of the rostral plate is triangular rather than cordiform or oval, there are no spines on the abdominal somites, and there is a large lobe

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between the spines of the basal prolongation of the uropod; the postlarvae of both of these genera lack teeth on the dactylus of the raptorial claw, although teeth are added subsequently in species of *Pseudosquilla*. The postlarvae of all four of these genera are of similar size, with a total length of less than 35 mm; the postlarvae of *Pseudosquilla ciliata* are usually under 24 mm in length and are smaller than those known for other species of *Pseudosquilla* as well as representatives of the other genera.

### **Schmittius** new genus

*Definition*: Eye large, cornea bilobed, wider than and set very obliquely on stalk. Ocular scales separate. Carinae of carapace reduced, median carina absent; anterolateral angles of carapace each with spine, posterolateral angles broadly rounded. Mandibular palp absent; 4 epipods present. Dactylus of raptorial claw with 4 teeth; superior margin of propodus of claw evenly pectinate. Lateral processes of fifth, sixth, and seventh thoracic somites single, process of fifth somite a flattened, anteriorly curved spine; fifth somite also with ventral spine on each side. Carinae of abdomen reduced, submedians absent on anterior 5 somites. Telson lacking supplementary dorsal ornamentation, submedian teeth with movable apices; prelateral lobes absent. Basal prolongation of uropod slender, elongate; inner margin crenulate.

*Type-species*: *Schmittius peruvianus* new species. Gender: Masculine.

*Discussion*: The genus *Schmittius* as defined here includes two species from the Eastern Pacific region, *Schmittius politus* (Bigelow, 1891) [NEW COMBINATION] and *S. peruvianus* new species; *S. politus* originally was described in *Squilla* but subsequently was transferred to *Meiosquilla* by me in 1968. A comparison of the species of *Schmittius* with species of *Meiosquilla* and *Squilloides* reveals that *Schmittius* more closely resembles the latter genus than the former. It seems likely that *Schmittius* represents an Indo-West Pacific element in the Eastern Pacific stomatopod fauna. *Schmittius* resembles *Meiosquilla* in several features: the retention of the movable submedian teeth of the telson, the suppression of body carination, the reduction in numbers of epipods and teeth on the raptorial claw, and in the absence of the mandibular palp. It differs from *Meiosquilla* and resembles *Squilloides* in having anterolateral spines on the carapace, in the shape of the lateral processes of the exposed thoracic somites, and in the structure of the basal prolongation of the uropod; most species of *Meiosquilla* have a broader basal prolongation of the uropod armed with spines or slender spinules on its inner margin. Comparative figures of the lateral processes of the exposed thoracic somites and the basal prolongations of the uropod for both species of *Schmittius* and *Squilloides leptosquilla* are shown in Figure 3.

*Etymology*: It is most appropriate to dedicate a genus of stomatopods from the Eastern Pacific region to Dr. Waldo L. Schmitt, Zoologist Emeritus in Crustacea at the National Museum of Natural History. Dr.

Schmitt's work on the stomatopods of the Eastern Pacific, published in 1940, provided a firm foundation for subsequent work on American stomatopods.

### **Schmittius peruvianus** new species

Figures 2, 3*c*, *f*

*Holotype*: 1♀, TL 60 mm; south of the Banco del Mancora, Perú; 350 meters; trawl; 2 January 1971; E. M. Del Solar; USNM 139514.

*Paratype*: 1♂, TL 33 mm; Banco de Mancora, Perú; 125 meters; trawl; November 1970; E. M. Del Solar; USNM 139515.

*Diagnosis*: Ocular scales subtruncate. Anterior margin of ophthalmic somite with median spinule. Rostral plate cordiform, slightly longer than broad, apex pointed. Carapace smooth, with spines at anterolateral angles, reflected marginal and lateral carinae present on posterior fourth. Dactylus of raptorial claw with 4 teeth, greatest depth of propodus near midlength; dorsal ridge of carpus of claw undivided, terminating in blunt lobe. Exposed thoracic somites lacking submedian carinae, prominent, unarmed intermediate carinae present on sixth, seventh, and eighth somites. Lateral process of fifth thoracic somite a broad, anteriorly curved lobe, apex sharp; fifth somite with sharp ventral spine below each lateral process. Lateral processes of sixth and seventh thoracic somites rounded. Ventral keel of eighth somite an erect, rounded lobe. Abdominal carinae spined as follows: submedian 6, intermediate 3–6, lateral 2–6, marginal 2–5. Telson with 3 pairs of long, slender marginal teeth, submedians with movable apices, intermediates longer than submedians; marginal carinae of telson extending to base of lateral teeth; denticles spiniform, 4, 11, 1 in holotype, 6–9, 10–11, 1 in smaller paratype; ventral surface of telson with long postanal keel. Uropod slender, proximal segment of exopod longer than distal, with 6–7 movable spines on outer margin, distalmost extending about to midlength of distal segment. Basal prolongation of uropod with small, rounded lobe on outer margin of spine, inner margin of prolongation crenulate, unarmed.

*Color*: Body covered with scattered light brown chromatophores. Anterior margins and gastric grooves of carapace dark. Posterior margin and intermediate carinae of posterior three thoracic somites dark. All six abdominal somites with dark posterior line; second abdominal somite with dark, rectangular median patch. Telson with large dark spot at posterior end of median carina, pits on dorsal surface dark. Proximal segment of uropodal exopod with broad, dark dorsal stripe, distal margin dark; distal segment dark, with light longitudinal stripe. Uropodal endopod outlined in dark pigment.

*Measurements*: Female holotype, total length 60 mm; male paratype, total length 33 mm. Other measurements, in mm, of holotype: carapace length 13.3; cornea width 3.3; rostral plate length 2.1, width 1.9; fifth abdominal somite width 12.7; telson length ca. 8.6, width 10.0.

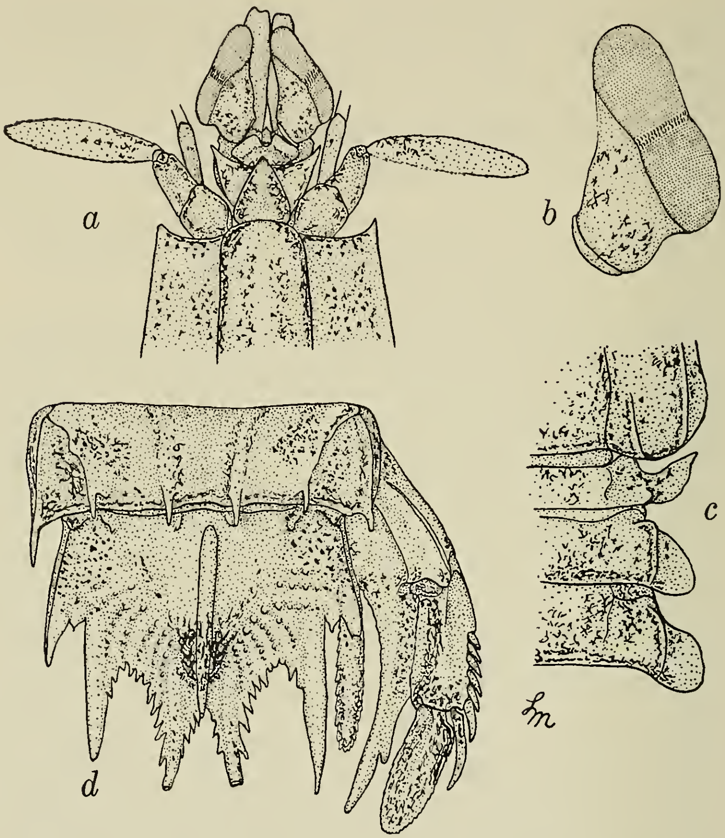

FIG. 2. *Schmittius peruvianus* new genus, new species, female holotype, TL 60 mm: *a*, anterior portion of body; *b*, eye; *c*, lateral processes of fifth, sixth, and seventh thoracic somites; *d*, sixth abdominal somite, telson, and uropod. (Setae omitted.)

*Remarks*: *Schmittius peruvianus* closely resembles its northern counterpart S. *politus* (Bigelow, 1891), but differs in having a slender eye, a more pointed apex on the rostral plate, the apex of the lateral process of the fifth thoracic somite pointed rather than rounded (Fig. 3*c*), both the lateral and marginal carinae of the second abdominal somite armed, a slenderer uropod, and a much smaller lobe on the basal prolongation of the uropod (Fig. 3*f*). In other respects the two species are very similar.

The male paratype is probably a juvenile; young specimens of squillids often have more submedian denticles than do adults.

FIG. 3. Lateral processes of fifth, sixth, and seventh thoracic somites and basal prolongation of uropod of: *a*, *d*, *Squilloides leptosquilla* (Brooks), female, TL 66 mm, Taiwan; *b*, *e*, *Schmittius politus* (Bigelow), female, TL 62 mm, California; *c*, *f*, *Schmittius peruvianus* new genus, new species, female holotype, TL 60 mm.

*Etymology*: The specific name is derived from the geographic area in which the species was discovered.

### *Squilla hancocki* Schmitt, 1940

*Squilla hancocki* Schmitt, 1940, p. 160, figure 10.—Manning, 1968, p. 129 [listed]; 1972, p. 102.

*Material*: 1 ♂, TL 61 mm; off Paita, Perú; 220 meters; trawl; 9 May 1969; Enrique M. Del Solar; USNM 139517.

*Remarks*: This specimen is in very poor condition and lacks the raptorial claws. It agrees very well with the original description of the species, differing only in that there are more submedian denticles, 12–14, rather than 7–10. The dark spots on the carapace and the second and fifth abdominal somites are present. Although it is as large as the holotype (TL 60 mm), the dorsal tubercles on the telson of this specimen are very poorly developed. Schmitt (1940) observed that these dorsal tubercles of the telson were poorly developed in the smaller specimens of the type-series.

*Distribution*: Eastern Pacific region, where it had been recorded from several localities off Mexico and Cape San Francisco, Ecuador, in depths to 73 meters. The present specimen extends the range southward to off Perú.

## DISCUSSION

In 1940 W. L. Schmitt recorded 29 species and subspecies of stomatopods from the Eastern Pacific region, of which as noted above, only three species were recorded from Perú. Since 1940, numerous additions have been made both to the Eastern Pacific fauna, which now includes 42 species, as well as to the Peruvian fauna, which now includes 15 species or 36% of the Eastern Pacific fauna. The majority of Peruvian stomatopods are tropical species—10 of the 15 species also occur at least as far north as Panamá. Four of the 15 species also occur in Chilean waters (Dahl, 1954), but only one of these, *Squilla aculeata aculeata* Bigelow, also occurs in the Panamic region. Only two of the species now known from Perú, *Eurysquilla delsolari* Manning and *Schmittius peruvianus*, described above, are endemic.

The Peruvian stomatopods may be distinguished by the following key.

## KEY TO STOMATOPOD CRUSTACEA FROM PERÚ

1. Telson lacking sharp median carina. Propodi of posterior 3 maxillipeds broad, beaded or ribbed ventrally (Family Lysiosquillidae) ........ 2

Telson with median carina. Propodi of posterior 3 maxillipeds slender, not beaded or ribbed ventrally ........ 4

2(1). Posterior armature of telson lacking movable submedian teeth. Posterior abdominal somites and telson with numerous dorsal spinules. Size moderate or large, adults 80 mm or more in length ........ *Lysiosquilla desaussurei* (Stimpson, 1857).

Posterior armature of telson with movable submedian teeth. Posterior abdominal somites and telson not spinulose dorsally ........ 3

3(2). Rostal plate longer than broad. Dactylus of raptorial claw with 17–20 teeth. Mandibular palp and 5 epipods present. Size moderate, adults not exceeding 100 mm in length ........ *Heterosquilla* (*Heterosquilla*) *polydactyla* (Von Martens, 1881).

Rostral plate broader than long. Dactylus of raptorial claw with 11 teeth. Mandibular palp absent, 4 epipods present. Size small, adults not exceeding 35 mm in length ........ *Nannosquilla decemspinosa* (Rathbun, 1910).

4(1). No more than 2 intermediate marginal denticles on telson (Family Gonodactylidae) .......... 5

Four or more intermediate marginal denticles on telson (Family Squillidae) .......... 8

5(4). Anterior 5 abdominal somites with longitudinal carinae. (Dactylus of claw with 3 teeth. Outer spine of basal prolongation of uropod the longest) .......... *Parasquilla* (*Parasquilla*) *similis* Manning, 1970.

Anterior 5 abdominal somites not carinate .......... 6

6(5). Sixth abdominal somite unarmed posteriorly. Dactylus of raptorial claw unarmed .......... *Hemisquilla ensigera ensigera* (Owen, 1832).

Sixth abdominal somite with spines on posterior margin. Dactylus of raptorial claw with teeth .......... 7

7(6). Inner spine of basal prolongation of uropod longer than outer. Dactylus of claw with 7 teeth .......... *Eurysquilla delsolari* Manning, 1970.

Outer spine of basal prolongation of uropod longer than inner. Dactylus of raptorial claw with 3 teeth .......... *Pseudosquillopsis lessonii* (Gúerin, 1830).

8(4). Submedian teeth of telson with movable apices. Median carinae of carapace, if present, lacking anterior bifurcation 9

Submedian teeth of telson with fixed apices. Median carina of carapace with anterior bifurcation. (Dactylus of claw with 6 teeth) .......... 10

9(8). Eyestalks dilated, eyes flask-shaped. No more than 3 epipods present. Dactylus of claw with 5–6 teeth .......... *Cloridopsis dubia* (H. Milne-Edwards, 1837).

Eyestalks not dilated, eyes T-shaped. 4 epipods present. Dactylus of claw with 4 teeth .......... *Schmittius peruvianus* new genus, new species.

10(8). Submedian carinae of anterior 5 abdominal somites unarmed 11

Submedian carinae of fifth and sixth abdominal somites with posterior spines .......... 13

11(10). Basal segment of raptorial claw with ventrally projecting spine. 4 epipods present .......... *Squilla aculeata aculeata* Bigelow, 1893.

Basal segment of raptorial claw unarmed. 5 epipods present 12

12(11). Median carina of carapace lacking anterior bifurcation. Rostral plate lacking median carina .......... *Squilla hancocki* Schmitt, 1940.

Median carina of carapace with anterior bifurcation. Rostral plate with median carina .......... *Squilla mantoidea* Bigelow, 1893.

13(10). Postanal keel of telson produced into spine .......... *Squilla biformis* Bigelow, 1891.

Postanal keel of telson unarmed .......... 14

14(13). Median carina of carapace lacking anterior bifurcation. Submedian carinae of fourth abdominal somite unarmed ........................................................ *Squilla parva* Bigelow, 1891.

Median carina of carapace with anterior bifurcation. Submedian carinae of fourth abdominal somite armed ........................................................ *Squilla panamensis* Bigelow, 1891.

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Vol. 85, No. 25, pp. 309–312 30 August 1972

PROCEEDINGS
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# ADDITIONS TO THE BIRDS RECORDED IN PANAMÁ

By Alexander Wetmore and Pedro Galindo
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*Balboa Heights, Canal Zone*

The two species listed, known previously from Chocó in northwestern Colombia, are now recorded in the Province of Darién as additions to the birds of the Republic of Panamá. The specimens are in the National Museum of Natural History, Smithsonian Institution.

### *Crypturellus kerriae* (Chapman)

### Chocó Tinamou

*Crypturus kerriae* Chapman, Bull. Amer. Mus. Nat. Hist., vol. 34, 30 December 1915, p. 636. (Baudó, Chocó, Colombia.)

The first record for Panamá is an adult female, collected by Galindo, 21 February 1970, at 760 meters elevation on the Darién side of Cerro Quia, near the trail leading down to the Río Mono. An adult male was taken March 13. The species was fairly common on the steep slopes of the higher ridges, down to about 460 meters, with a few noted as low as 300 meters. Though their low, tremulous, single-noted whistles, repeated constantly at two- or three-second intervals, were heard regularly, the birds were shy and were seen only occasionally, usually as they rose in rapid flight. All observed were in adult plumage. In this stage they appear dark, somewhat reddish brown, blacker on the crown and upper neck, and paler on the lower breast. The throat is white; the abdomen pale, faintly barred with dusky, with these markings

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somewhat heavier on the under tail coverts. Measurements in millimeters are as follows: Male, wing 167.0, tail 29.6, culmen from base 29.6, tarsus 51.2; female, wing 160.0, tail 42.5, culmen from base 27.4, tarsus 49.5.

The two in hand in general are like an adult male in the Academy of Natural Sciences in Philadelphia, collected by K. von Sneidern, 8 July 1940, at 460 meters in the Baudó range, above the Río Baudó, Chocó, Colombia. The type of the species, in the American Museum of Natural History, taken by Mrs. E. L. Kerr (for whom the species is named), is obviously a juvenile bird, and quite different in general appearance, as the back is heavily barred with cinnamon-buff. The two from Quia are similar to the adult male from the Baudó area, differing only slightly in minor details. The throat is whiter, the breast slightly paler, and the wings and wing coverts are faintly and finely spotted with cinnamon-buff and black. Birds from the two areas are so similar that there is no doubt as to their relationship as a species. If the slight differences noted hold when series are available, possibly those specimens from Darién may warrant recognition as a subspecies.

### *Cyanerpes caeruleus chocoanus* Hellmayr

### Purple Honeycreeper

*Cyanerpes caerulea chocoana* Hellmayr, Arch. f. Naturg., ser. A, vol. 85, pt. 10, 1920, p. 14, footnote 2. ("São Joaquim del Chocó" = San Joaquin, Valle, Colombia.)

This race of the Purple Honeycreeper, a species distributed widely in northern South America, including the island of Trinidad, comes barely within the southeastern border of Darién. From 1 to 17 April 1947, Wetmore found them fairly common in the forests of the upper Río Jaqué, near the mouth of its tributary the Río Imamadó, and beyond on the lower slopes of the hills of Los Peñitas. Often they were hidden from sight, as they ranged in the high tree crown among the abundant epiphytes covering the larger limbs. At that period in April all seen were in adult plumage, apparently with the breeding season near at hand. In 1971, Galindo found this race on the slopes of Cerro Quia above the Río Mono, a tributary of the Río Tuira near its source. He collected a male on 23 February and a female on 15 March 1971.

The race in Colombia is recorded in Chocó from the Darién boundary southwest of the Western Andes to Western Ecuador. In life, compared to the abundant Shining Honeycreeper, *Cyanerpes lucidus isthmicus*, in Panamá, the male Purple Honeycreeper is darker blue, with the tarsus and toes primuline yellow, a duller, more buffy shade than the lighter yellow of the other bird. The female Purple Honeycreeper has the dark streaking on the breast distinctly green, instead of the blue of these markings in that sex of the other species.

The work of Galindo was supported in part by Grant AI-02984 from the National Institute of Allergy and Infectious Diseases.

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Vol. 85, No. 26, pp. 313–316 30 August 1972

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# *CYPRETTA KAWATAI*, A NEW SPECIES OF FRESHWATER OSTRACODA (CRUSTACEA)[1]

By I. G. Sohn and L. S. Kornicker
*U.S. Geological Survey, Washington, D.C. 20242 and*
*Smithsonian Institution, Washington, D.C. 20560*

We have described laboratory experiments demonstrating that the new species *Cypretta kawatai* is an effective predator of *Biomphalaria glabrata* (Say, 1818) a vector snail of the blood fluke that causes schistosomiasis (Sohn and Kornicker, 1972). In that paper we used the name as a deliberate nomen nudum; this name is validated here.

### Family Cyprididae Baird, 1845

### Genus *Cypretta* Vávra, 1895

*Cypridopsis* (*Cypretta*) *tenuicauda* Vávra, 1895, Jahrb. Hamburg. Wiss. Anst., Beih., Jahrg. 12, p. 7, figs. 2, 1–3. Zanzibar. (Type-species by monotypy.)

### **Cypretta kawatai** Sohn and Kornicker, new species

Figures 1–3

*Etymology*: In honor of Dr. K. Kawata, The Johns Hopkins University.

*Holotype*: Adult female, USNM 139850. Length 0.75 mm, height 0.49 mm.

*Paratypes*: USNM 139851. Length 0.70 mm, height 0.42 mm, width 0.43 mm; 140953–140962, 140964–140993.

*Material*: Several hundred specimens in all stages of growth.

*Type-locality*: Aquaria in The Johns Hopkins University, Baltimore, Maryland.

*Habitat*: Presumed to be freshwater ponds and ditches in Belo Horizonte, Brazil (see Sohn and Kornicker, 1972, p. 1259).

*Diagnosis*: Differs from *C. globula* (Sars, 1889) in the carapace hav-

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

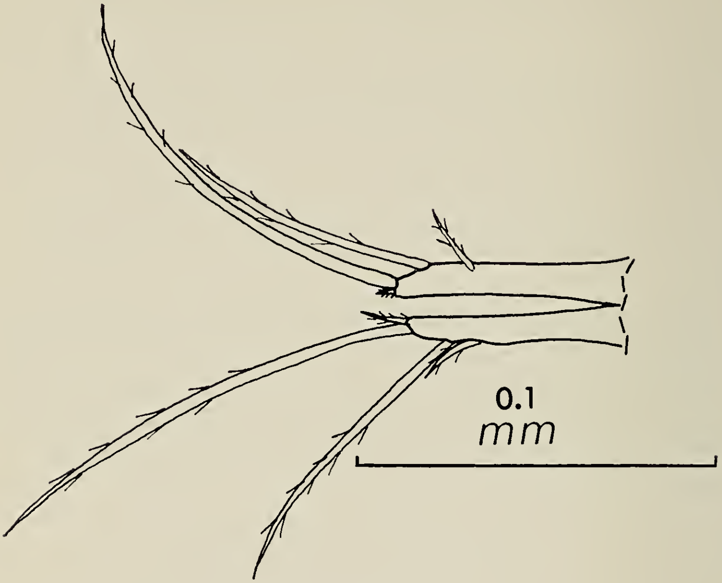
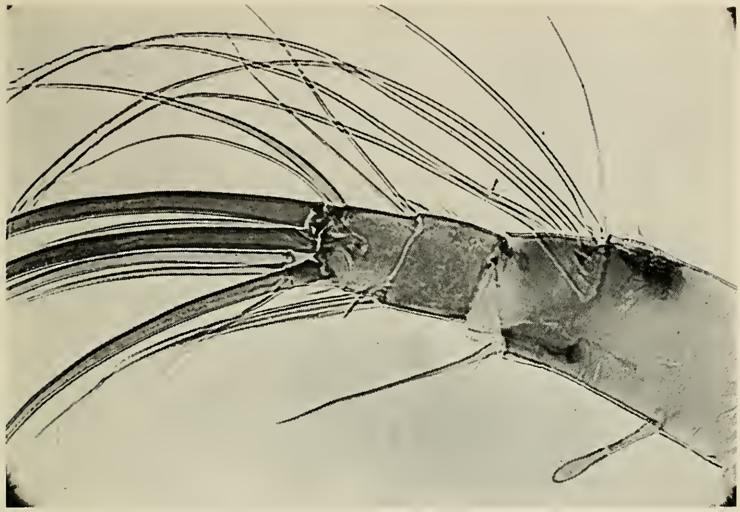


FIG. 1. *Cypretta kawatai* new species, furca, adult female, holotype.

ing more pointed ends in dorsal outline, and in that the dorsal seta of the furca is short, less than one-fourth the length of the adjacent claw; from *C. globulosa* (Sharpe, 1910) in that the length of the "sense club" of the second antenna is between 0.040 mm to 0.048 mm in our species, whereas in Sharpe's species it is 0.052 mm. Males unknown.

A detailed description of the species is in preparation. The above diagnosis validates the taxon in accordance with the Rules in I. C. Z. N. (Stoll et al., 1964).



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FIGS. 2–3. *Cypretta kawatai* new species: 2. left second antenna showing "sense club", approx. 360 ×, holotype; 3. carapace of adult female, paratype, dorsal view, anterior to left, approx. 125 ×. The specimen was treated with Clorox to remove the surface hair.

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Vol. 85, No. 27, pp. 317–322 30 December 1972

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# COPEPODA PARASITIC ON AUSTRALIAN FISHES, XI. *IMPEXUS HAMONDI* NEW GENUS, NEW SPECIES WITH A KEY TO THE GENERA OF LERNAEOCERIDAE

By Z. Kabata
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The parasitic copepods belonging to the family Lernaeoceridae, commonly found on fishes in many parts of the world's oceans, are conspicuously scarce in Australian waters. The author's collection contains no representatives of this family. Apparently, the only records of the lernaeocerids from Australia are those made by Heegaard (1962). He recorded *Lernaeenicus hemirhamphi* Kirtisinghe, 1933, from the eye of *Hemirhamphus intermedius* taken in St. Vincent Gulf, South Australia, and *Lernaeolophus sultanus* Heller, 1865, from the lower lip of *Tetraodon* sp. taken off Lord Howe Island, to the east of New South Wales.

It is, therefore, with great interest that the author examined a small lernaeocerid sent to him from New South Wales by Dr. Richard Hamond. The parasite was attached to the left flank of *Parvicrepis parvipinnis*, the anterior end of its trunk partially covered by the pelvic fin of the host (Fig. 1). The host was only 19.4 mm long and the dissection of the parasite, deeply embedded in its visceral cavity, proved extremely difficult. It was not accomplished without severing the parasite's trunk from its anterior part at the point of its penetration of the body wall.

Establishment of a new taxon on a single, damaged specimen is not to be undertaken lightly. In this instance, however, the parasite clearly belonged to none of the known genera of

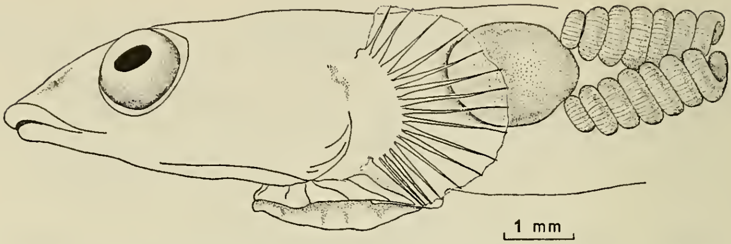


FIG. 1. Anterior part of *Parvicrepis parvipinnis,* showing trunk of *Impexus hamondi* protruding from its left flank.

Lernaeoceridae. It became necessary to erect a new genus to accommodate it in the family, to which it indubitably belongs. The small size and the fragility of the specimen made the description and even finding of the appendages impossible. The diagnosis, therefore, was based entirely on the distinctive gross morphology of the parasite.

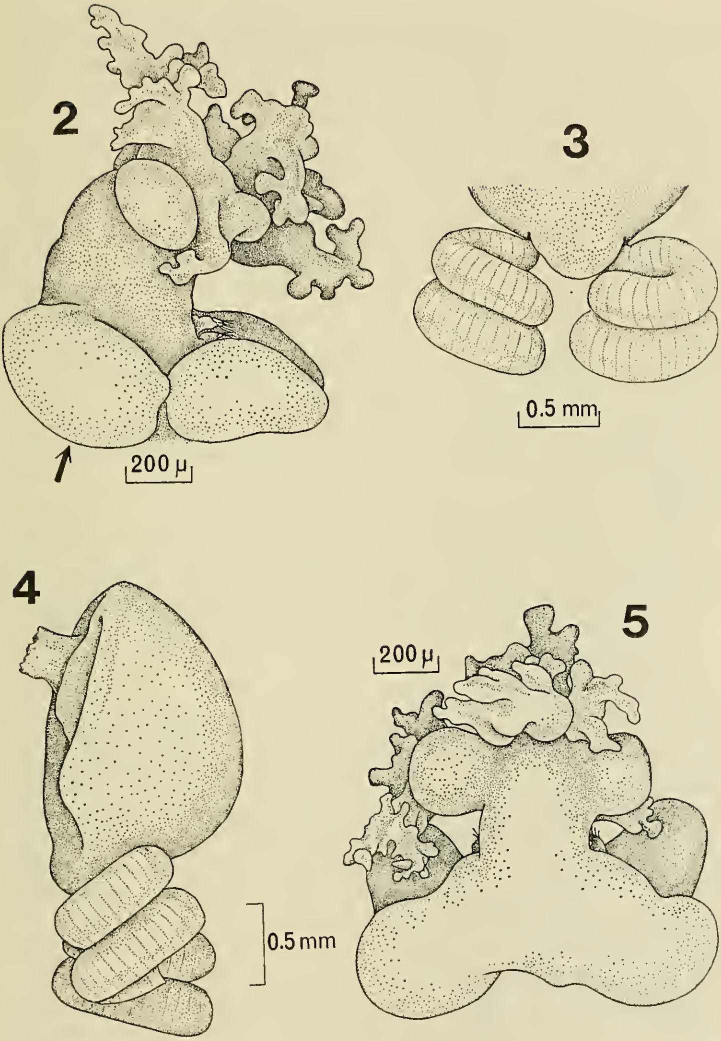
### **Impexus hamondi** new genus, new species

*Host*: *Parvicrepis parvipinnis* (Waite, 1906)

*Habitat*: Embedded in visceral cavity, trunk protruding from left flank of host.

*Locality*: Low water mark in the surf zone, on the northeast corner of the Long Reef, Collaroy (north of Sydney), New South Wales. Taken by Dr. R. Hamond on 25 August 1968. The specimen becomes the holotype of the species and is deposited in the National Museum of Natural Sciences, Ottawa, Cat. No. NMC 15315.

*Description of female*: The main feature of the cephalothorax (Figs. 2 and 5) is the presence of three pairs of ovoid tubercles. Four of them are of about the same size and are arranged at the same level, one pair being the dorsolateral and the other ventrolateral outgrowths of the cephalothorax. (The only appendages observed, a pair of thoracopods, is located immediately distal to the ventrolateral tubercles (Fig. 2)). Distal to the two pairs of tubercles is a short, cylindrical, necklike tube, connecting them with the third pair of tubercles, clearly seen in Figures 2 and 5. Directly in front of the anterior pair of tubercles the cephalothorax breaks up into numerous processes, branching in an irregular and complicated manner and forming a formidable holdfast. These processes are covered over and bound together by the connective tissue capsule produced by the host and are virtually impossible to dissect out. Parts of the holdfast were broken off in the course of dissection, particularly on the right side of the parasite (as can be seen in Figure 5).



FIGS. 2–5. *Impexus hamondi* new species. 2. Cephalothorax, lateral (arrow points to location of severed neck); 3. Posterior extremity, dorsal; 4. Trunk, lateral; 5. Cephalothorax, dorsal.

The mouth and the buccal appendages are present on the ventral surface of the cephalothorax at the level of the anterior pair of tubercles. The region is densely surrounded by the branches of the holdfast and cannot be explored without complete destruction of the specimen. The number of pairs of thoracopods was also impossible to determine.

The four posterior tubercles and the trunk are linked by a short, cylindrical neck, about as long as that linking the anterior and posterior tubercles and about a half of its diameter. It is this part (Fig. 4) that was severed during dissection. The position of the neck on the trunk is subterminal and the neck itself is at almost right angles to the long axis of the trunk. The trunk (Figs. 3 and 4) is oval in dorsal aspect. Its dorsum is convex and the ventral surface almost flat (Fig. 4). The posterior extremity (Fig. 3) is rounded and protrudes slightly beyond the points of attachment of the egg-sacs. No caudal furca was observed. There are also no processes or outgrowths on the trunk.

The egg-sacs are tightly coiled. In the specimen examined each egg-sac had seven coils, the left sac coiling clockwise and the right anticlockwise.

The dimensions of the specimen are as follows:

| | |
|---|---|
| Cephalothorax length | 0.90 mm |
| Cephalothorax width at level of anterior tubercles | 0.78 mm |
| Cephalothorax width at level of posterior tubercles | 1.00 mm |
| Trunk length | 1.96 mm |
| Trunk width | 1.52 mm |
| Distance of neck from anterior margin of trunk | 0.50 mm |

*Discussion*: The generic affinity of a lernaeocerid species can usually be determined by three characters: the shape of the body (distinction being made between trunks of sigmoid and cylindrical shapes); presence or absence of profusely branching holdfast and the nature of the egg-sacs. There are three types of egg-sacs in the family Lernaeoceridae: simple, long and straight sacs (e.g. in *Lernaeenicus*), sacs looped irregularly around a central axial rod, to which they are held by a mesenterylike membrane (e.g. *Lernaeocera*) and coiled sacs (e.g. in *Haemobaphes*). Different combinations of these three characters occur in each genus, but within the generic boundaries these combinations are constant.

It appeared to the author that the best way to determine the generic affiliation of the examined lernaeocerid was a key, based on the above three characters (with addition of others, if necessary). Such key would allow the identification of all known lernaeocerid genera (with the exception of *Thanatodectes* Leigh-Sharpe, based on a single, decapitated specimen). The key is given below.

## KEY TO GENERA OF LERNAEOCERIDAE

| | | |
|---|---|---|
| 1. | Body sigmoid | 2 |
| | Body not sigmoid | 6 |

2. Egg-sacs spirally coiled ........ 3
Egg-sacs coiled round axial rod ........ *Lernaeocera*
3. Posterior part of body covered with brushlike outgrowths ........ *Lernaeolophus*
Posterior part of body without brushlike outgrowths ........ 4
4. Neck long, with lateral outgrowths ........ *Haemobaphes*
Neck long, without outgrowths ........ 5
5. First three pairs of thoracopods biramous, fourth uniramous ........ *Trifur*
All four pairs of legs uniramous ........ *Allotrifur*
6. Egg-sacs spirally coiled ........ 7
Egg-sacs long and straight ........ 9
7. Body cylindrical, neck in line with trunk ........ 8
Body ovoid, with flat ventral and convex dorsal surfaces, neck at an angle with trunk, subterminal ........ *Impexus*
8. Neck smooth, or with one or two pairs of lateral processes; branching horns at anterior end of cephalothorax ........ *Phrixocephalus*
Anterior half of neck covered by branching outgrowths; cephalothorax ellipsoidal, with two pairs of lobes ........ *Creopelates*
9. Body very long, cylindrical, with brushlike outgrowths at posterior extremity ........ *Pennella*
Body with two long posterior processes ........ *Peniculisa*
Body cylindrical, without any outgrowths or processes ........ 10
10. Mouth and buccal appendages at tip of proboscis longer than rest of body ........ *Ophiolernaea*
Mouth at tip of short proboscis, or without proboscis ........ 11
11. Neck at about ⅓ of trunk length, at angle with trunk ........ *Peroderma*
Neck terminal, in line with long axis of trunk ........ 12
12. Cephalothorax oval, usually without processes, sometimes with two lateral, short, branching processes ........ *Peniculus*
Cephalothorax anteriorly with a tuft of finely branched processes in one, sometimes two groups ........ *Cardiodectes*
Cephalothorax without anterior tuft of processes ........ 13
13. Body narrowing anteriorly to form neck of more or less uniform diameter ........ *Lernaeenicus*
Diameter of neck narrowest at its midlength, expanding both posteriorly and anteriorly ........ *Sarcotretes*

The above key points to the necessity of isolating the specimen examined by the author in a separate genus, to which the name *Impexus* was given. The genera which resemble *Impexus* most closely are *Phrixocephalus* Wilson and *Creopelates* Shiino. In addition to differences enumerated in the key under numbers 7 and 8, *Impexus* differs from *Phrixocephalus* in the level of cephalothorax which produces the profusely branching holdfast. In *Impexus* this holdfast constitutes the most anterior part of the body; in *Phrixocephalus* it is posterior to the cephalic lobes (see

Kabata, 1967). In *Impexus*, therefore, it is the preoral segments and in *Phrixocephalus* postoral segments that are responsible for the formation of the holdfast. The differences between *Impexus* and *Creopelatus* are manifest in the nature of their holdfasts. The holdfast of *Creopelatus* is distributed around the neck, which it surrounds with short, bushy outgrowths. The anterior end of the cephalothorax, the "head," is an oval structure provided with two pairs of irregular lobes.

*Impexus* is, then, clearly distinguishable from all other genera with coiled egg-sacs. It should be mentioned, however, that the description of *Cardiodectes rotundicaudatus* by Izawa (1970) makes the matter more complicated by introducing some possibility of affinities between *Impexus* and species with noncoiled egg-sacs. Izawa's species, in all other respects identifiable as *Cardiodectes* with the aid of the key proposed above, differs from its congeners in the possession of coiled egg-sacs. The coils are not a typical tight spiral but are loose and have relatively large diameter. To the author's knowledge, this species constitutes the only exception to the rule that the members of the same lernaeocerid genus always have the same type of egg-sac. *Impexus hamondi* can be distinguished from all the species of *Cardiodectes* by the shape of its trunk (always cylindrical in *Cardiodectes* and with terminal neck). The author believes that it should be recognized as a distinct genus. The matter, however, should be kept in mind in further studies of Lernaeoceridae.

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Vol. 85, No. 28, pp. 323–352 30 December 1972

PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

# THE SYSTEMATICS OF SOME NEW WORLD MURICID SPECIES (MOLLUSCA, GASTROPODA), WITH DESCRIPTIONS OF TWO NEW GENERA AND TWO NEW SPECIES

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Intensive examination of material in the preparation of a guide to the species and genera of the Muricidae of the world, has led to a number of interesting revelations. Among these has been a better understanding of the relationship of several small, non-spinose forms most frequently assigned to the genus *Morula* Schumacher, 1817. This genus has been one of the more notorius catchall groups. Many otherwise unaffiliated species with non-varicate shells and denticulate apertures have been placed here. This has been done seemingly without regard to the restrictions implied by the choice of type-species.

The following abbreviations indicate the sources of the specimens we examined and cite in this study. SDSNH—San Diego Society of Natural History (Natural History Museum, San Diego, California); LACM—Los Angeles County Museum of Natural History; USNM—United States National Museum (National Museum of Natural History, Washington, D.C.).

## Family Thaididae

### Subfamily Drupinae

### *Morula* Schumacher, 1817

*Morula* Schumacher, 1817, p. 68: type-species: *Morula papillosa* Schumacher, 1817 (= *Drupa uva* Röding, 1798), by monotypy.

*Diagnosis*: Shell moderately small (20–25 mm), thick, broadly subfusiform; spire high and acute; aperture weakly sinuous and generally constricted by several prominent labial denticles; columella with a prominent medial, oblique fold; radula roughly similar to that of *Drupa* but with the base of the rachidian tooth modified and with denticles on the rachidian in a level, transverse line rather than an oblique orientation as in *Drupa*; operculum similar to that of *Drupa*. Protoconch two-whorled.

### *Morula uva* (Röding, 1798)

Figure 1K

*Drupa uva* Röding, 1798, p. 56, no. 703.
*Ricinula aspera* Lamarck, 1816, pl. 395, figs. 4a, 4b.
*Ricinula nodus* Lamarck, 1816, pl. 395, figs. 6a, 6b.
*Morula papillosa* Schumacher, 1817, p. 277.
*Ricinula morus* Lamarck, 1822, vol. 7, p. 232.
*Purpura sphaeridea* Duclos, 1832, vol. 26, p. 7, pls. 2, fig. 10.
*Ricinula alba* Mörch, 1852, p. 87.

*Distribution:* Generally throughout the Indo-West Pacific; no type-locality has ever been designated.

The shell is moderately small (maximum length—27 mm) and stoutly sub-fusiform. The spire is high and acute, consisting of five weakly shouldered postnuclear whorls and a protoconch of approximately two whorls. The sutures are well impressed, although this feature is not as well marked on the upper spire whorls. The body whorl is large and broadly fusoid. The aperture is narrow and irregular; with a narrow,

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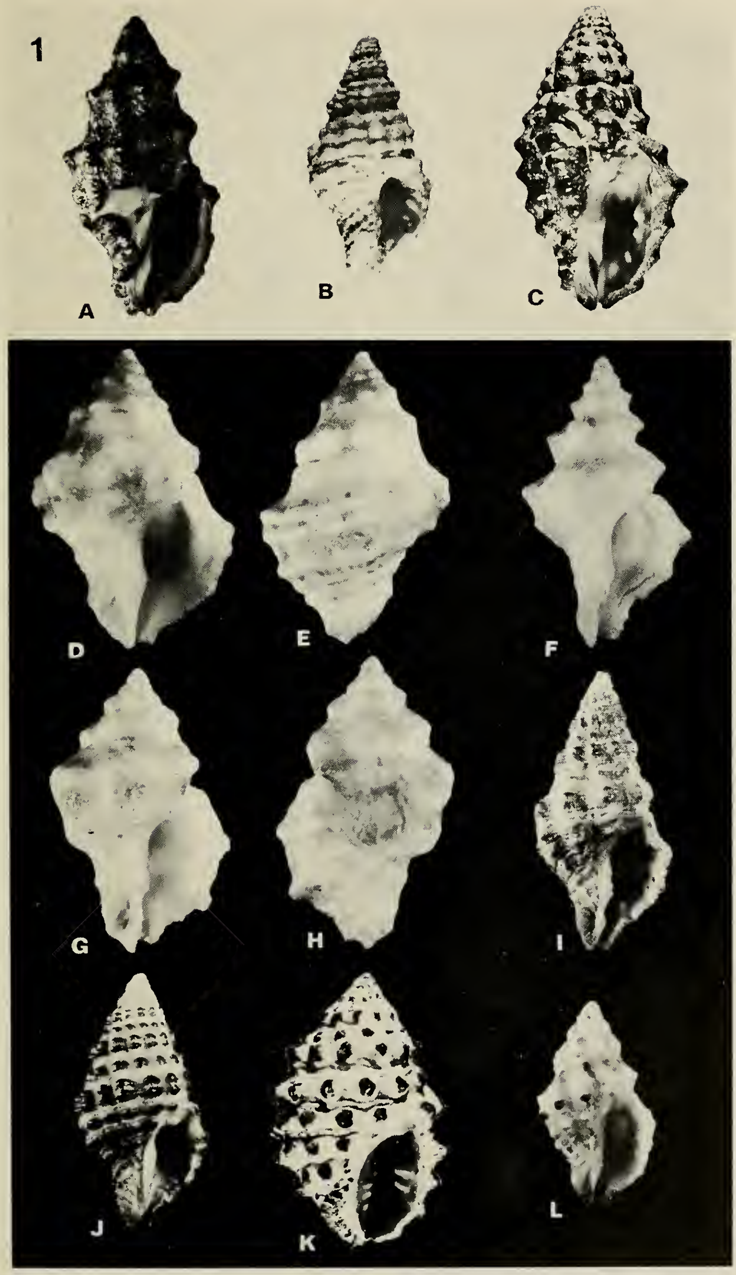
FIG. 1 (A–L). *Evokesia ferruginosa* (Reeve, 1856). SDSNH 44183, Pond Island, Baja California, Mexico. (4×). B. *Trachypollia sclera* Woodring, 1928. (paratype), USNM 135520, Loc. 2580, Bowden, Jamaica (Miocene). (10×). C. *Trachypollia nodulosa* (C. B. Adams, 1845). A. D'Attilio Coll., Ilha Grande, Brazil. (5×). D. *Bizetiella shaskyi* sp. nov. (holotype), SDSNH 56119, one mile south of Puerto Balleta, Maria Madre Island, Tres Marias Islands, Nayarit, Mexico. (9.5×). E. *B. shaskyi* sp. nov., data same as above, dorsal view. (9.5×). F. *Bizetiella carmen* (Lowe, 1935). (paratype), SDSNH 44717, off Carmen Island, Baja California, Mexico. (10×). G. *Bizetiella micaela* sp. nov. (holotype), SDSNH 56118, Bahia Coastocomate, Jalisco, Mexico (10×). H. *B. micaela* sp. nov., data same as above, dorsal view. (10×). I. *Trachypollia lugubris* (C. B. Adams, 1852). SDSNH 32985, Cedros Island, Baja California, Mexico. (6.5×). J. *Trachypollia didyma* (Schwengel, 1943). A. D'Attilio Coll., off Palm Beach, Florida. (7×). K. *Morula uva* (Röding, 1798). SDSNH 56269, West side of Oeno Island, Tuamotu Archipelago. (3.5×). L. *Evokesia rufonotata* (Carpenter, 1864). LACM 68-41, South side of Bahia Coastocomate, Jalisco, Mexico. (6.5×).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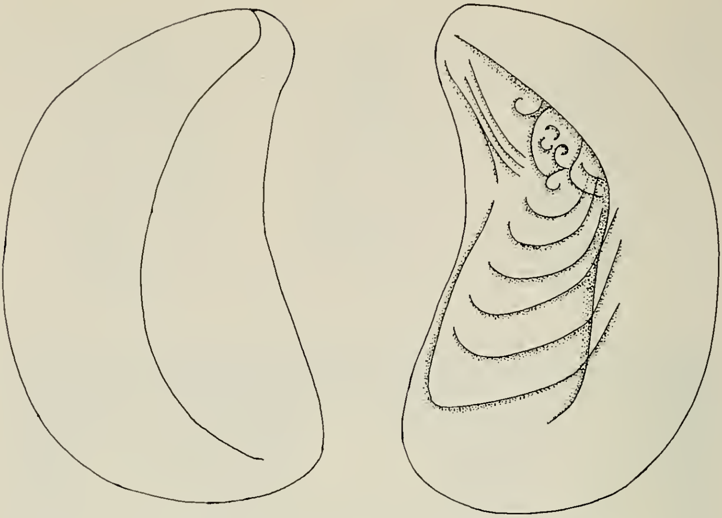

FIG. 2. *Morula uva*: operculum—left, interior; right, exterior.

deep anal sulcus. The outer apertural lip is non-erect and strongly denticulate on its inner surface. Just above the middle of the lip on this surface five tubercles are apparent. The uppermost one is largest, the next one somewhat smaller, followed by three smaller equal-sized ones. The inner lip is adherent above, barely detached and non-erect below. The anterior half of the inner lip bears two to four weak nodules. Medially on the inner lip and recessed more deeply into the aperture, a single weak to moderately strong, transverse to weakly oblique fold is apparent. The siphonal canal is short, generally straight and moderately broadly open.

The shell is essentially non-varicate. Axial sculpture consists of nine low costae, prominently nodulose or prickly over the major spiral elements. Spiral sculpture consists of major and minor cords. One or two minor cords on the shoulder are followed at the shoulder margin by a major cord. Below this two minor cords separate the shoulder margin cord from the next major cord. Each of the remaining four major cords is separated from its neighbor by a single minor cord. The canal bears two minor cords. Shell color is yellowish white with some to all of the nodules colored brownish black. The aperture is lavender when the lip is mature.

The operculum is small, opaque, black and kidney shaped. This shape is apparently related to the narrow, emarginate aperture.

The radula is small and unusually short compared to that of other muricine, ocenebrine, and thaidid species examined. In addition to the

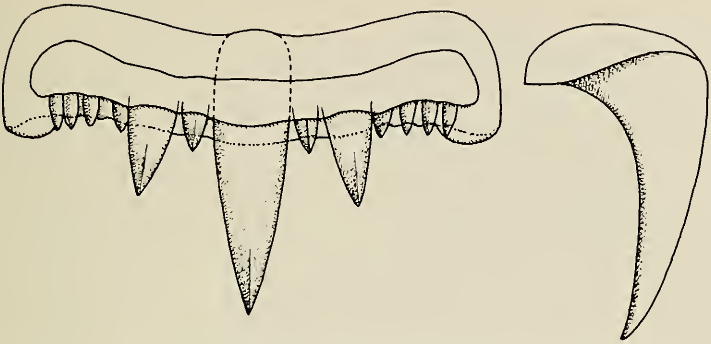

FIG. 3. *M. uva*: two-thirds of a transverse row of radular teeth.

small size of the teeth themselves, the brevity of the radula is attributable to a smaller number of tooth-rows than is typical for the family. Whereas most muricid radulae have 250–400 transverse rows of teeth, the present one had no more than 150 rows, including nascent (incompletely formed) teeth at the newest end of the ribbon.

The lateral teeth, one flanking the rachidian (central) tooth on each side, are unexceptional, save for their small size. The rachidian is generally muricoid but differs from rachidians in other groups in details of morphology. The base of the tooth is quite broad and, although possessing considerable thickness, does not show the cowl-like structure bearing the central cusp, as shown in ocenebrine and muricopsine species (Radwin & D'Attilio, 1972). The ends of the tooth-base are blunt and knoblike, lacking the single or double points found elsewhere in the family. The central cusp is very long and pointed but does not project appreciably beyond the lateral cusps. The lateral cusps are somewhat set in from the ends of the base. Between each lateral and the central cusp a single, very small, independent, intermediate cusp is evident. Immediately outside of each lateral cusp is a series of four small, equal-sized, independent denticles, each one not much smaller than the intermediate cusps. These denticles are in a straight, transverse orientation, not in an arching, oblique line as in most ocenebrine species. Of the several Indo-Pacific moruloid species whose radulae we have examined and those that have been figured in the literature (Arakawa, 1962, 1964, 1965; Wu, 1965, 1968), the only species clearly resembling this one in the details of its radular dentition is *Morula porphyrostoma* (Reeve, 1846). Other species may also belong here but those species having closely similar shells but widely divergent radulae indicate the complex and probably polyphyletic composition of *Morula* as presently understood. As Indo-Pacific species with similar shells are found to be dissimilar in other ways, we have begun to study all "moruloid" species, regardless of region, for their true affinities.

With respect to the above, Emerson and Hertlein (1964) have preceded us in proposing the muricid subgenus *Morula* (*Morunella*) (type-species: *Buccinum lugubris* C. B. Adams, 1852). *Morunella* is predated by *Trachypollia* Woodring (1928), a fossil genus which was placed in the Nassariidae. The first two authors included, in addition to the type-species, a western Atlantic species, *T. didyma* (Schwengel, 1943). We are adding another Recent species, *T. nodulosa* (C. B. Adams, 1850).

## Family Muricidae

### Subfamily Ocenebrinae

### *Trachypollia* Woodring, 1928

*Trachypollia* Woodring, 1928, p. 268; type-species, *T. sclera* Woodring, 1928, by original designation.

*Morula* (*Morunella*) Emerson & Hertlein, 1964, p. 361, type-species *Buccinum lugubris* C. B. Adams, 1852, p. 293.

*Diagnosis*: Shell small (12–20 mm), moderately thick, fusiform to sub-fusiform and non-varicate; spire high and acute; aperture ovate or sub-ovate and generally not strongly constricted; outer apertural lip generally thin, exceptionally, moderately thickened; inner lip denticulate but lacking a fold; sculpture finely to coarsely nodulose; radular dentition ocenebrine, with lower corners of rectangular base of rachidian tooth bearing points, denticles in oblique orientation; operculum ocenebrine, protoconch consisting of three and one-half convex, papillose whorls.

In addition to the type-species and the Recent species treated below, one other extinct fossil species has been reported. *Drupa* (*Morula*) *gilbertharrisi* Weisbord, 1962 appears, from the figure, to most closely resemble *T. lugubris*, although certain details of sculpture, proportion, and size serve to separate these two species.

### *Trachypollia lugubris* (C. B. Adams, 1852)

Figure 1I

*Buccinum lugubre* C. B. Adams, 1852, vol. 5, p. 293.

*Latirus lugubris* (Adams) Pilsbry & Lowe, 1932, vol. 83, p. 114.

*Cantharus lugubris* (Adams) T. Burch, 1940, vol. 54, p. 47, pls. 2, figs. 5–7.

*Drupa lugubris* (Adams) T. Burch, 1942, no. 17, p. 7.

*Morula lugubris* (Adams) Keen, 1958, p. 376, fig. 412.

*Morula* (*Morunella*) *lugubris* (Adams) Emerson & Hertlein, 1964, vol. 13, no. 17, p. 361.

*Distribution:* Redondo Beach and San Diego, California to Panama. The type-locality of *T. lugubris* is "Panama (City) and Taboga Island

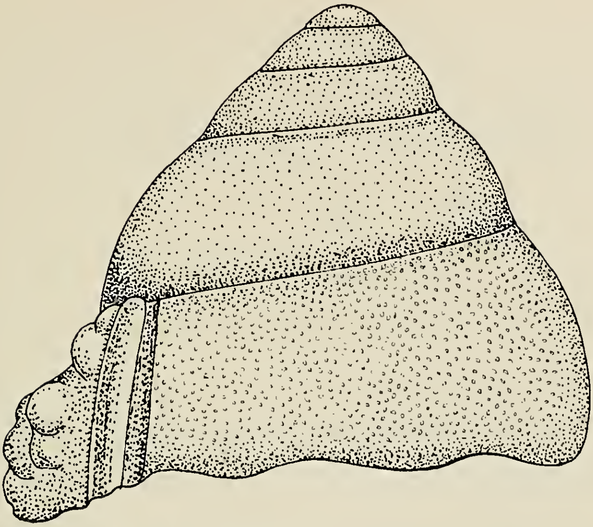

FIG. 4. *Trachypollia lugubris*: protoconch.

(Panama)." Fossil records from the Pleistocene have been reported (Emerson & Hertlein, 1964).

The shell is small (10–18 mm) and fusiform. The spire is quite high, consisting of five or six subangulate postnuclear whorls and a protoconch of three and one-half papillose, convex whorls (see Burch, 1940). The sutures are well defined. The body whorl is moderately large and fusoid. The aperture is moderately large and broadly ovate, with a narrow, deep anal sulcus. The outer lip is thin and minutely crenulate, reflecting the spiral sculpture of the shell surface. The inner surface of the outer lip bears six weak denticles recessed a short distance into the aperture. Each denticle corresponds to the trough between two major spiral cords. The inner lip is completely adherent, bearing a small knob delimiting the parietal extent of the anal sulcus, and a series of three moderately strong denticles at its anterior end. The anterior two of these denticles are closer together than they are to the third. The siphonal canal is moderately short, open, and bent to the left.

The shell is essentially non-varicate. Axial sculpture consists of eight to ten costae with shallow interspaces. These costae are most prominent over the major spiral cords. Spiral sculpture consists of primary, secondary, and tertiary scabrous cords. The shoulder bears three or four undulate, tertiary cords. One primary cord is evident subsuturally, a pair are present at the shoulder margin and three single primaries are evenly distributed over the lower half of the body. Between the pair of primary cords at the shoulder margin and the primary below, and between each

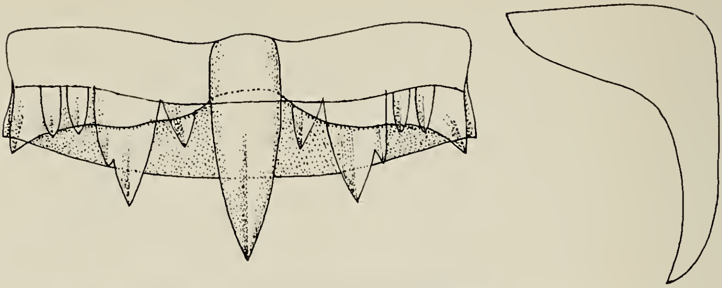

FIG. 5. *T. lugubris*: two-thirds of a transverse row of radular teeth.

two succeeding primary cords, three secondary cords are apparent, the outer two appended to their respective neighboring primary cords. Two secondary cords are found at the top of the siphonal canal, the bottom half of which is smooth. Where the primary cords intersect the axial costae, small, sharp nodules are developed.

Shell color is light tan to pale fleshy brown, including the aperture. The nodules are colored deep red-brown. Considerable variation in the size and overall proportions of the shell may be found, particularly associated with geographical (i.e. population) differences.

The radula is more or less ocenebrine. The lateral teeth are sickle shaped and of moderate size. The rachidian tooth is moderately broad, with the lower angles of the rectangular base produced into cusplike points. A long, slender central cusp projects a short distance forward on a narrow cowl. Flanking the central cusp on each side is a moderately short, independent, intermediate cusp. The lateral cusps, to the right and left of their respective intermediates, are moderately long and broad. In some views a single denticle is seen appended to the outer surface of each lateral cusp. Between each lateral cusp and the end of the tooth, a series of two or three moderately large denticles are apparent.

The operculum is thin, corneous, and almost semicircular. No growth lines are apparent on its outer surface; the inner surface shows traces of growth lines at one end and also bears a series of erratically concentric, ephemeral ridges. It appears to be ocenebrine.

### *Trachypollia didyma* (Schwengel, 1943)
Figure 1J

*Drupa didyma* Schwengel, 1943, vol. 56, pp. 76–77, pl. 7, fig. 7.

*Morula* (*Morunella*) *didyma* (Schwengel) Emerson & Hertlein, 1964, vol. 13, no. 17, p. 361.

*Distribution:* Known only from the southeastern coast of Florida; Palm Beach (type-locality) in 200 feet to off Miami in 120 ft.

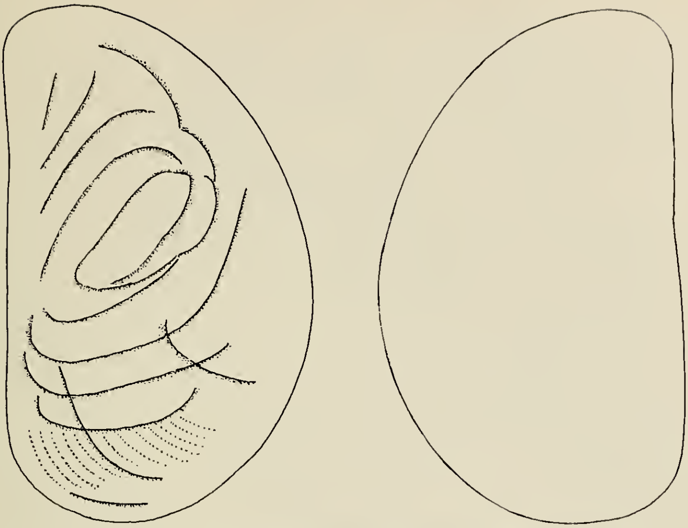

Fig. 6. *T. lugubris*: operculum—left, exterior; right, interior.

The shell of *T. didyma* is small (5–12 mm) and fusiform. The spire is high, consisting of three and one-half papillose, convex nuclear whorls and six strongly nodulose, postnuclear whorls. The sutures are impressed. The body whorl is moderately large and fusoid. The aperture is ovate to lenticular, with a well marked, U-shaped anal sulcus, the parietal margin of which is formed by a moderately strong transverse ridge. The outer apertural lip is unthickened and finely crenulate. On the inner surface of the outer lip, recessed a short distance into the aperture, a series of five moderately weak denticles are evident, diminishing in size with anterior progress. The inner lip is adherent at its posterior extremity; detached and weakly erect for its remaining length. At its anterior end the inner lip bears two oblique, elongate denticles. The siphonal canal is moderately short, open, weakly bent to the left and dorsally recurved.

The non-varicate shell has axial sculpture that consists of 13 low costae, nodulose over the major spiral cords. Spiral sculpture consists of major and minor cords. The major cords are distributed thusly: one subsuturally, a pair at the shoulder margin, three distributed evenly over the anterior half of the body, and one or two on the canal. Two minor cords are found between the subsutural major cord and the paired major cords at the shoulder margin. Additional single minor cords alternate with each major cord on the remainder of the body and canal. Small, sharp, hemispherical nodules are developed where the major cords intersect the costae.

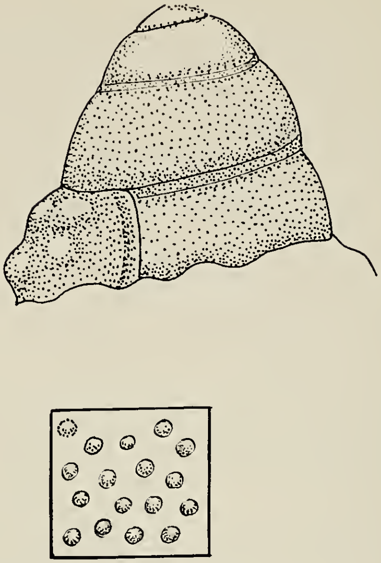

Fig. 7. *Trachypollia didyma*: protoconch.

Shell color is yellow-ochre with red-brown on the major spiral cords, strongest on the nodules. The aperture is fleshy white with deeper fleshy pink on the columellar denticles.

The radula, as in the previous species, is essentially ocenebrine. The major differences between the radulae of the two species is the chunkier, more compact base of the rachidian tooth and the relatively larger size of the lateral tooth in *T. didyma*. The most likely explanation of the former difference is that the entire tooth of *T. didyma* is very strongly

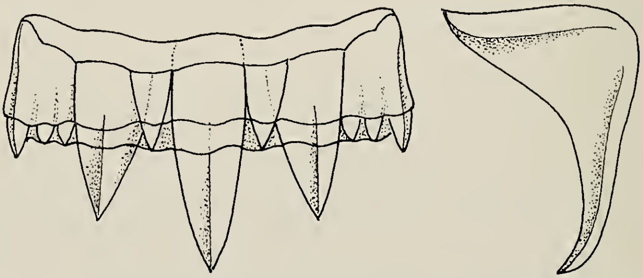

Fig. 8. *T. didyma*: two-thirds of a transverse row of radular teeth.

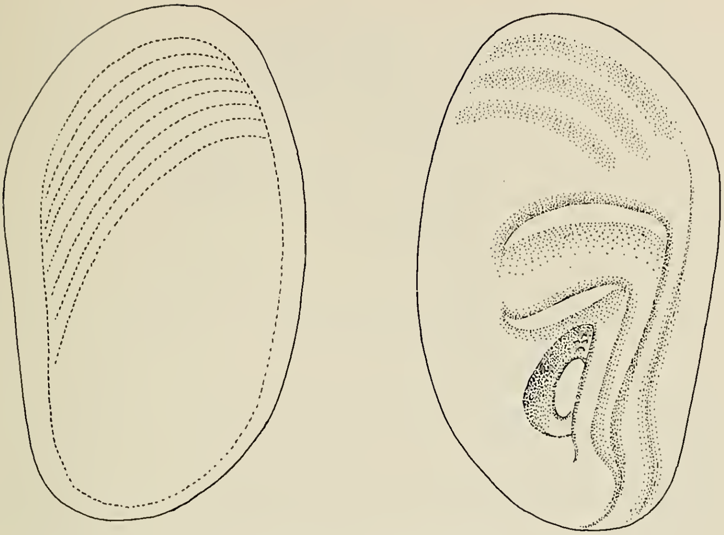

FIG. 9. *T. didyma*: operculum—left, exterior; right, interior.

curved, imparting a more compact appearance to the cusp arrangement. The lower corners of the base are produced into cusplike points. The central cusp is moderately long and quite broad and projects a short distance from the other cusps on a moderately narrow cowl. On each side of the central cusp there is a single, moderate-sized, independent, intermediate cusp, a large lateral cusp, and two small denticles.

The operculum is thin, corneous and sub-ovate. The outer surface has about eight faint growth lines at one end, the remainder is featureless. The inner surface shows indication of some of the growth lines in the form of three moderately broad, roughly concentric low ridges. Toward the center of the operculum several additional ridges lose their regular concentric configuration and turn at right angles to the normal course. In most ways the operculum is ocenebrine.

The restricted range of this species whose closest apparent relative is the widely distributed eastern Pacific *T. lugubris*, may indicate that *T. didyma* is a relict species whose former range may have been much more extensive. Unfortunately, no fossil records of this species are known to us.

### *Trachypollia nodulosa* (C. B. Adams, 1845)
Figure 1C

*Purpura nodulosa* C. B. Adams, 1845, vol. 2, pp. 2–3.
*Ricinula nodulosa* (Adams) Tryon, 1880, vol. 2, p. 190, pl. 59, fig. 275.

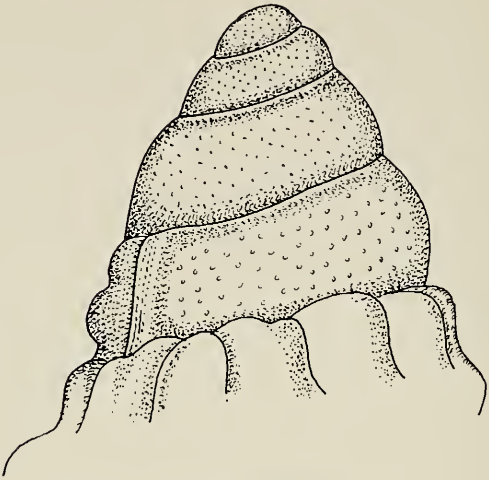

FIG. 10. *Trachypollia nodulosa*: protoconch.

*Sistrum nodulosa* (Adams) Johnson, 1934, vol. 40, no. 1, p. 118.
*Drupa nodulosa* (Adams) Warmke and Abbott, 1961, p. 106, pl. 19, fig. e.

*Distribution:* Throughout the entire Caribbean faunal province; southeastern Florida to southern Brazil, and west to Central America. Fossil range extends from the Mid-Miocene of Costa Rica (see Olsson, 1922, p. 133) to the Recent.

The shell of *T. nodulosa* is large for the genus (14–20 mm) and roughly fusiform. The spire is high and acute, consisting of a protoconch of three and one-half papillose, convex whorls and five or six weakly convex, postnuclear whorls. The sutures are weakly marked. The body whorl is moderately large and roughly fusoid. The aperture is narrow and sub-ovate, with a narrow, moderately shallow anal sulcus parietally delimited by a broad, low node-like ridge. The outer apertural lip is non-erect and smooth marginally. The inner surface of the outer lip bears four prominent denticles recessed a short distance from the apertural margin. The denticles diminish in size with anterior progress. The inner lip is entirely adherent, bearing three oblique, elongate denticles at its anterior end. The siphonal canal is moderately short, open, and barely bent to the left.

The presence of varices is difficult to determine. One or more apparent varices occur erratically but their number and position are not consistent. The animal does apparently pause briefly after the formation of each costa, but these pauses are apparently too short to qualify as varices. Axial sculpture consists of seven to 10 low costae prominent

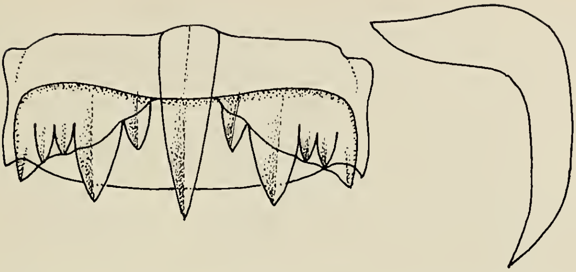

FIG. 11. *T. nodulosa*: two-thirds of a transverse row of radular teeth.

where they intersect the spiral elements. Spiral sculpture consists of five major cords on the body and one or two on the canal. One cord is subsutural, one cord is at the shoulder margin, and the remaining three are evenly distributed over the bottom half of the body. Where these cords intersect the costae, sharp nodules are developed. Between each two major cords six to 10 fine threads are evident.

Shell color is brown-black, in some specimens with white internodal spots on the shoulder margin cord and on an additional cord at the base of the body. The aperture is blue-gray with brown markings around the margin. The denticles are white.

The radula is essentially ocenebrine. Of the former two species the radula of *T. nodulosa* most closely resembles that of *T. lugubris*. The major differences are that the central cusp of the present species is slightly shorter than that of *T. lugubris* and that in no views of the radula of this species are any denticles appended to the outer surface of the lateral cusps. In addition, the lateral teeth are relatively smaller in *T. nodulosa*. The lower corners of the base of the rachidian are produced into cusplike points. The long slender central cusp protrudes slightly on a narrow cowl. On each side of the central cusp is a small, independent, intermediate cusp, a moderately large lateral cusp, and two small peripheral denticles.

The operculum was not available for study and comparison.

Several other species have been assigned to *Morula* or *Drupa*, or have been placed near these groups by implication. Examination of the shell, radula, protoconch and operculum of these forms has shown that they differ from both *Morula* and *Trachypollia*. A treatment of one such group follows.

## Subfamily Muricopsinae Radwin & D'Attilio, 1972

### **Evokesia** Radwin & D'Attilio, new genus

Type-species: *Sistrum rufonotatum* Carpenter, 1864.

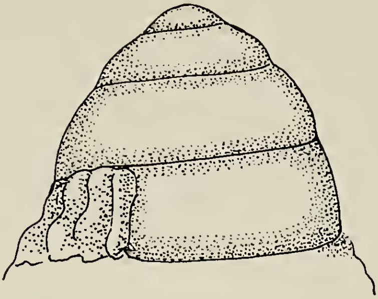

Fig. 12. *Evokesia rufonotata*: protoconch.

*Diagnosis*: Shell small to moderately small (15–30 mm), thin to moderately thick, fusiform to sub-fusiform and non-varicate; spire moderately high to very high and acute; aperture ovate and more or less constricted anteriorly, outer apertural lip thin to moderately thickened marginally, lirate to weakly denticulate within; inner lip entirely adherent and smooth; sculpture consisting of sharply raised, transversely elongate nodes; radular dentition muricopsine (Radwin & D'Attilio, 1972); rachidian tooth with lower corners of base weakly pointed if at all; no denticles present; five cusps present, moderate-sized lateral cusps, small intermediate cusps, and a long, sharp, central cusp projecting forward on a narrow cowl; lateral teeth simple; operculum closest to muricine type; protoconch of three swollen, papillose or granulose whorls.

In addition to the two species treated below, one Caribbean species apparently belongs in *Evokesia*. On the basis of a comparison of the shell and radular dentition, the systematic placement of *Nassaria* (*Nassarina*) *grayi* Dall, 1889 in *Evokesia* is indicated.

*Etymology:* The basis for this patronym is Dr. Emily H. Vokes, whose delineation of the New World Cenozoic Muricidae has assisted us immeasurably in understanding the evolution of this family.

### *Evokesia rufonotata* (Carpenter, 1864) NEW COMBINATION

Figure 1L

*Sistrum* (?*ochrostoma*, var.) *rufonotatum* Carpenter, 1864, ser. 3, vol. 14, p. 48.

*Morula rufonotata* (Carpenter) Keen, 1968, vol. 10, no. 4, p. 435.

*Attiliosa rufonotata* (Carpenter) Keen, 1971, p. 530, fig. 1022.

*Distribution:* Cabo Pulmo, Baja California and the Tres Marias Islands to Manzanillo, Mexico, the Revillagigedo Islands, and the Galapagos Islands.

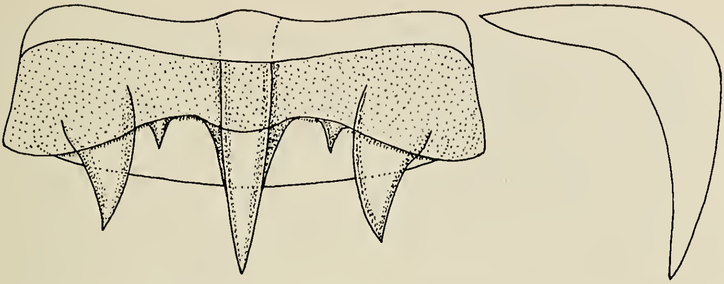

FIG. 13. *E. rufonotata*: two-thirds of a transverse row of radular teeth.

The shell of *E. rufonotata* is small (10–20 mm) and heavily fusiform. The spire is high, consisting of three and one-half convex, rapidly expanding, granulose nuclear whorls and four to six weakly angulate postnuclear whorls. The sutures are weakly impressed. The body whorl is moderately large and more or less swollen. The aperture is sub-ovate and moderate in size, with a broad, moderately deep anal sulcus. The outer apertural lip is weakly erect and minutely crenulate. The inner surface of the outer lip bears five or six moderately weak lirae, diminishing in strength with anterior progress. The inner lip is entirely adherent and smooth. The siphonal canal is short, open, weakly bent to the left and dorsally recurved.

The non-varicate shell has axial sculpture consisting of six to eight more or less strong costae, most prominent at their intersection with the major spiral cords. Spiral sculpture consists of major and minor cords which are only apparent over the axial costae; the interspaces are devoid of spiral sculpture. The shoulder is bare, followed by a major cord at the shoulder margin, one medially on the body, and one at the base of the body. Minor cords alternate with these majors on the body; the upper half of the canal bears two or three minor cords as well. Moderately sharp, more or less prominent nodules are developed where the major spiral cords intersect the costae.

Shell color is white to light tan, with more or less consistent darker brown markings on the receding slopes of the knobs. The apertural margin is white, with a marked gold-colored suffusion more deeply within. Shell proportions may vary with the population, as some specimens are short and globose and others are more slender and almost fusinoid in shape.

The radula is muricopsine (Radwin & D'Attilio, 1972). The lateral tooth is of moderate size and unexceptional. The rachidian is moderately broad and five cusped. The broadly rectangular base of the rachidian tooth has square or bluntly lobate lower corners. The central cusp is long and slender and projects far in front of the other cusps on a

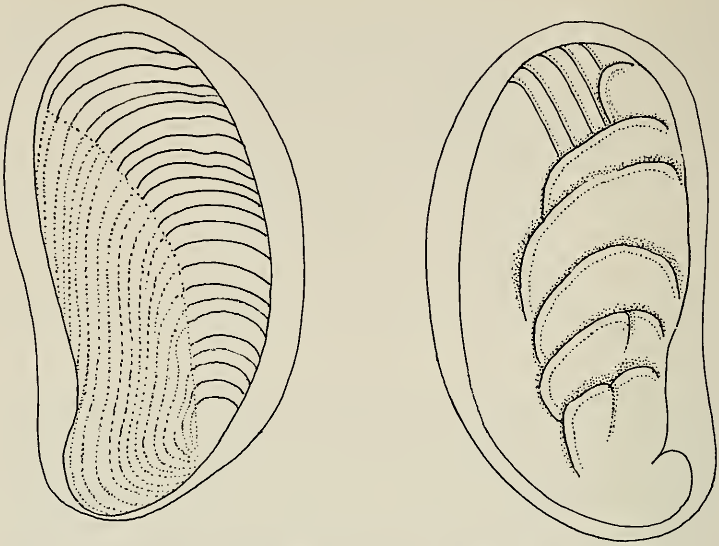

FIG. 14. *E. rufonotata*: operculum—left, exterior; right, interior.

moderately slender cowl. The lateral cusps are heavy and moderately long (about two-thirds the length of the central). The very small, independent, intermediate cusps are situated between the central and each lateral.

The operculum is muricoid and resembles the muricine type more than it does any other. It is thin and corneous and roughly kidney shaped. The outer surface shows growth lines, becoming ephemeral in its lower and left-hand areas. The inner surface shows a few parietal growth lines and numerous, low, flat-topped ridges.

### *Evokesia ferruginosa* (Reeve, 1856) NEW COMBINATION
Figure 1A

*Ricinula ferruginosa* Reeve, 1856, vol. 3, *Ricinula*, pl. 6, fig. 50.
*Morula ferruginosa* (Reeve) Keen, 1958, p. 376, sp. 411.
*Morula* (*Morunella*) *ferruginosa* (Reeve) Keen, 1971, p. 554, fig. 1092.

*Distribution:* Magdalena Bay, Baja California, Mexico, along the entire western shore of the Gulf of California, and on the eastern shore south to Guaymas, Sonora, Mexico.

The shell of this species is moderately small (23–30 mm) and fusiform. The spire is high and acute, consisting of three and one-half rapidly expanding, papillose nuclear whorls and six weakly angulate, postnuclear whorls. The sutures are weakly impressed to completely obscure. The

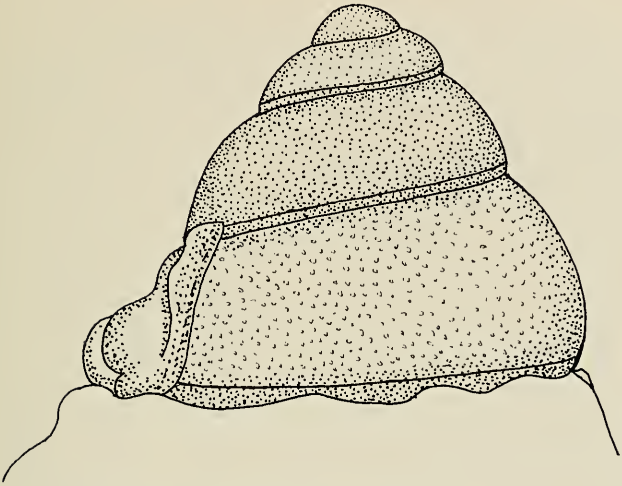

FIG. 15. *Evokesia ferruginosa*: protoconch.

body whorl is moderately large and sub-ovate, with a narrow, moderately deep anal sulcus, angled toward the columella. A very weak transverse ridge forms the left side of the anal sulcus. The outer apertural lip is unthickened to weakly thickened and minutely, marginally crenulate. The inner surface of the outer lip bears a series of four more or less weakly developed denticles recessed a short distance into the aperture. The inner lip is entirely adherent and smooth. The siphonal canal is short, open, bent to the left and dorsally recurved.

The shell is essentially non-varicate. Axial sculpture consists of seven to nine low costae, most prominent over the major spiral cords. Spiral sculpture consists of five major cords and numerous minor cords arranged as follows: immediately below the suture a single major cord is evident, the major cord at the shoulder margin is the most prominent one; three other major cords are distributed evenly over the lower half of the body; a single major cord is found at the top of the short siphonal canal; six minor cords separate the shoulder margin cord from the major cord below it. In all other cases, four minor cords occupy the space between each two neighboring major cords. Sharp, transversely elongate knobs are developed where the major cords intersect the costae.

Shell color is uniformly dark brown-black, except for white areas on the major cords immediately after the knobs. These white areas are erratically present on all cords except for the shoulder margin cord, where they are consistent. The aperture is blue-gray except for a dark brown margin and white denticles.

The shell is typically encrusted with coralline algae and mature speci-

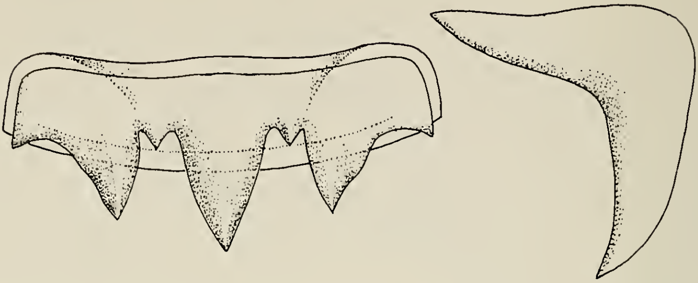

FIG. 16. *E. ferruginosa*: two-thirds of a transverse row of radular teeth.

mens frequently have a soft brown surface deposit on the spire. The nature of this deposit has not been determined.

The radular dentition of this species is muricopsine (Radwin & D'Attilio, 1972). In may ways it closely resembles that of *E. rufonotata*. It differs from it only in the greater proportional size of the lateral teeth and the greater breadth and bulging of the lateral cusps. The lateral tooth is large and simple. The rachidian is moderately broad and five cusped. The base of the rachidian is moderately broad and almost rectangular, with little or no projection of the lower corners. The central cusp is moderately long, somewhat broader than that of *E. rufonotata*, and projecting far ahead of the other cusps on a moderately slender cowl. The lateral cusps are moderately long and quite broad, with a distinctive bulge on the outer surface of each, visible in some views. The intermediates are tiny and are situated between the central cusp and each lateral cusp.

The operculum resembles the muricine type. It is moderately thin and corneous. The margin is exceptionally thin and fragile. On the inner surface, there is a moderately thickened ridge that follows the contours of the margin. The eccentric depressed region contains three or four low, roughly concentric, flat-topped ridges. The outer surface shows several parietal growth lines, the raised margins of a number of which have a frayed appearance.

Certain disparities in the details of the protoconch and small differences in the radular dentition and operculum have caused us to assign this species only tentatively to *Evokesia*.

A third group of obscure, small moruloid muricids, apparently limited to the Panamic faunal province, has also been studied. A treatment of this group follows. Although only one of three species included here has been previously described, specimens of all three species may turn up in collections from the Gulf of California and West Mexico.

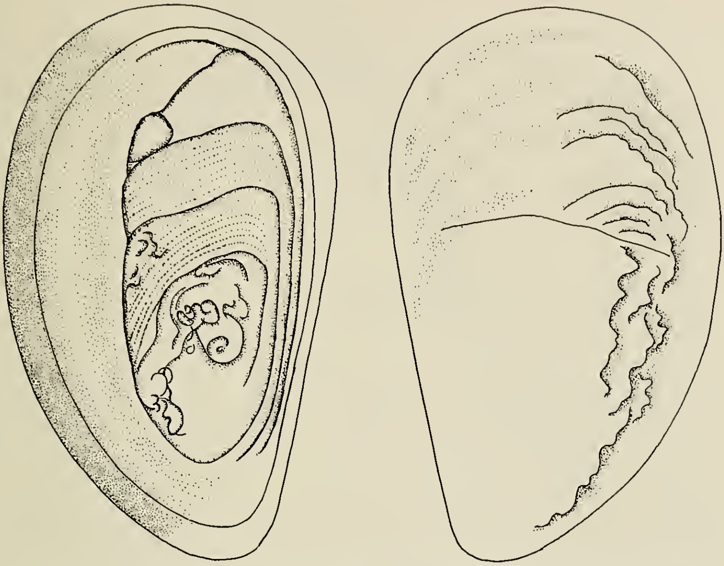

FIG. 17. *E. ferruginosa*: operculum—left, interior; right, exterior.

**Bizetiella** Radwin & D'Attilio, new genus

Type-species: *Tritonalia carmen* Lowe, 1935.

*Diagnosis*: Shell small (9–15 mm), moderately thin to thick, broadly fusiform; spire moderately high to high and acute; aperture moderately large and ovate, outer apertural lip weakly marginally thickened and lirate to weakly denticulate within; inner lip entirely adherent and smooth; sculpture of two to four strong cords on the body, knobby over varices; radular dentition muricopsine (Radwin & D'Attilio, 1972). Lateral tooth simple and small, rachidian small and compact, with the lower corners of the base of the rachidian produced into prominent, cusplike points; a small, strongly projecting central cusp is borne on a broad cowl; the large, heavy lateral cusps are unusually close to the midline of the tooth; and tiny intermediate cusps are closely associated with the lateral cusps; operculum of the muricine type but not definitive, its outer surface faintly annulate, inner surface almost featureless; protoconch unexceptional, consisting of two or three convex, glossy whorls.

*Etymology:* The basis for this generic name stems from the trivial name of its type-species. Thus from *–carmen–* comes *Bizetiella* (little Bizet), the composer of the opera Carmen.

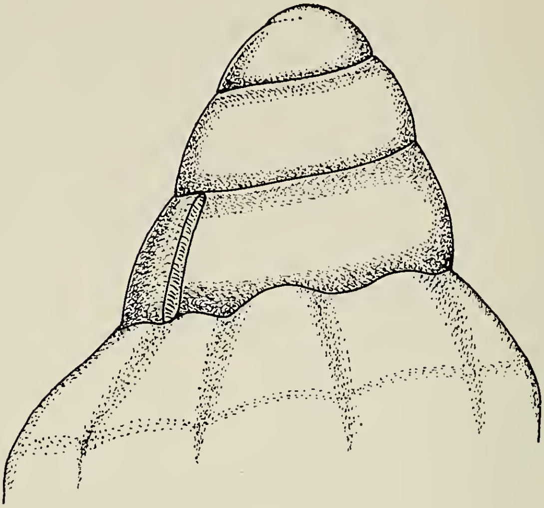

FIG. 18. *Bizetiella carmen*: protoconch.

*Bizetiella carmen* (Lowe, 1935) NEW COMBINATION
Figure 1F

*Tritonalia carmen* Lowe, 1935, vol. 8, no. 6, p. 20.
*Ocenebra carmen* (Lowe) Keen, 1958, p. 359, fig. 353.
*Attiliosa carmen* (Lowe) Keen, 1971, p. 529, fig. 1020.

*Distribution:* Central Gulf of California; Angel de La Guarda Island to La Paz and at Guaymas, Mexico.

The shell of *B. carmen* is small (7–10 mm) and fusiform. The spire is high and acute, consisting of three convex nuclear whorls and four or five strongly shouldered, postnuclear whorls. The sutures are impressed. The body whorl is moderately large, fusoid, and strongly constricted below the periphery. The aperture is sub-ovate, with a broad entrance into the moderately broadly open siphonal canal, and no perceptible anal sulcus. The outer apertural lip is non-erect and weakly, broadly crenulate. The inner surface of the outer lip bears eight moderately weak lirations, two in the shoulder region and six below it. The inner lip is entirely adherent and smooth. The siphonal canal is moderately short and open, bent to the left and dorsally recurved.

The body whorl bears five erect, sub-spinose varices. Intervarical axial sculpture is lacking, except for weak growth lamellae. Spiral sculpture consists of major and minor cords. Three strong major cords are evident on the body, diminishing in prominence with anterior progress; one at the shoulder margin, one medially and one basally. A single minor

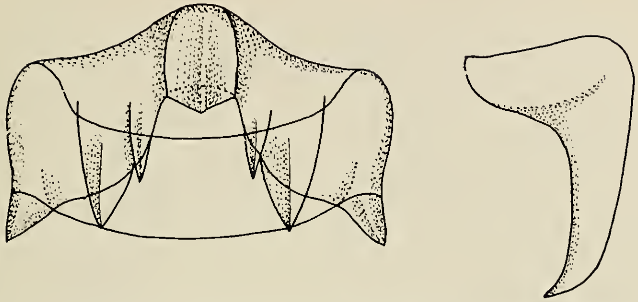

FIG. 19. *B. carmen:* two-thirds of a transverse row of radular teeth.

cord, between the upper two major cords, is visible only on the varix. A series of two or three minor cords are present on the upper canal.

Shell color is white to waxy yellow-orange. In some specimens, intervarical blotches of brown are evident on the shoulder.

The radular dentition is muricopsine (Radwin & D'Attilio, 1972). The lateral tooth is proportionally quite small and simple. The rachidian tooth is small and solid, and its base is almost square. The compactness of the base is also reflected in the tightly bunched cusps appended to it. The central cusp is stout and projects a short distance in advance of the other cusps on a moderately broad cowl. The lower front corners of the base are produced into cusplike points. The lateral cusps are heavy and are almost as long as the central. They are situated as close to the central cusp as to the outer edge of the tooth. The intermediate cusps are very small and closely associated with the inner surface of the lateral cusps, generally appearing, at least partially, coalescent with them.

The tiny operculum of this species is almost featureless. It is roughly semicircular, thin and corneous. The outer surface has numerous ephemeral growth lines. The inner surface has a polished outer margin and a dull, apparently barely depressed central region that shows no details.

Since its description almost 40 years ago this species has led an unclear generic existence. Although its identity and validity as a distinct Panamic species has never been in doubt, its placement first in *Tritonalia* and later in its objective synonym, *Ocenebra*, has seemed irreconcilable with its shell features. A comparison of its shell, radular dentition, and opercular morphology, with those of the type of *Ocenebra* (*O. erinacea* Linne), and of other West American species of that genus has shown the need for an appropriate new generic taxon.

### **Bizetiella micaela** Radwin & D'Attilio, new species
Figures 1 G,H

*Distribution:* Known only from Coastocomate Cove, Navidad Bay and Tamarindo Cove, Tenacatita Bay, both Jalisco, Mexico.

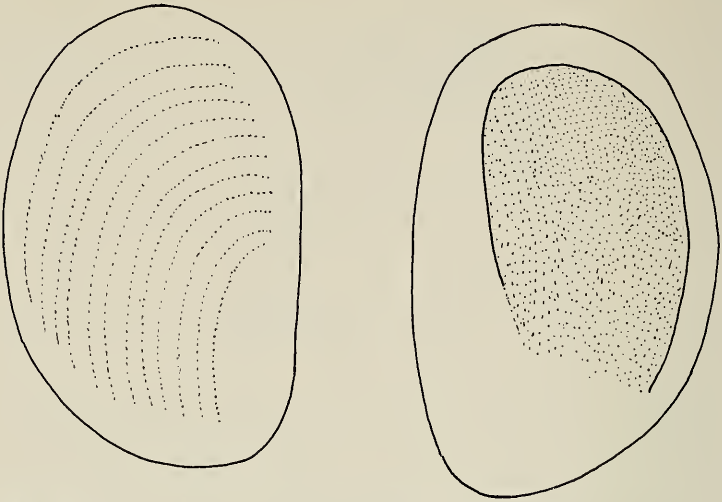

FIG. 20. *B. carmen*: operculum—left, exterior; right, interior.

The shell of this species is small (7–9 mm) and broadly fusiform. The spire is high and acute, consisting of two and one-half convex nuclear whorls and four and one-half strongly angulate, postnuclear whorls. The sutures are strongly impressed. The body whorl is moderately large and broadly fusoid. The aperture is moderately broad and ovate, with a broad, shallow anal sulcus. The posterior end of the outer apertural lip is arcuate, almost reaching the shoulder margin of the previous whorl. The margin of the outer apertural lip is erect, moderately thickened, and broadly, gently undulate. Eight denticles are apparent on the inner surface of the outer lip; two in the shoulder region and six below, the anterior-most being the most prominent. The inner lip is entirely adherent and smooth except for a knoblike protuberance where it makes a sharp angle entering the siphonal canal. The siphonal canal is moderately short and open, bent to the right and dorsally recurved.

The body whorl bears five low to moderately prominent varices. Spiral sculpture consists of two approximately equal-sized major cords on the body, one at the shoulder margin, and one near the base of the body. These cords are intervarically ephemeral, becoming prominent only immediately before and on the varices. Other sculpture is lacking.

Shell color is white with two broad, interrupted, transverse, pale red-brown bands, one just above the shoulder margin and one between the two spiral cords. The interrupted nature of these bands is due to their disappearance immediately after each varix, the markings being apparent just before and on each varix. The aperture is white with a rosy pink suffusion on the columella.

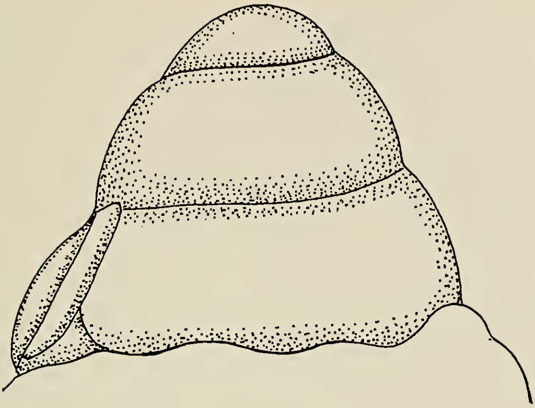

FIG. 21. *Bizetiella micaela*: protoconch.

The radular dentition is muricopsine and very similar to that of *B. carmen*. The major differences between the two are the differently shaped, smaller lateral teeth of *B. micaela*. The lateral tooth is hook-shaped rather than sickle-shaped as in *B. carmen*. In addition, the central cusp of *B. micaela* is borne on a somewhat narrower, lower cowl than that of *B. carmen*. The rachidian tooth of *B. micaela* is somewhat less compact with a rectangular base. The lower corners of the base are pointed but are not as cusplike in shape as in *M. carmen*. The central cusp projects far ahead of the other cusps on a moderately broad cowl. The moderately large lateral cusps and their associated tiny intermediate cusps are not situated as close to the midline as in *B. carmen*.

The operculum shows ephemeral growth lines on the outer surface and the inner surface is almost featureless. An irregular, depressed area,

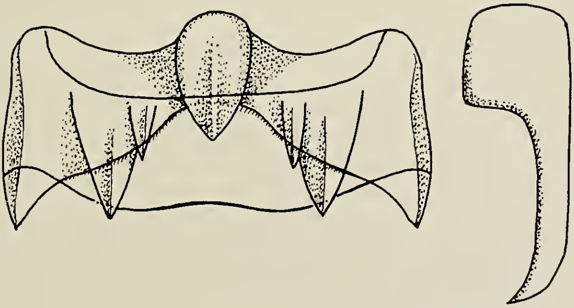

FIG. 22. *B. micaela*: two-thirds of a transverse row of radular teeth.

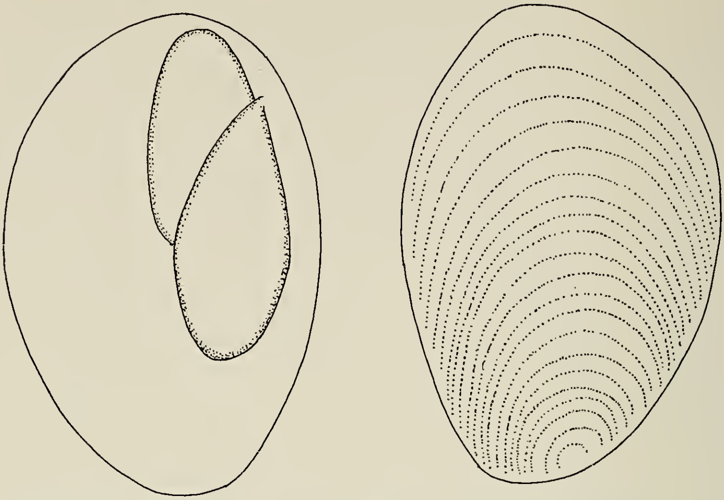

FIG. 23. *B. micaela*: operculum—left, interior; right, exterior.

bisected by a shallow groove, is surrounded by a broader, shiny, smooth, barely raised zone.

*Measurements:* Holotype—length, 8.7 mm; width, 4.5 mm. Largest paratype—8.4 mm; width, 4.1 mm. Smallest mature paratype—length, 5.4 mm; width, 3.2 mm.

*Type-locality:* Coastocomate Cove, Navidad Bay, Jalisco, Mexico, 10–30 feet, Donald R. Shasky, 13–20 October 1968.

*Type depositories:* Holotype, SDSNH 56118; 3 paratypes, SDSNH 51822, 13–20 October 1968, 1 paratype, SDSNH 51823, 17 October 1968, all from the type-locality. 8 paratypes, D. R. Shasky Coll., 8–9 August 1965, Tamarindo Cove, Tenacatita Bay, Jalisco, Mexico, 5–10 feet depth.

This species has generally been confused with *Evokesia rufonotata* or mixed with specimens of that species and its distinctness has thus gone unnoticed. This is primarily because the two species are generally about the same size and live together on the undersides of small to moderately large rocks in shallow water. Also responsible for the anonymity of the present species is the fact that it and *Evokesia rufonotata* are inevitably encrusted with calcareous algae. The two species can be separated on the basis of the following differences in shell morphology. The well-formed, ovate aperture of *E. rufonotata* is bounded by a weak, sloping shoulder; its spire is higher and its aperture is white marginally; gold-colored within. *B. micaela* is generally somewhat smaller, has a strongly shouldered whorl causing the posterior margin of the aperture to be flattened, a somewhat lower spire, and a white aperture with a rosy pink columellar suffusion.

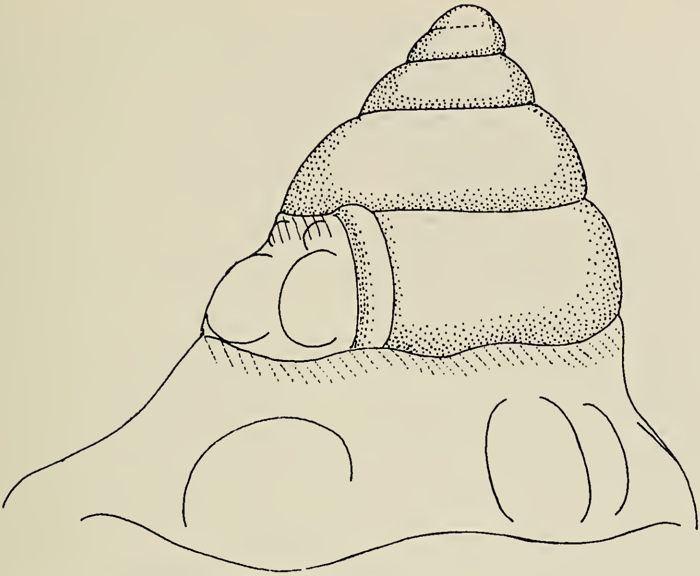

FIG. 24. *Bizetiella shaskyi*: protoconch.

The basis for the present name is the secondary female lead character in the opera "Carmen," in keeping with the name of the genus and the trivial name of the type-species (*Bizetiella carmen*).

### **Bizetiella shaskyi** Radwin & D'Attilio, new species
Figures 1 D,E

*Distribution:* The Tres Marias Islands, Cabo Pulmo, Baja California, and Banderas Bay, Jalisco, all Mexico; Perlas Islands, Panama and from the Galapagos Islands, Ecuador.

The shell of *B. shaskyi* is moderately small (9–13.5 mm) and rhomboid in outline. The spire is high, consisting of three and one-half weakly convex nuclear whorls and five shouldered, postnuclear whorls. The shoulder region of each whorl is weakly concave. The sutures are impressed and strongly undulate. The body whorl is moderately large and broadly fusoid. The aperture is widely ovate with a broad, shallow anal sulcus. The outer apertural lip is weakly thickened and non-erect. The inner surface of the outer apertural lip bears five lirae and a knobby swelling at its anterior end. The inner lip is adherent, with a weak transverse ridge delimiting the left side of the anal sulcus, and with another ridge at its anterior end. The siphonal canal is moderately broadly open and short, is weakly bent to the left, and dorsally recurved.

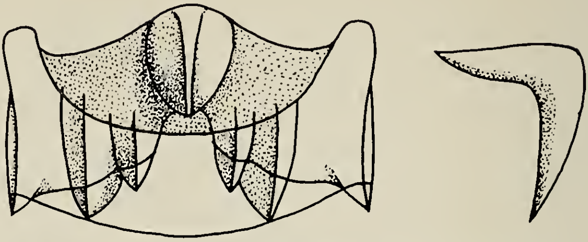

FIG. 25. *B. shaskyi*: two-thirds of a transverse row of radular teeth.

The body whorl bears eight weakly defined varices. Intervarical axial sculpture is lacking. Spiral sculpture consists of major and minor cords. The shoulder region lacks sculpture. Progressing anteriorly from the shoulder margin one notes a pair of major cords, a single minor cord, another major cord, followed by another minor cord, and a final major cord. Where the major cords intersect the varices, sharp transversely elongate nodes are developed, most strongly on the uppermost pair of cords. The siphonal canal has no spiral sculpture.

Shell color is pale blue-white with spiral bands of ivory subsuturally and on the canal. Numerous brown markings are apparent between the spiral cords, just before and on each varix.

The radular dentition is muricopsine and very similar to that of *B. carmen* and *B. micaela*. The primary radular differences between this species and the other two are that the lateral teeth in *B. shaskyi* are the smallest of the three and the intermediate cusps of the rachidian are the largest. The base of the rachidian tooth is almost square and thus, is very compact looking. The lower corners of the base are produced into cusplike points but these are smaller than those of its two congeners. The central cusp is the broadest of the three species and projects ahead of the other cusps on a broad cowl. The lateral cusps are comparatively large and broad. The intermediate cusps are moderately large (about two-thirds the length of the lateral cusps) and broader than their counterparts in the other two species.

*Measurements:* Holotype—length, 13.5 mm; width, 7.7 mm. Largest paratype—length, 14.0 mm; width, 8.4 mm. Smallest mature paratype—length, 8.3 mm; width, 4.5 mm.

*Type-locality:* One mile south of Puerto Balleta, Maria Madre Island, Tres Marias Islands, Nayarit, Mexico, 10–15 feet depth, Donald R. Shasky, 22 December 1964.

*Type-depositories:* Holotype, SDSNH 56119; 5 paratypes, D. R. Shasky Coll., 22 December 1964, all from type-locality. 5 paratypes, SDSNH 34688, February, 1930, Maria Madre Island, Tres Marias Islands, Nayarit, Mexico; 11 paratypes, LACM 65-11, 15 March 1965, South Anchorage, Maria Magadalena Island, Tres Marias Islands, Nayarit,

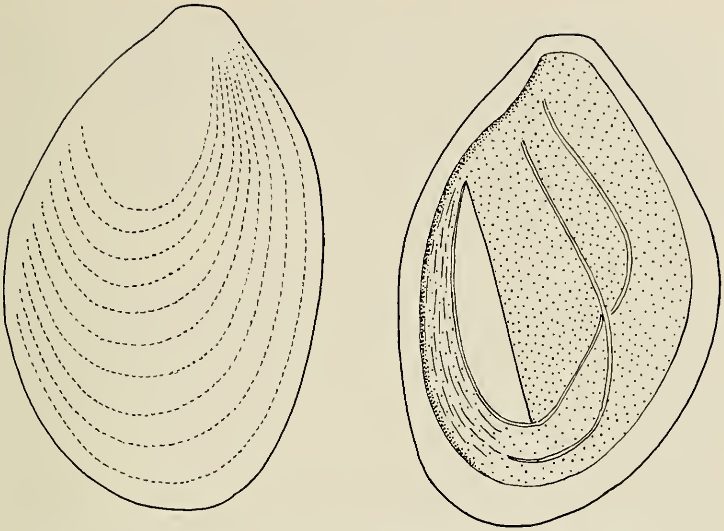

FIG. 26. *B. shaskyi*: operculum—left, interior; right, exterior.

Mexico; 8 paratypes, LACM 65-12, 16–19 March 1965, East Anchorage, Maria Cleopha Island, Tres Marias Islands, Nayarit, Mexico; 23 paratypes, LACM 65-13, 16–18 March 1965, East Anchorage, Maria Cleopha Island, Nayarit, Mexico; 2 paratypes, LACM 65-15, 22 March 1965, Los Arcos, Banderas Bay, Jalisco, Mexico, 15–80 feet depth; 2 paratypes, D. R. Shasky Coll., 27–29 November 1967, Cabo Pulmo, Baja California, Mexico, 25 feet depth; 1 paratype, D. R. Shasky Coll., Perlas Islands, Panama, March, 1971; 3 paratypes, Ameripagos Expedition Collections, Station 14, 19 March 1971, Punta Estrada, southeast side of Academy Bay, Santa Cruz Island, Galapagos Islands, Ecuador, 25–35 feet depth; 2 paratypes, Ameripagos Expedition Collections, Station 21, 21 March 1971, North Seymour Island, Galapagos Islands, Ecuador, 35–45 feet depth; 1 paratype, Ameripagos Expedition Collections, Station 23, 22–24 March 1971, Sombrero Chino Island, Galapagos Islands, Ecuador, 3–8 feet depth; 7 paratypes, Ameripagos Expedition Collections, Station 27, 24 March 1971, Jervis Island, Galapagos Islands, Ecuador, 10–75 feet depth; 1 paratype, Ameripagos Expedition Collections, Station 29, 25 March 1971, Punta Alfaro, Isabela Island, Galapagos Islands, Ecuador, 10–20 feet depth; 2 paratypes, Ameripagos Expedition Collections, Station 21, 26 March 1971, Duncan Island, Galapagos Islands, Ecuador, 3–10 feet depth.

The Ameripagos Expedition was a privately financed expedition to the Galapagos Islands consisting of seven members, most of whom are affiliated with museums.

In collections where specimens of this species have been found, they have been assigned to genera such as *Engina* and *Coralliophila*. Additionally, early inclinations of the authors would have placed the species in *Attiliosa*. All this must emphasize the pitfalls inherent in conclusions based on the study of too few characters.

This species is named for Dr. Donald R. Shasky, who first brought it to our attention and whose collecting zeal and generosity have enriched the collections of many museums.

## Acknowledgments

We gratefully acknowledge our debt to the following friends and colleagues for courtesies and assistance of various kinds in the preparation of this paper: Drs. William K. Emerson, James M. McLean, Joseph Rosewater, Wendell P. Woodring and Donald R. Shasky, Mr. Walter J. Byas, Mrs. Grace M. Boyne, Mrs. Carol A. Allbaugh, Dr. William A. Burns and Mr. David K. Mulliner.

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Vol. 85, No. 29, pp. 353–358 30 December 1972

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# NOTES ON ANTHRIBID WEEVILS. II. THE SPECIES DESCRIBED BY ADOLPHE HOFFMANN

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This is the second in a proposed series of summaries of needed taxonomic changes in the Anthribidae. For introductory comments, explanations of format, and acknowledgments see the previous paper (Valentine, 1971).

Adolphe Hoffmann was the author of the anthribid portion of the "Faune de France" (1945). No new taxa were described in that work. Later, during the 13-year period from 1954–1967, he and a co-worker described two genera and eight species of Anthribidae from Europe, Madeira, and Western Africa. I have recently seen type-material of each of these taxa in the Museum National d'Histoire Naturelle in Paris, and present the following notes on their identification and synonymy. They are discussed in alphabetical order, by genera.

Branconymus Hoffmann, 1959:341. Type-species: *Branconymus vayssierei* Hoffmann, 1959:342, by original designation.

The type-species of this genus has eyes deeply notched by the edge of the rostrum; rostrum bicarinate, short, in males flared above the lateral scrobes; transverse carina of pronotum appearing basal, lateral carina extending slightly past middle of prothoracic sides; mesosternum with intercoxal process broad, almost vertical, apically truncate; female antennae extending to the elytral base; male antennae surpassing the elytra, the club slender and ill defined. It is a perfectly normal non-tufted species of *Phloeobius* Schoenherr, 1823:1126, type-species *Anthribus griseus* Fabricius, 1792:377, by original designation and monotypy.

NEW GENERIC SYNONYMY.

*Branconymus vayssierei* Hoffmann, 1959:342. The holotype is a teneral male labeled in part "Ile de San-Thome / Rec. Castel-Branco / Larve dans rameau de / Café-21-x-58."

The holotype has the basically uniform non-tessellate pubescence and tiny white isolated spots in the odd-numbered elytral interspaces that are the characteristic feature of *Phloeobius hypoxanthus* Jordan, 1911:91, also described from St. Thomé, and examined by me in London. The two names obviously apply to the same species. NEW SYNONYMY. Hoffmann actually mentions Jordan's species in his general comments on the St. Thomé anthribid fauna; and then goes on to redescribe it as a new genus and species.

*Branconymus pujoli* Hoffmann, 1959:342. The male holotype is labeled in part "Jacques Felix / Rec. Côte d'Ivoire"; and "s/Rameau de / Cafeier Arabica / 27-7-50."

Hoffmann's type is tessellate with small spots along the suture, larger dashes on the remaining odd-numbered interspaces, and has a dusting of gray posterior to the subbasal callosities concentrated mainly between the third and fifth interspaces; the pronotum has three pale orange spots on each side, two are so close that they almost form a longitudinal dash, the third is isolated and more lateral. This color pattern, plus the narrow tarsi, spined apices of antennal segments nine and ten, non-tufted vestiture, etc., are the characteristic features of *Phloeobius catenatus silaceus* Jordan, 1955:347. NEW SYNONYMY. Jordan's holotype is labeled "Gold Coast: / C. Ashanti / Juaso. 900 ft.," the subspecies occurs in the Ivory Coast, Sierra Leone, and "Senegambia."

*Cylindroides descarpentriesi* Hoffmann, 1967:1316. The unique male holotype from the Congo is labeled in part "Mbila (Mts du Chaillu) XII, 1963"; "Muséum Paris / Mission / A. Descarpentries / et A. Villiers / 1963–1964"; and "Cylindroides / spec. nov. / det. R. Frieser, 1966."

This seems to be a valid species for I can find nothing like it in the British Museum under *Cylindroides, Anaulodes,* or *Aulodina.*

*Mecocerus confusus* Hoffmann, 1967:1313. The unique female holotype is labeled in part "Sibiti / Congo / XII-1963"; "Muséum Paris / Mission / A. Descarpentries / et A. Villiers / 1963–1964"; and "Mecocerus / spec. nov. / det. R. Frieser, 1966."

This species is not a member of the genus *Mecocerus*, it is, in fact, one of several geographically variable populations of *Acorynus pachys*

Jordan, 1911:101. NEW SYNONYMY. This is the largest and most *Mecocerus*-like species of *Acorynus* in Africa, but it can be immediately distinguished from *Mecocerus* by the more dorsal eye. In *A. pachys* in en face view the entire eye margin is visible as are the sides of the head capsule posterior to the eye. In *Mecocerus* the eye is more lateral, in en face view the posterior margin is not visible and the eye interrupts the line of the head capsule. The rostrum is also quite different being broader, flatter, almost on the same plane as frons and vertex, sides evenly in-curved between base and apex, a vague median carina highest on a basal swollen area flanked by two apically divergent rows of weak rugosities, and apex flatter without the ridges and depressions of most *Mecocerus*.

The holotype of *Acorynus pachys pachys* Jordan is labeled "Kumassi / (Newberry)." The British Museum also has a series from "Kassai: Kondué / E. Luja" received from the Musée du Congo. These specimens have an almost uniformly brown pronotum, and elytra with a short basal longitudinal sutural stripe which divides and then turns laterally. In the population named by Hoffmann the pronotum has a pair of oblique lateral yellowish stripes which do not reach the anterior margin of the thorax, and complexly spotted elytra. A female in the British Museum labeled "Despallières / Loango / 1893" is similar. Other specimens from "Kassai district, / Congo F. St. / (Taymans)." have three complete pronotal stripes and were named *Acorynus pachys vitticollis* Jordan, 1911. Specimens from Uganda are the most completely marked with extensive pale areas on both pronotum and elytra. It is difficult to tell if the variation is demic or geographic; however, *confusus* Hoffmann looks more like *pachys vitticollis* Jordan than *pachys pachys* Jordan.

*Mecocerus villiersi* Hoffmann, 1967:1312. The male holotype and two female paratypes are labeled in part "Sibiti / Congo / XII-1963"; "Musèum Paris / Mission / A. Descarpentries / et A. Villiers / 1963–1964"; and "Mecocerus / spec. nov. / det. R. Frieser, 1966."

The holotype is a virtually perfect match for a male in the R. Oberthur collection in Paris which may be the type of *Mecocerus mniszchi* Thomson, 1858. This male is the first specimen in Oberthur's series and stands next to a label which in addition to the determination also states "Gabon" and "Type." I do not know if this is Thomson's type, however, it certainly is the common species we recognize today as *mniszchi*, and it agrees with Thomson's illustration. NEW SYNONYMY.

*Mecocerus* is a large genus with 30 described species from Africa. *Mecocerus mniszchi* is the commonest species in all the collections I have studied, and especially in material from the Congo. Hoffmann does not list it in the Villiers-Descarpentries collection, the reason now being clear.

*Tropideres* (*Opisthotropis*) *vasconicus* Hoffmann and Tempère, 1954:66. The female holotype in the A. Hoffmann collection in Paris is labeled in part "Basses-Pyrénées / Urrugne / 30.6.53 / G. Tempere"; "Quercus / pedunculata"; "Genre nouveau / pré de *Tropideres* / à décrire?!!" The specimen card has the number "5890" written on the underside.

*Opisthotropis* Hoffmann and Tempère was described as a new subgenus with *vasconicus* as its only species. The subgeneric name is a junior synonym of *Ormiscus* Waterhouse, 1845, the largest and most wide-spread genus in the Americas with more than one hundred species ranging from Canada to Argentina, including the West Indies and Galapagos Islands. NEW GENERIC SYNONYMY. *Ormiscus* is the oldest of five generic names which were discussed by me (1960), one of these names, *Eusphyrus* Leconte, 1876, may eventually be used as a subgenus. *Opisthotropis* with its apparently basal transverse pronotal carina and laterally protruding prothoracic hind angles, is one of the *Eusphyrus*-like species of *Ormiscus*.

Although the synonymy of *Opisthotropis* with *Ormiscus* is clear, the identity of *vasconicus* Hoffmann and Tempère is not. Approximately half of the described species of *Ormiscus* are of the *Eusphyrus* type. The genus has recently been transported accidentally to Hawaii and I assume that the French specimens are imports too. The rarity or possible absence of males in some species, and the concomitant possibility of parthenogenesis, increases the potential for successful chance dispersal; Hoffmann and Tempère mention the absence of males in their species. *Ormiscus vasconicus* is not one of the Nearctic species; however, I do not know all the many Neotropical forms well enough to determine whether the French species is valid or a synonym. For the present it should be listed as a questioned valid species, probably introduced into southern France from Central or South America.

*Tropideres* (*Enedreutres*) [sic] *lindbergi* Hoffmann, 1963:128. A paratype in the A. Hoffmann collection is labeled in part "Madeira Funchal / 9–10. 6. 1957 / Lindberg."

This is another example of the flagrant abuse of generic names that characterizes the Palearctic classification. The name *Tropideres* is a huge wastebasket into which has been thrown an extraordinary variety of Anthribidae, in all, at least 10 different, distinct genera. In the fauna of western Europe, only two species are actually *Tropideres* Schoenherr, 1823, they are *Tropideres albirostris* (Herbst, 1784) which is the type-species by original designation, and *T. dorsalis* (Thunberg, 1795). The various "subgenera" of *Tropideres* are actually all valid genera none of which belongs in the Tropiderini.

The present species, "*Tropideres*" *lindbergi*, is a synonym of *Trigonorhinus zeae* (Wolfrum, 1931). NEW SYNONYMY. *Trigonorhinus* Wollaston, 1861 includes the Mediterranean type-species *pardalis* Wollaston, 1861 (= *areolatus* Boheman, 1845) (Wollaston's Cape Verde Islands type-locality is apparently an error), plus many described American species ranging from Canada to Argentina. The genus and its synonymy was discussed by me (1960). *Trigonorhinus zeae* was described (as a *Brachytarsus* Schoenherr) from Buenos Aires, Argentina, and ranges north into Mexico. In the United States and Canada it is replaced by a related species *T. sticticus* (Boheman, 1833).

## A Summary of the Hoffmann Species of Anthribidae

*Mecocerus* Schoenherr, 1833
    *Mecocerus mniszchi* Thomson, 1858
        (= *Mecocerus villiersi* Hoffmann, 1967) NEW SYNONYMY.
*Acorynus* Schoenherr, 1833
    *Acornynus pachys* Jordan, 1911
        (= *Mecocerus confusus* Hoffmann, 1967). NEW SYNONYMY.
*Trigonorhinus* Wollaston, 1861
    *Trigonorhinus zeae* (Wolfrum, 1931)
        (= *Tropideres lindbergi* Hoffmann, 1963) NEW SYNONYMY.
*Cylindroides* Fairmaire, 1886
    *Cylindroides descarpentriesi* Hoffmann, 1967
*Phloeobius* Schoenherr, 1823
        (= *Branconymus* Hoffmann, 1959) NEW SYNONYMY.
    *Phloeobius hypoxanthus* Jordan, 1911
        (= *Branconymus vayssierei* Hoffmann, 1959) NEW SYNONYMY.
    *Phloeobius catenatus silaceus* Jordan, 1955
        (= *Branconymus pujoli* Hoffmann, 1959) NEW SYNONYMY.
*Ormiscus* Waterhouse, 1845
        (= *Opisthotropis* Hoffmann & Tempère, 1954) NEW SYNONYMY.
    *Ormiscus vasconicus* (Hoffmann & Tempère, 1954) NEW COMBINATION.

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Vol. 85, No. 30, pp. 359–384 30 December 1972

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# PSEUDARCHASTERINAE (ECHINODERMATA, ASTEROIDEA) OF THE ATLANTIC

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Goniasterid sea stars are an important part of the Atlantic echinoderm fauna. This family contains the subfamily Pseudarchasterinae, which has two genera in the Atlantic, *Pseudarchaster* and *Paragonaster.* These genera have been a great source of difficulty. They have been confused with astropectinid genera by previous workers, and there are a large number of invalid nominal species. The latter is due to several species which display considerable amounts of intraspecific morphological variation and have wide geographic and bathymetric distributions. Thus, the Pseudarchasterinae of the Atlantic are reviewed, with a large number of revisions being made.

This research was supported by National Science Foundation grant GB-4936. The abbreviations used in the material studied sections are as follows: BMNH—British Museum (Natural History); IOM—Institute d'Oceanographique de Monaco; MCZ—Museum of Comparative Zoology, Harvard University; MNHN—Museum National d'Histoire Naturelle; UMML—Rosensteil School of Marine and Atmospheric Sciences, University of Miami; USNM—National Museum of Natural History, Smithsonian Institution.

## Subfamily Pseudarchasterinae Sladen, 1889 (emended)

Abactinal plates paxilliform. Unpaired (but not recurved) median spine at apex of each mouth plate pair.

The feature that separates this subfamily from the more primitive genera of the Goniasterinae is the unpaired median spine. This is formed by the fusion of the two median spines. Sometimes these do not fuse so that in some specimens one or two of the mouth plate pairs bear a pair of median spines.

### *Pseudarchaster* Sladen, 1885

*Pseudarchaster* Sladen, 1885, p. 617; 1889, p. 109.—Verrill, 1899, pp. 189–190.—Fisher, 1911, pp. 179–180.—Koehler, 1924, p. 180.—Mortensen, 1927, p. 86.—Djakonov, 1950, pp. 43–44.—Bernasconi, 1963, pp. 4–5; 1964, p. 254.

*Aphroditaster* Sladen, 1885, p. 612; 1889, pp. 116–117.—Fisher, 1919, p. 228.

*Astrogonium* (pars) Perrier, 1894, pp. 338–342.—Koehler, 1909, pp. 64–65.

non *Astrogonium*: Müller and Troschel, 1842, p. 52.

*Diagnosis*: Several rows of abactinal plates extending far along arm; usually more than one row reaching terminal plate. Unpaired (but not recurved) median spine at apex of each mouth plate pair.

*Discussion*: Sladen (1889, p. 117) separated *Aphroditaster* from *Pseudarchaster* on the basis of "the longitudinal arrangement of the adambulacral armature and the presence of the remarkable 'fascioles' on the post-adambulacral plates." The remarkable "fascioles" are actually pectinate pedicellariae, which are found in several species of *Pseudarchaster*. The "longitudinal arrangement of the adambulacral armature" does not refer to the furrow spines, which are in an arc, i.e., the furrow margin is curved. The subambulacral spines are fairly regularly arranged, but well within the range of variation in *Pseudarchaster*.

*Pseudarchaster* and *Aphroditaster* were named in the same paper (Sladen, 1885). Mortensen (1927, p. 86), as first reviser, made *Aphroditaster* the junior synonym of *Pseudarchaster*.

*Type-species*: *Pseudarchaster discus* (by subsequent designation: Verrill, 1899, p. 189).

### A KEY TO THE SPECIES OF *PSEUDARCHASTER* FROM THE ATLANTIC

1. Actinal and inferomarginal plates bearing conical spines three to five times longer than wide .................... *gracilis*
   Actinal and inferomarginal plates bearing flattened lanceolate spines one to three times longer than wide; or spines sometimes absent .................... 2
2. Pectinate pedicellariae along suture of each mouth plate pair .................... *discus**
   No pedicellaria on mouth plate pairs .................... 3
3. Actinal plates usually bearing lanceolate spines .................... *parelii*
   Actinal plates usually lacking lanceolate spines .................... *tessellatus*

* Limited to Antarctic and subantarctic waters.

### *Pseudarchaster gracilis* (Sladen, 1889)

Figures 1–2

*Aphroditaster gracilis* Sladen, 1889, pp. 117–120, pl. 17, figs. 1–2, pl. 18, figs. 7–8.—Verrill, 1899, p. 195.—Fisher, 1919, pp. 227–228.

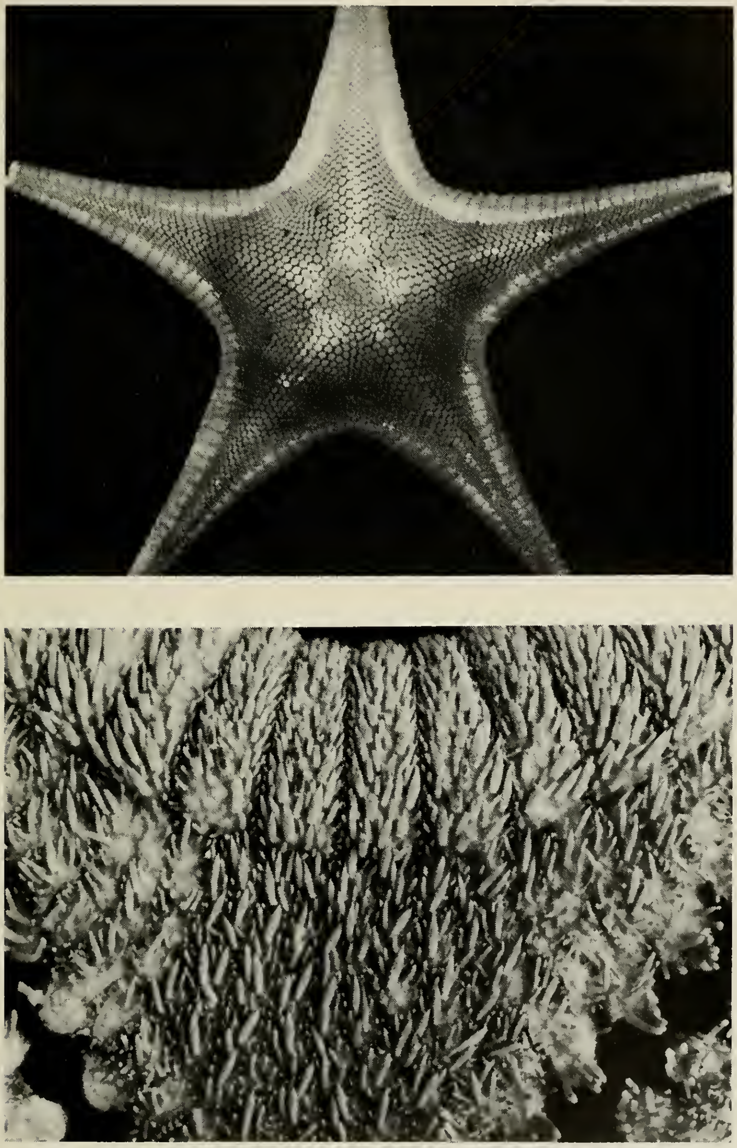

FIG. 1. *Pseudarchaster gracilis* (Sladen), lectotype of *P. concinnus*: top, abactinal view, 0.5×.—bottom, actinal view, 2.5×.

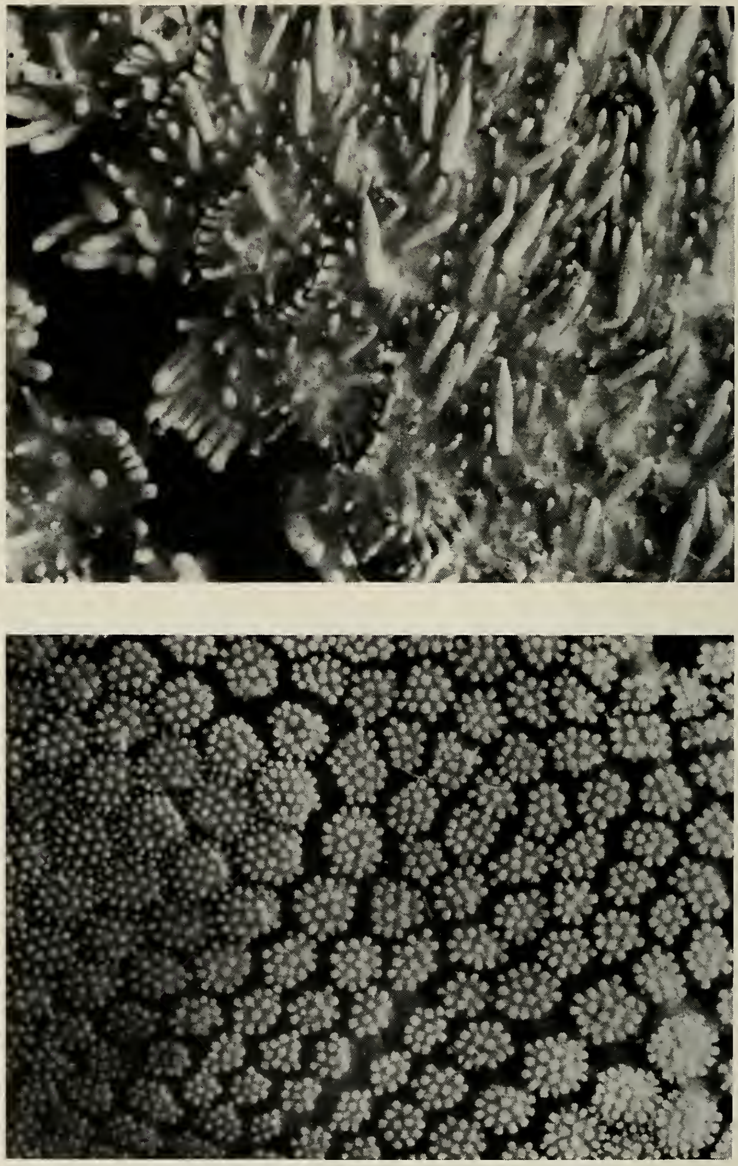

FIG. 2. *Pseudarchaster gracilis* (Sladen), lectotype of *P. concinnus*: top, actinal view, 7×.—bottom, abactinal view, 4×.

*Pseudarchaster concinnus* Verrill, 1894, pp. 250–255; 1895, p. 132; 1899, p. 193, pl. 30, figs. 3–3b.—H. L. Clark, 1941, pp. 31–32.—Madsen, 1951, p. 89.—A. H. Clark, 1954, p. 375.

*Astrogonium gracile.*—Perrier, 1894, pp. 342, 354.

*Astrogonium aphrodite* Perrier, 1894, pp. 342, 354, pl. 21, fig. 2, pl. 23, fig. 2.

*Astrogonium necator* Perrier, 1894, pp. 350–352, pl. 23, fig. 1.—Koehler, 1909, pp. 74–75.

*Pseudarchaster aphrodite.*—Verrill, 1899, p. 195.

*Pseudarchaster necator.*—Verrill, 1899, p. 195.

*Pseudarchaster ordinatus* Verrill, 1899, pp. 194–195, pl. 30, figs. 4–4b.—A. H. Clark, 1954, p. 375.

*Astrogonium eminens* Koehler, 1907, pp. 34–37; 1909, pp. 68–71, pl. 16, figs. 3–6.

*Astrogonium aequabile* Koehler, 1907, pp. 37–40; 1909, pp. 66–68, pl. 11, figs. 1–4.

*Astrogonium marginatum* Koehler, 1909, pp. 71–73, pl. 14, figs. 1–4.

*Pseudarchaster gracilis.*—Mortensen, 1927, p. 86.—Macan, 1938, p. 355.

*Material studied*: 80 specimens. Holotype: $R = 58$ mm, $r = 14$ mm, $R/r = 4.1$; 37°26′N, 25°13′W, 1830 m, *Challenger* sta. 78, 10 July 1873, BMNH 1890.5.7.106.—41°29′N, 65°36′W, 2174 m, *Albatross* sta. 2706, 27 August 1886, USNM 14944 & E11297, 3 spec., (lectotype and paralectotypes of *Pseudarchaster concinnus* Verrill).—40°17′N, 67°26′W, 1515 m, *Albatross* sta. 2533, 15 July 1885, USNM 33315, 4°C, 1 spec.—39°32′N, 29°02′W, 1900 m, *Princesse-Alice* sta. 1334, 13 August 1902, IOM, (holotype of *Astrogonium aequabile* Koehler).—39°20′N, 26°55′W, 1940 m, *Princesse-Alice* sta. 863, 1 August 1897, IOM, 2 spec., (syntypes of *Astrogonium eminens* Koehler).—39°11′N, 30°45′W, 1846 m, *Princesse-Alice* sta. 698, 18 July 1896, 1 spec., (syntype of *Astrogonium eminens* Koehler).—38°40′N, 26°01′W, 1805 m, *Princesse-Alice* sta. 1331, 9 August 1902, IOM, (holotype of *Astrogonium marginatum* Koehler).—38°38′N, 30°41′W, 1258 m, *Talisman* sta. 127, 1883, MNHN 330, 4°C, 3 spec., (syntypes of *Astrogonium necator* Perrier).—29°03′N, 88°16′W, 592 m, *Albatross* sta. 2376, 11 February 1885, USNM 10345, 8°C, 2 spec.—28°34′N, 86°48′W, 613 m, *Albatross* sta. 2396, 13 March 1885, USNM 18438 (holotype of *Pseudarchaster ordinatus* Verrill).—24°17′N, 82°34′W, 320–437 m, R/V *Gerda* sta. 968, 2 February 1968, 1 spec.—16°53′N, 61°55′W, 750–842 m, M/V *Oregon* sta. 6703, 21 May 1967, 2 spec.—16°35′N, 80°10′W, 576 m, M/V *Oregon* sta. 3560, May 1962, 7°C, 2 spec.—15°39′N, 61°10′W, 650 m, M/V *Oregon* sta. 5929, 5 March 1966, 1 spec.—13°31′N, 81°54′W, 549 m, M/V *Oregon* sta. 1920, 12 September 1957, 1 spec.—13°25′N, 82°01′W, 549 m, M/V *Oregon* sta. 1918, 12 September 1957, 1 spec.—13°22′N, 82°04′W, 549 m, M/V *Oregon* sta. 1929, 13 September 1957, 1 spec.—12°44′N, 82°14′W, 641 m, M/V *Oregon* sta. 1911, 11 September 1957, 1 spec.—12°40′N, 82°18′W, 641 m, M/V *Oregon* sta. 1910, 11 September 1957, 1 spec.—12°33′N, 82°20′W, 641 m, M/V *Oregon* sta. 1908, 11 September 1957, 1 spec.—11°49′N, 69°24′W, 366 m, M/V *Oregon* sta. 4421, 4 October 1963, 1 spec.—11°43′N, 69°10′W, 381 m, *Albatross* sta. 2125, 18 February 1884, USNM 7076, 10.5°C, 1 spec.—11°40′N, 62°27′W, 403 m, M/V *Oregon* sta. 2771, 15 April 1960, 3 spec.—11°35′N, 64°35′W, 1409–1629 m, R/V *Pillsbury* sta. 719, 20 July 1968, 5 spec.—11°35′N, 62°41′W, 388–458 m, M/V *Oregon* sta. 2353, 23 September 1958, 5 spec.—11°33′N, 62°09′W, 586–608 m, R/V *Pillsbury* sta. 478, 2 August 1966, 1 spec.—08°11′N, 56°12′W, 2672–2736 m, R/V *Pillsbury* sta. 681, 14 July 1968, 1 spec.—07°46′N, 54°35′W, 547 m, M/V *Oregon* sta. 10602, 10 May 1969, 1 spec.—07°44′N, 54°19′W, 550 m, M/V *Oregon* sta. 4300, 23 March 1963, 6 spec.—07°37′N, 55°24′W, 1221–1336 m, R/V *Pillsbury* sta. 672, 11 July 1968, 8 spec.—07°34′N, 56°21′W, 1318–1345 m, R/V *Pillsbury* sta. 682, 14 July 1968, 3 spec.—07°30′N, 55°29′W, 805 m, M/V *Oregon* sta. 10624, 17 May 1969, 3 spec.—07°21′N, 53°15′W, 550 m, M/V *Oregon* sta. 4294, 21 March 1963, 10°C, 13 spec.—0.3°50′N, 02°33′W, 1949–1986 m, R/V *Pillsbury* sta. 34, 29 May 1964, 1 spec.

*Diagnosis*: Bases of paxillae not imbricate. Actinal and inferomarginal plates covered by both small, terete spinules and long, conical spines. One pectinate pedicellaria between every two adjacent actinal plates along row contiguous to adambulacrals. Five to 10 adambulacral furrow spines; seven to 11 mouth furrow spines.

*Description*: Five arms. R = 109 mm, r = 35 mm, R/r = 3.1.

General form stellate with wide, rounded interbrachial arcs.

Abactinal plates paxillose, extending to terminal plates. Paxillae having short pedicels with rounded tops bearing large, rounded, flattened central granules (tabulate in profile) and one peripheral row of short, slender spinelets. Papulae confined to large radial areas. Six papular pores surrounding each plate, each pore containing single papula.

Superomarginal and inferomarginal plates corresponding; 78 plates in each series. Lateral angle of superomarginals compressed so that plates broad and mainly in vertical plane. Superomarginals about four times as wide as long in interbrachial arc; width decreasing distally so that most distal pair less than twice as wide as long. Superomarginals completely covered by large, rounded, flattened granules; granules along lateral margins about half as large as others. Inferomarginals covered by short, terete spinules interspersed among conical spines about five times larger.

Each actinal plate covered by terete spinules and one to four lanceolate spinules. Actinal spines and spinules similar to those on inferomarginals. One pectinate pedicellaria between every two adjacent actinal plates along row contiguous to adambulacrals; pedicellaria along entire width of plate.

Adambulacral plates rectangular (wider than long); with angular furrow margin bearing six to nine cylindrical furrow spines with blunt tips. Subambulacral spines irregularly arranged; similar to actinal spinules but more widely spaced. One to three long, conical spines in center of each adambulacral plate.

Mouth plates moderately prominent; each plate bearing 11 furrow spines similar to adambulacral furrow spines. Large, thick, unpaired median spine at apex of each mouth plate pair. Rest of each plate covered by 12 or 13 spinules along suture and row of two to four spinules between suture and furrow spines. Proximal spinule in each row similar to and slightly smaller than furrow spines; spinules grading into actinal spinules distally.

Madreporite rhombic, small (about one and one-half times size of adjacent abactinals); located about one-third distance from center of disk to middle of interbrachial arc.

*Type*: British Museum (Natural History) cat. no. 1890.5.7.106.

*Type-locality*: 37°26'N, 25°13'W, 1830 m, *Challenger* sta. 78.

*Distribution*: In the western Atlantic this species is known from the northeast coast of the United States, 41°29'N–40°17'N, 1515–2174 m; and throughout the Caribbean, from the northern Gulf of Mexico to Surinam, 320–2736 m. It is known from the Azores in 1095–1940 m. In the eastern Atlantic it occurs off the west coast of Africa, from the Tropic of Cancer to the equator, 1090–1986 m. The known temperature range is 3.5°–10.5°C.

*Discussion*: The range of R/r is 2.5–3.7; most adult specimens fall between 2.8 and 3.2. The abactinal surface extends to the terminal plates in about 95 percent of the specimens I examined, but several have one to four superomarginals in contact medially. The flattened superomarginal plates of the lectotype of *P. concinnus* are "pushed in," so that they are mainly in the vertical plane. In most specimens the superomarginals are mainly in the horizontal plane. The spines on the actinal and inferomarginal plates are conical and three to five times as long as wide. The actinal surface ranges from very spinose to having scattered spines. Pectinate pedicellariae are always present along the row of actinal plates adjacent to the adambulacrals. There are five to 10 furrow spines and seven to 11 mouth furrow spines.

Most goniasterids release their eggs through the many papular pores but in *Pseudarchaster gracilis* two pores on the edge of each interradius (for each pair of interradial gonads) are enlarged and the unbranched gonoduct leads only to these pores. The presence of these large gonopores suggests that the species produces large, yolky eggs. This type of egg usually either develops directly or gives rise to short-term, nonfeeding larvae.

*Remarks*: It is necessary to designate a lectotype and paralectotypes for *Pseudarchaster concinnus* Verrill. There are eight extant syntypes in the National Museum of Natural History, Smithsonian Institution, from three stations. Four specimens (*Albatross* sta. 2528) are *Mediaster* *bairdi* and one specimen is *Pseudarchaster parelii* (*Albatross* sta. 2060). The three specimens from *Albatross* sta. 2706 are *Pseudarchaster gracilis* (as *Pseudarchaster concinnus*) and I designate the largest specimen (R = 109 mm, r = 35 mm), upon which the original description was based, the lectotype. The two smaller specimens (R = 73 mm and R = 47 mm) are designated paralectotypes.

### *Pseudarchaster parelii* (Düben and Koren, 1846)
Figure 5

*Astropecten parelii* Düben and Koren, 1846, pp. 247–248, pl. 7, figs. 14–16.—Hoffmann, 1882, pp. 8–9.

*Archaster parelii*.—M. Sars, 1861, pp. 35–38, pl. 3, figs. 1–2.—Norman, 1865, pp. 119–120.—Lütken, 1871, p. 236.—Verrill, 1874, p. 504.—Möbius and Bütschli, 1875, p. 148.—Perrier, 1875, pp. 347–348.—Danielssen and Koren, 1881, p. 268.—Verrill, 1882, p. 140; 1885, p. 543, pl. 13, fig. 37.—Appellöf, 1896, p. 11; 1897, p. 13.

*Archaster parelii* var. *longobranchialis* Danielssen and Koren, 1876, p. 17; 1884, pp. 88–89.

*Astrogonium fallax* Perrier, 1885, pp. 37–38; 1894, pp. 347–350, pl. 23, fig. 4, pl. 25, fig. 4.—Koehler, 1909, p. 71, pl. 18, fig. 2.—Grieg, 1921, p. 21, pl. 5, fig. 1.

*Plutonaster* (*Tethyaster*) *parelii*.—Sladen, 1889, p. 102.—Sluiter, 1895, p. 51.

*Pseudarchaster intermedius* Sladen, 1889, pp. 115–116, pl. 19, figs. 3–4, pl. 42, figs. 5–6.—Verrill, 1894, pp. 249–250; 1895, pp. 131–132; 1899, p. 190, pl. 30, figs. 1–1b.

*Plutonaster parelii*.—Bell, 1892, p. 63.—Grieg, 1896, pp. 5, 12; 1897, p. 37.—Ludwig, 1900, pp. 449–450.

*Astrogonium annectens* Perrier, 1894, pp. 343–345, pl. 23, fig. 5, pl. 24, fig. 1.—Koehler, 1895, p. 453.—Perrier, 1896, p. 45.—Koehler, 1909, p. 65.

*Astrogonium hystrix* Perrier, 1894, pp. 345–347, pl. 23, fig. 3, pl. 24, fig. 2.

*Pseudarchaster intermedius* var. *insignis* Verrill, 1895, p. 132.

*Pseudarchaster tessellatus* var. *arcticus* Sluiter, 1895, p. 51.

*Pseudarchaster fallax*.—Verrill, 1899, pp. 190–191, pl. 30, figs. 2–2a.—Koehler, 1921, p. 2.—Macan, 1938, p. 355.

*Pseudarchaster granuliferus* Verrill, 1899, pp. 192–193, pl. 30, figs. 6–6a.—Macan, 1938, p. 355.

*Pseudarchaster annectens*.—Verrill, 1899, p. 195.—Macan, 1938, p. 355.

*Pseudarchaster hystrix*.—Verrill, 1899, p. 195.—Macan, 1938, p. 355.

*Astrogonium longobrachiale* Koehler, 1907, pp. 30–33.

*Astrogonium parelii* var. *longobrachiale*.—Koehler, 1909, pp. 75–83, pl. 14, figs. 8–12, pl. 15, figs. 7–8, 10–12.—Mortensen, 1913, p. 329.

*Tethyaster parelii*.—Süssbach and Breckner, 1911, pp. 202–203.

*Pseudarchaster parelii*.—Fisher (pars), 1911, pp. 202–203.—Farran, 1913, pp. 13–14.—Mortensen, 1924, p. 20.—Koehler, 1924, pp. 180–182, pl. 3, figs. 14–16.—Mortensen, 1927, pp. 87–88, fig. 49.—Macan, 1938, p. 356.—Einarsson, 1948, p. 10.—Djakonov, 1950, pp. 44–45, fig. 184.

*Astrogonium parelii.*—Grieg, 1912, pp. 5–6.

*Material studied:* 87 specimens. 72°26′N, 18°00′W, 366 m, BMNH 1969.6.12.136, 4.5°C, 1 spec.—61°10′N, 00°34′E, 132 m, BMNH 1947.-8.15.608, 1 spec.—Shetland Islands, 311 m, BMNH 1900.4.1.381, 1 spec.—Hardangerfjord, coll. Norman, BMNH 98.5.3.1056, 2 spec.—59°13′N, 04°35′E, 213 m, BMNH 1947.8.15.607, 2 spec.—44°01′N, 63°20′W, 202 m, *Speedwell* sta. 108, 20 September 1877, USNM 33289, 2°C, 1 spec.—43°32′N, 59°22′W, 202 m, *Albatross* sta. 2704, 23 August 1886, USNM 14982, 1 spec.—43°03′N, 63°39′W, 156 m, *Challenger* sta. 49, 20 May 1873, BMNH 90.5.7.105, 1.5°C, 4 spec., (syntypes of *Pseudarchaster intermedius* Sladen).—42°49′N, 68°50′W, 95–165 m, *Bache* sta. 21, 16 September 1873, USNM 24558, 6°C, 1 spec.—42°10′N, 66°46′W, 225 m, *Albatross* sta. 2060, 31 August 1883, USNM 21641, 1 spec. (syntype of *Pseudarchaster concinnus* Verrill).—41°47′N, 65°38′W, 1240 m, *Albatross* sta. 2528, 13 July 1885, USNM 11285, 3.5°C, 1 spec.—41°41′N, 65°46′W, 222 m, *Albatross* sta. 2526, 13 July 1885, USNM 12083, 1 spec.—40°10′N, 67°09′W, 2480 m, *Albatross* sta. 2571, 1 September 1885, USNM 11818, 3°C, (holotype of *Pseudarchaster intermedius* var. *insignis* Verrill).—39°57′N, 69°16′W, 838 m, *Fish Hawk* sta. 1029, 14 September 1881, USNM 24560 & 24800, 4.5°C, 3 spec.—39°55′N, 70°28′W, 725 m, *Fish Hawk* sta. 952, 23 August 1881, USNM 9960, 4.5°C, 1 spec.—39°52′N, 70°56′W, 609 m, *Albatross* sta. 2186, 2 August 1884, USNM 8026 & 24561, 4.5°C, 4 spec.—39°49′N, 71°02′W, 667–891 m, *Fish Hawk* sta. 893, 2 October 1880, USNM 9741 & 24559, 4.5°C, 12 spec.—39°23′N, 33°46′W, 1384 m, *Princesse-Alice* sta. 213, 2 August 1888, IOM, 1 spec.—39°17′N, 70°32′W, 896 m, *Albatross* sta. 2214, 22 August 1884, USNM 7945, 4°C, 1 spec.—38°38′N, 73°11′W, 445 m, *Albatross* sta. 2232, 12 September 1884, USNM 8108, 6°C, 2 spec.—38°37′N, 30°41′W, 1258 m, *Talisman* sta. 126, August 1883, MCZ 48, 3.5°C, 2 spec., (syntypes of *Astrogonium fallax* Perrier).—38°35′N, 73°05′W, 1015 m, *Albatross* sta. 2744, 18 September 1886, USNM 16248 & 16303, 4°C, 2 spec.—38°28′N, 73°22′W, 796 m, *Fish Hawk* sta. 1049, 10 October 1881, USNM 4121 & 9742, 4.5°C, 5 spec.—38°20′N, 28°05′W, 1550 m, *Princesse-Alice* sta. 683, 7 July 1896, IOM, 1 spec.—37°59′N, 73°49′W, 813 m, *Albatross* sta. 2171, 20 July 1884, USNM 7659, 4°C, 1 spec.—37°35′N, 31°46′W, 1440 m, *Talisman* sta. 131, 12 August 1883, MNHN 326c, 4 spec., (syntypes of *Astrogonium fallax* Perrier).—32°39′N, 76°51′W, 875 m, *Albatross* sta. 2677, 6 May 1886, USNM 18443, 4°C, 6 spec.—32°28′N, 77°21′W, 645 m, *Albatross* sta. 2626, 21 October 1885, USNM 18446, 3 spec.—32°24′N, 76°56′W, 966 m, *Albatross* sta. 2628, 21

October 1885, USNM 18434, 2 spec.—24°33′N, 84°23′W, 3532 m, *Blake* sta. 31, 1877–78, MNHN 331, 2 spec.—23°21′N, 80°23′W, 869 m, *Atlantis* sta. 2991, 14 March 1938, MCZ 3928, 2 spec.—20°44′N, 18°07′W, 1495 m, *Talisman* sta. 96, 14 July 1883, MNHN 327, 4.5°C, 14 spec.—16°54′N, 63°12′W, 1260 m, *Albatross* sta. 2751, 28 November 1887, USNM 18448, 4.5°C, (holotype of *Pseudarchaster granuliferus* Verrill).

*Diagnosis.*—Bases of paxillae imbricate. Actinal and inferomarginal spines lanceolate, never more than three times as long as wide. Actinal pectinate pedicellariae variable. Four to seven adambulacral furrow spines; six to eight mouth furrow spines.

*Description.*—Five arms. R = 48 mm, r = 17 mm, R/r = 2.8.

General form stellate with wide, rounded interbrachial arcs.

Abactinal plates paxillose, extending to terminal plates. Paxillae having short pedicels with rounded tops bearing large, rounded, flattened central granules (tabulate in profile) and one peripheral row of short, slender spinelets. Bases of paxillae six lobed, imbricate. Papulae confined to large radial areas. Six papular pores surrounding each plate, each pore containing single papula.

Superomarginal and inferomarginal plates corresponding; 64 plates in each series. Lateral angle of superomarginals compressed so that plates broad and mainly in vertical plane. Superomarginals three to four times as wide as long in interbrachial arc; width decreasing distally so that most distal pair slightly less than twice as wide as long. Superomarginals completely covered by large, rounded, flattened granules; granules along lateral margins about half as large as others. Inferomarginals covered by squamiform granules; one to six enlarged into flattened, lanceolate spinules one to four times larger.

Each actinal plate covered by squamiform granules similar to those on inferomarginals. Some plates bearing one or two flattened, lanceolate spinules. Proximal actinal plates bearing pectinate pedicellariae formed by marginal granules of adjacent plates.

Adambulacral plates approximately square; with angular furrow margin bearing five to seven cylindrical furrow spines with blunt tips. Subambulacral spines irregularly arranged; first one or two irregular rows about two-thirds as tall as furrow spines; one or two more irregular rows similar to actinal granules.

Mouth plates moderately prominent; each plate bearing six furrow spines similar to adambulacral furrow spines. Large, thick, unpaired median spine at apex of each mouth plate pair. Rest of each plate covered by 10 spinules along suture and row of two to four spinules between suture and furrow spines. Proximal spinule in each row similar to and slightly smaller than furrow spines; spinules grading into actinal spinules distally.

Madreporite rhombic, small (about one and one-half times size of adjacent abactinals); located about one-third distance from center of disk to middle of interbrachial arc.

*Type*: Not traced.

*Type-locality*: Off Kristiansund, Norway, 550 m.

*Distribution*: In the western Atlantic this species is known from the northeast coast of the United States (44°26′N to Florida) and the West Indies, 100–3000 m. It is known from Greenland (366 m) and the Azores (1250–1400 m). In the eastern Atlantic it is known from off Norway from the Murman coast south to Christiana (72°N–58°N); the Shetland Islands and Ireland. The bathymetric range in the eastern Atlantic is 75–2500 m. The known temperature range is 1.5°–6°C.

*Discussion*: Because pectinate pedicellariae may be absent, poorly formed or well formed, a discussion of them is pertinent. I have observed live specimens of *Pseudarchaster* which appeared to have no pedicellaria, but in which groups of spines acted as pedicellariae. When the animals were preserved there were no signs of pedicellariae. In some specimens the pedicellariae are well formed and obvious, but in others they are poorly formed.

The enlarged spinules of the actinal and inferomarginal plates range from absent to several on each plate. They are always flattened and lanceolate and never more than three times longer than wide.

The R/r ranges from 2.2 to 3.4. The long and short armed forms are each represented in the major faunal provinces. Specimens with no enlarged spines (the basis for the establishment of *P. granuliferus*) are similarly distributed.

This species, like many other goniasterid species, has a wide geographic and bathymetric range. There is also a wide range of such prominent characters as general form (R/r) and the actinal granulation. I have carefully analyzed a large number of characters for a large number of specimens and could find no basis for separation.

*Pseudarchaster tessellatus* is very close to *P. parelii* and they may be conspecific. A better knowledge of the Mauritanean region may show continuous distribution along the eastern Atlantic, as in the western Atlantic.

*Pseudarchaster parelii* differs from *P. gracilis* in having the bases of the paxillae imbricate; often lacking or having poorly developed pedicellariae; having short, flattened, lanceolate spines on the actinal and inferomarginal plates; and having fewer adambulacral and mouth furrow spines.

*Pseudarchaster discus*, from the Magellanic region, is closely related to *P. parelii* and differs from it by having a pectinate pedicellaria along the suture of each mouth plate pair and having longer, more conical, more numerous spinules on the actinal and inferomarginal plates.

The species from the Pacific that Fisher (1911) considered to be *Pseudarchaster parelii* with the subspecies *P. parelii alascensis*, is a separate species, *Pseudarchaster alascensis* Fisher. *P. alascensis* differs from *P. parelii* in many small ways, but the major distinction is that it bears spines on the aboral surface of its mouth plates.

### *Pseudarchaster tessellatus* Sladen, 1889

Figures 3–4

*Pseudarchaster tessellatus* Sladen, 1889, pp. 112–114, pl. 17, figs. 3–4, pl. 18, figs. 9–10.—Verrill, 1899, p. 195.—H. L. Clark, 1923, pp. 253–254; 1926, p. 9.—Mortensen, 1933, pp. 240–241.

*Pseudarchaster brachyactis* H. L. Clark, 1923, pp. 254–256, pl. 12, figs. 1–2; 1926, pp. 8–9, pl. 2, figs. 1–2.—Madsen, 1950, pp. 211–212, fig. 10.

*Material studied*: 14 specimens. Syntypes: R = 48 mm, r = 16 mm, R/r = 3.0; R = 32, r = 11, R/r = 2.9; 34°41′N, 18°36′W, 179 m, *Challenger* sta. 141, 17 December 1873, 10°C, BMNH 90.5.7.104.—05°05′N, 04°01′W, 403–586 m, R/V *Pillsbury* sta. 44, 30 May 1964, UMML 40.123, 1 spec.—South West Africa, west of Roast Beef Island, 567 m, *Pickle* sta. 342, 4 May 1921, MCZ 2846, 1 spec.—Cape Colony, west of Saldanha Bay, 168 m, *Pickle* sta. 53, 27 April 1920, MCZ 2848, 2 spec.—Cape Colony, WSW from Saldanha Bay, 561 m, *Pickle* sta. 41, 9 April 1920, MCZ 2847, 2 spec.—off Table Mountain, Cape of Good Hope, 458 m, BMNH 1903.8.1.73-7, 5 spec.—38 miles NE of Cape Point, 576–732 m, *Pieter Faure* sta. 17965, MCZ 2565, 1 spec.

*Diagnosis*: Bases of paxillae imbricate. Actinals mainly covered by granules; sometimes bearing scattered, incipient, lanceolate spines. Actinal pedicellariae variable. Five to seven adambulacral furrow spines.

*Description:* Five arms. R = 40 mm, r = 20 mm, R/r = 2.

General form stellate with short, broad, arms. Interbrachial arcs wide, rounded.

Abactinal plates low paxillae; each plate bearing one to six prismatic central granules and eight to fourteen slightly smaller peripheral granules.

Papulae confined to large radial areas. Six papular pores surrounding each plate, each pore bearing single papula.

Superomarginal and inferomarginal plates corresponding; 36 plates in each series. Lateral angle of marginals depressed so that plates very broad and mainly in horizontal plane. Superomarginals about five times as wide as long in interbrachial arc; width decreasing distally so that most distal pair less than two times as wide as long. Superomarginals completely covered by large, rounded, closely crowded granules. No superomarginals in contact medially; abactinal surface extending to terminal plate. Terminal plate small, heart-shaped.

Inferomarginals about four times as wide as long in interbrachial arc, becoming almost square distally. Outer third of inferomarginals covered by rounded granules slightly larger and taller than those on supero-

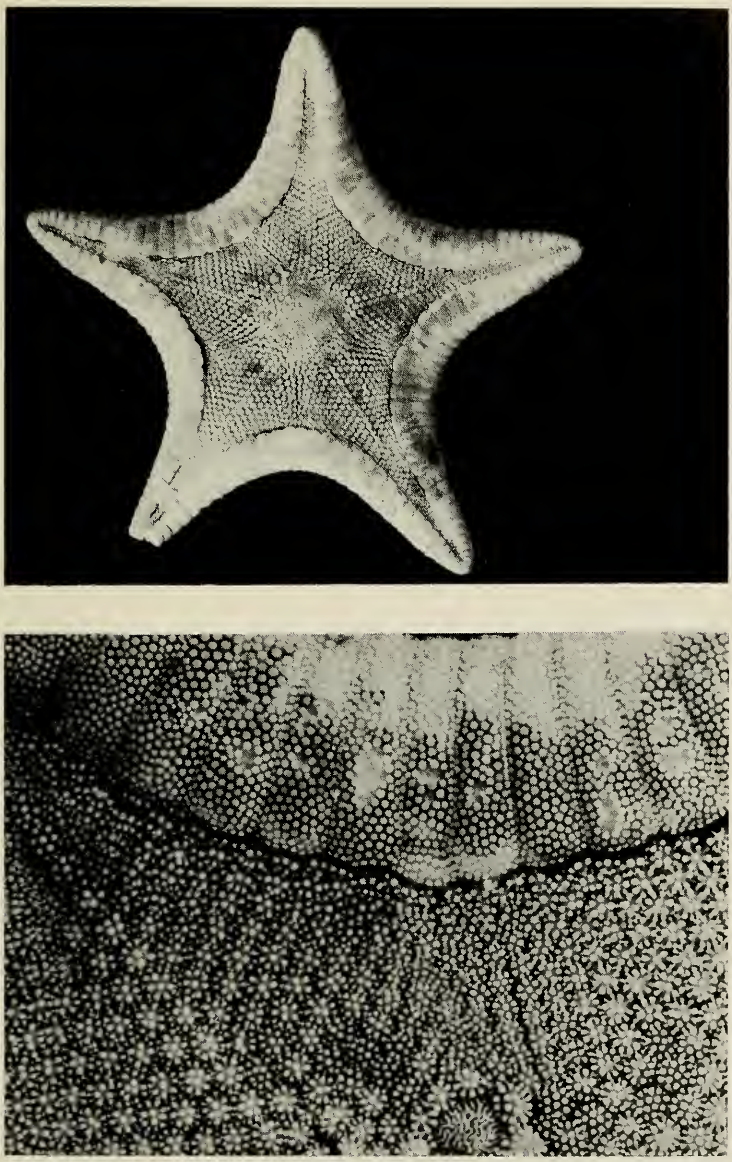

FIG. 3. *Pseudarchaster tessellatus* Sladen, specimen from R/V *Pillsbury* sta. 44: top, abactinal view, 0.8×.—bottom, abactinal view, 5×.

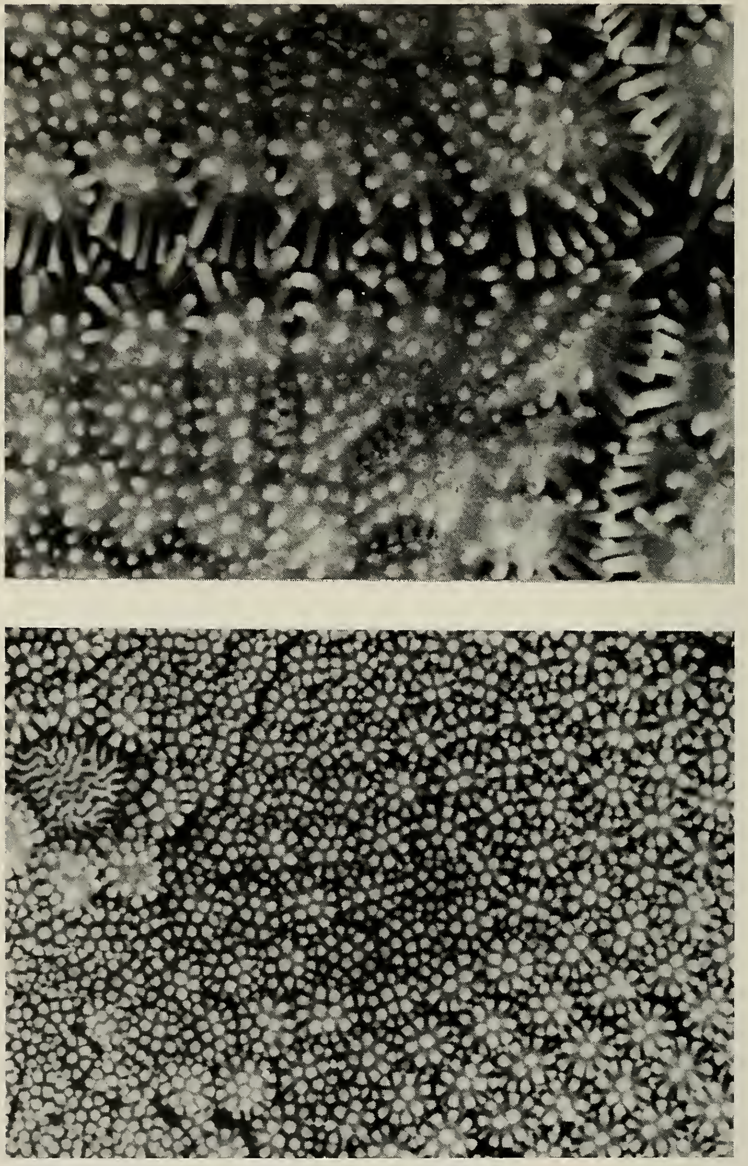

FIG. 4. *Pseudarchaster tessellatus* Sladen, specimen from R/V *Pillsbury* sta. 44: top, actinal view, 8.5×.—bottom, abactinal view, 11×.

marginals. Inner two-thirds bearing rounded granules slightly smaller than those of superomarginals; one to six granules enlarged into short, stout, conical spines.

Actinal intermediate area restricted to disk. Actinal plates covered by rounded granules similar to those on inner portion of inferomarginals. Proximal actinal plates bearing pectinate pedicellariae formed by marginal granules of adjacent plates.

Adambulacral plates slightly longer than wide. Angular furrow margin bearing five to seven long, blunt furrow spines; longest spines in center of each series. Subambulacral spines in two to three irregular rows of three to five short, blunt spinules grading into actinal granules.

Mouth plates moderately prominent; each plate bearing seven furrow spines similar to adambulacral furrow spines. Large, thick, unpaired median spine at apex of each mouth plate pair. Rest of each plate covered by row of nine spinules along suture and row of six spinules between suture and furrow spines. Proximal spinule in each row similar to and slightly smaller than furrow spines; spinules grading into actinal granules distally.

Madreporite rhombic, two to three times as large as adjacent abactinals; located one-third distance from center of disk to middle of interbrachial arc.

*Type*: British Museum (Natural History), cat. no. 90.5.7.104 (2 syntypes).

*Type-locality*: False Bay, South Africa, 34°41′N, 18°36′W, 179 m, *Challenger* sta. 141.

*Distribution*: This species is found on the west coast of Africa, from Cape Palmas to Capetown, 168–732 m. The only known temperature record is 10°C.

*Discussion*: *Pseudarchaster brachyactis* was separated from *P. tessellatus* on the basis of its shorter arms, wider marginal plates and the greater number of abactinal plates along the arms (H. L. Clark, 1923 and 1926). Some of the specimens I examined are intermediates and I consider the characters used for separating the species to be invalid. This case is very similar to the long-armed and short-armed forms found in *Pseudarchaster parelii*. In fact, *Pseudarchaster tessellatus* is very similar to *P. parelii* and may prove to be a junior synonym.

### *Paragonaster* Sladen, 1885

*Paragonaster* Sladen, 1885, p. 617; 1889, p. 310.—Perrier, 1894, pp. 355–358.—Fisher, 1911, p. 163.

*Diagnosis*: Single row of large, flat (not paxilliform) abactinal plates along most of arm; always reaching terminal plate. Unpaired (but not recurved) median spine at apex of each mouth plate pair.

*Type-species*: *Paragonaster ctenipes* (by subsequent designation: Fisher, 1919, p. 228).

### A key to the species of *Paragonaster* from the Atlantic

1. R/r greater than four; actinal plates bearing scattered, small spines .......... *subtilis*
   R/r less than three; actinal plates bearing crowded, large spines .......... *grandis*

### *Paragonaster subtilis* (Perrier, 1881)

Figures 5–6

*Goniopecten subtilis* Perrier, 1881, p. 26; 1884, pp. 168, 183, 187, 253–254, pl. 5, figs. 3–4; 1885a, p. 41; 1885b, p. 884.—Sladen, 1889, p. 726.

*Archaster formosus* Verrill, 1884, pp. 383–384; 1885, pp. 519, 543.

*Pentagonaster elongatus* Perrier, 1885a, p. 38.

*Paragonaster cylindratus* Sladen, 1889, pp. 311, 314–318, 655, 693, 713, 752, pl. 51, figs. 3, 4, pl. 53, figs. 3, 4.—Perrier, 1894, p. 357.—Verrill, 1894, p. 257; 1899, p. 196.

*Paragonaster formosus.*—Verrill, 1894, p. 257; 1895, p. 137; 1899, p. 196.

*Paragonaster elongatus.*—Perrier, 1894, pp. 35, 357, 362–363, pl. 21, fig. 3, pl. 24, fig. 4.—Verrill, 1899, p. 196.

*Paragonaster strictus* Perrier, 1894, pp. 35, 357, 363–365, pl. 25, fig. 5.—Verrill, 1899, p. 196.

*Paragonaster subtilis.*—Perrier, 1894, pp. 31, 35, 40, 357, 358–362, pl. 23, fig. 5, pl. 24, fig. 3.—Verrill, 1899, p. 196.—Koehler, 1909, pp. 86–87, pl. 4, fig. 2.—Grieg, 1921, pp. 20–21.—Mortensen, 1927, p. 79.—Macan, 1938, p. 361.—Madsen, 1951, p. 89.

*Material studied*: 36 specimens. Holotype: R = 60 mm, r = 13 mm, R/r = 4.6; 24°33′N, 84°23′W, 3514 m, *Blake* sta. 31, 1877–78, MCZ 464, 4°C.—39°49′N, 70°32′W, 1058 m, *Albatross* sta. 2215, 22 August 1884, USNM 6621, 4°C, 1 spec.—39°49′N, 68°29′W, 2675 m, *Albatross* sta. 2043, 30 July 1883, USNM 9081, 3.5°C, 4 spec., (syntypes of *Archaster formosus* Verrill).—39°33′N, 68°27′W, 2846 m, *Albatross* sta. 2042, 30 July 1883, USNM 9083 & 14294, 3.5°C, 8 spec., (syntypes of *Archaster formosus* Verrill).—39°23′N, 68°25′W, 2943 m, *Albatross* sta. 2041, 30 July 1883, USNM 9082 & 14295, 3.5°C, 4 spec., (syntypes of *Archaster formosus* Verrill).—39°22′N, 71°24′W, 2543 m, *Albatross* sta. 2564, 11 August 1885, USNM 12045, 3°C, 1 spec.—39°19′N, 71°24′W, 2602 m, *Albatross* sta. 2563, 11 August 1885, USNM 12046, 3°C, 1 spec.—38°59′N, 70°07′W, 2826 m, *Albatross* sta. 2711, 16 September 1886, USNM 15168, 1 spec.—38°38′N, 27°26′W, 2995 m, *Talisman* sta. 131, 22 August 1883, MNHN 332, 3 spec., (syntypes of *Pentagonaster elongatus* Perrier).—38°22′N, 70°18′W, 3341 m, *Albatross* sta. 2714, 17 September 1886, USNM 15171, 1 spec.—38°20′N, 79°09′W, 3402 m, *Albatross* sta. 2713, 17 September 1886, USNM 15174, 1 spec.—

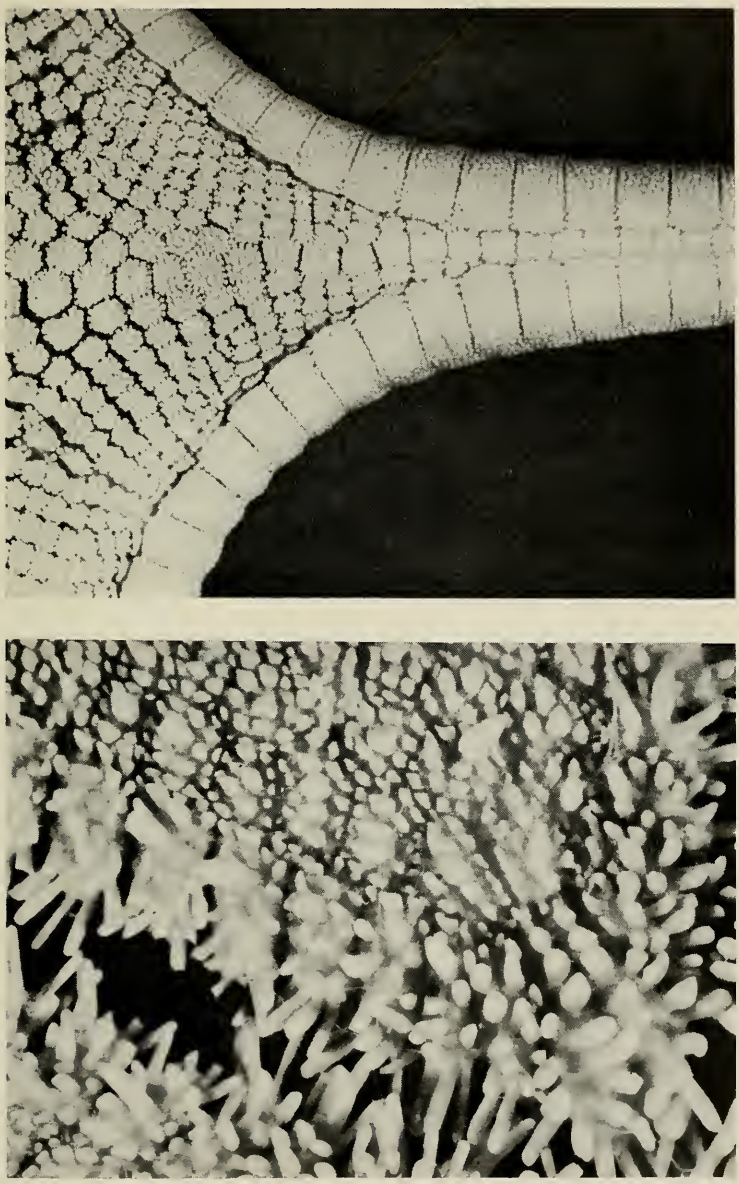

FIG. 5. Top, *Paragonaster subtilis* (Perrier), syntype of *P. formosus*, abactinal view, 3×.—bottom, *Pseudarchaster parelii* (Düben & Koren), holotype of *P. intermedius* var. *insignis*, actinal view, 7×.

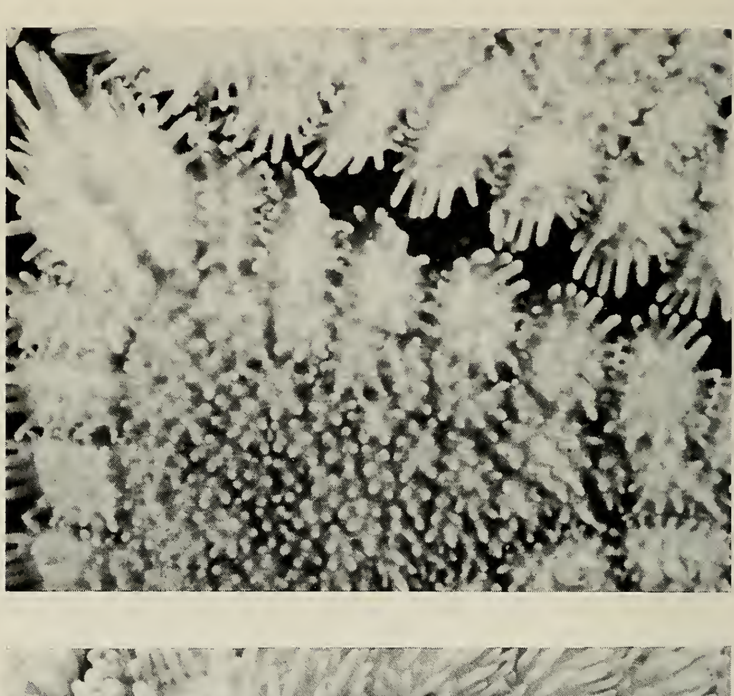

FIG. 6. Top, *Paragonaster subtilis* (Perrier), syntype of *P. formosus*, actinal view, 7×.—bottom, *Paragonaster grandis* H. L. Clark, specimen from M/V *Oregon* sta. 4226, actinal view, 5.5×.

38°15′N, 72°03′W, 2917 m, *Albatross* sta. 2174, 21 July 1884, USNM 7963, 1 spec., (syntype of *Archaster formosus* Verrill).—38°09′N, 23°17′W, 4020 m, *Princesse-Alice* sta. 527, 25 June 1895, IOM, 2 spec.—37°17′N, 20°14′W, 4275 m, *Princesse-Alice* sta. 1306, 29 July 1902, IOM, 1 spec.—37°00′N, 71°54′W, 3742 m, *Albatross* sta. 2226, 10 September 1884, USNM 8151, 2.5°C, 2 spec., (syntypes of *Archaster formosus* Verrill).—36°55′N, 22°23′W, 4261 m, *Princesse-Alice* sta. 652, 23 June 1896, IOM, 1 spec.—16°12′N, 24°44′W, 3890 m, *Princesse-Alice* sta. 1150, 25 July 1901, IOM, 1 spec.—25°27′N, 86°06′W, 3103 m, R/V *Alaminos* sta. 68-A-7/4A, 28 July 1968, USNM 279503, 1 spec.—15°48′N, 22°43′W, 3655 m, *Talisman* sta. 102, 19 July 1883, MNHN 333, 3 spec., (syntypes of *Paragonaster strictus* Perrier).—Same as above (*Talisman* sta. 102), MNHN 323b, 1 spec., (labeled *subtilis*).—01°47′N, 24°26′W, 3386 m, *Challenger* sta. 106, 25 August 1873, BMNH 1890.5.7.441, 2.5°C, 2 spec., (syntypes of *Paragonaster cylindratus* Sladen).

*Diagnosis*: Adults with R/r ratio greater than four. Abactinal plates along arms not wider than long. Inferomarginal and actinal plates not strongly spinose, but at least some actinals bearing spines. Five to eight adambulacral furrow spines.

*Description*: Five arms. R = 73 mm, r = 17 mm, R/r = 4.3.

General form stellate, with long, narrow arms.

Abactinal surface paxillose, extending to terminal plates. Paxillae having short pedicels with rounded tops bearing large, rounded flattened central granules (tabulate in profile) and one peripheral row of short, slender spinelets. Single row of large, flat, rectangular abactinals beyond seventh superomarginal, about twice as long as wide. Papulae in large radial areas; lacking in interradial areas, small center of disk and on arms. Six papular pores surrounding each plate, each pore containing single papula.

Superomarginal and inferomarginal plates corresponding; 84 plates in each series. Lateral angle of marginals depressed so that plates broad and mainly in horizontal plane. Superomarginals about three times as wide as long in interbrachial arc; width decreasing distally so that most distal pair less than twice as wide as long. Superomarginals completely covered by large, rounded, flattened granules; granules along lateral margin about half as large as others. Inferomarginal plates covered by spaced, short, terete spinules and six to 10 lanceolate spines, three to four times as large as other spinules.

Actinal plates covered by spaced, terete spinules slightly taller than those on inferomarginals. Most plates covered only by these spinules but some also bearing one or two lanceolate spines slightly taller than those on inferomarginals.

Adambulacral plates large, rectangular (wider than long); with curved furrow margin bearing five to eight cylindrical furrow spines with blunt tips. Subambulacral spines irregularly arranged; similar to actinal spinules but more widely spaced. One to three lanceolate spines in center of each adambulacral plate.

Mouth plates convex; prominent. Each plate bearing eight to 10 furrow spines similar to those of adambulacrals but slightly larger. Each mouth plate pair bearing single unpaired median spine; median spine about one and one-half times larger than other furrow spines. Rest of mouth plate covered by scattered spinules similar to those on actinals but slightly larger. Spines on oral half along suture enlarged, about one and one-half times larger than others.

Madreporite small, rhombic; located approximately one-half distance from center of disk to middle of interbrachial arc.

*Type*: Museum of Comparative Zoology, cat. no. 464.

*Type-locality*: 24°33′N, 84°23′W, 3514 m, *Blake* sta. 31.

*Distribution*: In the western Atlantic this species occurs along the northeast coast of the United States, 41°07′N–37°00′N, 2455–3742 m, and from the Gulf of Mexico, 3103–3514 m. It is known from the Azores in 2995–4275 m. In the eastern Atlantic it is known from the Bay of Biscay, 4700 m, and the Cape Verde Islands 3386–3890 m. The known temperature range is 1.5°–4°C.

*Discussion*: There is a strong positive allometric growth of the arms in this species. Eighteen specimens with $r = 5–10$ mm had $R/r$ ratios of 2.2–3.8 and eight specimens with $r = 11–16$ mm had $R/r$ ratios of 3.8–4.6. All except two specimens had $R/r$ greater than 3.3. These two specimens measure only $R = 11$ mm, $r = 5$ mm and $R = 15$ mm, $r = 6$ mm.

The spination of the actinal surface varies, but it is never strongly spinose and in adults at least some of the actinal plates bear spines.

*Remarks*: The many nominal species of *Paragonaster subtilis* have already been synonymized by Grieg (1921), Mortensen (1927), Macan (1938) and Madsen (1951).

This species is not closely related to *P. grandis* and more closely resembles the Indo-Pacific species of this genus.

### *Paragonaster grandis* H. L. Clark, 1941

Figure 6

*Paragonaster grandis* H. L. Clark, 1941, pp. 32–34, pl. 4, fig. 1.—A. H. Clark, 1954, p. 375.

*Material studied*: 3 specimens. Holotype, $R = 80$ mm, $r = 27$ mm, $R/r = 3.0$; 23°10′N, 81°29′W, 311–467 m, *Atlantis* sta. 3000, 21 March 1938, MCZ 3816.—23°06′N, 79°40′W, 540 m, *Atlantis* sta. 3439, 2 May 1939, MCZ 3936, 1 spec. (paratype).—00°18′N, 44°17′W, 275 m, M/V *Oregon* sta. 4226, 9 March 1963, UMML 40.163, 8.5°C, 1 spec.

*Diagnosis*: R/r less than three. Superomarginals five times as wide as long in interbrachial arc. Seven to 10 adambulacral furrow spines; subambulacral spines large, crowded.

*Description:* Five arms. R = 85 mm, r = 35 mm, R/r = 2.4.

General form stellate.

Abactinal surface paxillose, extending to terminal plates. Each paxilla consisting of convex base and short, broad pedicel. Each pedicel bearing large, rounded, flattened central granules and one peripheral row of short, slender spinelets. Single row of large, flat, rectangular abactinals beyond seventh superomarginal; about four times as wide as long proximally, becoming square distally.

Papulae in large radial areas; lacking in large interradial areas, small center of disk and on arms.

Superomarginal and inferomarginal plates corresponding; 58 plates in each series. Lateral angle of marginals depressed so that plates very broad and mainly in horizontal plane. Superomarginals about five times as wide as long in interbrachial arc; width decreasing distally so that most distal pair less than twice as wide as long. Superomarginals completely covered by large, rounded, flattened granules; granules along lateral margin very small, chisel-shaped. Inferomarginals completely covered by closely crowded lanceolate spines; lateral margins bearing small spinelets.

Actinal plates bearing peripheral row of slender spinelets and central group of lanceolate spines similar to those on inferomarginals.

Adambulacral plates large, rectangular (wider than long); with slightly curved furrow margin bearing eight to 10 cylindrical furrow spines with blunt tips. Subambulacral spines irregularly arranged; similar to actinal spines but slightly larger.

Each mouth plate bearing nine to 10 furrow spines similar to those of adambulacrals but slightly larger. Each mouth plate pair bearing single unpaired median spine; median spine slightly larger than other furrow spines. Rest of mouth plate covered by closely crowded spinules similar to subambulacral spinules of adambulacral plates.

Madreporite very small, rhombic; located approximately one-third distance from center of disk to middle of interbrachial arc.

*Type*: Museum of Comparative Zoology, cat. no. 3816.

*Type-locality*: 23°10′N, 81°29′W, 311–467 m, *Atlantis* sta. 3000.

*Distribution*: This species is known from the northern coast of Cuba and from off Brazil, near the equator. The bathymetric range is 275–540 m. The only temperature record is 8.5°C.

*Remarks*: This species is very distinctive and differs from all the other known species of *Paragonaster* by its small R/r ratio, spinose actinal surface, and large number of adambulacral furrow spines.

H. L. Clark (1941, p. 34) states, "This fine sea-star resembles *Pseudarchaster concinnus* so much not merely in general form and proportions but in the paxillae and the armature of the marginal, actinal and even the adambulacral plates that it was at first supposed to be simply a peculiar adult stage of the species . . . ." The armature of the inferomarginal, actinal and adambulacral plates of *Paragonaster grandis* is very different from that of *Pseudarchaster concinnus.*

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Vol. 85, No. 31, pp. 385–388 30 December 1972

PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

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# THE TYPES OF PLUSIINE NOCTUIDS DESCRIBED BY J. B. SMITH (LEPIDOPTERA)

By E. L. Todd
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The following comments pertaining to type-material of four species of plusiine noctuid moths described by J. B. Smith have been taken from my collective study of the types of Noctuidae described by that author. They are presented separately at this time to facilitate publication of a study of the subfamily Plusiinae in North America by Thomas Eichlin.

Two of the species treated were described by Smith in 1895 in a paper titled "Descriptions of new species of Noctuidae." The paper was published in two parts in successive numbers of Entomological News. The first part was in the "December" number of volume 6. This number was mailed November 30, 1895. The second part appeared in the first number of volume 7 and it was mailed on December 18, 1895. The first part of Smith's paper contains a short introduction in which he states (p. 332) that the species described were collected by F. H. Wolley Dod, Calgary, Canada, written descriptions of 10 species (pp. 332–339), plate XV with an illustration of an adult of each of 17 species, and an explanation of plate XV (p. 340) which is composed of a list of the names of the 17 species. For the seven species lacking a written description in this part, publication of a figure in association with the name validates the names proposed (International Code, Articles 12, 16a(vii). In my opinion the specimens figured are the holotypes, the names being based on single specimens,

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but to assure that the illustrated specimen is considered to be the type-specimen by all, lectotype designations will also be made when necessary.

*Plusia angulidens* Smith, 1891, Trans. Amer. Ent. Soc., 18(2):111. "*Hab.*—Colorado (Bruce)." "Several specimens were taken by Mr. Bruce, who has also taken *P. snowi* in some numbers." Smith, 1893, U.S.N.M. Bull. 44, p. 255 stated: "Types are in the National Museum, the Neumoegen collection, and in the Rutgers College collection."

Syntypes examined: 2 (USNM)

1) "Plusia angulidens Smith Type"; "Colo. Bruce"; "Type No. 34105"; "Collection Brkyln. Mus." [A ♀.]
2) "Plusia angulidens Smith"; "Colo. Bruce"; "Type No. 276 U.S.N.M."; "Acc. no. 25975"; "♀ genitalia on slide 534, J. F. G. Clarke"

*Discussion*: Only one specimen has been located that is marked as a type by Smith. The second syntype listed is so considered, even though it is not marked type by Smith, because Smith sent it to the USNM as a type of the species. There are other specimens in the National Museum of Natural History, Smithsonian Institution labeled "Colo. Bruce," but they are all also labeled as being from the William Schaus or the Barnes collections. Rindge, 1955, Bull. Amer. Mus. Nat. Hist. 106:101, did not record any specimens as having been received with the material from Rutgers. In view of these facts, it is difficult to understand Smith's statement in 1893 to the effect that types were in the National Museum, the Neumoegen collection, and in the Rutgers College collection. The specimen marked "Type" by Smith now in the National Museum of Natural History has been selected, labeled, and is now designated lectotype.

*Behrensia hutsonii* Smith, 1904, Psyche, 11(2):60.

"*Habitat*: Yuma County, Arizona, in March, Mr. Hutson." "One male and one female, both in good condition save that the antennae are gone."

Syntypes examined: 2 (AMNH)

1) "Behrensia hutsonii Smith ♂ type"; "Yuma Co., Ariz."; "3/23"; "Collection J. B. Smith" [Good condition and complete.]
2) "Behrensia hutsonii Smith ♀ type"; "Yuma Co., Ariz."; "Collection J. B. Smith" [A ♂, in fair condition, abdomen greasy.]

*Discussion*: The second male that was marked "♀ type" by Smith has had the original label modified by a mark through the female sex symbol preceding the word "type." This fact was noted by F. H. Rindge, 1955, Bull. Amer. Mus. Nat. Hist. 106:115, but he stated that the specimen was labeled "type female," and that the words had been crossed out on the label. The specimen marked "♂ type" in the American Museum of Natural History has been selected, labeled, and is presently designated as the lectotype.

*Plusia insolita* Smith, 1895, Ent. News, 6:340, pl. 15, fig. 17.

"EXPLANATION OF PLATE XV. 17.—*Plusia insolita* n. sp." On page 332 Smith stated: ". . . the specimens were all collected by Mr. F. H. Wolley Dod, Calgary, Canada."

Smith, 1895, Ent. News 7(1):30 refers to pl. 15, fig. 17 of the previous issue, provides a written description, and states: "*Hab.*—Calgary, in 1894." "Two specimens, both females, were sent me by Mr. Dod, who says "they are rare."

*Holotype*: In the National Museum of Natural History, Washington, D.C. The specimen is labeled: "Plusia insolita Smith Type 1"; "Calgary, 1894, (A. H.)"; "Type No. 15 USNM." It is a male! It is the specimen figured on plate 15. The other specimen referred to in the first number of volume 7 on Ent. News, page 30 is in the American Museum of Natural History, New York, N.Y. It is labeled: "Plusia insolita Smith Type 2"; "Calgary, July, Dod"; "Collection J. B. Smith." It is also a male! I do not consider that it is a syntype, but rather an additional specimen subsequently placed as this species. However, since others may consider both specimens to be syntypes, I have selected, labeled, and now designate the specimen marked "Type 1" as the lectotype of this species. This will assure that it be considered to be the type-specimen by all subsequent workers.

*Deva trabea* Smith, 1895, Ent. News, 6:340, pl. 15, fig. 16.

"EXPLANATION OF PLATE XV. 16.—*Deva trabea* n. sp." On page 332 Smith said: ". . . the specimens were all collected by Mr. F. H. Wolley Dod, Calgary, Canada."

Smith, 1895, Ent. News 7(1):29, (pl. 15, fig. 16, previous issue of Ent. News) provided a written description and stated: "*Hab.*—Calgary, 1894." "The specimen is numbered 20, and is said by Mr. Dod to be unique."

*Holotype*: In the National Museum of Natural History, Washington, D.C. The specimen is labeled: "Deva trabea Smith Type"; "Calgary, 1894 (AH)"; "20"; "Type No. 14 USNM." The specimen is a male.

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Vol. 85, No. 32, pp. 389–398 30 December 1972

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# *CALIGUS CHELIFER* WILSON, 1905 (COPEPODA: CALIGIDAE), WITH A DESCRIPTION OF THE MALE

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Described more than half a century ago, *Caligus chelifer* Wilson, 1905 (Copepoda:Caligidae) is known in the literature from only three original records. Wilson (1905) described the female of the species, taken off the coast of Massachusetts on *Brevoortia tyrannus*, a "swordfish" (presumably *Xiphias gladius*), and *Trichiurus lepturus*. The same author (Wilson, 1908) recorded it later from the last-named host off the coast of North Carolina, without either illustrating it or identifying the sex of its specimens. Brian (1924) reported finding a presumed male of the species in plankton in Baie du Repos, off the Mauretanian coast of Africa.

The remaining references to *C. chelifer* are either listings of the original three records (Rathbun, 1905; Wilson, 1932; Yamaguti, 1963 and Silas and Ummerkutty, 1967) or comparisons of Wilson's original description with other species of *Caligus* (cf. Oakley, 1926; Redkar, Rangnekar and Murti, 1949; Brandes, 1956 and Shen, 1957).

The original description of the female (Wilson, 1905) stressed the characteristic structure of the maxilliped of the species. Alone among *Caligus*, it approaches a cheliform structure and provides an easy distinguishing mark as well as having given the name to the species. In view of ease with which *C. chelifer* is identifiable, one must presume the species is rare enough not to have been recorded along the Atlantic seaboard of North America subsequent to Wilson's find of 1908.

Late in 1969 I received from Dr. C. Sindermann, Tropical Atlantic Laboratory, Marine Fisheries Service, Miami, Florida, some specimens of *Caligus* implicated in fairly extensive mortality of fish larvae in experimental tanks of the Laboratory. Chalimus stages of this *Caligus* were found attached to the fish, belonging to various clupeid and engraulid species, usually in front of the dorsal fin, sometimes to the head or in the region of the vent. The copepods grew rapidly and killed fish less than 15 mm long in about 4 days. In addition to the clupeoids, the same copepod was found on one occasion attached to *Cynoscion nebulosus.* Fish were maintained on a diet of wild plankton that presumably provided also the source of infection. The same plankton contained also several adult male *Caligus* and one female, adult and ovigerous. Having examined the adults, I identified the female as *C. chelifer.* I concluded that the male, which I could not place in any known species of *Caligus,* was also *C. chelifer.*

This paper is intended as a redescription of those morphological features of the female *C. chelifer* that were either neglected or misrepresented in the original description. It also proposes to give an adequate description of the hitherto unknown male.

## THE FEMALE

General appearance (Fig. 1) similar to that described by Wilson (1905). Differences between this specimen and the type of the species are mainly in the shape of the genital complex and are attributable to differences of age and of condition of maturity. A very characteristic feature not mentioned by Wilson is a broad, shelflike inwards extension of the lateral margins of the dorsal shield (Fig. 10, sh). Both the extension and the ventral surface of the adjacent marginal membrane of the shield (Fig. 10, mr) are densely covered by fine and fairly long setae, imparting a hirsute appearance to the area marked by interrupted line in Figure 10. A square 20 × 20 $\mu$ within that area is covered by about 25 such setae. Dimensions of the female specimen are as

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FIGS. 1–8. *Caligus chelifer.* 1. Female, dorsal. 2. Male, dorsal. 3. Female and male, postantennary process, in situ. 4. Male. Second antenna, ventral. 5. Same, claw, full view. 6. Female, second antenna, in situ. 7. First maxilla, ventral. 8. Male, first maxilla, ventral.

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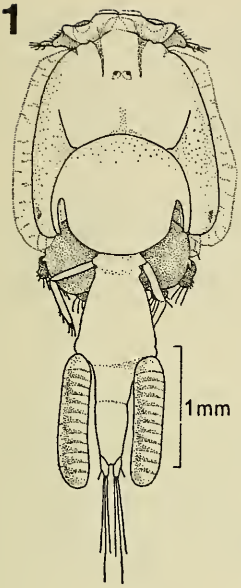

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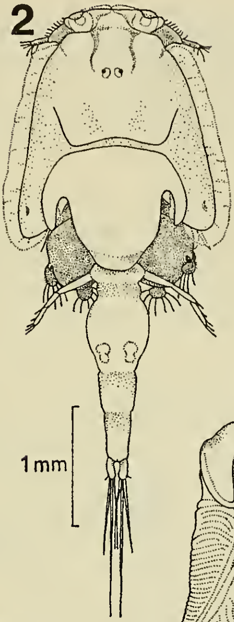

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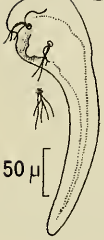

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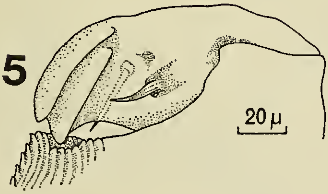

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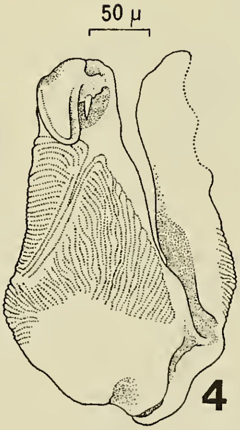

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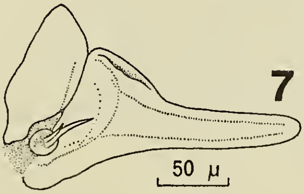

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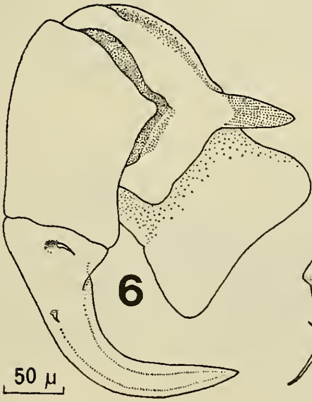

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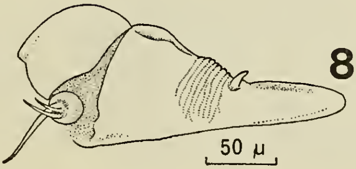

follows (in mm): total length 4.08; cephalothorax length 2.00, width 1.92; fourth segment length 0.20, width 0.44; genital complex length 0.88, width 0.68; abdomen length 0.80, width (at base) 0.28; egg-sac length 1.16, width 0.18. The specimen was, therefore, smaller than Wilson's females (from 5.0 to 6.5 mm) and had relatively shorter egg-sacs, but its proportions did not differ significantly from the type-specimen.

Two distinguishing features of the first antenna are: a long seta at the base of the distal segment being longer than that segment and the posterior group of the five setae of apical armature being plumose.

The second antenna (Fig. 6) has its posterior process on the second segment covered with fine longitudinal grooves. Its hook is rather heavy and the setae it carries are rather shorter than is usual for the genus.

The postantennary process (Fig. 3) is long and slender, with a small tubercle protruding from its medial margin not far from the base.

The first maxilla (Fig. 7) is moderately long, with a bluntly rounded tip. A short longitudinal groove runs in parallel with the lateral margin of the inflated base. The basal papilla of the female carried only two setae in place of the more usual three, probably due to injury.

The second maxilla (Fig. 12), in contrast to Wilson's specimen, has four strips of finely serrated membrane on the longer of its distal processes and two on the shorter.

The maxilliped (Figs. 13 and 14) carries distally on its medial margin a strong and very prominent outgrowth with a bifurcation at its tip. The two parts of the bifurcation (Fig. 14) have rounded outlines and are covered by fine corrugations. The outgrowth extends distally so far that the subchela, when closed, is at right angles with the long axis of the appendage, thus being almost chelate in its arrangement. The subchela itself is short and robust, gently curving and provided with a narrow flange on the distal part of its claw (Fig. 14). The basal seta of the claw is sturdy and appears stiff. (Wilson's original description presented the bifurcations of the medial process as being covered with stiff short setae. This has not been confirmed in examination of the present specimen.)

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Figs. 9–17. *Caligus chelifer*. 9. Male, postoral adhesion pad, ventral. 10. Female and male, diagram of cephalothorax showing lateral shelves and setiferous area. 11. Sternal furca, ventral. 12. Second maxilla, ventral. 13. Female, maxilliped, entire, ventral. 14. Same, tip of claw and medial process, ventral. 15. Male, maxilliped, entire, ventral. 16. Same, tip of claw and medial process, ventral. 17. Female and male, first leg, tip of exopod, ventral.

mr—marginal membrane; sh—marginal shelf.

9

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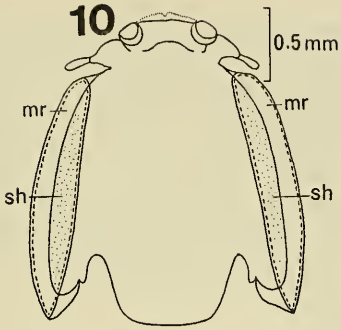

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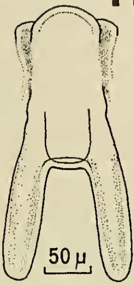

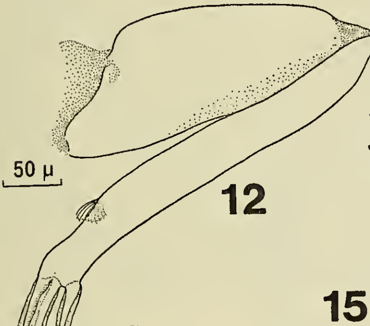

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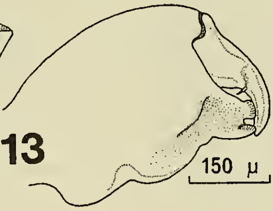

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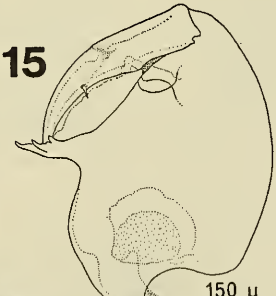

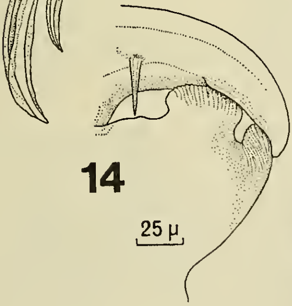

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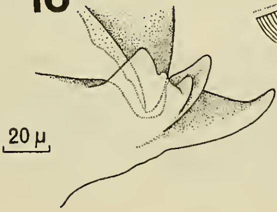

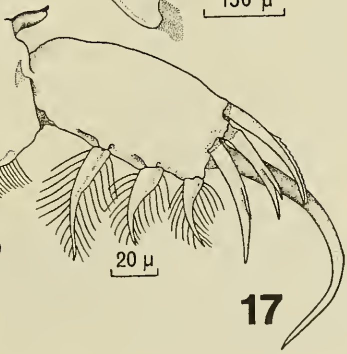

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The sternal furca (Fig. 11) has an oblong, narrow box and straight, slightly divergent tines with rounded tips and narrow flanges on both lateral and medial margins.

The first leg (Fig. 17) has a characteristic bifid spine at the distal corner of the first exopod segment. The first apical seta on the second exopod segment is provided with a strip of serrated membrane on its outer margin. The second and the third setae are bifid, their shorter branches also having slightly serrated margins. The fourth is more than twice the length of the others and is unarmed. (Wilson refers to it as a "long, strongly curved claw."). The pinnate setae of the posterior margin are characteristically short, the longest of them barely exceeding the width of the segment.

The characteristic features of the second leg (Figs. 18 and 19) are the lateral armature of the exopod and the lateral margin of the endopod. The former (Fig. 18) consists of a long serrated spine on the first segment (s1), similar though shorter spine on the second (s2) and of two structures on the third (s3). The proximal of them is a slender and flexible seta with serrated membranes along two margins. The distal is a curious pedunculate structure with a rounded tip and a fringe of fine setules along its inner margin. The endopod (Fig. 19) carries on the lateral margins of its second and third segments a broad strip of long slender setae, covering also a part of the ventral surfaces of these segments. The lateral margin of the first segment appears to have on it only a small group of setae, shorter and stiffer than those on the other two segments.

The third leg (Fig. 20) is characterised by a straight, blunt process of the basal segment of the exopod, apparently devoid of membranes or flanges. The lateral ridge of the sympod of this leg is weak and its ventral surface unarmed.

The distal part of the fourth leg (Fig. 21) is two segmented. In addition to the three terminal setae and the distal seta of the first segment, there is also a fifth seta on the posterior margin of the second segment, marking the point of segmental division, now obsolete. The first terminal seta is the longest of the five, the second only about two-thirds of the length of the first and the remaining setae of similar length. All have well-developed pectens at their bases.

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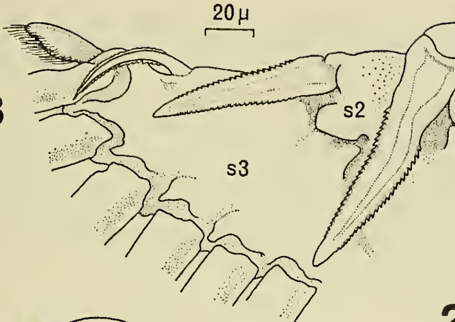
FIGS. 18–24. *Caligus chelifer*. 18. Female and male, second leg, tip of exopod, ventral. 19. Same, endopod, ventral. 20. Third leg, exopod, ventral. 21. Fourth leg, distal half, ventral. 22. Female, posterolateral corner of genital complex, ventral. 23. Male, posterolateral corner of genital complex, ventral. 24. Female and male, caudal ramus, ventral.

s1–s3—segments 1 to 3.

**18**



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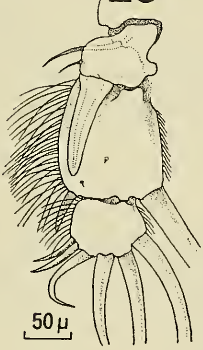

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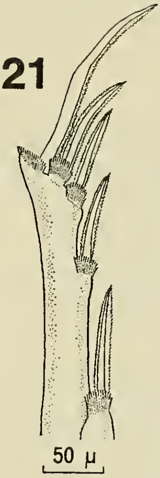

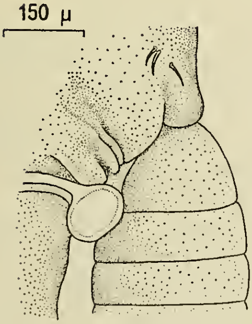

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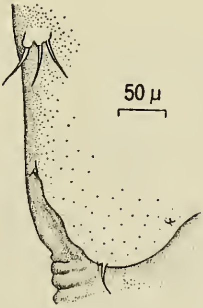

**23**

The vestigial fifth leg (Fig. 22) appears to consist of only three small setae on the ventral surface of the posterolateral corner of the genital complex. It is possible that another seta was either broken off or overlooked by the author.

The caudal ramus (Fig. 24) is long, narrow, armed with six setae. The distal margin is occupied by three long and strong, pinnate setae. The medial pinnate seta is equipped with three rows of pinnae (cf Kabata and Hewitt, 1971), the others with two rows. The medial seta partly overlaps the second seta. The dorsal surface carries two shorter setae and the lateral margin another similar seta.

### THE MALE

The general appearance of the male (Fig. 2) greatly resembles that of the immature female illustrated by Wilson (1905). It differs from it by the smaller genital complex. The latter is oviform, posteriorly tapering and followed by an also tapering, two-segmented abdomen. The anterior part of the body closely resembles the corresponding part of the female. The dimensions (in mm, based on a single specimen) are as follows: total length 3.96; cephalothorax length 2.16, width 1.60; fourth segment length 0.16, width 0.44; genital complex length 0.76, width 0.52; abdomen length 0.52, width (at base) 0.36.

The appendages generally resemble those of the female, with the following exceptions.

The second antenna (Figs. 4 and 5) has a long and narrow adhesion pad on the basal segment. The surface of the second segment is largely occupied by another adhesion pad, divided into two parts by obliquely running ridges. The claw (Fig. 5) is short and sturdy, with bifid tip and two flanges running along one side. Two setae are present on the claw, one on each side.

The first maxilla (Fig. 8) is provided with a band of transverse ridges at about the midlength. A short digitiform outgrowth arises from its surface on the lateral side just distal to the transverse ridges. The basal papilla has the normal number of three setae, one much longer than the other two. Posteromedial to the tip of the first maxilla there is an adhesion pad on the ventral surface of the cephalothorax (Fig. 9). It is oval and marked by numerous transverse grooves.

The maxilliped (Figs. 15 and 16) is oval, with the subchela longer and more slender than that of the female. Its medial margin is armed with a long, fairly slender process with a flat tip separated distally into several dentiform outgrowths (Fig. 16). A small crypt near the tip of the process receives the tip of the claw, when closed. The latter is much more slender and longer than in the female, but is also equipped with a narrow, almost membranous flange.

The fifth leg (Fig. 23) is situated on the lateral margin of the genital complex and is vestigial. It consists of three setae based on a bifurcated swelling. As in the female, I was unable to find a fourth seta. The sixth leg is represented by a single seta in the posterolateral corner of the genital complex. Near it is a small setiferous papilla, probably sensory. Several similar papillae are scattered in this region.

*Comment:* It is regrettable that Brian (1924) gave neither description nor illustration of the specimen from the Mauretanian coast of Africa, identified by him as a possible male of *C. chelifer.* As the male of this species was not known at that time, Brian's identification and his omission to provide this information are surprising. If correct, this find would extend the range of the species from the American side of the Atlantic over to the Mediterranean. In view of the scarcity of the species and the absence of corroborating evidence, one must presume that Brian's identification was in error.

*Summary:* The female of *Caligus chelifer* is redescribed and the male described for the first time. The parasite came from plankton fed to fish in the tanks of the Tropical Atlantic Laboratory, U.S. Marine Fisheries Service, in Miami, Florida.

*Acknowledgment:* I am indebted to Dr. C. Sindermann, Marine Fisheries Service, United States Department of Commerce for affording me the opportunity of examining this rare and interesting species of *Caligus.*

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Vol. 85, No. 33, pp. 399–404 30 December 1972

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# A NEW SPECIES OF *FELICOLA* (MALLOPHAGA: TRICHODECTIDAE) FROM THE LIBERIAN MONGOOSE (*LIBERIICTIS KUHNI*)

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Recently Mr. Duane Schlitter, Division of Mammals, National Museum of Natural History, was able to collect the first known complete specimens of the rare Liberian Mongoose, *Liberiictis kuhni* Hayman, the original description having been based only on skulls. Fortunately, he also obtained from this host a series of Mallophaga representing a new species. This new species is herewith described and illustrated.

## **Felicola liberiae** new species

Figures 1–3

*Holotype male*: Total length, 1.42 mm (paratypes 1.40–1.43 mm). External morphology and chaetotaxy as shown in Figure 2. Genitalia as shown in Figure 3; genital sac small and not prominent.

*Allotype female*: Total length, 1.42 mm (paratypes 1.41–1.45 mm). External morphology and chaetotaxy as shown in Figure 1.

*Discussion*: *Felicola liberiae* is closest to *F. bedfordi* Hopkins in that the male genitalia, female genitalia, and external morphology are grossly similar for the two species. The male of *F. bedfordi* has the parameres of the genitalia much thinner than for *F. liberiae*, and the latter has a pair of setae on protuberances on abdominal tergite II, while *F. bedfordi* has six setae, arranged 2-1-1-2, in the same location. The female genital region of *F. bedfordi* has eight setae on the posterior vulval margin and four widely spaced setae on each gonopod; in *F. liberiae*, there are 12 setae on the posterior vulval margin and four closely grouped setae on each gonopod. Both sexes of *F. liberiae* have more abdominal tergal and sternal setae on segments III-IX and have three pairs of well-developed abdominal spiracles, whereas *F. bedfordi* is apparently unique in having only a single pair of abdominal spiracles. *F. liberiae* averages 0.2 mm larger than *F. bedfordi.*

*Type-host*: *Liberiictis kuhni* Hayman.

*Type-material:* Holotype male, allotype female, and 24 paratypes collected off the type-host at Tar's Town, Grand Gedeh County, Liberia on 29 July 1971 by Duane Schlitter. The holotype and allotype will be deposited in the National Museum of Natural History, Smithsonian Institution.

Most mammalogists presently recognize 23 species of African Mongooses. Werneck (1948) reviewed the species of Mallophaga found on these hosts, and since then Emerson and Stojanovich (1966) and Emerson and Price (1967) each have added one new species. Mallophaga have not been recorded from: *Bdeogale jacksoni* (Thomas), *Herpestes naso* de Winton, *Crossarchus ansorgei* Thomas, *Crossarchus obscurus* F. Cuvier, *Mungos gambianus* (Ogilby), *Helogale hirtula* Thomas, and *Dologale dybowskii* (Pousargues). These mammals are rarely collected, so it may be years before their parasites are known.

The species of Mallophaga recorded to date from African Mongooses, subfamily Herpestinae, are:

- *Liberiictis kuhni* Hayman
  - *Felicola liberiae* n. sp.
- *Suricata suricatta* (Schreber)
  - *Suricatoecus cooleyi* (Bedford, 1929)
- *Paracynictis selousi* (de Winton)
  - *Felicola setosus* Bedford, 1932
- *Bdeogale crassicauda* Peters
  - *Felicola bedfordi* Hopkins, 1942
- *Bdeogale nigripes* Pucheran
  - *Felicola bedfordi* Hopkins, 1942
- *Cynictis penicillata* (G. Cuvier)
  - *Felicola cynictis* (Bedford, 1928)
- *Herpestes ichneumon* (Linnaeus)
  - *Felicola inaequalis* (Piaget, 1880)
- *Herpestes auropunctatus* (Hodgson)
  - *Felicola rohani* Werneck, 1956
- *Herpestes pulverulentus* Wagner
  - *Felicola calogaleus* (Bedford, 1928)
- *Herpestes sanguineus* (Rüppell)
  - *Felicola calogaleus* (Bedford, 1928)
  - *Suricatoecus mungos* (Stobbe, 1913)

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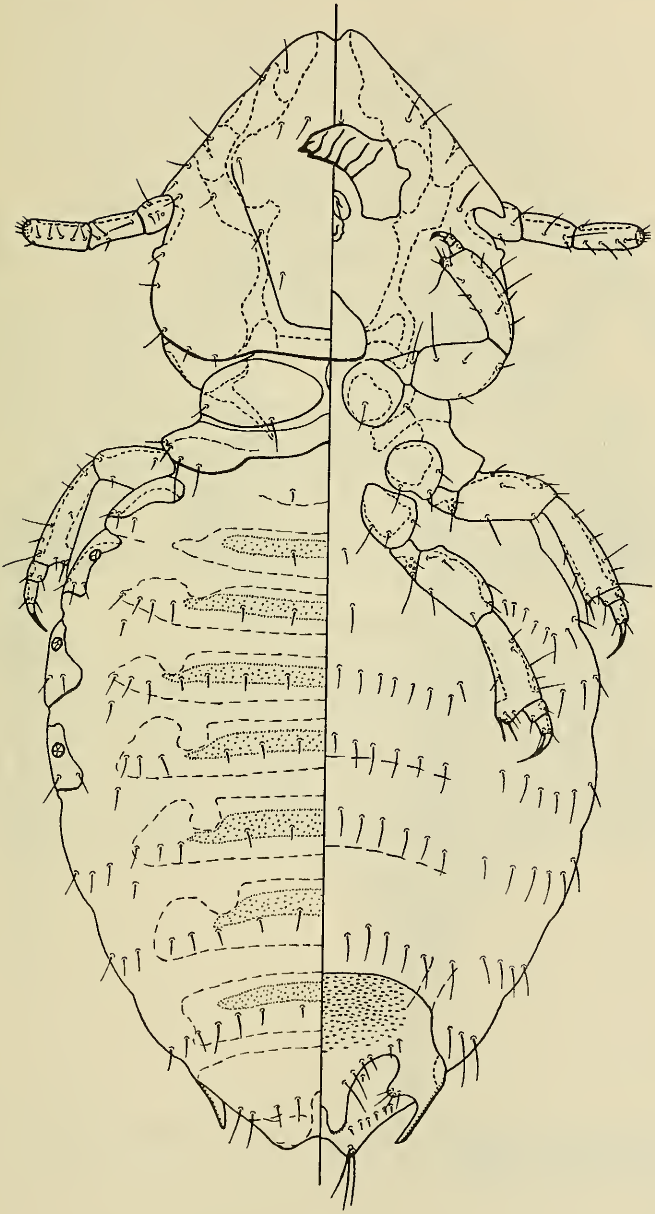
FIG. 1. *Felicola liberiae* new species, dorsal-ventral view of female.



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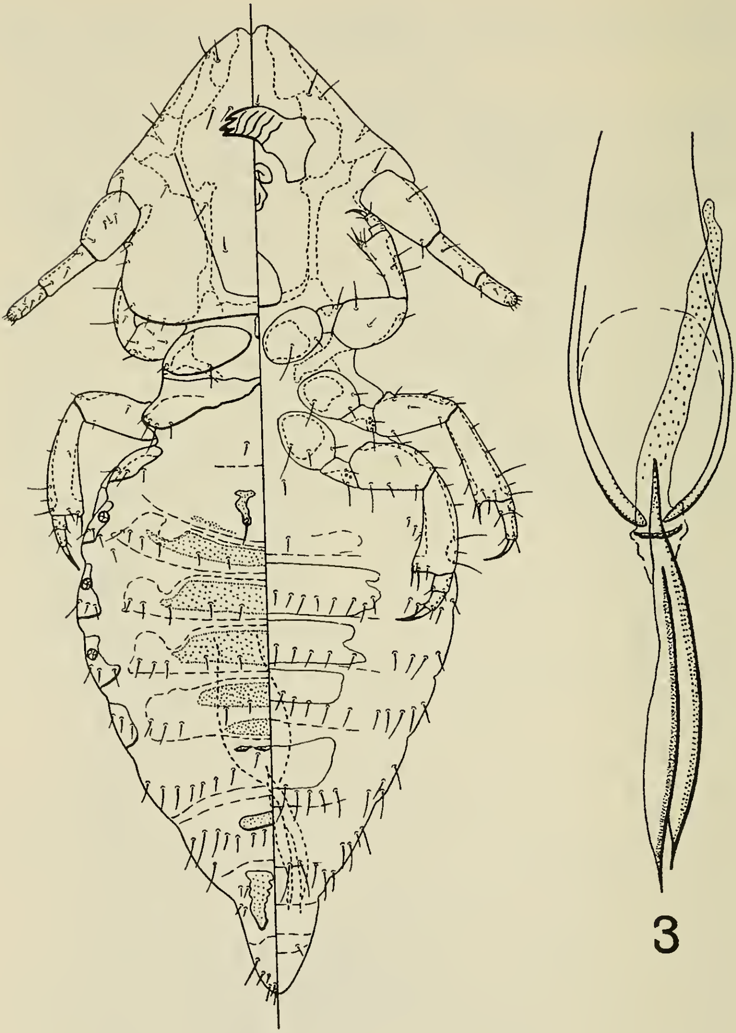

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Figs. 2–3. *Felicola liberiae* new species. 2, dorsal-ventral view of male. 3, male genitalia.

*Rhynchogale melleri* (Gray)
    *Felicola robertsi* Hopkins, 1944
*Ichneumia albicauda* (G. Cuvier)
    *Felicola subrostratus* (Burmeister, 1838)
*Atilax paludinosus* (G. Cuvier)
    *Felicola macrurus* Werneck, 1948
    *Felicola minimus* Werneck, 1948
    *Felicola pygidialis* Werneck, 1948
    *Felicola rahmi* Emerson and Stojanovich, 1966
    *Suricatoecus laticeps* (Werneck, 1942)
    *Suricatoecus paralaticeps* Werneck, 1948
*Crossarchus alexandri* Thomas and Wroughton
    *Suricatoecus congoensis* Emerson and Price, 1967
*Mungos mungo* (Gmelin)
    *Suricatoecus decipiens* (Hopkins, 1941)
*Helogale parvula* Sundevall
    *Suricatoecus helogale* (Bedford, 1932)
    *Suricatoecus helogaloidis* Werneck, 1948

In the references listed below may be found excellent illustrations and descriptions of all species listed above.

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Vol. 85, No. 34, pp. 405–412 30 December 1972

PROCEEDINGS
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# MARINE TURBELLARIANS OF THE PACIFIC COAST I

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The polyclad fauna of the Pacific Coast of North America was reviewed extensively in 1953 by L. Hyman. Two additional articles (Hyman 1955, 1959) have added to the fauna and expanded known geographic ranges. There have been three articles describing the marine triclad fauna of the Pacific Coast (Hyman 1954, 1956 and Holleman and Hand 1962). The specimens described below represent geographic extensions of two marine triclads and one polyclad and a new species of the poyclad genus *Stylostomum.*

The specimens were collected during 1964 and 1965 in Puget Sound and the waters of the San Juan Islands. They were preserved in boiling sea water saturated with mercuric chloride and treated by the method described by Hyman (1953). Whole mounts were stained with acetocarmine and specimens sectioned at 15 microns were stained with hematoxylin and eosin.

## ORDER TRICLADIDA

### Suborder Maricola

### Procerodidae

### *Procerodes*

Procerodidae with fused oviducts opening into the vagina by a distinct duct.

### *Procerodes pacifica* (Hyman 1954)

Figures 1, 2

Seventy specimens were collected by Dr. Peter Ax in coarse gravel at Deadman's Bay on San Juan Island.

Three whole mounts and three sets of serial sagittal sections were made. The specimens were white except for the intestine and its branches which had various shades of green, orange, brown, and black.

Auricles are present in the living worms but upon fixation are contracted.

A single pair of oceli are located in the anterior end of the worm.

The pharynx is long, greater than one-third the length of the body.

The male reproductive system consists of 17 to 21 pairs of testes segmentally arranged between intestinal diverticula. One whole-mount specimen had 29 pairs of testes. The spermiducal vesicles containing sperm can be observed on either side of the posterior part of the pharynx. The two spermiducal vesicles arch dorsally and enter separately the base of the penis forming the seminal vesicles which then unite. A short ejaculatory duct follows this union. The male antrum opens into a common antrum which exists via a common gonopore.

The ciliated vagina ascends dorsally from the common antrum and continues as the bursal canal after receiving the common ovovitelline duct from the posterior side. The vagina terminates in a large seminal bursa which is lined with tall columnar epithelium. The single pair of ovaries is located anteriorly behind the eyes.

The specimens collected at Deadman's Bay differ in two ways from the original description. They differ first in the presence of cilia in the vagina and bursal canal; and second, in the uniformity of the columnar epithelium lining the seminal bursa, not just tall dorsally as originally described by Hyman.

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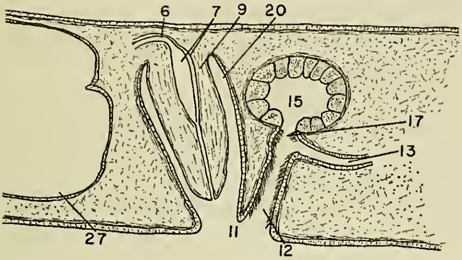
Fig. 1. *Procerodes pacifica*, entire worm from life.
Fig. 2. *Procerodes pacifica*, sagittal view of copulatory apparatus.
Fig. 3. *Nexilis epichitonius*, from life.
Fig. 4. *Stylostomum sanjuania*, from life.
Fig. 5. *Stylostomum sanjuania*, cleared whole mount.
Fig. 6. *Stylostomum sanjuania*, sagittal view of copulatory apparatus.
Fig. 7. *Notoplana atomata*, cerebral and tentacular eyes.

1. Auricle, 2. Cerebral eyes, 3. Marginal eyes, 4. Pharynx, 5. Testis, 6. Spermiducal vesicle, 7. Seminal vesicle, 8. Prostatic vesicle, 9. Penis, 10. Penis sheath, 11. Common gonopore, 12. Vagina, 13. Common ovovitelline duct, 14. Cement glands, 15. Seminal bursa, 16. Ovary, 17. Bursal canal, 18. Ejaculatory duct, 19. Penis stylet, 20, Male antrum, 21. Mouth, 22. Female gonopore, 23. Female antrum, 24. Cement pouch, 25. Uterus, 26. Tentacular eyes, 27. Pharyngeal pocket, 28. Sucker, 29. Main intestine, 30. Uteri with eggs, 31. Penis papilla.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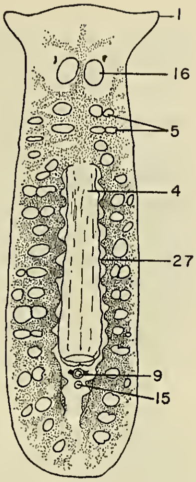
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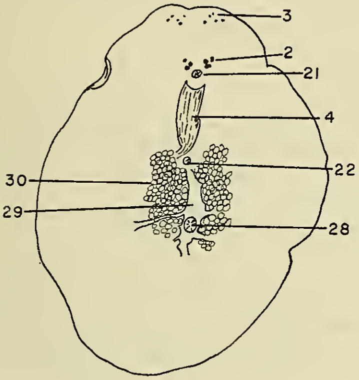
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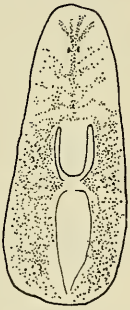

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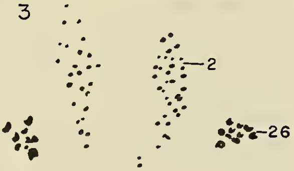
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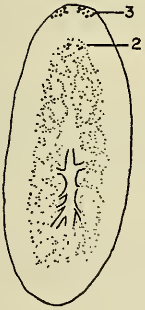
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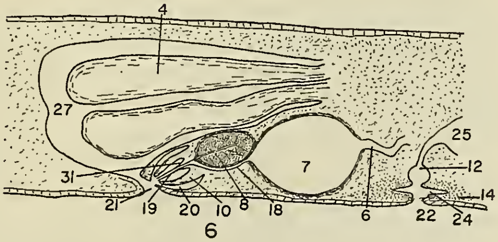
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The presence of spermiducal vesicles entering the base of the penis separately is the principal character used in assigning these species to *P. pacifica.* Figure 1 is drawn from a living specimen showing the auricles, position of the testes and pharynx.

Previously, *P. pacifica* had been reported only from southern California. The occurrence at San Juan Island shows this species to have a range from Washington to San Diego, California.

One whole mount, USNM 45705; one set of serial sagittal sections of two slides, USNM 45705; and a vial containing 20 preserved specimens, USNM 45705 have been deposited with the National Museum of Natural History, Smithsonian Institution. One whole mount, a set of serial sagittal sections of three slides and a vial of 10 specimens have been deposited with the California Academy of Science.

### Nexilidae

### *Nexilis*

Nexilidae with oviducts entering separately into the uterus and without a copulatory bursa.

### *Nexilis epichitonius* (Holleman and Hand 1962)

Figure 3.

Eleven specimens were collected from the shells of *Mytilus californianus* at False Bay, San Juan Island, Washington.

Two whole mounts and a set of serial sagittal sections were made.

The specimens varied in size from 1 to 2 mm in length and 0.5 to 1 mm in width.

The specimens were white except for the intestine and its dark brown branches.

A pair of eyes is located in the anterior end.

The male and female reproductive structures are the same as initially described (Holleman and Hand 1962). However, the number of pairs of testes differ. The specimens from California and Oregon had three or four pairs of testes while the species from False Bay had seven or eight pairs of testes.

*N. epichitonius* was previously reported from Central California and Oregon. The range is now extended to include Washington where it is found on *Mytilus californianus.*

One whole mount, USNM 45704; one set of serial sagittal sections of two slides, USNM 45704; and a vial of four preserved specimens, USNM 45704 have been deposited with the National Museum of Natural History, Smithsonian Institution. One whole mount, a set of serial sagittal sections of two slides and a vial of four preserved specimens have been deposited with the California Academy of Science.

## ORDER POLYCLADIDA

### Suborder Cotylea

### Euryliptidae

### *Stylostomum*

Euryleptidae of small to moderate size and oval form with a smooth dorsal surface. Tentacles when present are of the marginal type and small; eyes in typical cerebral and marginal clusters. The pharynx is cylindrical with few intestinal branches. The male apparatus is beneath the anterior part of the pharynx with an opening in common with the mouth. Usually a pair of uterine vesicles is present.

### **Stylostomum sanjuania** new species

Figures 4–6

Seven specimens were collected by Dr. Robert Fernald of the University of Washington at Argyle Lagoon, San Juan Island in 1964. Five specimens were collected in 1965 at Arygle Lagoon, San Juan Island on the compound ascidian, *Distaplia occidentalis.*

*Stylostomum sanjuania* is small, oval, reaching a length of 6 mm and a width of 3 mm in life. Tentacles are absent. The ventral sucker is positioned in middle of the body.

The color is a translucent white on the margin shading to a light yellow middorsally. The region over the pharynx is white.

The cerebral eyes consist of three or four small eyes on each side, and the marginal eyes consist of two groups of 5 to 11.

The digestive system is typical of the genus with a tubular pharynx directed forward and the main intestine extending posteriorly. The main branches of the intestine subdivide and these subdivisions do not anastomose.

Sagittal sections of one of the specimens showed that the spermiducal vesicles are united prior to entering the oval seminal vesicle. The seminal vesicle is positioned ventrally and at the posterior margin of the oval prostatic vesicle. The prostatic duct and the ejaculatory duct unite and pass into the slender, armed penis. The penis is surrounded by a penis sheath. The large male antrum opens in common with the mouth of the exterior.

The female gonopore is located posterior to the base of the pharynx. From the ciliated female antrum the vagina ascends with an expansion into a cement pouch surrounded by a dense mass, the cement glands. The vagina continues to ascend then turns posteriorly and enlarges into the paired uteri.

There have been five species described in the genus *Stylostomum*; *ellipse* (Dazell 1853); *frigidum* (Bock 1931); *hozawai* (Kato 1939); *maculatum* (Kato 1944); and *lentum* (Heath and McGregor 1912).

S. *sanjuania* differs from *lentum* and *frigidum* in that it lacks tentacles and has a reduced number of eyes. *Stylostomum sanjuania* is similar to S. *ellipse* in the number of eyes but lacks the marginal tentacles of *ellipse.* S. *sanjuania* is similar to the two Japanese species, *hozawai* and *maculatum,* in the absence of marginal tentacles and in the reduced number of cerebral and marginal eyes. In S. *hozawai* the prostatic vesicle is ventral to the penis and the seminal vesicle and in S. *maculatum* it is slightly ventral to the penis and seminal vesicle; whereas the prostatic vesicle in S. *sanjuania* is larger than the prostatic vesicle in *hozawai* and *maculatum* and is located dorsal to the penis and seminal vesicle.

Holotype, USNM 45702, one set of serial sagittal sections on five slides, and paratypes, USNM 45703, one whole mount and a vial with one preserved specimen have been deposited with the National Museum of Natural History, Smithsonian Institution. One whole mount, designated as a paratype has been deposited with the California Academy of Science.

## SUBORDER ACOTYLEA

### Section Schematommata

### Leptoplanidae

### *Notoplana*

Leptoplanidae of oval, obovote or cuneate form generally without tentacles; cerebral and tentacular eyes present, seminal vesicle present, prostatic vesicles chambered and usually interpolated. The penis is armed or unarmed and Lang's vesicle is usually present.

### *Notoplana atomata* (O. F. Muller 1776)

Figure 7

This species was collected at Alki Point, Seattle, under rocks during the winter of 1964 and at Jackel's Lagoon, San Juan Island, in the summer of 1965. It has been described by Bock (1913) and Hyman (1939) and the material collected and studied is identical with theirs. The color of the specimens is a medium brown with darker brown flecks distributed over the dorsal surface. The ventral surface is colorless. The tentacular eyes occur in two groups varying from 10 to 18 eyes, the clusters of cerebral eyes in linear arrangement of 13 to 48, Figure 7. The arched penis stylet, thick-walled spherical prostatic vesicle and the enlarged Lang's vesicle are the distinguishing features of this species.

*Notoplana atomata* is distinctive from the other *Notoplana* of the Puget Sound region with a penis stylet. *N. inquieta* has a common gonopore, *N. longastyletta* has a small oval Lang's vesicle, *N. inquilina* a short arched penis stylet and a Lang's vesicle of moderate length.

Two whole mounts, USNM 45706; one set of serial sagittal sections of 17 slides and a paraffin block, USNM 45706 have been deposited with the National Museum of Natural History, Smithsonian Institution. Two whole mounts and a set of serial sagittal sections have been deposited at the California Academy of Science.

I thank Dr. Robert Fernald, Director, Friday Harbor Laboratories and Dr. Paul Illg, University of Washington, for their assistance and for making space available for this work. The work was supported by a National Science Foundation Science Faculty Fellowship, No. 64268.

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Vol. 85, No. 35, pp. 413–418 30 December 1972

PROCEEDINGS
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# A DESCRIPTION OF THE EGG CASE AND LARVA OF THE WATER SCAVENGER BEETLE, *HELOBATA STRIATA* (COLEOPTERA: HYDROPHILIDAE)[1]

By Paul J. Spangler and Jarrett L. Cross[2]
*Smithsonian Institution, Washington, D.C. 20560*

The larvae of only a few genera of the aquatic hydrophilids of the United States remain undescribed. One of these genera is *Helobata*, a monotypic tropical genus whose range reportedly extends from Buenos Aires, Argentina, north through the West Indies, Central America, Mexico, and along the Gulf Coast to Louisiana and Florida in the United States. *Helobata striata* Brullé, is presently recognized as the only species in the genus.

Females of *Helobata*, like those of *Helochares*, *Epimetopus*, and *Spercheus*, carry their egg cases beneath the abdomen. The anterolateral corners of the egg cases of *H. striata* (Fig. 1) are attached to the upper surfaces of the hind femora, at the apices, by a narrow matted group of silklike fibers.

Because *Helobata* females carry their egg cases beneath their abdomens, larvae may be obtained simply by confining an egg-carrying female until the eggs hatch. The larva described (Fig. 2) below was obtained in this manner. Two egg-carrying females were collected 15 miles west of Pijije, Department of Jutiapa, Guatemala, on 5 August 1965 by P. J. Spangler. Thirty larvae hatched from one egg case several days after the female was collected but the total length of time required for the eggs to develop is unknown. Because the eggs hatched while in transit, the larvae could not be

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[1] This study was made possible in part by Grant GB-1697 from the National Science Foundation.

[2] Smithsonian Institution Visiting Research Student.

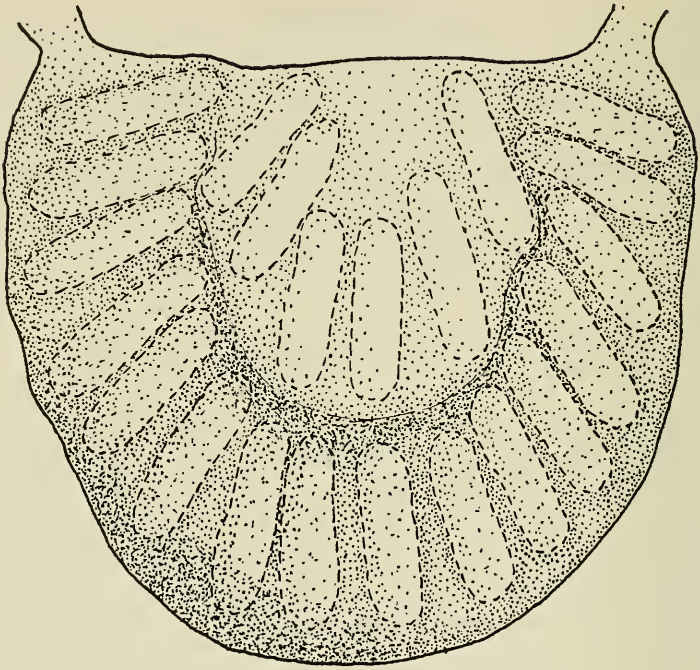

FIG. 1. *Helobata striata* Brullé, egg case, dorsal view.

easily reared and they were preserved. The second female and her egg case containing 35 eggs also were preserved for descriptive purposes.

*Egg case and eggs:* Length of egg case, 2.0 mm through midline, width, 2.8 mm; loosely constructed of silklike fibers; dorsal surface clean, transparent and shining where it lies against the abdominal sterna; fibers of ventral surface and hind margin mostly opaque, coated with debris. Eggs deposited horizontally, oriented posteriorly in a semicircular fashion, with a full layer of eggs on bottom and two successively shorter layers above at posterior end resulting in a tapered saclike egg case, thick posteriorly and thin anteriorly. Egg creamy yellow, 0.75 mm long, 0.25 mm wide.

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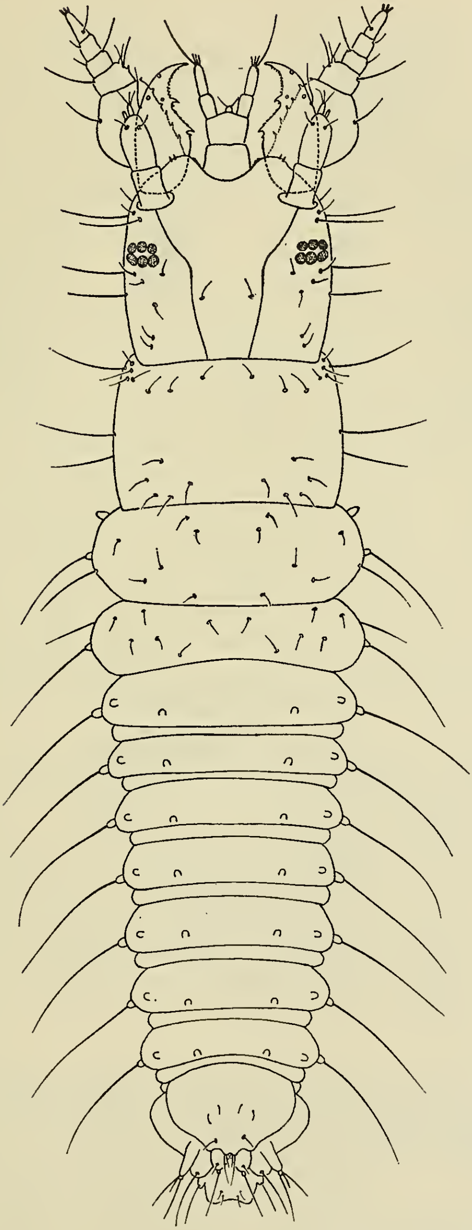
FIG. 2. *Helobata striata* Brullé, first-instar larva, habitus.



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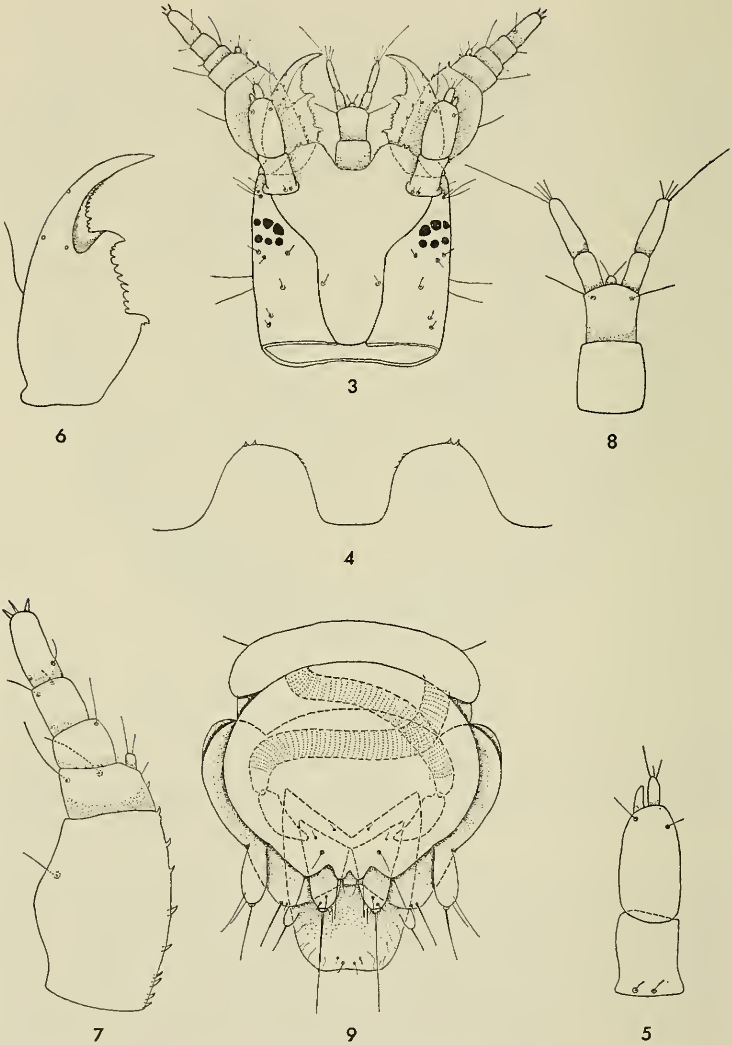

FIGS. 3–9. *Helobata striata* Brullé, first-instar larva: 3, head; 4, labroclypeus; 5, antenna; 6, mandible; 7, maxilla; 8, labium; 9, stigmatic atrium.

*First instar larva*: Total length 1.4 mm; width of prothoracic segment 0.32 mm.

Color, creamy yellow; sclerites slightly darker yellow; ocelli black.

Head (Fig. 3), almost as wide as long, 0.26 mm wide; 0.28 mm from anterior extremity of labroclypeus to occipital foramen. Frontoclypeal suture absent. Stem of ecdysial cleavage line absent; frontal branches present delimiting a broadly U-shaped frons with a distinct constriction immediately posteriad to the ocelli. Frons glabrous except 2 short setae behind constriction. Remainder of head capsule sparsely setose as illustrated (Fig. 3).

Labroclypeus (Fig. 4) symmetrical with deep medial emargination; 2 stout teeth on outer margin and 4 fine teeth on inner margin of well-developed anterolateral projections of epistoma.

Ocular area with 2 curved rows of 3 ocelli forming an ellipse. Inner 2 ocelli of anterior row large, irregular in shape, and almost fused.

Antenna robust (Fig. 5), 3 segmented, slightly longer than stipes. First antennal segment shorter than penultimate antennal segment and bearing 2 small, dorsobasal setae. Penultimate antennal segment bearing 2 dorsal preapical setae and 1 stout apical sensory peg. Ultimate antennal segment small, subcylindrical, terminating in 3 apical setae.

Mandibles symmetrical, prominent, stout, sharply pointed apically (Figs. 2, 3, 6). Inner margin of mandible (Fig. 6) with 3 large teeth; 13 small teeth forming a serrate edge between apical tooth and medial tooth; 9 small teeth forming a serrate edge between medial tooth and basal tooth, and 1 small tooth projecting from posterior margin of basal tooth. Outer edge of mandible with 1 long seta slightly behind mid-length.

Maxilla (Fig. 7) with central axis of palpus and palpifer directed laterally at a distinctly obtuse angle to the central axis of the stipes. Stipes swollen, nearly bulbous in appearance, and bearing a row of spines on its inner margin, and 1 ventrolateral seta. Palpifer with 1 spine near midlength on inner margin; 1 seta distad to spine on inner margin; 2 long ventral setae on distal margin; and a sensory lobe at anteromedial angle bearing 2 apical setae. Basal segment of palpus bearing 1 seta at anteromedial angle. Penultimate segment bearing 2 ventral setae near distal margin. Ultimate segment longer than penultimate; bearing 1 dorsal seta at inner posteromedial angle and 3 stout apical setae.

Labium (Fig. 8) not extending as far forward as palpifer. Ultimate segment of palpus one and a half times as long as penultimate and bearing 4 apical setae. Ligula distinct but small, less than one-half as long as segment one of labial palpus and bearing 2 apical setae. Prementum bearing 2 ventral setae arising near base of ligula.

Prothorax broader than long, slightly wider posteriorly; anterolateral corners each with 4 short setae and 1 long seta; remainder of dorsal surface sparsely setose as illustrated (Fig. 2). Mesothorax wider than prothorax but only three-fourths as long; lateral margin with a prominent spiracular tubercle and a seta-bearing lobe; dorsal surface sparsely setose. Metathorax slightly wider than mesothorax and half as long; lateral margin with a seta-bearing lobe; dorsal surface sparsely setose.

Abdomen with 8 distinct pubescent segments; ninth and tenth segments reduced. All segments separated by intersegmental folds. Lateral margins of segments 1–7 each with a seta-bearing lobe and 2 bare dorsolateral tubercles. Eighth tergum represented by suboval superior valve of stigmatic atrium, a large sclerite with 4 lobes on caudal margin as illustrated (Fig. 9). Ninth tergum trilobed. Middle lobe subquadrangular with 4 short setae near middle of caudal margin; margins apparently wrinkled; lateral margins each with 1 papilliform projection bearing a single apical seta. Lateral lobes less distinct, with 1 short seta and 1 long seta at each posterolateral angle. Mesocercus prominent, conical; bearing 1 long terminal seta and 4 shorter setae near apex, 2 dorsal and 2 medial. Paracercus prominent, subcylindrical, wider at apex than at base; bearing 3 setae near apex, 1 apical and 2 lateral.

The larva of *Helobata* runs to the second alternative in couplet 6 in Chandler's key (1956, pp. 339–341) but does not fit all of the characters given there. The following couplets substituted for Chandler's couplets 6 and 7 will separate *Helobata* from the other genera in Chandler's key.

1. Epicranial suture (stem of ecdysial cleavage line) absent, frontal sutures parallel; left expansion of epistoma much more prominent than the right expansion; ligula absent .......... *Laccobius* Erichson
   Epicranial suture (stem of ecdysial cleavage line) present or not; frontal sutures not parallel: lateral expansions of epistoma similar and usually in line with anterior margin of labroclypeus; ligula present .......... 2
2. Ligula shorter than segment 1 of labial palpus .... *Helobata* Bergroth
   Ligula longer than segment 1 of labial palpus .......... 3
3. Antennae short; epicranial suture absent; legs reduced .......... [to couplet 8 in Chandler's key]
   Antennae longer; epicranial suture present but usually short; legs fairly long, not reduced .......... [to couplet 9 in Chandler's key]

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Vol. 85, No. 36, pp. 419–426 30 December 1972

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# *APOGON LEPTOCAULUS*, A NEW CARDINALFISH FROM FLORIDA AND THE WESTERN CARIBBEAN SEA

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The shallow-water species of Atlantic Apogonidae have been the subject of several recent systematic papers (Böhlke, 1959; Böhlke and Randall, 1968; Fraser and Robins, 1970). Twenty-two valid species, belonging to three genera, have so far been described from the area; 16 belong to the genus *Apogon*, three to the genus *Phaeoptyx*, and three to the genus *Astrapogon*. Of these, *Apogon imberbis* (Linnaeus) occurs only in the eastern Atlantic, *Apogon americanus* Castelnau is confined to the southwestern Atlantic, and *Apogon axillaris* (Valenciennes) apparently is endemic to the islands of Ascension and St. Helena, in the mid-southern Atlantic (Bauchot and Blanc, 1961:68–69; Cadenat and Marchal, 1963:1272). *Apogon affinis* (Poey) and *Phaeoptyx pigmentaria* (Poey) occur on both sides of the ocean (Fraser and Robins, 1970). *Apogon powelli* Fowler, which was tentatively recognized by Böhlke and Randall (1968), has been shown (Fraser and Robins, 1970) to be a junior synonym of *A. imberbis*. Six additional species, all in the genus *Apogon*, occur in the eastern Pacific. Most of these species appear to be most common at shallow to moderate depths, although adults of *Apogon anisolepis* Böhlke and Randall[1] and *A. affinis* apparently have their center of abundance at greater depths (150–300 feet).

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[1] The status of *Apogon anisolepis* will be discussed in a subsequent paper by Böhlke and Randall.

In July 1970 I collected a specimen of a distinctive new *Apogon* off Boca Raton, Florida, and in August 1971 I obtained a second individual off Providencia Island, in the western Caribbean. Dr. David W. Greenfield subsequently sent me a third specimen he had taken on Glovers Reef, off the coast of British Honduras. Inasmuch as these are the only specimens known from hundreds of western Atlantic reef-fish collections, the new species evidently is rare in shallow water, and probably is also one that attains its greatest abundance in relatively deep water. The systematics of the shallow-water western Atlantic Apogonidae are well understood, and thus it seems desirable to describe this distinct new form (the 23rd from Atlantic waters) from the three specimens.

Type material has been deposited at the Academy of Natural Sciences of Philadelphia (ANSP), the Field Museum of Natural History (FMNH), and the Florida State Museum, University of Florida (UF). Measurements were made with dial calipers and recorded to the nearest 0.1 mm. Body proportions are expressed as thousandths of standard length (SL). Step measurements appearing in the second and third paragraphs of the description are based on the two largest specimens. The order and format in which the various morphological characters appear in the description is similar to that appearing in Böhlke and Randall's (1968) paper.

Appreciation is extended to Thomas H. Fraser, J. L. B. Smith Institute of Ichthyology, Rhodes University, Grahamstown, Republic of South Africa, and James E. Böhlke, Academy of Natural Sciences of Philadelphia, for comments regarding the new species; David W. Greenfield, Northern Illinois University, for loan of one of the paratypes; Carl L. Hubbs, Scripps Institution of Oceanography, for suggestions and help regarding the species name; Sid R. Anderson, New Milford, Connecticut, for the opportunity to conduct field work on Providencia Island; Kay Purington, Florida State Museum, who took the photograph; and John Larsen, John Dwyer, William Astras, Russell Parks, and Dianne Lieberman, who aided in the fieldwork.

FIG. 1. *Apogon leptocaulus* new species; holotype UF 17287, 51.5 mm SL, off Boca Raton, Florida, 65–70 ft.

Funding for fieldwork resulting in collection of the first (Florida) specimen of the new *Apogon* was provided by research contract number DACW-72-71-C-0004 from the Coastal Engineering Department of the Army to Dr. Walter R. Courtenay, Jr. (Project Leader), Florida Atlantic University, Boca Raton, Florida.

### **Apogon leptocaulus** new species

Slendertail cardinalfish

Figure 1

*Holotype*: UF 17287 (51.5 mm SL); Florida, Palm Beach Co., Atlantic Ocean, ca. 3700 yds. off Boca Raton, depth 65–70 ft.; in a low coral ridge; 19 July 1970; C. R. Gilbert and party (field no. G 70-4).

*Paratypes:* ANSP 117463 (41.8 mm SL); Colombia, Providencia Id., Caribbean Sea, WNW of Santa Catalina Id., south of "Channel Mouth," depth 95–100 ft.; in small cave along moderately sloping dropoff; 18 August 1971; C. R. Gilbert and party (field no. G 71-51). FMNH

71014 (23.5 mm SL); British Honduras, Glovers Reef, dropoff area just south of Long Cay, depth 70–100 ft.; 22 December 1970; D. W. Greenfield and G. Deckert (field no. G 70-127).

*Diagnosis*: A species of *Apogon* with six first-dorsal spines; a shallowly forked caudal fin; complete lateral line; a long, very slender caudal peduncle, with eight caudal-peduncle circumferential scales; dentigerous portion of premaxillary continued outside mouth laterally on bone, as in *Apogon robinsi*; free preopercular margin with a well-developed, rounded flap of skin (not so well developed or evenly rounded as in genus *Phaeoptyx*) that extends posteriorly beyond an imaginary ventral continuation of the line formed by the free posterior preopercular margin and covers (but does not extend past) part of angle of opercle; posterior half of each scale with a narrow, vertical, broadly crescentic area of dark pigment, particularly evident in preserved specimens, varying somewhat in width but never extending back to border of scale; a broad band of pigment, nearly the width of second dorsal and anal-fin bases, extending from second dorsal fin to the anal fin, and an equally broad band of pigment encircling posterior part of caudal peduncle; neither band sharply defined; body deep red in life; head pointed; dark pigment on posterior parts of upper and lower caudal lobes.

*Description*: Dorsal rays VI-I,9 (last ray composite); anal rays II,8 (last ray composite); pectoral rays I,11; lateral-line scales to caudal-fin base 25; scales above lateral line 2; scales below lateral line 7 or 8; predorsal scales 8; scales around caudal peduncle 8; gill rakers on first arch 5 or 6 + 15 or 16 = 20 to 22; serrae along vertical limb of free preopercular margin 13 to 18.

Greatest depth of body contained 3.1 to 3.2 times in standard length (SL); caudal peduncle long, its length slightly less than greatest body depth (1.1 times in body depth, 3.3 to 3.4 in SL); caudal peduncle very slender, its least depth 2.6 times in its length; head length 2.5 in SL; eye diameter 3.2 to 3.4 in head length; snout length 4.5 to 4.8 in head length; end of snout bluntly pointed; dorsal profile of head a straight line from just above terminal curve of snout to origin of dorsal fin.

First dorsal spine 2.6 to 2.7 in length of second dorsal spine; second dorsal spine equal to, or slightly longer than, third; second dorsal spine thickest spine in fin; spine of second dorsal fin 1.4 to 1.5 in second spine of first dorsal fin; pelvic fins extending posteriorly almost to anal-fin origin; innermost pelvic rays connected to body by membrane at or just beyond halfway out on its mesial branch; pectoral fins narrow and rather long, extending posteriorly to midpoint of anal-fin base; first anal spine short, its length 3.9 to 4.0 in length of second spine; second anal spine 0.9 to 1.0 in length of spine in second dorsal fin; caudal fin moderately forked, the lobes blunt.

Upper angle of rear margin of maxillary extending posteriorly to a vertical about four-fifths of way below posterior part of eye; rear margin of maxillary slightly concave; upper edge of maxillary slipping up beneath suborbital when mouth is closed; no orbital or anterior preopercular serrations; posterior margin of preopercle finely serrate; free tip of opercular spine short, sharp, and broad-based; anterior nostril tubular; posterior nostril a simple, broad, teardrop-shaped opening that is nearer eye than anterior nostril.

Large ctenoid scales present on cheek and opercle; scales on body all finely ctenoid, including those on thorax and nape, except for a few anteriorly on thorax and those before pectoral-fin base; scales on nape extending forward to occiput line; fins naked except for small scales basally on caudal fin; lateral line complete; lateral-line scales similar in size to adjacent body scales.

Tiny villiform teeth present on jaws, vomer, and palatine, none of them enlarged; teeth on jaws in broad patches; tooth patches on palatines in single series; gill rakers long and slender, particularly those on lower limb of first arch near angle; longest raker about three times length of opposing gill filament in outer series.

Body color deep red throughout; anterior half of anal fin red, the red extending posteriorly along base; pelvic and spinous dorsal fins reddish throughout; anterior part of soft dorsal fin with red pigment extending back along rays; caudal fin red, becoming lighter medially.

In the following paragraph morphometric and meristic data are listed (in order) for the holotype, the larger paratype, and the smaller paratype. Measurements are given in thousandths of SL. Greatest body depth 326, 316, 251; greatest body width 194, 203, 128; snout to first dorsal fin 394, 409, 404; snout to second dorsal fin 586, 598, 583; snout to anal fin 590, 593, 604; snout to pectoral fin 348, 373, 378; snout to pelvic fins 344, 364, 345; snout to anus 526, 543, 562; caudal-peduncle depth 118, 115, 98; caudal-peduncle length 303, 294, 340; head length 398, 395, 400; head depth at occiput 239, 234, 243; orbit diameter 118, 124, 128; snout length 83, 89, 77; post-orbital length 183, 177, 166; upper-jaw length 194, 194, 200; bony interorbital width 62, 62, 68; first dorsal spine 82, 74, 64; second dorsal spine 219, 196, 243; spine of second dorsal fin 146, 144, —; longest dorsal soft ray 243, 251, 217; first anal spine 39, 38, 43; second anal spine 155, 148, 187; longest anal soft ray 249, 220, 243; longest pectoral ray 322, 311, 277; pelvic spine 200, 196, 200; pelvic-fin length 252, 249, 234; caudal-fin length 363, 352, 438; caudal concavity 148, 127, —. Gill rakers (left side) 6 + 16 = 22, 5 + 15 = 20, 5 + 16 = 21; preopercular serrae (left and right) 14/15, 16/18, 13/13; lateral-line scales 25, 25, —; caudal-peduncle circumferential scales 3/3 = 8, 3/3 = 8, 3/3 = 8; predorsal scales 8, 8, —; pectoral rays 12-12, 12-12, 12-12; pelvic rays I,5–I,5, I,5–I,5, I,5–I,5; dorsal rays VI–I,9, VI–I,9, VI–I,9; anal rays II–8, II–8, II–8.

*Relationships*: *Apogon leptocaulus* is, in many respects, the most distinctive species of Atlantic Apogonidae. The long, slender caudal peduncle and eight scales in the caudal-peduncle circumferential series are unique to the species; other Atlantic apogonids usually do not have fewer than 12 scales in this series. It is also unique, among Atlantic species of *Apogon*, in having an unusually well-developed free preopercular margin, which extends to the angle of the opercular bone; in this regard it closely approaches the genus *Phaeoptyx*, although the upper angle of the margin, where the flap of skin joins the preopercular bone, is not so acute, nor the flap so evenly rounded, as in the three members of that genus (*see* Fraser and Robins, 1970:309, fig. 1). This character was considered by Fraser and Robins (1970:303) to be of fundamental generic importance in their diagnosis of the genus *Phaeoptyx*. The possibility that *A. leptocaulus* should be included in *Phaeoptyx* is unlikely, since it has, in contrast to that genus, bright red color in life and the inner pelvic ray connected to the body only on the lower half of the ray. Finally, the pigmentation pattern shows no close similarity to any other known apogonid.

*A. leptocaulus* possesses teeth on the exposed part of the premaxillary bone, a character found, among other Atlantic apogonids, only in *Apogon robinsi* Böhlke and Randall. In view of the many other trenchant differences between the two species, however, this is considered most likely to be the result of convergence.

No conclusions regarding relationship of the species can presently be drawn on the basis of osteological characters.

*Ecology:* The holotype of *A. leptocaulus* was collected in a long, low coral formation (known locally as "The Ledge") in 65–70 feet of water, off Boca Raton, Florida. Despite many other collections in this, and adjacent areas, no other specimens have been found. It may be significant that on the day prior to the collection a mass of cold water moved into the area, resulting in a very sharp thermocline about halfway to the surface (John Larsen, pers. comm.). Although temperatures were not recorded, the bottom temperature was estimated to be about 70 to 75°F, and was probably 10 to 15 degrees colder than at the surface. Possibly the presence of the specimen was related to this, and it was brought in with the cold water mass. The Providencia specimen was collected in a small cave, on a moderately sloping dropoff, at 95 to 100 feet. In contrast to the previous situation, however, no unusual temperature phenomenon was noted. The individual from Glovers Reef was taken along a dropoff at 70 to 100 feet.

It seems likely that *A. leptocaulus* is a deepwater species that occasionally strays into shallow water, as appears to be the case with *A. anisolepis*. It is remarkable that the species was not discovered till 1970, particularly in view of the intensive surveys (involving a number of collections at depths over 100 feet) made by Dr. Walter A. Starck on Alligator Reef, in the upper Florida Keys, and by others in the Keys, Bahamas, and Caribbean area. The reefs paralleling the east Florida coast north of Miami possess certain unique features, and several species of fishes that apparently occur in the Keys only as strays maintain permanent populations north of Miami. Among these may be mentioned the chaetodontids *Prognathodes aculeatus* and *Centropyge argi*, and the lutjanid *Lutjanus mahogoni*. The pomacentrid *Chromis scotti* and the serranid *Hypoplectrus gemma* are extremely common to the north, and reach a far greater abundance than in the Keys. The serranid *Lipogramma trilineata,* like *Apogon leptocaulus*, has been recorded from Florida only off Boca Raton.

It should be noted that the Gulf Stream is closer to shore north of Miami than in the Keys, and this, coupled with the turbid water that frequently makes its way into the Keys from Florida Bay, results in more consistently clear inshore water to the north. Starck (1968:11) concluded that turbidity is probably the primary factor involved in explaining these faunal differences.

*Etymology*: The species name *leptocaulus* is derived from the greek adjective λεπτο (= fine or slender) and the greek noun καυλος (= stem or stalk), in reference to the unusually slender caudal peduncle.

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Vol. 85, No. 37, pp. 427–432 30 December 1972

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# A REMARKABLE PSEUDOSCORPION FROM THE HAIR OF A RAT (PSEUDOSCORPIONIDA, CHERNETIDAE)

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Through the courtesy of Dr. Robert E. Lewis, I received for study a pseudoscorpion from Celebes, collected from the body of a rat by Mr. Gwilym S. Jones. This proved to be a male of an undescribed genus and species belonging to the family Chernetidae. The species is definitely modified for commensal life on a mammal and shows some interesting resemblances to the genus *Pseudochiridium* With. The type-specimen is deposited in the National Museum of Natural History, Smithsonian Institution.

This work was supported in part by a research grant (GB 17964) from the National Science Foundation.

### **Chiridiochernes** new genus

*Diagnosis*: Body stout, appendages relatively long. All parts heavily sclerotized; all surfaces strongly granulate except tips of chelal fingers and pedal tibiae and tarsi; most vestitural setae short and truncated or paucidenticulate, but those on chelal fingers and ventral surfaces becoming long and acuminate. Carapace with two very well-developed transverse furrows; eyes absent. Tergites 1–3 entire, 4 and 5 incompletely divided, 6–11 completely divided; sternites 4–11 divided; lateral edges of tergites and sternites turned abruptly ventrally and dorsally, respectively, and tergites broader than sternites, so that tergites and sternites fit together as though they were the top and bottom of a pill box; circumanal plate small, membranous and withdrawn between tergite 11 and sternite 11; pleural membranes thin, longitudinally striate; genital opercula and internal genitalia generally typical of the Chernetidae. Chelicera with three setae in flagellum; hand with five setae, *sb* terminally denticulate, *b* apparently acuminate, *ls* unusually heavy; galea with several rami. Palps very stout in dorsal view, but greatly flattened in dorso-ventral direction; femur with large, rounded elevation on medial surface just distad of pedicel, this elevation beset with numerous microsetae; in dorsal view, chela greatly expanded just distad of pedicel, fingers distinctly shorter than hand; a few accessory teeth only on internal surface of fixed finger; movable finger with only three trichobothria, *st* apparently wanting; fixed finger with the normal complement (8) of trichobothria, distributed along the length of finger; movable finger with venedens and small venom duct, fixed finger with prominent terminal tooth but no visible venom duct. Coxa of fourth leg with a unique, conical, posterior projection, extending back to fourth sternite, reminiscent of the posterior extension of the fourth coxa in males of *Pseudochiridium.* Femoral articulations of legs I and II more like those of legs III and IV than in most chernetids, also similar to the situation in *Pseudochiridium.* Basifemora and tibiae of all legs distinctly pedicellate. Fourth tarsus without a tactile seta. Subterminal tarsal setae acuminate, curved near tip. Each tarsus with a prominent slit sensillum near proximal end.

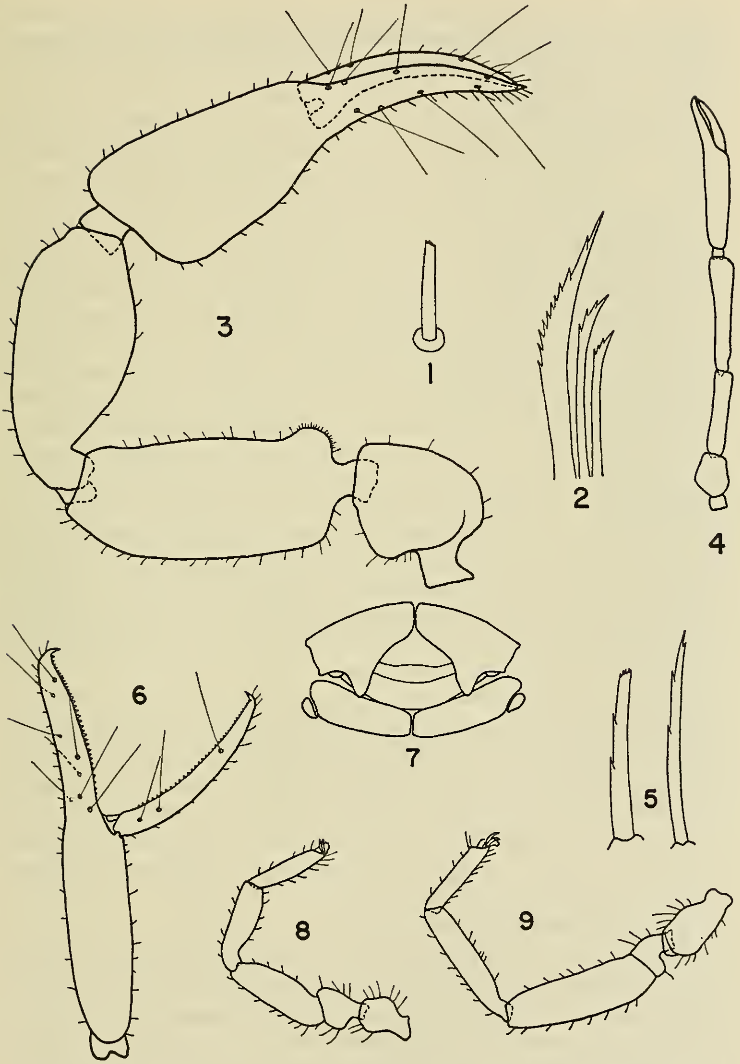
*Type-species*: *Chiridiochernes platypalpus* new species.

*Remarks*: The genus *Chiridiochernes* clearly belongs within the family Chernetidae, because of the presence of a venom apparatus in only the movable chelal finger and the details of the genitalia. However, the type-species, at least, is considerably modified for life on the body of its host mammal—the long legs and long, flattened palps certainly facilitate movement among hairs and the capture of prey, while the heavily armored body protects against desiccation and against scratching by the host. In many ways it appears closely related to *Megachernes* from the western Pacific islands and eastern Asia, which is also commonly found on rats but is much less modified for the association. On the other hand, *Chiridiochernes* bears many resemblances to the genus *Pseudochiridium*, circumtropical in distribution, the life habits of which are little known.

### **Chiridiochernes platypalpus** new genus and new species

*Material*: Holotype male (WM 2363.01001) combed from the fur of a rat (*Rattus penitus*, USNM, #359791) taken at Biroro, at the base of Mt. Lampobathang, south of Melino, Celebes, Indonesia, 29 January 1969, by G. S. Jones.

*Description*: *Male*: With the overall appearance, as seen from above, of a large pseudochiridiid with trapezoidal carapace, smoothly ovoid abdomen and stout palps, but in detail definitely a chernetid. All parts heavily sclerotized, mostly dark brown but legs lighter. Carapace as long as broad, narrowest at anterior and broadest at posterior border; surface heavily granulate; no eyes evident; with 2 well-developed transverse furrows, the median furrow 0.52 and the posterior furrow



Figs. 1–9. *Chiridiochernes platypalpus* new species, holotype male. 1. Seta characteristic of those on carapace and anterior tergites. 2. Cheliceral flagellum. 3. Dorsal view of left palp. 4. Lateral view of right palp, showing dorsoventral flattening of the segments. 5. Two setae characteristic of those on palpal femur and tibia. 6. Lateral view of right chela. 7. Ventral view of coxae IV, genital opercula, and sternites 4. 8. Anterior aspect of left leg I. 9. Anterior aspect of left leg IV.

0.825 the length of the carapace from anterior margin; with about 150 setae scattered over surface, 4 at anterior and 22 at posterior margin; dorsal setae (Fig. 1) short and truncated or denticulate at tip, lateral ones becoming longer and acuminate.

Abdomen one-third longer than broad, heavily sclerotized and rigid in form; tergites 1–3 entire, 4 and 5 incompletely and 6–11 completely divided; all sternites, except genital opercula, divided; surfaces of tergites and sternites heavily granulate except for a rounded area in the medial third of each tergal or sternal half where the granules become flattened; lateral edges of tergites and sternites turned abruptly ventrally and dorsally, respectively, and tergites broader than sternites so that top and bottom can fit together like a pill box; circumanal plate membranous and withdrawn between tergite 11 and sternite 11; pleural membranes thin and longitudinally plicate; tergites each with 20–40 and sternites each with about 40 setae in irregular row along posterior and lateral margin; just anterior to the row of setae on each sclerite is an irregular row of small pit sensilla, each on a distinct elevation; anal plate with 4 setae; most vestitural setae lost from specimen, but remaining ones on dorsal surface short and terminally denticulate, on ventral surface long and acuminate. Anterior genital operculum with about 50 setae, the more posterior ones much longer than the anterior ones; posterior operculum with 2 groups of 4 and 5 small setae at middle of anterior edge just inside the aperture, and about 30 setae in marginal row. Anterior spiracular plate not visible under expanded fourth coxa; posterior plate with 4 setae.

Chelicera typical of the Chernetidae, but relatively small. Length less than one-third that of carapace; palm with 5 setae, *sb* dentate near tip, *b* and *es* acuminate, *ls* relatively heavy; fixed finger with 3–4 small teeth; movable finger with prominent subapical lobe; galea typical, with 5 spinules in distal half; serrula exterior with 19 blades; serrula interior with 4 dentate blades and a basal velum; flagellum of 3 setae, the anterior one long, broad and dentate along its distal half, the others shorter and denticulate near tips (Fig. 2).

Palps dorso-ventrally much compressed, broad when viewed from above, but quite thin when viewed from the side, as shown in Figures 3 and 4; femur with large, rounded elevation on medial surface, just distal to pedicel, this elevation beset with about 50 microsetae; in dorsal view chelal hand greatly expanded just distal to pedicel and tapering sharply toward fingers; fingers distinctly shorter than hand. As viewed from above trochanter 1.4, femur (not including basal elevation) 2.75, tibia 2.45, and chela (without pedicel) 3.35 times as long as broad; hand (without pedicel) 3.45 times as long as deep; movable finger 0.84 as long as hand. All surfaces heavily granulate, including chelal fingers, where granules become smaller and more widely spaced; most vestitural setae short and multidenticulate (Fig. 5), those on fingers longer and acuminate. Trichobothria as shown in Figure 6; fixed finger with usual number of 8, but movable finger with only 3, *st* apparently the missing one. Movable finger with venedens and small venom duct, a nodus ramosus not visible in this specimen; terminal tooth of fixed finger prominent but with no evidence of venom duct. Each finger with 36 nearly contiguous, conical marginal teeth; only fixed finger with accessory teeth, 1 small and 3 large, on internal surface.

Coxae of fourth legs expanded and with unique conical, posterior projections extending back to fourth sternite (Fig. 7), reminiscent of similar situation in *Pseudochiridium.* Legs themselves grossly similar to those of *Pseudochiridium* but more attenuated (Figs. 8, 9); basifemora and tibiae of all legs distinctly pedicellate; femoral articulations of legs I and II more like those of legs III and IV than is usual among the Chernetidae, though former are still movable while latter are fixed; fourth tarsus without a tactile seta; "sense dome" (slit sensillum on small elevation) near proximal end of each tarsus; subterminal tarsal setae acuminate, curved near tips.

*Measurements (in mm)*: *Male*: Body length 2.92. Carapace 0.88 long, posterior breadth 0.81. Chelicera 0.245 long by 0.135 deep; movable finger 0.15 long. Palpal trochanter 0.465 by 0.33; femur 0.88 by 0.32 (not including elevation); tibia 0.76 by 0.31; chela (without pedicel) 1.235 by 0.37; hand (without pedicel) 0.66 by 0.19; movable finger 0.555. Leg I: basifemur 0.215 by 0.16; telofemur 0.43 by 0.14; tibia 0.38 by 0.11; tarsus 0.33 by 0.075. Leg IV: trochanter 0.355 by 0.16; entire femur 0.725 long; basifemur 0.17 by 0.15; telofemur 0.615 by 0.185; tibia 0.555 by 0.11; tarsus 0.37 by 0.065.

*Discussion*: *Chiridiochernes platypalpus* is the first species of pseudoscorpion known to be modified specifically for life on a vertebrate animal. Representatives of other genera have long been known to live on or in the nests of mammals, such as *Lasiochernes* on moles and *Megachernes* on rats, but none of these shows any striking structural modification to favor the association.

There is no evidence that *C. platypalpus* feeds on the host rat, that is, the chelicerae and other mouth parts are not modified and appear incapable of penetrating the skin of a mammal. On the other hand, the flattened body and long thin legs should allow easy movement and the long, flattened palps seem admirably suited to reaching for prey between the hairs of the host. Rats are notorious for their ectocommensals and parasites and Mr. Jones reports (personal communication) that the rat which yielded the pseudoscorpion also harbored one louse, 20 mites, 25 chiggers, and 21 ocular chiggers. Our species has obviously adapted for the efficient utilization of this rich food source.

The heavy sclerotization of all parts and the tight, boxlike construction of the abdomen are certainly adaptations for protection. They probably serve to prevent desiccation in the rather dry environment on the rat's skin; and they are doubtless good defense against the scratching claws and biting teeth of the host as it attempts to rid itself of unwanted guests.

The similarities between *Chiridiochernes* and *Pseudochiridium* are very interesting and deserve further consideration. However, because they are probably of greater relevance to the taxonomic position of *Pseudochiridium*, they will be discussed in detail elsewhere. Suffice it to say that a close relationship between the Pseudochiridiidae and the Chernetidae is indicated.

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Vol. 85, No. 38, pp. 433–444 30 December 1972

PROCEEDINGS
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# THE UNIQUE, CAVE-RESTRICTED GENUS *APHRASTOCHTHONIUS* (PSEUDOSCORPIONIDA, CHTHONIIDAE)

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Through the efforts of a number of speleologists and the special kindness of Stewart B. Peck and James R. Reddell, I have received for study numerous pseudoscorpions from caves in various parts of America. Among these were four specimens belonging to the genus *Aphrastochthonius* Chamberlin, which had been known previously from only three specimens, all from Alabama (see Chamberlin, 1962, and Muchmore, 1968). Study of these few, new specimens has revealed many more interesting features of the genus and makes possible the description of three new species, from Mexico and Guatemala. This work was supported in part by a research grant (GB 17964) from the National Science Foundation.

Types of the new species are deposited in the American Museum of Natural History.

## Genus *Aphrastochthonius* Chamberlin

*Aphrastochthonius* Chamberlin, 1962, p. 307.

*Diagnosis* (*emended*): Based on examination of all known specimens of *Aphrastochthonius*, the characteristics of the genus now appear to be as follows (cf. Chamberlin, p. 307–308).

Carapace of typical chthoniid facies but completely lacking eyes; constricted behind; with vestiture of 16 or 18 macrosetae plus 2–6 lateral microsetae; epistomal process reduced or wanting. Abdomen of usual ovate proportions; pleural membranes finely papillate; tergites and sternites of usual structure; tergal chaetotaxy 4:4:4:4-6:6:6:6:6:6:2

or 4:T2T:0; genital area of male as illustrated by Chamberlin (p. 309, Fig. 2 H,I); anterior genital operculum of female with 5–7 setae. Coxal area grossly typical; apex of maxilla with 2 setae, the medial one long and heavy, the lateral one short, thin, and turned medially so as to lie against the maxilla dorsal to the other seta (Fig. 1); dorsolateral surface of maxilla with 2–7 microsetae in a linear series extending posteriorly from level of trochanteral fossa; apex of coxa I produced into well-developed process (U.S. species) or rounded lobe (Mexican and Costa Rican species) with 1 to 3 microsetae on the medial side; coxal spines on coxae I and II, comprising in each case a transverse, continuous series of short, bipinnate (U.S.) or parallel-rayed (Mexico and Costa Rica) blades; small, bisetose, intercoxal tubercle present. Chelicera typical; galea vestigial or absent; 5 or 6 setae on palm. Palp very attenuated; chela homodentate, with prominent spaced teeth on each finger and with 1 small, external accessory tooth on fixed finger at base of terminal tooth; base of movable finger with prominent interior sclerotic process (attachment apodeme); movable finger with what appears to be a bipolar neuron running from terminal tooth back into finger, the swollen (presumed) perikaryon lying between finger tip and trichobothrium *t*; movable finger also with a large sensory pit, served by conspicuous bipolar neuron, on dental margin just proximal of last tooth; trichobothria situated as illustrated by Chamberlin (p. 309, Fig. 2A) and below (Fig. 7). Legs of typical chthonioid facies, but attenuated; metatarsus of fourth leg with tactile seta at about middle of segment. All parts lightly sclerotized and pale in color.

*Remarks*: The emended diagnosis embodies the correction of three errors in the original diagnosis as well as the addition of several important characters not previously noted. Chamberlin was in error when he stated that the intercoxal tubercle of one of the types ("holotype," p. 308, column 1; "allotype," p. 308, column 2) is monosetose—both, upon reexamination, prove to be bisetose. Somehow Chamberlin overlooked the small lateral seta on the apex of the maxilla—it is present, as described, on both types and on all other specimens of the genus. The reduced size and odd placement of this seta in *Aphrastochthonius* is apparently unique among pseudoscorpions, certainly among the chthonioids. In addition, Chamberlin states (p. 308), "base of fixed finger (fig. 2B) with prominent interior sclerotic process. . . ." This is, of course, a typographical error; as Figure 2B itself shows and as mentioned on page 310 in the description of *A. tenax*, it is the *movable* finger which has the sclerotized basal process.

Neither Chamberlin (1962) nor I (1968) noted four other unusual characteristics of *Aphrastochthonius*, all of them unique, or rare, among pseudoscorpions. The pit at the proximal end of the dental row on the movable chelal finger is apparently a sense organ of some sort. While some other pseudoscorpions have a small pitlike sense organ on the lateral surface of the movable finger (unpublished observations), the placement and morphology of the organ in *Aphrastochthonius* appear not to be duplicated elsewhere. The structure in the tip of the movable finger is nearly identical to the bipolar neuron attached to the pit organ; it is therefore assumed to be connected to some sensory organ in or near the terminal tooth, though none is visible. When first noticed, this structure was considered to be a vestigial venom duct. While this interpretation is now rejected, it is conceivable that the neuron is secretory in nature (though a parallel for such a situation is unknown to me). A third unusual feature is the presence of a small, external accessory tooth at the base of the terminal tooth of the fixed chelal finger. Such a tooth, which meets the tip of the terminal tooth of the movable finger when the chela is closed, is not known to occur in any other heterosphyronid. The fourth feature is the presence of microsetae on the dorsolateral surface of the maxilla, such setae being unreported and unknown to me elsewhere.

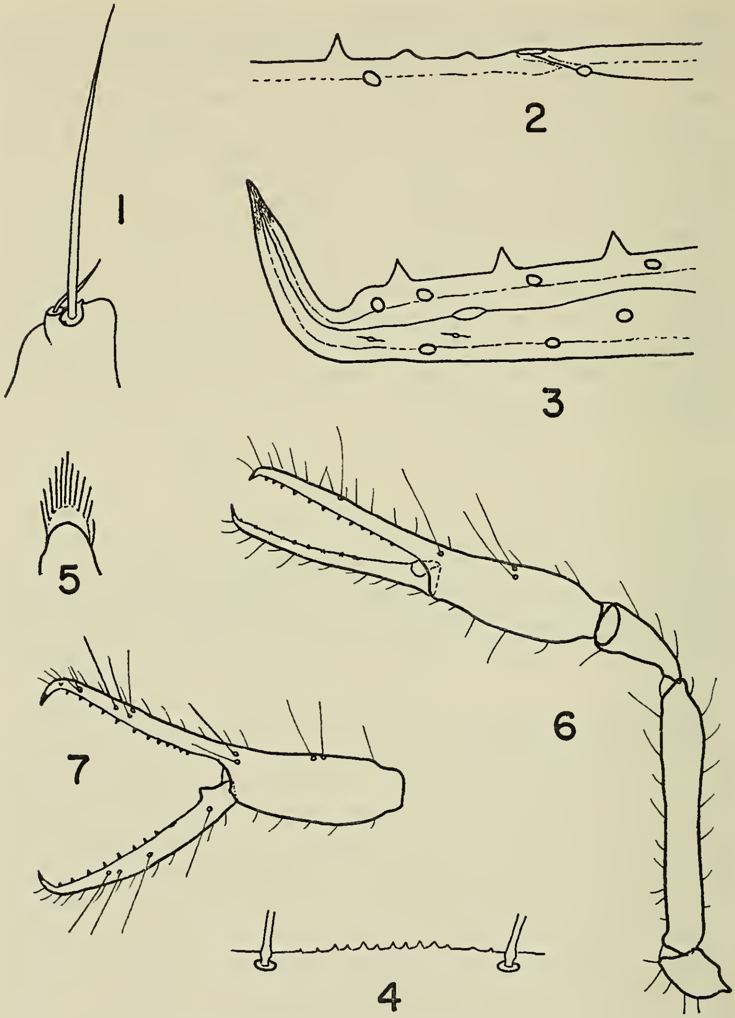
### *Aphrastochthonius tenax* Chamberlin

*Aphrastochthonius tenax* Chamberlin, 1962, p. 308.

In view of the small number of known individuals of this genus, it is appropriate to report here the discovery of a third specimen of *A. tenax*, a female referable to this species found in Catfish Cave, 0.5 mile S.W. of Bangor, Blount County, Alabama, on 28 June 1967 by S. Peck and A. Fiske. (This location is about 1.5 miles from the type-locality, Bangor Cave.)

In general this specimen is very similar to the allotype female, described by Chamberlin and reexamined by the present author. Both of these show clearly the features mentioned above in correction of Chamberlin's errors, namely the small, recumbent, lateral apical seta on the maxilla (Fig. 1), the bisetose intercoxal tubercle, and the enlarged sclerotic process at the base of the movable chelal finger. Also, they both show clearly the four newly discovered, unique features of *Aphrastochthonius*, namely the sensory pit at the basal end of the dental margin of the movable chelal finger (Fig. 2), the bipolar neuron in the distal end of the movable finger (Fig. 3), the external accessory tooth at the base of the terminal tooth of the fixed chelal finger, and two small setae on the dorsolateral surface of the maxilla.

Two additional features should be noted about the specimen from Catfish Cave, in which it differs from the allotype: the coxal spines number five rather than seven on each coxa I and II, and the cheliceral flagellum consists of 10 or 11, rather than eight or nine, setae. The former certainly represents intraspecific variation, while the latter may be only a result of the great difficulty in seeing clearly the individual setae in a chthoniid flagellum.



Figs. 1–3. *Aphrastochthonius tenax* Chamberlin. 1. Ventral view of apex of right maxilla. 2. Proximal end of dental edge of movable chelal finger, showing sensory pit just proximal of last denticle. 3. Tip of movable chelal finger, showing presumed bipolar neuron extending into terminal tooth (only sockets of setae represented).

Figs. 4–7. *Aphrastochthonius parvus* new species, holotype female. 4. Middle section of anterior margin of carapace. 5. Coxal spine from coxa I. 6. Dorsal view of right palp. 7. Lateral view of left chela.

**Aphrastochthonius parvus** new species

*Material*: Holotype female (WM 1759.01001) from La Cueva de la Florida, 15 kilometers S.S.W. of Mante, Tamaulipas, Mexico, 10 March 1969 (J. Reddell and S. Fowler). "Found on wall, in left-hand passage."

*Description*: *Female*: With the general characteristics of the genus, but distinctly smaller than other known species. Carapace about as long as broad; anterior margin straight, but with 8–10 small denticles at center (Fig. 4); no eyes or eyespots present. Carapace with 16 long, stout setae, and a microseta at each side of anterior margin (m4m-4-4-2-2). Coxal area generally typical; chaetotaxy 1+m-2-1-(2m):3m-3-1-CS:3-2-CS:2-5:2-5; maxilla with 2 microsetae (2m) on the dorsolateral surface; each coxa I with 5 and each coxa II with 7 unique spines, each having a low rounded base and many, long thin parallel rays (Fig. 5); small, bisetose intercoxal tubercle present.

Abdomen typical. Tergal chaetotaxy 4:4:4:5:6:6:6:6:6:4:T2T:0. Sternal chaetotaxy 7:(3)10(3):(3)11(3):11:11:11:10:11:8:0:2.

Chelicera distinctly shorter than carapace; 2.1 times as long as broad. Palm with 6 setae, *es* very small; fixed finger with 7 teeth, the distal one much the largest; movable finger with about 12 teeth; galea a low bump on margin of movable finger; serrula exterior of about 14 blades; serrula interior of 12 blades; flagellum with about 9 pinnate setae.

Palps typical. Surfaces generally smooth, except flexor surface of femur covered with tiny papillae arranged in longitudinal rows. Proportions of segments shown in Figure 6; trochanter 1.45, femur 6.0, tibia 2.2, and chela 5.4 times as long as broad; hand 2.5 times as long as deep; movable finger 1.22 times as long as hand. Femur 1.55 and chela 2.1 times as long as carapace. Trichobothria of chela as shown in Figure 7. Fixed finger with marginal row of 13 widely spaced, acute teeth and 1 tiny rounded denticle at proximal end of row; also with 1, small accessory tooth on external surface just proximal to base of terminal tooth. Movable finger with 7 spaced, acute teeth, and 1 small rounded, tooth; with a sensory pit in finger margin just proximal to last tooth. Terminal teeth of fixed and movable fingers similar in size and shape, but latter with a bipolar neuron running inward from the tip. Base of movable finger heavily buttressed and with long apodeme for attachment of adductor muscles.

Legs of typical facies. Leg IV with entire femur 2.4 and tibia 5.1 times as long as deep.

*Male*: Unknown.

*Measurements* (*mm*): Body length 1.21. Carapace length 0.31; greatest breadth 0.31. Chelicera 0.265 long by 0.125 broad; movable finger 0.14 long. Palpal trochanter 0.125 by 0.085; femur 0.48 by 0.08; tibia 0.185 by 0.085; chela 0.65 by 0.12; hand 0.30 by 0.12; movable finger 0.365. Leg IV: entire femur 0.385 long; basifemur 0.17 by 0.16;

telofemur 0.265 by 0.155; tibia 0.28 by 0.055; metatarsus 0.135 by 0.045; telotarsus 0.30 by 0.03.

*Remarks*: This species is easily distinguished from others of the genus by its small size; the palpal femur, for example, being less than 0.5 mm in length. For further discussion, see below.

*Etymology*: This species is named *parvus* because it is the smallest in the genus.

### **Aphrastochthonius verapazanus** new species

*Material*: Holotype female (WM 1903.01001) found in La Cueva Sepacuite #2, Senahu Finca Sepacuite, Alta Verapaz, Guatemala, 26 August 1969 (S. and J. Peck).

*Description*: *Female*: With the general characteristics of the genus. Carapace a little longer than broad; anterior margin straight, but with about 9 small denticles at middle; no eyes or eyespots present. Carapace with 16 long, stout setae, and a microseta at each side of anterior margin (m4m-2-6-2-2). Coxal area generally typical; chaetotaxy 1+m-2-1-(3m):m-3-1-CS;3-2-CS:-2-5:2-5; maxilla with 3 microsetae (3m) on the dorsolateral surface; each coxa I and each coxa II with 7 spines, similar in structure to those of *A. parvus*; small bisetose intercoxal tubercle present.

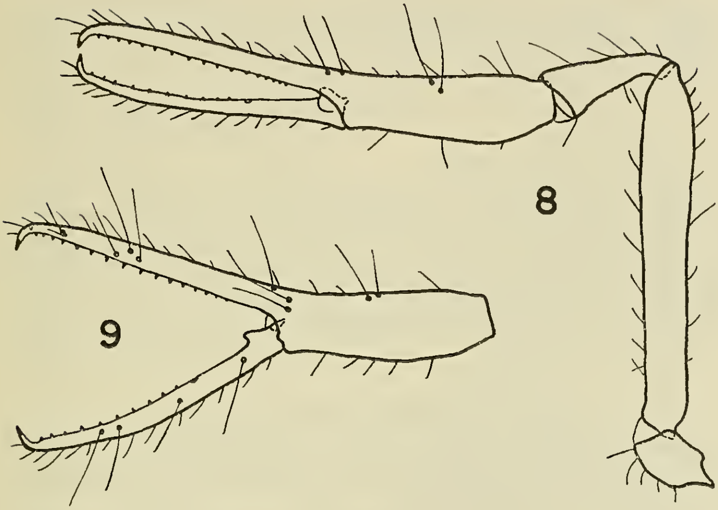
Abdomen typical. Tergal chaetotaxy 4:4:4:4:6:6:6:6:6:2:T2T:0. Sternal chaetotaxy 5:(3)8(3):(3)11(3):13:12:12:10:?:?:0:2.

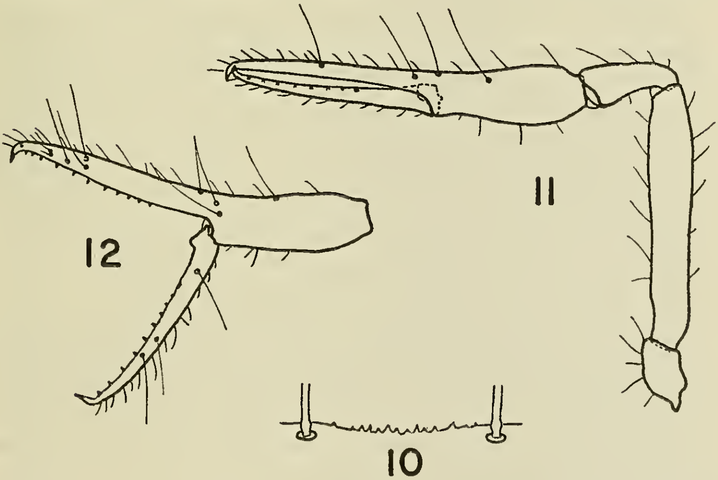
Chelicera shorter than carapace; 2.2 times as long as broad. Palm with 6 setae, *es* very small; fixed finger with 8 teeth, the distal ones largest; movable finger with about 10 teeth; galea a very small elevation of finger margin; serrula exterior of 15 blades and serrula interior of 12 blades; flagellum with 8 pinnate setae.

Palps typical. Surfaces, except fingers, covered with tiny papillae, those on flexor surface of femur arranged in longitudinal rows. Proportions of segments shown in Figure 8; trochanter 1.7, femur 7.7, tibia 2.9, and chela 6.7 times as long as broad; hand 3.1 times as long as deep; movable finger 1.27 times as long as hand. Femur 1.91 and chela 2.4 times as long as carapace. Trichobothria of chela as shown in Figure 9. Fixed finger with marginal row of 16 widely spaced, acute teeth, and with small external accessory tooth just proximal to base of terminal tooth. Movable finger with 10 spaced, acute teeth and 1, tiny, rounded denticle at proximal end of row; also with sensory pit in finger margin just proximal to the small denticle. Terminal teeth of fixed and movable fingers similar in size and shape, but latter with delicate neuron running inward from tip. Base of movable finger heavily buttressed and with long apodeme for attachment of adductor muscles.

Legs typical. Leg IV with entire femur 3.7 and tibia 6.7 times as long as deep.

*Male*: Unknown.





Figs. 8 and 9. *Aphrastochthonius verapazanus* new species, holotype female. 8. Dorsal view of right palp. 9. Lateral view of left chela.

Figs. 10–12. *Aphrastochthonius russelli* new species, holotype tritonymph. 10. Middle section of anterior margin of carapace. 11. Dorsal view of right palp. 12. Lateral view of left chela.

*Measurements* (mm): Body length 1.34. Carapace length 0.35; greatest breadth 0.31. Chelicera 0.31 long by 0.14 broad; movable finger 0.17 long. Palpal trochanter 0.15 by 0.09; femur 0.67 by 0.085; tibia 0.26 by 0.09; chela 0.84 by 0.125; hand 0.385 by 0.125; movable finger 0.49 long. Leg IV: entire femur 0.575 long; basifemur 0.205 by 0.155; telofemur 0.40 by 0.14; tibia 0.40 by 0.06; metatarsus 0.18 by 0.05; telotarsus 0.50 by 0.035.

*Remarks*: This species is easily separated from *A. parvus* by its larger size and more attenuated appendages. Both these species differ from the Tennessee forms, *A. tenax* and *A. pecki*, in their smaller size, the characteristic rayed structure of the coxal spines, and the presence of only two setae at the posterior margin of the carapace.

*Etymology*: This species is named for the area in which it was found, Alta Verapaz, Guatemala.

### **Aphrastochthonius russelli** new species

*Material*: Holotype tritonymph (WM 1752.01001) from La Cueva Pinta, about 12 kilometers N.E. of Valles, San Luis Potosi, Mexico, 31 January 1969 (W. Russell).

*Description*: *Tritonymph*: With the characteristics of the genus. Carapace about as long as broad; anterior edge slightly emarginate and with about 12 small denticles at the middle (Fig. 10); no eyes or eyespots present. Carapace with 16 long, stout setae and with 3 microsetae on each side (m4m-m2m-m6m-2-2). Coxal area typical; chaetotaxy 1+m-2-1-(7m):2m-2-1-CS:3-1-CS:1-4:1-4; maxilla with 7 microsetae (7m) in an irregular longitudinal row on the dorsolateral surface; each coxa I with 5 and each coxa II with 6 spines similar in structure to those of *A. parvus*; small, bisetose intercoxal tubercle present.

Abdomen typical. Tergal chaetotaxy 4:4:4:4:6:6:6:6:4:2:T2T:0. Sternal chaetotaxy 5:(2)6(2):(2)8(2):9:9:9:9:9:7:0:2.

Chelicera shorter than carapace, 2.1 times as long as broad. Palm with 6 setae, *es* very short; fixed finger with 11 teeth, the largest being the third from the distal end; movable finger with 9 teeth, the third and fourth being largest; galea represented by a barely discernible elevation of finger margin; serrula exterior with 12 and serrula interior with 10 blades; flagellum of 7 pinnate setae.

Palps typical. Surfaces, except fingers, covered with tiny papillae, those on flexor surface of femur arranged in longitudinal rows. Proportions of segments shown in Figure 11; trochanter 1.8, femur 5.65, tibia 2.3 and chela 5.85 times as long as broad; hand 2.7 times as long as deep; movable finger 1.39 times as long as hand. Femur 1.45 and chela 1.95 times as long as carapace. Trichobothria of chela typical (Fig. 12), with *sb* absent from movable finger and *isb* absent from dorsum of hand. Fixed finger with 11 spaced, acute, marginal teeth and a small external accessory tooth near base of terminal tooth. Movable finger with 8 spaced teeth and a small rounded denticle at proximal end of row; also, with sensory pit just proximal to the denticle. Terminal teeth of the fingers similar in size and shape, but latter with a delicate neuron running inward from the tip. Base of movable finger typically heavily buttressed and with long apodeme.

Legs without unusual features.

*Male and female*: Unknown.

*Measurements* (mm): Body length 1.04. Carapace length 0.33, greatest width 0.335. Chelicera 0.27 long by 0.13 broad; movable finger 0.155 long. Palpal trochanter 0.125 by 0.07; femur 0.48 by 0.085; tibia 0.185 by 0.08; chela 0.645 by 0.11; hand 0.28 by 0.105; movable finger 0.39 long. Leg IV: entire femur 0.415 long; basifemur 0.155 by 0.135; telofemur 0.28 by 0.125; tibia 0.26 by 0.06; metatarsus 0.125 by 0.045; telotarsus 0.35 by 0.04.

*Remarks*: While the author is usually very critical of describing new species on the basis of nymphal specimens, it seems best to do just that in the present instance. The specimen under consideration is from a cave about 65 kilometers from the type-locality of *A. parvus*, and it might be expected to represent the tritonymph of that species. However, its size, the proportions of its appendages, and the number of teeth on the chelal fingers do not allow its inclusion in *A. parvus*.

A number of morphological features of *A. russelli* are remarkable and should be mentioned here, but extended discussion will not be profitable at this point, in the absence of any knowledge of adults of this or of nymphs of other species. Chief among the unusual features is the occurrence of three dwarf setae on each side of the carapace. Inasmuch as all known adults of *Aphrastochthonius* have only a single dwarf seta, near the anterior margin, the question arises and remains unanswered whether this feature is diagnostic of *A. russelli* or is only a characteristic of the tritonymphal stage. The same may be said of the occurrence of seven small setae on the side of the maxilla in this species, while others have only two or three such setae. Other interesting features, the systematic significance of which is not known, are the occurrence of two small setae on the apical margin of coxa I, the emargination of the anterior edge of the carapace, and the virtual absence of a galeal elevation.

*Etymology*: It is a pleasure to name this species for William Russell, who collected the specimen.

### KEY TO THE SPECIES OF *APHRASTOCHTHONIUS* (BASED ON FEMALES)

1. Posterior margin of carapace with four setae; coxal spines elongate and bipinnate (eastern U.S.) .......... 2
   Posterior margin of carapace with two setae; coxal spines short and parallel-rayed (Mexico and Costa Rica) .......... 3
2. Palpal femur greater than 0.75 mm in length, l/w ratio greater than 7.0; cheliceral palm with six setae ....... *A. tenax* Chamberlin

Palpal femur less than 0.70 mm in length, l/w ratio less than 6.0; cheliceral palm with five setae ........................ *A. pecki* Muchmore

3. Carapace with a single microseta on each side, "preocular" in position; maxilla with two or three microsetae dorsolaterally ...... 4

Carapace with three microsetae on each side, one "preocular," the others "postocular," in position; maxilla with seven microsetae dorsolaterally (known only from tritonymph) ........................ *A. russelli* new species

4. Palpal femur greater than 0.6 mm in length; l/w ratio greater than 7.5 ........................ *A. verapazanus* new species

Palpal femur less than 0.5 mm in length; l/w ratio less than 6.5 ........................ *A. parvus* new species

*Discussion:* It is evident from the distribution of *Aphrastochthonius* species, in Alabama, Tamaulipas, San Luis Potosi, and Guatemala, that these are relicts of a formerly widespread group. It is likely that additional representatives of the genus exist in other American caves; and it is not inconceivable that epigean forms may be discovered in the mountains of Mexico or Central America, where the chthoniid fauna is still virtually unknown. It seems clear that the special characteristics of the genus were developed before the known species retreated into caves, inasmuch as these characteristics are shared by forms in widely separated and independently developed cave systems. Thus, while the genus as we know it at present is cave restricted, the features such as the presumed sensory neuron in the tip of the movable chelal finger, the sensory pit on the dental margin of the same finger, the accessory tooth on the fixed chelal finger, and the microsetae on the side of the maxilla must have evolved in some widespread epigean environment which has since disappeared.

As Chamberlin pointed out (1962), the relationship of *Aphrastochthonius* to other heterosphyronid genera is obscure. In the possession of coxal spines on coxae I and II and in the shape and dentition of the chela it resembles some dithids and the chthoniid genus *Pseudochthonius*. It differs from the dithids in the lack of distinct, oblique stigmatic plates and in the possession of a bisetose, intercoxal tubercle, though some members of that group have only very weakly sclerotized and nearly transverse stigmatic plates and a monosetose intercoxal tubercle. From *Pseudochthonius* it differs mainly in the presence of the intercoxal tubercle and in some details of chaetotaxy of the carapace, coxae, and chela. While most species of *Pseudochthonius* have chelal fingers very different from those of *Aphrastochthonius*, *P. orthodactylus* Muchmore (1971) possesses a chela which is very like that of *Aphrastochthonius* in shape and dentition. If it can be assumed that the condition of the chela in *P. orthodactylus* is primitive for *Pseudochthonius*, then a relationship between that genus and *Aphrastochthonius* is more easily conceived. However, separation of the genera must have been of long duration to have allowed for the many peculiar characteristics of each. Further speculation along these lines will have to await fuller knowledge of all the various heterosphyronid genera.

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574.0673

Vol. 85, No. 39, pp. 445–468 30 December 1972

PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

# A REVIEW OF THE VIVIPAROUS OPHIDIOID FISHES OF THE GENUS *SACCOGASTER*

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Over the past 5 years we have examined specimens of several species of small viviparous ophidioid fishes from the continental slopes, which seemed to defy rational placement in a scheme of classification. The opportunity to examine all of the species at the same time has resulted in the present paper, in which we recognize *Saccogaster* Alcock as a senior synonym of *Barbuliceps* Chan. We refer six species to the genus, four of which are described for the first time, and discuss the relationships of the species.

We are greatly indebted to all of the following, who have helped us by providing specimens and in other ways: N. Chirichigno, W. Eschmeyer, G. Krefft, A. G. K. Menon, N. Parin, C. R. Robins, J. Staiger, P. Struhsaker, A. Wheeler, P. Whitehead, the Smithsonian Oceanographic Sorting Center and the British Museum (Nat. Hist.). Robert H. Gibbs and Richard Winterbottom read and commented on a part of the paper. Bruce B. Collette criticized the entire manuscript.

The following abbreviations are used throughout the paper: SL, standard length; BMNH, British Museum (Natural History), London; IM, Instituto del Mar, Lima; IOM, Institute of Oceanology, Moscow; ISH, Institut für Seefischerei, Hamburg; USNM, National Museum of Natural History, Washington; ZMUC, Zoological Museum University of Copenhagen; ZSI, Zoological Survey of India, Calcutta.

## *Saccogaster* Alcock

*Saccogaster* Alcock, 1889, p. 386. Type-species by monotypy, *Saccogaster maculata* Alcock, 1889.

*Barbuliceps* Chan, 1966, p. 4. Type-species by original designation, *Barbuliceps tubercularis* (lapsus pro *tuberculatus*) Chan, 1966.

*Diagnosis*: Barbels absent. Live bearing; male genitalia (so far as known) borne on a fleshy stalk, lacking ossified parts. Ventral fins each with a single ray immediately adjacent to each other. Dorsal, anal and caudal fins confluent. Pectoral fin rays supported by elongated radials. Scales lacking on head and reduced or absent on body. Anterior nostril directly above upper lip. Tongue with an anterior prowlike extension. Spine present on opercle. Branchiostegal rays 8; 4 attached to the outer surface of the epihyal and enlarged distal part of ceratohyal, 4 attached ventrally or medially along shaft of ceratohyal. Tail section of body not greatly elongated, anal fin originating posterior to the midlength of the fish. Teeth present on palatine. Maxillary vertically expanded posteriorly.

First neural spine smaller than those following. Ribs absent from first two centra. At least some neural spines with truncate or spatulate tips.

*Description*: Small fishes, largest specimen 140 mm SL. Relatively short-bodied, depth at vent 6.2 to 8.7 in standard length; head 3.0 to 4.4 in standard length. Musculature generally weak and flabby, virtually absent around the belly. Eyes small. Caudal fin with 12 rays inserted on 2 hypurals. So far as known, paired tooth patches at the bases of gill arches 3 and 5. Total vertebrae 51 to 57 (not including ural centra). Most specimens with a rayless, predorsal pterygiophore.

*Relationships*: *Saccogaster* appears to be closely related to the *Cataetyx–Diplacanthopoma* group of genera (including also the nominal genera *Oculospinus, Pseudonus* and *Myxocephalus*), all of which contain viviparous species with conjoined median fins. The limits of these genera are not precisely defined at present; however, some characters shared with *Saccogaster* include a stalked intromittent organ in the male, eight branchiostegal rays and (so far as known) the parietals separated by the supraoccipital. *Saccogaster* particularly resembles *Diplacanthopoma* in its naked head and in the absence of ribs on the first two centra. *Diplacanthopoma* is more generalized in its complete complement of imbricate body scales but more specialized in its longer, tapering tail and single hypural.

*Bythites* (and a related undescribed genus, Nielsen and Cohen, in press) is also close to *Saccogaster*, resembling it in the same ways given above for the *Cataetyx–Diplacanthopoma* group (although eight branchiostegal rays is not characteristic of all species in the *Bythites* group). Some differences are the presence in *Bythites* (and in the undescribed genus) of a complete complement of imbricate scales on the body and the absence of elongated pectoral radials.

The single most distinctive feature of the species of *Saccogaster* is the presence of greatly elongated pectoral radials, a character shared with *Calamopteryx* and with *Sciadonus* and *Leucochlamys* among the aphyonid ophidioids. *Calamopteryx* has scales on the head and body, seven branchiostegal rays, ribs on the first two centra and an unstalked intromittent organ and does not seem very close to *Saccogaster.* The two aphyonid genera mentioned above also resemble several *Saccogaster* species in lacking scales; however, the aphyonids have a notably high number of abdominal centra (Nielsen, 1969). It seems obvious that elongate pectoral radials have evolved independently at least three times in ophidioid fishes.

*Synonymy*: *Barbuliceps* Chan, which we refer to the synonymy of *Saccogaster*, was recognized on the basis of comparison with the genera of scaleless ophidioids. Chan (1966) stressed relationship with *Spectrunculus* Jordan and Thompson, 1914, a deep-bodied pelagic form with a high vertebral count (79–80),[1] which undoubtedly represents the metamorphosing stage of some ophidioid. We cannot properly place *Spectrunculus* but doubt that it is close to the species discussed herein.

*Barbuliceps* differs in only one significant respect from S. *maculata*, the type-species of *Saccogaster*, and that is in the presence of incomplete body squamation in S. *maculata* and the absence of all scales in *B. tuberculata.* We do not consider this to be sufficient to warrant the recognition of a distinct genus.

*Distribution*: All of the known specimens of *Saccogaster* have been taken with bottom trawls at depths ranging from about 100 to ~~1200~~ 820 meters beneath tropical seas. S. *maculata* has been captured four times in the Bay of Bengal. S. *staigeri* is known from two specimens from different localities off Florida. S. *hawaii* is described from a single specimen taken off Maui in the Hawaiian Islands. S. *tuberculata* has been taken from the South China Sea and off Maui. The related S. *parva* is known only from the holotype taken off the coast of Brazil. The most highly specialized species, S. *normae* has been caught at two localities off the coast of northern Peru. Too little information is available to allow any conclusions to be drawn about distribution patterns.

## KEY TO SPECIES

1a. Scales present on body.
    2a. Spine on opercle with a single point; pectoral fin rays 16 to 18; dorsal fin rays 75 to 88.
        3a. Gill filaments on first arch not notably reduced in size (Fig. 1a); palatine tooth row several teeth wide; dorsal fin rays 75 to 83 .................... S. *maculata* Alcock.
        3b. Gill filaments on first arch notably reduced in size (Fig. 1b); palatine teeth in a single row; dorsal fin rays 87 to 88 .................................... S. *staigeri* new species.

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[1] Based on our examination of the holotype of S. *radcliffei* Jordan and Thompson, 1914, the type-species of the genus, and one additional specimen.

- 2b. Spine on opercle with three points; pectoral fin rays 22; dorsal fin rays 92 ........................................ *S. hawaii* new species.
- 1b. Scales absent.
  - 4a. Gill opening extending above level of pectoral fin base; gill filaments on first arch short (Fig. 1d).
    - 5a. Developed rakers on first gill arch 3; pectoral fin rays 20 to 23; jaw teeth granular; anal fin rays 57 to 59 ........................................................ *S. tuberculata* (Chan).
    - 5b. Developed rakers on first gill arch 6; pectoral fin rays 14; some jaw teeth longer, needlelike; anal fin rays 64 ........................................................ *S. parva* new species.
  - 4b. Gill opening not extending above level of dorsal margin of pectoral fin base. Gill filaments on first arch long (Fig. 1e) ........................................................ *S. normae* new species.

### *Saccogaster maculata* Alcock

Figures 1a, 2

*Saccogaster maculatus* Alcock, 1889, p. 389 (orig. descr. based on 2 ♀ ZSI F 11673–4; Bay of Bengal, 20°17′30″ N, 88°50′ E, 193 fms. = 353 m.).—Menon and Yazdani, 1968, p. 150 (types in ZSI).

*Saccogaster maculata* Alcock, 1891a, p. 30, pl. 7, fig. 3 (♂ from Bay of Bengal, 439–505 m., 11.1°C.).—Alcock, 1891b, p. 226, fig. (longer descr. of previous spec.).—Alcock and McArdle, 1900, pl. 29, figs. 2, 2a (♂ intromittent organ).

*Diplacanthopoma* (*Saccogaster*) *maculatum* Alcock, 1899, p. 102 (descr. based on 5 spec. including types, Bay of Bengal).

*Diagnosis*: Scales present on sides of body; relatively long gill filaments on first arch (Fig. 1a); palatine tooth row several teeth wide; see Table 1 for comparisons of meristic characters.

*Study material*: All from Bay of Bengal. ZSI 11673, syntype (x-ray photograph only); ZSI 13527–8 (2 specimens); ZSI 13045 (1); IOM (1), "Vitiaz" cr. 33, stat. 4929, 16°56′ N, 83°13′ E, 600 m.

*Description*: Selected measurements are presented in Table 2. Body compressed, relatively short, greatest depth 4.6 to 5.6 in SL. Preanal 1.5 to 1.7 in SL. The skin is thin and transparent.

Scales are absent from the predorsal part of the body and from a band along the bases of the dorsal and anal fins except posteriorly where they cover the entire depth of the body. The most anterior scales are widely scattered; more posteriorly they are progressively more closely spaced, and on the rear part of the body they are regularly imbricate. The figure given by Alcock and McArdle (1900) is inaccurate with respect to the pattern of scale distribution.

The lateral line is in 2 non-overlapping sections along the body; an anterior, dorsal part with about 12 small papillae in a row extending from near the upper angle of the opercle to a point somewhat anterior to the level of the vent; and a lower, posterior section, which does not extend to

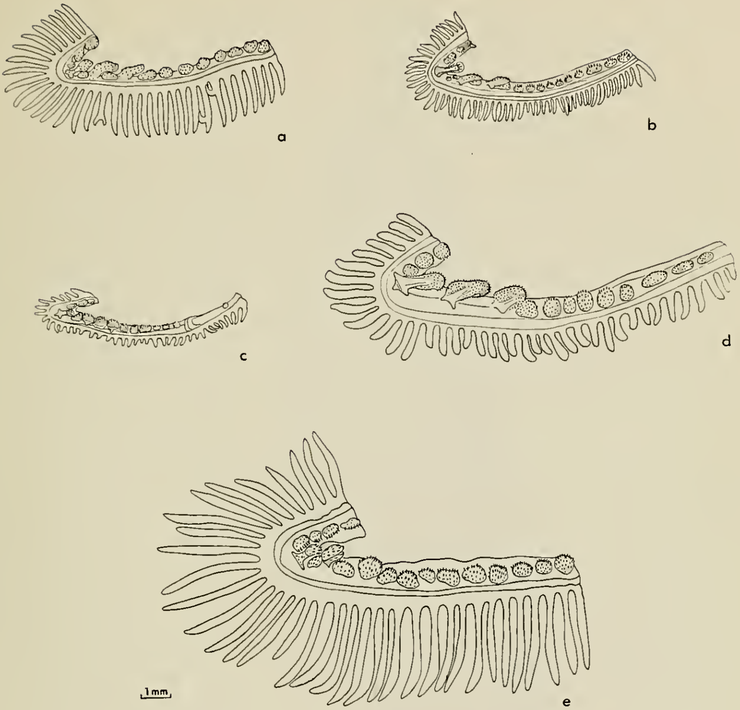

FIG. 1. Lateral view of first right gill arch in five species of *Saccogaster*. A, *maculata*, IOM; B, *staigeri*, USNM 207357, holotype; C, *hawaii*, USNM 207355, holotype; D, *tuberculata*, USNM 207354; E, *normae*, IM 421, paratype. All drawn to same scale, by Keiko H. Moore.

the very end of the body, consisting of 8 to 10 papillae in a row along the midline.

The lateral head canal has 1 pore above the angle of the gill opening; supraorbital pore 1, above the upper lip and medial to the tubular anterior nostril; infraorbital pores 5, 3 along upper lip posterior to anterior nostril and 2 very small pores above the posterior expanded part of the maxillary; mandibular pores 2 or 3, near the tip of the jaw; in addition, a pore is present slightly posterior to the rear margin of the maxillary.

Head compressed in postorbital region. Snout depressed, broadly rounded from above. Lower jaw slightly included. Small, darkly pigmented papillae and dermal fringes sparsely distributed on the snout, a few on the postorbital part of the head. An irregular row of widely spaced papillae on the mandible. The posterior tip of the opercle produced into a

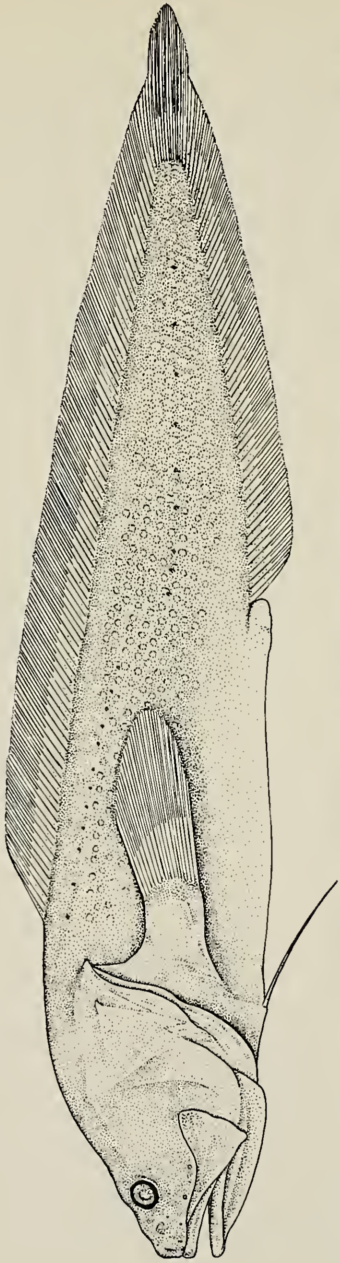

Fig. 2. *Saccogaster maculata*, IOM; 87.4 mm SL. Head pores and papillae not shown in detail. Drawn by Keiko H. Moore.

single blunt spine; in some specimens the ventral arm of opercle terminates as a short spine. The posterior, vertically expanded part of the maxillary is not sheathed posteriorly; the posteroventral corner is produced into a blunt projection.

First gill arch (Fig. 1a) with 3 developed rakers, 1 at the angle and 2 on the lower arm; both arms with low spiny pads. Gill filaments longer than developed rakers. Pseudobranch present, consisting of 2 filaments.

Dentition on premaxillary consisting of a narrow band of granular teeth. Medial to the band near the tip of the jaw is a series of 7 to 9 more elongate needlelike teeth in a widely spaced row. Vomer with a broadly V-shaped band of sharp pointed teeth. Palatine teeth similar, in a narrow band several teeth wide. Dentary with an irregular inner row of about 15 pointed teeth and an outer band 3 to 5 teeth wide of smaller teeth.

Dorsal fin originating over vertebral centra 6–7, anal fin under centra 21–23. Adpressed pectoral fin extending more than one-half the distance from the upper angle of the pectoral peduncle to the origin of the anal fin.

Peritoneum tough and silvery; swimbladder thin walled and clear. Pyloric caeca absent.

Intromittent organ of male borne on a thick, fleshy, posteriorly directed stalk with the vent on its ventral surface. The stalk has 2 prominent lobes at its tip; the cleft between the lobes leads to a pit, from which a penis protrudes. The penis in the "Vitiaz" specimen is 1.5 mm long; however, Alcock and McArdle (1900, fig. 2) show a longer one. Penis length may be correlated with degree of sexual maturity (as discovered in *Barathronus* by Nielsen, 1969). The paired testes of the "Vitiaz" specimen are not notably enlarged. A section of gonadal material shows spermatozoa arranged in spermatophores.

With the exception of a small amount of dusky pigmentation on the snout, there is no obvious color pattern in preserved specimens.

Abdominal centra 12. Centra 5–10 with neural spines variously truncate to spatulate, not sharp and needlelike. First parapophyses on centrum 7. Parietals separated by supraoccipital.

*Distribution*: All known specimens are from the Bay of Bengal and have been taken at depths ranging from 265 to 600 m.

### **Saccogaster staigeri** new species

Figure 1b

*Diagnosis*: Scales present on sides of body, relatively short gill filaments on first arch (Fig. 1b); palatine teeth in a single row; see Table 1 for comparisons of meristic characters.

*Study material*: HOLOTYPE, USNM 207357 (formerly UMML 20757), "Gerda" stat. 657, 27°11′N, 79°49′W, 201–216 m, 10′ otter trawl, 16 July 1965. PARATYPE, USNM 164144, "Oregon" 1005, 24°20′ N, 82°55′ W, 347 m, 40′ shrimp trawl, 13 April 1954; bottom temp. 10.0°C. Neither specimen is suitable for illustrating.

*Description*: Selected measurements are presented in Table 2. Similar

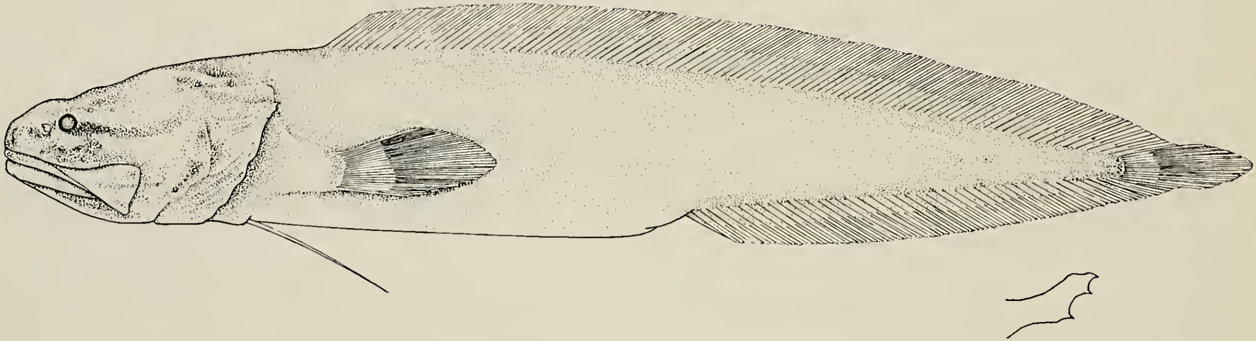

FIG. 3. *Saccogaster hawaii*, USNM 207355, holotype; 69.2 mm SL. Scales not shown. Lower right figure is enlarged view of opercle spine. Drawn by Keiko H. Moore.

TABLE 1. Frequency distributions of numbers of fin rays and vertebral centra in *Saccogaster*

| | Dorsal rays | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 |
| *maculata* | 1[1] | | | | 1[1] | | | | 1 | | | | | | | | | |
| *staigeri* | | | | | | | | | | | | | 1 | 1 | | | | |
| *hawaii* | | | | | | | | | | | | | | | | | | 1 |
| *tuberculata* | | | | | | | | | | | 1 | 1 | 1[2] | | | 1 | | |
| *parva* | | | | | | | | | | | | | | | | | 1 | |
| *normae* | | | | | | | | | 1 | | | | 1 | | | | | |

| | Anal rays | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 |
| *maculata* | 1[1] | | | | | 1[1] | | 1 | | | | | | | | | | | |
| *staigeri* | | | | | | | | | 1 | 1 | | | | | | | | | |
| *hawaii* | | | | | | | | | | 1 | | | | | | | | | |
| *tuberculata* | | | | | | | | | | | | 2 | | 2[2] | | | | | |
| *parva* | | | | | | | | | | | | | | | | | | | 1 |
| *normae* | | | | | | | | 1 | 1 | | | | | | | | | | |

| | Pectoral rays | | | | | | | | | | Vertebrae[3] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 51 | 52 | 53 | 54 | 55 | 56 | 57 |
| *maculata* | | | 1 | 2 | 1 | | | | | | | 1 | | | | | |
| *staigeri* | | | | | 2 | | | | | | 1 | | 1 | | | | |
| *hawaii* | | | | | | | | | 1 | | | | | 1 | | | |
| *tuberculata* | | | | | | | 1 | | 2[2] | 1 | | | | | 1[2] | 2 | 1 |
| *parva* | 1 | | | | | | | | | | | | | 1 | | | |
| *normae* | | | | 2 | | | | | | | | | | 1 | 1 | | |

[1] Not read from x-ray photograph.

[2] Holotype from S. China Sea; others from Hawaii.

[3] Not including ural centra.

in most respects to S. *maculata*; only the differences are described in the following account. Greatest depth 4.6 in holotype, 6.2 in paratype.

Squamation of the holotype is similar to that of *maculata*; however, the paratype has fewer scales, which are doubtfully imbricate anywhere on the body. Whether greatly reduced squamation of the paratype is due to sex, size or individual variability we cannot say.

Lower part of the lateral line in the holotype with about 20 papillae; the lateral line cannot be traced in the paratype and head pores are indistinct.

Gill filaments on first arch shorter than developed rakers (Fig. 1b). The enlarged, needlelike teeth at the tip of the premaxillary (about 20 in the holotype, 9 in the paratype) are in a cluster. Vomerine teeth about 10, similar to larger premaxillary teeth. Palatine with 8 to 12 sharp

TABLE 2. Measurements on S. *maculata* and S. *staigeri*

| | *S. maculata* | | | | | | | | *S. staigeri* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ZSI 13527 | | ZSI 13528 | | ZSI 13045 | | IOM | | Holotype USNM 207357 | | Paratype USNM 164144 | |
| Sex | ♂ mm | % SL | ♂ mm | % SL | ♂ mm | % SL | ♂ mm | % SL | ♂ mm | % SL | ♀ mm | % SL |
| SL | 80.8 | | 75.0 | | 76.8 | | 87.4 | | 93.1 | | 61.2 | |
| Snout to dorsal fin | 28.9 | 35.8 | 24.9 | 33.2 | 23.5 | 30.6 | 28.7 | 32.8 | 29.1 | 31.2 | 18.2 | 29.7 |
| Snout to anal fin | 52.2 | 64.6 | 44.3 | 59.1 | 45.9 | 59.8 | 52.6 | 60.2 | 55.5 | 59.6 | 37.1 | 60.6 |
| Snout to ventral fin | – | – | 20.0 | 26.7 | 18.6 | 24.2 | 20.8 | 23.8 | 20.2 | 21.7 | 13.5 | 22.1 |
| Body depth at vent | – | – | – | – | – | – | 12.0 | 13.7 | 14.8 | 15.9 | 7.0 | 11.4 |
| Head length | 26.8 | 33.2 | 22.4 | 29.9 | 22.4 | 29.2 | 25.2 | 28.8 | 25.1 | 27.0 | 16.6 | 27.1 |
| Snout length | 5.0 | 6.2 | 3.8 | 5.1 | 3.7 | 4.8 | 5.1 | 5.8 | 6.1 | 6.5 | 4.0 | 6.5 |
| Eye diameter[1] | 2.4 | 3.0 | 2.3 | 3.1 | 2.3 | 3.0 | 2.1 | 2.4 | 2.0 | 2.1 | 1.7 | 2.8 |
| Interorbital width[2] | 3.2 | 4.0 | 3.8 | 5.1 | – | – | 4.2 | 4.8 | 5.0 | 5.4 | 3.3 | 5.4 |
| Upper jaw length[3] | 10.8 | 13.4 | 10.7 | 14.3 | 11.0 | 14.3 | 12.8 | 14.6 | 13.6 | 14.6 | 8.5 | 13.9 |
| Depth of maxilla[4] | 4.1 | 5.1 | 3.8 | 5.1 | 3.7 | 4.8 | 5.2 | 5.9 | 4.5 | 4.8 | 2.8 | 4.6 |
| Cleithrum to ventral fin[5] | 2.8 | 3.5 | 2.6 | 3.5 | – | – | 3.3 | 3.8 | 2.8 | 3.0 | 2.5 | 4.1 |
| Ventral fin length | 8.7 | 10.8 | 6.9 | 9.2 | – | – | 10.3 | 11.8 | 11.5 | 12.3 | 7.2 | 11.8 |
| Pectoral peduncle length[6] | 5.0 | 6.2 | 4.1 | 5.5 | 4.1 | 5.3 | 6.0 | 6.9 | 5.1 | 5.5 | 2.6 | 4.2 |
| Pectoral peduncle depth | 4.6 | 5.7 | 3.2 | 4.3 | 4.3 | 5.6 | 4.2 | 4.8 | 4.5 | 4.8 | 2.4 | 3.9 |
| Pectoral fin length[7] | 10.0 | 12.4 | 8.9 | 11.9 | – | – | 12.4 | 14.2 | 13.4 | 14.4 | 7.5 | 12.2 |

[1] Horizontal diameter of clear window.

[2] Least distance between dorsal margins of clear windows (= fleshy interorbital).

[3] Snout tip to posterior margin of maxilla.

[4] Greatest depth, measured at rear of bone.

[5] Cleithrum to ventral fin.

[6] Upper angle of peduncle to origin of fin rays.

[7] Longest fin ray.

pointed, widely spaced teeth in a single row. Dentary with outer series of small teeth in a band 1 to 2 teeth wide.

Pyloric caeca of holotype developed as 2 hemispherical protuberances. Peritoneum transparent; swimbladder tough and silvery.

The holotype has a 9 mm long penis and the rear part of the body cavity occluded by great swollen testes. Eggs are visible through the body wall of the paratype; a fleshy, protruding genital papilla is present; it is cleft transversely to form anterior and posterior hoodlike structures, with the vent at the base of the anterior one.

Abdominal centra 14 in holotype, 13 in paratype.

*Distribution*: Known from two localities: off Jupiter Inlet on the east coast of Florida, and south of Tortugas in the Gulf of Mexico.

*Etymology*: Named for Dr. Jon C. Staiger, who first called this species to our attention.

### **Saccogaster hawaii** new species

Figures 1c, 3

*Diagnosis*: Scales present on sides of body; very short gill filaments on first arch; opercular spine with 3 prongs; see Table 1 for comparisons of meristic characters.

*Study material:* HOLOTYPE, USNM 207355. "Townsend Cromwell" 40–62, 21°00′ N, 156°47′ W, 234 m, bottom temp. 15.9°C.

*Description*: Measurements are given in mm first followed by percent of standard length. Explanations of measurements are given in Table 2. SL 69.2; snout to dorsal fin 21.7 (31.3); snout to anal fin 42.8 (61.8); snout to ventral fin 15.5 (22.4); body depth at vent 8.4 (12.1); head length 17.9 (25.9); snout length 3.8 (5.5); eye diameter 1.5 (2.2); interorbital width 3.4 (4.9); upper jaw length 9.8 (14.2); depth of maxilla 3.5 (5.1); cleithrum to ventral fin 2.5 (3.6); ventral fin length 8.6 (12.4); pectoral peduncle length 4.0 (5.8); pectoral peduncle depth 2.6 (3.7); pectoral fin length 9.2 (13.3).

Body compressed, relatively elongate for a *Saccogaster*, greatest depth 6.9 in SL. Preanal 1.6 in SL.

Scales are absent from the predorsal part of the body and from a band along the bases of the dorsal and anal fins. The most anterior scales are widely scattered; more posteriorly they are progressively more closely spaced and on the rear of the body they are regularly imbricate.

The lateral line is obscure.

The head pore system cannot be described with any degree of precision due to the delicate condition of the extremely thin skin. However, subdermal neuromasts outlined in brown pigment are readily visible: lateral canal 5; supraorbital 5; suborbital 4 or 5; mandibular 4 or 5; preopercular 2 or 3.

Head slightly compressed in suborbital region. Snout depressed, broadly rounded from above. Lower jaw slightly included. Small darkly pigmented papillae are sparsely distributed on the snout, a few on the postorbital part of the head. A row of papillae is present along each mandible; the pores near the tip of the lower jaw are rimmed with dermal fringe.

The posterior part of the opercle terminates in a flattened antlerlike 3-pronged spine (Fig. 3, inset). The posterior, vertically expanded part of the maxillary is not sheathed dorsally. A stout, short, anteriorly directed spine projects upward from ethmoid.

First gill arch with 3 barely developed rakers, scarcely longer than the spiny pads supported on the arch. Gill filaments on first arch short, a bare fringe (Fig. 1c). Pseudobranch absent.

Dentition on premaxillary a band of small granular teeth. Medial to the band at the tip of the jaw is a series of 8 elongate needlelike teeth in a widely spaced row. Vomer with 6 teeth similar to the longer premaxillary teeth, plus a scattering of shorter teeth. Palatine with 10–15 sharp pointed teeth in a single row. Dentary with an irregular row of about 15 longer, pointed teeth and an outer narrow band of shorter teeth.

Dorsal fin originating over vertebral centrum 7, anal fin under centrum 25. Adpressed pectoral fin extending about one-half the distance from the insertion of the pectoral rays to the vent.

Peritoneum thin walled and transparent.

No well-developed intromittent organ; probably an immature female. A pair of elongate gonads visible through the transparent belly skin.

Body generally pale, but with some fine brown pigmentation along the bases of the dorsal and anal fins. Similar pigmentation on the head, particularly on the snout and beneath the eyes. An intense dark brown band originating at the posteroventral segment of the eye and becoming more diffuse posteriorly. As noted above, neuromasts outlined in dark pigment.

Abdominal centra 16. Centra 5 to 12 with neural spines variously truncate, markedly so in the middle ones. First parapophyses on centrum 7.

*Distribution*: Off Maui, Hawaiian Islands.

### *Saccogaster tuberculata* (Chan)
Figure 1d, 4

*Barbuliceps tuberculatus* Chan, 1966, p. 4, fig. 1, 1 (orig. descr., ♂; S. China Sea).

*Diagnosis*: Scales absent; relatively short gill rakers on first arch; teeth granular; see Table 1 for comparisons of meristic characters.

*Study material*: BMNH 1965.11.6.1, holotype, 6°01.8′ N, 109°57.4′E, 823–834 m; USNM 207354 (2♀, 1 cleared and stained) and ZMUC P77540 (1♀), "Townsend Cromwell" 52–88, 21°06′ N, 156°13′ W, 585–640 m.

*Description*: Selected measurements are presented in Table 3. Body compressed, relatively short, greatest depth 5.3 to 5.9 in SL. Preanal 1.9 to 2.0 in SL. Skin relatively thick, loose and not transparent.

Lateral line continuous, marked by a narrow, unpigmented line along which 28 to 30 small papillae are arranged. The lateral line originates anteriorly above the angle of the gill opening and descends gradually to the midline, becoming obscure posteriorly.

The lateral head canal with 1 prominent pore above the angle of the

TABLE 3. Measurements on S. *tuberculata*

| | Holotype BMNH | | USNM 207354 | | ZMUC | |
|---|---|---|---|---|---|---|
| Sex | ♂ mm | % SL | ♀ mm | % SL | ♀ mm | % SL |
| SL | 107 | | 134 | | 98.0 | |
| Snout to dorsal-fin | 31.6 | 29.5 | 39.8 | 29.7 | 30.0 | 30.6 |
| Snout to anal-fin | 56.3 | 52.6 | 67.9 | 50.7 | 51.8 | 52.8 |
| Snout to ventral-fin | 21.8 | 20.4 | 26.1 | 19.5 | – | – |
| Body depth at vent | 15.2 | 14.2 | 17.4 | 13.0 | 12.2 | 12.4 |
| Head length | 29.4 | 27.5 | 33.5 | 25.0 | 26.1 | 26.6 |
| Snout length | 6.5 | 6.1 | 7.0 | 5.2 | 6.0 | 6.1 |
| Eye diameter[1] | 2.1 | 2.0 | 3.0 | 2.2 | 2.0 | 2.0 |
| Interorbital width[2] | 5.9 | 5.5 | 7.5 | 5.6 | 5.7 | 5.8 |
| Upper jaw length[3] | 14.7 | 13.7 | 17.3 | 12.9 | 13.6 | 13.9 |
| Depth of maxilla[4] | 4.4 | 4.1 | 5.3 | 3.9 | 4.1 | 4.2 |
| Cleithrum to ventral fin[5] | 4.2 | 3.9 | 4.2 | 3.1 | 4.0 | 4.1 |
| Ventral fin length | 10.3 | 9.6 | 15.8 | 11.8 | 11.7 | 11.9 |
| Pectoral peduncle length[6] | 6.0 | 5.6 | 7.1 | 5.3 | 5.8 | 5.9 |
| Pectoral peduncle width | 5.2 | 4.8 | 6.8 | 5.1 | 4.9 | 5.0 |
| Pectoral fin length[7] | 13.3 | 12.4 | 21.2 | 15.8 | 13.8 | 14.1 |

[1–7] See Table 2 for footnote references.

gill opening; supraorbital pore 1, above the upper lip and medial to the tubular anterior nostril; infraorbital pores 3, above the upper lip and posterior to the forward nostril; mandibular pores 2 or 3 near the tip of the jaw; also a single pore slightly posterior to the rear margin of the maxillary.

Head compressed in postorbital region. Snout depressed, broadly rounded from above. Jaws subequal, a slight bony protuberance at the symphysis of the mandibles. The holotype with small darkly pigmented papillae sparsely distributed about the head, more densely concentrated on the snout; the Hawaiian specimens with more and larger papillae, roughly arranged in several series: infraorbital, supraorbital, a V-shaped median one converging anteriorly between the eyes, and a roughly elliptical one around the ethmoid region; simple papillae along the mandible of the holotype and smaller Hawaiian specimen, the larger fish with more papillae, many of which have branched tips. Opercle with a single flattened spine. The posterior, vertically expanded part of the maxillary is barely or not at all sheathed.

First gill arch (Fig. 1d) with 3 developed rakers, 1 at the angle, 2 on the lower arm; both arms with low spiny pads. Some gill filaments on first arch shorter than developed rakers. Pseudobranch present, consisting of 2 filaments.

Dentition on premaxillary a band of granular teeth; similar teeth on dentary in a broader band, on vomer in a hemispherical to broadly V-shaped patch, and in a long narrow band on the palatine.

Fig. 4. *Saccogaster tuberculata*, BMNH 1965.11.6.1, holotype; four views of stalked intromittent organ of male, anterior to the right. A, lateral view; B, lateral view with stalk pushed forward; C, ventral view; D, looking into distal end of stalk. Photographs by British Museum (Natural History).

Dorsal fin originating over centrum 7; anal fin under centrum 20 in the holotype, 22 in the Hawaiian specimens. Adpressed pectoral fin extending more than one-half the distance from the upper angle of the pectoral peduncle to the origin of the anal fin.

Peritoneum dusky in the holotype, less so in the Hawaiian fish. Swimbladders of holotype and one Hawaiian specimen relatively thick walled, translucent; swimbladder of largest Hawaiian specimen thinner walled and nearly transparent. Pyloric caeca 2 hemispherical protuberances.

Intromittent organ of holotype (Fig. 4) on a thick, fleshy posteriorly directed stalk with the vent immediately anterior to its base; the distal rim of the stalk is swollen with anterior and posterior median clefts dividing the rim into two lobes; a fleshy mound in the posterior cleft gives rise to a short stringy penis; a section of gonadal material shows spermatozoa arranged in spermatophores. Largest Hawaiian fish with elongate (21.3 mm) separate ovaries containing several hundred (estimated) eyed embryos with attached yolk sacs.

Color of holotype generally pale, but with light smudges of dusky pigmentation on the body; the peritoneum showing darkly through the skin. Hawaiian specimens much darker. The largest Hawaiian fish has narrow pigmented lines running parallel to the dorsal and anal fin bases but terminating before the base of the caudal fin; the two subdorsal lines join in the predorsal region. Other specimens show traces of the same pattern but less well developed.

Abdominal centra 14. Centra 3 through 6 with ribs inserting directly on centra; the first pair of ribs slanting posteriorly at a more acute angle than those following . Pleural ribs absent beyond centrum 7. Centra 7 through 14 with stout parapophyses. Epipleurals associated with either the pleural ribs or parapophyses on centra 4 through 11. Neural spines on centra 4 to 13 variously truncate to spatulate.

The caudal fin skeleton is described and figured from an x-ray photograph of the holotype by Chan (1966) as a fused "bilobed hypural plate." On the basis of subsequent x-ray photographs of the holotype and examination of a cleared and stained Hawaiian specimen we find two separate hypurals, each supporting 6 caudal fin rays.

Parietals separated by supraoccipital.

*Distribution*: Described from the South China Sea at a depth of 823–834 m. Here recorded from off Maui in the Hawaiian Islands. Except for color, Hawaiian specimens seem remarkably similar to the type.

### **Saccogaster parva** new species

Figure 5

*Diagnosis*: Scales absent; very short gill filaments on first arch; 6 developed gill rakers on first arch; see Table 1 for comparisons of meristic characters.

*Study material*: HOLOTYPE, ISH. "Walther Herwig" 90/68, 24°~~33′~~ 21 S, 43°~~32′~~ 54 W, ~~1200~~ 500 m, bottom trawl, 2 March 1968.

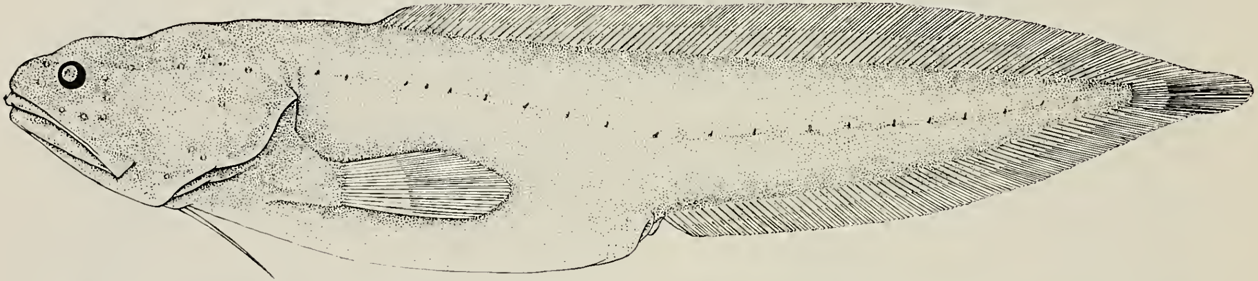

Fig. 5. *Saccogaster parva*, ISH, holotype; 58.0 mm SL. Head pores not shown. Drawn by Keiko H. Moore.

*Description*: Measurements are given in mm first followed by percent of standard length. Explanations of measurements are given in Table 2. SL 58.0; snout to dorsal fin 20.2 (34.8); snout to anal fin 34.0 (58.6); snout to ventral fin 11.0 (19.0); body depth at vent 9.3 (16.0); head length 14.9 (25.7); snout length 3.5 (6.0); eye diameter 2.0 (3.4); interorbital width 3.6 (6.2); upper jaw length 7.9 (13.6); depth of maxilla 2.7 (4.6); cleithrum to ventral fin 1.8 (3.1); ventral fin length 5.7 (9.8); pectoral peduncle length 3.7 (6.4); pectoral peduncle depth 2.2 (3.8); pectoral fin length 9.8 (16.9).

Body compressed, relatively short, greatest depth 5.3 in SL. Preanal 1.7 in SL. The skin is thin and delicate.

The lateral line is continuous, originating about midway between the upper angle of the gill opening and the dorsal profile; it descends gradually to the midline at about the level of the vent, whence it extends posteriorly. There are 9 papillae in the anterodorsal section and 11 or 12 in the midline.

The lateral head canal has 1 pore above the upper angle of the gill opening; supraorbital 1, above the upper lip and medial to the anterior nostril; infraorbital 2, on the upper lip below the posterior nostril; mandibular 4, 3 near the tip of the lower jaw and another near the angular. Neuromasts on the head are outlined in dark pigment and easily visible: lateral canal 5; supraorbital 5; suborbital 6; mandibular 4; preopercular 3.

Head compressed, snout blunt with subequal jaws. Very small papillae scattered on the snout, top of head and along mandibles. Opercle with a single flattened spine. The posterior, vertically expanded part of the maxillary strongly sheathed dorsally.

First gill arch with 6 developed rakers, 1 at the angle and 5 along the lower arm. Pseudobranch apparently lacking.

Dentition on premaxillary a narrow band of small granular teeth. Medial to the band near the tip of the jaw is a cluster of about 10 elongate needlelike teeth. Vomer with about 6 teeth similar to the longer premaxillary teeth and a scattering of smaller teeth. Palatine with 15 small, sharp-pointed teeth in a single row. Dentary with an irregular row of about 15 longer, pointed teeth and an outer narrow band of shorter teeth.

Dorsal fin originating over vertebral centrum 8, anal fin under centrum 23. Adpressed pectoral fin extending about one-half the distance from the insertion of the pectoral fin rays to the origin of the anal fin.

Peritoneum thin walled and transparent. Pyloric caeca developed as 2 hemispherical protuberances.

No well-developed intromittent organ. Paired ovaries joined posteriorly, packed with developing eggs.

Head and body evenly covered with a relatively dense concentration of fine brown chromatophores. According to data slip, "In life violet."

Abdominal centra 16. Centra 7 to 9 have neural spines with spatulate tips, not sharply pointed. First parapophyses on centrum 7.

*Distribution*: Off the coast of Brazil south of Rio de Janeiro.

*Etymology*: From the Latin *parvus*, little or small.

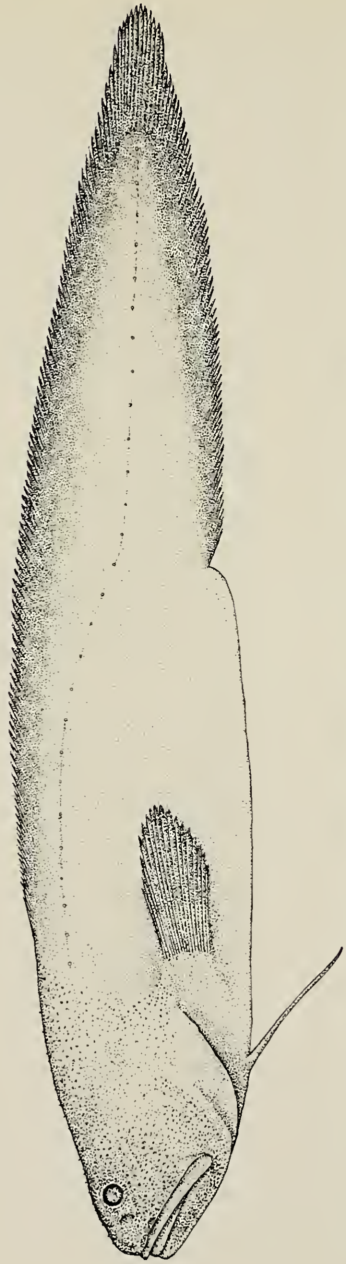

Fig. 6. *Saccogaster normae*, USNM 207356, holotype; 140 mm SL. Head pores not shown. Drawn by Keiko H. Moore.

### **Saccogaster normae** new species
Figures 1e, 6, 7

*Diagnosis*: Scales absent; long filaments on first gill arch (Fig. 1e); gill opening restricted, not extending above level of pectoral peduncle; see Table 1 for comparisons of meristic characters.

*Study material*: HOLOTYPE, USNM 207356, "Anton Bruun" cruise 16, stat. 625A (Southeastern Pacific Biological and Oceanographic Program), 4°57′ S, 81°23′ W, 118–133 m, otter trawl, 2 June 1966. PARATYPE, IM 421 "Lance" Stat. 76, 5°04′ S, 80°24′ W, 150 m, 7 May 1969.

*Description*: Measurements are given in mm, holotype first followed by the paratype in parentheses. Due to the distorted nature of both specimens many measurements lack precision, particularly SL and other longer ones; hence, it does not seem worthwhile to present percentages of SL. Explanations of measurements are given in Table 2. SL 140 (138); snout to dorsal fin 41.1 (42.9); preanal 88.6 (84.5); snout to ventral fin 29.3 (31.3); body depth at vent 17.2 (17.8); head length 31.9 (31.8); snout length 7.6 (7.8); eye diameter 2.5 (2.9); interorbital width 6.6 (—); upper jaw length 16.0 (15.0); depth of maxilla 5.0 (5.0); cleithrum to ventral fin 8.4 (8.3); ventral fin length 15.7 (13.3); pectoral fin length 20.2 (20.5).

Body relatively elongate in appearance. Preanal about 1.7 in SL. Skin thick, loose and opaque.

Scales absent. Parts of the sides of the paratype have ridges of dark pigment that superficially resemble scale pockets. There are also areas containing fields of small irregular flattened pockets; none of these take up alizarin stain.

Lateral line continuous, with about 27 papillae in the holotype.

Lateral canal head pores 0; supraorbital pores 1, on the upper lip medial to the tubular anterior nostril; infraorbital pores 2, on the upper lip below the posterior nostril; mandibular pores 3, 2 near the tip of the lower jaw, 1 near the angular.

Head blunt, jaws subequal. Many small darkly pigmented filaments on the head and the predorsal part of the body, particularly densely distributed on the snout and dorsal region of the head. No externally developed opercular spine. The posterior part of the maxillary is buried dorsally in thick skin which restricts its free movement.

Gill opening restricted dorsally, not extending above the level of the dorsal base of the pectoral fin. This is a nearly unique condition among ophidioid fishes and so far as we know occurs among viviparous species only in the Australian *Dipulus caecus* Waite, 1905, a distantly related form. Obviously, a restricted gill opening has occurred independently on two occasions among ophidioids.

First gill arch (Fig. 1e) with 2 or 3 small clublike rakers that are barely more prominent than the spiny pads on the arch. Gill filaments on first arch notably elongate. Pseudobranch present, with 2 filaments.

Dentition on premaxillary a band of small granular teeth. Medial to the band at tip of the lower jaw is a cluster of larger teeth. Vomer with 15 to

Rotate Fig 180°

Fig. 7. *Saccogaster normae*, IM 421, paratype; 138 mm SL; two views of stalked intromittent organ of male, anterior to the left. Left, lateral view; right, looking into distal end of stalk.

20 small pointed teeth in a broadly V-shaped pattern on the vomer. Palatine teeth similar to those on vomer, in a narrow band 2 to 4 teeth wide. Dentary teeth in a band 4 to 8 teeth wide with inner teeth larger, but no clear distinction between large and small teeth.

Dorsal fin originating over centrum 7, anal fin under centrum 25. Adpressed pectoral fin extending less than one-half of distance from insertion of pectoral fin rays to vent. Although the ossified pectoral radials are elongated, as in other species of *Saccogaster*, they are for the most part imbedded in the body wall and not enclosed in a fleshy pectoral peduncle.

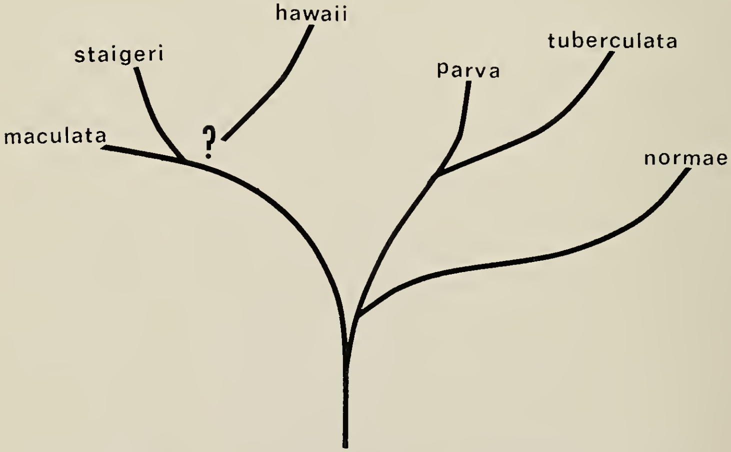

Fig. 8. Summary of possible relationships of species of *Saccogaster*.

Peritoneum thick, transparent to translucent. Pyloric caeca absent.

Intromittent organ of paratype on a thick, fleshy, posteriorly directed stalk with the vent on the anteroventral surface. The distal rim is inflated laterally giving a bilobed appearance. The two sides of the rim curve inward at the anterior midline and form an S-shaped ridge inside of the mouth of stalk, from which a short fleshy penis protrudes. A section of gonadal material shows spermatozoa arranged in spermatophores. The holotype, a female with a small fleshy intromittent organ, not in good condition.

Color chocolate brown, the fins darker.

Abdominal centra 15 or 16. Centra 6 to 12 with tips of neural spines variously truncate to spatulate. First parapophyses on centrum 7.

*Distribution:* Off the coast of Peru.

*Etymology:* Named for Miss Norma Chirichigno, Peruvian ichthyologist, who independently recognized this fish as an undescribed species and graciously placed her material at our disposal.

## SPECIES RELATIONSHIPS

The characters that we have used to separate the species of *Saccogaster* are similar in magnitude to those which have been used to separate some ophidioid genera; however, no matter how divergent are these six species, they are nonetheless more closely related to each other than to any other ophidioid species. It seems more desirable to emphasize similarities rather than to multiply the number of mono- or bitypic genera.

S. *maculata* and *staigeri* appear to be the most generalized species. The others differ in at least some ways that might be considered as specializations of character states found in these two. We note, however, that for many characters, there is no way to know if we are dealing with general, primitive states or specialized, advanced ones. The same is true for the shared characters of *maculata* and *staigeri.* Reason demands that any two species which are as similar as are these two be considered as closely related. Two differences worthy of mention are the dentition on the palatine and the size of the gill filaments on the first arch. The palatine teeth are in a band several teeth wide in *maculata,* in a single row in *staigeri.* We do not know which is the generalized and which is the derived character state. For gill filament size, it seems most reasonable to assume that short gill filaments, as in *staigeri,* are derived from the more normal condition as seen in *maculata.* But this character must be used with caution, for in some fishes longer gill filaments are characteristic of species living in low oxygen water (for example the midwater stomiatoid genus *Chauliodus,* Gibbs and Hurwitz, 1967).

S. *hawaii* has an opercular spine that is to the best of our knowledge unique among ophidioid fishes; we assume it is derived. It resembles *staigeri* in its single row of palatine teeth and short gill filaments.

The previous three species agree in having scales, surely a generalized character; however, the distribution pattern of the scales is a shared specialization that is derived from the more general pattern of squamation in ophidioid fishes. S. *maculata* and *staigeri* have interrupted lateral lines (no information on this character for *hawaii*), a character state that we interpret as being generalized among viviparous ophidioids. Each of the three species discussed below has a continuous lateral line and lacks scales. Absence of scales must be used with caution as there are numerous instances of independent loss of scales in ophidioids and other fishes.

S. *tuberculata*, which also has short gill filaments, differs from all *Saccogaster* species in having all teeth granular and even-sized, that is, in lacking the fairly uniform and consistent pattern of dentition described for the other species. We cannot say whether the teeth of *tuberculata* represent a primitive or advanced character state in *Saccogaster.*

S. *parva*, also with short gill filaments, is unique within the genus in having six, rather than three or fewer developed gill rakers. Because of the widespread occurrence of three or fewer developed gill rakers in viviparous ophidioids we think that this character state in *parva* may be derived.

S. *normae* is surely the most divergent of all *Saccogaster* species. The smaller gill opening and restricted maxillary must be derived conditions. A fleshy pectoral peduncle is lacking, superficially a primitive condition, but the presence of elongate pectoral radials indicates that absence of a peduncle has been secondarily derived from the condition as manifested in the other *Saccogaster* species. Notably long gill filaments are present on the first arch in *normae*, perhaps a character state derived from the *maculata* condition. In palatine dentition *normae* resembles only *maculata.*

In Figure 8 we present a diagram that summarizes a possible interpretation of the relationships of the known species of *Saccogaster.* As we have tried to demonstrate in the previous section, interpretation of character states is imprecise at best. Even so, an attempt at prediction seems worthwhile. We look forward to a test of our ideas, to be provided by more detailed knowledge of characters and by the likely discovery of as yet undescribed species.

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Vol. 85, No. 40, pp. 469–480 30 December 1972

PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

# STUDIES ON POLLEN MORPHOLOGY IN THE VELLOZIACEAE

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The family Velloziaceae contains about 250 species of perennial herbs and shrubs. Three or four genera are recognized from Madagascar, Southern Africa, Arabia, and South America. *Vellozia*, which is the type-genus, has the largest number of species (about 170); *Barbacenia* is the second largest genus with about 80 species. *Xerophyta* constitutes all the Madagascan and African species except for one, *Talbotia elegans* Balfour, which occurs in South Africa (cf. Smith and Ayensu, in press).

In recent years there has been heightened interest in the Velloziaceae because of their phytogeographical and evolutionary implications (Ayensu, in press). A treatment of the American species by Smith (1962) brought the family up to date, and since that time I have been studying the vegetative anatomy of the family with the intent of amassing further data to improve the systematics of the group (cf. Ayensu, 1968; 1969a, b). One of the problems in this family is how to resolve the highly controversial generic limits of the taxon.

The aim of this study, therefore, is to add new positive correlative information from pollen morphology to the existing characters that have been building up in recent years. Erdtman (1963) described the pollen of the Velloziaceae as being 1-sulcate of two distinct types, *Barbacenia-Barbaceniopsis* consisting of single grains while *Vellozia* grains are united in tetrads. *Barbacenia* grains are also smaller than those of *Vellozia*, in fact, in a ratio of about 1:2. His study was based on 16 species from both Africa and South America. A more extensive study involving about 44 species was undertaken by Maguire (1969), also using the light microscope. Both studies showed that *Barbacenia* pollen grains are simple, ellipsoidal, and 1-sulcate with exine reticulations. *Vellozia* grains, on the other hand, are united tetragonal tetrads and nonsulcate.

The Old World species so far investigated by Erdtman (1963) and Maguire (1969) do not conform to the *Vellozia*-*Barbacenia* pollen breakdown which occurs in the American species. Maguire (1969) indicated that the pollen grains of the six American species he investigated were simple, ellipsoidal, 1-sulcate with a reticulate exine which was very similar to the American *Barbacenia* species. He therefore surmised that "It is not unreasonable, therefore, to suspect that all African elements belong neither to *Barbacenia* nor to *Vellozia*."

Attempts to classify the Velloziaceae genera on the basis of floral morphology have always been difficult because of intergradations that characterize the species (Smith and Ayensu, in press). This work represents the beginning of a pollen morphological survey of the Velloziaceae principally with the aid of scanning reflection electron micrographs. I have decided to use the SEM to survey the pollen in this family because it represents a rapid means of observing pollen wall surfaces coupled with a much greater resolution than the light microscope. Furthermore, very little work is required in the preparation of pollen grains to obtain satisfactory results with this instrument.

*Materials and Methods:* Pollen samples were removed from recently collected herbarium vouchers and put on a micro cover glass which was in turn placed on a specimen stub. The grains were suspended in a drop of absolute alcohol on the cover glass. The slight alcohol on the grains evaporated within a few seconds. There was no need for acetolysis or staining. The stub holding the micro cover glass and grains was rotated under pressure in high vacuum and coated with gold plating approximately $200^{A}$ thick.

Pollen grains of some monocotyledons have a tendency to collapse readily, and it is therefore necessary to take special precautions before the specimens are subjected to coating. In the Velloziaceae I observed that *Barbacenia* grains are much sturdier than those of *Vellozia.* The following reasoning may be a contributing factor to the difference. *Barbacenia* grains are unisulcate, small-sized, and seem to maintain a turgid posture even under very dry conditions. *Vellozia* grains, on the other hand, are in united tetrads, nonsulcate, about twice the size of *Barbacenia* grains, and appear to collapse quite easily under extreme desiccation or pressure.

It was also observed that specimens fixed in formalin-acetic acid-alcohol (FAA) did not produce satisfactory results. The fixative seemed to dissolve some of the waxy substance on the grain surface, thus leaving a slimy coating which obscured the sculpturing on the grains. Furthermore, fixed materials seemed to explode and collapse much more easily under pressure in high vacuum.

Current experience shows that freshly dried specimens give the best results. More experimentation will be needed before conclusive statements can be made on the preparation procedures that will ensure optimal results.

The following specimens collected in Brazil were examined for this investigation. *Vellozia abietina* Mart. (Irwin et al. 20672); *V. crassicaulis* Mart. ex Schult. f. (Irwin et al. 15520); *Barbacenia gentianoides* Goeth and Henr. (Irwin et al. 22533); *Barbacenia magalhaesii* L. B. Smith (Irwin et al. 20972); *B. stenophylla* Goeth and Henr. (Irwin 9901).

I am very grateful to Dieter Wasshausen and Walter Brown for their technical assistance in the preparation of the above specimens.

*Observations:* This paper represents the beginnings of a catalogue of stereoscan photomicrographs of Velloziaceae pollen. The few photomicrographs accompanying this paper seem to suggest that further studies along these lines will achieve two objectives. Firstly, the definition of the two major genera —*Vellozia* and *Barbacenia*—will eventually be clearly delimited. Secondly, the detailed structure of the exine patterns will provide species-specific characters that are not easily discerned with a light microscope. If one compares the results achieved with the light microscope (cf. Maguire, 1969) and the photomicrographs in this paper, the superiority of the scanning electron microscope will be immediately obvious.

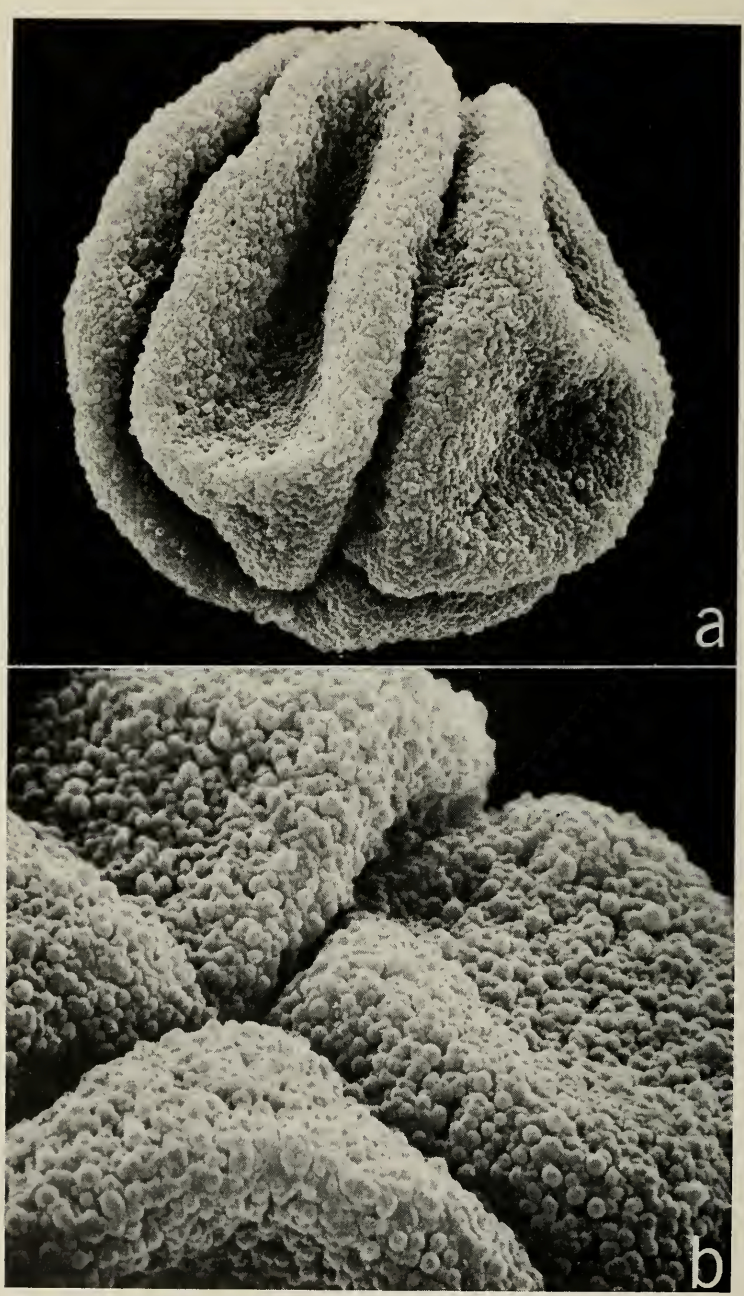

FIG. 1. *Vellozia abietina.* a. Oblique view. × 2,000. b. Polar view of tetrad. × 5,000.

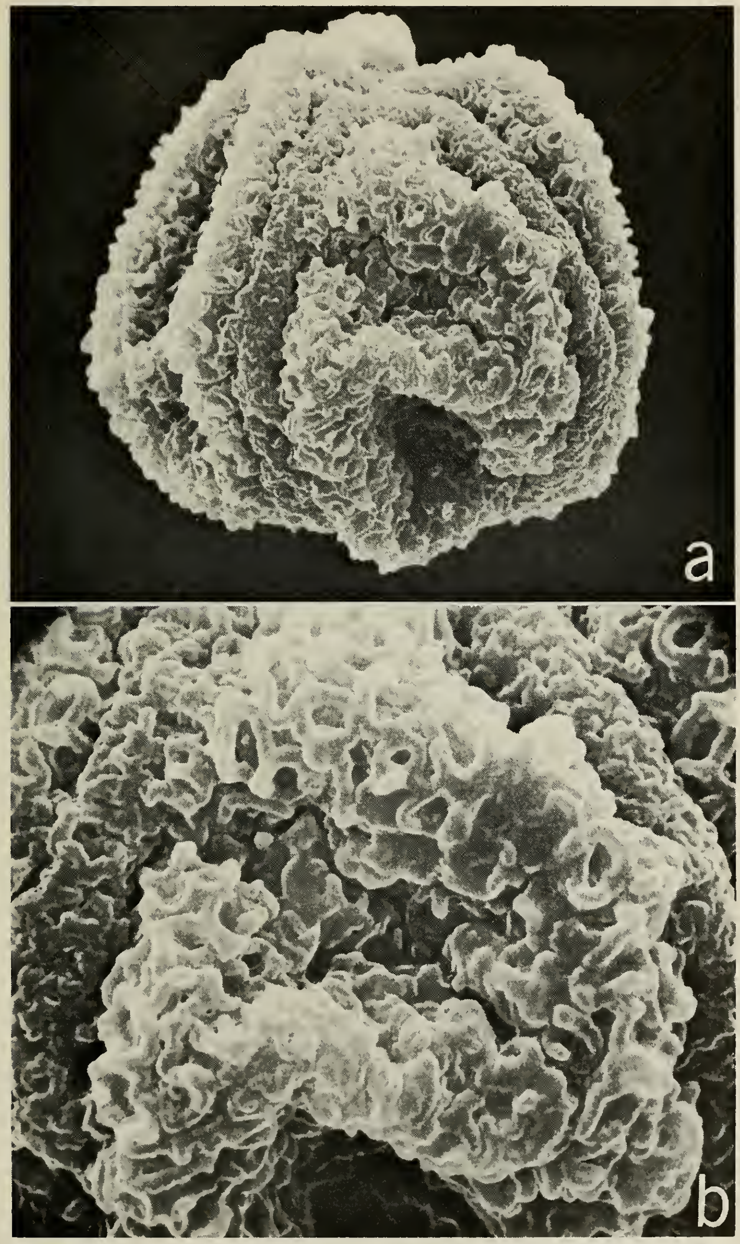

FIG. 2. *Vellozia crassicaulis.* a. Showing three side views. × 1,500. b. Details of a side view showing appressed vermiform-reticulations. × 3,000.

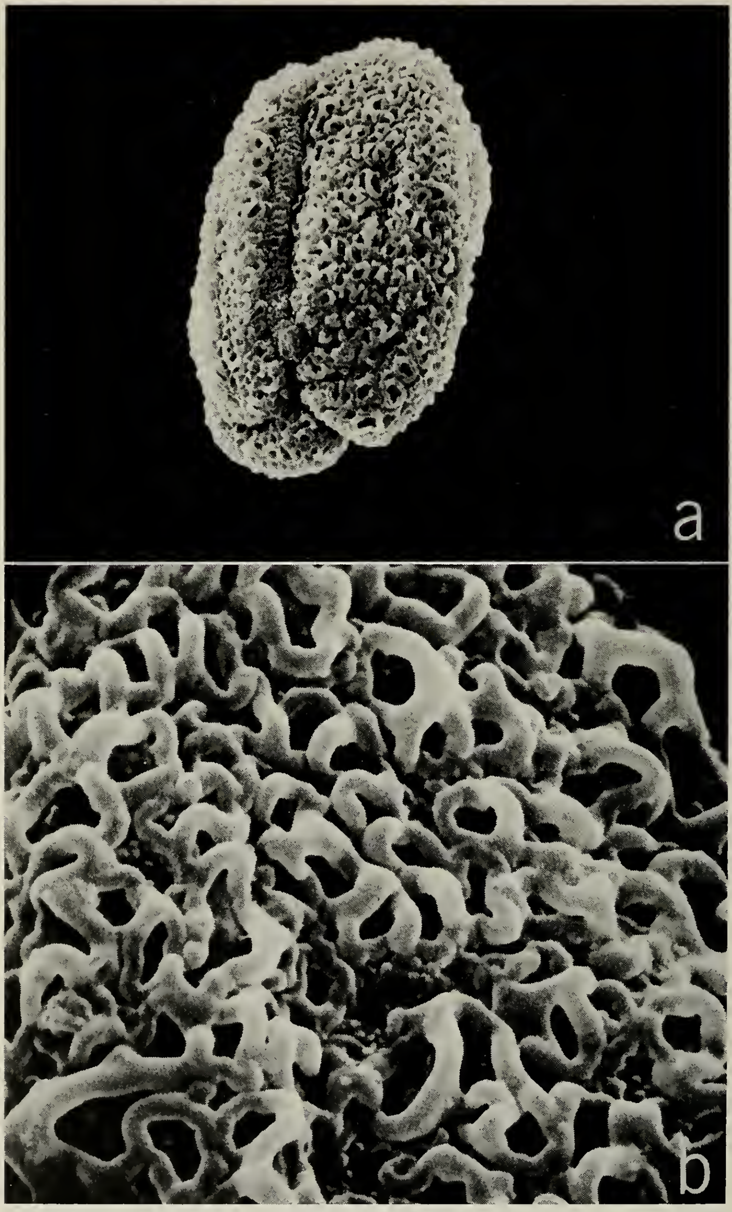

Fig. 3. *Vellozia flavicans.* a. Oblique view of tetrad. × 1,000. b. Details of a side view showing vermiform reticulations. × 5,000.

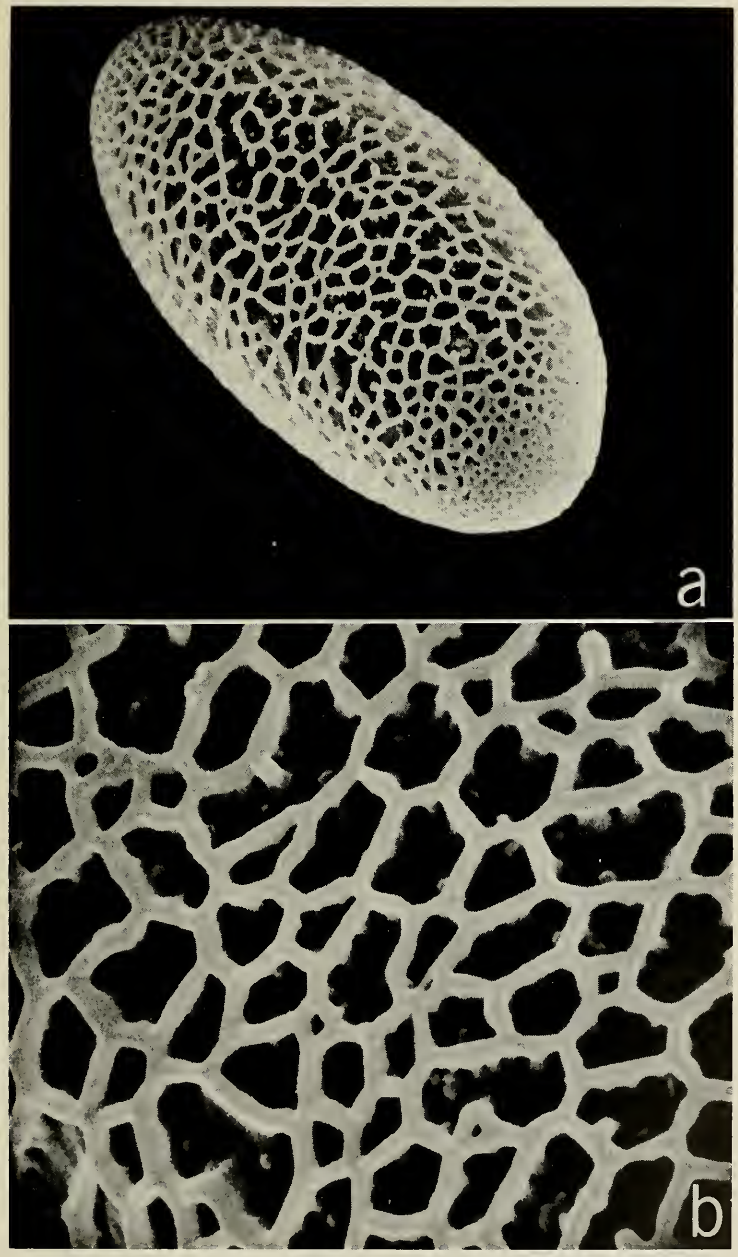

FIG. 4. *Barbacenia gentianoides.* a. Equatorial view showing reticulate exine. × 3,000. b. Side view showing sporoderm detail. × 10,000.

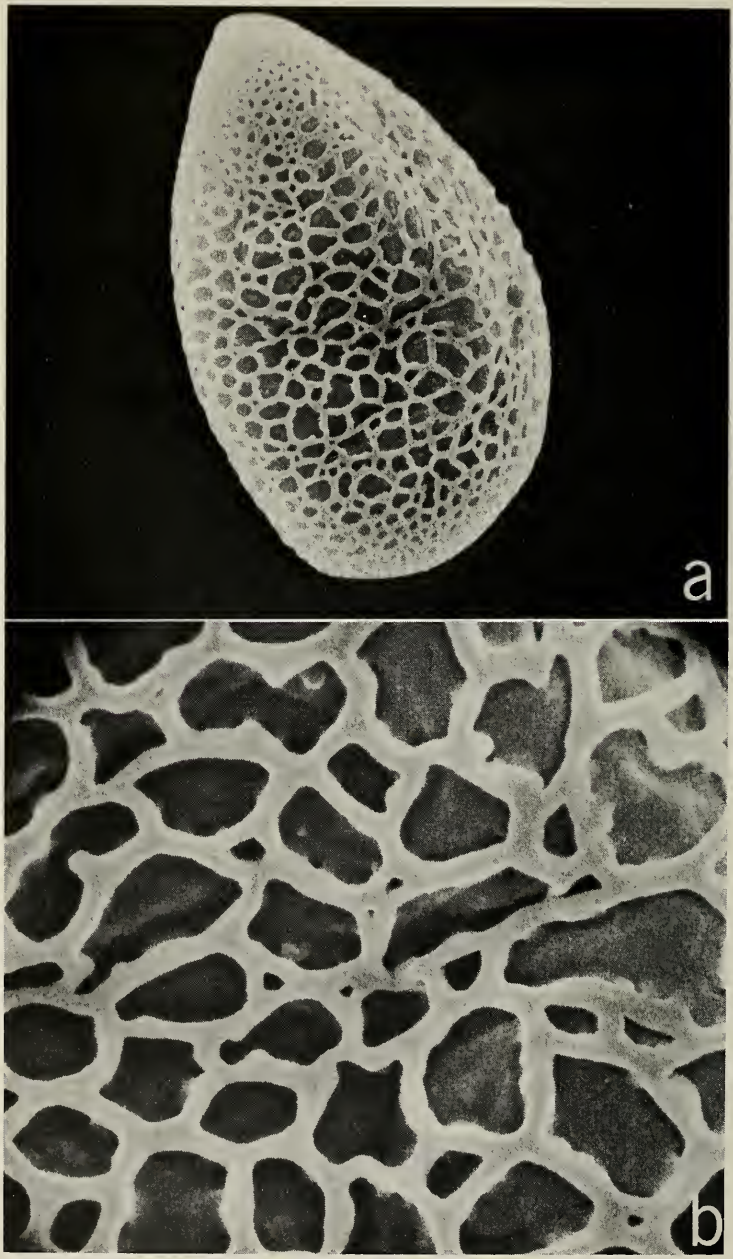

FIG. 5. *Barbacenia magalhaesii.* a. Equatorial view showing detail of reticulate exine. × 2,600. b. Side view showing sporoderm detail. × 10,000.

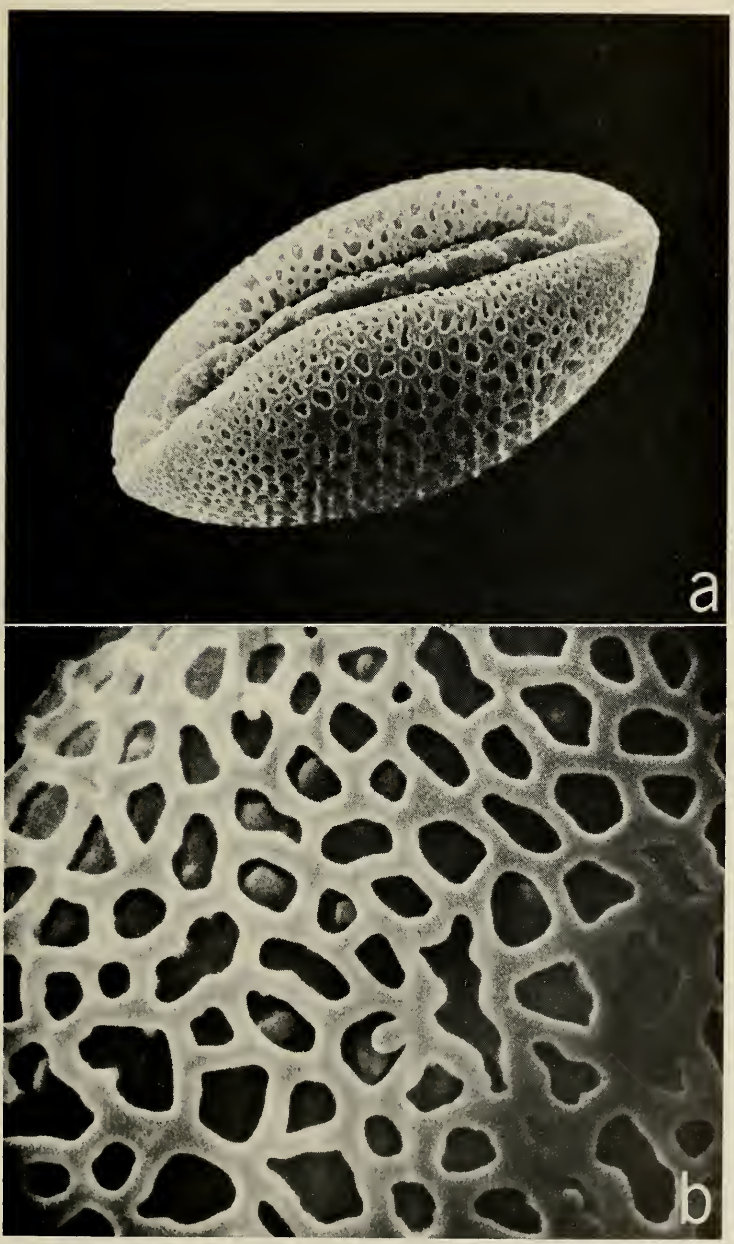

FIG. 6. *Barbacenia stenophylla.* a. Distalipolar view showing sulcus. × 3,000. b. Side view showing sporoderm detail. × 10,000.

My studies have confirmed the coherent, tetragonal tetrad nature of *Vellozia* pollen which Maguire (1969) illustrated; however, distinct variations among *Vellozia* species are clearly evident in the photographs (Figs. 1–3).

The exine sculpturing of *Vellozia* is often described as being reticulate or vermiform-reticulate (cf. Maguire, 1969). The exine of *Vellozia abietina* (Fig. 1a, b) can hardly fit this stereotyped exine sculpturing of *Vellozia* pollen wall. In fact, the sculpturing of *V. abietina* is neither reticulate nor vermiform-reticulate. It can be easily observed from Figure 1 that the exine of *V. abietina* is compactly multibaculate. The exine sculpturing of *V. crassicaulis* (Fig. 2) and *V. flavicans* (Fig. 3) are both vermiform-reticulate. However, the two species can be easily distinguished from each other by the form and size of the pollen grains as well as the degree of vermiculation.

*Barbacenia* pollen, on the other hand, is easily identifiable because of its simple, ellipsoid, unisulcate structure. But again it is clearly observed that there is variation in the reticulate exine sculpturing which characterizes the pollen walls of *Barbacenia* species (Figs. 4–6). The lumina of *Barbacenia gentianoides* (Fig. 4) are smaller than *B. magalhaesii* (Fig. 5). Although the sculpturing of these two species shows a close resemblance, especially on the contents of their muri, one can differentiate the two species by the protrusions on the muri and in the lumina of *B. gentianoides.* The lumina of *B. stenophylla* are smaller than those of *B. gentianoides* and *B. magalhaesii.* Furthermore, the muri of *B. stenophylla* are much straighter and more solid, without any tendency towards the development of protrusions, than the other species.

In summary, the few pollen specimens included in this study indicate the potential of the stereoscan in enhancing certain characteristics in the systematics of the Velloziaceae. The success of any such studies depends largely upon the availability of suitable pollen and standardization of preparation techniques.

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Vol. 85, No. 41, pp. 481–488 30 December 1972

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# A NEW SPECIES OF *ACETABULASTOMA* SHORNIKOV FROM CENTRAL CALIFORNIA WITH A REVIEW OF THE GENUS[1]

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While most paradoxostomids are associated with marine plants, at least three genera are known to be commensal with crustaceans (McKenzie, 1969). Recently Shornikov (1970) described the new genus *Acetabulastoma* to accommodate several species parasitic on boreal gammarid amphipods. Hart (1971) described a new species, *A. kozloffi* from Washington State. This paper describes a new species in this genus from California.

## SUBCLASS OSTRACODA LATREILLE 1806

### Order Podocopida Muller 1894

### Paradoxostomatidae Brady and Norman 1889

### Paradoxostomatinae Brady and Norman 1889

### *Acetabulastoma* Shornikov 1970

*Type-species: Acetabulastoma littorale* Shornikov, 1970:1132–1133.

*Diagnosis:* The following diagnosis is modified from Shornikov (1970). The carapace is smooth, but sometimes may have a scarcely perceptible sculpture. It is flattened ventrally so that in end view it presents a triangular shape. The anterior margin is pointed, the posterior broadly rounded; the carapace being highest posteriorly. On the anterior ventral surface the valve margins are modified such that when the valves are closed an opening remains through which the animal can move the sucking disc. A vestibule is present anteriorly and posteriorly. Marginal pore canals are simple, rare, and occur only on the anterior and posterior

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[1] College of Marine Studies Contribution Number 64.

TABLE I. Species of *Acetabulastoma*, their hosts and their distribution

| Species | Hosts | Distribution |
|---|---|---|
| A. *littorale littorale* Shornikov | *Gammarus oceanicus* Dementieva | East Murman Coast |
| A. *l. robustum* Shornikov | *Gammarus setosa* Dementieva | East Murman Coast<br>Cross Bay, Bering Sea |
| A. *arcticum* Shornikov | *Gammarus wilkitzii* Birula | Artic basin |
| A. *longum* Shornikov | *Amphithoe djakonovi* Gurjanova | Providence Bay, Bering Sea |
| A. *kurilense* Shornikov | Host unknown | Urup Island |
| A. *rhomboideum* Shornikov | Host unknown | Posjet Bay, Sea of Japan |
| A. *kozloffi* Hart | *Amphitoe humeralis* Stimpson | San Juan Archipelago<br>Washington |
| A. *californica* sp. nov. | Host unknown | Tomales Point, California |

margins. Normal pore canals are simple. The hinge is lophodont with the tooth on the right valve strong, pointed and directed distally. There are four adductor muscle scars in a slantwise arrangement, and two frontal scars. The eye is single, very small, and located medially in the anterior of the carapace. The first antenna is six segmented. The terminal endopodite segment of the second antenna possesses a single claw. A three-segmented palp is present on the mandible while the maxilla does not possess a palp.

*Ecology and distribution:* For the most part, the species in this genus have been found to be ectoparasitic on gammarid amphipods. The known species, their hosts, and their geographic distribution are given in Table I. Shornikov (1970) notes that the ostracodes are found on the ventral side or in the incubation chamber of the hosts. When they feed, the ostracodes apparently pierce the host integument with the stylelike mandibles. Eggs are laid on the branchial vesicles. The ostracodes probably spread throughout the amphipod population by contact. Baker and Wong (1968) describe similar habits for specimens identified as *Paradoxostoma rostratum* Sars. On the basis of host specificity, Shornikov (1970) believes the specimens of Baker and Wong to be synonymous with *Acetabulastoma arcticum*, and not to belong to *Paradoxostoma rostratum*.

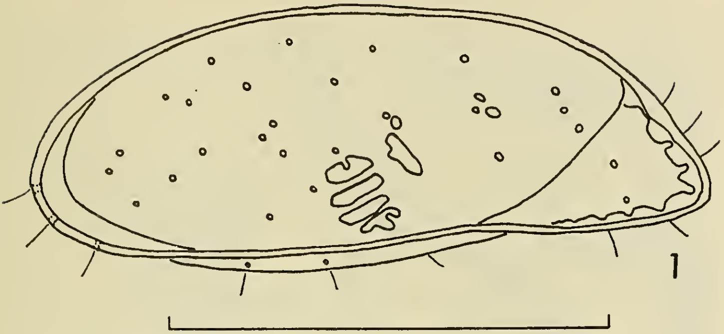


FIG. 1. *Acetabulastoma californica* n. sp., male, left valve, lateral view. Scale equals 0.5 mm.

### **Acetabulastoma californica** new species
Figures 1–11

*Holotype:* U.S.N.M. 128702.

*Paratype:* U.S.N.M. 128701.

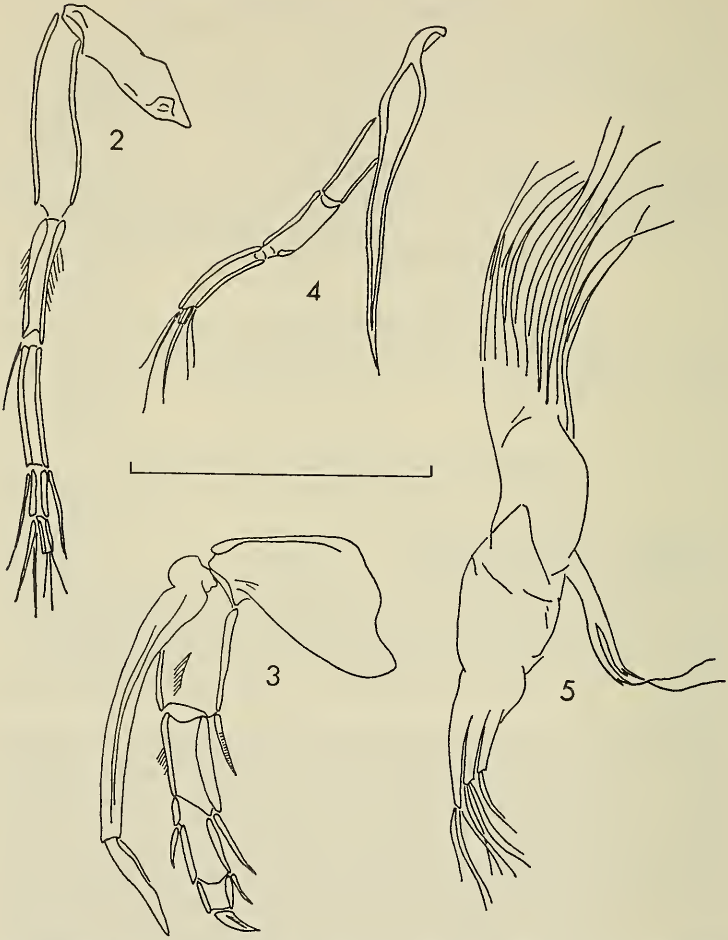
*Type-locality:* All specimens were taken in the low intertidal zone on the exposed side of Tomales Point, Marin County, California (122° 57′ W. long., 38° 12′ N. lat.) in the zone of the red alga *Corallina gracilis.*

*Material:* Three adults, consisting of two males and one female were examined.

*Diagnosis:* The species is distinguished from the other species in the genus by the suboval, upper scar in the adductor muscle scar group, the lack of a seta on the distal-ventral corner of the fifth segment of first antenna, and the strong, sub-triangular falcate structure on the male copulatory apparatus.

*Description:* The carapace is clear, highest posteriorly, flattened ventrally and presents a triangular shape in end view. The valves are equal in size. The dorsal margin is strongly convex; the ventral margin is straight with an anterior opening for the protrusion of the sucking disc. The anterior end is acutely rounded below while the posterior end is broadly rounded, without the appearance of a caudal process. The marginal zone is moderately wide with a vestibule present anteriorly and posteriorly. Marginal pore canals are few in number. The normal pores are open and widely scattered. No hinge structures were observed. The central muscle scar group consists of four, obliquely vertical adductor scars and a large frontal scar.

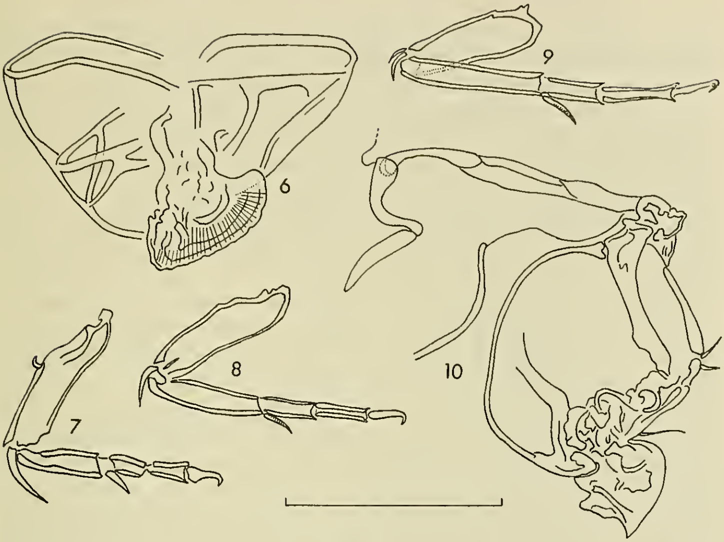
The first antenna consists of six segments. The second, third, and fourth segments are elongate. The lengths of the segments (in microns) being as follows: I 44; II 55; III 39; IV 39; V 17; VI 8. The first and second segments are without hairs or bristles. The third segment has a



Figs. 2–5. *Acetabulastoma californica* n. sp., male. 2, first antenna; 3, second antenna; 4, mandible; 5, maxilla. Scale equals 0.1 mm.

dorsal-distal bristle and a row of fine hairs on the dorsal and ventral side. The fourth segment has a single bristle on the dorsal and ventral distal corners. On the fifth segment are two bristles at dorsal distal corners, these bristles extending beyond the terminal bristles of the last segment. The sixth segment has three terminal bristles.

The second antenna is composed of a two-segmented exopodite and a three-segmented endopodite. The lengths of the segments are as follows: protopodite 66; exopodite I 103; II 33; endopodite I 36; II 68; III 11.



FIGS. 6–10. *Acetabulastoma californica* n. sp., male. 6, upper and lower lips and sucking disc; 7, first walking leg; 8, second walking leg; 9, third walking leg; 10, male copulatory apparatus. Scale equals 0.1 mm.

The protopodite is subtriangular in outline and is without hairs or bristles. Both exopodite segments are also without hairs or bristles; a ventral groove extends the length of both segments. The endopodite first segment has a lateral row of fine hairs and a ventral-distal bristle. The second segment is superficially jointed, thus appearing as two segments. On the dorsal side of the segment is a proximal row of fine hairs and a medial bristle; on the ventral side is a single medial and a single distal bristle. The third segment has only a single terminal claw.

The mandible first protopodite segment is styliform; the palp consists of the second protopodite segment and three endopodite segments. The lengths of the segments are as follows: protopodite I 110; II 39; endopodite I 28; II 33; III 8. All segments are devoid of bristles except the second and third endopodite segments. The second segment has two ventral and two dorsal-distal bristles; the third segment has a single terminal bristle.

The maxilla consists of a thinly sclerotized vibratory (respiratory) plate and three endites. A palp is not present. A respiratory plate has 10 plumose bristles and two aberrant setae. The endites become shorter posteriorly, and bear four, four, and two bristles, respectively.

The walking legs increase in length posteriorly. The lengths of the segments are as follows: first walking leg I 69; II 39; III 19; IV 17;

second walking leg I 66; II 50; III 20; IV 17; third walking leg I 55; II 61; III 22; IV 33. The first segment of the first leg bears a sharply upturned bristle on the dorsal surface and a large bristle at the dorsal-distal corner. The second segment has a single bristle at dorsal-distal corner while the fourth segment bears a terminal, hooked claw. The second leg is similar to the previous leg but is without the upturned seta on the first segment. The third leg is similar to the second but has two bristles at the dorsal-distal corner of the first segment.

The male paired copulatory structures consists of heavily sclerotized, extremely muscular, sub-circular penifera and ventrally situated subtriangular falcate structures (terminology from Hart and Hart, 1969).

*Discussion:* The possession of a styliform mandible coxale, together with the reduced maxilla palp and endites characterizes this genus as a member of the Subfamily Paradoxostomatinae as outlined by McKenzie (1969). The suctorial disc on the oral cone allies this genus with both *Paradoxostoma* and *Cytherois.* The styliform mandible coxale, the lack of a maxillary palp, and the strong distal spine on the protopodite of the first walking leg suggests a closer affinity with *Paradoxostoma* than with *Cytherois*, which lacks these features. Furthermore, the mandible palp of *Paradoxostoma* is two segmented while that of *Acetabulastoma* is three segmented. The outline and ventral flattening of the valves of this genus had been illustrated previously only for *Paradoxostoma rostratum* Sars (Sars, 1928; Elofson, 1940).

*Acknowledgments:* The author thanks Dr. K. G. McKenzie of the British Museum for his evaluation of the taxon, and Dr. F. M. Swain of the University of Delaware who critically reviewed the manuscript.

## Résumé

*Acetabulastoma californica* n. sp., est décrit. Les caractéres distingués sont les valves ventralement aplatit, la large empreinte de front, la palpe mandibulaire de trois segments, et la maxille sans une palpe.

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Vol. 85, No. 42, pp. 489–492 30 December 1972

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OF THE
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# THE MILLIPED GENUS *BIDENTOGON* (DIPLOPODA, POLYDESMIDA, TRICHOPOLYDESMIDAE)

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Buckett and Gardner (1968) described the milliped genus *Bidentogon* for a new species, *B. helferorum*, from Mendocino County, California. While examining the general collection of millipeds in the Museum of Comparative Zoology, Cambridge, Massachusetts, I ran across the type-specimen of *Brachydesmus californicus* Chamberlin, described in 1918, and apparently never filed in the type-collection, even though the vial was clearly labelled "HOLOTYPE." Detailed examination of the gonopods of the minute animal revealed that the species does not, of course, belong to *Brachydesmus*, an European genus with no native species in the United States, but is a member of the family Trichopolydesmidae, and is undoubtedly congeneric with *Bidentogon helferorum.* The purpose of this paper is thus to provide illustrations of *B. californicus*, not previously available, with comparative figures and a new record of *B. helferorum.* I have also added a brief note on the use of the family name Trichopolydesmidae, a source of some recent confusion.

## ORDER POLYDESMIDA

### Trichopolydesmidae Verhoeff, 1910

### *Bidentogon* Buckett and Gardner

*Bidentogon* Buckett and Gardner, 1968, Pan-Pacific Entomol. 44:198. Type-species *Bidentogon helferorum* Buckett and Gardner.

*Diagnosis:* Distinct from other known North American trichopolydesmid genera in having 19 segments rather than 20, and in the simple, two-branched gonopods. See Loomis (1960) for detailed illustrations and descriptions of other genera.

Despite the reduced segment number, a rather common adaptation among millipeds to small size, species of *Bidentogon* seem at present to be most closely related to *Speorthus tuganbius* Chamberlin (Loomis, 1960, p. 66–68, Figs. 14–16), a 20-segmented trichopolydesmid from Carlsbad Caverns, New Mexico, with simple gonopods.

### *Bidentogon helferorum* Buckett and Gardner
Figures 1–3

*Bidentogon helferorum* Buckett and Gardner, 1968, Pan-Pacific Entomol. 44:198–202, Figs. 1–7, ♂, ♀.

*New record:* California: Alameda County, Oakland, 24 February 1962, Art Raske, ♂♂, ♀♀. Specimens deposited in Museum of Comparative Zoology.

### *Bidentogon californicus* (Chamberlin) NEW COMBINATION
Figures 4–5

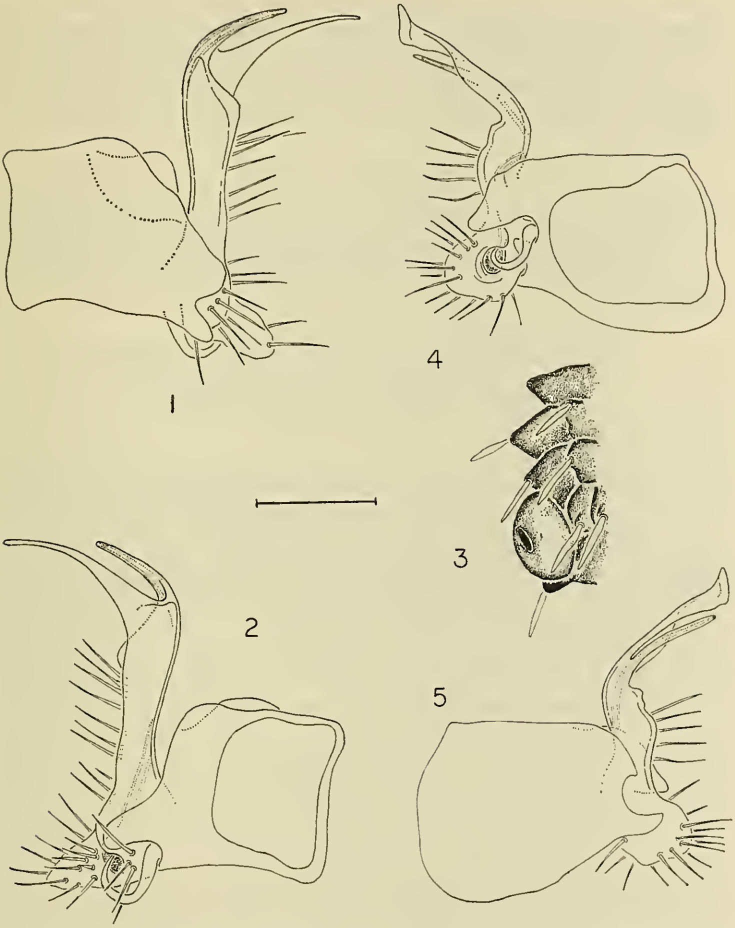
*Brachydesmus californicus* Chamberlin, 1918, Pomona College J. Ent. Zool. 10:9, no figures; Chamberlin and Hoffman, 1958, U. S. Nat. Mus. Bull. 212:64.

*Types:* Male and female cotypes from Sacramento, California, collected January 1914, by M. G. Childs, from debris in a hollow apple tree; deposited in Museum of Comparative Zoology.

The two species of *Bidentogon* differ mainly in the form of the gonopods; the mesal branch has a spatulate, incurved tip in *B. californicus* and is evenly tapered and acuminate in *B. helferorum.* The exhaustive description of the nonsexual characters of *B. helferorum* given by Buckett and Gardner (1968) fits *B. californicus* nearly to the letter.

*Usage of the family name Trichopolydesmidae:* Buckett and Gardner (1968) used the family name Vanhoeffeniidae in describing *Bidentogon.* Loomis (1960) pointed out, citing the papers of Jeekel mentioned below, that the usage of this family name may be incorrect, but continued to refer to the several genera and species he treated (Loomis, 1960) as "vanhoeffeniids." I followed Loomis (Shear, 1969) and used the name Vanhoeffeniidae in a key to United States cave millipeds.

However, Jeekel (1956) placed the generic name *Vanhoeffenia* as a senior subjective synonym of *Gnomoskelus*, and transferred the genus to the family Dalodesmidae (Jeekel, 1965). The other genera included in the old "family" Vanhoeffeniidae are not dalodesmids, and thus the removal of the type-genus of the family to the Dalodesmidae leaves these genera, which do belong together, without a family name. Kraus (1957) pointed out that the oldest family group name remaining for them is Trichopolydesmidae Verhoeff, 1910. The results of this nomenclatorial tangle are the placement of the name Vanhoeffeniidae as a junior subjec-



Figs. 1–3. *Bidentogon helferorum.* Fig. 1, right gonopod, lateral view. Fig. 2, right gonopod, mesal view. Fig. 3, left paranotum of segment 13. Figs. 4–5, *B. californicus.* Fig. 4, right gonopod, mesal view. Fig. 5, right gonopod, lateral view.

tive synonym of Dalodesmidae Cook, 1896, and the mandated use of the family name Trichopolydesmidae for the genera formerly grouped with *Vanhoeffenia.*

Thus North American authors should abandon the use of the family name Vanhoeffeniidae and use the family name Trichopolydesmidae for the former "vanhoeffeniids."

Taxonomists working on other groups often express astonishment at the complications of milliped nomenclature. If diplopod taxonomists seem overly preoccupied with names, it is out of a necessity for untangling the redundant, carelessly proposed higher category names published by early authors with a complete disregard for priority and for each other's work.

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Vol. 85, No. 43, pp. 493–498 30 December 1972

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# A NEW MILLIPED IN THE GENUS *APHELORIA* FROM SOUTHERN WEST VIRGINIA, AND THE TAXONOMIC POSITION OF *RUDILORIA MOHICANA* (DIPLOPODA, POLYDESMIDA, XYSTODESMIDAE)

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The Appalachian millipeds of the family Xystodesmidae present many problems to the taxonomist, but one of the most difficult is the delimitation within the family of meaningful genera. Genera of unwieldy size (*Nannaria*, *Brachoria*, etc.) are to be found listed with numerous monotypic genera (*Erdelyia*, *Rudiloria*, etc.). Some of the larger genera, in particular *Apheloria*, *Sigiria*, and *Sigmoria*, are connected by a range of intermediate species that make the genera very difficult to separate. This situation is not necessarily undesirable, if the genera are meaningful groups of related species. The real difficulties arise when monotypic genera are described on the basis of a few "generic characters" rather than on the basis and examination of a whole group of species in an attempt to infer their genetic relationships. Small and monotypic genera are only appropriate, when, in the opinion of experienced taxonomists, a species or small group of species represents a distinct phyletic line.

Though it will be some years before generic categories can be authoritatively established in the family Xystodesmidae, it does seem clear now that quite a number of the smaller genera, and some of the larger ones, will have to be combined in order to present a rational phyletic picture. In the present paper, I describe a new species of *Apheloria* from southern West Virginia that is similar in many ways to the animal known as *Rudiloria mohicana* Causey, described (Causey, 1955) from

Ashland County, Ohio. The similarities between the new species and *mohicana* coupled with several key items in the description of the genus *Rudiloria* strongly suggest that this genus should be synonymized under *Apheloria.*

My thanks to Paul Vogel and Michael McGraw for the animals comprising the type-series of *Apheloria guyandotta* new species, to Nancy Price Platnick for additional material of the new species from Mercer County, West Virginia, and Dr. J. A. L. Cooke, American Museum of Natural History, for the loan of the male holotype of *Rudiloria mohicana.*

### **Apheloria guyandotta** new species

Figures 1, 2

*Types*: Male holotype and six male and two female paratypes from Shaft Hollow, near McGraws, Wyoming County, West Virginia, collected under logs and rocks by Paul Vogel and Michael McGraw, 28 May to 1 June 1968, deposited in Museum of Comparative Zoology, Cambridge, Massachusetts.

*Etymology:* The specific epithet is an adjective formed from the name of nearby Guyandotte Mountain.

*Diagnosis:* Other West Virginia species of *Apheloria* are *A. trimaculata*, *A. corrugata*, and *A. kleinpeteri.* Both *corrugata* (found throughout the state) and *trimaculata* (found only in the easternmost ridges south to Greenbrier County) have the gonopod telopodites coiled in at least a complete circle; *kleinpeteri* (known only from the slopes of East River Mountain) has the telopodites arched as in *guyandotta*, and expanded distally, but *guyandotta* differs in lacking a prefemoral process. *Apheloria corrugata* is black, cross-banded yellow with red paranota, *trimaculata* is black with red median spots and yellow paranota (Greenbrier County) or cross-banded pinkish orange (Pocahontas County), and *kleinpeteri* is solid black with distinctive red paranota. *Apheloria guyandotta* resembles Greenbrier County *trimaculata*, but is about two-thirds the size of *trimaculata*, and differs in the gonopods as described above.

*Description of male holotype:* Length, 32 mm, width 7.5 mm. Structure typical of species of *Apheloria.* Paranota broad, not raised, heavily rebordered at margins; posterior angles rounded right angles becoming acute posteriorly; anterior margins nearly straight, becoming slightly recurved posteriorly; general impression of paranota is one of almost square lateral projections evenly continuing arch of dorsum. Collum evenly rounded in front, slightly broader than head, posterior angles rounded. Sternum between third legs with two conelike projections which diverge distally. Other sterna not modified. Coxae of anterior legs with small angles ventrodistally that gradually become well-developed spines on posterior legs. Prefemora of legs with long, strong spines nearly three-fourths length of prefemora on posterior legs. Gonopods (Figs. 1, 2):

FIGS. 1–2. *Apheloria guyandotta* n. sp. Fig. 1. Gonopods, in situ, anterior view. Fig. 2. Left gonopod, posteriodorsal view. FIG. 3. *Apheloria mohicana* (Causey), left gonopod, posteriodorsal view. Scale line = 0.35 mm for Fig. 1, 0.30 mm for Figs. 2–3.

Coxae globose, joined in midline by weak membrane; anteriorly with two setae. Prefemora relatively small, not much swollen, heavily setose around pocket receiving distal end of sharply curved coxal solenite. Prefemoral spine absent. Telopodite strongly arched, distally expanded. No torsion evident in telopodite from course of seminal channel. Coloration: collum black to dark brown with anterior median red spot, posterior corners yellow, extending into diffuse yellow band along posterior margin. Anterior segments dark brown to black, with median red-orange spot tending to contact yellow spots on caudal two-thirds of paranota; on posterior segments median spot is red and completely distinct and separated from yellow paranotal spots. On last four segments, median spot becomes more orangish; anal segment mostly yellow. Legs and venter yellow.

*Description of female paratype:* Length, 37 mm; width, 8.2 mm. Structure in general as in the male, but larger, broader, dorsum more highly arched. Coloration similar to male; some females in the type-series are lighter brown with median red spot tending to become cross-band contacting paranotal yellow spots. Female genitalia typical of genus.

*Distribution:* Known from Wyoming and Mercer Counties, West Virginia. In addition to the specimens from the type-locality, I collected a female in Camp Creek State Forest, 21 September 1970, and N. P. Platnick collected a male in the same place on 20 June 1971. A few females from Logan County, West Virginia, that are superficially similar to females of *A. guyandotta* may also belong to this species.

### *Apheloria mohicana* (Causey) NEW COMBINATION
Figure 3

*Rudiloria mohicana* Causey, 1955, Proc. Biol. Soc. Washington, 68:28, fig. 6, ♂.

*Types:* Male holotype from Mohican State Park, Ashland County, Ohio, collected August 1951, by Leroy Gray. Deposited in American Museum of Natural History, examined.

*Description of male holotype:* Specimen in three fragments, length between 25 and 30 mm, width ca. 6 mm. Head anomalous with large swelling above left antenna. Paranota broad, not raised, moderately rebordered, posterior angles broadly rounded right angles, anterior margins slightly recurved, anterior angles of paranota broadly and evenly rounded, not nearly square as in *A. guyandotta*; paranota evenly continue arch of dorsum. Anterior margin of collum evenly rounded, posterior edge slightly sinuate. Sternum between third legs with two unequal projections that are closely appressed, not divergent and cone shaped. Other sterna unmodified. Coxae of anterior legs without any sign of spines; ventrodistal angles becoming acute on posterior legs; coxae of last few pairs of legs with evident spines. Prefemoral spines moderate, about one-half length of segment. Gonopod (Fig. 3) very similar to that of *A. guyandotta*, but more arched, distal expansion not so evident, curved into definite hook. Causey (1955) described color pattern as dark brown, with yellow paranota and cross-bands; specimen has since faded to even light brown. Females unknown.

*Distribution:* Known only from the type-locality, but probably occurs in much of the hill country in southern Ohio.

*Notes on synonymy:* Causey (1955) set up the genus *Rudiloria* for *R. mohicana*, the type and only species, on the basis of the small body size of *mohicana* and the lack of a prefemoral spine on the gonopods. In all other characters, the species is typical of *Apheloria.* Relative body size is unsuitable as a measure of distinctness in millipeds, since geographic variation in size and proportions is a widespread phenomenon in the group, with its tendency to form isolated populations that then respond to local selective pressures. The prefemoral spine on the gonopods is probably a degenerating character. It is highly prominent and sometimes branched in the species usually assigned to *Sigmoria* and *Sigiria,* and in species of *Apheloria* sensu strictu is usually small and acute. In some midwestern populations of *A. corrugata,* the spine is nearly absent and nubbinlike. Thus neither of the characters used to differentiate species of *Rudiloria* from those of *Apheloria* are really indicative of phyletic distinctness, and *Rudiloria mohicana* should henceforth be considered a species of *Apheloria.*

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Vol. 85, No. 44, pp. 499–508 30 December 1972

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# THE GENERIC DISTINCTION OF THE HISPANIOLAN WOODPECKER, *CHRYSERPES STRIATUS* (AVES: PICIDAE)

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The Hispaniolan Woodpecker, *Chryserpes striatus*, is the only resident woodpecker on an island of nearly 30,000 square miles area. Throughout most of its taxonomic history it has been considered a member of the *Centurus* group of barred-backed woodpeckers now often included in the genus *Melanerpes*. Miller (1915) recognized the distinctiveness of *striatus* and created for it the monotypic genus *Chryserpes*. This name found some usage at first, but Peters (1948) did not recognize it and *striatus* subsequently resided in *Melanerpes* (or *Centurus*) unchallenged.

In 1963, Selander and Giller reviewed the genus *Centurus*, including *striatus*. Of this species they said (p. 256), "without question it is not closely related to any species of [*Centurus*] or of *Melanerpes*, and there would seem to be much justification for placing it in its own monotypic genus, *Chryserpes*. . . ." They speculated that there might be some possibility of its being allied to *Piculus*.

Bond (1963) took issue with the judgment of Selander and Giller. "Granted that *C. striatus* is an aberrant species of *Centurus*, its affinity with that genus is clearly felt by ornithologists with experience of this bird in life," (Bond, 1963:6). He cited his own field observations and those of Wetmore and Swales (1931) as confirming the behavior of *striatus* to be like that of *Centurus*. Selander (*In* Bond, 1964:7) later wrote Bond as follows . . . "I was in Hispaniola last summer and spent about 2 weeks working with the woodpecker. I am sure that *striatus* is a melanerpine type, and in fact I have no objection to putting

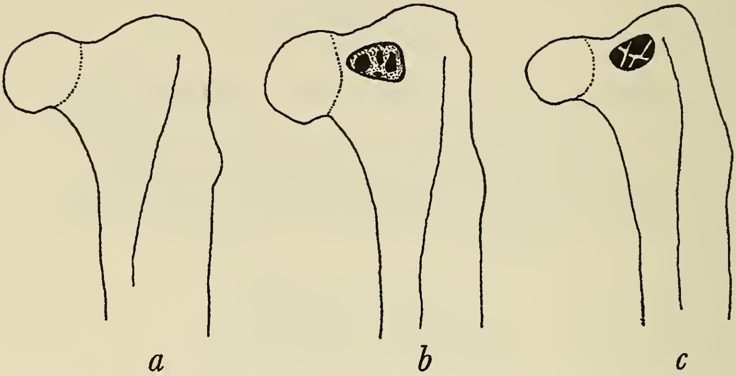

FIG. 1. Proximal femur, anterior aspect. a. *Melanerpes superciliaris.* b. *Chryserpes striatus.* c. *Xiphidiopicus percussus.*

it in *Centurus.* However, it is, as you noted recently, a somewhat aberrant species." Here the matter has rested, with the taxonomic fate of *striatus* apparently being decided on the basis of rather subjective assessments of its general demeanor.

Quite by accident I was led to investigate certain aspects of the osteology of *striatus* which fully confirm the views expressed by Miller (1915) and by Selander and Giller (1963). The species shall hereinafter be referred to under the name *Chryserpes.* In the course of identifying subfossil bone material from cave deposits in Haiti, I discovered that in *Chryserpes* there is a large pneumatic foramen in the anterior face of the neck of the femur. This is a feature that occurs in but few other families and is not characteristic of the Picidae. Subsequent checking disclosed such a foramen in only one other species of picid, the Cuban Green Woodpecker, *Xiphidiopicus percussus* (see Appendix for species examined). *Xiphidiopicus* is a monotypic genus restricted to Cuba. In all 12 specimens of *Chryserpes* and two of *Xiphidiopicus* examined, the anterior femoral foramen was a more or less regular ellipsoid lying transverse to the line of the shaft (Fig. 1). It is variable in size and shape but is always large and conspicuous.

A pneumatic foramen of somewhat similar position and extent may be found elsewhere only in the Upupidae, Phoeniculidae, Bucerotidae (where it is much reduced), Trogonidae, and Musophagidae. The anterior proximal femur is also pneumatic in the Sulidae, Ciconiidae, Phoenicopteridae, Anhimidae, Cathartidae, Sagittariidae, Accipitridae, Falconidae, Megapodiidae, Phasianidae, and Tetraonidae, but in these groups the foramina are longitudinally oriented in the trochanteric ridge and are seldom regular in outline.

A pneumatic opening is found in the *posterior* face of the femur beneath the ridge of the neck in a number of picid genera (e.g. *Celeus*, *Mulleripicus*, *Dryocopus*, *Dinopium*, *Campephilus*, and *Phloeoceastes*). In many woodpeckers this is reduced to a tiny pinhole, and as such, is present in *Melanerpes*, *Chryserpes*, *Xiphidiopicus*, and numerous other genera.

From dissection of two specimens of *Chryserpes*, it was apparent that a branch of the air sac system passed into the anterior pneumatic foramen of the femur. This branch communicated with a small foramen in the pelvis directly anterior to the acetabulum and may possibly have had other ramifications down the shaft of the femur and under the pubis. The foramen anterior to the acetabulum is also present in *Melanerpes* and other picid genera. In a dissection of a specimen of *M. superciliaris*, the pneumatization of the area around the head of the femur appeared to be reduced compared to *Chryserpes* and, of course, there was no communication directly into the femur as in that genus. However, tracing small branches of the air sac system is notoriously difficult and can be carried out effectively only by special methods such as latex injection of fresh specimens. More conclusive results could not be obtained from the specimens at hand.

It is difficult to perceive what advantages might accrue to *Chryserpes* and *Xiphidiopicus* by having this pneumatic modification of the femur. Regardless of its function, however, it would not seem to be a primitive character, as it is not found elsewhere in the order, even in the more primitive families. Its presence in *Chryserpes* and *Xiphidiopicus* can only be regarded as a specialization and one that speaks strongly for the affinity of the two.

With this novel view in mind, it becomes of interest to compare the skulls of *Chryserpes*, *Xiphidiopicus*, and *Melanerpes*. Here again we find that the skull of *Chryserpes* is unlike

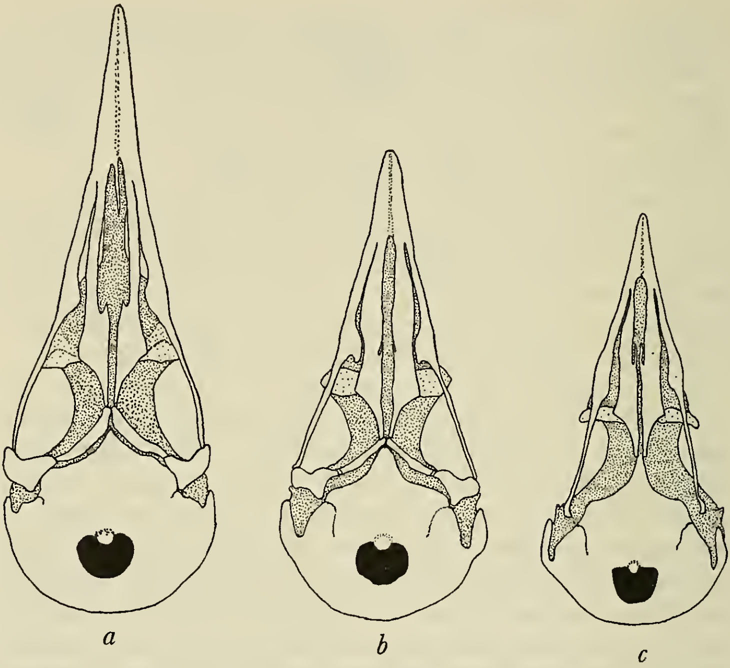

FIG. 2. Ventral aspect of skull. a. *Melanerpes superciliaris*. b. *Chryserpes striatus*. c. *Xiphidiopicus percussus* (lacking quadrates and pterygoids; size difference from *Chryserpes* is due to the specimen's being of the small race from the Isle of Pines).

any species of *Melanerpes* and most closely resembles that of *Xiphidiopicus*. The bill of *Chryserpes* is broader and flatter than any of the *Centurus* group of *Melanerpes* (it is, however, exceeded by *M. cruentatus* in relative width). This is especially noticeable in the internarial bridge which is broad and flattened in *Chryserpes* and *Xiphidiopicus* and narrower and rounded in the *Centurus* group.

In ventral view (Fig. 2) the anterior portions of the palatines in *Chryserpes* are much more expanded and flattened than in any species of *Melanerpes* but resemble the condition found in *Xiphidiopicus*. Also, in both *Chryserpes* and *Xiphidiopicus*, the pterygoids are more slender and lack the winglike expansions seen in *Melanerpes*.

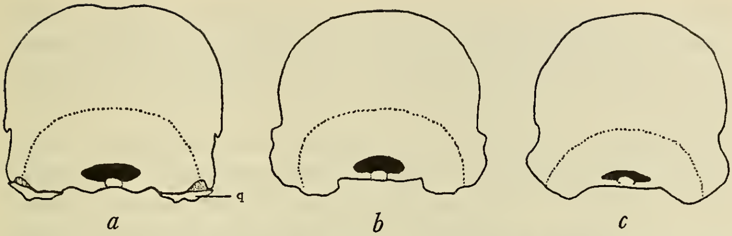

FIG. 3. Posterior aspect of skull. a. *Melanerpes superciliaris* (q = quadrate). b. *Chryserpes striatus.* c. *Xiphidiopicus percussus.*

Most striking is the posterior aspect of the skull. In *Chryserpes* and *Xiphidiopicus* (Fig. 3b, c) the cranium is a high rounded dome, whereas in all *Melanerpes* the cranium is squared and flatter on top with a distinct longitudinal furrow in the middle (Fig. 3a). Even more impressive is the great lateral and ventral expansion of the auditory region exhibited by *Chryserpes* and *Xiphidiopicus.* In these two genera the auditory bulge is the widest point of the skull, extending laterally past the plane of the postorbital processes and ventrally far enough to obscure the quadrates. In *Melanerpes,* the auditory region is much less well developed and does not obscure the quadrates in posterior view. In this genus the widest point of the skull is at the postorbital processes.

A lateral view of the auditory region shows further the much greater development of *Chryserpes* (Fig. 4b) and *Xiphidiopicus* (Fig. 4c) as compared to *Melanerpes* (Fig. 4a). The lateral portion of the otic cup is a short spur in *Melanerpes,* a large, well-developed pointed projection in *Xiphidiopicus,*

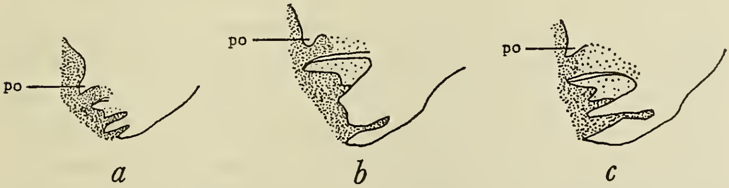

FIG. 4. Lateral aspect of left auditory region. a. *Melanerpes superciliaris.* b. *Chryserpes striatus.* c. *Xiphidiopicus percussus.* The postorbital process (po) is indicated for orientation.

and a broad, rounded flange in *Chryserpes.* The ventral portion of the otic cup is most extensive in *Xiphidiopicus*, somewhat less so in *Chryserpes*, and negligibly developed in *Melanerpes.*

The external peculiarities of *Chryserpes* have been discussed by Selander and Giller (1963) and enumerated in detail by Miller (1915). In plumage, *Chryserpes* differs from *Melanerpes* and agrees with *Xiphidiopicus* by its greenish coloring, barred outer webs of the primaries, and by the red anterior crown of the males being replaced by black in the females. The anterior crown is black in females of a few species of *Melanerpes*, but in these, the entire dorsum is also black. The black crown of female *Xiphidiopicus* is streaked with white, and it is interesting to note that in some females of *Chryserpes* the shafts of the black crown feathers are also very narrowly streaked with white. This condition is not found in *Melanerpes.*

*Chryserpes* differs from both *Melanerpes* and *Xiphidiopicus* in its red upper tail coverts, unbarred flanks and undertail coverts, and bright yellow iris. It differs further from *Xiphidiopicus* in lacking the black chin and ocular stripes, red throat patch, and streaked breast, and in having a shorter crest and longer, narrower and more pointed rectrices that lack barring.

In both *Chryserpes* and the *Centurus* group of *Melanerpes* the dorsum and wings are barred and this has no doubt been the major factor masking the true affinities of *striatus.* Selander and Giller (1963:256) commented that this character "was probably acquired independently in *Chryserpes*, the resemblance to species of *Centurus* being a matter of convergence." With this I heartily concur, especially in view of the fact that a barred dorsum occurs in other groups of woodpeckers.

The reputedly "melanerpine" appearance of *Chryserpes* in life may be in part due to its being the only resident woodpecker on Hispaniola. Thus it probably occupies a much wider range of habitats and niches than it might if faced with melanerpine competitors, and in so doing may have independently acquired some behavioral similarities to *Melanerpes.* It is worthwhile to note that Wetmore and Swales (1931) reported that *Chryserpes* was not heard to produce the "rattling drum" characteristic of species of *Melanerpes.*

On the basis of available information there is little indication that *Chryserpes striatus* is in any way related to *Melanerpes* and every indication that it is not. Its closest relative is certainly *Xiphidiopicus percussus,* and this affinity is quite tenable on zoogeographic as well as morphological grounds. The differences in plumage, rectrices, and auditory region of the skull I think justify the retention of monotypic genera for both *Chryserpes* and *Xiphidiopicus.*

Although it is not my intention to deal in this paper with the broader aspects of picid taxonomy, it is necessary to consider the possible relationships of *Chryserpes* and *Xiphidiopicus* outside the Antilles. Pertinent to this topic is the most interesting discussion by Short (1970) on the affinity of certain African and Neotropical woodpeckers wherein Short also presents some preliminary views of his classification of the Picidae. He considers the African genera *Campethera*, *Geocolaptes*, and *Dendropicos* (including *Thripias*, *Polipicus*, and *Mesopicos*) to be related to the New World "colaptine" woodpeckers, *Colaptes*, *Piculus*, and *Veniliornis.* Short also states (p. 37) that, "The peculiar, generalized and exclusively New World melanerpine group of woodpeckers (*Melanerpes*, *Xiphidiopicus*, *Sphyrapicus*; Bock and Short, Ms) may be a derivative of an early, generalized stock of woodpeckers that gave rise to colaptine and campetherine woodpeckers. I note the similarity of certain African woodpeckers, especially *Dendropicos goertae* and *D. griseicephalus*, with various species of *Melanerpes* (e.g. *M. striatus*)." Reasons for placing *Xiphidiopicus* with the melanerpine group are not given. However, neither *Chryserpes* nor *Xiphidiopicus* could fairly be called "generalized" and their similarities to *Melanerpes* are very superficial while the differences are quite profound.

I would remove *Xiphidiopicus* and *Chryserpes* entirely from the melanerpine group and place them in or near the campetherine-colaptine assemblage. When this is done, the resemblance between the melanerpine group and the campetherine-colaptine group is considerably diminished. On the other hand, resemblance of *Chryserpes* and *Xiphidiopicus* to the campetherine-colaptines is strong and almost all the plumage characters of the Antillean genera may be found in one or another of the mainland genera of this group. The females with black crowns marked with white, the greenish coloring, and the barred outer primary webs of *Chryserpes* and *Xiphidiopicus* are also seen in the campetherine line but not in the melanerpines. The same is true of the scarlet rump of *Chryserpes.* The barred dorsal plumage previously thought to ally *Chryserpes* with "*Centurus*" is also present in some campetherines (e.g. *Dendropicos fuscescens* and *Colaptes*). While distinct in themselves, the skull characters of *Chryserpes* and *Xiphidiopicus* are much more similar to the campetherine line than to the melanerpines to which they show little resemblance.

The two endemic Antillean genera, *Xiphidiopicus* and *Chryserpes* are unquestionably more closely related to each other than either is to any existing mainland form. They probably represent the result of a single invasion of the Antilles by some campetherine-colaptine stock. Their distinctiveness argues well for their being the oldest picid inhabitants of the West Indies (with the possible exception of the piculet, *Nesoctites*) and this is concomitant with the presumed relatively great age of the campetherine-colaptine line emphasized by Short.

I am grateful to Richard L. Zusi, John Farrand, and Alexander Wetmore for suggesting several valuable improvements in the manuscript.

## Resumen

Algunos carácteres del cranio, del femur, y de la plumaje muestran que el Carpintero de Hispaniola, *Chryserpes striatus*, no tiene afinidad con *Melanerpes* donde usualmente se encuentra. En lugar de esto, es más cerca al Carpintero Verde, *Xiphidiopicus percussus*, de Cuba. El género *Chryserpes* es válido por la especie *striatus. Chryserpes* y *Xiphidiopicus* probablemente representan la linea más vieja de los carpinteros antillanos. Sus relaciones aparecen ser con el grupo "*Campethera-Colaptes*" y no con el de *Melanerpes.*

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## Appendix

The following list is of the species of Picidae in the National Museum of Natural History, Smithsonian Institution, collections examined for the anterior pneumatic foramen in the neck of the femur and found to lack it. Number of specimens follows the name:

*Jynx torquilla*, 1; *J. ruficollis*, 2; *Picumnus exilis*, 1; *P. aurifrons*, 4; *P. cirratus*, 1; *Nesoctites micromegas*, 2; *Verreauxia africana*, 2; *Colaptes auritus* (including *cafer* and *chrysoides*), 22; *C. pitius*, 2; *C. campestris*, 1; *Nesoceleus fernandinae*, 1; *Chrysoptilus melanochloros*, 1; *Piculus rivolii*, 2; *P. rubiginosus*, 1; *P. chrysochloros*, 1; *Campethera abingoni*, 1; *C. permista*, 2; *C. caroli*, 2; *C. nivosa*, 1; *Celeus lugubris*, 2; *C. castaneus*, 6; *C. elegans*, 1; *C. undatus*, 1; *C. flavus*, 1; *Micropternus brachyurus*, 2; *Picus viridis*, 1; *P. vittatus*, 4; *P. canus*, 10; *P. erythropygius*, 1; *P. flavinucha*, 1; *P. chlorolophus*, 1; *P. mentalis*, 1; *Dinopium bengalense*, 3; *D. javense*, 6; *Meiglyptes tristis*, 1; *Mulleripicus pulverulentus*, 2; *M. funebris*, 1; *M. fulvus*, 2; *Dryocopus martius*, 3; *D. javensis*, 4; *D. pileatus*, 9; *D. lineatus*, 8; *Asyndesmus lewis*, 1; *Melanerpes erythrocephalus*, 5; *M. formicivorus*, 9; *M. uropygialis*, 4; *M. carolinus*, 9; *M. aurifrons*, 8; *M. superciliaris*, 1; *M. radiolatus*, 1; *M. rubricapillus*. 8; *M. cruentatus*, 5; *Leuconerpes candidus*, 3; *Sphyrapicus varius*, 10; *S. thyroideus*, 2; *Trichopicus cactorum*, 1; *Veniliornis passerinus*, 4; *V. affinus*, 3; *V. kirkii*, 2; *Dendropicos fuscescens*, 7; *D. gabonensis*, 1; *Dendrocopos syriacus*, 1; *D. major*, 7; *D. leuconotos*, 2; *D. hyperythrus*, 1; *D. atratus*, 2; *D. macei*, 2; *D. canicapillus*, 2; *D. temminckii*, 1; *D. villosus*, 6; *D. pubescens*, 10; *D. borealis*, 4; *D. arizonae*, 1; *D. scalaris*, 4; *D. nuttallii*, 5; *D. lignarius*, 4; *Picoides tridactylus*, 1; *P. arcticus*, 1; *Thripias namaquus*, 2; *T. xantholophus*, 2; *Chrysocolaptes lucidus*, 3; *Phloeoceastes melanoleucus*, 7; *P. rubricollis*, 2; *P. leucopogon*, 1; *Campephilus principalis*, 4; *C. imperialis*, 3; *C. magellanicus*, 2.

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Vol. 85, No. 45, pp. 509–522 30 December 1972

PROCEEDINGS
OF THE
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# THE CUBAN *ANOLIS SPECTRUM* COMPLEX (SAURIA, IGUANIDAE)

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*Anolis spectrum* W. Peters is one of a group of three species Cuban anoles (including *A. cyanopleurus* Cope and *Anolis alutaceus* Cope) characterized by an attenuate shape and a dorsal zone of greatly enlarged scales, but with either smooth (*alutaceus*) or keeled (*spectrum, cyanopleurus*) ventral scales. Of the three included species, only *A. alutaceus* has been well represented in collections, and both *A. spectrum* and *A. cyanopleurus* have long been considered quite rare. W. Peters described *A. spectrum* on the basis of two specimens sent to him by the noted Cuban zoologist Juan Gundlach; in addition to these two syntypes (which are a male and a female), there was a third specimen which was sealed in a jar in La Habana so that the delicate lizard would not be destroyed by students. Barbour and Ramsden (1919:150) examined the La Habana specimen at a distance and characterized it as "a strange looking wraith of a lizard." The original material apparently was secured by Gundlach in the jurisdictions of Matanzas and Cárdenas in west-central Cuba (Gundlach, 1875:358; 1880:51), and no individuals of the species were taken until Dunn (1926) found *A. spectrum* in the mountains near Soledad (= Sierra de Trinidad) in south-central Las Villas Province, about 180 kilometers to the southeast of Gundlach's specimens.

No further records of *A. spectrum* appeared until that of Schwartz and Ogren (1956:98); they secured a female specimen north of Santiago de Cuba, Oriente Province, some 470 kilometers southeast of Dunn's Sierra de Trinidad records. Ruibal (1964:509) noted that the species is presently known only from the Sierra de Trinidad, but that Gundlach had collected the type-material in Matanzas. Ruibal's comment that "The destruction of the forest in most of lowland central Cuba may have destroyed this species in all areas outside the Sierra de Trinidad" is reasonable; Ruibal stated, without examination of the lizard, that the presumed *A. spectrum* recorded by Schwartz and Ogren from Oriente was probably an erroneous identification.

Under the auspices of National Science Foundation grants G-3865 and G-6252, Schwartz collected *Anolis spectrum* in the Sierra de Trinidad in 1957 and 1960, and found the species to be very easily secured in the area about Topes de Collantes in that range. It was not until 1964 that Garrido secured *A. spectrum* in Pinar del Río Province at the Valle de Pica Pica, about 200 kilometers west of the Gundlach locality for the type-material. Further collecting in the Pica Pica region by Garrido with Luis Moreno, Miguel L. Jaume, and Günther Peters resulted in their securing of a series from this region. A third visit to Pica Pica was made by Garrido with Jaume and George Gorman in 1967. Garrido also examined the La Habana specimen which had been sealed by Gundlach; finding that there were certain discrepancies between the description of *A. spectrum* given by Ruibal and others (based on Sierra de Trinidad specimens) and the characteristics of the Gundlach specimen from Matanzas Province, Garrido visited the Sierra de Trinidad to collect specimens in that range and then made a special effort to secure specimens from Matanzas Province, since these might in a broad sense be considered topotypic. In this latter quest, Garrido was successful, since he secured three specimens at San Miguel de los Baños, in March 1969, and eight in August 1969, the first "topotypes" of *A. spectrum* taken since Gundlach's original material. Additional specimens were collected at San Miguel by Raul Shelton in 1969 and by Garrido in 1970. Thus, single individuals to moderate or extensive series of *A. spectrum* are now available from four widely separated areas in Cuba—Pica Pica in Pinar del Río, San Miguel de los Baños in Matanzas, the Sierra de Trinidad in Las Villas, and near Santiago de Cuba in Oriente. Study of some of these lizards convinced Garrido that there were two distinct species involved, since those from Pinar del Río and

Matanzas resembled each other in many details, whereas those from Las Villas differed from the more western lots in ways that he interpreted as being on a specific level. Garrido communicated these facts to Schwartz, who in turn borrowed the *A. spectrum* in American collections; study of all this material readily confirms Garrido's assumption: there are two species presently confounded under the name *Anolis spectrum.*

Günther Peters (1970) meanwhile had studied the 21 specimens of *A. spectrum* collected by him in Cuba in 1967 (on the Erste Kubanisch-Deutschen Alexander von Humboldt-Expedition der Deutschen Akademie der Wissenschaften zu Berlin and conjointly sponsored by the Academia de Ciencias de Cuba) along with the W. Peters syntypes. Peter's 1967 specimens included three from Pica Pica and 18 from the Sierra de Trinidad at Arroyo La Mariposa. On the basis of these Pica Pica lizards, Peters named *Anolis spectrum sumiderensis.* In the light of Garrido's specimens, the lizards which G. Peters considered *A. s. spectrum* are in actuality representatives of the eastern species, rather than related subspecifically to *sumiderensis* which resembles near-topotypic *A. spectrum* (sensu stricto, from Matanzas Province). Accordingly, we herein reexamine the named taxa (*spectrum, sumiderensis*) and describe two new taxa, one of which is a subspecies of the other.

Our cooperation has been made possible by Luis Moreno of the Academia de Ciencias, Instituto de Biología, in La Habana. In addition to specimens secured by Garrido and now in the Instituto de Biología (IB), we have examined the material collected by Schwartz and now in the American Museum of Natural History (AMNH), as well as those in the Museum of Comparative Zoology (MCZ), the National Museum of Natural History, Smithsonian Institution (USNM), and the Oriente specimen in the Charleston Museum (ChM). For the loans of these lizards we are indebted to Richard G. Zweifel, George W. Foley, Ernest E. Williams, George R. Zug, and Albert E. Sanders. Two of the IB specimens have been deposited in the collection of the junior author (ASFS). We are especially grateful to Dr. Günther Peters of the Zoologische Museum der Humboldt-Universität zu Berlin (ZMB) for allowing us to examine not only the syntypes of *A. spectrum* and the holotype of *A. s. sumiderensis* but also his extensive series from the

Sierra de Trinidad. In all, we have studied 160 specimens of this complex, far more than has been previously available to any worker.

### *Anolis spectrum* W. Peters

*Anolis spectrum* W. Peters, 1863. Monatsber. Akad. Wiss. Berlin: 136. Syntypes—ZMB 421a–b. Type-locality: "Cuba"; effectively restricted by Gundlach (1875:358) to the vicinity of Matanzas and Cárdenas, Matanzas Province, Cuba; further stated (Gundlach, 1880:51) to have been observed in the jurisdictions of Cárdenas and Matanzas; here restricted to the *mogotes* at San Miguel de los Baños, 500 meters from the swimming pool at San Miguel, before arriving at the Río los Paredones, Matanzas Province, Cuba.

*Anolis spectrum sumiderensis* G. Peters, 1970. Mitt. Zool. Mus. Berlin, 46(1):226. Holotype—ZMB 41783. Type-locality: Valle de Pica Pica near Sumidero, Pinar del Río Province, Cuba. NEW SYNONYMY.

*Distribution:* Known only from the region of the Valle de Pica Pica, Pinar del Río Province, and San Miguel de los Baños, Matanzas Province, Cuba, but doubtless persisting in suitable ecological situations throughout much of western Cuba.

*Definition:* Body long and attenuate with body equal to about 41 percent (36.9–50.0) of tail length, head very narrow and elongate (crocodile-like) with a mean head length/head width ratio of 3.8 in males and 3.9 in females, head deeply concave between canthal ridges, especially in males and with a dark U lying in the concavity; dorsal scales large with very elevated keels, from 7 to 9 in snout-orbit distance and with about 10 enlarged dorsal rows of scales grading abruptly into the small, almost granular, lateral scales which in turn grade abruptly into very large and heavily keeled ventral scales of which there are 12 to 15 in the snout-orbit length; starting at the dorsal midline and counting to above the forelimb insertion, between 16 and 20 scales; no sexual dichromatism in color, both sexes uniform white to ashy in preservative, straw-colored to wood-brown in life and without a differently colored middorsal zone or stripe; a prominent black supra-axillary spot or dot in males; dewlap chestnut to iodine-colored; iris yellowish; mean ratio of snout-vent length to femur 4.2 in males, 3.8 in females; snout-vent length to 42 mm in males and 40 mm in females.

We have examined 22 specimens of *A. spectrum* from the Valle de Pica Pica and 15 from Matanzas Province, including the two ZMB syntypes. Data from the 18 Pica Pica lizards are: largest male 42 mm (IB 1714), largest female 40 mm (IB 1717); snout scales between first canthal scales (reckoned from orbit) 4–7 (mean 5.2; mode 6); scales between supraorbital semicircles 0 (= semicircles in contact)–2 (mode 0); scales between semicircles and interparietal scale (written as a fraction with right and left sides as numerator and denominator) 1/1 (2 individuals), 1/2 (3), 2/2 (5), 2/3 (1); fourth toe lamellae on phalanges II and III 13–16

(14.3); postmentals 2–4 (mean 2.3, mode 2); loreals 15–25 (19.9); dorsal axilla to groin 26–31 (28.3); scales between dorsal midline and forelimb insertion (= shoulder scales) 16–20 (17.4). Three Matanzas specimens have the following counts: largest male 40 mm (ZMB 421a), largest female 38 mm (IB 2374); snout scales between first canthal scales 4–7 (5.7; no mode); scales between semicircles 0–1 (mode 0); scales between semicircles and interparietal scale 1/1 (1), 1/2 (2); fourth toe lamellae 13–15 (14.0); postmentals 2–4 (mean 2.7, mode 2); loreals 17–21 (18.3); dorsals axilla to groin 27–31 (29.0); shoulder scales 17–19 (17.7).

Comparison of the meristic data from the above two samples (and we admit to the small size of the Matanzas sample[1]) suggests that there are no size or scale count differences between the Pinar del Río and Matanzas lizards. In all cases, extremes are similar or identical, and the ranges of each count in the Matanzas specimens fall within the parameters of the same counts in the much larger Pica Pica sample. We therefore can find no justification for the recognition of *sumiderensis* as a taxon distinct from *spectrum* on the basis of either size or counts. If *sumiderensis* is to be recognized, then it must be on the basis of color or pattern.

The senior author has made the following notes on a male *A. spectrum* from San Miguel de los Baños: dorsal ground color brownish straw; about seven dark brown spots on the back and in the postnuchal area a spot which resembles a pineal eye and is grayish; iris yellowish; a conspicuous black axillary spot; a fine vinaceous line from behind the orbit to the body-tail junction; insertion of base of tail with the hindlimbs ashy white; tibiae with two dark brown bands, thighs with three less conspicuous and clearer brown bands; elbow spot violet-brown; no labial stripe although with a spot of the same color as the elbow spot beneath the orbit; dewlap well developed, iodine-colored with about five clearer bands of scales along its anterior; anal triangle the same color as the elbow.

A male from Pica Pica was recorded by Garrido as being brownish straw-colored, like a dry twig, with the elbows more yellow; neck with a slight vinaceous cast, the beginning of a greenish dorsal region; hindlimbs more brownish; eye whitish or clear yellowish; dewlap iodine-colored with about six longitudinal rows of clearer scales; brownish color clear as far as the throat; venter brownish straw-colored with a slight violet wash toward the midline.

An adult female from San Biguel de los Baños was noted in life by Garrido as uniform brownish above from the neck to the tail; head chestnut-colored as if it had been soiled with red earth; a mark in the shape of a U, colored darker chestnut, on the forehead; about eight brown spots which are like irregular rectangles on the back, quite conspicuous in life, becoming fainter in captivity and becoming only irregular dots

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[1] Although the senior author has handled 13 *A. spectrum* from San Miguel de los Baños and took scale counts on them, both the specimens and the counts have been lost. Our comments upon the Matanzas population of *A. spectrum* are thus perforce based upon only three specimens. The other lizards did not differ appreciably from the color data presented here.

after death; limbs deep chestnut-colored, the insertion of the tail with the posterior portions of the thighs ashy white; elbows whitish brown or clear cinnamon; forelimb with two well-defined black dots; eyelids with two or three brownish or streaked lines or rays; gular fan brownish; brownish bands on the tail and toward the base with four or five yellowish rings; two whitish spots in the anal triangle; ventral coloration uniformly chestnut.

W. Peters (1863:138), quoting Gundlach's color data on the original material in life, stated that *Anolis spectrum* was "above brownish straw-yellow, below blackish brown, somewhat violet. The scales on the dorsal surface are reddish. The nares, a double V-shaped line (open anteriorly) in the depression before the eyes, a round spot on the scapula, the center of the upper and lower arm, thigh, and toes, as well as some flecks on the body and bands on the tail, are colored like the ventral surface of the body. Thigh with a white ground color on the rear. The colors are changed, so that they show the following: overall clear brown, only the nares, the V-shaped lines, the round spot on the scapula, a few paired flecks on the back and tail and fine dots on the venter blackish brown. Elbows and knee joints whitish, sharply separated from the blackish sides. Thigh ground color white and with a dark streak on the inner face."

Comparison of Garrido's field notes on the male from Pica Pica with those from the San Miguel male, along with the data presented originally by Gundlach as well as the color information on the San Miguel female, all suggest that there are no differences in color and pattern between Pinar del Río and Matanzas *A. spectrum*. This fact, coupled with the absence of meristic differences, leads us to place *A. s. sumiderensis* G. Peters in synonymy with *A. spectrum* W. Peters and to consider the latter species monotypic.

As far as the habitat and habits of *A. spectrum* are concerned, the species is primarily terrestrial and forages on the ground proper, as well as on small leafy or dry twigs, low shrubs, grass, and on small bushes which may or may not be leafy. The specimens secured at San Miguel were occupying these levels. The female was in open grass and, upon becoming aware of Garrido's approach, jumped in its characteristic manner to hide among the dry twigs of a small plant not more than two feet high. Other individuals were secured on dry leaf litter in the same area, and still others on the foliage of green leaves of the dense trees of the area where the leaves were compact and offered a secure refuge, although the level above the ground was no more than 2 feet.

*Specimens examined:* Cuba, Pinar del Río Province, Valle de Pica Pica, Sumidero, 18 (IB 717, IB 719–23, IB 1710–17, ASFS V20446–47, MCZ 93505, ZMB 41781–83—holotype and paratypes of *A. spectrum sumiderensis*); Valle de Pío Domingo, Pica Pica, 4 (IB 2239, IB 3003–05); Matanzas Province, between Matanzas and Cárdenas, 2 (ZMB 421a–b); 0.5 km from Balneario de San Miguel de los Baños, Lomas del Río Paredones, 13 (IB 2328, IB 2373–74, IB 2702–09, IB 2732, IB 2853).

## **Anolis vanidicus** new species

*Definition:* Body elongate and attenuate with body equal to about 42 percent (31.0–48.8) of tail length, head narrow and elongate (but not crocodile-like) with a mean head length/head width ratio of 3.6 in both sexes, head depressed between canthal ridges but not deeply so and with a dark half-moon figure in the depressed area, the figure lighter and generally smaller than that in *A. spectrum*; dorsal scales smaller and with less elevated keels than in *A. spectrum*, from 8 to 13 in snout-orbit distance and with about 7 to 9 enlarged dorsal scale rows grading fairly abruptly into the small, almost granular, lateral scales which in turn grade abruptly into large keeled ventral scales of which there are 18 to 20 in the snout-orbit length; starting at the middorsal line and counting to above the forelimb insertion, between 15 and 34 scales; sexual dichromatism prominent, both sexes brownish green to olive green, the females with a pale wide middorsal band set off from the darker sides and often with a median dark ventral line; no black supra-axillary spot or dot in males; dewlap olive green (varying to pale greenish yellow); iris pale green; mean ratio of snout-vent length to femur 3.6 in males, 3.7 in females; snout-vent length to 39 mm in males and 37 mm in females.

*Distribution:* Known only from the Sierra de Trinidad and vicinity (near Soledad) in Las Villas Province, and north of Santiago de Cuba in Oriente Province, Cuba, but presumed to occur in suitable ecological situations in central and eastern Cuba.

### **Anolis vanidicus vanidicus** new subspecies

*Holotype:* AMNH 78400, an adult female, from 4 km W, 12 km N Trinidad (road to Topes de Collantes), Las Villas Province, Cuba, taken 28 July 1957 by John R. Feick. Original number ASFS 3185.

*Paratypes:* (All from Las Villas Province, Cuba.) AMNH 96006, 1.8 mi. (2.9 km) S Topes de Collantes, 12 July 1960, R. F. Klinikowski, D. C. Leber, A. Schwartz; AMNH 78401–10, Topes de Collantes, 30 July 1957, W. H. Gehrmann, Jr., A. Schwartz; MCZ 20290, near Soledad, August 1924, E. R. Dunn; MCZ 21861–64, MCZ 21866–67, Mina Carlota, July 1925, E. R. Dunn; MCZ 22763, MCZ 22765, MCZ 22767–98, western edge of Trinidad Mts., Mina Carlota, toward Cienfuegos, November–December 1926, P. J. Darlington; MCZ 42585, USNM 120760–61, Buenos Aires, 2,500–3,500 feet (762–1,068 meters), 9–14 March 1936, P. J. Darlington; MCZ 74080, MCZ 74082–88, 3–4 km from Topes de Collantes, 27 August 1959, R. Molina, R. Ruibal, E. E. Williams; ZMB 31874–91, Arroyo La Mariposa, 1967, G. Peters; IB 2647–56,[2] IB 2658–

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[2] Of this and the following four lots of IB paratypes of *A. v. vanidicus*, only IB 2651 (a male) and IB 2721 (a female) are still known to exist. Due to the uncertainties of American-Cuban postal service, the remainder of these lots (as well as some specimens of *A. spectrum*—see footnote 1) never reached the junior author from La Habana, along with some manuscript and field notes by the senior author. We here include all these specimens as paratypes in the perhaps futile hope that some day they will be located.

74, Cafetal de Gaviñas, 14 July 1969, O. H. Garrido; IB 2710–11, La Mariposa, 6 km SW Topes de Collantes, 8 August 1969, O. H. Garrido; IB 2712–17, IB 2721, Cafetal de Gaviñas, 8 August 1969, O. H. Garrido.

*Definition:* A subspecies of *A. vanidicus* characterized by larger scales (15 to 26 between dorsal midline and forelimb insertion).

*Variation:* A series of 87 *A. v. vanidicus* has the following counts: snout scales at level of first canthal 3–8 (mean 5.5; mode 6), scales between supraorbital semicircles 0 (35 individuals), 1 (50), or 2 (2); scales between supraorbital semicircles and interparietal 0/1 (1 individual), 1/1 (21), 1/2 (9), 2/2 (50), 2/3 (5), or 3/3 (1); fourth toe lamellae 12–16 (13.7); postmental scales 1–3 (mean 2.0; mode 2); loreal scales 15–25 (19.8); dorsal scales between axilla and groin 23–36 (29.9); shoulder scales 15–26 (20.4). Largest male 39 mm (MCZ 21861), largest females (MCZ 20290, MCZ 21866, + two ZMB specimens) 37 mm snout-vent length.

*Description of holotype:* An adult female with a snout-vent length of 36 mm and a tail length of 77 mm (snout-vent/tail ratio 46.8); 7 snout scales at level of first canthal; 2 scales between supraorbital semicircles; 2/2 scales between supraorbital semicircles and interparietal; 14 fourth toe lamellae on phalanges II and III; 2 postmental scales; 24 loreal scales; 32 dorsal scales between axilla and groin; 21 scales between dorsal midline and insertion of forelimb.

Coloration, as preserved, dull tan with a slightly paler middorsal zone encompassing about 7 rows of enlarged dorsal scales; sides slightly darker; a few scattered dark brown to black flecks on the median dorsal scale row on the neck; head unicolor with dorsum and without any prominent markings; limbs brown, with a pale tan spot at the elbows; tail dark brown above, its base with 1 or 2 paler irregular crossbands and several irregular scattered paler areas scattered along its length; venter pale tan without a midventral line.

Preserved females agree well with the above description of coloration and pattern in the holotype. Some specimens (MCZ 74088) are much darker brown laterally, thereby setting off the pale dorsal zone much more sharply than in the holotype. In one female (MCZ 21866) there is a bright white ventrolateral line below the dark brown sides, extending from beneath the eye to the groin. Rarely is there a head figure in adult females; MCZ 20290 and AMNH 96005 (FN 9082) are exceptional in this regard in that they have a dark U-shaped figure in the intercanthal depression. This figure occurs in some young females but is absent in others at the same snout-vent length and collected at the same time. The dark midventral line is equally variable; of 59 females, this pattern feature occurs in 25, ranging in snout-vent lengths from 17 to 37 mm (and thus including both one of the two smallest juveniles and one of the maximally sized females). The presence or absence of a midventral dark line in female *A. v. vanidicus* is not ontogenetic.

Preserved males resemble females in details of pattern and coloration, although no males have a contrasting middorsal zone. If an intercanthal figure is present (as it is in all juvenile males and in several adult males: AMNH 96006, MCZ 21867, MCZ 22772, MCZ 22781) it is in the form of a sharply truncate V. One male (MCZ 22763) has the intercanthal figure present only as a pair of fine dark parallel lines, and another male (MCZ 74082) has the entire snout, anterior to the position of the V, dark and in sharp contrast to the balance of the head color. The midventral dark line is absent in all males.

The senior author's color notes on a male and a female from Cafetal de Gaviñas, a few kilometers north of San Blas, show the following details. Male: dorsal coloration varying with the incident light but predominantly pale greenish straw, capable of becoming darker (olive); a series of black markings along the median dorsal scales, these markings usually disappearing in captivity; vestiges of a middorsal zone, although much less apparent than in females, and also much paler or more gray than in females; the dorsal zone is much less apparent in wild males than in males kept in captivity; a white line from beneath the eye to the auricular opening; head with a half-moon shaped design in the central depression, although this tends to disappear in captivity; venter the same in both pattern and color as that of the female (see below); dewlap greenish olive with the more central scales weakly yellow, the dewlap color varying from pale greenish yellow to more olivaceous. Another male in the dark phase was recorded as having a black horseshoe shaped intercanthal head marking, the median dorsal band grayish in contrast to the reddish terra cotta sides; venter terra cotta; dewlap darker, almost grayish; the upper portion of the snout clearer than the remainder of the head.

A female from the same locality was recorded as olivaceous brown laterally and on the sides of the head; median dorsal zone straw-cinnamon; a whitish line below the eye; superior portion of snout ashy chestnut-colored without markings; insertion of the hindlimbs and dorsum with a white spot on the olivaceous lateral color, the spot coming to form a triangle with its mate from the other side; three or four dots on the lower posterior face of the thigh; venter yellowish, brightest laterally; remnants of a midventral reddish line from the throat posteriorly; iris pale green.

The junior author's notes indicate that the dewlap was brown, grading to dirty yellow basally.

*Etymology:* The name *vanidicus* is from the Latin meaning "talking vainly" or "lying" in reference to the confusion of this species with *A. spectrum.*

### **Anolis vanidicus rejectus** new subspecies

*Holotype:* ChM 55.1.63, an adult female, from 2 mi. (3.2 km) N Santiago de Cuba, Oriente Province, Cuba, taken 24 December 1954 by Daniel R. Stanland. Original number ASFS 117.

*Definition:* A subspecies of *A. vanidicus* characterized by smaller scales (34 between dorsal midline and forelimb insertion).

*Distribution:* Known only from the type-locality in south-central Oriente Province, Cuba.

*Description of holotype:* An adult female with a snout-vent length of 32 mm and a tail length of 82 mm (snout-vent/tail ratio 39.0); 7 snout scales at level of first canthal; 1 scale between supraorbital semicircles; 2/2 scales between supraorbital semicircles and interparietal; 17 fourth toe lamellae on phalanges II and III; 3 postmental scales; 23 loreal scales; 33 dorsal scales between axilla and groin; 34 scales between dorsal midline and insertion of forelimb.

Dorsum brownish in life, with a paler (creamy) middorsal stripe involving 8 enlarged rows of middorsal scales; upper surfaces of limbs and tail concolor with sides but elbows with a tiny cream spot and one weak darker brown crossband on the shank; a very weak intercanthal depression, without a U-shaped dark mark; middorsal pale zone with 2 widely spaced dark brown dots on the midline and a dark U-shaped figure at the sacrum; upper surface of tail with darker and very elongate semireticulum; venter cream and without a median dark line; a pale labial line along the supralabials as far as the ear opening; dorsal and ventral body pigmentation sharply set off from each other, the pigmental transition occurring at the level of the transition from the lateral granular scales to the large keeled ventral scales.

*Comparisons:* Since there is but a single specimen of *A. v. rejectus*, it is difficult to compare this eastern subspecies with more western *A. v. vanidicus*. In all characteristics, the holotype of *rejectus* falls within the known parameters of the long series of nominate *vanidicus*, with one striking exception. The lateral scales are much tinier and more numerous than they are in *vanidicus*, and thus the shoulder count of dorsals and laterals is much higher in *rejectus* (34) than it is in any *vanidicus* (15 to 26). This difference is readily observable in comparison of specimens of the two taxa. As far as the other counts are concerned, the holotype of *rejectus* falls above the mode in *vanidicus* in number of snout scales at the first canthal, agrees with *vanidicus* is having the semicircles separated by one row of scales (the mode in *vanidicus*), has 2/2 scales between the semicircles and the interparietal (the mode in *vanidicus*), has 23 loreals which falls within the range of this count in *vanidicus* (15 to 25) but lies near the upper extreme, has 33 dorsals between the axilla and groin (whereas *vanidicus* has from 23 to 36), and has 3 postmentals (mode of 2 in *vanidicus*) and 17 fourth toe lamellae (12 to 16 in *vanidicus*). The facts that in several counts the sole *rejectus* falls near the upper extreme in *vanidicus*, and that the subspecies is characterized by much smaller lateral scales suggest that, once a series of *rejectus* is secured, this eastern subspecies will be shown to differ from nominate *vanidicus* in generally higher scale counts.

As far as pattern is concerned, the specimen of *rejectus* does not as preserved appear to differ in any feature from some *vanidicus*. The absence of a median ventral line and the presence of a few dark flecks in the pale dorsal zone, as well as the presence of the U-shaped sacral figure are all features which are found in *A. v. vanidicus*. The junior author's notes on the *rejectus* holotype suggest that its color was more brown in contrast to the olive-greens or brownish greens of *vanidicus.*

*Remarks:* We realize that we may be criticized for naming a subspecies on the basis of a single female specimen; however, the senior author was unable to secure more specimens from the region of the type-locality of *rejectus*, and the junior author never secured additional specimens despite much time spent in the region of Santiago de Cuba. Since *rejectus* differs from all other specimens of *vanidicus* in its much smaller lateral scales, since the only specimen was collected some 470 kilometers to the east of the known range of *A. v. vanidicus*, and since there seems little possibility of our being fortunate enough to secure additional specimens, we have named this taxon.

Schwartz and Ogren (1956:98) stated that the holotype of *A. v. rejectus* was secured "in a clump of waist-high grass" along with *A. argillaceus* Cope. The situation was an open grassy hillside with scattered trees above the Carretera Central. A cemented drainage ditch, about 3 meters deep and perhaps 5 meters wide, was overgrown with tall grasses and low shrubs, and the holotype was taken in this situation.

*Etymology:* The name *rejectus* refers to the fact that Ruibal (1964: 509) suggested that this Oriente specimen was erroneously identified as *A. spectrum.*

## DISCUSSION

Our action in dividing *A. vanidicus* from *A. spectrum* depends strongly on the acquisition of fresh and well-documented material of the latter taxon, which heretofore has been only very poorly represented in collections—namely the two syntypes in Berlin and the third specimen in La Habana. Although we are tempted to regard *vanidicus* and *spectrum* as siblings, and this may well be the case, it is pertinent to note that *A. vanidicus* resembles *A. cyanopleurus* in that both have (especially in females) a contrastingly colored middorsal band. Although we would be very reluctant at this time to suggest that *vanidicus* is more closely related to *cyanopleurus* than to *spectrum*, this may well be the case. *A. cyanopleurus* is an eastern species, limited to the mountains of Oriente Province, and it is also primarily a bright green lizard—basically, it is a green edition of *A. vanidicus.* Ruibal (1964:511), however, pointed out that Gundlach reported *A. cyanopleurus* from near Cárdenas in Matanzas Province, so it is possible that this species had (or still has) a much broader distribution than is currently recognized. Even more intriguing are data on color and pattern in *cyanopleurus*, gathered by the senior author, which suggest that that species, like *A. "spectrum"* is also a composite. Further details of this aspect of the *alutaceus* group (sensu Ruibal, 1964:477) must await more information and specimens.

It is possible that some workers will feel that, by recognizing two species (*A. spectrum* and *A. vanidicus*), rather than two or more subspecies of *A. spectrum*, we have erred in the direction of multiplication of specific entities. This is, of course, a possibility. It is quite possible that *spectrum*, *vanidicus*, and *rejectus* are better interpreted as a west-east series of subspecies rather than as two species. There are few absolute scale count differences between *spectrum* and *vanidicus*; an exception is ventral scales in snout-orbit distance (12 to 15 in *spectrum*, 18 to 20 in *vanidicus*), and dorsal scales in snout-orbit distance overlap but slightly (7 to 9 in *spectrum*, 8 to 13 in *vanidicus*). The major features of differentiation between the two taxa are involved with color and pattern. But none of the above assures the worker that he is dealing with species or subspecies. The chance of finding both taxa sympatrically is obviously extremely remote, and this relatively certain criterion for species (rather than subspecies) relationship is best discarded in this particular instance. Our arrangement, then, of *spectrum* and *vanidicus* as species is inductive. We feel strongly that the differences between these taxa are such as we and others would elsewhere regard as being of specific, rather than of subspecific, rank. Since anoles are primarily eye-minded lizards, a fact which is by now well documented and has been additionally confirmed by field observations, it seems reasonable to assume that differences in pigmentation and pattern are of primary importance in species differentiation and should not be considered as incidental to often more orthodoxly regarded morphological and scutellogical characteristics. Garrido, in a forthcoming comprehensive work on Cuban anoles, will show that *spectrum* and *vanidicus* are ethologically distinct.

We interpret *A. spectrum* as a species which evolved in the Pinar del Río massifs (Sierra del Rosario-Sierra de los Organos). From this center, *A. spectrum* has invaded at least as far west as the limestone Bejucal-Madruga-Limonar anticline at San Miguel de los Baños and the Llanura Roja in the Matanzas-Cárdenas area. It is perhaps pertinent that the two recent collecting stations for *A. spectrum* are in karst regions, areas where forests have persisted, since lumbering in such situations presents physical problems which are difficult to solve. It is not unlikely, however, that *A. spectrum* at one time was more widely distributed in these western Cuban lowlands when they were more forested and less cultivated than they are today. There are still many areas between Pica Pica and San Miguel de los Baños where forest, often on a limestone base, remains; it is not unlikely that *A. spectrum* will be found to persist in such regions.

We interpret *A. vanidicus* as being a species which evolved in the Sierra de Trinidad; surely it is an abundant lizard in that range. In our experience it is a lizard of openings in forest, where at night the species sleeps on grass, ferns, and vines, within 1.5 meters of the ground. The holotype of *A. v. vanidicus* was secured, however, asleep on a leaf of a shrub in a fully wooded situation, so that perhaps *A. vanidicus* is better regarded as a forest-dwelling lizard that is more commonly encountered (or more easily collected) in forest openings than in the forest itself. Garrido feels that *A. vanidicus* is quite localized in the Sierra de Trinidad, and that there are more or less widely scattered populations (= colonies) where the species is abundant, scattered throughout a large general area where the species is very uncommon.

The ecology of *A. v. rejectus* is totally conjectural. The open and relatively treeless hillside where the only specimen was taken is so very different from the shaded and moist forests where *A. v. vanidicus* occurs that it is certain that this is not the natural habitat of the Oriente subspecies. The fact that the holotype was secured in an open, cemented, and overgrown drainage ditch suggests that the lizard might have reached this locality during a period of flooding, i.e., it had been washed there from its normal habitat. The Sierra de Boniato lies to the north of the type-locality of *A. v. rejectus* and much of this range is still moderately well forested. It remains to be determined if *A. vanidicus* is very widely distributed in Oriente, and if so, what its ecology is there. It is remarkable that, with all the recent field work in various sections of Oriente, the senior author has not collected additional specimens of *A. vanidicus* in that province.

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Vol. 85, No. 46, pp. 523–540 30 December 1972

PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON

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# FOUR NEW PARASITIC COPEPODS OF THE FAMILY CHONDRACANTHIDAE FROM CALIFORNIA INSHORE FISHES

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The four new species of chondracanthid copepods described in the following are part of a collection of parasitic copepods made by Mr. Edmund Hobson, National Marine Fisheries Service, at La Jolla, California. The collection was sent to Dr. Roger F. Cressey, Smithsonian Institution, who in turn passed the chondracanthid specimens to me for identification.

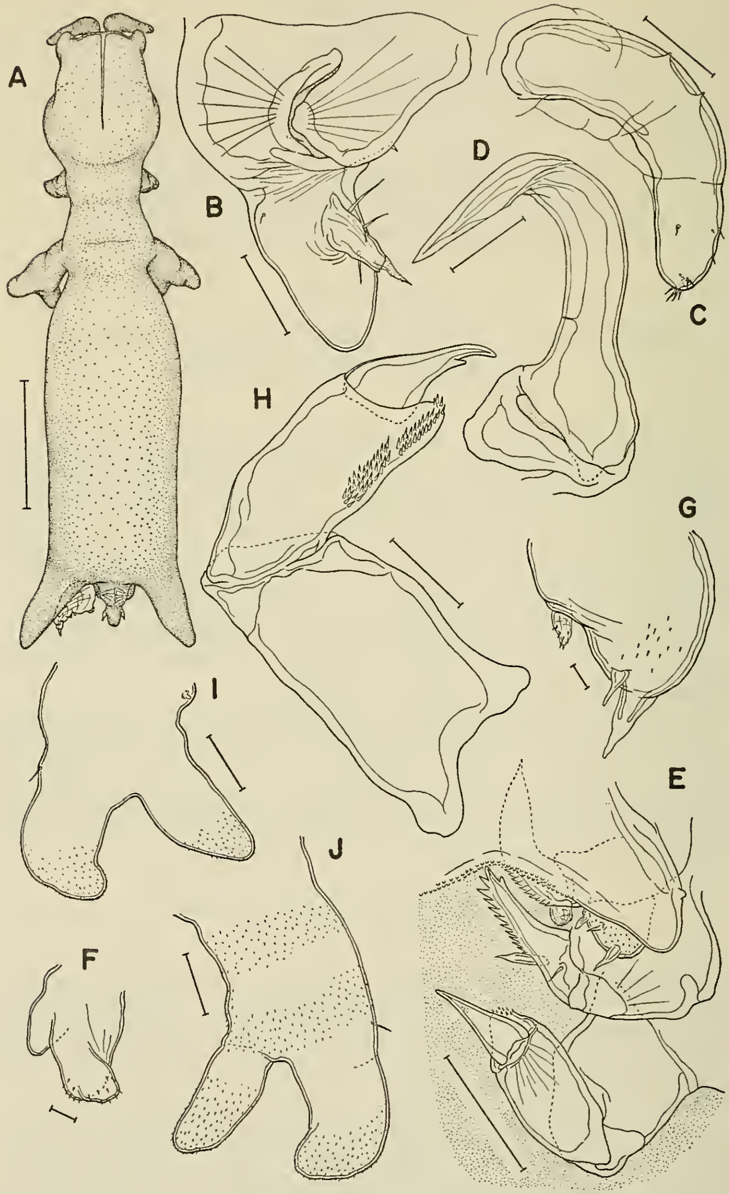
All material has been deposited in the Smithsonian Institution, except the dissected specimens that were mounted on slides and kept in the author's collection.

This study has been aided by the grants from Long Beach California State College Foundation and from the National Science Foundation (GB 8381X) to Dr. Arthur G. Humes, Director of Boston University Marine Program, Marine Biological Laboratory, Woods Hole, Massachusetts.

## **Acanthochondria fraseri** new species
Figures 1–2

*Material studied:* 61 ♀♀ (each carrying a ♂) collected from the gill cavity of *Pleuronichthys coenosus* Giard. Holotype ♀ (USNM 134662) and 46 paratype ♀♀ (USNM 134663) collected on 4 December 1968; 4 ♀♀ on 6 July 1968; 2 ♀♀ on 19 July 1968; 6 ♀♀ on 6 August 1968 and 2 ♀♀ on 15 January 1969.

*Female:* Body (Fig. 1A) small and rather cylindrical. Head longer than wide, with small rounded knob at each anterior corner and swollen posterolateral surface. First and second pedigerous segments narrower than head. Third and fourth pedigerous segments fused into a cylindrical trunk. Posterior processes either diverged or converged. Genital segment (Fig. 1B) distinctly wider than long. Abdomen (Fig. 1B) about as long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J

as genital segment, with widest portion occurring at the level where the caudal rami protrude. Caudal ramus (Fig. 1B) bearing 3 setae, 1 small subterminal knob, and a spinulose terminal process. Egg sac shorter than body, with many rows of eggs.

First antenna (Fig. 1C) fleshy and cylindrical; armature being (from proximal to distal) 1–1–2–2–8. Second antenna (Fig. 1D) 2 segmented; terminal segment a strong, recurved hook. Labrum (Fig. 1E) with denticulated posterior margin. Mandible (Fig. 1E) 2 segmented, terminal blade bearing 31 teeth on convex (inner) side and 28 teeth on concave (outer) side. Paragnath (Fig. 1F) bilobate and spinulose. First maxilla (Fig. 1G) bearing 3 elements. Second maxilla (Fig. 1E) 2 segmented; first segment robust and unarmed; second segment bearing 1 small, simple seta, 1 large seta with hyaline tip, a row of 11 teeth on posterior surface, and a single subterminal tooth on anterior surface. Maxilliped (Fig. 1H) 3 segmented; first segment unarmed, second segment with 2 patches of denticles, and terminal segment a claw with a small hooklet. Both leg 1 (Fig. 1I) and leg 2 (Fig. 1J) bilobate and bearing fine spinules. Spinulation on legs confined to distal portion of both rami on anterior surface (Fig. 1I). Protopod bearing a small outer seta. Leg 2 always larger than leg 1.

*Measurements:* Body ranging from 2.60 mm to 4.84 mm; head 1.04 × 0.83 mm; genital segment 0.22 × 0.33 mm; abdomen 0.21 × 0.15 mm; egg sacs 3.63 and 3.70 mm.

*Male:* Body (Fig. 2A) 627 × 264 $\mu$, with swollen cephalosome and cylindrical metasome and urosome. Main body flexure located between first and second pedigerous segments. A single setule on lateral surface of second and third pedigerous segments. Fourth pedigerous segment rather distinct but unarmed. Genital segment bearing usual ventrolateral ridges. Abdomen indistinguishably fused with genital segment and carrying a pair of setules on dorsal surface. Caudal ramus as in female, only smaller.

First antenna (Fig. 2B) elongate and cylindrical; with usual armature of 1–1–2–2–8. Second antenna (Fig. 2B) indistinctly 2 segmented; first segment short, stout and unarmed; second segment a recurved hook bearing an inner setule. Rostral area bearing a median protrusion located between bases of second antennae (Fig. 2B). Labrum with denticulated posterior surface as in female. Mandible different from that of female in having only 16 teeth on convex side and 10 teeth on concave side.

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FIG. 1. *Acanthochondria fraseri* n. sp., female: A, body, dorsal; B, genito-abdomen, lateral; C, first antenna; D, second antenna; E, mouth parts; F, paragnath; G, first maxilla; H, maxilliped; I, leg 1; J, leg 2. Scale: 1 mm in A; 0.1 mm in B, C, D, E, I, J; 0.01 mm in F, G; 0.05 mm in H.

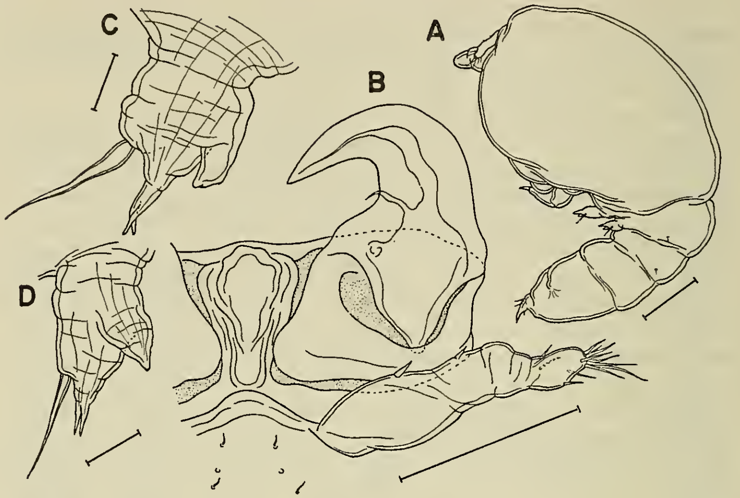

Fig. 2. *Acanthochondria fraseri* n. sp., male: A, body, lateral; B, first and second antennae; C, leg 1; D, leg 2. Scale: 0.1 mm in A; 0.05 mm in B; 0.01 mm in C, D.

Paragnath, first maxilla, and maxilliped as in female. Second maxilla showing usual sexual dimorphism in having naked terminal process. Leg 1 (Fig. 2C) larger than leg 2 (Fig. 2D). Both legs similarly constructed; with protopod bearing a long outer seta; exopod a small lobe tipped with 2 elements; and endopod a smaller unarmed conical lobe. Surface of legs without spinules.

*Etymology:* The species is named for Mr. C. M. Fraser who first discovered the present species.

*Remarks:* In the summer of 1967, while making a revisional study of the chondracanthid copepods in the Smithsonian Institution, I found a vial (USNM 60526) labelled as "*Acanthochondria rectangularis* (Fraser)" containing seven specimens of two apparently different forms. They were collected by C. M. Fraser from *Platichthys stellatus* (Pallas) at Vancouver Island, British Columbia. Three of them are distinctly larger (with the smallest measuring 6.41 mm long) and are unmistakably attributable to what Fraser (1920) has described as "*Chondracanthus rectangularis.*" The remaining four smaller specimens (with the largest measuring 3.35 mm long) are, however, not attributable to any known species of *Acanthochondria.* They are different from *A. rectangularis* in having 1) a cylindrical first antenna, 2) denticulated labrum, 3) only one row of teeth on the concave side of mandible, and 4) only 31 teeth on the convex side of the mandible (it is 54 in *A. rectangularis*). The *Acanthochondria* from

La Jolla is apparently identical with the smaller forms of Fraser's "*Chondracanthus rectangularis.*" Hence, it is named *fraseri* in commemorating Mr. Fraser's first discovery of the present species.

### **Chondracanthus heterostichi** new species
Figures 3–4

*Material studied:* 16 ♀♀ (each carrying a ♂) collected from the gill cavity of *Heterostichus rostratus* Giard. Holotype ♀ (USNM 134660) and 6 paratype ♀♀ (USNM 134661) collected on 5 September 1968; 2 ♀♀ on 28 June 1968; 2 ♀♀ on 8 July 1968; 1 ♀ on July 1968; 3 ♀♀ on 11 July 1968; and 1 ♀ on 15 July 1968.

*Female:* Body (Figs. 33A, B) rather plump. Head slightly wider than long, with posteroventral surface, which is slightly protruded on each side into a bilobate protrusion. First pedigerous segment narrower than head, with or without a dorsal process. Second pedigerous segment wider than head, bearing a cylindrical lateral process. Third and fourth pedigerous segments fused into a large trunk, bearing two dorsal processes, one lateral process on each side, and a pair of rather long posterior processes. Both genital segment and abdomen wider than long. A pair of small vermiform processes located ventrally in front of the genital segment (Fig. 3C). Egg sac longer than body, containing many rows of eggs.

First antenna (Fig. 3D) large, distinctly bipartite; basal part elongated rather than inflated; distal part small; armature being 1–1–1–2–2–8. Second antenna (Fig. 3E) a strong recurved hook. Labrum (Fig. 3F) with smooth posterior surface. Mandible armed with a row of 60 teeth on convex surface and 2 rows of (4 and 43) teeth on concave surface. Paragnath with a small basal lobe. First maxilla bearing 3 elements. Second maxilla (Fig. 3F) of usual form, bearing a row of 15–18 teeth on posterior surface of terminal process. Maxilliped (Fig. 3F) 3 segmented, terminal segment bearing a hooklet. Leg 1 (Fig. 3G) bilobate; bearing fine spinules on entire anterior surface, but on posterior surface they are restricted to distal portion of the rami. Leg 2 (Fig. 3H) larger than leg 1; with similar spinulation. Both legs carrying an outer seta on distal surface of protopod.

*Measurements:* Body ranging from 2.42 to 4.09 mm; head 0.83 × 0.86 mm; genital segment 0.25 × 0.41 mm; abdomen 0.17 × 0.21 mm; egg sacs 6.68 and 6.56 mm.

*Male:* Body (Fig. 4A) 556 × 272 μ; with its general appearance similar to that of *A. fraseri.*

First antenna (Fig. 4B) cylindrical, bearing a group of 8 rather long setae at tip. Second antenna a stout, recurved hook bearing an accessory antennule as shown in Figure 4B. Labrum as in female, but bearing a median and a lateral knob. Mandible bearing 24 teeth on convex side and 4 and 20 (in 2 rows) on concave side. First maxilla as in female, except having a relatively larger outer element. Second maxilla showing

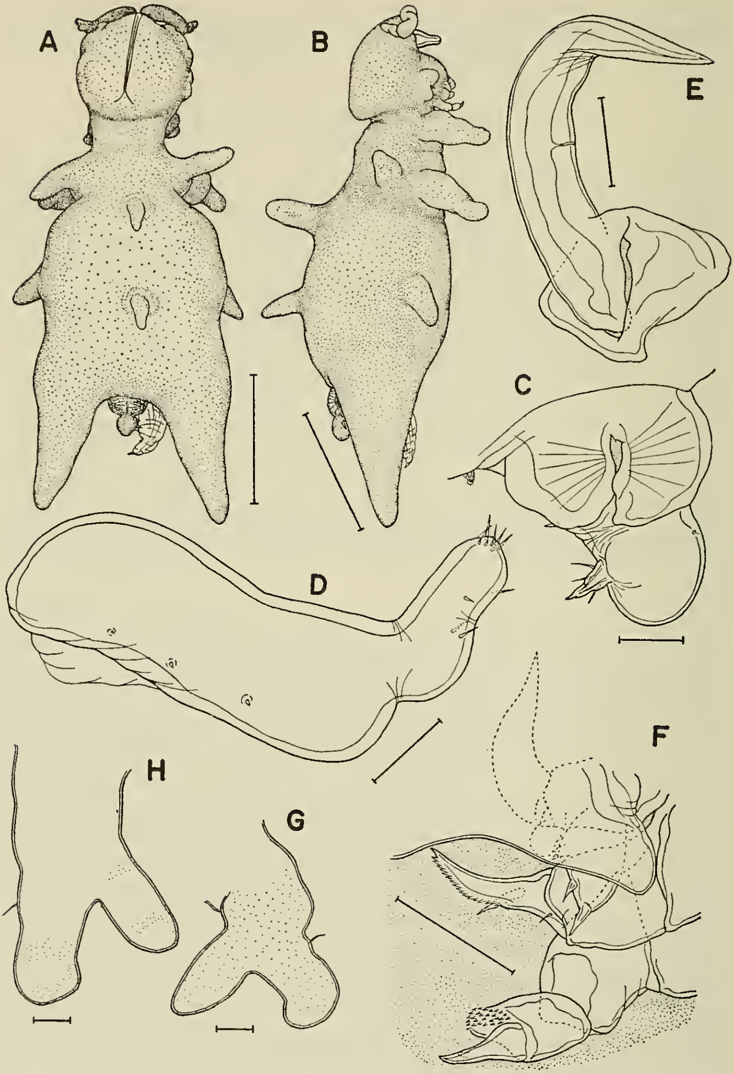

FIG. 3. *Chondracanthus heterostichi* n. sp., female: A, body, dorsal; B, body, lateral; C, genito-abdomen, lateral; D, first antenna; E, second antenna; F, mouth parts; G, leg 1; H, leg 2. Scale: 1 mm in A, B; 0.1 mm in C, D, E, F, G, H.

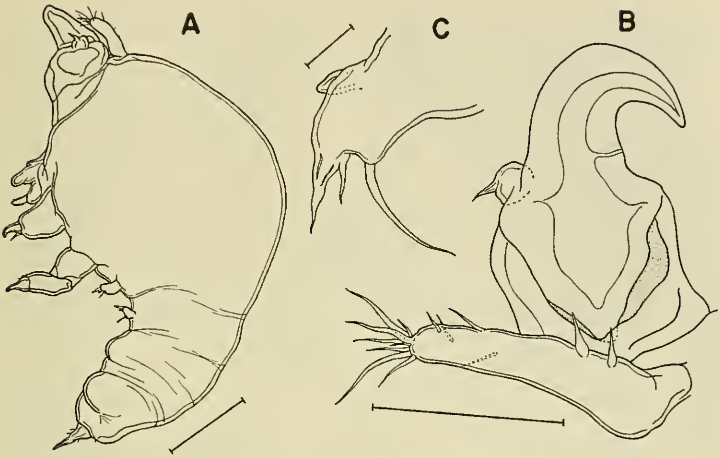

FIG. 4. *Chondracanthus heterostichi* n. sp., male: A, body, lateral; B, first and second antennae; C, leg 1. Scale: 0.1 mm in A; 0.05 mm in B; 0.01 mm in C.

usual sexual dimorphism in lacking teeth on terminal process. Maxilliped as in female. Leg 1 (Fig. 4C) larger than leg 2. Both similar to *A. fraseri,* except unequally developed 2 terminal elements on exopod.

*Etymology:* The specific name *heterostichi* refers to the host of the present species.

*Remarks: Ch. heterostichi* is distinguishable from other species of *Chondracanthus* in having two dorsal processes and two lateral processes on the trunk. *Ch. pusillus* Kabata, 1968 (parasitic on *Apodichthys flavidus* Giard in Departure Bay, Vancouver Island, British Columbia) is the only species that shows some similarities to the present species in the number and disposition of the body processes. However, the body processes of *Ch. pusillus* are in a form of knob rather than a drawn out process as in *Ch. heterostichi* and, furthermore, it lacks any form of outgrowths in the cephalic region.

Several specimens show an inconspicuous dorsal outgrowth in the neck region between the first and the second thoracic segment, and in one of the three specimens collected on 11 July, it is even as large as the two processes in the trunk region. Since all 16 females are ovigerous, these differences in the condition of the neck process seem to be an intraspcific variation that is not correlated with age or maturity of the female.

### **Heterochondria atypica** new species
Figures 5–7

*Material studied:* 18 ♀♀ (each carrying a ♂) collected from the gill filaments of *Oxyjulis californica* (Günther). Holotype ♀ (USNM 134664)

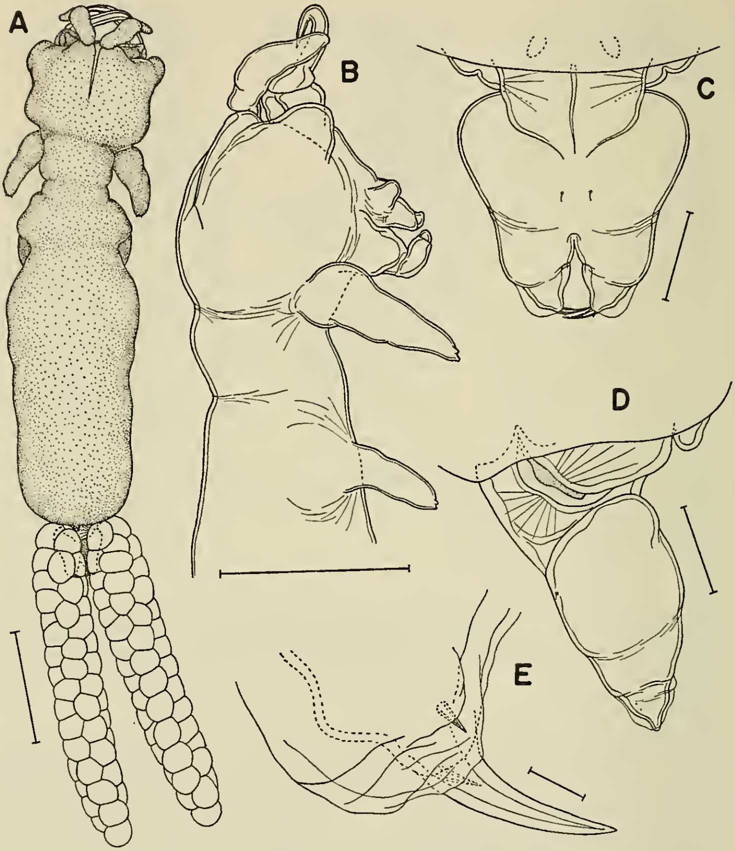

FIG. 5. *Heterochondria atypica* n. sp., female: A, body, dorsal; B, anterior portion of body, lateral; C, genito-abdomen, dorsal; D, genito-abdomen, lateral; E, caudal ramus. Scale: 0.5 mm in A, B; 0.1 mm in C, D; 0.01 mm in E.

2 paratype ♀♀ (dissected), and one other specimen collected on 23 September 1968; 3 ♀♀ on 14 October 1968; 2 ♀♀ on 15 October 1968; 2 ♀♀ on 18 October 1968; 2 ♀♀ on 30 October 1968; 1 ♀ on 31 October 1968.

*Female:* Body (Fig. 5A) cylindrical, without processes. Head wider than long, with a prominent knob on anterolateral corner. Another smaller knob located lateral to oral region (Fig. 5B). First pedigerous segment distinctly narrower than head, while second pedigerous segment nearly as wide as head. Third and fourth pedigerous segment fused into a large,

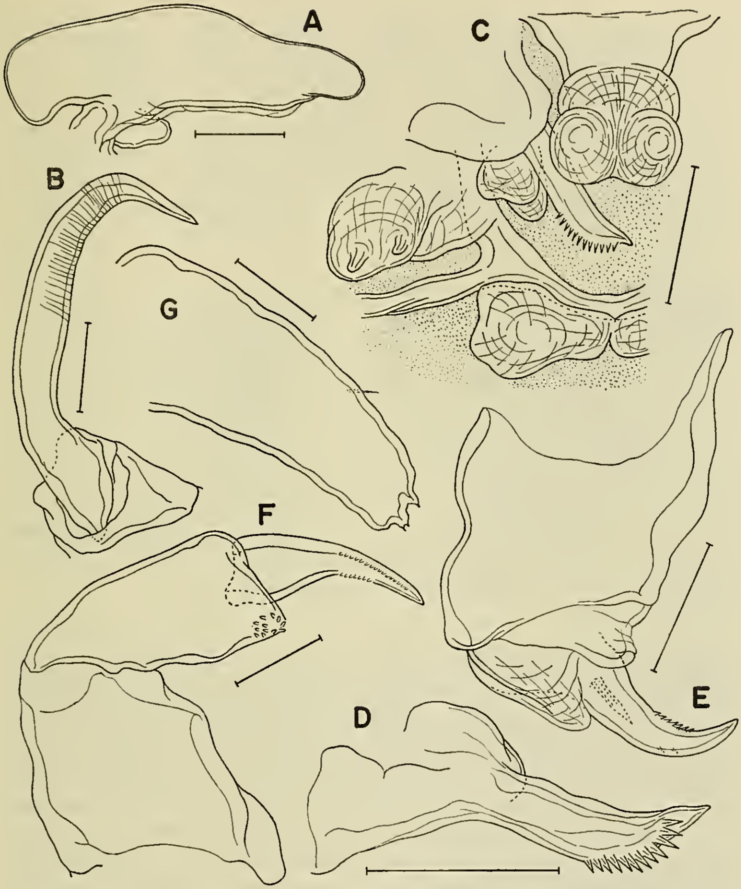

FIG. 6. *Heterochondria atypica* n. sp., female: A, first antenna; B, second antenna; C, mouth parts; D, mandible; E, second maxilla; F, maxilliped; G, leg 1. Scale: 0.1 mm in A, B; 0.05 mm in C, D, E, F, G.

cylindrical trunk which has a rounded off posterior end carrying no processes. Genital segment shorter than abdomen, which is characteristic in having a smaller anterolateral surface (Figs. 5C, D). Dorsal surface of abdomen bearing a pair of median spinules. Caudal ramus (Fig. 5E) tipped with 3 unequal spines (middle one the largest). A pair of vermiform processes located ventrally in front of genital segment (Figs. 5C, D). Egg sacs (Fig. 5A) shorter than body, containing few rows of eggs.

First antenna (Fig. 6A) fleshy and naked; with much shorter, conical, distal portion. Second antenna (Fig. 6B) 2 segmented; terminal segment

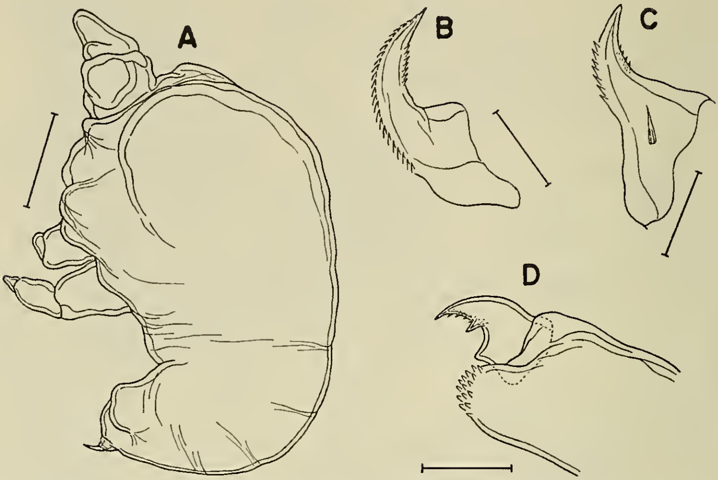

FIG. 7. *Heterochondria atypica* n. sp., male: A, body, lateral; B, mandible; C, distal segment of second maxilla; D, terminal portion of maxilliped. Scale: 0.05 mm in A; 0.01 mm in B, C, D.

a long, slender hook. Labrum (Fig. 6C) very characteristic, a conical plate tipped with a fleshy lobe which is bilobate at the tip. Mandible (Fig. 6D) a simple, pointed process armed subterminally with a row of 12 or 13 teeth. Paragnath a bilobate sac located postero-inner to the mandible (Fig. 6C). First maxilla tipped with two blunt elements (Fig. 6C). Second maxilla (Fig. 6E) 2 segmented; first segment swollen and unarmed; second segment a recurved process bearing 1 large spinous seta on proximal portion and a row of 4 to 7 teeth on anterior margin. Some specimens bearing 2 additional teeth on posterior surface. Maxilliped (Fig. 6F) 3 segmented; first segment unarmed; second segment bearing a patch of small teeth on disto-inner surface; and last segment a rather large claw bearing 2 rows of marginal teeth. A bipartite lobe located postero-inner to the base of first maxillae (Fig. 6C) probably representing labium. Leg 1 (Fig. 6G) unilobate, carrying a slender outer seta and tipped with 3 spinelike processes, of which the inner two are nearly fused. Leg 2 similar to leg 1, only slightly smaller.

*Measurements:* Body ranging from 1.62 to 2.86 mm; head 506 × 693 μ (including knobs); genital segment 143 × 238 μ; abdomen 209 × 221 μ; egg sacs 1.57 and 1.60 mm.

*Male:* Body (Fig. 7A) 253 × 149 μ; with strongly curved urosome. Lateral surface of metasome lacking usual spinules. Caudal ramus as in female, only with a weakly sclerotized terminal claw.

First antenna absent. Second antenna as in usual form; a stout, recurved hook. Rostral protrusion present. Labrum as usual form seen in *A. fraseri* and *Ch. heterostichi.* Mandible (Fig. 7B) different from female in having 2 rows of teeth (25 on convex surface and 6 on concave surface). Maxilla having 2 terminal setae proportionately longer than in female. Second maxilla armed with 1 spinous seta and 2 rows of teeth on distal process (Fig. 7C). Maxilliped (Fig. 7D) different from female in terminal claw, which has a large toothlike basal projection, a single tooth on the middle surface and a terminal row of 5 small teeth. Legs absent.

*Etymology:* The specific name *atypica* (*a* = without, *typica* = typical) refers to the unusual feature of the denticulation in the female mandible.

*Remarks:* This is the second species of the genus *Heterochondria* known to occur in the North American waters. The first species *H. crassicornis* (Krøyer, 1835) is so far only known from the Gulf of Mexico and the Caribbean, parasitic on *Labrus* sp. and *Pomacentrus planifrons* (Ho, 1970). The Californian species is readily distinguishable from the five other species of the genus in having in the female a conical labrum with fleshy tip and only one row of teeth on the mandible. The uniserial denticulation in the mandible is also unique in the family.

### **Pseudodiocus** new genus

*Female:* Body short, bearing processes. Head consisting of cephalosome and first pedigerous segment. Second pedigerous segment forming a short, wide neck and remaining pedigerous segments fused to form a stout trunk bearing a pair of large posterior processes. Genital segment well formed but abdominal segment extremely small or indistinct. Caudal ramus armed with 5 setae, with one of them much longer than the others. Egg sacs lobate, first antenna filiform and 3 segmented. Second antenna unknown. Oral appendages as in *Diocus*, except maxilliped that is more reduced. Only 1 pair of leg rudiments present, very small.

*Male:* Dwarf, with indistinct metamerism. Abdomen indistinct. Caudal ramus bearing 5 unequal elements. First antenna 4 segmented and setose. Second antenna uncinate, with accessory antennule. Oral appendages as in female, with usual sexual dimorphism in mandible. Two pairs of rudimentary legs present.

*Type-species: Pseudodiocus scorpaenus* new species.

*Etymology:* The generic name *Pseudodiocus* (*pseudo* = false) refers to its closeness to another chondracanthid genus *Diocus*. Gender masculine.

*Remarks:* The new genus, as indicated in the name, is most closely related to the genus *Diocus*. The first antenna, the mouth parts, the genital segment, and the abdomen are some of the structures that show the most remarkable similarities between the two genera. Nevertheless, the present genus is distinctly different from *Diocus* in having only one pair of rudimentary legs in the female and two pairs of such legs in the male.

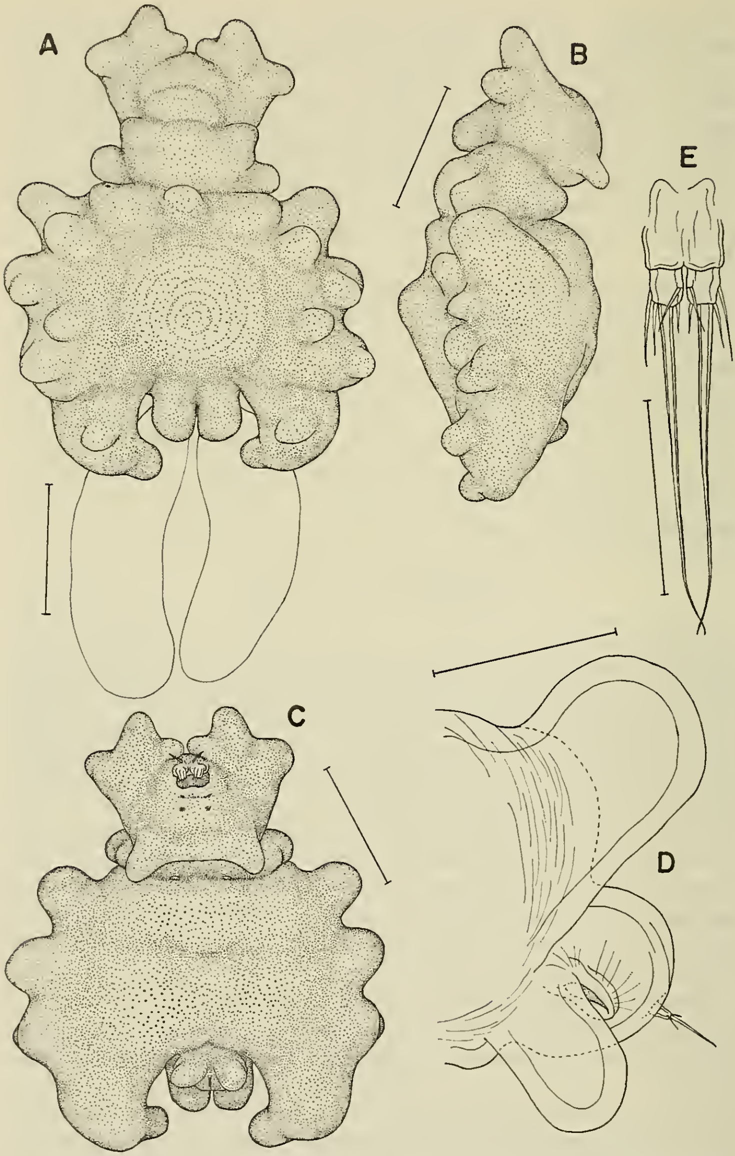

FIG. 8. *Pseudodiocus scorpaenus* n. gen., n. sp., female: A, body, dorsal; B, body, lateral; C, body, ventral; D, genito-abdomen; E, anal segment and caudal rami. Scale: 1 mm in A, B, C; 0.5 mm in D; 0.1 mm in E.

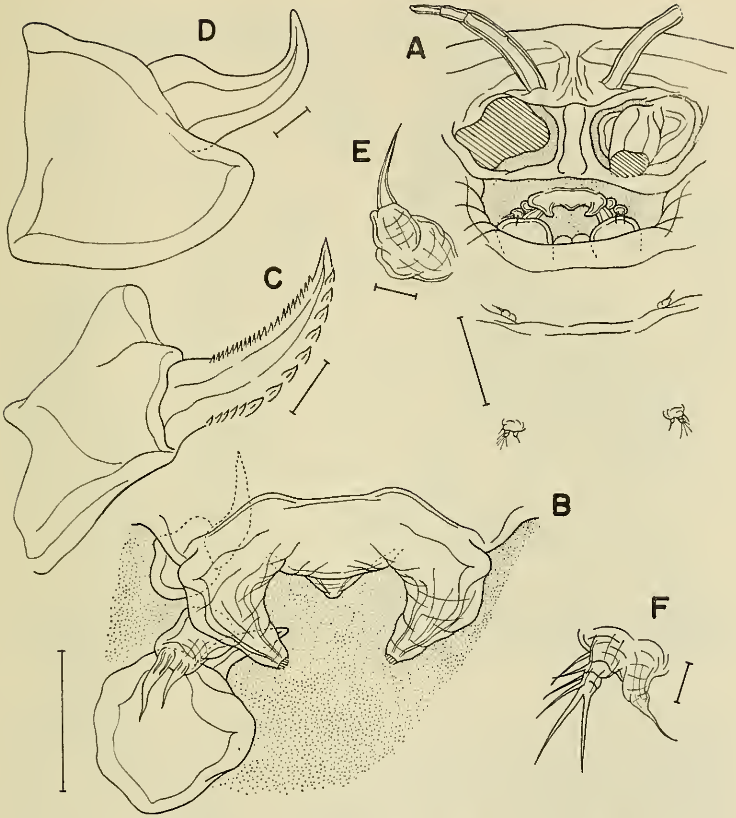

FIG. 9. *Pseudodiocus scorpaenus* n. gen., n. sp., female: A, antennal, oral, and postoral area; B, mouth parts; C, mandible; D, second maxilla; E, maxilliped; F, leg 1. Scale: 0.1 mm in A; 0.05 mm in B; 0.01 mm in C, D, E, F.

### **Pseudodiocus scorpaenus** new species
Figures 8–11

*Material studied:* 6 ♀♀ (three of them carrying ♂) collected from the gill cavity of *Scorpaena guttata* Giard. Holotype ♀ (USNM 134665, with a ♂ attached), 2 paratype ♀♀ (dissected for studying appendages) and 2 other ♀♀ collected on 10 October 1968; 1 ♀ on 16 October 1968.

*Female:* Body (Figs. 8A–C) short and wide, bearing many short processes. Head wider than long, with anterior corner expanded into a trilobate protuberance and posteroventral corner, a simple process. All six specimens showing a raised posterodorsal surface on head. First

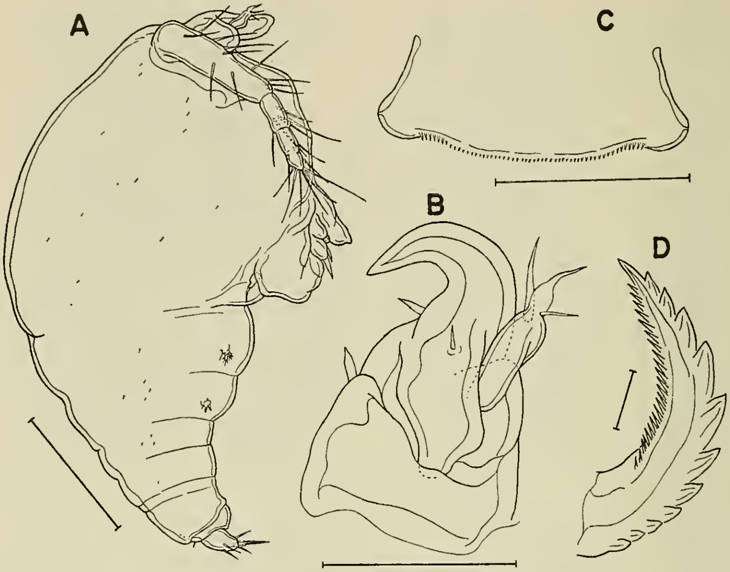

FIG. 10. *Pseudodiocus scorpaenus* n. gen., n. sp., female: A, body, lateral; B, second antenna; C, labrum; D, mandible. Scale: 0.1 mm in A; 0.05 mm in B, C; 0.01 mm in D.

pedigerous segment fused with cephalosome to form head. Second pedigerous segment forming the short but wide neck that bears a lateral protrusion. Remaining pedigerous segments fused to form the trunk, which bears 5 lateral stout tubercles, 2 dorsal swellings, and a pair of posteromedian processes that hang over the genito-abdomen. Posterior process large and bearing a dorsal tubercle. Genital segment (Fig. 8D) bearing a lateral lobe on each side anterior to the area of egg sac attachment. Abdomen inconspicuous, probably represented by a slightly raised area to where the caudal rami are attached. Caudal ramus (Fig. 8E) bearing 4 small, short setae and 1 large, long terminal seta. Egg sac (Fig. 8A) shorter than body; containing many rows of small eggs.

First antenna (Fig. 9A) filiform and 3 segmented, with proximal segment longer than 2 distal segments together. Second antenna broken in all 6 specimens examined. Mouth parts located in a depression immediately posterior to the antennal region, except maxillipeds that are found posterior to and out of the postantennal depression. Labrum (Fig. 9B) bearing 3 vermiform processes, without denticles. Mandible (Fig. 9C) armed with a row of 13 teeth on convex side and 21 teeth on concave side. First maxilla (Fig. 9B) tipped with 2 spinous setae. Second maxilla (Fig. 9D) with a naked terminal process. Maxilliped (Fig. 9E) greatly

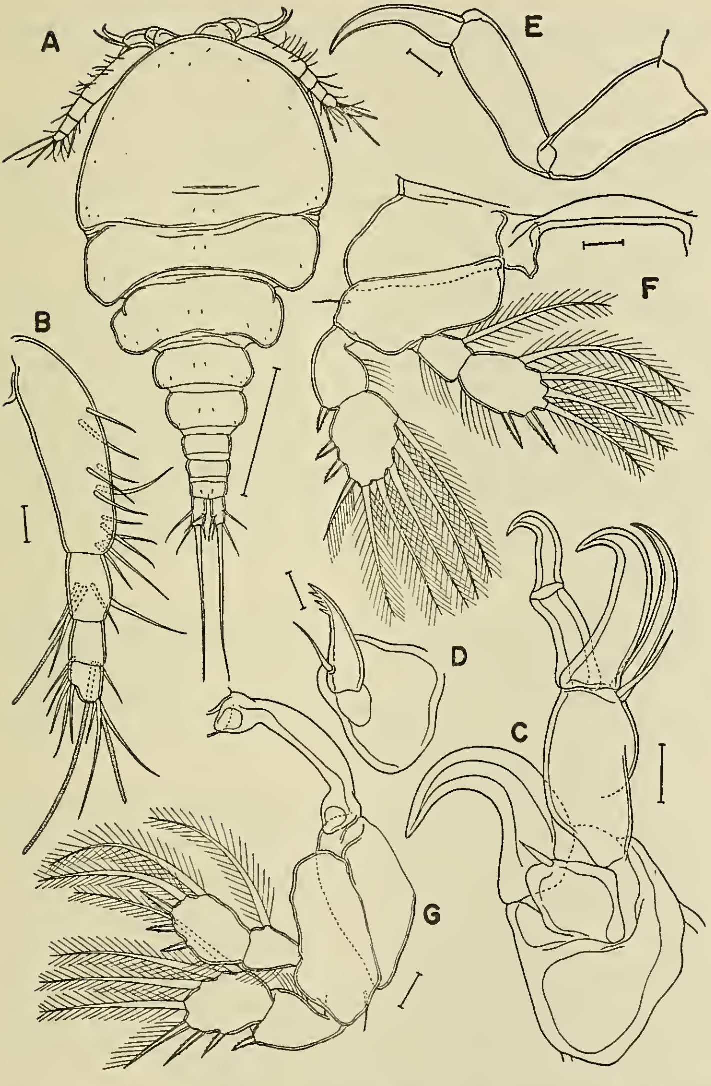

FIG. 11. *Pseudodiocus scorpaenus* n. gen., n. sp., copepodid: A, body, dorsal; B, first antenna; C, second antenna; D, second maxilla; E, maxilliped; F, leg 1 and intercoxal plate; G, leg 2 and intercoxal plate. Scale: 0.1 mm in A; 0.01 mm in B, C, D, E, F, G.

atrophied, but still with indication of 3-segmented condition. Leg 1 (Fig. 9F) greatly atrophied, biramous. Other legs absent.

*Measurements:* Body ranging from 1.77 to 3.35 mm; head 1.63 × 1.95 mm; genital segment 0.33 × 0.46 mm; egg sacs 3.04 and 2.6 mm.

*Male:* Body (Fig. 10A) 418 × 243 $\mu$; with greatest width at posterior portion of cephalosome. Metamerism on body rather distinct. Body surface scattered with some fine spinules. Genital segment with ventral ridges and abdomen carrying a pair of dorsal spinules. Caudal ramus armed as in female, only different in having a much shorter terminal element.

First antenna 3 segmented; terminal segment with an indication resulting from fusion of 2 segments. Armature on these segments being: 11, 5, and 2 + 7. Second antenna (Fig. 10B) a recurved, stout hook carrying 3 setae and an accessory antennule, which is tipped with 3 elements. Labrum (Fig. 10C) bearing a row of spinules on posterior surface. Mandible (Fig. 10D) armed with a row of 23–25 small teeth on concave side and another row of 11–12 larger teeth on convex side. First maxilla tipped with 3 elements and second maxilla bearing 1 or 2 teeth on terminal process. Maxilliped atrophied as in female. Two pairs of biramous, atrophied legs.

*Etymology:* The specific name refers to the host *Scorpaena* of the present species.

*Remarks:* In order to find the true morphology of the second antenna of the adult female, I have examined 57 sculpins collected off Los Angeles Harbor, Huntington Beach, New Port Beach, and Catalina Island for some additional, intact specimens. However, not a single specimen of *P. scorpaenus* was found. Therefore, the structure of this appendage, which is in this case rather important in deciding the systematic status of the new genus, remains unknown.

One of the dissected female was found carrying two males, with one on the right side of the head and the other on the usual location in the vicinity of the genital segment. However, after a closer examination it was discovered that the one attached to the head region was actually a larval form still in the second copepodid stage (Fig. 11A). It has a distinctly segmented body and two pairs of unmodified legs (Figs. 11F, G). The first antenna (Fig. 11B) is not much different from that of the modified mature male, but the second antenna (Fig. 11C) is quite different in the fine structure of the accessory antennule, which is armed terminally with three hooks (one of them articulate) and one seta. The second maxilla (Fig. 11D) and the maxilliped (Fig. 11E) of the copepodid larva are also different from those of the adult.

The copepodid larva of *Diocus gobinus* (Müller, 1776) that was found attached to a young adult female was described by Hansen (1923) as having an accessory antennule like the present species. The second antenna of the male *Pseudodiocus* resembles that of the *Diocus* in bearing a well-developed accessory antennule. The same appendage in female *Diocus* is unique in possessing a T-shaped terminal part and lacking an accessory antennule. If this is also proved to be the case in the female *Pseudodiocus*, then these two genera will be even more closely related to each other than it is suggested here.

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Vol. 85, No. 47, pp. 541–548 30 December 1972

PROCEEDINGS
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# A NEW SUBTIDAL *SYNIDOTEA* FROM CENTRAL CALIFORNIA (CRUSTACEA: ISOPODA)

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The systematics and zoogeography of the isopod genus *Synidotea* have been recently reviewed by Menzies and Miller (1972). They recognize 36 valid species and subspecies in the genus, eight of which have been reported from California. Six of these species have emarginate pleotelsons, while two subtidal species, from southern California, have broadly rounded, spatulate pleotelsons. The present paper describes a third species characterized by a spatulate pleotelson. The new species was discovered among benthic debris otter trawled by the *R/V Searcher* on the 100 fathom (183 meters) contour off of Point Soberanes while collecting fish for Steinhart Aquarium, California Academy of Sciences in July 1971.

I am grateful to Dr. Milton A. Miller (University of California, Davis) for the many helpful suggestions made during the preparation of this paper, and for his critical review of the manuscript. Mr. James T. Carlton (California Academy of Sciences) offered helpful suggestions with the manuscript, and Dr. John S. Garth (University of Southern California) provided space for the study of the types of *Synidotea magnifica* Menzies and Barnard, 1959 and *S. calcarea* Schultz, 1966. Dr. Earl S. Herald (Steinhart Aquarium, California Academy of Sciences) arranged ship time on the *R/V Searcher* through the Janss Foundation, Thousand Oaks, California.

Family Idoteidae Dana, Miers, 1881
Genus *Synidotea* Harger, 1878

*Diagnosis:* Flagellum of antenna 2 multiarticulate. Maxilliped palp composed of 3 articles. Pereonites 2–4 with coxal sutures present, not visible in dorsal view, pereonites 1, 5, 6, and 7 completely fused with pereon. Pleon composed of a single segment, with partial suture line on either side at base indicating another partly coalesced segment.

### **Synidotea media** new species
Figures 1 and 2

*Diagnosis:* Preocular horns of female directed anteriorly, sloping gently to the side, extending only slightly beyond frontal margin; anteromedial tubercles tall and narrowly rounded. Dorsum of cephalon bearing 2 large conical tubercles between eyes. Three rows of low tubercles on dorsum of pereonites 1 to 4; lateral edge of partly coalesced pleonal segment truncate. Spatulate pleotelson bluntly rounded, posterolateral margin with 1 or 2 teeth.

*Supplementary description:* Anterior margin of cephalon concave with a slight, broad medial notch (somewhat deeper in male), frontal process triangular, extending to anterior end of article 1 of the first antenna. Eyes raised, forming part of lateral margins of head with many heavily pigmented ocelli. Preocular horns of female large, directed anteriorly, extending slightly beyond frontal margin, smaller in male, not extending to frontal margin. Anteromedial tubercle narrowly rounded, projecting anteriorly to the edge of the cephalon. Tubercles between eyes large, forming a bilobed ridge.

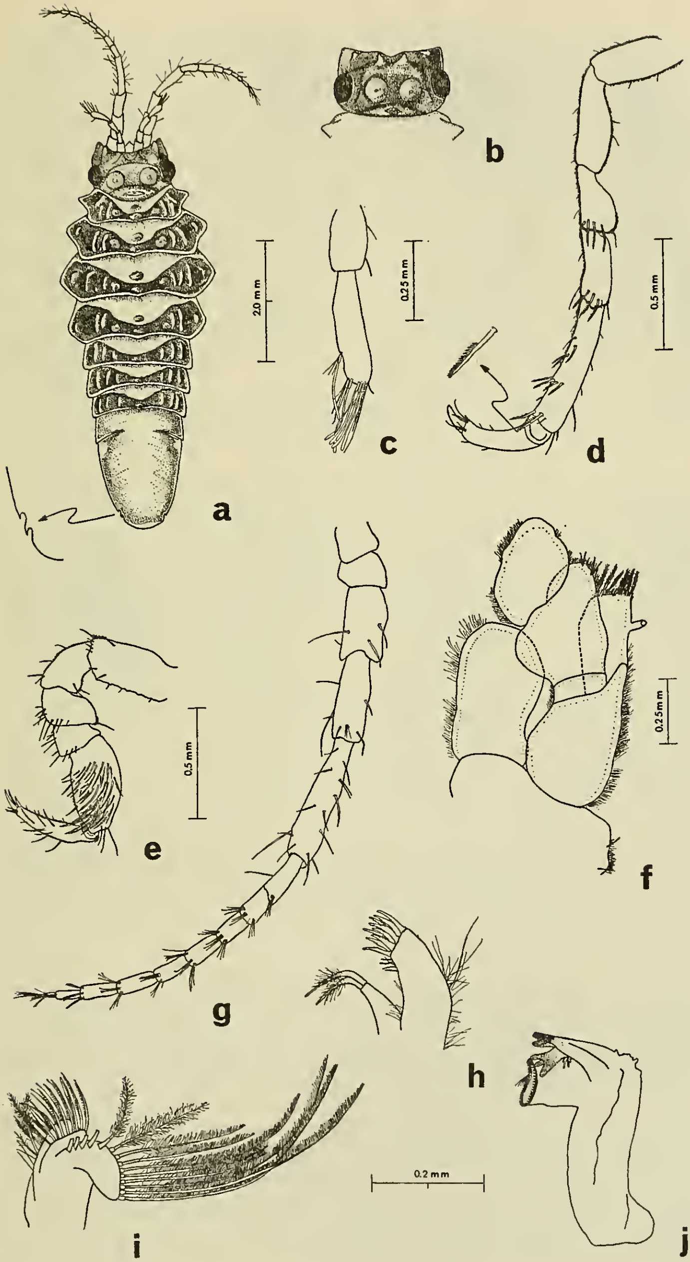
Antenna 1 composed of 4 articles, extending to middle of third peduncular article of antenna 2. First 2 articles of antenna 1 equal in length; slightly shorter than articles 3 and 4. Article 4 with 3 aesthetascs on anteromedial surface. Peduncle of antenna 2 with 5 articles; first 2 short, equal in length. Article 3 equal to article 4, and about twice the length of second, fifth article 1½ times the length of article 4. Flagellum of 9 or 10 articles; the first long and partially sutured at midlength.

Mouthparts normal. Incisor of mandible with 4 teeth, lacinia with 3 teeth; molar process truncate, bearing a setal brush and many small teeth along the margin. First maxillary exopod with 9 spines, many dentate, endopod with 2 long sensory setae. Second maxilla, long plumose setae on outer ramus, ctenoid setae on medial ramus, and several irregular types of setae on the inner ramus. Endite of maxilliped with 1 coupling hook on medial edge; sensory edge with many plumose setae.

Dorsum of each pereonite divisible into a smooth, depressed anterior area and an elevated, sculptured posterior area. Elevated areas are broad laterally, becoming progressively narrower and somewhat carinate medially. There are 3 or 4 rugae on lateral elevated area of each pereonite.

→

FIG. 1. *Synidotea media*, new species. A, female holotype; B, cephalon of immature male; C, apex of first antenna; D, seventh pereopod; E, first pereopod; F, maxilliped; G, second antenna; H, first maxilla; I, second maxilla; J, mandible.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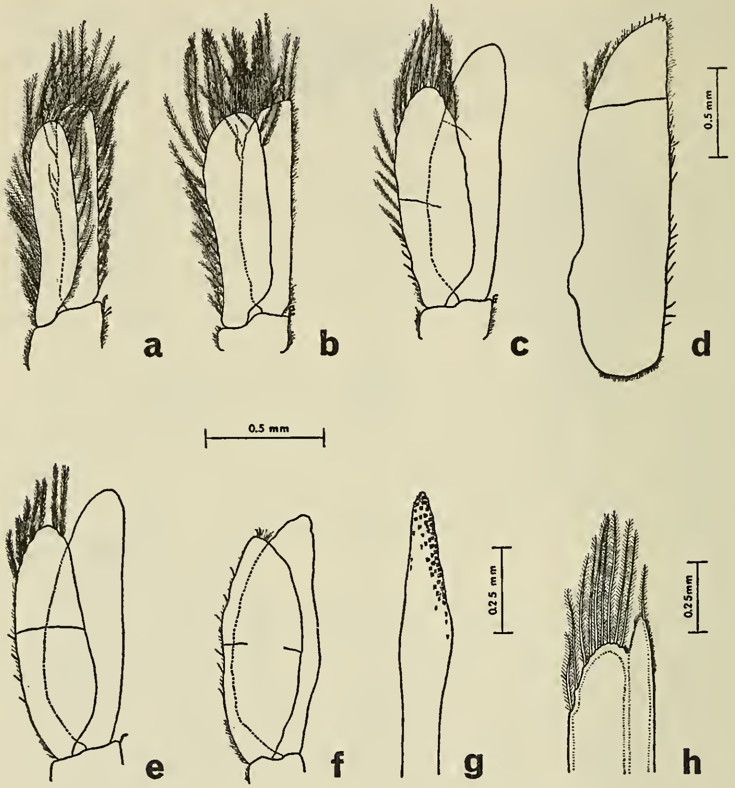

Fig. 2. *Synidotea media*, new species. A, first pleopod; B, second pleopod; C, third pleopod; D, uropod; E, fourth pleopod; F, fifth pleopod; G, apex of appendix masculina of paratype 2; H, immature appendix masculina of paratype 1.

Pereon with a median longitudinal row of tubercles; in female 2 on first 4 pereonites and 1 on last 3; in male 2 on first pereonite and only 1 on pereonites 2 to 7. First 4 pereonites in both sexes also bear a tubercle on each side of median row, thus forming 3 longitudinal rows. Lateral margin of first pereonite split into an upper and lower lobe.

Pereopod 1 shorter and broader than pereopods 2–7; bearing many ctenoid setae on anterior margin of propodus. Dactylus tri-unguiculate, narrower than propodus. Pereopod 7 with a row of 4 stout setae at distal margin of merus and carpus. Propodus with a row of 4 stout setae at about ⅔ the distance to distal end which bears a large denticulate seta and a ctenoid seta on inner margin.

Exopod of first pleopod with plumose marginal setae (PMS), endopod with PMS on medial edge and apex. Exopod of second pleopod with PMS on lateral margin and apex, endopod lacking PMS. Both rami with partial sutures. Exopod of fourth pleopod with PMS on apex only, two jointed; endopod lacking PMS, fleshy. Exopod of fifth pleopod partially jointed with a few simple setae; endopod fleshy. Uropod uniramous with 3 PMS at the posterolateral angle of the basal joint. Penes fused into a single rectangular process attached to sternite of seventh pereonite.

Color white; with cephalon, pereonal segments 1 and 4, and pleotelson dark red when collected. In alcohol the red has faded to light grey.

*Measurements:* Holotype, ovigerous female, length 6.4 mm, width 2.5 mm at pereonite 3; paratype 1, immature male, length 6.9 mm, width 1.9 mm; paratype 2, adult male in poor condition, length 8.7 mm, width 2.3 mm.

*Type-locality:* Southwest of Point Soberanes, California, between latitudes 36° 25′ 7″ north and 36° 26′ 23″ north on the 100 fathom (183 meters) contour.

*Distribution:* Known only from the type-locality.

*Disposition of material:* The types have been deposited in the type-series of the California Academy of Sciences, Department of Invertebrate Zoology, holotype no. 563; paratype 1, no. 564, and paratype 2, no. 565.

*Etymology:* The species name *media* is from the Latin meaning middle, referring to the close, intermediate relationship of this species between S. *magnifica* and S. *calcarea.*

*Relationships:* S. *media* may be distinguished from the closely related S. *magnifica* and S. *calcarea* by the characters given in Table 1. S. *bogorovi* Gurjanova (1955) from the Okhotsk Sea resembles the three California species in general body shape, but her figure shows a slight emargination of the pleotelson. The figure also shows the eyes entirely on the dorsum of the cephalon, a deep medial notch, and no anterior medial tubercles.

Menzies and Miller (1972) reported a progressive reduction in the sculpturing of the rugae with depth and possibly temperature. S. *magnifica* (55–92 meters) is the most sculptured, S. *media* (183 meters) is slightly more sculptured than S. *calcarea* (813 meters), and all three species are more sculptured than S. *bogorovi* (2,300 meters). The median frontal notch is deepest in S. *magnifica,* broad and shallow in S. *media,* and lacking in S. *calcarea.* It is quite deep, however, in S. *bogorovi.* Based on the holotypes, the pleotelson indices (PI = length/width) decreases with depth: S. *magnifica* (1.31), S. *media* (1.37), and S. *calcarea* (1.44).

The morphological similarities compared with distributional data suggest that the three California species evolved from a common ancestor. Definite conclusions can not be made at this time, because the latitudinal and bathymetric distribution of only one species, S. *magnifica,* is reasonably well known.

TABLE 1. Similarities and differences between *Synidotea magnifica*, *S. media*, and *S. calcarea*

| Character | *S. magnifica* | *S. media* | *S. calcarea* |
|---|---|---|---|
| Medial notch of cephalon | pronounced | shallow, broad (more distinct in male) | absent |
| Anteromedial tubercles | broadly rounded, tall | narrowly rounded, tall | conical, low |
| Interocular tubercles | small, narrowly rounded | large, conical | large, conical |
| Ocelli of eyes | numerous, heavily pigmented | numerous, heavily pigmented | few, lightly pigmented |
| Lateral margin of first pereonite | entire | bifurcate | entire |
| Dorsum of peraeon | anterior segments tuberculate | 3 rows of tubercles on segments 1–4 | medial row of tall conical tubercles |
| Flange on basis of pereopods 2–6 | present | absent | absent |
| Lateral edge of partly coalesced pleonal segment | broad, slightly rounded | truncate | narrow, tapering posteriorly |
| Maximum width of telson | at anterior end | at anterior end | at midlength |
| Posterolateral margin of pleotelson | smooth | 1–2 teeth | several teeth |

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Vol. 85, No. 48, pp. 549–556 30 December 1972

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# TWO NEW SPECIES AND TWO NEW RECORDS OF THE FAMILY PARAONIDAE (ANNELIDA, POLYCHAETA) FROM THE NORTHEASTERN PACIFIC OCEAN

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During studies of some Paraonidae of the northeastern Pacific Ocean, two species new to science and specimens that extend the known distributions of two other species were encountered and are described below. The material has been deposited in the Allan Hancock Foundation, University of Southern California, Los Angeles (AHF); the British Columbia Provincial Museum, Victoria (BCPM); the Friday Harbor Laboratories, Friday Harbor, Washington (FHL); the National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM); and the author's collection (KDH). I am grateful to Dr. Kristian Fauchald and to Dr. Marian H. Pettibone for the loan of material from the Allan Hancock Foundation and the National Museum of Natural History, respectively, and for helpful criticism of the manuscript.

## Paraonidae

### *Aricidea* Webster

### *Aricidea neosuecica* Hartman
Figure 1a

*Aricidea neosuecica* Hartman, 1965, p. 137.—Hartman, 1969, p. 63, fig. 1.—Hartman and Fauchald, 1971, p. 96, pl. 13, figs. d–f.
*Aricidea* near *suecica*.—Hartman, 1957, p. 319, pl. 43, fig. 7 (part).
*Aricidea jeffreysii*.—Berkeley and Berkeley, 1950, p. 55, fig. 3.—Berkeley and Berkeley, 1952, p. 39, figs. 70–73. Not *Scolecolepis* (?) *Jeffreysii* McIntosh, 1879.

*Material examined:* Slope off Massachusetts, 39° 47′ N, 70° 45′ W, 1,500 meters, *Atlantis* Sta. F1, 24 May 1961, holotype (Poly 0488) and

3 paratypes (Poly 0489) of *A. neosuecica* (AHF). British Columbia, Denman Is., Snake Is., Departure Bay, Howe Sound, and Mitlenatch Is., 119–420 meters, E. and C. Berkeley, 19 specimens (USNM 40110–40113, 45468, 45469). Southern California, near Santa Catalina Island, 33° 24′ N, 118° 21′ W, 80 meters, *Velero* Sta. 2120, 19 June 1952, 31 specimens (AHF).

*Description (British Columbia specimens):* A complete specimen (USNM 40112) has about 90 setigers and is about 12 mm long. The prostomium is bluntly conical, lacks eyes, and has a short clavate antenna which extends no farther than the posterior edge of the prostomium (Fig. 3, in Berkeley and Berkeley, 1950; and pl. 13, fig. d, in Hartmann and Fauchald, 1971). Branchiae begin on setiger 4 and number 12–16 pairs, except in the smallest specimen (4 mm long, complete), which has 8 pairs of branchiae (USNM 45468). They taper gradually to a blunt tip, rather than ending in a slender filament, and do not meet middorsally. Postbranchial notopodial postsetal lobes are slender and cirriform. Capillary setae are long and flowing, the neurosetae being the longer (as long as body width). After about setiger 20, neuropodia have up to 6 unhooded, strongly bent acicular setae (Fig. 1a). Under oil immersion, fibres are visible on the convex portion of the "shoulder" of the seta. Two of the worms (USNM 40112) have about 4 eggs (280 $\mu$m diameter) per segment in the postbranchial region.

*Remarks:* Much of the description of *Aricidea* near *suecica* (Hartman, 1957) was based on the collection from station 2120, which includes at least three species of *Aricidea*: *A. pseudoarticulata* new species, *A. wassi* (see below), and *A. neosuecica.* This accounts for the described variability in the length of the antenna and in the number and shape of the branchiae. The specimens of *A. neosuecica* from station 2120 have a clavate antenna not extending beyond the posterior edge of the prostomium and 11–15 pairs of branchiae tapering gradually to a blunt tip. Massachusetts specimens may be distinguished from specimens from British Columbia and California only by their usually smaller size (about 5–7 mm long) and fewer pairs of branchiae (3–7).

*Distribution:* British Columbia (new record), southern California, and off New England. In 16–4,749 meters.

### **Aricidea pseudoarticulata** new species

Figure 1b–h

*Aricidea* near *suecica.*—Hartman, 1957, p. 319 (part).

*Type-material:* Southern California, near Santa Catalina Island, 33° 24′ N, 118° 21′ W, 80 meters, *Velero* Sta. 2120, 19 June 1952—holotype (Poly 0511) and 11 paratypes (Poly 0512) (AHF); 2 paratypes (USNM 48062).

*Description:* The specimens are about 0.35 mm wide. None is complete, but an average specimen is about 10 mm long for about 80 setigers. Body cylindrical, becoming broader and somewhat flattened in the

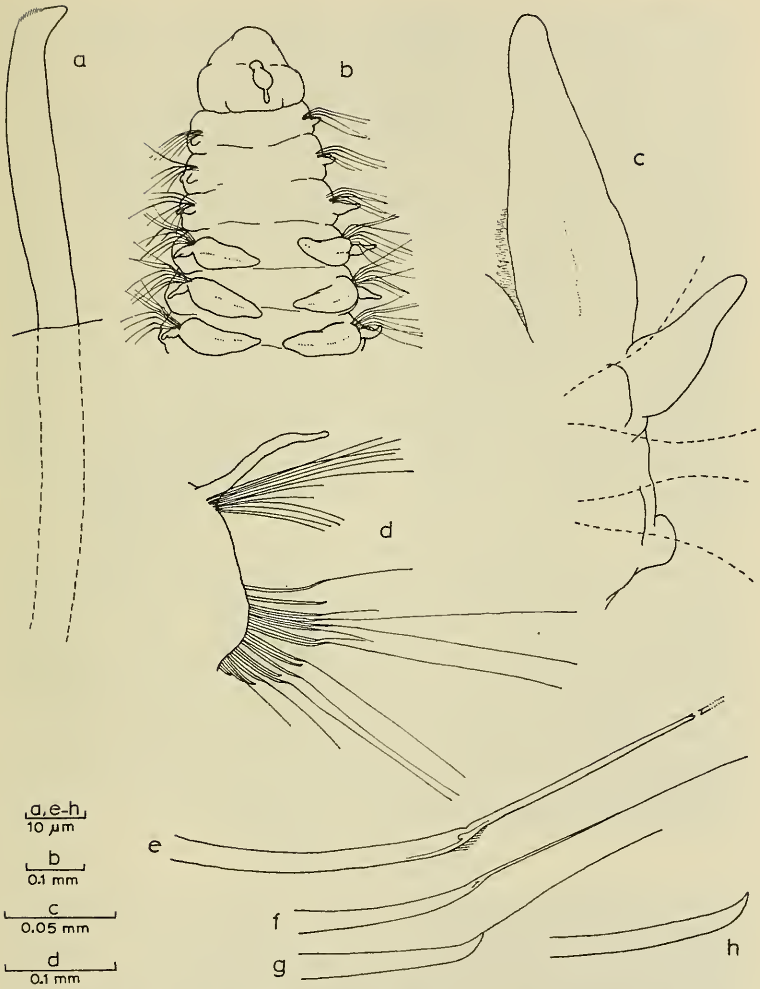

FIG. 1. a, Acicular seta from median neuropodium, *Aricidea neosuecica* (USNM 40112). b–h, *A. pseudoarticulata* new species; b, holotype (AHF); c–h, paratypes (AHF). b, Dorsal view of anterior end. c, Anterior view of parapodium 5, position of setae indicated by dashed lines. d, Anterior view of posterior parapodium. e–h, Neurosetae of posterior parapodium.

branchial region. The prostomium is triangular, without eyes (Fig. 1b). The median antenna is inserted in the centre of the prostomium, being clavate with a terminal papilla ("bottle-shaped") and extending to the posterior edge of the prostomium or the middle of setiger 1. Branchiae begin on setiger 4 and number 11–13 pairs. They taper gradually to blunt tips and meet middorsally only in the posterior branchial region. Notopodial postsetal lobes are short on setiger 1; becoming longer, broad at base with slender tip in the branchial region (Fig. 1c); and longer, cirriform in the postbranchial region (Fig. 1d). Low, truncate neuropodial postsetal lobes are present from setiger 1 through the end of the branchial region (Fig. 1c). All notosetae are capillaries. Anterior neurosetae are capillaries, but at setiger 28–35, the ventralmost neurosetae appear abruptly tapered; after about the next 5 setigers, all neurosetae appear either abruptly tapered, bent, or hooked (Fig. 1d). These neurosetae may be: (1) pseudoarticulate with a long appendage 2–4 times the length of the shaft, with fine hairs on the convex portion of the "shoulder" (sometimes are bent or broken at this region) (Fig. 1e); (2) abruptly tapered to hairlike tip (Fig. 1f); (3) weakly hooked, with hairlike tip (Fig. 1g); and (4) weakly hooked, without hairlike tip (Fig. 1h).

*Remarks: Aricidea pseudoarticulata* resembles *A. fragilis* Webster and *A. annae* Laubier in having similar "pseudoarticulate" neurosetae. *Aricidea pseudoarticulata* may be distinguished by the shape of the median antenna and the shorter neuropodial postsetal lobes. Both *A. pseudoarticulata* and *A. annae* have several types of median and posterior neurosetae, but they differ in form (Laubier, 1967). *Aricidea fragilis* possesses only pseudoarticulate median and posterior neurosetae, and has many (50–60) pairs of branchiae (Hartman, 1957; Pettibone, 1965).

*Etymology:* The specific name refers to the pseudoarticulate neurosetae.

*Distribution:* Southern California. In 80 meters.

### *Aricidea wassi* Pettibone

*Aricidea* (*Aricidea*) *wassi* Pettibone, 1965, p. 135, figs. 9–11.—Hobson, 1971, p. 247.
*Aricidea* near *suecica.*—Hartman, 1957, p. 319 (part).

*Material examined:* Southern California, near Santa Catalina Island, 33° 24′ N, 118° 21′ W, 80 meters, *Velero* Sta. 2120, 19 June 1952, 9 specimens (AHF); Massachusetts, Cape Cod Bay, 41° 48.5′ N, 70° 08′ W, 10 meters, Sta. 2012, 11 December 1968, 3 specimens (USNM 43518).

*Description (California specimens):* The worms are small, about 0.3 mm wide, whitish as preserved, and are incomplete posteriorly. The characteristic long, jointed median antenna extends to setiger 2 or 3. There are 7–9 pairs of branchiae, beginning on setiger 4. The lower neurosetae of median and posterior segments are curved and acicular, with a subterminal hairlike appendage arising from the concave side.

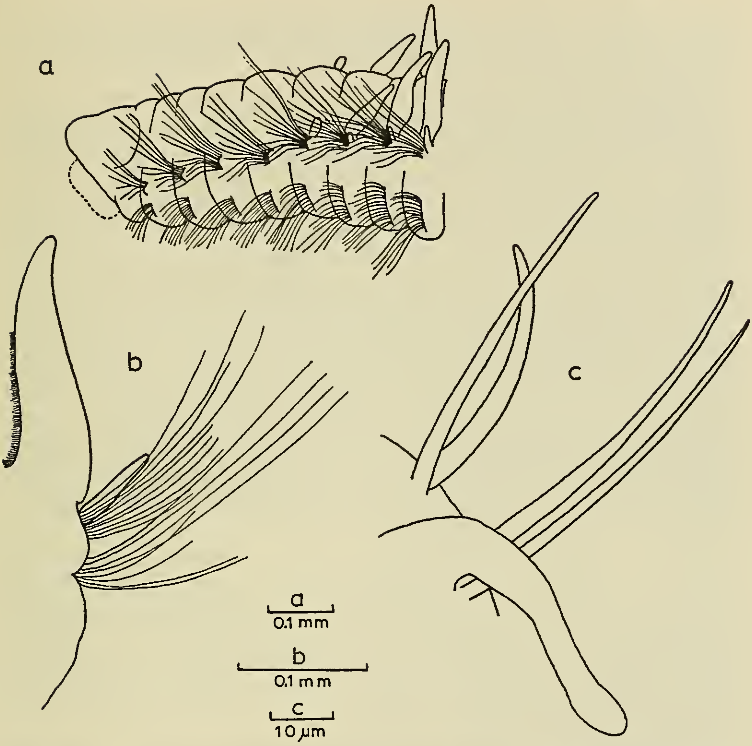

FIG. 2. *Paraonis spinifera* new species; a and c, holotype (USNM 48060); b, paratype (USNM 48061). a, Dorsolateral view of anterior end, setae of right side omitted. b, Anterior view of parapodium 13. c, Posterior view of far posterior notopodium.

*Remarks:* The California specimens differ from those described by Pettibone (1965) from Virginia only by their smaller size, a slightly shorter antenna (extending to setiger 2–3, rather than 3–5), and fewer pairs of branchiae (7–9, rather than 9–18).

*Distribution:* Southern California (new record), Massachusetts, and Virginia. In 10–80 meters.

### *Paraonis* Grube

### **Paraonis spinifera** new species

Figure 2a–c

*Type-material:* Washington, San Juan Islands; H. L. Sanders, Harney Pass, 27 meters, mud, July 1967, holotype (USNM 48060) and 18 paratypes (USNM 48061), 3 paratypes (BCPM), 3 paratypes (FHL), 1 paratype (KDH). West Sound, 40 meters, mud, July 1967, 1 paratype (Poly 0510) (AHF).

*Description:* The specimens are up to 0.3 mm wide, and 6 mm long; a small complete specimen has about 72 setigers. The body is cylindrical, becoming somewhat flattened, but not noticeably wider in the branchial region. The prostomium is triangular, without eyes and distinct from the peristomium (Fig. 2a). An eversible papillated proboscis is present. Branchiae begin on setiger 5 or 6 and number 12–20 pairs. The first and the last 1 or 2 pairs are small, the remaining pairs are slender and taper gradually (Fig. 2b). Notopodial postsetal lobes are small and cirriform throughout the branchial and postbranchial regions, becoming longer in far posterior segments. All setae are capillaries, except for some median and posterior notosetae. Median notopodia have a single slender spinelike notoseta. Far posterior notopodia have 1 (rarely 0) to 4 capillary notosetae and 2 to 4 spinelike notosetae, the uppermost spine sometimes being thick and strongly curved (Fig. 2c). The pygidium is typical for the family, with 3 subequal cirri, the ventral one being shorter and conical. Coloration in alcohol is pale peach, with reddish brown pigment variable in amount and distribution.

*Remarks: Paraonis spinifera* would not be a *Paraonis* species in the strict sense because the "modified setae" are notopodial rather than neuropodial. However, Jones (1968) offers some compelling reasons for dropping the use of the paraonid subgenera or genera that are based on the occurrence of "modified setae." *Paraonis spinifera* resembles *P. armata* (Glémarec, 1966) in having spinelike notosetae. However, the latter species also has furcate notosetae.

*Etymology:* The specific name refers to the spinelike median and posterior notosetae.

*Distribution:* Washington. In 27–40 meters.

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Vol. 85, No. 49, pp. 557–578 30 December 1972

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# THE KOREAN SNAKES OF THE GENUS *AGKISTRODON* (CROTALIDAE)

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For more than a century there has been confusion in the systematics of the Asiatic forms of *Agkistrodon* embraced by the *halys-intermedius-blomhoffii* complex within this genus. The publications of early typological taxonomists which have included descriptions of these snakes are in the main of little use at the present time. Some of the deficiencies of the early literature are due to limited material, unfortunate choice of diagnostic characters, failure to take into consideration the obvious sexual dimorphism in series of specimens, and neglect of the taxonomic importance of color patterns. Ecological knowledge was mostly nonexistent and the concept of the biological species had not yet developed. In more recent times, workers unable to use the Russian language at first hand found the important systematic works of such notable investigators as A. M. Nikol'skii, A. A. Emelianov, and S. C. Chernov difficult of access.

It is unlikely that any single investigator will be in a position to analyze thoroughly all populations of the species and subspecies of *Agkistrodon* that surely exist in the vast expanse of Central Asia from the Caspian Sea to Japan. Advances in the bionomics of this group of snakes will necessarily proceed slowly and piecemeal, and ultimately we must look to colleagues in Europe and Asia for definitive studies. Some of the problems, however, can be separated, examined, and to some extent clarified, and an effort in this direction is the object of this preliminary paper dealing with Korea and adjacent areas —southern Manchuria and the eastern Khabarovsk region, U.S.S.R.

The forms involved appear variously in the literature under the following names: 1) *halys* Pallas, 1776; 2) *blomhoffii* Boie, 1826; 3) *intermedius* Strauch, 1868; 4) *brevicaudus* Stejneger, 1907; 5) *ussuriensis* Emelianov, 1929; 6) *stejnegeri* Rendahl, 1933; 7) *saxatilis* Emelianov, 1937.

The principal source of confusion, and the most troublesome, has been Strauch's *intermedius*, apparently a composite from the very beginning and certainly a composite in the subsequent literature and in the labeling of specimens in museum collections. This name seems to have provided a convenient residuum for any and all specimens not definitely assignable to taxa more satisfactorily defined.

The great variation in specimens from Korea has been frequently remarked. For the most part, if subspecific names were used, these specimens have been listed both in the literature and in museum catalogs under the name *brevicaudus.* This was partly because differences in coloration are less conspicuous in preserved specimens and partly because not enough material has been assembled at one time and in one place to provide a comprehensive picture of the several components of the group. The problems have become less difficult, however, with the accumulation of specimens recently collected by various members of the American armed forces in Korea during, and subsequent to, the 1950's. Among those who have helped in this way and who should receive special mention are James R. Dixon, J. Knox Jones, Jr., the late Frederick A. Shannon, Donald Daleske, Donald E. Hahn, and James Hanlon, Jr. Some of them have published on their collections (see Literature Cited) and some have provided me with additional unpublished data.

Through the courtesy of Roger Conant I was able to examine a number of live specimens given to the Philadelphia Zoo by James Hanlon, Jr. This good fortune helped me to clarify some puzzling obscurities not easily resolved by means of preserved material alone.

On the basis of 150 specimens from Korea and adjacent areas, I find three recognizable forms of *Agkistrodon*: two already named, *A. blomhoffii brevicaudus* Stejneger and *A. saxatilis* Emelianov, and a third described below. Useful ecological data are scanty and precise localities are lacking for some specimens. These three forms are cryptic species, sympatric in several areas (Kaesong, Seoul, and others), but once diagnosed the great majority of specimens can be easily discriminated on characters of coloration, scutellation, body form and proportions. An apparently disjunct population in mainland China, referred to in the literature as *brevicaudus*, is not discussed in this paper but is reserved for consideration after further analysis of material from China and Central Asia. The three species diagnosed here will be treated in greater detail in a future review of the entire genus.

Shannon (1956) has correctly pointed out that Korean place names are difficult and exceedingly frustrating. Transliterations vary, political changes have been frequent, and in many cases the same spelling of a name applies to two or more different towns or villages. Gazetteers and maps issued by the U.S. Army Map Service have been of paramount usefulness, and I have had expert assistance from the map librarians of the University of Arizona Library. For names of provinces and cities of provincial status I have followed Department of the Army Pamphlets 550-11 and 550-41 and The International Atlas, Rand McNally, 1969. Shannon's list of localities (loc. cit.) has been helpful, although I have found it necessary to differ from it in some cases. The gazetteer included by Webb et al. (1962) is excellent for the localities involved in their study. Despite great care and diligence, it is likely that some of the localities listed here are incorrectly placed. In any case, the maps show only approximate areas from which the material studied is said to have come.

Thompson (1916), Hahn (1960), and others have indicated need for caution in accepting all place names at face value, pointing out that in countries of the Far East and elsewhere various snakes, and particularly "mamushis,"* are commonly sold in commercial shops for gastronomic and medicinal purposes. It is highly probable, therefore, that specimens from such sources commonly find their way into museum collections, and that their stated localities at best are only approximate.

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* The Japanese name "mamushi" is commonly applied to any or all snakes of the *halys-intermedius-blomhoffii* complex in both Japanese and Russian literature.

Abbreviations used in text for museums and private collections: AMNH—American Museum of Natural History, New York. BMNH—British Museum (Natural History), London. BYU—Brigham Young University, Provo, Utah. CAS—California Academy of Sciences, San Francisco. FMNH—Field Museum of Natural History, Chicago. Hahn—Donald E. Hahn, Cottonwood, Arizona. KU—University of Kansas Museum of Natural History, Lawrence. LACM—Los Angeles County Natural History Museum, California. MVZ—Museum of Vertebrate Zoology, University of California, Berkeley. NMW—Naturhistorisches Museum, Wien, Austria. TNHC—Texas Natural History Collection, University of Texas, Austin. UIMNH—University of Illinois Museum of Natural History, Urbana. UMMZ—University of Michigan Museum of Zoology, Ann Arbor. USNM—National Museum of Natural History, Washington, D.C.

### *Agkistrodon blomhoffii brevicaudus* Stejneger

### Short-tailed Mamushi

Figure 1

*Agkistrodon blomhoffii brevicaudus* Stejneger, 1907, p. 463.—Thompson, 1916, p. 62 (part).—Slevin, 1925, p. 99 (part).

*Ancistrodon halys brevicaudus.*—Nikol'skii, 1916, p. 283 (part); 1964 [translation], p. 191 (part).—Rendahl, 1933, p. 21 (part).—Shannon, 1956, p. 47 (part).

*Agkistrodon halys brevicaudus.*—Stejneger, 1925, p. 97 (part).—Sowerby, 1930, p. 22 (part).—Maki, 1931, p. 206 (part), fig. 138 A, 139.—Hahn, 1960, p. 21.—Webb et al., 1962, p. 170 (part).—Klemmer, 1963, p. 399 (part).

*Ancistrodon blomhoffi brevicaudus.*—Terent'ev and Chernov, 1949, p. 277 (part); 1965 [translation], p. 255 (part).

This form is here regarded as a subspecies of *A. blomhoffii* Boie, 1826, type-locality Japan, which in my view is separable from *A. halys* Pallas, 1776, and which has other subspecies in China, Japan, and the Far East.

In naming *brevicaudus,* Stejneger (1907) diagnosed the subspecies on a minimum of data and stated that no detailed description was thought necessary because of its similarity to the typical *A. blomhoffii* of Japan. Apparently he did not check the sexes of his specimens by dissection. In addition to the holotype, a female, the Korean individuals before him were USNM 14612, 14613, and 17508, and UMMZ 30525 ("young"), all females. He mentioned the uniform black bellies of the four adult specimens, but made no comment on the different coloration and the higher number of ventrals and subcaudals of the "young" one (which is

Fig. 1. *Agkistrodon blomhoffii brevicaudus* Stejneger, vicinity of Seoul, South Korea. AMNH 108499.

now referable to the form here described as new). At that time also he had specimens from China in mind, and he mentioned others supposedly from Hainan and Formosa, which localities are now thought to be erroneous. A redefinition of *brevicaudus*, entirely on the basis of Korean material, is necessary in order to distinguish it from the other two forms of the region. Variation of meristic characters is shown in Tables 1–3 and Figures 5 and 6 where all three forms are compared.

*Type-locality:* Fusan (= Pusan), South Korea; holotype USNM 17507, female, collected by P. L. Jouy, 1885.

*Diagnosis:* Body with a conspicuous pattern of subelliptical blotches (or half-bands) on a light brown or gray ground color; blotches brown, lighter at their center but with dark brown borders, opposite or alternating pairs meeting dorsally at midline or not in contact at all, 3–5 scales wide on sides and extending downward onto scale rows 3 or 2; number of half-bands 23–33 (28.9) in males, 25–36 (30.8) in females (Table 1).

Table 1. Variation in number of half-bands or crossbands of body

| | Males | | | Females | | |
|---|---|---|---|---|---|---|
| | N | Range | Mean | N | Range | Mean |
| *brevicaudus* | 24 | 23–33 | 28.9 | 32 | 25–36 | 30.8 |
| *caliginosus* | 25 | 23–33 | 27.6 | 41 | 22–31 | 27.4 |
| *saxatilis* | 16 | 30–42 | 38.3 | 4 | 29–44 | 39.0 |

TABLE 2. Variation in number of ventrals and subcaudals

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| Ventrals | N | Range | Mean | SE | N | Range | Mean | SE |
| *brevicaudus* | 25 | 135–145 | 138.9 | .519 | 31 | 140–149 | 143.2 | .439 |
| *caliginosus* | 34 | 139–153 | 146.8 | .605 | 41 | 143–155 | 148.0 | .443 |
| *saxatilis* | 37 | 149–164 | 154.4 | .618 | 23 | 148–165 | 159.2 | .852 |
| Subcaudals | | | | | | | | |
| *brevicaudus* | 24 | 35–44 | 40.5 | .416 | 33 | 30–38 | 34.9 | .317 |
| *caliginosus* | 32 | 40–52 | 46.8 | .533 | 42 | 36–48 | 42.2 | .350 |
| *saxatilis* | 34 | 37–48 | 41.6 | .452 | 21 | 34–41 | 37.4 | .434 |

Belly black or nearly so, especially posteriorly, lighter laterally; crown and parietal region with conspicuous dark brown markings and a lyriform figure extending backward on neck; cheek stripe strong, dark reddish brown in life, sharply bordered above and below with white, the upper light line extending across top of eye; tongue black; tip of tail light—yellow in life.

Internasals wider than long, the posterior margins curving obliquely backward from midline; loreals subquadrate, as high as wide; preoculars 2; postoculars 2 (60%) or 3, the lowest extending forward beneath the eye; supralabials 7 (95%), rarely 8; infralabials 10 (75%), occasionally 9 or 11; posterior supralabials not conspicuously low and narrow. Scale rows 21 at midbody, all with keels posteriorly, lowest without keels anteriorly; paired apical pits present but inconspicuous. Ventrals 135–145 (138.9) in males, 140–149 (143.2) in females; subcaudals 35–44 (40.5) in males, 30–38 (34.9) in females (Table 2).

*Size and form:* Adult body form relatively stout, head broad, and tail short. Tail in males 12–15 (13.5) percent of total length, in females 11–13 (11.7) percent (Table 3). The largest male examined is UIMNH 68750, Kumhwa, 710 mm in total length, tail 90 mm; largest female, FMNH 188974, Chorwon, 680 mm, tail 82 mm. Juveniles 173–217 mm.

*Habitat:* Hahn's specimen from Tong-du-Chon (1960, p. 21) was found "at dusk near a building in a low grassy area in a valley." In a

TABLE 3. Relative length of tail—in percentage

| | Males | | | Females | | |
|---|---|---|---|---|---|---|
| | N | Range | Mean | N | Range | Mean |
| *brevicaudus* | 16 | 12–15 | 13.5 | 18 | 11–13 | 11.7 |
| *caliginosus* | 19 | 15–17 | 15.8 | 34 | 12–15 | 14.0 |
| *saxatilis* | 10 | 11–14 | 13.0 | 4 | 11–12 | 11.2 |

personal communication Daleske, apparently with reference to both of two different forms, stated that in the vicinity of Munsan-ni he found these snakes on brushy, hillside slopes of second-growth pine-oak woodland with sandy loam soil and talus outcroppings. See further comment, p. 566.

*Range:* Korea, Masan-Pusan area in the south and northward into South Manchuria (Yalu River). Map 1.

*Specimens examined:* KOREA: CH'UNGCH'ONG-NAMDO PROVINCE—Chiksan, CAS 31523. Songwan-ni, TNHC 18437–8. Tongjin, Kimpo Peninsula, LACM 3130. CH'UNGCH'ONG-PUKTO PROVINCE—Pass between Sanju and Ch'ungju, FMNH 67118. KAESONG CITY—Songdo (= Kaesong), FMNH 11474, 25238. Kaesong (14 mi. E), FMNH 188972–3. KANGWON-DO PROVINCE—Chorwon (8 mi. S), UIMNH 68754; (8 mi. W), FMNH 188974–85. Hongchon (5 mi. S), FMNH 67119; (1½ mi. NW), FMNH 67120. Kumhwa (23 mi. S), UIMNH 68750. Wonsan, CAS 31508. KYONGGI-DO PROVINCE—Chipo-ri, USNM 132859; (3 mi. NW), KU 38804 (2). Kapyong, USNM 132455, UIMNH 68751; (4 mi. W), UIMNH 68752. Korangpo-ri, USNM 137276. Munsan-ni, TNHC 18441; (9–11 mi. NE), FMNH 188971. Songu-ri, USNM 132894. Tong-du-Chong (45 mi. NE Seoul), Hahn 1785. Uijongbu (2 mi. N), FMNH 188986–90. 40 mi. NE Seoul, UIMNH 68753. KYONGSANG-NAMDO PROVINCE—Masan, TNHC 16183. KYONGSANG-PUKTO PROVINCE—Andong, TNHC 18440. Yongchon (7 mi. NW), USNM 132352. PUSAN CITY—Fusan (= Pusan), USNM 17507 [type]. SEOUL CITY—Seoul, AMNH 180495–500; (7 mi. SE), BYU 11452; (7 mi. ESE), KU 38800; (6 mi. E), KU 38798–9; (5 mi. E), UMMZ 113464.

SOUTH MANCHURIA: Yalu River, about 180 mi. above mouth, USNM 52341 (Sowerby).

### **Agkistrodon caliginosus** new species

Caliginous Mamushi

Figure 2

*Agkistrodon blomhoffii brevicaudus* Stejneger, 1907, p. 463 (part).—Slevin, 1925, p. 99 (part).

*Ancistrodon halys.*—Thompson, 1916, p. 62 (part).

*Agkistrodon halys brevicaudus.*—Stejneger, 1925, p. 97 (part).—Stewart, 1954, p. 67.—Webb et al., 1962, p. 170 (part).

*Ancistrodon halys brevicaudus.*—Shannon, 1956, p. 47 (part).—Dixon, 1956, p. 56 (not part).

Stejneger was puzzled by specimens representative of this form. When he described *brevicaudus* from Korea (1907, p. 464) he listed UMMZ 30525 (locality indefinite) with his types, recorded its larger number of ventrals and subcaudals, considered it "young" (total length 335 mm), but made no other comment. When he reported additional material (1925, p. 98) he remarked on the difference between two specimens

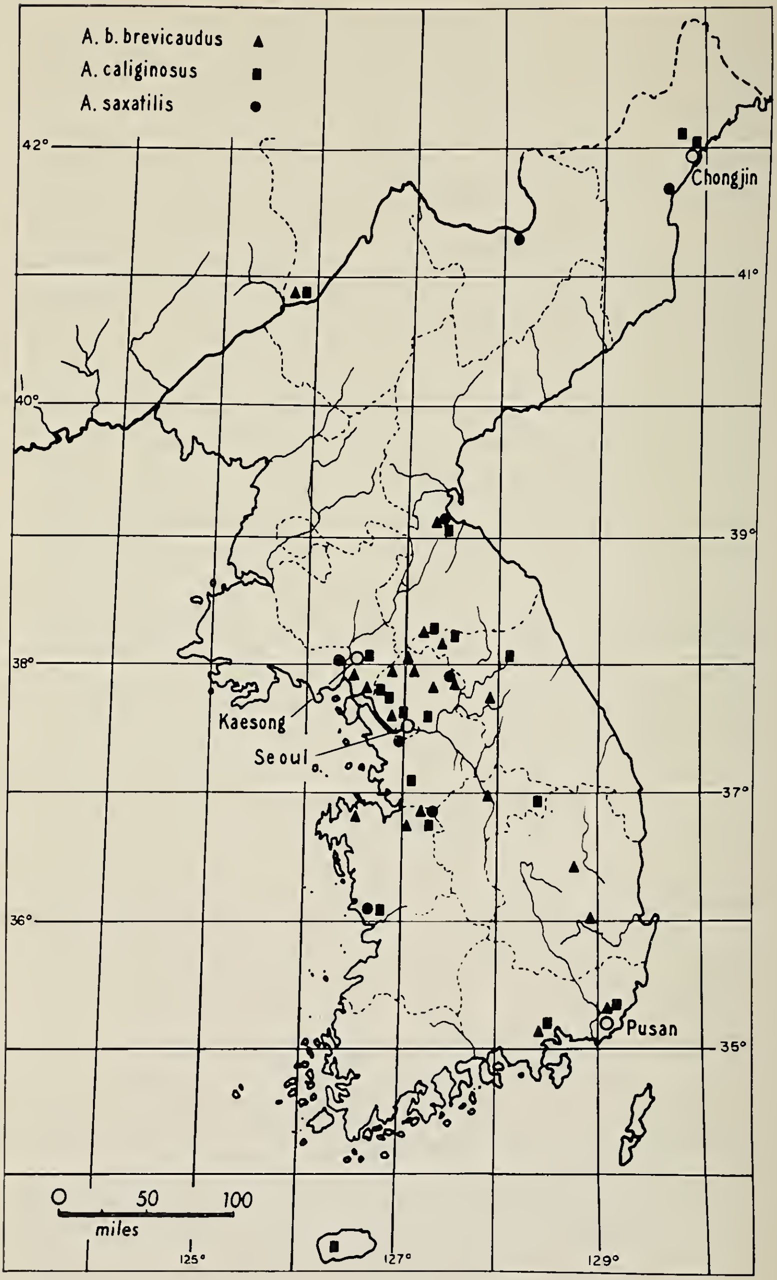
A. b. brevicaudus ▲
A. caliginosus ■
A. saxatilis ●
42°
41°
40°
39°
38°
37°
36°
35°
Chongjin
Kaesong
Seoul
Pusan
0 50 100
miles
125°
127°
129°

FIG. 2. *Agkistrodon caliginosus* new species, type-specimen, vicinity of Seoul, South Korea. AMNH 108508.

collected by Sowerby on the Yalu River in South Manchuria: one with 143 ventrals and 41 subcaudals (USNM 52341) he considered to be "... well within the limits of *A. brevicaudus.* But the other one [USNM 52339, here referred to *caliginosus*], which it would be absurd to refer to under a different subspecific name, has 151 ventrals and 44 subcaudals. . . . I have no hesitancy in calling it *A. brevicaudus,* the decisive factor of course being the fact that its companion is typical of this form. Were it not for these dubious intermediate specimens in the geographically intermediate territory we would be justified in applying a binomial appellation rather than the present trinomial."

*Holotype:* American Museum of Natural History 108508, adult female, from vicinity of Seoul, South Korea, spring of 1966, James Hanlon, Jr.*

*Paratypes:* CAS 87048–54, 3–7 mi. SE Munsan-ni, Kyonggi-do Province, South Korea, 4–31 May 1952, James R. Dixon; KU 38801–4, Central

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* In spite of lack of a more precise locality, this specimen was selected as the type because it was received alive and could be described in detail, photographed, and properly preserved. The name *caliginosus* refers to the generally dark coloration.

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MAP 1. Approximate locations of places from which the specimens studied are said to have come. Triangles refer to *A. b. brevicaudus,* rectangles to *caliginosus,* and solid circles to *saxatilis.*

National Forest, near Pup-yong-ni, 125 m, Kyonggi-do Province, South Korea, 29 July–23 October 1954, J. Knox Jones, Jr.; FMNH 11470–1, 11475, 11478, 11485, 11487, Songdo Higher Common School, Songdo (= Kaesong), North Korea, 1930, L. H. Snyder.

*Diagnosis:* General coloration dark gray or dark brown with little contrast between pattern and ground color; pattern of dark-edged subquadrangular crossbands, 4–6 scales wide, extending down each side to scale row 2, and numbering 23–33 (27.6) in males, 22–31 (27.4) in females (Table 1). Belly dark, heavily pigmented, or almost totally black; crown without conspicuous markings; cheek stripe brown, bordered above and below by narrow white lines, the upper extending across top of eye; tongue pink in life; tip of tail and terminal spine dark, sometimes lighter ventrally.

Internasals wide and narrow, posterior margins curving obliquely backward from midline; loreals subrectangular, notably wider than high; preoculars 2; postoculars 2 (97%), upper small, lower crescent shaped and extending beneath eye; lower postocular rarely divided; supralabials 7 (94%), rarely 6 or 8, posterior supralabials not conspicuously low and narrow; infralabials 10 (75%), occasionally 9 or 11.

Scale rows 21 at midbody, all with keels posteriorly, paired apical pits present, inconspicuous. Ventrals 139–153 (146.8) in males, 143–155 (148.0) in females; subcaudals 40–52 (46.8) in males, 36–48 (42.2) in females (Table 2).

*Description of holotype:* Top of head (crown) with nine symmetrically arranged scutes characteristic of genus. Internasals wider than long, extending obliquely backward and in contact dorsolaterally with loreals. Rostral slightly wider than high, broadly truncate above. No aberrations in frontal, prefrontals, supraoculars, or parietals. Nasals two on each side, the anterior one about three times larger than the posterior, nostril in suture between. Loreals one on each side, relatively small, wider than high, in direct contact with large prefoveals. Preoculars two on each side, the upper one extending anteriorly over the edge of the canthus, the lower forming the upper posterior border of the pit. Postoculars two, the upper one small, in contact with the supraocular; the lower one crescent shaped, extending around the orbit laterally and ventrally, and making contact with the upper tip of the third supralabial. A small postfoveal below the lower preocular, making a total of seven scales surrounding the eye. Pit bordered by a large prefoveal anteriorly, a narrow subfoveal, and the lower preocular. Supralabials seven on each side, the third largest and its upper margin entering the orbit. Infralabials 10 on the left side, nine on the right. Temporals of lowest (first horizontal) row consist of three large, smooth scales, the anterior one largest, the remaining two about equal in size; temporals of second row composed of four smooth scales slightly larger than those above. First infralabials with pointed tips extending backward and in contact behind the posterior tip of the mental. One pair of chin shields, each slightly longer than wide. Median gulars small, in two pairs followed by three transverse rows of three, four, and four scales each. Lateral gulars in two to four oblique rows.

Dorsal scales all strongly keeled on body and tail. Paired apical pits not discernible superficially but visible when individual scales are examined under magnification. Scale rows 23–21–19–17, the order of reduction as follows:*

$$23\ \frac{-5\ (17)}{4+5\ (18)}\ 21\ \frac{-4\ (100)}{-4\ (97)}\ 19\ \frac{-4\ (118)}{-4\ (115)}\ 17\ (148)$$

Ventrals 148, anal plate not divided. Subcaudals 41, all divided; terminal scute sharply pointed.

Total length 570 mm; tail length 78 mm; tail 13.5 percent of total length.

General coloration in life dark olivaceous gray to black above and below. Tongue conspicuously pink. Eye bicolored: upper portion of iris light brown, a continuation of the upper light line on the side of the head; lower portion dark reddish brown.

Dorsal pattern of head indistinct; irregular spots and flecks of dark brown and olive on scutes of crown; paraparietal region and posterior sides of head dark with a lighter area at middle, suggesting a pair of broad stripes but not a distinct figure; rostral and sides of snout salmon colored with fine gray and red stippling but no distinct markings; cheek stripe dark reddish brown with gray stippling, narrowly edged with white below, extending backward from orbit on upper edges of supralabials 4 to 7, across large temporals of first row and lower edges of temporals of second row; a sharp narrow line of brownish yellow extending backward across eye and from upper postocular across the four temporals of second row; supralabials flesh or salmon colored with gray stippling; infralabials with lighter centers, dark brown lower edges, and peripheral stippling; gulars profusely stippled with dark gray and black.

Dorsal pattern of body consisting of a series of dark crossbands, 28 in number, with borders of dark gray to black about one scale wide; some appear as half-bands, those of one side not meeting exactly those of opposite side but all connected at midline; a series of small, black ventrolateral spots on parts of scales of row one and tips of adjacent ventrals, more or less set off by irregular white edges.

Ventral coloration black with flecks of white and light gray laterally; anterior ventrals lighter but heavily stippled with black and reddish brown. Tail gray to black with eight or 10 indistinct dark crossbands, underside black with small light flecks proximally; tip black, terminal scute dark brown at base, black at point.

Coloration after preservation little changed except for absence of reds and yellowish browns.

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* Dowling recount system, Copeia 1951(2):131–134.

*Size and form:* Adults of this species are generally smaller and more slender than those of *brevicaudus.* The head is narrower and the tail relatively longer. The largest male examined is the Sowerby specimen from South Manchuria, USNM 53365, total length 625 mm, tail 104 mm; the largest female, KU 38803, Pup'yong-ni, total length 610 mm, tail 90 mm. Juveniles 203–215 mm. Tail in males 15–17 (15.8) percent of total length, in females 12–15 (14.0) percent.

*Habitat:* The live specimens from Hanlon, as well as Daleske's material and that of Shannon (1956, p. 47) and of Webb et al. (1962, p. 170), represent both *brevicaudus* and *caliginosus.* Thus these forms are sympatric in a geographical sense but their ecological requirements, whether similar or different, are not clear.

Daleske's notes on a locality 8 miles west of Chorwon mention sandstone bluffs with an abundance of cold springs and small creeks, brush and vegetation, pine-oak woodland, some spruce, "very different from [Munsan-ni]." He collected both forms here and mentioned one sunning in a pine tree several feet above ground.

Shannon (loc. cit.) in reference to those collected northeast of Seoul (Kapyong, Kumhwa) mentions low, marshy environment provided by rice paddies or meandering streams; on lower slopes of hills but seldom to any considerable altitude. Those listed by Webb et al. (loc. cit., Seoul, Pup'yong-ni, Chip'o-ri) were collected "on brushy or wooded hillsides, along rock walls or in piles of rocks, and in damp, rocky, wooded ravines near streams."

Specimens collected by Dixon (1956, p. 56), all here referred to *caliginosus* (P'aiu-ri, near Munsan-ni) were found in or near streams. In a personal communication he characterized the vegetation of the area as scattered individual trees of Korean pine, clumps of Manchurian ash, Mongolian oak, Mono maple, and Scotch elm. "The lower gallery forest along the streams consists of many species of grasses, sedges, and an occasional Manchurian walnut and many poplar. The areas where *Agkistrodon* were taken are mainly stream edges where grasses are low and shrubs are common. Three specimens were taken from a 'den' in a rock wall along the stream. All were taken within 30 meters of water."

Stewart's specimen of *caliginosus,* from 5.8 miles southwest of Inje (1954, p. 67), was "on a very small loose rock and sand island in the middle of a shallow stream."

*Range:* Korea, from the Masan-Pusan area and Chejo-do (Quelpart Island) in the south to the extreme northeast of the peninsula above Ch'ongjin, and South Manchuria (Yalu River and Imienpo, North Kirin). Map 1.

*Specimens examined:* KOREA: CH'UNGCH'ONG-NAMDO PROVINCE—Mundong-ni [Mundung-ni ?], (6½ mi. NW), TNHC 18447; (9 mi. SE), TNHC 18444–5, 18450–1. Chiksan, CAS 31524–7. CH'UNGCH'ONG-PUKTO PROVINCE—Tanyang Pass, TNHC 18443, 18448. HAMGYONG-PUKTO PROVINCE—Puryong, CAS 31537–9. Shoko [41° 56′ N, 129° 44′ E], CAS 31542. HWANGHAE-NAMDO PROVINCE—Kaesong (14 mi. E), FMNH 188991.

KAESONG CITY—Kaesong, USNM 129605–6. Songdo (=Kaesong), FMNH 11469–73, 11475–6, 11478–83, 11485–92, 25237. KANGWON-DO PROVINCE —Chorwon (8 mi. W), FMNH 188992–5. Inje (5.8 mi. SW), AMNH 72914. Kumhwa (23 mi. S), UIMNH 68749. Wonsan, CAS 31506–7, 31509–10, 31512. KYONGGI-DO PROVINCE—Munsan-ni, TNHC 18452. P'aiu-ri (3 mi. SE Munsan-ni), CAS 87048–9, 87051–3, 87055; (7 mi. SE), CAS 87050, 87054. Pup'yong-ni (Central National Forest), KU 38801–4. 54 mi. NE Seoul, UIMNH 68748. Suwon (15 mi. ESE), TNHC 18442. Uijongbu (2 mi. N), FMNH 18896–9000. "Indianhead Camp" [35 mi. NE Seoul ?], USNM 136576. "Commonwealth" [on Imjin River, near P'anmunjom ?], USNM 136577. Kwangnung [= Kwangnung-mal ?], MVZ 61831. KYONGSANG-NAMDO PROVINCE—Masan, TNHC 16182. PUSAN CITY—Fusan (Pusan), CAS 31484; (1 mi. NE), KU 94567. SEOUL CITY—AMNH 108508 [type]. CHEJO-DO PROVINCE (QUELPART ISLAND)—TNHC 18439, 18449. Mosulpo, USNM 139890; (16 mi. NE), UMMZ 113465. Sogwi-ri (7 mi. NNE), UMMZ 113466. KOREA, NO LOCALITY—BMNH 1953.1.12.69; MVZ 66683; UMMZ 30525.

SOUTH MANCHURIA: Yalu River, about 180 mi. above mouth, USNM 52339 (Sowerby). Imienpo, North Kirin, USNM 53365 (Sowerby).

### *Agkistrodon saxatilis* Emelianov

Brown Mamushi

Figures 3 and 4

*Trigonocephalus intermedius* Strauch, 1868, p. 295 (part); 1873, p. 245 (part).

*Ancistrodon intermedius*.—Nikol'skii, 1905, p. 326 (part).—Thompson, 1916, p. 62 (part).

*Agkistrodon blomhoffii intermedius*.—Stejneger, 1907, p. 464 (part).

*Ancistrodon halys intermedius*.—Nikol'skii, 1916, p. 276 (part); translation, 1964, p. 186.—Emelianov, 1929, p. 130 (part).

*Agkistrodon blomhoffii brevicaudus*.—Slevin, 1925, p. 99 (part).

*Agkistrodon halys intermedius*.—Maki, 1931, p. 209 (synonymy part), description and figure of Korean specimen, fig. 140 (not part).—Klemmer, 1963, p. 400 (part).

*Ancistrodon halys stejnegeri* Rendahl, 1933, p. 18 (part).

*Ancistrodon saxatilis* Emelianov, 1937, p. 26, figs. 1–4.

*Type-locality:* Vladivostok, Voroshilovo (Ussuriysk), and Suchan River (Emelianov, 1937, p. 30). Repository of types not clear; individual specimens of type-series not designated.

In describing this species, Emelianov carefully reviewed the works of Strauch, Nikol'skii, and others, including his own earlier studies (particularly *Snakes of the Far Eastern District*, 1929), examined a large number of specimens, including those in the Zoological Institute of the Academy of Sciences of the USSR, and made a highly convincing case for separating it from those with which it had long been confused.

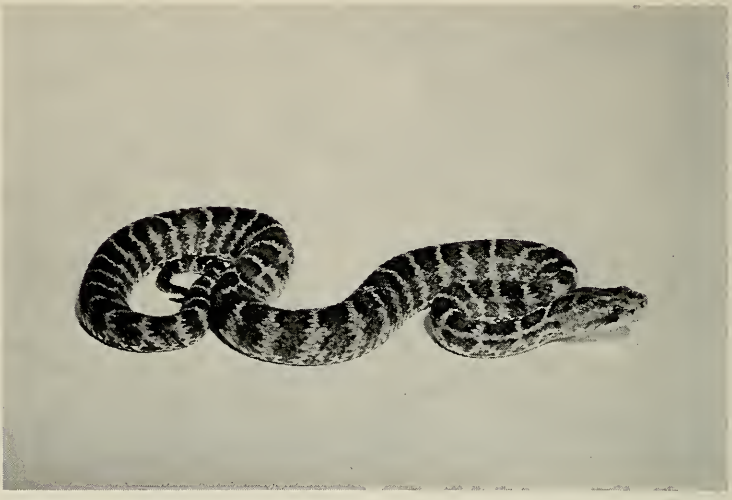


FIG. 3. *Agkistrodon saxatilis* Emelianov, vicinity of Seoul, South Korea. AMNH 108504. Photo by Isabelle Hunt Conant.

Unfortunately, he did not see the specimens of Strauch, 1868; he stated that they supposedly were lost at the time of a flood in Leningrad.

Emelianov's *saxatilis* seems to have been generally overlooked. In addition to the original paper, I have seen it mentioned in print only once: as a synonym of *intermedius* Strauch in Terent'ev and Chernov, 1965 (translation of Russian work of 1949). Although he listed only two specimens from Korea without specific localities, Emelianov included Korea in his statement of the range. In his meristic data, Tables I–III, the sexes and juveniles were separately listed, thus data from material examined by me can be readily and advantageously combined with his. My summaries of ventrals and subcaudals are so combined (Table 2 and Figs. 5 and 6). The diagnosis which follows, however, is based entirely on specimens examined by me, from Korea and USSR Maritime Territory (Vladivostok area north as far as Khabarovsk).

*Diagnosis:* Pattern of body a series of 29–44 irregular dark brown transverse bands (Table 1), 2–5 scales wide, each extending down sides to scale rows 1 or 2, separated by narrow lighter areas; belly light or dark gray, no distinct markings; crown and parietal region with indistinct, asymmetrical dark spots; a pair of elongate blotches curving laterally from the postparietal region to neck; cheek stripe relatively weak, not bordered above by a light line; tongue probably black in life; tip of tail and terminal spine dark.

Internasals not conspicuously narrow, their posterior margins approximately perpendicular to midline; loreals subquadrate, about as high as wide; preoculars 2; postoculars 2 (60%) or 3; supralabials 7 (61%) or 8;

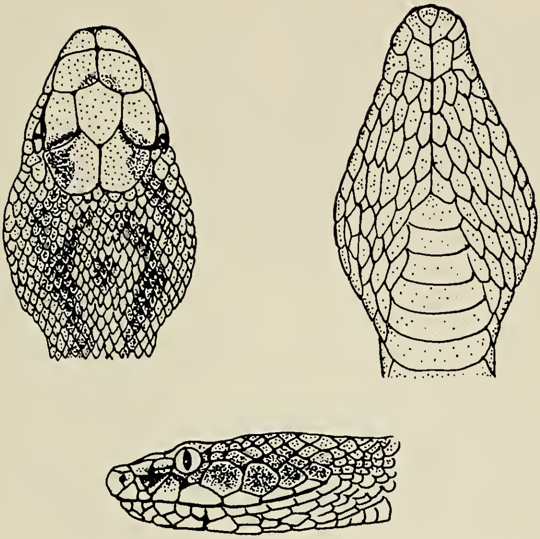


Fig. 4. *Agkistrodon saxatilis*, after Emelianov, 1937, fig. 1, p. 28.

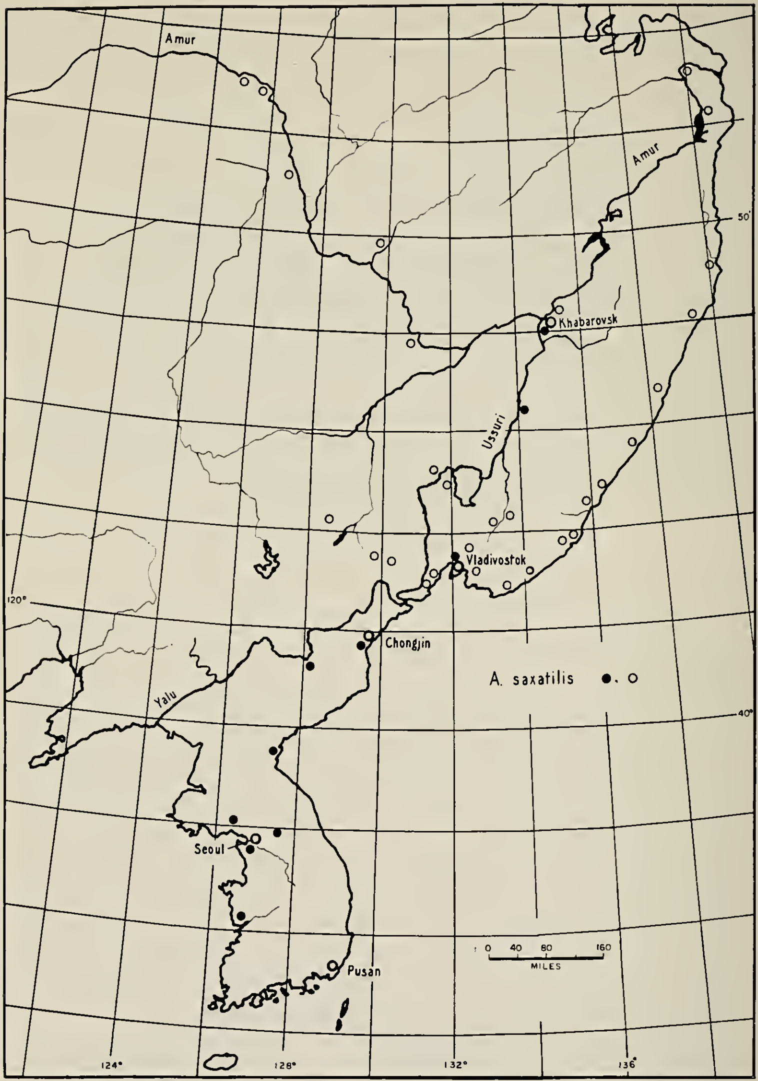
infralabials 10 (50%) or 11, last 3 or 4 supralabials conspicuously low and narrow.

Scale rows 23 at midbody, rarely 21, all strongly keeled except lowermost which are smooth or weakly keeled posteriorly; apical pits present, inconspicuous; ventrals 149–164 (154.4) in males, 148–165 (159.2) in females; subcaudals 37–48 (41.6) in males, 34–41 (37.4) in females.

*Size and form:* Adult individuals of this species are generally larger and more robust than those of *brevicaudus* and *caliginosus*. As recorded by Emelianov (op. cit., Tables I–III), the largest male, Pos'yet (just south of Vladivostok), was 790 mm in total length, tail 101 mm; largest female, Maytun, 695 and 82 mm; juveniles 210–250 mm. The largest seen by me, BMNH 89.12.16.140, male, Khabarovsk, is 780 mm in total length, tail 93. In specimens measured by me, the tail in males is 12–14 (13.0) percent of total length, in females, 11–12 (11.2) percent.

*Habitat:* The most typical habitat in the remote Ussuri taiga is the rocky taluses of the mountains, turned toward the sun [hence the name *saxatilis*]; also on the borders of the forest, along the banks of streams, between driftwood and windfallen trees and branches (Emelianov, 1937, p. 30).

*Range:* Far East, Manchuria and Korea, from the Pacific Coast west to the Great Khingan Range, north to the lower Amur River, south to Port Arthur on the Liaotung Peninsula (Emelianov, 1937, p. 26 and 40).



Map 2. Approximate locations with reference to *A. saxatilis.* Solid circles indicate localities of specimens examined in this study, open circles after Emelianov, 1937, Figure 4, page 31.

The southernmost specimen examined by me is from Mundong-ni, near the 36th parallel.

*Specimens examined:* KOREA: CH'UNGCH'ONG-NAMDO PROVINCE—Chiksan, CAS 31528. Mundong-ni (6½ mi. NW), TNHC 18446. HAMGYONG-PUKTO PROVINCE—Seishin (= Ch'ongjin), CAS 31540. KAESONG CITY—Songdo (= Kaesong), FMNH 11477, 11484. KANGWON-DO PROVINCE—Wonsan, CAS 31511. KYONGGI-DO PROVINCE—Kapyong, USNM 136575. SEOUL CITY—AMNH 108501–7. YANGGANG-DO PROVINCE—Musan Pass (Yalu River), CAS 31543.

USSR: Khabarovsk, BMNH 89.12.16.140–141. Ussuri River, BMNH 75.10.14.1. Vladivostok, NMW 17088.

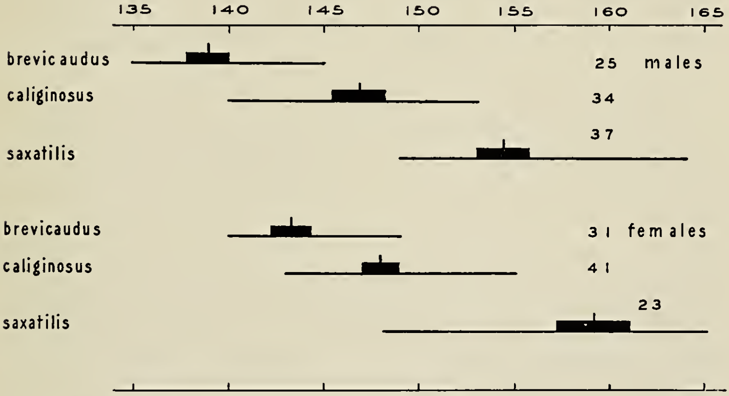


FIG. 5. Variation in the number of ventrals in the hypodigm of each of the three forms. The horizontal bar indicates the range of variation, the vertical bar the mean, and the black rectangles two standard errors on each side of the mean.

## VARIATION

"Red" mamushis, or individuals with considerable red in their coloration, are frequently mentioned by authors and others who have seen numbers of these snakes in life. Erythrism is well known in *blomhoffii* in Japan and apparently occurs in both *brevicaudus* and *caliginosus* in Korea. From preserved specimens, however, it is impossible to assess the frequence of occurrence or degree of variation in this aspect of coloration.

No reference to variation in color was made by Shannon (1956), Webb et al. (1962), or by Dixon (1956), but two of Dixon's specimens (*caliginosus*) show traces of pink ventrally and along the sides, even after several years in preservative. Daleske's notes frequently refer to a "red phase" but no red remains in his preserved matrial. Hanlon's notes mention, and some of his color slides show, individuals with con-

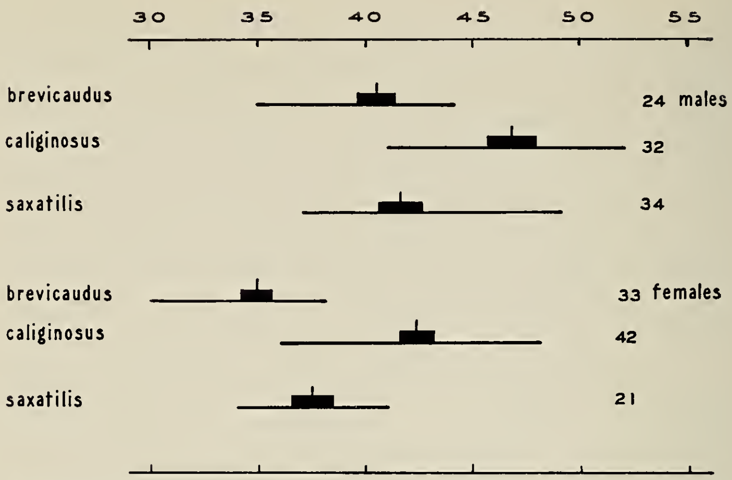


FIG. 6. Variation in the number of subcaudals in the hypodigm of each of the three forms. Symbols as in Figure 5.

siderable red ventrally and laterally, but I can not be certain of the form represented. None of his specimens that reached me alive was red. As to *saxatilis*, no red in the coloration was mentioned by Emelianov (loc. cit.), nor have I seen any indication of it in specimens examined.

Variation in the number of blotches (half-bands) or crossbands is similar in *brevicaudus* and *caliginosus* but the range is greater and the mean higher in *saxatilis* (Table 1).

In a few specimens of *caliginosus* (FMNH 11488–9, 11491, CAS 87049–50, 87055) the pattern of the body in part resembles that of *brevicaudus*. Some of the crossbands are divided at the midline and the resulting half-bands sometimes alternate. In the most divergent of these (CAS 87055) the pattern is distinct and the ground color, labials, and belly probably were red or pink in life. The divided crossbands of these specimens suggest hybridization, but in other features of coloration, and in scutellation and relative length of tail, all are readily referred to *caliginosus*.

The fact that *caliginosus* differs strikingly from *brevicaudus* not only in coloration but also in important meristic characters is indicated in the range and mean numbers of ventrals and subcaudals (Table 2, Figs. 5 and 6), and in the relatively long tail (Table 3). Differences in these characters are obvious in *saxatilis* also, but it is more closely allied with the *intermedius* complex; these data are presented here primarily as an aid to its discrimination from *caliginosus* and the subspecies of *blomhoffii*. It will be treated more fully in a monographic review of the genus.

### KEY TO KOREAN FORMS OF *AGKISTRODON*

1. Scales in 23 rows; body pattern a series of dark crossbands extending down sides to scale rows 1 or 2 and separated by narrow lighter areas; cheek stripe not bordered above by a sharp light line; internasals with posterior margins nearly perpendicular to midline; last 3 or 4 supralabials notably low and narrow (Figs. 3 and 4) ........................ *A. saxatilis* Emelianov

   Scales in 21 rows; internasals wider than long, posterior margins curving obliquely backward from midline; last 3–4 supralabials not unusually low and narrow ........................ 2

2. Body pattern of conspicuous pairs of subelliptical blotches, opposite or alternating, on a lighter ground color; cheek stripe bordered above and below with strong, sharply defined white lines (Fig. 1); loreals subquadrate, as high as wide; tongue black; tail relatively short, light at tip ........................ *A. blomhoffii brevicaudus* Stejneger

   Body pattern of dark subrectangular crossbands extending down sides to scale row 2; ground color also dark; cheek stripe narrowly bordered with white lines above and below (Fig. 2); loreals subrectangular, notably wider than high; tongue pink; tail relatively long, dark at tip ............ *A. caliginosus* new species

*Acknowledgments:* Many people have contributed directly or indirectly to this study. For loans of specimens in their curatorial care, I am indebted to Charles M. Bogert and Richard G. Zweifel, American Museum of Natural History; W. Frank Blair, University of Texas, Austin; the late Doris M. Cochran and James A. Peters, National Museum of Natural History; William E. Duellman, University of Kansas, Lawrence; Josef Eiselt, Naturhistorisches Museum, Wien; Alice G. C. Grandison, British Museum (Natural History); the late Norman Hartweg and Charles F. Walker, University of Michigan, Ann Arbor; Donald F. Hoffmeister and Dorothy Smith, University of Illinois, Urbana; Robert F. Inger and Hymen Marx, Field Museum of Natural History; Alan E. Leviton, California Academy of Sciences; Robert C. Stebbins, University of California, Berkeley; and Wilmer W. Tanner, Brigham Young University.

For specimens, notes, or comments in personal communications, I am indebted to James R. Dixon, Donald Daleske, James Hanlon, Jr., Robert G. Webb, and J. Knox Jones, Jr.

Literature in foreign languages has been made useable through translations from the Russian by Lorraine Ewbank and from the Japanese by Dr. Kazuo Koba of the Japan Snake Institute. Edmond V. Malnate gave me the use of his precious copy of a rare item of Russian literature. Gracious assistance with troublesome place names has been given by Mary L. Blakeley and Stephen A. Bahre of the University of Arizona Map Library; Stephen Bahre prepared the bases for Maps 1 and 2. I owe much to my colleagues Charles H. Lowe and Michael D. Robinson for computer time and assistance with statistical analyses, and to our department head, Newell A. Younggren, for making special equipment and laboratory facilities available.

Hobart M. Smith and Roger Conant have been continually encouraging and helpful with critical comments on numerous problems, and Isabelle Hunt Conant has supplied the highly definitive photograph reproduced in Figure 3. To all these friends and colleagues I am deeply grateful.

This contribution includes results of part of a study supported by the National Science Foundation (G2896, G8702, and G19400).

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# INDEX TO NEW TAXA

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(New taxa indicated in **boldface**; n.c. = new combination)

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