SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM

PROCEEDINGS

OF THE

UNITED STATES NATIONAL MUSEUM

VOLUME 121
NUMBERS 3568–3580

SMITHSONIAN PRESS
WASHINGTON : 1967

Publications of the United States National Museum

The scientific publications of the United States National Museum include two series, *Proceedings of the United States National Museum* and *United States National Museum Bulletins*.

In these series are published original articles and monographs dealing with the collections and work of the Museum and setting forth newly acquired facts in the fields of anthropology, biology, geology, history, and technology. Copies of each publication are distributed to libraries and scientific organizations and to specialists and others interested in the various subjects.

The *Proceedings*, begun in 1878, are intended for the publication, in separate form, of shorter papers. These are gathered in volumes, octavo in size, with the publication date of each paper recorded in the table of contents of the volume.

In the *Bulletin* series, the first of which was issued in 1875, appear longer, separate publications consisting of monographs (occasionally in several parts) and volumes in which are collected works on related subjects. *Bulletins* are either octavo or quarto in size, depending on the needs of the presentation. Since 1902, papers relating to the botanical collections of the Museum have been published in the *Bulletin* series under the heading *Contributions from the United States National Herbarium*.

Frank A. Taylor
Director, United States National Museum

CONTENTS

Number

BARNARD, J. LAURENS. New species and records of Pacific Ampeliscidae (Crustacea: Amphipoda). 20 pages, 4 figures. Published March 8, 1967. 3576

New species: *Byblis albatrossae, B. ampelisciformis, B. orientalis.*

CRESSEY, ROGER. Revision of the family Pandaridae (Copepoda: Caligoida). 133 pages, 356 figures. Published February 16, 1967. 3570

New genus: *Pannosus.*

New species: *Pandarus floridanus, P. katoi, Dinemoura discrepans, Nesippus tigris.*

CRESSEY, ROGER. Caligoid copepods parasitic on sharks of the Indian Ocean. 21 pages, 54 figures, 2 plates. Published March 15, 1967. 3572

New species: *Nemesis aggregatus, Eudactylina pusilla, E. pollex, Kroyeria gemursa.*

HUMES, ARTHUR G., and HO, JU-SHEY. New cyclopoid copepods associated with the alcyonarian coral *Tubipora musica* (Linnaeus) in Madagascar. 24 pages, 69 figures. Published March 8, 1967. 3573

New species: *Lichomolgus organicus, L. conjunctus, Hippomolgus latipes, H. cognatus.*

KIER, PORTER. Bredin-Archbold-Smithsonian Biological Survey of Dominica: 1, The echinoids of Dominica. 10 pages, 3 figures, 2 plates. Published December 30, 1966 3577

KORNICKER, LOUIS S. Supplementary descriptions of two myodocopid ostracods from the Red Sea. 18 pages, 6 figures. Published February 16, 1967 3571

KORNICKER, LOUIS S. The myodocopid ostracod families Philomedidae and Pseudophilomedidae (new family). 35 pages, 12 figures, 1 plate. Published February 16, 1967 . . 3580

New family: *Pseudophilomedidae.*

New combination: *Euphilomedes asper.*

LEWIS, ALLAN G. Copepod crustaceans parasitic on teleost fishes of the Hawaiian Islands. 204 pages, 70 figures. Published June 22, 1967. 3574

New species: *Pseudotaeniacanthus puhi, Anchistrotos moa, Hatschekia breviramus, Lepeophtheirus? fallolunulus, Caligus kapuhili, Brachiella regia.*

McFadden, Max W. Soldier fly larvae in America north of Mexico. 72 pages, 156 figures. Published February 1, 1967. 3569

Pettibone, Marian H. Some bathyal polynoids from Central and Northeastern Pacific (Polychaeta: Polynoidae). 15 pages, 5 figures. Published February 16, 1967 3575
New genera: *Bathyadmetella*, *Bathymoorea*.
New species: *Bathyadmetella commando*.
New combination: *Bathymoorea renotubulata*.

Quate, Laurence W., and Thompson, Sarah E. Revision of click beetles of genus *Melanotus* in America north of Mexico (Coleoptera: Elateridae). 83 pages, 12 figures, 1 plate. Published April 18, 1967 3568
New species: *Melanotus indistinctus*, *M. dietrichi*, *M. miscellus*, *M. lanei*, *M. beameri*, *M. lanceatus*.

Rehder, Harald A. Valid zoological names of the Portland Catalogue. 51 pages, 2 figures. Published March 21, 1967 . 3579

Stone, Alan. Bredin-Archbold-Smithsonian Biological Survey of Dominica: 2, New species of Diptera from Dominica (Anisopodidae and Bibionidae). 6 pages, 2 figures. Published December 30, 1966 3578
New species: *Mycetobia limanda*, *Olbiogaster danista*, *O. evansi*, *Plecia porca*.

U.S. GOVERNMENT PRINTING OFFICE 262-119-h

Proceedings of the United States National Museum

SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 121 | 1967 | Number 3568

REVISION OF CLICK BEETLES OF GENUS MELANOTUS IN AMERICA NORTH OF MEXICO (COLEOPTERA: ELATERIDAE)

By LAURENCE W. QUATE and SARAH E. THOMPSON[1]

Click beetles and wireworms of the genus *Melanotus* are common elements in the North American fauna. Some of the species are important to agriculture because the larvae are destructive to seeds and roots of corns, small grains, grasses, and some root crops; in spite of their importance, the North American species of the genus have never been revised. Early descriptions by LeConte (1853, 1866), Say (1823, etc.), Melsheimer (1846), Erichson (1842), and others are of little value in identifying the species. General treatments of local faunas (Blatchley, 1910; Dietrich, 1945; Brooks, 1960) are improvements but generally insufficient for identification except within a limited area. Descriptions of a few new species have appeared recently (Knull, 1959, 1962) and have increased the need for a thorough revision. M. C. Lane is the taxonomist most qualified to do this, having identified most North American collections of *Melanotus* in the past several decades, but the pressure of other duties has prevented him from committing his wide knowledge to print.

[1] Quate: B. P. Bishop Museum, Honolulu, Hawaii; Thompson: State Board of Health, Raleigh, N.C.

It was on the recommendation of Mr. Lane that in 1955 the senior author began a revision of North American *Melanotus*. Five years ago he was joined by the junior author. During most of this time, the work has been done during spare time by both.

The new species were recognized early in the study by the senior author and authorships are to be credited to him.

We have arrived at the following conclusions concerning the taxonomy of the genus: the features distinguishing one species from the other do not differ greatly; typical specimens of each species are identifiable on the basis of external characters; some specimens of each species vary enough to obscure the gap between the taxa; positive identification can be made by the study of the genitalia, which is specific in both sexes; and a natural division of the genus into subgeneric taxa is not apparent to us at this time.

One of the most striking features of the zoogeography of North American *Melanotus* is that the species are concentrated east of the 100th meridian. *Melanotus* in North America is predominantly an eastern genus (fig. 1). It is not within the scope of this paper to dwell at length on possible causes of this distributional pattern, but we may discuss it briefly. The apparent relationship of New and Old World faunas suggests that there have been migrations over a Bering Straits land bridge. We may further assume that the *Melanotus* click beetles which came from Eurasia and crossed the bridge stayed on the eastern side of the Rocky Mountains. This might have been the origin of the distributional pattern we see today. Adaptation to the more humid climate and edaphic conditions prevailing in the East may be responsible for the maintenance of the pattern.

In western North America there are only a few *Melanotus* and most of these are in the Southwest. There appears to be a group of species—*longulus, hamatus, lanceatus, beameri,* and *concisus*—which are derived from a single ancestor. Perhaps it was an offshoot from the main group in the East. At any rate, speciation has occurred in the Southwest where we now find the five species, and one of these has spread northward through the Great Basin and along the West Coast to Canada. In the northern part of its range it has further differentiated into a separate subspecies.

The two most distinctive species of North American *Melanotus* also are found in the Southwest. These are *cribricollis* and *chiricahuae,* and they are so distinct from others that we presume they are a Neotropical element.

The practical effect of these distributional patterns is that identification of *Melanotus* in the Far West is simple since there is only a single species with two subspecies; in the Southwest there are only a few species with which to contend, so identification of that *Melanotus* fauna is not difficult. The bulk of the *Melanotus* are in the eastern half of the United States, and this is where the greatest problems of identification will be encountered.

It appears that nearly all American species of *Melanotus* north of Mexico are now known. Supporting this conclusion is the fact that of the 46 Nearctic *Melanotus* only nine (20 percent) are named in this paper or have been named in the last few years, and half of these have been recognized for at least 20 years. What few species may remain undiscovered are probably in the Southwest.

We have made an artificial division of *Melanotus* into three groups. The first two, containing nearly all the species, are based on the

Figure 1.—Distribution of *Melanotus* in the United States (figures indicate the number of species recorded in each state or area).

presence or absence of mandibular pits. This is an obvious character and it simplifies identification; however, we do not feel that this single character indicates natural units, and the taxa based on it are merely utilitarian. The third group, composed of only *cribricollis* and *chiricahuae*, is characterized by large pronotal punctures and reduced parameres in the male genitalia; it is probably monophyletic.

A key has been prepared which will simplify identification of most specimens. The greatest difficulty will be individual variants that do not seem to quite fit either part of a couplet. Many revisions have failed to eliminate all deficiencies, but for the majority of specimens the key should provide a satisfactory shortcut to their proper identification.

The authors have been able to study all but six of the extant types. The locations of the types have been indicated in the appropriate places. Museums have been abbreviated thus: U.S. National Museum (USNM); Museum of Comparative Zoology, Harvard University (MCZ); Purdue University (PU); Cornell University (CU); University of Kansas (KU); California Academy of Sciences (CAS); British Museum (Natural History) (BMNH); Zoologisches Museum der Humboldt-Universität zu Berlin (ZM).

In addition to the types, over 13,000 specimens were examined by us during the course of this study.

FIGURE 2.—Distribution of the three types of female bursae of *Melanotus similis*.
○ normal ⊖ intermediate ● spiny

Morphological terms used by us are common ones, but those which might be unclear are defined. The "front" is the flat area between and above the eyes, bounded anteriorly by the "frontal margin." Below the frontal margin and occupying the central area between the antennae is the "nasale." On either side of the nasale and between it and the antennal bases is a pair of pits, the "parantennal foveae." Within some of the larger foveae is an elevated part that gives them an earlike appearance; the raised part is termed the "foveal tragus." The "mandibular pit" is a clearly marked depression of varying size on the lateral, exposed margin of the mandible.

The shape and measurements of the pronotum are important taxonomic features. The length is measured along the midline and does not include the projection of posterolateral "hind angles." The width is measured as the widest part of the pronotum before the hind angles and is not affected by their expansion if they are wider than the rest of the prothorax. The relation of the antennal length to the pronotum used in the descriptions refers to the distance before or beyond the tip of the hind angles, which the antenna reaches when stretched along and parallel to the side of the pronotum.

As an indication of size, we have measured only the length of the elytra. This is more accurately measured than the whole length of the insect and is as useful as an indication of its overall dimension.

The genitalia of both sexes are important taxonomically, but the parts are simple and easily defined. Following the terminology of Snodgrass (1957), the male genitalia consist of a central "aedeagus" (median lobe) which is flanked by a pair of "parameres" (lateral lobes,

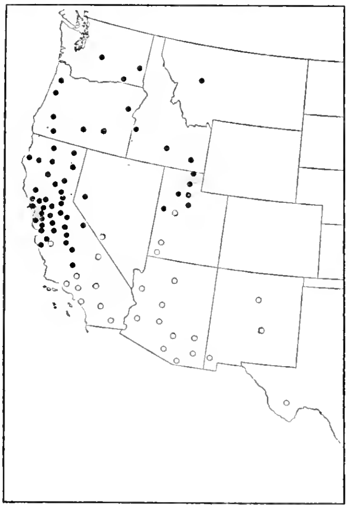


FIGURE 3.—Distribution of species.
○ *Melanotus longulus longulus*
● *M. l. oregonensis*

gonostyli). These are supported by the "phallobase." The paramere may be plain at the tip or expanded into an "apical blade." The taxonomically important parts of the female genitalia (fig. 5) are the large membranous sac, the "bursa," which contains spines of various shapes and number, and the "accessory gland" and "spermathecal duct," which arise from the bursa. A more detailed morphological description was given by Becker (1956); he also described the techniques used in dissecting the female genitalia. It is only necessary to add that light reflected from the substage mirror of a stereoptic microscope is helpful in seeing the delicate spermathecal duct, its diverticulum, and accessory gland.

Bibliographic references are intended to be complete; catalog references (Leng, 1920; Schenkling, 1927) are given only when new information is involved.

Because of the large number of records involved, distributional data have been reduced to listing states and counties (or locales and provinces) with the earliest and latest months of collections for each species. Only complete collecting data are given for the new species and the two subspecies.

M. C. Lane, Collaborator, Agricultural Research Service, USDA, has given invaluable assistance to this study. He permitted us to study specimens in his collection, allowed the use of his notes of type specimens, loaned numerous identified specimens, and identified many of the species in the early stages of this work.

Grants from the National Academy of Sciences (Marsh Fund Grant no. 130, 1960) and the American Philosophical Society (Grant 2614, Penrose Fund, 1960) permitted the senior author to study types in the Zoologisches Museum der Humboldt-Universität zu Berlin and the British Museum (Natural History). Another grant by the National Academy of Sciences (Marsh Fund) enabled the junior author to study *Melanotus* types at Purdue University and the Museum of Comparative Zoology, Harvard University. While a member of the faculty, the senior author was provided funds by the University of Nebraska Research Council to study the Lane Collection in Walla Walla, Wash.

Through the kindness of Prof. C. H. Lindroth and K. J. Hedquist, we were able to receive specimens of *M. communis* from the Gyllenhal Collection at the Swedish Museum of Natural History, Stockholm. While studying type specimens at various times, we enjoyed the help and hospitality of Dr. K. Delkeskamp, Humboldt-Universität, Miss C. M. F. von Hayek, British University; Dr. P. J. Darlington, Jr., Museum of Comparative Zoology; and Dr. Leland Chandler, Purdue University.

The large collections of the U.S. National Museum have been vital to our studies. We are indebted to the officials of the Smithsonian Institution and T. J. Spilman, USDA, for the privilege of studying the material.

We also thank the following for the loan of specimens: F. G. Werner, University of Arizona; H. B. Leech, California Academy of Sciences; P. D. Hurd, Jr., California Insect Survey; E. C. Becker, Canadian National Collection; H. Dietrich, Cornell University; H. O. Lund, University of Georgia; M. W. Sanderson and L. K. Gloyd, Illinois State Natural History Survey; G. W. Byers, University of Kansas; W. Enns, University of Missouri; D. A. Young, North Carolina State College; W. C. Stehr, Ohio State University; H. R. Burke, Texas Agricultural Experiment Station; and C. D. Fronk, University of Wyoming.

List of North American *Melanotus*

Similis Group

(Mandible without pit)

1. *similis* (Kirby)
2. *spadix* (Erichson)
3. *decumanus* (Erichson)
4. *castanipes* (Paykull)
5. *communis* (Gyllenhal)
6. *indistinctus*, new species
7. *dietrichi*, new species
8. *miscellus*, new species
9. *verberans* (LeConte)
10. *emissus* (LeConte)
11. *lanei*, new species
12. *pilosus* Blatchley
13. *opacicollis* (LeConte)
14. *clandestinus* (Erichson)
15. *ignobilis* Melsheimer

Americanus Group

(Mandible with pit)

16. *depressus* (Melsheimer)
17. *morosus* Candèze
18. *cribulosus* (LeConte)
19. *corticinus* (Say)
20. *sagittarius* (LeConte)
21. *hyslopi* van Zwaluwenburg
22. *prasinus* Blatchley
23. *piceatus* Blatchley
24. *difficilis* Blatchley
25. *macer* (LeConte)
26. *testaceus* (Melsheimer)
27. *trapezoideus* (LeConte)
28. *tenax* (Say)
29. *pertinax* (Say)
30. *infaustus* (LeConte)
31. *parallelus* Blatchley
32. *americanus* (Herbst)
33. *cribriventris* Blatchley
34. *obscuratus* Blatchley
35. *beameri*, new species
36. *concisus* Knull
37. *lanceatus*, new species
38. *hamatus* Knull
39. *longulus longulus* (LeConte)
40. *l. oregonensis* (LeConte)
41. *gradatus* (LeConte)
42. *insipiens* (Say)
43. *leonardi* (LeConte)
44. *taenicollis* (LeConte)

Cribricollis Group

45. *cribricollis* Candèze
46. *chiricahuae* Knull

List of Synonymical Names in North American *Melanotus*

abdominalis (Erichson) = 2. *spadix* (Erichson)
angustatus (Erichson) = 32. *americanus* (Herbst)
blatchleyi Leng = 33. *cribriventris* Blatchley
canadensis Candèze = 3. *decumanus* (Erichson)
carinus Blatchley = 20. *sagittarius* (LeConte)
cuneatus (LeConte) = 3. *decumanus* (Erichson)
debilis Blatchley = 17. *morosus* Candèze
divarcarinus Blatchley = 16. *depressus* (Melsheimer)
dubius (LeConte) = 26. *testaceus* (Melsheimer)
exuberans (LeConte) = 1. *similis* (Kirby)
fissilis (Say) = 1. *similis* (Kirby)
fransiscanus Van Dyke = 40. *longulus oregonensis* (LeConte)
glandicolor (Melsheimer) = 19. *corticinus* (Say)
inaequalis (LeConte) = 4. *castanipes* (Paykull)

incertus (LeConte) = 3. *decumanus* (Erichson)
laticollis (Erichson) = 1. *similis* (Kirby)
lixus Blatchley = 16. *depressus* (Melsheimer)
longicornis Blatchley = 33. *cribriventris* Blatchley
longulus (LeConte) = 17. *morosus* Candèze
ochraceipennis Melsheimer = 1. *similis* (Kirby)
paganus Candèze = 5. *communis* (Gyllenhal)
paradoxus (Melsheimer) = 4. *castanipes* (Paykull)
parumpunctatus (Melsheimer) = 16. *depressus* (Melsheimer)
peninsularis Candèze = 14. *clandestinus* (Erichson)
perplexus Blatchley = 14. *clandestinus* (Erichson)
prolixus (Erichson) = 1. *similis* (Kirby)
scrobricollis (LeConte) = 4. *castanipes* (Paykull)
secretus (LeConte) = 15. *ignobilis* Melsheimer
simulans Blatchley = 17. *morosus* Candèze
sphenoidalis (Melsheimer) = 1. *similis* (Kirby)
tenellus (Erichson) = 42. *insipiens* (Say)
texanus Candèze = 4. *castanipes* (Paykull)
variolatus LeConte = 40. *longulus oregonensis* (LeConte)
vetulus (Erichson) = 19. *corticinus* (Say)

Melanotus Eschscholtz

Melanotus Eschscholtz, 1829, p. 32. [For additional references, see Schenkling, 1927, p. 271.]

Perimecus Stephens, 1830, p. 263 [Type: *Elater fulvipes* Herbst, by monotypy.]

Ctenonychus Stephens, 1830, p. 272 [Type: *Ctenonychus hirsutus* Stephens, by monotypy.]

Cratonychus Dejean, 1833, p. 87. [Type: *Elater obscurus* Oliver, designated by Blanchard, 1845, p. 76.]

Type species: *Elater fulvipes* Herbst, designated by Westwood, 1840, p. 26.

Adult (partly after Lane, in litt.): Color usually uniformly yellowish brown to dark reddish brown, only 2 species bicolored. Head with front coarsely punctate, punctures hexagonal and separated by less than own diameter; frontal margin complete, carinate (sometimes obsolescent); parantennal fovea and nasale variously developed, but well defined (nasale indistinct in few species). Antenna 11-segmented; segment 1 elongate and cylindrical, 2 spherical, 3 variable from spherical and equal size of 2 to much longer and triangular, 4 and following triangular; male only with dense, erect hairs on mesal margin. Palpus 3-segmented, light reddish brown and lighter than rest of body.

Pronotal punctures present, but size and distribution variable; hind angles well developed and carinate. Elytron with 9 striae formed by rows of punctures and rows of quadrate, subcuticular spots under striae. No prothoracic groove for receiving antenna; meso- and metasternum not meeting to enclose mesocoxal cavities, mesocoxae separated, metasternum truncate anteriorly. Tibiae with apical spurs; tarsal claws pectinate; tarsi simple, without lobes. Punctures on venter of body teardrop shaped.

Key to North American Species of *Melanotus*

1. Pronotum and elytron of different colors, pronotum partly or completely reddish orange and elytron black 2
   Pronotum and elytron of same color 3

2(1). Pronotum almost entirely orange and abdomen entirely black; antenna of ♂ usually exceeding tip of hind angle by 1 segment or less, ♀ antenna ending about at tip . . . . 43. **leonardi**
   Pronotum black in center and orange elsewhere, and abdominal venter partly or entirely orange; antenna of ♂ ending before tip of hind angle by about 1 segment and less in ♀ . . . . 44. **taenicollis**

3(1). Antennal segments 4 and following much longer than wide; antenna generally extends to or beyond hind angle; not with following combination 4
   Antennal segments 4 and most of following wider than long, and lobes lighter in color than rest of antenna; antenna ends 2 or more segments before tip of hind angle; frontal margin slightly indented in center, when viewed from front curves down, and hence nasale is only narrow space between frontal margin and clypeus; frontal and pronotal punctures very large; Arizona to Baja California . . 45. **cribricollis**

4(3). Mandible without pit on lateral, exposed margin 5
   Mandible with pit on lateral margin 21

Similis Group

(Mandible without pit on lateral margin)

5(4). Antennal segment 3 small, subequal to 2 or at least much nearer size of 2 than 4 6
   Antennal segment 3 intermediate in size between 2 and 4, clearly larger than 2 8

6(5). Antennal segments beyond 3 triangular, same color as body, triangular, erect male hairs well developed 7
   Antennal segments beyond 3 testaceous, lighter in color than rest of body, subquadrate, erect male hairs poorly developed; sides of pronotum with marked concavity before hind angles, angles rather small and not widely divergent; ♂ paramere incurved near center and tapering to point, without apical blade . . . . 15. **ignobilis**

7(6). Smaller species, elytron less than 8.0 mm; frontal margin thin and jutting over nasale; nasale and parantennal fovea obsolescent; sides of pronotum with concavity before hind angles, angles small; ♂ paramere with apical blade . . . . 14. **clandestinus**
   Large species, elytron more than 9.0 mm; frontal margin not strongly jutting over nasale; nasale and parantennal fovea poorly developed, but usually present; sides of pronotum often straight and divergent posteriorly with large hind angles; ♂ paramere with apical blade . . . . 4. **castanipes**

8(5). Frontal and pronotal punctures not greatly enlarged; punctures on venter of abdomen oblong and lateral ones but little larger than central ones; ♂ paramere little shorter than aedeagus and with apical blades 9

Frontal and pronotal punctures very large (fig. 10*l*); punctures on venter of abdomen teardrop shaped and lateral ones several times larger than central ones; ♂ paramere about two-thirds length of aedeagus and abruptly tapering to sharp, recurved apex; New Mexico to Baja California . . . . 46. **chiricahuae**

9(8). Pronotum wider than long 10

Pronotum narrow, longer than wide (measured in front of hind angles); frontal margin scoop shaped, jutting and a little upturned. 31. **parallelus** (part)

10(9). Pronotal punctures not so thick as to appear granulose; vestiture of thorax and elytra of about same length and density 11

Pronotal punctures very dense and appearing granulose; vestiture of pronotum short and fine, nearly velvety, considerably denser than on elytra . . . . 13. **opacicollis**

11(10). Pronotal punctures smaller than those on frons, dense and nearly contiguous on all sides; small species, elytron length less than 7.5 mm . 12

Pronotal punctures sparser and larger; most species with elytron length 7.5 mm or more 13

12(11). Vestiture of thorax rather sparse, that on venter sparser than on dorsum; antennal segment 3 intermediate in size between 2 and 4; frontal margin not upturned . . . . 11. **lanei**

Vestiture of thorax long and thick, that on venter as long and thick as on dorsum; antennal segment 3 shorter, closer to length of 2 than 4; frontal margin thin, shelflike and a little upturned . . . 12. **pilosus**

13(11). Frontal margin not strongly protuberant, usually without a depression before margin 14

Frontal margin strongly protuberant, when viewed from side extends out in shelflike extension, marked depression behind margin; ♀ bursa without spines or with only patch of 5–8 small spines on each side near base; ♂ paramere with margins before apical blade straight and without indentation; large species, elytron 10–12mm. 3. **decumanus**

14(13). Frontal margin well defined, dark brown or black, not weakened in center; elytron rarely as long as 13 mm and most species considerably less 15

Frontal margin usually weakened in center, when viewed directly in front appears obliterated and without black margin in center; large species with elytron 11.4–14.9 mm (aver. 13 mm); ♀ bursa with spines in large basal packet and small, separated distal patch (fig. 5*f*). 4. **castanipes**, females

15(14). Antennal segment 4 about 1½ times as long as wide and considerably wider than 3; elytron often less than 10 mm long 16

Antennal segment 4 usually slender, about two times as long as wide and only a little wider than 3; average elytron length 10.8 mm; ♂ gonostyle with thick patch of 30–40 long, soft hairs on apical blade (fig. 1*e*); ♀ bursa with dense packet of long, close-set spines arranged nearly in trapezoid (fig. 5*e*) . . . . 2. **spadix**

16(15). Pronotal punctures smaller than those on front, those in center generally separated by at least own diameter; elytron usually less than 8 mm long; ♂ aedeagus parallel sided until near apex and sharply tapering to acute tip 17

Pronotal punctures subequal in size to those on front; elytron usually more than 8 mm; ♂ aedeagus often with convergent sides and tapering to tip 18

17(16). Antenna same color as head and thorax; ♂ paramere evenly tapering to apical blade; outer margin of apical blade nearly straight . 9. **verberans**

Antenna usually lighter in color than head and thorax; ♂ paramere with marked constriction at base of blade; outer margin of blade rounded . . . . 10. **emissus**

18(16). Male aedeagus broad until near apex and then abruptly tapering to apex; spines of ♀ bursa confined to basal third 19

Male aedeagus slender and evenly tapering from base to apex; spines of ♀ bursa in center 20

19(18). Pronotal punctures large and separated by less than own diameter; dark reddish brown to black species; spines of ♀ bursa without large base (fig. 8*b*); ♂ genitalia as in figs. 4*a–d* . . . . 1. **similis**

Pronotal punctures smaller and central punctures separated by own diameter; reddish-brown species; spines of ♀ bursa with large, plaque-like bases (fig. 9*c*); ♂ genitalia as in figs. 4*j–l* . . . . . 8. **miscellus**

20(18). Male genitalia as in fig. 4*j* . . . . 5. **communis**

Male genitalia as in fig. 4*k* . . . . 6. **indistinctus**

Male genitalia as in fig. 4*l* . . . . 7. **dietrichi**

Americanus Group

(Mandible with pit on lateral margin)

21(4). Antennal segment 3 small, subequal to 2 (in doubtful cases of some ♀♀, 3 less than 1½ length of 2) 22

Antennal segment 3 intermediate in size between 2 and 4, clearly larger than 2 (in doubtful cases of some ♀♀, more than 1½ length of 2) 27

22(21). Small species, elytron less than 6 mm 23

Larger species, elytron more than 6 mm 24

23(22). Pronotum wider than long; pronotal punctures smaller than those on front and sparse, widely separated, equal size throughout; East Coast to Nebraska . . . . 32. **americanus**

Pronotal punctures coarse, larger than on front on anterior two-thirds and fine, sparse on basal one-third in ♂; Southwest . 36. **concisus**

24(22). Antenna exceeds tip of hind angle by 1–4 segments; parantennal fovea large; flagellar segments elongate 25

Antenna of ♂ barely exceeds tip of hind angle, ♀ antenna shorter; parantennal fovea, clearly smaller than antennal segment 2; flagellar segments triangular, not elongate; pronotal punctures large and dense; ♂ paramere with peculiar, winglike flaps near center; Texas. 38. **hamatus**

25(24). Elytron length 6–8 mm 26

Large species, elytron 8.5–11.5 mm; nasale quadrate, about as wide as high; antenna exceeds tip of hind angle by about 2 segments; ♂ paramere with definite apical blade and antennal hairs long and dense. 19. **corticinus**

26(25). Antenna very long, exceeds tip of hind angle by 2–4 segments; sides of pronotum divergent posteriorly; nasal narrow, higher than wide. 33. **cribriventris**

Antenna shorter, exceeds tip of hind angle by no more than 1 segment; sides of pronotum subparallel; nasale much wider than high. 34. **obscuratus**

27(21). Elytron more than 5 mm 28

Very small species, elytron less than 4.5 mm; nasale flat; frontal margin rounded, moderately thin and jutting; pronotal punctures nearly as large as those on front; parantennal and mandibular foveae relatively large; southeast U.S. to Texas . . . . 42. **insipiens**

28(27). Pronotal punctures and vestiture uniform except usual small increase in density and size along sides 29

Pronotal punctures change from rather sparse anteriorly to smaller and denser along posterior border, vestiture also becomes fine over same area; antenna of ♂ exceeds tip of hind angle by no more than one-half segment, ♀ antenna shorter; ♂ aedeagus broad; paramere with small apical blade; elytron about 8.5 mm long . . . . 41. **gradatus**

29(28). Parantennal fovea very large, as large or larger than antennal segment 3; nasale large and protuberant, especially in ♂; frontal margin strongly projecting, angular with blunt apex when viewed from above; elytron 8 mm or more; sides of pronotum straight behind anterior curvature and divergent posteriorly, pronotum wider than long 30

Parantennal fovea clearly smaller than antennal segment 3; not with above combination 31

30(29). Frontal margin scarcely overhanging protruding nasale, not extended in angular apex; pronotal punctures as large as those on front; ♂ paramere with apical blade; elytron 8.9–11.2 mm . . 20. **sagittarius**

Frontal margin overhanging nasale and usually curved down on sides above nasale, margin extends out sharply and ends in truncated, angular apex; pronotal punctures smaller than those on front; ♂ paramere without apical blade; elytron 8.2–9.3 mm . . . 21. **hyslopi**

31(29). Sides of pronotum straight behind small anterior curvature; hind angles large and expanded, beginning at about center of pronotum and thence noticeably divergent, carina usually long and distinct 32

Sides of pronotum concave or parallel from center to base of hind angles, which arise well behind center; not with above combination of characters 34

32(31). Parantennal fovea and nasale large and well developed, nasale about as high as wide; antenna not greatly elongate; smaller species, elytron 7.5 mm or less 33

Parantennal fovea and nasale weak, nasale wider than high; antenna very long, exceeds tip of hind angle by 3–4 segments, flagellar segments elongate and slender, 4 about twice as long as wide; pronotal punctures about as large as those on front and separated by own diameter; apex of last visible sternite slightly inflated; elytron 8.5–10 mm. 24. **difficilis**

33(32). Pronotal punctures smaller than those on front; frontal margin often rounded in center; ♂ paramere expanded at base, abruptly rounded at tip . . . . 26. **testaceus**

Pronotal punctures about same size as those on front (but widely separated); frontal margin often coming to blunt point in center; ♂ paramere slender, gently tapering to tip . . . . 27. **trapezoideus**

34(31). Frontal margin thin, shelflike, and extending in front of nasale by several times width of black rim, front with depression behind margin; parantennal fovea small 35

Frontal margin not strongly protruding 36

35(34). Pronotal punctures separated by no more than own diameter; flagellar segments elongate, ♂ antenna exceeds tip of hind angle by 3–4 segments; elytron about 7 mm . . . . 25. **macer**

Pronotal punctures sparse, separated by more than own diameter; flagellar segments triangular, antenna exceeds hind angle by no more than 2 segments; mandibular pit very small; elytron 6–7 mm. 31. **parallelus**

36(34). Antenna extending to or beyond hind margin of pronotum 37

Antenna short, ending before hind margin of pronotum in both sexes; nasale flat, shallow; ♂ paramere slender, aedeagus broad until near apex . . . . 23. **piceatus**

37(36). Nasale clearly defined, not obsolescent; color reddish brown or darker. 38

Nasale obsolescent; color brownish yellow; ♂ paramere without apical blade; pronotal punctures large and compact; vestiture rather thick; small species, elytron 5.0–6.5 mm; Texas . . . . 35. **beameri**

38(37). Antenna, legs, and body of same color 39

Antenna and legs reddish brown and body black (teneral specimens with body dark brown but darker than appendages); pronotum convex and rounded dorsally, rounded and concave at base of hind angles; central pronotal punctures small and sparse; ♂ paramere without apical blade. . . . . 29. **pertinax**

39(38). Western U.S., not occurring east of New Mexico 40

Eastern U.S. and as far west as western Texas, Kansas, etc 41

40(39). Reddish-brown species; southwestern U.S. from south of Tehachapi Mts., California to New Mexico, elytron 6.5–9.8 mm. 39. **longulus longulus**

Dark reddish-brown to black species; California north of Tehachapi Mts., Great Basin, Pacific Northwest; elytron 7.5–10.9 mm. 40. **longulus oregonensis**

41(39). Larger species, elytron more than 7.5 mm 42

Smaller species, elytron less than 7.5 mm 44

42(41). Parantennal fovea well developed; pronotal punctures well separated 43

Parantennal fovea shallow; nasale flat; pronotal punctures very close together; ♂ paramere tapering and lateral margin straight; color usually reddish brown . . . . 18. **cribulosus**

43(42). Sides of pronotum parallel or concave over distal half; pronotal punctures usually smaller than those on front; color often reddish brown. 17. **morosus**

Sides of pronotum divergent posteriorly; pronotal punctures usually as large as those on front; color usually dark reddish brown, darker than *morosus* . . . . 16. **depressus**

44(41). Nasale well developed, about as wide as high 45

Nasale flat, not protuberant, wider than high 46

45(44). Pronotal punctures about as large as those on front; pronotum flattened and not rounded . . . . 27. **trapezoideus** (part)

Pronotal punctures small, smaller than those on front; pronotum rounded . . . . 32. **americanus** (part)

46(44). Side of pronotum straight, without curvature before hind angle . . 47

Side of pronotum with slight curvature before hind angle; frontal margin broad and nearly straight when viewed from above . . 22. **prasinus**

47(46). Male paramere with definite apical blade; thorax about as long as wide; distributed in central and south central U.S 48
Male paramere without apical blade; thorax wider than long; largely distributed along east coast . . . . 28. **tenax**

48(47). Male paramere not unusually slender, base of apical blade angled at about 90° . . . . 30. **infaustus**
Male paramere very slender, base of apical blade gently rounded and not strongly angulate . . . . 37. **lanceatus**

The *similis* Group

(Mandible with pit on lateral margin)

1. *Melanotus similis* (Kirby)

FIGURES 4*a–d*, 8*b*, *c*; PLATE 1*a*

Perimecus similis Kirby, 1837, p. 149.
Melanotus similis.—Erichson, 1842, p. 116.—Candèze, 1860, p. 363.
Elater fissilis Say, 1839, p. 183. [New synonymy.]
Cratonychus fissilis.—LeConte, 1853, p. 477.
Melanotus fissilis.—Candèze, 1860, p. 352.—Blatchley, 1910, p. 750.—Van Zwaluwenburg, 1922, p. 12.—Thomas, 1941, p. 259.—Dietrich, 1945, p. 57.—Severin, 1949, p. 16.—Brooks, 1960, p. 40.
Cratonychus laticollis.—Erichson, 1842, p. 102.
Ctenonychus ochraceipennis Melsheimer, 1846, p. 150.
Melanotus ochraceipennis.—Thomas, 1941, p. 259.
Ctenonychus sphenoidalis Melsheimer, 1846, p. 150.
Melanotus sphenoidalis.—Thomas, 1941, p. 260.
Cratonychus exuberans LeConte, 1853, p. 477. [New synonymy.]
Melanotus exuberans.—Candèze, 1860, p. 354.—Thomas, 1941, p. 260.

MALE.—Body color dark reddish brown, covered with yellowish hairs evenly distributed over body.

Head: Front coarsely punctate, most punctures hexagonal shaped, distance between punctures less than half puncture diameter, center slightly protuberant; clypeus lightly punctate, parantennal fovea shallow, width of nasale 1½ to 2 times height. Mandible without pit; palpi yellowish brown. Antenna exceeds tip of hind angle by 2 segments, average ratio of segments 2:3:4=4:8:12; erect male hairs moderately dense, often sparse enough to be inconspicuous; third segment 1½ to 2 times longer than wide; outer angles of flagellar segments often lighter in color than rest of segment, usually testaceous.

Pronotum often moderately flattened and expanded; wider than long, ratio of width length=1.18 (1.06–1.25); punctures moderately coarse at center, about size of those of front, separated by distance equal to less than puncture diameter, punctures little more dense on sides and front, oval shaped except those on anterior angles hexagonal shaped as on front; hind angles divergent, often with 2 carinae; side concave before hind angle.

Elytron with punctures of striae moderately deep, separated by distance equal to less than own diameter, interstrial area at center of elytron about 3 times as wide as puncture diameter. Venter of metathorax and abdomen with evenly distributed, elongate punctures. Metacoxal plate evenly tapering to apex. Genitalia as figured; paramere with well-defined angle at tip, with about 8 hairs along outer angle of apical blade.

Elytron: 9.4 ± 0.5 mm (7.9–11.4). 180 spec.

Female.—Similar to male, larger, antenna shorter, extending to tip of hind angle. Genitalia as figured, bursa with few to large number of spines, spines short, about as long as diameter of base, accessory gland very long and slender, as long as spermathecal duct and one-half as wide, diverticulum branching near center of sperm, duct without visible blind pouch apically in usual position near spermatheca.

Elytron: 10.2 ± 0.9 mm (8.4–12.8). 120 spec.

Types.—Lectotype of *similis:* Male, "Amer. Bor./ex Mus. Murray/Frey Coll. 1905–100" (BMNH). Selected by Quate, 1960.

Types of *fissilis:* Specimens lost.

Lectotype of *laticollis:* Male, "Amer. Sept., Norwish" (ZM). Lectotype selected by Quate, 1960, from cotypes of 1 male and 5 females.

Lectotype of *ochraceipennis:* Female, "Pa./Ziegler" (MCZ). Selected by Quate, 1962. First specimen of this species in Melsheimer Collection too badly broken for positive identification and therefore not selected as lectotype.

Type of *sphenoidalis:* Male. "Pa." (MCZ). Only specimen in Melsheimer Collection.

Lectotype of *exuberans:* Male, probably Santa Fe, N. Mex. (MCZ). First specimen in type series selected by Quate, 1962. Second specimen of type series is a female belonging to the *communis* complex and is not *exuberans*.

Distribution.—Southern Canada and U.S. east of Montana, Utah, and Arizona; southwest to southern California andMexico.

Alabama: Mobile; February, June. Arizona: Apache, Cochise, Coconino, Gila, Graham, Madera, Maricopa, Pinal, Pima, Santa Cruz, Yavapai, Yuma; April, October. Arkansas: Hempstead, Lawrence, Polk, Washington; March, June. California: Riverside (Blythe); May, July. Colorado: El Paso, Montezuma (Berkeley); July, August. Connecticut: Fairfield, Hartford, Litchfield (January, reared?), Middlesex, New Haven, Tolland; May–November. Florida: Brevard, Hendry, Manatee, Orange, Osceola, Palm Beach, Seminole, Volusia; February, August. Georgia: Chatham, Floyd, Fulton, Peach, Thomas, Warren, Okefenoke Swamp; March, September. Illinois: Boone, Champaign, Cook, DeKalb, Edgar, Iroquois, Jackson, Jo Daviess, Johnson, Kanakakee, Lake McHenry, McLean, Marion, Marshall, Mason, Peoria, Putnam, Union, Vermilion; March, September. Indiana: Clark, DeKalb, Greene, Knox, Lake, Marion, Orange, Porter, Pulaski, Stark, Steuben, Tippecanoe, White; April, October.

IOWA: Buchanan, Clayton, Fayette, Floyd (reared), Franklin, Harrison, Henry, Jasper, Johnson, Muscatine, Pottawattamie, Poweshiek, Story, Woodbury; May, October. KANSAS: Atchinson, Bourbon, Clark, Decatur, Dickinson, Doniphan, Douglas, Gove, Gray, Johnson, McPherson, Miami, Norton, Osborne, Pottawatomie, Rawlins, Reno, Riley, Scott, Sedgwick, Shawnee, Sheridan, Sumner; April, August. KENTUCKY: Jefferson, Ohio: June, August. LOUISIANA: Lafourche, Orleans, Plaquemines, St. Landry, St. Tammany; January, September. MAINE: Penobscot, Washington; June, July. MARYLAND: Anne Arundel, Calvert, Harford, Montgomery, Plummers Isl., Prince Georges, Queen Annes, Washington; April, December. MASSACHUSETTS: Berkshire, Essex, Franklin, Hampden, Hampshire, Middlesex, Norfolk, Plymouth, Suffolk, Worcester; April, September. MICHIGAN: Calhoun, Cheboygan, Huron, Monroe, Oakland, Ottawa, St. Clair, Sanilac, Tuscola, Wayne; April, August. MINNESOTA: Big Stone, Dakota, Hennepin, Pope, Ramsey, St. Louis, Winona, Wright; May, August. MISSISSIPPI: George, Greene, Lauderdale, Oktibbeha; January, September. MISSOURI: Boone, Buchanan, Callaway, Cape Girardeau, Lawrence, Pike, St. Louis, Wayne; April, October. MONTANA: Custer; August. NEBRASKA: Dakota, Dawes, Dodge, Holt, Lancaster, Lincoln, Otoe, Red Willow, Scotts Bluff, Sioux, Washington; May, August. NEW HAMPSHIRE: Coos, Strafford; May, June. NEW JERSEY: Atlantic, Bergen, Burlington, Gloucester, Middlesex, Morris, Ocean; April, November. NEW MEXICO: Bernalillo, Dona Ana, Grant, Lincoln, Sandoval, San Miguel, Santa Fe, Socorro; June, August. NEW YORK: Albany, Cattaraugus, Cayuga, Clinton, Columbia, Cortland, Delaware, Dutchess, Erie, Essex, Franklin, Greene, Herkimer, Jefferson, Madison, Monroe, Nassau, New York, Niagara, Oneida, Ontario, Orange, Orleans, Oswego, Queens, St. Lawrence, Suffolk, Sullivan, Tompkins, Ulster, Warren, Wayne, Westchester, Wyoming, Yates; March, October. NORTH CAROLINA: Buncombe, Chowan, Iredell, Pasquotank, Polk, Richmond, Swain, Wake, Watauga, Wilson; April, July. NORTH DAKOTA: Cass, Grand Forks; June. OHIO: Ashtabula, Athens, Delaware, Fairfield, Franklin, Fulton, Greene, Hamilton, Hocking, Holmes, Lucas, Pike, Preble, Summit, Warren; May, October. OKLAHOMA: Atoka, Cleveland, Latimer, Oklahoma, Tulsa; March, July. PENNSYLVANIA: Adams, Allegheny, Bradford, Dauphin, Delaware, Erie, Franklin, Lehigh, Lycoming, Montgomery, Northampton, Philadelphia, Sullivan, Susquehanna, Westmoreland, York; March, October (Janaury and December, reared or in hibernation?). RHODE ISLAND: Washington; June, July. SOUTH CAROLINA: Oconee; April, August. SOUTH DAKOTA: Brookings, Codington, Sanborn, Union; June, July. TENNESSEE: Davidson, Knox, Morgan, Sevier, Smith; January, August. TEXAS: Anderson, Bexar, Brazos, Brewster, Cameron, Colemen, Dallas, Goliad, Jeff Davis, Jim Wells, Lamar, Lubbock, Palo Pinto, Presidio, Smith, Shelby, Travis, Victoria, Wallers, Wharton, Wilbarger, Williamson; February, September. UTAH: Cache, San Juan, Utah, Washington, Zion Canyon; June, July. VERMONT: Orange, Windham; May. VIRGINIA: Fairfax, Montgomery, Nelson; June. WASHINGTON, D.C.: March, December. WEST VIRGINIA: Greenbrier, Lewis, Preston; July, August. WISCONSIN: Bayfield, Columbia, Dane, Dodge, Grant, Jefferson, Lafayette, Rock, Sauk, Trempealeau, Waukesha; June, November. MANITOBA: Aweme, Killarney, Winnipeg; June, August. NOVA SCOTIA: Annapolis Royal; June. ONTARIO: Belleville, Muskoka, Ottawa, Prince Edward, Ridgeway, Sudbury, Toronto; May, July. QUEBEC: Aylmer, Montreal, Mt. St. Hilaire, Rigaud, St. Johns; June, August.

It is regrettable that the widely used name *fissilis* has to be replaced by the unfamiliar *similis;* however, both Mr. Lane and the senior author have examined types of *similis*, and there is no doubt that that species is the same as the one known as *fissilis*.

Melanotus similis exhibits a good deal of variation throughout its range. Variations in the ratio of the thoracic width to length, in the size of the pronotal punctures, in the shape of the distal enlargement of the male paramere, and the spines of the female bursa have been observed. Some of the variation appears in a regular pattern with an east-west cline and some is oriented in a north-south pattern in an irregular manner. The two patterns are noncorrelated and independent of each other (fig. 2).

The eastern populations of *M. similis* have a relatively wider pronotum which generally narrows to the west and finally the narrowest pronotum is found in the Southwest. There is an approximate east-west clinal variation, but this is irregular through the Midwest. Table 1 shows the ratios of the pronotal length/width. There is no significant difference between adjacent populations, but, as shown in the chart, there are significant differences between nonadjacent populations. All measurements were made of males with dissected genitalia. Females are not included because samples of uniform sizes were not available in dissected specimens; however, less extensive analysis of females indicates that a similar pattern also exists in that sex.

The male genitalia show variation roughly correlated with the pronotal width/length ratio. No satisfactory means of expressing the difference qualitatively was found, but the differences in various parts of the range are illustrated in figures 5*a–e*. Generally, the distal enlargement of the paramere is longer and the subapical indentation is more abrupt in eastern populations, but there is less constancy than in the pronotal variation and only a weak clinal trend is noted. From a taxonomic viewpoint, the differences are not great enough to cause difficulty with identification, and the male genitalia are the most reliable criteria for recognition of the species.

The female genitalia display marked differences in the number of spines on the bursa. Females can be sorted roughly into three classes on the basis of the bursal spines. In the northern and western part of its range, the three types are found with a little dominance of the "normal" type, which has few spines; in the southeastern United States there is almost exclusively the "spiny" type, which has a large number of spines (fig. 2). There are intermediates to the two types which unite them in a gradient series, and no formal taxonomic discrimination is warranted.

Ratio of width/length of pronotum of *Melanotus similis* (analysis based on 20 males from each area, total of 140 specimens):

New York	*Illinois*	*Iowa Missouri*	*Kansas*	*Lincoln, Nebraska*	*North Platte, Nebraska*	*Arizona*
1. 20	1. 19	1. 17	1. 16	1. 17	1. 14	1. 12

LSD 0.01=0.024

In the southwestern United States there is a form which has been described under the name *exuberans*. Many specimens of this form appear quite different from typical *similis*—the punctures of the pronotum are more coarse and dense, the pronotum is narrower, the distal enlargement of the paramere is smaller, and the indentation is gradual and not abrupt. Viewed apart, this form does appear to be a distinct species, but the complete picture shows it is connected with other *similis* forms by an intergrading series. The shape of the pronotum and genitalia appears to be merely an extreme extension of the clinal trend described above, and southwestern specimens are more similar to specimens from western Nebraska, Kansas, Texas, and eastern Colorado than to eastern populations. The narrower pronotum and smaller genitalia are characteristic of the western populations; furthermore, in the same locality one finds typical "*exuberans*" types intermediated with clear intergrades to typical *similis*. Specimens have been seen with the coarse pronotal punctation of "*exuberans*," typical *similis* genitalia, and others with the opposite combination. Some are intermediate between the two forms in both features. Females possess the "spiny" bursa and are quite like other *similis* females except that generally they have coarser pronotal punctation. It therefore appears that "*exuberans*" is a synonym of *similis* and represents a geographical variant not defined well enough to justify segregating it as a separate taxon. (A similar, though less well documented, trend to larger pronotal punctures and a narrower pronotum was also noted in *communis* from the Southwest.)

Most specimens identified by Mr. Lane or by us will be labelled in collections as *M. fissilis* Say.

2. *Melanotus spadix* (Erichson)

Figures 4*e*, 8*e*

Cratonychus spadix Erichson, 1842, p. 103.
Melanotus spadix.—Candèze, 1860, p. 354.
Melanotus abdominalis of authors, not Erichson, 1842.
Melanotus decumanus.—Dietrich (not Erichson), 1945, p. 55.

Male.—Large species, body color reddish brown to dark reddish brown, covered with yellowish hairs evenly distributed over body.

Head: Front coarsely punctate, most punctures hexagonal shaped, distance between punctures less than half puncture diameter, surface sometimes with slight, broad depression anteriorly, frontal margin evenly convex, not strongly protuberant; parantennal fovea very shallow. Mandible without pit; palpi reddish to yellowish brown. Antenna exceeds tip of hind angle by about 2 segments, erect male hairs usually very dense and readily observed; average ratio of segments 2:3:4=4:8:13, segment 4 slender, about twice as long as maximum width (10:6), outer parts of flagellar segment lighter in color than rest of segment.

Pronotum wider than long, ratio of width/length=1.2; punctures about same size as those of front, at center separated by distance equal to puncture diameter or less, little more dense on sides and front, oval in shape except those on anterior angles hexagonal shaped as on front; hind angles divergent, with single, strong, dark carina; sides divergent and nearly straight to about two-thirds distance from front, rather sharply angled before concavity in front of hind angles.

Elytron and venter of thorax and abdomen as in *similis*. Genitalia as figured; paramere with well-defined angle at tip, large cluster of 30–40 long hairs along outer part of apical blade.

Elytron: 10.8±0.97 mm (8.5–13.0). 30 spec.

Female.—Similar to male; larger in size, antenna shorter. Genitalia as figured; bursa nearly trapezoidal with numerous spines compacted to extent that bursa appears sclerotized; spermathecal duct without diverticulum.

Elytron: 11.3±0.84 mm (10.8–12.6). 12 spec.

Type.—Holotype of *spadix:* Male, "Amer. Sept." (ZM 17035). Only specimen in type series.

Distribution.—Eastern U.S. west to Nebraska and Arkansas.

Arkansas: Washington; July. Florida: Manatee; March. Georgia: Clarke, Fulton, Habersham; April, July. Illinois: Piatt, Whiteside; June. Indiana: Clark, Lake; June, July, December. Maryland: Anne Arundel, Baltimore, Montgomery, Plummer's Is.; May, June. Michigan: Marquette, Oceana; June, July. Montana: Barry; June. Nebraska: Washington; June. New Jersey: Atlantic, Burlingtion, Middlesex, Ocean; May–August. New York: Erie, Queens, Suffolk; May–July. North Carolina: Moore, Polk; May. Pennsylvania: Dauphin; August. South Carolina: Oconee; June. Tennessee: Sevier; June. Virginia: Gloucester, Nelson; May, June.

M. spadix is closely allied to *M. similis* but is usually larger and lighter in color, and antennal segment 4 is more slender. For positive identifications, however, it is usually necessary to examine the dissected genitalia. The male genitalia of the two species are quite dissimilar, and *spadix* males are easily recognized by the large tuft of hairs covering the whole surface of the lateral part of the gonostyle apical lobe. The female genitalia are also conspicuously different, and the densely spined bursa of *spadix* bears little resemblance to that of *similis*.

Many specimens identified by Mr. Lane and by us will be labelled as *M. abdominalis* since this name is believed to be the correct one for *spadix*, but study of the types of *abdominalis* reveals it is an unfamiliar species which apparently does not occur in North America.

3. *Melanotus decumanus* (Erichson)

FIGURES 4*f*–*h*, 8*d*; PLATE 1*b*

Cratonychus decumanus Erichson, 1842, p. 104.—LeConte, 1853, p. 474.
Melanotus decumanus.—Candèze, 1860, p. 341.—Blatchley, 1910, p. 749.—Thomas, 1941, p. 258.—Severin, 1949, p. 15.—Fattig, 1951, p. 20.
Cratonychus cuneatus LeConte, 1853, p. 473.
Melanotus cuneatus.—Thomas, 1941, p. 258.
Cratonychus incertus LeConte, 1853, p. 474.
Melanotus canadensis Candèze, 1860, p. 342.—Blatchley, 1910, p. 751.—Thomas, 1941, p. 258.—Dietrich, 1945, p. 55.

MALE.—Large species, body color dark reddish brown, covered with yellowish hairs evenly distributed over body.

Head: Front coarsely punctate, most punctures hexagonal shaped, distance between punctures less than half puncture diameter, surface with broad depression anteriorly, margin strongly jutting and forming noticeable shelf above clypeus; parantennal fovea very shallow, usually teardrop shaped. Mandible without pit; palpi reddish to yellowish brown. Antenna about exceeds tip of hind angle by 1½ segments, erect male hairs dense and easily observed, average ratio of segments 2:3:4 varies from 5:10:20 to 5:8:19, segments 4 and following longer and more slender than *similis*.

Pronotum wider than long, ratio of width/length =1.2, a little flattened dorsally, punctures about same size as those on front, at center separated by distance equal to puncture diameter or less, little more dense on sides and front, oval in shape except those on anterior angles hexagonal shaped as on front; hind angles divergent, with single, strong, black carina, and often a second smaller one; sides divergent and nearly straight to about two-thirds distance from base, rather sharply angled before concavity in front of hind angles.

Elytron and venter of metathorax and abdomen as in *similis*. Genitalia as figured, paramere straight or with gently sloping sides basad of apical blade, blade with 8 hairs.

Elytron: 11.2±0.6 mm (10.0–12.4). 33 spec.

FEMALE.—Similar to male. Larger, antenna little shorter. Genitalia as figured; bursa completely devoid of spines or sometimes with patch of 5–8 small spines (like those of *similis*) on either side of bursa near base.

Elytron: 12.2±0.8 mm (10.0–14.1). 47 spec.

TYPES.—Holotype of *decumanus:* Female, "Amer. Sept." (ZM). Only specimen in type series.

Lectotype of *cuneatus:* Male, labelled with orange circle (Southern States). (MCZ). First specimen of type series selected as lectotype by authors in 1962.

Lectotype of *incertus:* Male, labelled with green circle "Middle States." (MCZ). First specimen to type series selected as lectotype by authors in 1962.

Holotype of *canadensis:* Male, "Canada" (BMNH).

DISTRIBUTION.—Eastern U.S. and Canada west to South Dakota, Colorado, and New Mexico.

ALABAMA: Mobile; May. CONNECTICUT: Fairfield, Hartford, New Haven; March, August. GEORGIA: Bibb, Clarke, Crawford, DeKalb, Fayette, Fulton, Richmond, Walton; April, June. INDIANA: Greene, Vigo; June, October. ILLINOIS: Champaign, Marshall; May, June. IOWA: Dickinson, Woodbury; July. KANSAS: Douglas, Greenwood, Leavenworth, McPherson, Reno; May, June. KENTUCKY: no data. MARYLAND: Montgomery; June. MASSACHUSETTS: Hampshire, Middlesex; June. MICHIGAN: Cheboygan; July. NEBRASKA: Cuming, Dakota, Lancaster, Lincoln, Otoe, Thomas; May, June. NEW HAMPSHIRE: Strafford; June. NEW JERSEY: Atlantic, Bergen, Essex, Monmouth, Montclair, Morris, Ocean, Passaic; June, July. NEW MEXICO: Bernalillo, Sandoval; May, June. NEW YORK: Cattaraugus, Greene, Kings, Nassau, Tompkins, Westchester; June, July. NORTH CAROLINA: Beaufort, Brunswick, Buncombe, Columbus, Duplin, Hyde, Jackson, Johnston, Montgomery, Wake; May, June. OHIO: Clark, Erie, Hamilton; May, July. PENNSYLVANIA: Delaware, Northampton, Philadelphia; June, September. RHODE ISLAND: Washington; June, July. SOUTH CAROLINA: Aiken, Dorchester, Edgefield, Florence, Oconee; May, June. SOUTH DAKOTA: Brookings, Union; June. TENNESSEE: Smith. VIRGINIA: Alexandria, Dinwiddie, Essex, Faquier, Nelson, Nottaway, Prince Edward; May, June. NOVA SCOTIA: Annapolis; June.

The large, jutting frons of *M. decumanus* is usually sufficient to distinguish this species from *M. similis, spadix,* and *castanipes;* it is variable, however, and there are specimens that have a reduced frontal margin which might cause them to be confused with the other species. The females often have a smaller margin than males. The male genitalia differ from *similis* in the gradual expansion of the paramere basad of the apical blade but can be confused with some *similis* in which the enlargement is not abrupt. The female bursa is strikingly different from that of the allied species with the complete lack of spines.

4. *Melanotus castanipes* (Paykull)

FIGURES 4*i*, 8*f*; PLATE 1*c*

Elater castanipes Paykull, 1800, p. 23.

Cratonychus castanipes.—Erichson, 1842, p. 95.

Melanotus castanipes.—Redtenbacher, 1849, p. 249.—Schwartz, 1892, p. 152 [as a synonym of *rufipes*].—Putzeys, 1908, p. 294 (larva).—Blatchley, 1910, p. 746.—Binaghi, 1939, p. 224.—Thomas, 1941, p. 257.—Dietrich, 1945, p. 54.—Severin, 1949, p. 15.—Fattig, 1951, p. 19.—Jeuniaux, 1955, p. 234.

Melanotus paradoxus Melsheimer, 1846, p. 152.
Cratonychus paradoxus.—LeConte, 1853, p. 480.
Cratonychus inaequalis LeConte, 1853, p. 476.
Melanotus inaequalis.—Leng, 1920, p. 174.—Thomas, 1941, p. 258.
Cratonychus scrobicollis LeConte, 1853, p. 476.
Melanotus scrobicollis.—Leng, 1920, p. 174.—Thomas, 1941, p. 258.—Fattig, 1951, p. 19.
Melanotus texanus Candèze, 1860, p. 351.

Male.—Large species, body color reddish to dark reddish brown, covered with yellowish hairs evenly distributed over body.

Head: Front coarsely punctate, most punctures hexagonal shaped, distance between punctures less than half puncture diameter, surface often with shallow depression on disc, margin not protuberant, extending little beyond level of clypeus, rounded, weakened in center and when viewed from directly in front appears obliterated; parantennal fovea very shallow. Mandible without pit; palpi yellowish brown. Antenna exceeds tip of hind angle by about 3 segments, segments 2 and 3 small, much smaller than 4, ratio of 2:3:4=5:7:17.

Pronotum wider than long, punctures about same size as those of front, little deeper than in *similis*, at center separated by distance equal to puncture diameter or less, little more dense on sides and front, oval in shape except those on anterior angles hexagonal shaped as on front; hind angles divergent, with single, strong, black carina; sides markedly divergent beyond center, appear thinner than usual.

Genitalia as figured; paramere with large apical blade, side nearly straight basad of blade.

Elytron: 11.2±0.7 mm (9.9–12.6). 50 spec.

Female.—Similar to male, but larger. Antennal segments 2 and 3 not as small, ratio of 2:3:4=7:9:17. Pronotum is fuller and does not have thin appearance toward margin. Genitalia as figured; bursa with numerous, long spines on basal ¾ arranged so densely to give bursa sclerotized, striated appearance, apical ¼ membranous except small patch of spines; accessory gland distinctly clavate.

Elytron: 12.7±0.7 mm (10.8–14.1). 50 spec.

Types.—Types of *castanipes:* 3 males, 2 females; 1 labelled with red and green tags and "213/61," others only with green tag (Riksmuseum, Stockholm). These are presumed to be Paykull's types, but no lectotype has been selected because we feel that the validity of these types may be questioned.

Lectotype of *paradoxus:* Male, no collection data (MCZ). Only specimen in type series.

Lectotype of *inaequalis:* Female, labelled with pale blue circle "Lake Superior" (MCZ). First specimen in type series selected as lectotype by authors, 1962.

Lectotype of *scrobicollis:* Male, labelled with pink circle "Middle States" (MCZ). Third specimen in type series selected as lectotype by authors in 1962. First specimen with broken antennae and second specimen, apparently male, doubtfully referred to this species.

Type of *texanus:* Female, "Texas, Jansen Coll. ex Candèze 1903, 130," (BMNH).

Distribution.—Holarctic. Southeastern Canada, eastern U.S. west to Utah, Arizona, southern California, Mexico.

Arizona: Coconino, Pima; June, July. California: "S. Cal." Colorado: Larimer, "Waldo Canon"; June, July. Illinois: McHenry; May. Maine: Penobscot; June, July. Massachusetts: Suffolk; May. Michigan: Alpena, Crawford, Marquette, Oakland; June, July. Minnesota: St. Louis. New Hampshire: Carroll, Cheshire, Coos; April, August. New Mexico: San Miguel. New York: Cattaraugus, Cortland, Erie, Essex, Niagara, Oswego, Tompkins, Warren; March, September. North Carolina: Wake; June. Ohio: Summit; May. Pennsylvania: Carbon; June. Rhode Island: Washington; August. Utah: Juab, Utah; January, July. Wisconsin: Dodge, Milwaukee; May, July. Nova Scotia: Bridgetown; July. Ontario: Prince Edward; May. Quebec: Mt. St. Hilaire, Regaud, Deparquest, Hull, Aylmer, Hudson; May, July. Mexico: El Salto Diego, June.

With its large size and small second and third antennal segments, the male of *castanipes* is not difficult to recognize; it is easily separable from *ignobilis* by the shape of the flagellar segments. The females are more difficult to identify, since the third antennal segment is larger and more nearly intermediate between the second and fourth, which makes it similar to *spadix* or *similis*. The weakened frontal margin, when viewed from directly in front, is the most useful external character for separating *castanipes*, but in doubtful cases only the dissected genitalia will provide a reliable answer.

M. castanipes is a widely distributed and variable species. Large series from throughout its range might show it divides into subspecies, but, from our rather limited material, we can only point out the pattern of variation we observe without applying names to any of the variants. Throughout the species there is sexual dimorphism with the females larger, the edges of the pronotum less flattened laterally, the frontal margin less jutting, and the third antennal segment longer. Specimens from the eastern United States are observably different from those in the Southwest and the Great Plains. The western specimens are smaller (male average elytron length is 10.7 mm compared to overall average elytron length of 11.2 mm), and the pronotum is more strongly flattened laterally and often more strongly divergent posteriorly. The most conspicuous variation of the western specimens is the thin, jutting frontal margin which often contrasts sharply with the flattened or rounded, obsolescent margin in eastern specimens.

These differences are more strongly marked in males than in females, but the trend is parallel in the two sexes. The distinctive genitalic characters in both the male and female, however, are constant throughout the range of the species.

Two females from Europe have been dissected and examined. No observable differences are noted between these specimens and American ones and, externally, they are similar to the eastern forms described above. The female internal genitalia is precisely as the American specimens. The bursa bears a dense patch of spines centrally and a smaller, separated patch distally. The accessory gland is enlarged, clublike apically and the spermathecal duct branches as shown in the illustration.

Specimens examined: 1 ♀, Skane, Sweden, "Stromberg Det."; I.N.H.S. 1 ♀, Germany (?), Andreas Bolter Collection; I.N.H.S.

Melanotus rufipes (Herbst) is a European species closely related to *castanipes*, and the synonymizing of the two species as proposed long ago by Schwartz (1892) would seem warranted; however, we accept the decision of recent students of the European fauna who regard the two species as distinct (Binaghi, 1939; Jeuniaux, 1955).

5. *Melanotus communis* (Gyllenhal)

FIGURES 4*j*, 9*a*,*b*; PLATE 1*d*

Elater communis Gyllenhal, 1817, p. 138.—Say, 1839, p. 184.
Perimecus communis.—Kirby, 1837, p. 148.
Cratonychus communis.—Erichson, 1842, p. 102.—LeConte, 1853, p. 477.
Melanotus communis.—Emmons, 1854, p. 88.—Candèze, 1860, p. 353.—Comstock and Slingerland, 1891, p. 262.—Blatchley, 1910, p. 750.—Hyslop, 1916, p. 5.—van Zwaluwenburg, 1922, p. 12.—Fenton, 1926, p. 502.—Thomas, 1941, p. 259.—Dietrich, 1945, p. 57.—Jewett, 1946, p. 10.—Fattig, 1951, p. 20.
Melanotus paganus Candèze, 1860, p. 359.

MALE.—Body color reddish brown, covered with white or yellow vestiture evenly distributed over body, specimens in Southwest often darker.

Head: Front coarsely punctate, punctures rounded hexagonal, separated by distance equal to less than own diameter, surface with transverse depression anteriorly, sometimes very weak or reduced to pair of shallow, anterolateral depressions, margin black or dark reddish brown, not strongly protuberant above clypeus; clypeus lightly punctate, parantennal fovea shallow, comma shaped, width of interfoveal area 1½–2 times height. Mandible without pit; palpi yellowish brown. Antenna 1 or 2 segments longer than pronotum, reddish brown, usually outer angles of flagellar segments testaceous and usually with median, dark brown, longitudinal streak on each side of flagellar segments; ratio of segments 2:3:4=4:7:9, segment 4 about 1½ times as long as maximum width; erect male hairs short and rather sparse.

Pronotum wider than long, ratio of width/length=1.22 (1.16–1.30, S.D.=0.03, 100 spec.); punctures at center usually separated by distance equal to more than own diameter, denser on margins, punctures often larger in specimens from Southwest; hind angles divergent, often with two carinae, lateral carina extending little anterior of base of hind angle, median carina, when present, shorter and weaker than lateral; side concave before hind angle.

Genitalia as figured; paramere with small indentation marking apical blade, aedeagus evenly tapering to acute apex.

Elytron: 9.0±0.5 mm (8.1–10.1). 50 spec.

Female: Similar to male. Genitalia as figured; accessory gland, spermathecal duct, and diverticulum originate close together near apex of bursa, bursal spines tacklike, large, conspicuous.

Elytron: 9.0±0.7 mm (7.1–10.6 mm). 40 spec.

Types.—Lectotype of *communis:* Male, "Amer. Bor. ??—401/62" (Schöenherr Collection, Riksmuseum, Stockholm). First of two specimens in type series selected as lectotype by Quate, 1962.

Lectotype of *paganus:* Female, "Amer. Bor., Coll. Janson, Ex Dejean" (BMNH). First of two specimens in type series selected as lectotype by Quate, 1960.

Two females from the Zoologiska Instit., Uppsala, were sent to us when we requested the loan of *communis* types. These belong to the species *morosus* and we believe they are not the type specimens of Gyllenhal.

Distribution.—Eastern U.S. west to South Dakota, Oklahoma, and Texas.

Alabama: Mobile; March. Arizona: Graham; August. Arkansas: Hempstead, Washington; April, June. Connecticut: Hartford, Litchfield, Middlesex, New Haven, Tolland; (Jan.), March–November. Colorado: Pingree Pk. (County?); August. Florida: Dade, Palm Beach; May, July. Georgia: Fulton, Harris; June. Illinois: Champaign, Cook, Gallatin, Lake, Piatt, Pike, Pope, Union, Vermilion, Wabash; March–September. Indiana: Clark, Greene, Pulaski, Spencer, Starke, Tippecanoe; April–September. Iowa: Decatur, Henry, Scott; April–May. Kansas: Barton, Douglas, Gray, Reno, Republic; June–July. Kentucky: Jefferson; March. Louisiana: East Baton Rouge, Saint Tammany; June. Maryland: Calvert, Harford, Prince Georges, Washington; February–November. Massachusetts: Essex, Franklin, Hampden, Hampshire; April–September. Michigan: Kent, Monroe, Ottawa, Washtenaw; April–June. Minnesota: St. Louis, no date. Mississippi: George; April–May. Missouri: Boone, Callaway, Mississippi, Phelps, St. Louis, Stoddard; March–November. Nebraska: Cherry, Lancaster, Lincoln, Sarpy; April–July. New Jersey: Bergen, Burleigh, Burlington, Camden, Essex, Middlesex, Morris, Ocean, Union; February–September. New York: Dutchess, Erie, Nassau, Niagara, Orange, Rockland. Schenectady, Tompkins, Wayne, Westchester; March–December. North Carolina: Wake (Mills River); June, September. Ohio: Athens, Franklin, Hocking, Richland; March, November. Oklahoma: Woodward; June. Pennsylvania: Allegheny, Bucks, Philadelphia, York; March–September. South Carolina: Oconee; September, December. South Dakota: Bon Homme, Brookings, Union; June–July. Tennessee: Montgomery; April. Texas: Harrison, Gonzales; April, June. Virginia: Alexandria, Canal, Fairfax, Loudoun, Nottaway, Spotsylvania; March–December. Washington, D.C.: March–September. West Virginia: Marion; no date.

6. *Melanotus indistinctus* Quate, new species

Figures 4*k*, 9*f*,*g*

Male.—Same as *communis*, but average size smaller, a little darker in color, frontal margin little wider than black border, parantennal fovea small but distinct, and pronotal punctures somewhat larger and denser. Genitalia with slender, tapering aedeagus, paramere shorter and thicker in *communis*, emargination before blade deeper and more marked, blade broader and shorter.

Elytron: Holotype 8.2 mm; paratypes 8.3±0.5 mm (7.4–9.4). 50 spec.

Female.—Not clearly separable from *communis* (see discussion below).

Distribution.—Virginia west to Kansas, Oklahoma, and Texas.

Holotype, male (USNM): Pittsfield, Pike Co., Ill., July 6, 1946, A. T. McClay.

Paratypes, 122 males (USNM, CU, ILL, U. Mo., U. Nebr., TEX AM, CAS, Lane Coll'n): Illinois: same as holotype, July 5–9, 1946; same, June 24, July 1, 7, 9, 1947, B. Cadwell; La Clede, Fayette Co., July 7, 1950, Ross and Sanderson; Shawneetown, Gallatin Co., June 14, 1934, Ross and DeLong; Havana, Mason Co., July 8, 1910, at light; Harrisburg, Saline Co., June 25, 1932, Ross, Dozier, Park; Dubois, Washington Co., July 2, 1909, at light; Fox Ridge St. Pk., July 9, 1944. Virginia: Holland, Nansemond Co., April 28, 1947, W. D. Fronk. Kentucky: no other data. Mississippi: Lincoln Co., May 18, 1938, peach tree, W. F. Turner. Missouri: St. Louis, August 12, 1935, June 22, 1937, USDA traps; Webster Groves, St. Louis, May 31, 1919, June 17, 1919, Satterthwait; Charleston, Mississippi Co., June 12, 1917, Satterthwait; Columbia, Boone Co., May 4, 1940, W. R. Enns; same, June 15, 1907, R. H. Wolcott; same, July 14, 1941, H. E. Brown; Lathrop, Clinton Co., July 3, 1948, E. C. Becker. Louisiana: Shreveport, Caddo Co., June 2, 1949, J. H. Robinson; Olivier, Iberia Co., April 1904, E. S. G. Titus; Leesville, Vernon Co., May 1948, H. S. Fitch. Arkansas: Clark Co., May 12, 1939, M. W. Sanderson; Hope, Hempstead Co., April 30, 1925, April 23, 1926, May 17, 1926, July 5, 1926, June 25, 1931, L. Knobel; Hempstead Co., May 8, 1939, Sanderson and Van Dyke; Miller Co., May 8, 1939, Sanderson; Fayetteville, Washington Co., May 31, 1942, at light, Sanderson; Washington Co., May 30, 1938, Sanderson and C. Cameron. Kansas: Medora, Reno Co., July 3; same, July 14, 1926, J. W. McColloch. Oklahoma: Muse, LeFlore Co., May 7, 1939, Sanderson. Texas: Luling, Gonzales Co., May 2, 1953, B. J. Adelson; Tyler, Smith Co., May 20, 1942, L. D. Christenson, Bronson, Sabine Co., May 30, 1945, J. H. Robinson; Tyler, Smith Co., March 24, 1939, L. S. Jones. "So. McAlester, Ind. T., June 11, Wickham." Cherokee Co., May 5, 1952, June 1, 1952, light trap; Smith Co., April 6, 14, 1956, April 24, 1937, May 2, 1956; Nacogdoches, Nacogdoches Co., March 28, 1940.

Other specimens: TENNESSEE: Milan, Gibson Co., June 2. TEXAS: Orange, Orange Co., June 20, 1949, W. C. Stehr.

Only from Pittsfield, Ill., do we have a good series of females associated with males. In this series there appear to be two types: one is indistinguishable from *communis*, and the other has large bursa spines; the spermathecal duct branches farther from the bursa, and the bursa surface is coarsely reticulate. It is possible that the second type represents the female of *indistinctus*, but, since the evidence is not unequivocal, we have not definitely identified any of the females nor included them in the type series.

This species will be found in some collections identified by Lane as "species 20."

7. *Melanotus dietrichi* Quate, new species

FIGURES 4*l*, 9*d,e*

Melanotus communis var. A.—Dietrich, 1945, p. 57.—Severin, 1949, p. 16.

MALE.—Same as *communis* in all features except male genitalia. Male genitalia with very narrow aedeagus and paramere, paramere with elongate blade at tip and several hairs.

Elytron: Holotype 8.7 mm; paratypes 9.9+0.4 mm (8.8–10.6). 60 spec.

FEMALE.—Unknown (or inseparable from *communis*).

DISTRIBUTION.—Connecticut to Pennsylvania, west to Iowa.

Holotype, male (CU): Fairmont, Marion Co., W. Va., March 24, 1930, P. N. Musgrave.

Paratypes, 67 males (USNM, CU, ILL, CIS, U. Mo., Ohio U., Lane Coll'n): NEW YORK: Poughkeepsie, Dutchess Co., June 19, 1933, P. J. Chapman; Staatsburg, Dutchess Co., June 23, 1934, H. Dietrich; Rhinebeck, Dutchess Co., Nov. 5, 1934, Dietrich; Yonkers, Westchester Co., Nov. 21, 1940; Kensico,? Co., April 27, 1935, J. A. Angell. NEW JERSEY: Teaneck, Bergen Co., October 1923; Brookdale, Essex Co., April 24, 1916, E. R. Kolmbach. CONNECTICUT: New Canaan, Fairfield Co., Sept. 24, 1919, M. P. Zappe. WASHINGTON, D.C.: Rock Creek, Dec. 30, 1906; same, April 21, 1907, C. E. Burden. MARYLAND: Cumberland, Allegany Co., Nov. 4, 1915, W. F. Pennington; Woliville,? Co., May 2, 1913. WEST VIRGINIA: same as holotype. OHIO: Columbus, H. H. P. Severin; Athens, Athens Co., Sept. 25, 1949, P. J. Spangler; same, June 26, 1935, A. Sintic; same, April, June, Oct., Nov., Dec., W. C. Stehr; Ames Twp., Athens Co., April 24, 1934, Stehr; Delaware Co., April 1921, D. J. & J. N. Knull. INDIANA: Beverly Shores, Porter Co., Aug. 6, 1932. ILLINOIS: Summit, Cook Co., April 17, 1908; Vermilion Co., April 25, 1926, K. F. Auden. IOWA: Ames, Story Co., June 19, 1926; same, July 2, 1931, W. C. Stehr. LOUISIANA: Baton Rouge, June 20, 1916, T. H. Jones.

Other specimens: CONNECTICUT: Middlesex Co., April. NEW YORK: Columbia Co., June, Queens Co. PENNSYLVANIA: Westmoreland Co., June, July. MARYLAND: Allegany Co., Nov. OHIO: Athens Co., June, July. WEST

VIRGINIA: Fayette Co., TENNESSEE: Knox Co., May. IOWA: Henry Co., April.

8. *Melanotus miscellus* Quate, new species

FIGURES 4*n*, 9*c*

Melanotus communis var. B.—Dietrich, 1945, p. 57.—Severin, 1949, p. 16.

MALE.—Same as *communis*, except averages little smaller in size, often darker reddish brown, and genitalia differ in being shorter, aedeagus wider, paramere thicker, and with broader and shorter apical blade, blade with dense cluster of hairs. Ratio of pronotal width/length=1.2 (1.1–1.3).

Elytron, holotype 8.9 mm; paratypes 8.5±0.4 mm (7.6–9.7). 40 spec.

FEMALE.—Similar to male except sexual differences. Genitalia as figured; differs from *communis* in that spines of bursa nearer apex, spermathecal duct, spermathecal duct diverticulum and accessory gland arise independently from bursa, accessory gland base far removed from base of spermathecal duct.

Elytron: Allotype 8.7 mm; paratypes, 8.5±0.4 mm (7.8–9.5). 19 spec.

DISTRIBUTION.—Ontario, eastern U.S. west to Illinois.

Holotype, male and allotype, female (USNM): Chapel Hill, Orange Co., N.C., Feb. 3, 1935.

Paratypes, 52 males, 41 females (USNM, CU, ILL, NU, CAS): same data as holotype and allotype. MARYLAND: Sparrows Pt., Baltimore, July 3, 1932, J. W. Green; Edgewood, Harford Co., Nov. 3, 1918, H. Dietrich. VIRGINIA: Pennington Gap, Lee Co., Hubbard and Schwarz. FLORIDA: Apalachicola, Franklin Co., *Taxodium distishum*, W. F. Fiske. GEORGIA: Savannah, Chatham Co., March 9, 1940, Van Dyke. MISSISSIPPI: Lucedale, George Co., Feb. 27, 1931, March 22, 1932, H. Dietrich; New Augusta, Perry Co., Feb. 12, 1931, H. Dietrich. INDIANA: LaPorte Co., June 9, 1953, wheat, K. Pruess. ILLINOIS: Homer, Champaign Co., March 30, 1907, Hart and Hood; Mahomet, Champaign Co., Sept. 13, 1933, H. H. Ross; St. Joseph, Champaign Co., May 4, 1913; Dec. 24, 1944, J. L. C. Rapp; Riverside Wds., Cook Co., Sept. 13, 1949, W. Tietz; Western Springs, Cook Co., June 16, 1949, Ross and Stannard; Willow Springs, Cook Co., May 12, 1921; Havana, Mason Co., July 11, 1948, Sanderson, Stannard, Becker; White Heath, Piatt Co., March 20, 1942, Ross and Riegel; April 6, 1926, K. F. Auden; Allendale, Wabash Co., April 30, 1950, Smith and Stannard; Benson, Woodford Co., Oct. 11, 1933, Frison and Ross. ONTARIO: Prince Edward Co., April 16, June 12, July 15, 1922.

This species appears intermediate between *similis* and *communis*. External characters of color and pronotal punctures resemble *communis*, but the male genitalia more closely resemble *similis;* the position of spines of the female bursa is as in *similis*, but the shape of the spines is like that of *communis*. The genitalia structures, however, are distinct and although not easily recognized, seem constant. The larvae, according to Lane (in litt.), are also distinctive.

This species will be found in some collections identified by Lane as "species 2."

9. *Melanotus verberans* (LeConte)

FIGURES 4*m*, 9*i*; PLATE 1*e*

Cratonychus verberans LeConte, 1853, p. 478.
Melanotus verberans.—Candèze, 1860, p. 356.—Blatchley, 1910, p. 753.—Thomas, 1941, p. 260.

MALE.—Same as *communis*, except generally smaller in size and usually reddish brown, but some specimens darker, antenna and thorax usually concolorous, erect male hairs in antenna dense and conspicuous, with smaller and sparser pronotal punctures, genitalia with aedeagus nearly parallel sided and abruptly tapering to apex, paramere rather broad and with little curvature basad of apical blade. Ratio of pronotal width/length=1.2 (1.1–1.3).

Elytron: 7.7±0.45 mm (6.9–8.3). 9 spec.

FEMALE.—Similar to male except sexual differences. Genitalia as figured; differs from *communis* in that apex of bursa more bulbous and truncate, spermathecal duct diverticulum branches at or near base of duct.

Elytron: 6.8–7.4 mm.

TYPES.—Lectotype of *verberans:* Male, labelled with pink circle "Md." (MCZ). Only specimen now in type series, selected as lectotype by authors in 1962; location of second type unknown.

DISTRIBUTION.—Maryland to Florida and west to South Dakota and Texas.

ALABAMA: Locality?; January. ARKANSAS: Washington; May. FLORIDA: Pinellas; March, May. GEORGIA: Ribb, Peach; April, June. ILLINOIS: Mason; July. INDIANA: Tippecanoe; April. KANSAS: No data. MARYLAND: Baltimore; July. MISSISSIPPI: Forrest, George; January, April. NEBRASKA: Lancaster; May. NEW JERSEY: Middlesex; April. NEW YORK: Essex, Niagara; May, November. NORTH CAROLINA: Duplin, Moore, Orange, Wake, Wayne; April, May, October. OHIO: Athens; November. SOUTH CAROLINA: Bamberg, Oconee; May, July, December. SOUTH DAKOTA: Bon Homme; June. TEXAS: Bowie, Victoria; March. VIRGINIA: Fairfax; April.

10. *Melanotus emissus* (LeConte)

FIGURES 4*o*, 9*k*; PLATE 1*h*

Cratonychus emissus LeConte, 1853, p. 478.
Melanotus emissus.—Candèze, 1860, p. 372.—Thomas, 1941, p. 260.

MALE.—Similar to *verberans;* antenna reddish brown and lighter than rest of body, which is generally dark reddish brown, erect male hairs of antenna dense and conspicuous, hind angles of pronotum sometimes lighter in color than rest of pronotum, pronotal punctures denser. Genitalia differ in being shorter, aedeagus wider (but not as wide as *verberans*), apical blade broader, and bearing four bristles.

Elytron: 6.6±0.6 mm (5.9–8.4). 32 spec.

FEMALE.—Not positively identified (see discussion below).

TYPE.—Holotype of *emissus:* Male, labelled with orange circle "Ga." (MCZ). Damaged specimen only one in type series.

DISTRIBUTION.—Maryland and North Carolina west to South Dakota and Kansas.

ALABAMA: Mobile; April. IOWA: Story; June. KANSAS: Douglas; no date. MARYLAND: Baltimore; July. NEBRASKA: Lancaster; July. NORTH CAROLINA: Bladen, New Hanover, Pender; May. SOUTH DAKOTA: Union, Yankton; June, July. VIRGINIA: Elizabeth City; May.

In the material studied there are two different females associated with the males on the basis of similarity in appearance and locality. One seems to be the same as the female of *verberans* and the other a distinct form (fig. 9*k*). The latter, from Ash, N.C., is tentatively assigned to *emissus* but not with certainty. This also poses the question as to the proper association of sexes in *verberans*, but that cannot be answered at this time.

11. *Melanotus lanei* Quate, new species

FIGURES 5*a*, 9*h*; PLATE 1*f*

MALE.—Same as *communis*, but smaller in size, generally darker in color; antenna as in *communis*, ratio of segments 2:3:4=5:9:12, segment 4 about 1½ times as long as wide; pronotum narrower, ratio of width/length=1.0–1.1, vestiture thicker, pronotal punctures smaller and denser; genitalia shorter, aedeagus evenly tapering from base to apex.

Elytron: Holotype 6.6 mm; paratypes 6.7±0.6 mm (5.9–8.2). 17 spec.

FEMALE.—Same as male, but larger. Genitalia as *communis* with diverticulum branching from spermathecal duct, differs from *communis* in that bursa has fewer spines, from 15 to 20 (allotype with 17).

Elytron: Allotype 8.0 mm; paratypes 7.6±0.5 mm (6.7–8.7). 21 spec.

DISTRIBUTION.—Pennsylvania south to Florida and west to South Dakota and Kansas.

Holotype, male, allotype, female (USNM): Lincoln, Nebraska, July 2, 1957, black light trap.

Paratypes, 9 males, 13 females (USNM, NU, CAS, MCL). Washington, D.C., May 22, Hubbard and Schwarz. PENNSYLVANIA: Darby, Delaware Co., July 4. IOWA Ames, Story Co., June 6, 1931, J. F. Glawe; same, June 10, 1925. SOUTH DAKOTA: Brookings, June 22, 1943, H. C. Severin; Kimball, Brule Co., June 17, 1947, Severin; Turner Co., June 15, 1929, Severin. NEBRASKA: Lincoln, June 27, 1909, F. H. Shoemaker; Fairmont, Fillmore Co., June 17, 1914, G. W. Denning;

Bradshaw, York Co., July 9, 1917, *Amaranthus*, E. J. Yates. KANSAS: Douglas Co., J. C. Bridwell; Topeka, Popenoe. ARKANSAS: Hope, Hempstead Co., May 19, 1931, June 11, 1954, J. W. Green; "Vinita, Ind. T., June 7–8, '99, Wickham." FLORIDA: Lake City, Columbia Co., 1933, Wickham.

It is a pleasure to dedicate this species to M. C. Lane in recognition of his long and diligent studies of the Elateridae that are greatly advancing the taxonomic knowledge of this large family.

12. *Melanotus pilosus* Blatchley

FIGURES 5*b*, 9*l*; PLATE 1*g*

Melanotus pilosus Blatchley, 1910, p. 751.—Fenton, 1926, p. 502.—Blatchley, 1930, p. 35.—Dietrich, 1945, p. 59.

MALE.—Similar to *communis*, but smaller and more densely covered with whitish or gray vestiture; antenna with erect hairs very dense, segment 3 short, ratio of segments 2:3:4=4:7:12, segment 4 broad, twice as long as wide; frontal margin very thin, upturned and nearly straight on center rather than rounded; pronotal punctures smaller and denser than *communis;* paramere with short, broad apical blade and deep indentation basad of blade.

Elytron: 6.9±0.4 mm (6.4–8.0). 24 spec.

FEMALE.—Similar to male, bursa small, with about 30 spines, spines with large bases; spermathecal duct and diverticulum arising separately from bursa; accessory gland far basad of spermathecal duct.

Elytron: 6.9 mm (6.5–7.2).

TYPE.—Holotype: Male, Posey Co., Ind., June 6, 1904, Blatchley (PU).

DISTRIBUTION.—Central U.S.

ARKANSAS: Washington; May. ILLINOIS: Wabash; June. INDIANA: Bartholomew; Tippecanoe; June. IOWA: Linn; June. KANSAS: Riley, Sedgwick; June. MONTANA: Big Springs St. Pk.; June. NEBRASKA: Antelope, Chase, Custer, Keith, Lancaster, Lincoln, Scotts Bluff; June. OKLAHOMA: Hayes; July.

13. *Melanotus opacicollis* LeConte

FIGURES 5*d,e*, 9*j*; PLATE 1*i*

Melanotus opacicollis LeConte, 1866, p. 390.—Blatchley, 1910, p. 751.

MALE.—Similar to *communis* but vestiture of pronotum very dense, velvety, pronotal punctures numerous, dense, and so close together as to appear granulose; frontal margin thin and protruding. Genitalia with evenly tapering aedeagus, paramere with marked indentation below blade, slightly sinuous before center.

Elytron: 7.2 mm (6.9–7.5). 4 spec.

FEMALE.—Similar to male. Bursa with 6 to 11 spines, much less numerous than *communis*, spermathecal duct diverticulum branches from spermathecal duct at distance clearly distal of base of duct.

Elytron: 8.0 ± 0.5 mm (7.1–8.8). 18 spec.

TYPES.—Lectotype: Female, "Ill./477" (MCZ). First specimen in type series selected as lectotype by authors in 1962.

DISTRIBUTION.—Indiana and Mississippi, west to Kansas.

ARKANSAS: Hempstead; May. ILLINOIS: Greene, Marion, Rock Is.; May, June. INDIANA: Owen; July. IOWA: no other data. KANSAS: Linn, Montgomery, Riley; June. LOUISIANA; ? Co.; May. MISSISSIPPI: George, Greene; May. MONTANA: Boone, Callaway, Clinton, Jackson; May, July.

14. *Melanotus clandestinus* (Erichson)

FIGURE 5*f*

Cratonychus clandestinus Erichson, 1842, p. 112.—LeConte, 1853, p. 474.
Melanotus clandestinus.—Candèze, 1860, p. 343.—Thomas, 1941, p. 258.—Dietrich, 1945, p. 55.—Fattig, 1951, p. 20.
Melanotus peninsularis Candèze, 1889, p. 46.—Fattig, 1951, p. 22. [New synonymy.]
Melanotus perplexus Blatchley, 1920, p. 46; 1930, p. 44.—Fattig, 1951, p. 22.

MALE.—Body color reddish brown, head and pronotum usually darker than appendages and elytra, covered with white (sometimes yellowish) vestiture evenly distributed over body.

Head: Front with prominent anterior transverse depression, margin strongly protuberant above clypeus, a little angulate and blunt across center when viewed from above; parantennal fovea obsolescent, nasale not at all developed. Mandible without pit. Antenna exceeds pronotum by 1–1½ segments, ratio of segments 2:3:4=2:2:7, segment 4 about 1½ as long as maximum width; erect male hairs long and very dense.

Pronotum about as long as wide (variable and apparently Texas specimens usually narrower), punctures very dense and subequal to those on front, vestiture little finer than on elytra; sides rounded, with slight concavity at base of hind angles; hind angle subparallel, each with single carina extending slightly beyond base of hind angle.

Genitalia as figured; paramere without apical blade.

Elytron: 5.9 ± 0.5 mm (5.0–6.9). 47 spec.

FEMALE.—Unknown to us.

TYPES.—Lectotype of *clandestinus:* Male, "Amer. Sept." No. 17056 (ZM). Selected by Quate, 1960. One other specimen in type series.

Lectotype of *peninsularis:* Male, "Florida, ex. coll. Morrison" (Roy. Mus. Nat. Hist., Brussels). Selected by Quate, 1960. Eight other males in type series.

Holotype of *perplexus:* Male, Dunedin, Fla., July 5, 1915, W.S.B. (PU).

DISTRIBUTION.—New Jersey south to Florida and west to Texas.

ALABAMA: Mobile; July. FLORIDA: Highlands, Hillsborough, Lee, Levy, Palm Beach, Pinellas, Suwannee, Volusia; May, July. MISSISSIPPI: George, Jackson, Pearl River; June. NEW JERSEY: Atlantic, Burlington, Cape May, Ocean; June, August. NORTH CAROLINA: Columbus, Johnston, Moore; June, July. SOUTH CAROLINA: Charleston; May. TEXAS: Bexar; July.

M. clandestinus is one of the few, small species with the elytra less than 7 mm. It is easily recognized by the dense pronotal punctures, small third antennal segment, lack of parantennal fovea and mandibular pit, in addition to the small size.

15. *Melanotus ignobilis* Melsheimer

FIGURES 5*g*, 10*a*

Melanotus ignobilis Melsheimer, 1846, p. 152.—Candèze, 1860, p. 371.—Blatchley, 1910, p. 746.—Thomas, 1941, p. 258.—Dietrich, 1945, p. 55.—Jewett, 1946, p. 9.—Severin, 1949, p. 16.
Cratonychus ignobilis.—LeConte, 1853, p. 474.
Cratonychus secretus LeConte, 1853, p. 474. [New synonymy.]
Melanotus secretus.—Candèze, 1860, p. 344.—Thomas, 1941, p. 258.—Deen and Cuthbert, 1955, p. 193.—Fattig, 1951, p. 20.

MALE.—Body color dark reddish brown, but some specimens lighter, covered with yellowish vestiture evenly distributed over body.

Head: Front with shallow anterior transverse depression, margin very narrow, not strongly protuberant above clypeus, evenly rounded or anteriorly flattened when viewed from above; parantennal fovea small and shallow, nasale flattened, width usually twice height. Mandible without pit. Antenna exceeds tip of hind angle by 1–2 segments, largely testaceous with reddish-brown streak on either side, lighter in color than rest of body; segments 2 and 3 subequal, ratio of 2:3:4=2:3:6, flagellar segments nearly quadrangular; segment 4 about twice as long as maximum width; erect male hairs short but dense.

Pronotum usually wider than long, ratio of width/length=1.0–1.2; punctures at center usually separated by distance equal to less than own diameter, subequal to those on front, denser on margins; sides of pronotum rounded with slight concavity at base of hind angles, hind angles subparallel with one strong carina extending well cephalad of base. Genitalia as figured; paramere without apical blade.

Elytron: 7.2 mm (5.2–9.3). 13 spec.

FEMALE.—Antenna short of pronotal base by about 1 segment; segment 3 about 1½ times 2, but about ½ times 4; internal genitalia as figured, bursa with 3 groups of dense, setiform spines near apex; accessory gland short and clavate, spermathecal duct very short, diverticulum arising near center of duct.

Elytron: 7.6 mm (5.2–10.0). 24 spec.

Types.—Lectotype of *ignobilis*: Male, no data (MCZ). Unlabelled specimen in LeConte Collection, assumed to be type, agrees with our interpretation of the species; to forestall possible confusion, specimen selected as lectotype by authors in 1962.

Lectotype of *secretus*: Male, labelled with orange circle "Southern States" (MCZ 2510). First specimen of type series selected as lectotype by authors in 1962.

Distribution.—New York south to Florida and west to South Dakota and Texas.

Alabama: Colbert, Mobile; May, June. Arkansas: Washington; June, July. Florida: Highlands, Alachua, Putnam, Volusia; April, May. Georgia: Charlton, Fulton; July. Illinois: Marshall, Putnam; June, July. Indiana: Clark; June. Louisiana: Madison; June, July. Mississippi: Greene, Jackson, Perry; May, July. Montana: Phelps, St. Louis; June. Nebraska: Lancaster; July. New Jersey: Ocean; June, July. New York: Niagara, Tompkins; July. North Carolina: Wake; June. Pennsylvania: Dauphin; June. South Carolina: Charleston, Oconee; March, July. South Dakota: Brookings; July. Tennessee: Morgan; June, August. Texas: McCulloch; July.

M. ignobilis is a distinctive species easily recognized by the short third antennal segment, quadrate yellowish flagellar segments, lack of mandibular pit, and dense pronotal punctures. The female internal genitalia are quite different from any other North American *Melanotus*, and the male genitalia are also markedly different from other species.

We can find no significant differences between *secretus* and *ignobilis*. The former name was applied to smaller specimens of *ignobilis* which often have the prothorax as long as wide and are usually lighter in color. The male and female genitalia of these smaller, lighter colored specimens do not differ from *ignobilis*, and we consider them as a part of the variation range of that species; hence, *secretus* is synonymized with *ignobilis*.

The *americanus* Group

(Mandible with pit)

16. *Melanotus depressus* (Melsheimer)

Figures 5*i*, 10*b*; Plate 1*j*

Ctenonychus depressus Melsheimer, 1846, p. 151.
Cratonychus depressus.—LeConte, 1853, p. 475.
Melanotus depressus.—Candèze, 1860, p. 345.—Blatchley, 1910, p. 755.—Thomas, 1941, p. 258.—Dietrich, 1945, p. 55.—Fattig, 1951, p. 20.
Ctenonychus parumpunctatus Melsheimer, 1846, p. 151.
Cratonychus parumpunctatus.—LeConte, 1853, p. 478.
Melanotus parumpunctatus.—Candèze, 1860, p. 355.—Blatchley, 1910, p. 754.—Thomas, 1941, p. 260.—Dietrich, 1945, p. 57.—Fattig, 1951, p. 21.

Melanotus divarcarinus Blatchley, 1910, p. 754.—Thomas, 1941, p. 259.—Dietrich, 1945, p. 56.—Severin, 1949, p. 16.—Deen and Cuthbert, 1955, p. 193. [New synonymy.]
Melanotus lixus Blatchley, 1910, p. 754. [New synonymy.]

Male.—Body color dark reddish brown, covered with white or yellow hairs evenly distributed over body.

Head: Front with pair of shallow anterolateral depressions not strongly protuberant above clypeus, evenly rounded or a little angulate and flattened when viewed from above, parantennal fovea crescent shaped, small, but moderately deep and well defined; nasale obsolescent. Mandible with shallow, slitlike pit. Antenna exceeds tip of hind angle by 1 to 1½ segments; reddish brown, ratio of segments 2:3:4=3:5:6, segment 4 about twice as long as maximum width; erect male hairs short but dense.

Pronotum wider than long; punctures at center usually separated by distance equal to little less or little more than own diameter, equal to or little smaller than those on front; sides of pronotum straight behind small anterior curvature, divergent posteriorly; hind angles subparallel, strong carina extending cephalad of base of hind angle Genitalia as figured; paramere without apical blade.

Elytron: 8.7±0.6 mm (6.5–10.2). 85 spec.

Female.—Similar to male. Pronotum with sides often more strongly divergent; antenna exceeds pronotum by ½–1 segment; internal genitalia as figured, bursa long and coiled in loop, with scattered, peglike spines nearly throughout entire length, accessory gland originates near base, clavate, spermathecal duct branches near base.

Elytron: 9.3±0.7 mm (8.2–10.2). 44 spec.

Types.—Lectotype of *depressus:* Male, labelled with red label "PA." (MCZ). First species of type series selected as lectotype by authors in 1962.

Lectotype of *parumpunctatus:* Female, labelled with red label "Pa." (MCZ). First specimen of type series selected as lectotype by authors in 1962. Second specimen is *ignobilis.*

Holotype of *divarcarinus:* Male, Posey Co., Ind., June 2, 1909, W. S. B. (PU).

Holotype of *lixus:* Female, Posey Co., Ind., July 6, 1912, W. S. B. (PU).

Distribution.—Connecticut to North Carolina, west to Nebraska and Texas.

Arkansas: Benton, Hempstead, Pike, Washington; May, July. Connecticut: Fairfield, New Hampshire; June. Georgia: Catoosa, Fulton, Gwinnett, Lumpkin, Moran, White, Worth; May, July. Illinois: Champaign, Clay, Jackson, Johnson, Kane, Marion, McLean, Peoria, Pope, Putnam, Rock Island, Scott, Union, Vermilion, Washington; April, July. INDIANA: Spencer, Tippecanoe; June. IOWA: Henry, Story; June, August. KANSAS: Chautaugua, Cowley, Douglas, Miami, Montgomery, Riley; May, June. KENTUCKY: Jefferson; June. LOUISIANA: Madison; June. MARYLAND: Anne Arundel, Washington; June, July. MISSISSIPPI: George, Greene; April, May. MONTANA: Callaway, Clinton, Jefferson, Lawrence, St. Louis, Webster; April, July. NEBRASKA: Cass, Dakota, Lancaster; June. NEW JERSEY: Lakehurst, Morris, Ocean, Warren; June, August. NEW YORK: Dutchess, Essex, Seneca, Tompkins; May, July. NORTH CAROLINA: Guilford; June. OHIO: Clifton, Delaware, Erie, Franklin, Greene, Hocking, Pickaway, Ross; May, July. OKLAHOMA: Payne, Sequoyah; July. PENNSYLVANIA: Adams, Allegheny, Northampton, Philadelphia; May, July. TENNESSEE: Sevier; June. TEXAS: Bexar, Brazos, Brewster, Dallas, Kerr, Madison, Val Verde; April, July. VIRGINIA: Fairfax, Loudoun; May, July. WASHINGTON, D.C.: June. WEST VIRGINIA: Greenbrier; July.

Melanotus depressus is subject to considerable variation. Most conspicuous is the range in overall size. The variation in elytron length from 6.5–10.2 mm is about as large as any North American *Melanotus*. There appears to exist a cline in the males with size of the elytron diminishing to the west and south, as shown in the following chart. Curiously, the female does not appear to vary in the same way.

Variation in elytron length of *M. depressus* (average length in mm):

East Coast to Indiana		*Arkansas, Illinois*	*Missouri*	*Kansas*	*Nebraska*	*Texas*
♂	♀	♂	♀	♂	♀	♂
9.3	9.1	8.8	9.3	8.5	9.3	7.9

Nonclinal variation exists in the size of the parantennal fovea and mandibular pit. The pronotal punctures vary in size and density but are almost always as large as those on the front, which are larger than in *morosus*, and never as compact as in *cribulosus*. The sides of the pronotum are usually markedly divergent and are a useful feature in identifying the species when one is familiar with it. Few specimens have the sides subparallel and lack the characteristic wedge shape.

Other than a broader than usual aedeagus seen in some northern specimens, the male genitalia are constant. The female genitalia also show little variation and are characteristic of the species. We have found the genitalia to be reliable features of identification, and dissected specimens can be identified positively with little difficulty.

The bulk of specimens of the "americanus group" which we have seen belong to either *morosus* or *depressus*. We have dissected a large number of specimens to verify our identifications. We concluded that there are only two species in this section of the genus. We can find nothing to support the recognition of the third species. The type of *parumpunctatus* appears to us to be *depressus*, and it is within the size range of that species. *M. depressus* has page priority over *parumpunctatus* and is the preferred name.

17. *Melanotus morosus* Candèze

FIGURES 5*h*, 10*e*

Cratonychus longulus LeConte, 1853, p. 480. [Not LeConte, 1853, p. 473.]
Melanotus morosus Candèze, 1860, p. 346.—Fattig, 1951, p. 22.
Melanotus debilis Blatchley, 1910, p. 754; 1930, p. 36. [New synonymy.]
Melanotus simulans Blatchley, 1927, p. 140; 1930, p. 48.—Fattig, 1951, p. 22.

MALE.—Body color reddish brown, covered with white hairs, evenly distributed over body.

Head: Front with shallow or no anterior depression, margin not strongly protuberant above clypeus, evenly rounded or flattened anteriorly; parantennal fovea moderately large and deep, circular; nasale about 1½ times as wide as high. Mandible with deep teardrop-shaped pit; palpus light reddish brown. Antenna exceeds tip of hind angle by 1–2 segments, reddish brown, ratio of segments 2:3:4=3:5:6, segment 4 about twice as long as maximum width; erect male hairs short but dense and easily seen.

Pronotum wider than long, ratio of width/length=1.04–1.18; punctures at center usually separated by distance equal to more than own diameter, smaller than punctures on front; sides of pronotum usually straight behind anterior curvature and subparallel, but often rounded with concavity at base of hind angles; hind angles slightly divergent, carina usually extending cephalad of base of hind angle. Genitalia as figured; paramere without apical blade.

Elytron: 7.8±0.6 mm (6.3–8.8). 40 spec.

FEMALE.—Antenna extends to or beyond base of pronotum by 1 segment; genitalia as figured, bursa with very dense, shaggy appearing, quadrate patch of setiform spines and few peglike spines on apical extension, accessory gland very slender, spermathecal duct branches near center.

Elytron: 8.1±0.6 mm (7.0–9.0). 20 spec.

TYPES.—Lectotype of *longulus:* Male, labelled with orange circle "Southern States" (MCZ 2524). First specimen of type series selected as lectotype by authors in 1962. Second and 3rd specimens not true types, labelled "Tex."; 4th specimen apparently *infaustus.*

Holotype of *debilis:* Female, Marshall Co., Ind., June 26, 1904, W.S.B. (PU).

Lectotype of *simulans:* Male, Dunedin, Fla., Mar. 15, 1918, W.S.B. (PU).

In the Institut Royal des Science Naturelles, Brussels, there is a male from Iowa City, Iowa, labelled as the type of *morosus.* In the British Museum (Natural History) there is another female from Georgia labelled as the type of *morosus.* Neither of these specimens are true types, since *morosus* is a substitute name for the secondary homonym *longulus*, and the types of *morosus* Candèze are those selected by LeConte for *longulus* (1853, p. 480, not 1853, p. 473).

DISTRIBUTION.—Quebec to Florida and west to Nebraska and Texas.

ALABAMA: Mobile; June. ARKANSAS: Clark, Hempstead, Lawrence; April, June. CONNECTICUT: Tolland; May. FLORIDA: Manatee, Osceola, Pinellas; March. GEORGIA: Catoosa, Clarke, Cobb, Fulton, Hall, Rabun, Seminole, Thomas; March, June. ILLINOIS: Champaign, Cook, Knox, Putnam, Scott, Washington; May, July (Nov.). MARYLAND: Anne Arundel, Baltimore, Harford, Prince Georges; June, October. MASSACHUSETTS: Barnstable, Middlesex, Nantucket, Worcester; May, July. MISSISSIPPI: George, Greene, Harrison, Lamar; April, May. MONTANA: Jefferson, Lawrence, St. Louis; April, July. NEBRASKA: Douglas; June. NEW HAMPSHIRE: Carroll; July. NEW JERSEY: Atlantic, Camden, Ocean; May, August. NEW YORK: Orange, Suffolk, Tompkins, Washington; June, August. NORTH CAROLINA: Buncombe, Duplin, Hyde, Moore, Sampson, Swain, Wake, Wayne; April, July. OHIO: Adams, Delaware, Fairfield, Franklin, Greene, Hocking, Scioto; June, August. PENNSYLVANIA: Allegheny, Indiana, Monroe, Northampton, Philadelphia; April, July. SOUTH CAROLINA: Oconee; April. TENNESSEE: Carter, Sevier; June, September. TEXAS: Bastrop; April. VIRGINIA: Fairfax, Fauquier, Prince Edward; May. WASHINGTON, D.C.: April, June. ONTARIO: "Go Home Bay"; June. QUEBEC: Windsor Co.; July.

M. morosus is most likely to be confused with *depressus*. In general, *morosus* may be separated from that species by the small pronotal punctures, subparallel sides of the pronotum with pronounced anterior curve, and a more slender, jutting frontal margin. Less frequently, *morosus* is lighter in color than *depressus*. Typical specimens are not difficult to identify when one is familiar with the characters, but small variations (artificial or natural) make it necessary to dissect the genitalia for positive identification. The thick mat of spines in the bursa easily identifies the females. The male genitalia are characterized by the angulate paramere, rather than evenly rounded as in *depressus*, the moderately dense hairs at the apex of the paramere, and the rather broad, tapering aedeagus.

Specimens from Florida are usually smaller and the pronotal width/length ratio is more variable, but they do not seem to differ significantly from other *morosus*. *M. simulans* is regarded as a synonym of *morosus*.

18. *Melanotus cribulosus* (LeConte)

FIGURES 5*j*, 10*d*

Cratonychus cribulosus LeConte, 1853, p. 478.
Melanotus cribulosus.—Candèze, 1860, p. 357.—Hyslop, 1915, p. 17.—Thomas, 1941, p. 260.—Severin, 1949, p. 17.—Srivastava, 1958, p. 87.

MALE.—Body color reddish brown, covered with fairly dense whitish hairs evenly distributed over body.

Head: Front with shallow depression, margin not strongly protuberant above clypeus, rounded to flat when viewed from above; parantennal fovea small, but well defined; nasale obsolescent. Mandible with pit variable from ovoid to slit shaped. Antenna exceeds tip of hind angle by ½ to 1½ segments, reddish brown, ratio of segments 2:3:4=2.5:4:5, segment 4 about 1½ times as long as maximum width; erect male hairs very short and inconspicuous.

Pronotum wider than long, ratio of width/length=1.05–1.13; punctures at center usually separated by distance equal to less than own diameter, as large as those on front; sides of pronotum mostly straight behind moderate anterior curvature, with slight concavity at base of hind angles; hind angles divergent, carina extending cephalad of base of hind angle. Genitalia as figured; paramere without apical blade.

Elytron: 7.5±0.4 mm (6.4–8.5). 24 spec.

FEMALE.—Similar to male, except antenna slightly shorter in comparison to pronotum; genitalia as figured, bursa with few naillike spines with large bases, accessory gland short and clavate, spermathecal duct branches near base.

Elytron: 7.2–7.3 mm.

TYPES.—Lectotype of *cribulosus:* Male, labelled with green circle "Nebr. Terr." (MCZ 2519). First specimen of type series selected as lectotype by authors in 1962.

DISTRIBUTION.—Central U.S.

ILLINOIS: Champaign, Kane, Mason, McHenry, Warren; June, July. KANSAS: Cowley, Douglas, Gove, Greenwood, Gray, Kingman; June, July. NEBRASKA: Lancaster, Saline; June, July. OKLAHOMA: Cleveland; April, May. SOUTH DAKOTA: Haakon; June.

In superficial appearance, *cribulosus* looks like a member of the *communis* complex; however, the mandibular pit removes it from that group. The shallow parantennal fovea and dense pronotal punctures distinguish it from other members of the *americanus* group.

19. *Melanotus corticinus* (Say)

FIGURES 5*n*, 10*i*

Elater corticinus Say, 1823, p. 174; 1839, p. 183.
Cratonychus corticinus.—LeConte, 1853, p. 473.
Cratonychus vetulus Erichson, 1842, p. 105. [New synonymy.]
Melanotus vetulus.—Leng, 1920, p. 175.
Melanotus glandicolor Melsheimer, 1846, p. 152.—Emmons, 1854, p. 88.—Candèze, 1860, p. 371.—Blatchley, 1910, p. 745.—Thomas, 1941, p. 259.
Cratonychus glandicolor.—LeConte, 1853, p. 477.

MALE.—Body color reddish brown, covered with whitish vestiture, evenly distributed over body.

Head: Front with shallow depressions, margin thick, dark reddish brown, not strongly protuberant above clypeus, angulate and blunt when viewed from above; parantennal fovea large, deep and rounded, foveal tragus weakly developed; nasale usually as wide as or a little less than height, well developed. Mandible with large slitlike pit; palpus reddish brown, antenna exceeds tip of hind angle by 2 or 3 segments, segments 2 and 3 subequal, flagellar segments elongate and slender, segment 4 about twice as long as maximum width, erect male hairs sparse, but long and easily seen.

Pronotum wider than long; punctures in center usually separated by distance equal to less than own diameter, equal to size of punctures on front; sides of pronotum straight and divergent posteriorly with slight anterior curvature, hind angles divergent with carina usually extending little cephalad of base. Genitalia as figured; paramere with apical blade.

Elytron: 10.6 mm (10.1–11.8). 11 spec.

Female.—Similar to male; antenna 3 a little larger than 2, but still much smaller than 4, so not intermediate in size between 2 and 4; genitalia as figured, accessory gland slender, bursa with moderate number of tacklike spines.

Elytron: 11.8 mm (11.0–12.7). 7 spec.

Types.—Types of *corticinus:* "United States," specimens lost.

Lectotype of *glandicolor:* Female, no locality data, but stated to be Pa. (MCZ). First specimen of type series selected as lectotype by authors in 1962, but other 2 specimens probably not true types.

Holotype of *vetulus:* Female, "America Sept." (ZM). Only specimen in type series.

Distribution.—Ontario, eastern U.S. west to Illinois and Missouri.

Illinois: Kankakee, Vermilion; June, July. Indiana: Clark; June. Maryland: Baltimore; June. Montana: Montgomery; May. New Jersey: Warren; June. North Carolina: Buncombe; June. Pennsylvania: Adams; May. Tennessee: Sevier; June. Virginia: Norfolk; May. Ontario: Pr. Edward.

Melanotus corticinus is one of the more easily identified species; the small third antennal segment, large parantennal fovea, and large size make its recognition relatively easy. Females with a larger third antennal segment may cause a little trouble in running through the key, but even though the third segment is larger than the second, it is not intermediate in size between the second and fourth and should not be taken out in the wrong part of the couplet.

20. *Melanotus sagittarius* (LeConte)

Figures 5*m*, 10*c*; Plate 1*k*

Cratonychus sagittarius LeConte, 1853, p. 480.

Melanotus sagittarius.—Candèze, 1860, p. 547.—Blatchley, 1910, p. 751.—Thomas, 1941, p. 260.—Dietrich, 1945, p. 58.
Melanotus carinus Blatchley, 1910, p. 752; 1930, p. 35. [New synonymy.]

MALE.—Body color reddish brown, covered with yellowish vestiture, evenly distributed over body.

Head: Front with pair of shallow anterolateral or an anterior transverse depression, margin angulate with blunt apex when viewed from above, not strongly protuberant above clypeus; parantennal fovea large and deep, as long as antennal segment 2, opening rounded, foveal tragus weakly developed; nasale protuberant, width 1 to 1$\frac{3}{10}$ times height. Mandible with deep, teardrop-shaped pit. Antenna exceeds tip of hind angle by 2 to 2$\frac{1}{2}$ segments, reddish brown, ratio of segments 2:3:4=3:6:9, flagellar segments rather elongate, segment 4 about twice as long as maximum width; erect male hairs long, rather dense, and easily seen.

Pronotum wider than long, ratio of width/length=1.14(1.05–1.22); punctures at center usually separated by distance equal to about own diameter, subequal to size of those on front; sides of pronotum nearly straight beyond small anterior curvature, sometimes with slight concavity at base of hind angle. Genitalia as figured; paramere with apical blade.

Elytron: 9.90±0.54 mm (8.70–10.80). 50 spec.

FEMALE.—Antenna exceeds tip of pronotum by 1 to 1$\frac{1}{2}$ segments; genitalia as figured, bursa with moderate number of peglike spines; accessory gland little longer than bursa, arises well before sperm duct; sperm duct branches near base.

Elytron: 10.2±0.9 mm (8.5–12.0). 31 spec.

TYPES.—Lectotype of *sagittarius:* Male, labelled with white circle "Eastern States & Canada" (MCZ). First specimen in type series selected as lectotype by authors in 1962. Second specimen labelled with pink circle "Middle States" is probably the type mentioned in the description but is damaged and cannot be identified definitely, so has not been selected. There appears no question that LeConte studied the first specimen and that it agrees with current interpretation of *sagittarius*, and its selection as the lectotype will fix the name of the species without disturbing the present nomenclature.

Holotype of *carinus:* Male, Lake Co., Ind., June 4, 1905 (PU).

DISTRIBUTION.—New York to Florida and west to Illinois.

FLORIDA: Pinellas; February, April. ILLINOIS: Putnam; July. INDIANA: Marion; May. MARYLAND: Baltimore; July. MASSACHUSETTS: Hampshire, Middlesex; June, July. MISSISSIPPI: George; April. NEW JERSEY: Middlesex; July. NEW YORK: Dutchess, Rockland, Tompkins, Westchester; June, July. OHIO: Athens; June. PENNSYLVANIA: Allegheny, Bradford, Monroe; May, July. VIRGINIA: Page; July. WEST VIRGINIA: Hardy; July.

21. *Melanotus hyslopi* Van Zwaluwenburg

Figures 5*l*, 10*f*

Melanotus hyslopi Van Zwaluwenburg, 1921, p. 210.—Thomas, 1941, p. 261.—Dietrich, 1945, p. 59.—Fattig, 1951, p. 22.

Male.—Body color reddish brown, covered with white or yellowish vestiture, evenly distributed over body.

Head: Front with pair of shallow anterolateral depressions, not strongly protuberant above clypeus, angularly produced into truncated projection when viewed from above; parantennal fovea large and deep, excavated as deep as length of antennal segment 2, crescent shaped, foveal tragus weakly developed; nasale strongly protuberant, as wide as high. Mandible with deep, rounded, or ovate pit. Antenna exceeds tip of hind angle by 2–3 segments, segment 3 intermediate to 2 and 4, reddish brown, flagellar segments rather elongate, segment 4 about twice as long as maximum width; erect male hairs long, but sparse.

Pronotum wider than long, ratio of width/length=1.05–1.18; punctures at center usually separated by distance equal to more than twice own diameter, smaller than those on front; sides of pronotum straight behind anterior curvature and divergent posteriorly; hind angles divergent, with carina usually extending well cephalad of base of hind angle. Genitalia as figured; paramere without apical blade.

Elytron: 8.5±0.3 (7.6–9.1). 60 spec.

Female.—Antenna exceeds tip of hind angle by 1½–2 segments; internal genitalia as figured, bursa with large swelling at base of accessory gland, gland clavate, elongate apex of bursa looped, spermathecal duct branches near base, diverticulum very short and curled.

Elytron: 8.7±0.4 mm (7.6–9.4). 55 spec.

Type.—Holotype: Male, South Mountain, Md. (USNM 24561). Not studied by authors.

Distribution.—New Hampshire south to North Carolina and west to Wisconsin and Illinois.

Connecticut: Litchfield; June. Illinois: Champaign, McHenry; July, September. Maryland: Anne Arundel, Baltimore, Frederick; June, July. Massachusetts: Barnstable, Bristol, Essex, Hampshire, Middlesex; June, August. Michigan: Oceana; August. Mississippi: Forrest; April. New Hampshire: Carroll; August. New Jersey: Atlantic, Bergen, Camden, Ocean; May, July. New York: Erie, Essex, Niagara, Rockland, Suffolk, Sullivan, Tompkins; May, September. North Carolina: Buncombe, Macon; July. Ohio: Delaware, Fairfield, Hocking, Summit; May, July. Pennsylvania: Dauphin, Monroe, Northampton, Philadelphia; May, July. Tennessee: Sevier; June, July. Virginia: Giles, Rockbridge; July, August. Wisconsin: No other data. Ontario: Pr. Edward Co.; June.

M. hyslopi and *sagittarius* have larger parantennal fovea than any other North American *Melanotus* and can be distinguished by that character in addition to more usual features of ordinary size, mandibular pit, and intermediate sized third antennal segment. They may be separated from each other by *hyslopi* generally being smaller, having sparser pronotal punctures, longer antennae, larger parantennal fovea, and a more angulate frontal margin.

22. *Melanotus prasinus* Blatchley

FIGURES 6*a*, 10*g,h*

Melanotus prasinus Blatchley, 1910, p. 752; 1930, p. 35.—Thomas, 1941, p. 258.

MALE.—Body color reddish brown, covered with white vestiture evenly distributed over body.

Head: Front with pair of shallow anterolateral transverse depressions, margin dark reddish brown, sometimes strongly protuberant above clypeus and turned up in front, fairly thin, parantennal fovea moderately small, but well defined, arc shaped, with small foveal tragus; nasale poorly developed 1½–2 times as wide as high. Mandible with deep slit or teardrop-shaped pit. Antenna exceeds tip of hind angle by 1–2 segments, reddish brown, ratio of segments 2:3:4=3:4:5, segment 4 about twice as long as maximum width; erect male hairs short and rather sparse but easily seen.

Pronotum usually wider than long, ratio of width/length=1.0–1.07; punctures at center usually separated by distance equal to about twice own diameter, slightly denser on margins, smaller than punctures on front; sides of pronotum gently rounded and divergent posteriorly on anterior half, with concavity at base of hind angles; hind angles divergent, carina weak, extending little cephalad of base of hind angle. Genitalia as figured; paramere without apical blade.

Elytron: 6.8 mm (6.2–7.3). 14 spec.

FEMALE.—Similar to male; bursa with moderate number of pointed, plaquelike spines; accessory gland originates near apex of bursa.

Elytron: 7.5 mm. 1 spec.

TYPE.—Holotype of *parasinus:* Male, Vermilion Co., Ind., June 15, 1904, W. S. B. (PU).

DISTRIBUTION.—Connecticut to North Carolina, west to Illinois and Missouri.

CONNECTICUT: Windham; August. ILLINOIS: Champaign; July. MARYLAND: Plummers Isl.; April, June. MASSACHUSETTS: Barnstable, Middlesex; July. MONTANA: Carter; June. NEW HAMPSHIRE: Hillsboro; no date. NEW JERSEY: Bergen, Cape May; June, July. NEW YORK: Kings; July. NORTH CAROLINA: Buncombe; July. OHIO: Hocking, Lucas; June. PENNSYLVANIA: "Estes"; July, TENNESSEE: Smith; no date.

The few specimens of *prasinus* available to us do not give a satisfactory picture of this species, and we know little of its variation or geographical distribution. We have three more males and two females that might belong to *prasinus*, but they differ in outline and shorter, less jutting frontal margin and are questionably identified as *prasinus* and are not included in the description.

Probably *M. prasinus* will most likely be confused with small specimens of *depressus* from which *prasinus* differs in having smaller and sparser pronotal punctures, a better developed nasale, and a more strongly jutting frontal margin.

23. *Melanotus piceatus* Blatchley

FIGURES 5*k*, 10*j*

Melanotus piceatus Blatchley, 1927, p. 141; 1930, p. 48.—Fattig, 1951, p. 22.

MALE.—Body color dark reddish brown to black, covered with sparse yellowish vestiture, evenly distributed over body.

Head: Front with pair of shallow to marked depressions, margin variable from thick and barely protruding beyond clypeus to thin and extending beyond clypeus by little more than own width, rounded or angulate and flattened anteriorly when viewed from above; parantennal fovea small, shallow, arc shaped; nasale flat, width about 1½ times height. Mandible pit slit to teardrop shaped; palpus light reddish brown. Antenna short of tip of hind angle by about 1 segment, reddish brown, segment 3 nearly as long as 4, 4 about 1½ times maximum width, erect male hairs very short and evident only at base of segments.

Pronotum wider than long; punctures at center usually separated by distance equal to 1–2 times own diameter, subequal to those on front; sides gently curved over anterior one-third or one-half, subparallel or convergent posteriorly with small concavity; hind angles slightly divergent with carina usually extending cephalad of base of hind angles. Genitalia as figured; paramere without apical blade.

Elytron: 8.4 mm (7.5–10.2). 10 spec.

FEMALE.—Antenna short of tip of hind angle by 1–3 segments; internal genitalia as figured, bursa large, with 50–100 scattered, peglike spines.

Elytron: 8.6 mm (7.7–9.2). 7 spec.

TYPE.—Holotype of *piceatus:* Male, Dunedin, Fla., March 17, 1922, W.S.B. (PU).

DISTRIBUTION.—Southeastern U.S.

ALABAMA: Colbert, Mobile; May, June. FLORIDA: Brevard, Charlotte, Highlands, Hillsborough, Pinellas, Volusia; February, May. GEORGIA: Chatham; March. SOUTH CAROLINA: Charleston, Georgetown, Pickens; May. TENNESSEE: Great Smoky Mts. Nat. Pk.; June.

The male genitalia of *piceatus* are somewhat similar to *cribulosus*. However, it is readily distinguished from that and other species by the short antennae and other characters. It apparently has no close relatives in North America and may be of Neotropical origin as suggested by its distribution.

24. *Melanotus difficilis* Blatchley

FIGURE 6*g*

Melanotus difficilis Blatchley, 1910, p. 751; 1930, p. 35.—McClure, 1933, p. 145.—Dietrich, 1945, p. 59.

MALE.—Body color reddish brown, covered with whitish vestiture, evenly distributed over body and longer than usual.

Head: Front without marked, transverse depressions but sometimes with pair of shallow anterolateral ones, margin extending as thick shelf in front of clypeus usually twice width of rim, anteriorly rounded when viewed from above; parantennal fovea lacking or obsolescent; nasale not developed. Mandible with small teardrop-shaped pit. Antenna reddish brown, exceeds tip of hind angle by 3 to 3½ segments, segment 3 intermediate to 2 and 4, flagellar segments long and slender, segment 4 twice as long as maximum width, following more slender; erect male hairs very short but dense.

Pronotum flattened dorsally, wider than long; punctures at center usually separated by distance equal to about own diameter, subequal to those on front; sides of pronotum divergent posteriorly on anterior half and parallel or a little convergent over remainder, hind angles divergent, with carina usually extending about to base of hind angle.

Abdomen with last visible sternite usually inflated to give tip enlarged appearance. Genitalia as figured; paramere with apical blade.

Elytron: 7.5–9.7 mm.

FEMALE.—Unknown to us.

TYPE.—Holotype of *difficilis:* Male, Posey Co., Ind., July 8, 1903, W.S.B. (PU).

DISTRIBUTION.—Central U.S.

KANSAS: Douglas; June. ILLINOIS: Alexander; June. MISSISSIPPI: George; May. OKLAHOMA: Delaware; June. TEXAS: Austin, Dallas, Navarro; May.

25. *Melanotus macer* (LeConte)

FIGURES 6*e,f*, 10*l*

Cratonychus macer LeConte, 1853, p. 473.
Melanotus macer.—Candèze, 1860, p. 339.—Blatchley, 1910, p. 752.—Dietrich, 1945, p. 54.—Fattig, 1951, p. 20.

MALE.—Body color reddish brown, covered with whitish hairs, evenly distributed over body and longer than usual.

Head: Front with conspicuous anterior, transverse depression, margin extends as a thin shelve in front of clypeus by distance equal to 2–3 times width of rim, angulate and flattened in front when viewed from above and often with small, median notch; parantennal fovea small but well defined, crescent shaped, opening much longer than wide; nasale not developed. Mandible with small, slit-shaped pit. Antenna long, exceeds tip of hind angle by 3–4 segments, reddish brown, segment 3 intermediate to 2 and 4, flagellar segments slender, nearly parallel sided, not serrate, segment 4 twice as long as maximum width, following more slender; erect male hairs short, sparse, and inconspicuous.

Pronotum wider than long; punctures at center usually separated by distance equal to little less than own diameter, subequal to those on front; sides of pronotum straight with little or almost no anterior curvature and slightly divergent posteriorly; hind angles almost parallel with carina, usually extending cephalad of base of hind angles. Genitalia as figured; paramere with apical blade.

Elytron: 7.2–7.6 mm.

Female.—Unknown to us.

Types.—Lectotype of *macer:* Male, labelled with pink circle "Middle States, incl. N.Y." (MCZ 2507). First specimen of type series selected as lectotype by authors in 1962.

Distribution.—North Carolina west to Kansas.

Iowa: Story; June. Kansas: Cherokee, Riley; June, July. Mississippi: George; May. New York: Nassau; July. North Carolina: Moore, Wake; May.

The two species *difficilis* and *macer* can be separated from other North American *Melanotus* by the long, slender, nonserrate antennae greatly extending beyond the pronotum, the obsolescent nasale, and poorly developed or vestigial parantennal fovea. The two can be distinguished without difficulty by characters cited in the key.

26. *Melanotus testaceus* (Melsheimer)

Figures 6*b*, 11*c*,*d*

Ctenonychus testaceus Melsheimer, 1846, p. 151.

Melanotus testaceus.—Thomas, 1941, p. 258.

Cratonychus dubius LeConte, 1853, p. 479. [New synonymy.]

Melanotus dubius.—Candèze, 1860, p. 372.—Thomas, 1941, p. 260.—Fattig, 1951, p. 21.

Melanotus angustatus of authors, not Erichson, 1842.

Male.—Body color reddish brown, covered with white vestiture, evenly distributed over body.

Head: Front with pair of shallow anterolateral transverse depressions, margin not strongly protuberant above clypeus, evenly rounded or angulate and flattened across center; parantennal fovea small, deep and well defined, semicircular; nasale protuberant, width 1 to 1¼ times height. Mandible with deep, oval pit. Antenna exceeds tip of hind angle by 1 to 1½ segments along sides, reddish brown, ratio of segments 2:3:4=3:4.5:5, segment 4 about 1⅔ times as long as maximum width, erect male hairs short but easily seen.

Pronotum usually as wide as long, ratio of width/length=1.0–1.07; punctures at center usually separated by distance equal to about twice own diameter, smaller than punctures on front; sides of pronotum behind small anterior curvature nearly straight except slight concavity near center and markedly divergent posteriorly; hind angles divergent, carina usually extending cephalad of base of hind angle. Genitalia as figured; paramere slender, tapering, without apical blade.

Elytron: 7.0±0.5 mm (5.2–7.8). 29 spec.

FEMALE.—Similar to male; bursa with moderate number of scattered, plaquelike spines, accessory gland originates near center of bursa, spermathecal duct diverticulum originates not far from base of duct, short and capitate.

Elytron: 6.9±0.3 mm (6.3–7.5). 23 spec.

TYPES.—Type of *testaceus:* No specimen found at MCZ definitely labelled and unquestionably the type. In LeConte Collection a teneral (and hence testaceous) male labelled (by LeConte?) "*angustatus.*" We suspect this specimen is the type of *testaceus* and think LeConte placed it with *angustatus* after he decided the two species were synonymous (1853, p. 475).

Type of *dubius:* Male, labelled with orange circle "Southern States" (MCZ 2520). Only specimen in type series; the orange label indicating locality in South does not correspond with LeConte's (1853, p. 479) listing of N.Y., but nonetheless is regarded as the type.

DISTRIBUTION.—New York to Florida, west to Missouri and Texas.

ARKANSAS: Hempstead, Washington; April, August. FLORIDA: Pinellas; April. GEORGIA: Fulton; June. ILLINOIS: Alexander, Lawrence; April, July. MONTANA: Callaway; May. NEW JERSEY: Ocean; June. NEW YORK: Suffolk, Tompkins; June, August. NORTH CAROLINA: Wayne; April. OHIO: Delaware, Greene, Hocking, Scioto; May, June. TEXAS: no data. VIRGINIA: Nottoway; May.

This species has been identified as *angustatus*, and nearly all of our identifications will bear a label with that name. However, the type of *angustatus* is a specimen of *americanus*, and for a long time the species has been misidentified in North America.

The name *testaceus* is used for this species, although it is based on tenuous grounds, as there appears to be no unequivocal type specimen; however, this seems to be the name most aptly applied to the species.

Undissected specimens will often be confused with *trapezoideus*, although the characters in the key will be useful in separating the two most of the time. It is advisable to dissect the genitalia from at least a part of the collection being identified.

27. *Melanotus trapezoideus* (LeConte)

FIGURES 6*c*, 11*b*

Cratonychus trapezoideus LeConte, 1853, p. 475.
Melanotus trapezoideus.—Candèze, 1860, p. 348.—Blatchley, 1910, p. 752.—Thomas, 1941, p. 259.—Dietrich, 1945, p. 55.—Jewett, 1946, p. 9.—Fattig, 1951, p. 20.

MALE.—Body color reddish to dark reddish brown, covered with white or yellowish vestiture, evenly distributed over body.

Head: Front usually with pair of shallow anterolateral depressions; margin dark reddish brown, thinner in center, angulate and flattened when viewed from above, weakly protuberant in front; parantennal fovea semicircular or circular, well defined; nasale raised, as wide as high. Mandible with small teardrop-shaped or oval pit. Antennae exceeds tip of hind angle by 1 to 1½ segments, reddish brown, ratio of segments 2:3:4=5:8:10, segment 4 about 1⅔ times maximum width, erect male hairs of moderate length and dense.

Pronotum wider than long, ratio of width/length=1.07–1.16; punctures at center usually separated by distance equal to little more than own diameter, equal or subequal to those on front; sides of pronotum straight behind small anterior curvature, diverging posteriorly; hind angles divergent, with carina usually extending cephalad of base of hind angles. Genitalia as figured; paramere without apical blade.

Elytron: 6.1±0.5 mm (5.2–7.3). 35 spec.

FEMALE.—Antenna exceeds tip of hind angle by about one-half segment; internal genitalia as figured, bursa not elongate or enlarged at base of accessory gland and with more than 50 peglike spines.

Elytron: 5.1–6.9 mm. 6 spec.

TYPES.—Lectotype of *trapezoideus:* Male, labelled with pink circle "Middle States, incl. N.Y." (MCZ 2511). First specimen of type series selected as lectotype by authors in 1962.

DISTRIBUTION.—Ontario to North Carolina, west to Minnesota, Illinois, and Arkansas.

ARKANSAS: Garland, Washington; June. CONNECTICUT: Litchfield, New Haven; June, July. ILLINOIS: Champaign, Knox, McHenry, Putnam, Rock Island; May, July. MASSACHUSETTS: Berkshire, Hampshire, Middlesex, Norfolk; June, July. MINNESOTA: Hennepin; July. MISSISSIPPI: George; June. NEW HAMPSHIRE: Carroll; August. NEW JERSEY: Bergen, Gloucester; June. NEW YORK: Erie, Essex, Oswego, Rockland, Suffolk, Tompkins, Westchester; April, September. NORTH CAROLINA: Macon; June. PENNSYLVANIA: Adams, Dauphin, Indiana, Philadelphia; May, July (November). WEST VIRGINIA: Marion, Pendleton; August. ONTARIO: Ridgeway; August.

28. *Melanotus tenax* (Say)

FIGURES 6*d*, 11*a*; PLATE 1*m*

Elater tenax Say, 1839, p. 185.
Cratonychus tenax.—LeConte, 1853, p. 479.
Melanotus tenax.—Candèze, 1860, p. 360.—Blatchley, 1910, p. 755.—Thomas, 1941, p. 260.—Dietrich, 1945, p. 58.—Fattig, 1951, p. 21.

MALE.—Body color reddish to dark reddish brown, covered with white or yellow vestiture, evenly distributed over body.

Head: Front with pair of shallow anterolateral transverse depressions, margin dark reddish brown, not strongly protuberant above clypeus, thinner in center, evenly rounded or a little flattened anteriorly when viewed from above; parantennal fovea smaller than *trapezoideus*, well defined, circular; nasale slightly raised, width equal to 1⅓ times height. Mandible with deep, teardrop-shaped pit. Antenna exceeds tip of hind angle by one-half segment, reddish brown, ratio of segments 2:3:4=4:6:9, segment 4 about twice as long as maximum width; erect male hairs short and dense.

Pronotum as wide as or little wider than long; punctures at center usually separated by distance equal to own diameter, subequal to those on front; sides of pronotum straight, subparallel; hind angles slightly divergent, carina usually extending well cephalad of base of hind angle. Genitalia as figured; paramere without apical blade.

Elytron: 5.5±0.3 mm (5.2–6.3). 15 spec.

FEMALE.—Antenna not extending to tip of hind angle; internal genitalia as figured, bursa with about 50 peglike spines, elongate and enlarged at base of accessory gland, gland short and clavate.

Elytron: 5.0–6.2 mm. 4 spec.

TYPES.—Types of *tenax*: "Mass." Specimens lost.

DISTRIBUTION.—New York south to Georgia and west to Illinois.

GEORGIA: Houston; June. ILLINOIS: Greene; June. MARYLAND: Prince Georges; June. MASSACHUSETTS: Middlesex, Nantucket; June. NEW YORK: Albany; June. NORTH CAROLINA: Craven; May. SOUTH CAROLINA: Berkeley; April.

M. trapezoideus and the *tenax* can be distinguished from other species of the *americanus* group by their small size, large pronotal punctures, and large parantennal fovea. The two are separable by characters in the key. Also, the pronotum of *trapezoideus* is usually flatter and the sides more markedly divergent than in *tenax*. The female internal genitalia are dissimilar; the chief differences are the unusual swelling of the bursa at the base of the accessory gland and the midlateral origin of the spermathecal duct of *tenax*, but not in *trapezoideus*. Unlike most species of *Melanotus*, the male genitalia of these species appear indistinguishable and are not of value in separating the two.

29. *Melanotus pertinax* (Say)

FIGURES 6*l*, 10*k*

Elater pertinax Say, 1839, p. 185.
Cratonychus pertinax.—LeConte, 1853, p. 479.
Melanotus pertinax.—Candèze, 1860, p. 359.—Blatchley, 1910, p. 755.—Thomas, 1941, p. 260.—Dietrich, 1945, p. 58.—Severin, 1949, p. 17.—Fattig, 1951, p. 21.

MALE.—Body color black or dark reddish brown and appendages lighter reddish brown (light colored teneral specimens also have appendages paler than body), covered with white vestiture evenly distributed over body.

Head: Front with pair of shallow anterolateral or transverse depressions, margin narrow and evenly rounded when viewed from above, thick and not strongly protuberant above clypeus; parantennal fovea small but moderately deep circular or semicircular, foveal tragus seldom developed; nasale flat, width about 2 times height. Mandible with deep, teardrop-shaped pit. Antenna exceeds tip of hind angle by about 1 segment, reddish brown, ratio of segments 2:3:4=3:4:5, segment 4 about 1$\frac{7}{10}$ times as long as maximum width; erect male hairs short and dense.

Pronotum wider than long, ratio of width/length=1.06–1.20; punctures at center usually separated by distance equal to more than twice own diameter, smaller than those on front, sides of pronotum rounded and concave at base of hind angles; hind angles divergent, carina weak, usually not extending cephalad of base of hind angle. Genitalia as figured; paramere without blade.

Elytron: 6.4 ± 0.4 mm (6.0–7.3). 50 spec.

FEMALE.—Antennal tip short of pronotum base by 1 segment; internal genitalia as figured, bursa with sparse, scattered peglike spines, accessory gland very short and clavate.

Elytron: 7.2 ± 0.4 mm (6.6–8.1). 27 spec.

TYPES.—Types of *pertinax:* "Mass." Specimens lost.

DISTRIBUTION.—Maine to North Carolina, west to Wisconsin and Illinois.

CONNECTICUT: Litchfield, New Haven; May, July. GEORGIA: Clarke; May. ILLINOIS: Champaign, Knox, McHenry, McLean; May, July. MAINE: York; July. MASSACHUSETTS: Berkshire, Bristol, Hampshire, Middlesex, Suffolk, Worcester; April, August. MINNESOTA: Hennepin, St. Louis; May, June. NEW HAMPSHIRE: Hillsboro, Strafford; May, July. NEW YORK: Columbia, Erie, Putnam, Tompkins, Washington, Wyoming; May, August. NORTH CAROLINA: Buncombe; June. PENNSYLVANIA: Lycoming; July. SOUTH CAROLINA: Aiken; June. VERMONT: No data. WISCONSIN: Milwaukee; June.

That the appendages are of a different color than the body sets *pertinax* apart from other American *Melanotus*, since no other species has this coloration.

30. *Melanotus infaustus* (LeConte)

FIGURES 6*i*, 11*i,j*; PLATE 1*o*

Cratonychus infaustus LeConte, 1853, p. 478.
Melanotus infaustus.—Candèze, 1860, p. 357.—Thomas, 1941, p. 260.—Severin, 1949, p. 17.—Fattig, 1951, p. 21.

MALE.—Body color reddish brown, covered with whitish vestiture evenly distributed over body.

Head: Front with pair of shallow, anterolateral, transverse depressions, margin dark reddish brown, thin and strongly protuberant above clypeus, flattened anteriorly and straight when viewed from above; parantennal fovea small, but well defined, arc shaped, and depth about equal to width of opening; nasale as wide as high, slightly protuberant. Mandible with deep slitlike pit. Antenna exceeds tip of hind angle by about 1½ segments, reddish brown, ratio of segments 2:3:4=3:6:9, segment 4 about 1½ times as long as maximum width; erect male hairs short and only moderately dense.

Pronotum about as long as wide, punctures at center usually separated by distance equal to or less than own diameter, subequal to those on front, sides of pronotum straight behind anterior curvature, nearly parallel; hind angles divergent, carina usually extending slightly cephalad of base of hind angle. Genitalia as figured; paramere with apical blade.

Elytron: 5.5–7.6 mm. 10 spec.

FEMALE.—Antenna exceeds tip of hind angle by 1 or less segment; internal genitalia as figured, bursa with large patch of spines anteriorly and few, scattered ones posteriorly, spines teardrop shaped, spermathecal duct and accessory gland originate close together on bursa.

Elytron: 6.5–7.5 mm. 3 spec.

TYPES.—Lectotype of *infaustus:* Male, labelled with orange circle "Ga." (MCZ 2518). First specimen of type series selected as lectotype by authors in 1962.

DISTRIBUTION.—Florida, Georgia, Indiana, Illinois, Kansas, South Dakota, and Texas.

INDIANA: Tippecanoe; June. ILLINOIS: Whiteside; May. KANSAS: Douglas, Reno; June. SOUTH DAKOTA: Brookings, Lake; June, July. TEXAS: Big Bend Nat. Pk., Bexar, Kerr; March, June.

M. infaustus appears to be a rare species seldom seen in collections. It is difficult to identify positively unless the genitalia are dissected. Undissected specimens may be confused with the more common *tenax*, *trapezoideus*, and *prasinus* in the Midwest and South or with *lanceatus* in Texas. The slender thorax is helpful in separating it from other species, except *lanceatus*, but positive identification requires a study of the distinctive genitalia.

31. *Melanotus parallelus* Blatchley

FIGURES 6*h*, 11*g*; PLATE 1*n*

Melanotus parallelus Blatchley, 1920, p. 45; 1930, p. 44.—Deen and Cuthbert, 1945, p. 193.—Fattig, 1951, p. 22.

MALE.—Body color reddish brown, covered with white or yellowish vestiture, evenly distributed over body.

Head: Front with marked anterior depression, margin dark reddish brown, strongly protruding in front of nasale by several times own width, evenly rounded or angulate and flattened in center when viewed from above; parantennal fovea small, shallow, arc shaped or sometimes obsolescent; nasale flat, width equal to slightly more than height. Mandible with shallow, slit-shaped pit (easily obscured if specimen is dirty; thus, also keyed out in *fissilis* group). Antenna exceeds tip of hind angle by 1 to 1½ segments; reddish brown, segment 3 intermediate in size between 2 and 4, 4 about 1⅔ times as long as maximum width; erect male hairs short and moderately thick.

Pronotum slender, longer than wide; punctures at center usually separated by distance equal to own diameter or more, equal or subequal to those on front, sides of pronotum nearly straight behind anterior curvature and parallel or slightly convergent posteriorly, hind angles divergent, carina usually extending just to base of hind angle, close to and paralleling sides. Genitalia as figured; paramere with apical blade.

Elytron: 5.9 mm (5.7–6.3). 4 spec.

FEMALE.—Antenna ends short of tip of hind angle by about 1 segment; internal genitalia as figured.

Elytron: 5.9 mm.

TYPE.—Holotype of *parallelus:* Male, Dunedin, Fla., April 5, 1915, W. S. B. (PU).

DISTRIBUTION.—Southern U.S.

ARKANSAS: No data. FLORIDA: Highlands, Marion, Pinellas; February, April. NORTH CAROLINA: Montgomery, Moore; April, May.

The relatively slender pronotum which is as long as or longer than wide, and the thin, jutting frontal margin are the main features separating *parallelus* from other species of the *americanus* group. The outline of *parallelus* pronotum accentuates its narrowness and makes it appear longer in relation to the width than it really is. This is another species rarely seen in collections.

32. *Melanotus americanus* (Herbst)

FIGURES 6*j*, 11*e*,*f*

Elater americanus Herbst, 1806, p. 74.
Cratonychus americanus.—Erichson, 1842, p. 114.—LeConte, 1853, p. 479.

Melanotus americanus.—Candèze, 1860, p. 361.—Blatchley, 1910, p. 747.—Fattig, 1951, p. 21.

Cratonychus angustatus Erichson, 1842, p. 113.—LeConte, 1853, p. 475. [New synonymy.]

Melanotus angustatus.—Candèze, 1860, p. 345.—Blatchley, 1910, p. 753.—Thomas, 1941, p. 258.

Male.—Body color reddish brown, covered with white vestiture evenly distributed over body. Small species.

Head: Front with pair of shallow, anterolateral, or single, curved anterior depressions, margin dark reddish brown, protuberant above clypeus, a little angulate or flat across center when viewed from above; parantennal fovea large, semicircular, moderately deep, with weak foveal tragus; nasale usually as wide as high, well developed. Mandible with deep, teardrop-shaped pit. Antenna exceeds tip of hind angle by 1½–2 segments; segment 3 short but intermediate between 2 and 4, ratio of segments 2:3:4=2:3:5, segment 4 about 1⅗ times as long as maximum width; erect male hairs long and conspicuous.

Pronotum usually wider than long, ratio of width/length=1.00–1.17, rounded in appearance when viewed from side; punctures small at center and usually separated by distance equal to twice own diameter; sides of pronotum rounded anteriorly and almost parallel behind. Genitalia as figured; paramere enlarged apically, but without apical blade.

Elytron: 5.4±0.4 mm (4.5–6.3). 50 spec.

Female.—Antenna extends to tip of hind angle or exceeds it by about one-half segment; genitalia as figured, numerous spines in anterior half, spines long and without flat bases, pouchlike swelling at base of accessory gland, gland short and expanded beyond base, diverticulum branching from spermathecal duct near center of duct.

Elytron: 5.7±0.3 mm (4.8–6.7). 93 spec.

Types.—Lectotype of *americanus:* Male, "America Sept." (ZM). Selected by Quate, 1960. Seven other males in type series.

Lectotype of *angustatus:* Female, "Pennsylvania" (ZM 17057). Selected by Quate, 1960; 4 other females in type series.

Distribution.—Eastern U.S. west to Indiana and Illinois.

Connecticut: Hartford, Litchfield; June. Delaware: Sussex; May. Georgia: DeKalb, Fulton, Rabun; May, June. Illinois: McHenry, Putnam, Rock Is.; June, July. Indiana: Marion; July. Maryland: Anne Arundel, Baltimore, Frederick, Plummers Is.; June, July. Massachusetts: Barnstable, Hampshire, Middlesex; June, September. Nebraska: Cass; May, July. New Jersey: Bergen, Middlesex, Morris, Union; June, July. New York: Putnam, Suffolk, Westchester; April, August. North Carolina: Buncombe, Cherokee, Cumberland, Moore, Montgomery, Pender, Pickens, Swain, Wake; April, July. Ohio: Delaware, Fairfield, Franklin, Greene, Hocking; May, June. Pennsylvania: Allegheny, Dauphin, Northampton, Perry; June,

221-532—67——5

July. Rhode Island: Washington; July. South Carolina: Oconee; March. West Virginia: Greenbrier; July.

Melanotus americanus is one of the smaller species of North American *Melanotus*. This feature, with the small third antennal segment and high rounded pronotum bearing small, scattered punctures, makes the species more readily recognized than many others.

Examination of the types of *angustatus* indicates that this species has been misidentified for many years. The type series is mixed, but the first is definitely *americanus* and has been selected as the lectotype. This specimen has been dissected and the identification has been confirmed by M. C. Lane.

33. *Melanotus cribriventris* Blatchley

Figures 6*k*, 11*h*

Melanotus cribriventris Blatchley, 1910, p. 747; 1930, p. 33.

Melanotus longicornis Blatchley, 1910, p. 746; 1930, p. 35.—Thomas, 1941, p. 258. [New synonymy.]

Melanotus blatchleyi Leng, 1918, p. 205. [New name for *longicornis* Blatchley, not Candèze, 1860. New synonymy.]

Male.—Body color reddish brown, covered with white or yellowish vestiture, evenly distributed over body.

Head: Front with shallow to marked anterior depression, margin dark reddish brown, not strongly protuberant above clypeus, angulate and blunt when viewed from above; parantennal fovea large, deep and well defined, nasale higher than wide, prominently raised. Mandible with deep, rounded pit. Antenna exceeds tip of hind angle by 3 to 3½ segments, segments 2 and 3 subequal, flagellar segments elongate and slender, segment 4 about twice as long as maximum width; erect male hairs long and shaggy.

Pronotum wider than long; punctures at center separated by distance equal to less than own diameter, subequal to size of punctures on front; sides of pronotum straight, divergent posteriorly with slight anterior curvature; hind angles divergent, with strong carina, extending cephalad of base. Genitalia as figured; paramere without apical blade.

Elytron: 7.2–7.6 mm. 5 spec.

Female.—Antenna exceeds tip of hind angle by 2 segments; internal genitalia as figured, bursa with about 20 sharp, thornlike spines, accessory gland long and very slender, spermathecal duct branched near base.

Elytron: 7.8 mm (7.7–8.1). 8 spec.

Types.—Type of *longicornis:* Male, Orange Co., Ind., May 31, 1904. Not seen by us, but studied by M. C. Lane and determined to be same as *cribriventris*.

Holotype of *cribriventris*: Female, Kosciusko Co., Ind., July 11, 1904, W. S. B. (PU).

DISTRIBUTION.—New Jersey west to Kansas.

ILLINOIS: Rock Is.; no date. INDIANA: Allen; June. KANSAS: Douglas; no date. MARYLAND: Baltimore, Plummers Is.; April. NEW JERSEY: Warren; June. OHIO: Hamilton, Hocking; June. PENNSYLVANIA: Northampton; June. TENNESSEE: Morgan; May.

The long antennae and short third antennal segment are distinctive characteristics of *cribriventris*, and specimens go through the key with little difficulty. The shaggy antennae are especially characteristic of the male and provide an obvious clue to its identification.

Blatchley apparently believed the male and female belonged to two different species. He first named the male *longicornis*, but this name is preoccupied by *longicornis* Candèze. Leng observed the homonymy and renamed Blatchley's species *blatchleyi*. However, *cribriventris* is merely the female of *longicornis* Blatchley and is therefore available as a replacement name and has precedence over *blatchleyi*. Some identifications will bear this latter name, but the correct one is *cribriventris*.

34. *Melanotus obscuratus* Blatchley

FIGURES 7*b*, 11*l*

Melanotus obscuratus Blatchley, 1927, p. 141; 1930, p. 45.

MALE.—Body color dark reddish brown, vestiture white.

Head: Front with shallow, anterior depression, margin rounded, not strongly protuberant; parantennal fovea small but distinct, nasale wider than high, not well developed. Mandible with slitlike pit. Antenna exceeds tip of hind angle no more than 1 segment; segments 2 and 3 subequal, ratio of segments 2:3:4=2:3:6, segment 4 about twice as long as maximum width; erect male hairs short and inconspicuous.

Pronotum little longer than wide, ratio of width/length=0.9; punctures at center separated by about own diameter, subequal to size of punctures on front; sides of pronotum nearly parallel, hind angles a little divergent.

Genitalia as figured; paramere with well-defined apical blade.

Elytron: 6.0–6.4 mm. 2 spec.

FEMALE.—Antenna extends just to tip of hind angle; genitalia as figured, bursa with few spines largely in distal half, accessory gland originates well before apex, which leads to spermathecal duct.

Elytron: 7.4 mm. 1 spec.

TYPE.—Holotype: Male, Ormond, Fla., April 13, 1913, W. S. B. (PU).

DISTRIBUTION.—Southeastern U.S.

NORTH CAROLINA: Brunswick; June. FLORIDA: Volusia; April.

Three females in the type series belong to *morosus* as shown by their long third antennal segment and the internal genitalia characteristic of that species. However, the holotype and paratype males are distinct from other North American *Melanotus*. The female description above is based on a specimen from North Carolina associated with a male *obscuratus* and agreeing with that specimen in external characters.

35. *Melanotus beameri* Quate, new species

FIGURE 6*m*

MALE.—Body color light reddish brown, covered with yellowish vestiture evenly distributed over body.

Head: Front with shallow transverse, anterior depression; margin protruding in front of nasale by about twice width of rim, angulate or sometimes rounded and flattened in center when viewed from above; parantennal fovea small but well defined, crescent shaped; nasale obsolescent. Mandible with shallow, small, slitlike pit. Antenna reddish brown, exceeds tip of hind angle by 1–2 segments; segment 3 intermediate in size between 2 and 4; erect male hairs dense and of moderate length.

Pronotum slender, about as wide as long; punctures large and dense, as large as, or larger than, those on front and separated by less than own diameter; sides of pronotum with little or no anterior curvature and nearly parallel but a little rounded; hind angles markedly divergent, carina extends to base of hind angle, close to and paralleling side. Genitalia as figured; paramere without apical blade.

Elytron: 5.3 ± 0.3 mm (4.6–6.0). 34 spec.

FEMALE.—Unknown.

DISTRIBUTION.—Texas.

Holotype, male (KU): 65 mi. south of Marathon, Brewster Co., Texas, July 10, 1938, R. H. Beamer.

Paratypes, 33 males (KU, USNM, CNC): same as holotype; near Dugout Well, Big Bend Nat. Pk., Texas, April 17, 1953, B. J. Adelson; Panther Jct. and Nine Pt. Draw, Big Bend Nat. Pk., Texas, May 20, 1959, 2,600–4,000 ft., Howden and Becker; Oak Spring, Big Bend Nat. Pk., May 22, 1959, 4,000 ft., Howden and Becker.

M. beameri is similar to the following species, but readily separated from them by the undeveloped nasale, large and coarse pronotal punctures, and male genitalia.

The species is named in honor of Dr. R. H. Beamer, the late Curator of the Snow Collection, University of Kansas, who did much work in the American Southwest and through his diligent efforts added significantly to our knowledge of insect fauna in that region.

36. *Melanotus concisus* Knull

FIGURES 7*a*, 12*a*

Melanotus concisus Knull, 1959, p. 281.

MALE (after Knull).—Body color dark brown, legs lighter, vestiture short.

Head: Frontal margin broadly rounded, projecting over nasale; parantennal fovea deep. Mandible with deep pit. Antenna exceeds tip of hind angle by part of 1 segment; segment 3 subequal to 2.

Pronotum little longer than wide; punctures dense, coarse, umbilicate on anterior two-thirds, fine and sparse on posterior one-third; sides of pronotum rounded. Genitalia as figured; paramere with apical blade.

FEMALE (?).—Frontal margin nearly straight across center, projects in front of nasale by width of rim; nasale poorly developed, parantennal fovea shallow but definite. Antenna fails to reach tip of hind angle by about 1 segment. Pronotum wider than long. Genitalia as figured; bursa with dense patch of pointed plaquelike spines, accessory gland originates near apex of bursa.

Elytron: 6.1 mm (5.8–6.3). 5 spec.

TYPE.—Holotype: Male, Artesia (Eddy Co.), N. Mex. (Knull Collection).

DISTRIBUTION.—Arizona and New Mexico.

ARIZONA: Cochise, Santa Cruz; August. NEW MEXICO: Sandoval; August.

The above females agree reasonably well with the male described by Knull and tentatively we are assigning them to *concisus*. The small third antennal segment, large pronotal punctures, small size, and distribution are the main recognition characters of the species, aside from the genitalia. Positive identification of the female cannot be made, however, until associated with male in the field.

37. *Melanotus lanceatus* Quate, new species

FIGURES 7*c*, 12*b*

MALE.—Body color reddish to dark reddish brown, covered with white vestiture evenly distributed over body.

Head: Front with pair of shallow anterolateral or no depressions, margin scarcely protruding in front of nasale, angulate and flattened in center when viewed from above; parantennal fovea moderately large, deep and circular, or semicircular; nasale protuberant, as wide as or wider than high. Mandible with slit-shaped or teardrop-shaped slit. Antenna reddish brown, exceeds tip of hind angle by 2–3 segments; segment 3 intermediate in size between 2 and 4; erect male hairs short but dense.

Pronotum as wide as or less wide than long; punctures at center separated by about own diameter, smaller than those on front; sides of pronotum straight behind small anterior curvature, parallel or divergent posteriorly; hind angles divergent, carina extending to base of hind angle, close to and paralleling side. Genitalia as figured, very slender; paramere with weakly developed apical blade.

Elytron: 6.5 ± 0.4 mm (5.7–7.2). 64 spec.

FEMALE.—Antenna exceeds tip of hind angle by about one-half segment; pronotum with sides more rounded and not parallel; internal genitalia as figured, bursa with patch of close-set, plaquelike spines, bases of accessory gland and spermathecal duct at apex of bursa, gland not clavate.

Elytron: 6.5 mm (6.3–7.0). 12 spec.

DISTRIBUTION.—Arizona and Texas.

Holotype, male (USNM): Dimmit Co., Texas, May 21, 1934, light trap. Allotype, female (USNM): same, June 7, 1933, H. J. Reinhard.

Paratypes, 99 males, 12 females (USNM, CAS, CIS, CU, INHS, U. Ariz., Texas A and M, CNC): ARIZONA. Cochise Co.: Huachuca Mts., July 19, Knull; same, Aug. 8, 9, 1952, 5400 ft., Leech and Green. Santa Cruz Co.: Canelo, July 10, 1957, G. A. Butler; Nogales, Aug. 12, 1906; Santa Rita Mts., July 20, 25, 1959, J. G. Franclemont. TEXAS. Bell Co.: Salado, April 10. Bexar Co.: San Antonio, Mar. 17, 1953, B. J. Adelson. Brewster Co.: Alpine, July 1–15, 1926, O. C. Poling; same, July 11, 1962, L. W. Hepner; Chisos Mts., June 10–12, 1908, Mitchell and Eichmann; Santa Elena, Big Bend Nat. Pk., May 4, 1959, 2,200 ft., Howden and Becker. Blanco Co.: Cypress Mills, April 2. Burnet Co.: no locality, June. Cameron Co.: Brownsville, March 20, 1937, T. N. Freeman; same, May 17, 1904, H. S. Barber; same, May 20, 1937, May 30, 1932, June 3, 1932. Dimmit Co.: no locality, March 17, 1933, April 3, 30, 1933, June 7, 1933. Duval Co.: San Diego, April 27. Goliad Co.: Goliad, April 18, E. A. Schwarz. Gonzales Co.: Luling, April 11, 1953, at light, B. J. Adelson. Hidalgo Co.: Edinburg, no date. Jeff Davis Co.: Davis Mts., June 28, July 8, 1946. Jefferson Co.: Sabina, March, April 1910, F. C. Pratt. Kerr Co.: Kerrville, April 2–18, 1959, Becker and Howden; same, April 11, 1906, June 1906, F. C. Pratt. Kleberg Co.: Kingsville, no date. LaSalle Co.: Cotulla, April 17, 1906, May 12, 1906, March 27, 1908, F. C. Pratt. Robertson Co.: Hearne, June 7, 1936, K. L. Maehler. Randall Co.: 15 mi. east of Canyon, June 26, 1956, R. E. Selander. Sutton Co.: Sonora, April. Terrell Co.: Sanderson, April 27, 1959, Becker and Howden. Val Verde Co.: Del Rio, April 13, 1949, Michener and Beamer; 13 mi. south of Del Rio, April 10, 1950, Beamer et al.; Devil's River, May 5, 1907, E. A. Schwarz. Victoria Co.: Victoria, March 26, J. D. Mitchell.

M. lanceatus is closely related to *longulus*. The male genitalia of the two are similar, but in *lanceatus* are much more elongate and slender; the female internal genitalia have the same type of bursal spines, but the origin of the accessory gland is in a different position in each. Externally, the smaller pronotal punctures in *lanceatus* are the most noticeable difference.

In view of the closeness of the two and their allopatric distribution, it is debatable if *lanceatus* should be considered a subspecies of *longulus*. We decided against that ranking on the basis that the differences between *lanceatus* and *longulus* are greater than between the two subspecies of *longulus* and that the female internal genitalia indicate a greater divergence of the two than other characters. It seems to us highly improbable that the two are capable of interbreeding with female reproductive organs so dissimilar, and, therefore, they should not be considered as belonging to the same species.

38. *Melanotus hamatus* Knull

FIGURE 7*d*

Melanotus hamatus Knull, 1959, p. 280.

MALE.—Body color reddish brown, covered with whitish vestiture. Head: Front with small, transverse depression behind margin, margin angulate, coming to obtuse but noticeable point at midline, protruding in front of nasale only by width of black rim; nasale not strongly elevated but defined, wider than long; parantennal fovea shallow, C-shaped, definite. Mandible with deep, elongate pit. Antenna exceeds tip of hind angle by about one-half segment; segment 3 small, much smaller than 4 but a little larger than 2.

Pronotum wider than long; punctures large as on front, compact, separated by less than own diameter; sides rounded with concavity in front of hind angles; hind angles small, divergent. Genitalia as figured; paramere with peculiar winglike flap on venter near center and without apical blade.

Elytron: 6.4 mm (5.8–6.9). 8 spec.

FEMALE.—Unknown to us.

TYPE.—Holotype: Male, Chisos Mtns., Texas (Knull Collection).

DISTRIBUTION.—Texas.

TEXAS: Big Bend Nat. Pk., Jeff Davis; July .

The small size, small third antennal segment, large and dense pronotal punctures, together with the limited distribution in the Southwest, will readily identify this species. Of course, dissected males show the unusual male paramere that is dissimilar to all other American *Melanotus*.

38a. *Melanotus longulus* (LeConte)

Cratonychus longulus LeConte, 1853, p. 473.
Melanotus longulus.—Candèze, 1860, p. 339.

MALE.—Body color reddish brown to black, covered with yellowish vestiture, evenly distributed over body.

Head: Front with shallow to marked anterior transverse depression, margin projects in front of nasale by width of rim or less, rounded or angulate and flattened in front when viewed from above, sometimes depressed in center; parantennal fovea small, deep and crescent shaped, foveal tragus sometimes well developed; nasale usually developed but not strongly protuberant, wider than high. Mandible with small teardrop- or slit-shaped pit. Antenna light to dark reddish brown and lighter than body in dark specimens, exceeds tip of hind angle by 1 to 1½ segments, ratio of segments 2:3:4=3:4:7, flagellum usually strongly serrate, segment 4 about 1½ times as long as maximum width; erect male hairs short, variable from dense to sparse, but always evident.

Pronotum as long as or little wider than long; punctures subequal or clearly as large as those on front, separated by distance equal to less or more than own diameter.

FEMALE.—Antenna exceeds tip of hind angle by about one-half segment; sides of pronotum generally rounded; bursa with numerous, plaquelike spines, spermathecal duct branching at apex of bursa.

39. *Melanotus longulus longulus* (LeConte)

FIGURES 7*e*, 12*c*,*d*

Cratonychus longulus LeConte, 1853, p. 473.

Melanotus longulus.—Candèze, 1860, p. 339.—Horn, 1874, p. 23.—Van Dyke, 1932, p. 331.—Fall, 1934, p. 23.—Van Dyke, 1942, p. 51.—Stone and Howland, 1944, p. 1.

Reddish brown to black, lighter colored in Southwest. Antenna flagellum usually moderately serrate. Pronotal punctures subequal to those on front in Southwest and larger and denser in California, sides of pronotum nearly straight behind small anterior curvature, usually slightly convergent posteriorly.

Male genitalia as figured; apical blade sharply angulate with sharp outer, basal corner, concavity at base of blade well developed in Arizona and New Mexico and poorly developed in California.

Female internal genitalia as figured, accessory gland longer than bursa and very slender.

Male elytron: 7.2±0.6 mm (6.5–8.8). 50 spec.

Female elytron: 7.8±0.6 mm (6.3–9.0). 24 spec.

TYPES.—Lectotype of *longulus:* Male, labelled with gold circle "San Diego, Calif." (MCZ 2506). First specimen of type series selected as lectotype by authors in 1962.

DISTRIBUTION.—Southwestern U.S. south of Tehachapi Mtns., California, Great Basin, and Baja California.

ARIZONA. Cochise Co.: Chiricahua Mts., June 20, 1950; Douglas, Aug.: Huachuca Mts., 1960 m, Aug. 9, 1952; Portal, 2420 m, July 20, 1944; Whetstone Mts., SE, Aug. 10, 1952. Coconino Co.: Oak Creek Cyn., July 1941; Williams, July 2, 1953. Graham Co.: Graham Mts., Aug. 1, 1957. Maricopa Co.:

Aguila, Aug. 21, 1927. Mojave Co.: Valentine, Aug. 26, 1952. Pima Co.: Baboquivari Mts., west side, July 27, 1952; Santa Catalina Mts., July 2, 1954, July 3, 1955. Pinal Co.: Magna, Aug. 18, 1921; Oracle, July 7, 1950; Tucson, August 1935. Santa Cruz Co.: Mt. Washington, Nogales, 1829 m, July 13, 1919; Patagonia, July 1936. Yavapai Co.: Congress Jctn., July; Prescott, July 1, 1919. Yuma Co.: Yuma, March 7, 1879. CALIFORNIA. Imperial Co.: Salton Sea, Apr. 3, 1927. Inyo Co.: Lone Pine, May 12, 1937; Westgard Pass Plateau, Apr. 24, 1937; Whitney Portal, July 3, 1953. Kern Co.: Tejon Cnyn., May 12, 1927. Los Angeles Co.: Camp Baldy, June 26, 1958; Claremont, Apr. 19, 1926, May 13, 1927; Crystal Lake, June 29, 1950; La Canada, July 28, 1948; Lancaster, May 1895; Los Angeles, Mar. 27, 1879; Mt. Wilson, Apr. 30, 1916, June 13, 1904; Palmdale, June 9, 1918; Pasadena, no date; Santa Catalina Is., May 1932; South Gate, Apr. 9, 1952; Tanbark Flat, June 20–July 26, 1952. Orange Co.: Newport Bay, May 14, 1940. Riverside Co.: Andreas Cnyn., Apr. 3, 1927; Coachella, May 19, 1927; Idyllwild, June 7, 1940; Indio, June 2, 1918; Murray Cnyn., Mar. 24, 1918; Olanche, May 14, 1917; Palm Springs, Apr. 19, 1924, May 10, 1927, May 30, 1939. San Benito Co.: Idria, June 29, 1955. San Bernardino Co.: Forest Home, June 27, 1924; Lytle Creek, June 7, 1928. San Diego Co.: Upland, Dec. 4, 1952. Ventura Co.: Rincon Beach, July 4, 1923; Saticoy, June 11, 1927; Ventura, Apr. 25, 1932, Apr. 28, 1932, May 10, 1941; Santa Catalina Is., May 27, 1932. NEVADA. Esmeralda Co.: Goldfield, Aug. 4, 1905. NEW MEXICO. Hidalgo Co.: Animas Mts., 1670 m, Aug. 15, 1952. Lincoln Co.: Ruidoso, June 26, 1940. Santa Fe Co.: Santa Fe, no date. TEXAS. Brewster Co.: Alpine, July 11, 1938. UTAH. Iron Co.: Cedar City, Coal Cnyn., 1890 m, June 25, 1919. Juab Co.: Eureka, June 17, 1902, July 26, Aug. 14. Washington Co.: St. George, May 28, 1935. BAJA CALIFORNIA. 10 mi. south of Catavina, July 29, 1938; 17 mi. south of Ensenada, June 14, 1938.

There is a marked color variation with a geographical basis in *l. longulus*. Western populations, particularly in and around Los Angeles Co., Calif., are colored like *l. oregonensis* with a black or nearly black body and reddish-brown appendages. Farther east in Arizona and New Mexico, the coloration is more like that of *lanceatus* and *beameri* with body and appendage reddish brown. Few specimens have been seen from the intervening area of southeast California and we don't know if a cline of color characters exists. Genitalia and other structural characters are quite constant, although a more detailed analysis might reveal differences in some structures as the overall size and shape of the pronotum.

40. *Melanotus longulus oregonensis* (LeConte)

FIGURES 7*f*, 12*e*,*f*

Cratonychus oregonensis LeConte, 1853, p. 480.
Melanotus oregonensis.—Candèze, 1860, p. 373.—Lane, 1952, p. 67.
Melanotus longulus oregonensis.—Van Dyke, 1932, p. 331.
Melanotus variolatus LeConte, 1861, p. 377. [New synonymy.]
Melanotus longulus variolatus.—Van Dyke, 1932, p. 331.
Melanotus longulus franciscanus Van Dyke, 1932, p. 332. [New synonymy.]
Melanotus franciscanus.—Fall, 1934, p. 24.

Larger than *l. longulus;* frontal margin more broadly flattened than in *longulus*. Usually black with lighter colored antennae. Antenna flagellum often strongly serrate. Pronotal punctures large, as large as those on front and separated by less than own diameter; sides of pronotum often more strongly rounded than in *longulus* with marked concavity at base of hind angle.

Male genitalia as figured; apical blade weakly developed, gently rounded at base.

Female internal genitalia as figured, accessory gland shorter than bursa and distinctly clavate.

Male elytron: 9.0 ± 0.7 mm (7.3–10.3). 50 spec.

Female elytron: 9.1 ± 0.9 mm (7.5–10.9). 50 spec.

Types.—Lectotype of *oregonensis:* Male, labelled with dark blue circle (Oregon) (MCZ 2522). First specimen of type series selected as lectotype by authors in 1962.

Lectotype of *variolatus:* Male, labelled with gold circle (Calif.) (MCZ 2522). Third specimen of type series selected as lectotype by authors in 1962; first and second specimens are females, and males are definitive for recognizing the form.

Holotype of *franciscanus:* Male, hills back of Oakland, ca. May 8, 1910 (CAS 3132).

Distribution.—Northwestern U.S., north of Tehachapi Mtns., California; overlaps with *longulus* in north-central Utah.

California. Alameda Co.: Berkeley, May 9, 1940, June 9, 1949; Castle Rock Pk., May 25, 1932; Moraga, June 1, 1940; Niles, May 30, 1933; Pleasanton, June 5, 1932. Butte Co.: Oroville, May 29, 1926. Calaveras Co.: Big Trees, May 17, 1937; Murphys, May 23, 1936, Jan. 17, 1951. Contra Costa Co.: Brentwood, May 19, 1949; Giant, May 24, 1932; Mount Diablo, May 30, 1930, Apr. 20, 1942, May 3, 1957; Walnut Creek, May 30, 1913, June 1930. El Dorado Co.: Camino, June 21–29, 1948; Pollock Pines, July 10, 1948. Fresno Co.: Clovis, Apr. 21, 1931; Dalton Creek, Apr. 18, 1920; Mendota, Apr. 19, 1956. Humboldt Co.: Blocksburg, June 3, 1935; Fort Seward, May 22, 1935. Kern Co.: Bakersfield, May 5, 1931. Lake Co.: Anderson Springs, May 17, 1952. Lassen Co.: Doyle, May 20, 1934. Madera Co.: Bass Lake, July 24, 1934; Coarsegold, May 12, 1942; Madera, May 2, 1947; Northfork, Feb. 29–Mar. 30, 1920. Marin Co.: Fairfax, May 1922; Mill Valley, May 9, 1949. Mariposa Co.: Miami Ranger Sta., July 29, 1946. Merced Co.: Los Banos, Mar. 16, 1946; Panoche Hills, Apr. 23, 1921; Yosemite, May 29, 1937. Modoc Co.: Cedar Pass, July 29, 1946. Mono Co.: Leavitt Meadows, June 26, 1937. Monterey Co.: Carmel, Jan. 7, 1908. Napa Co.: Monticello, May 30, 1930. Nevada Co.: Greenhorn, August 28, 1954; Tahoe, June 3–July 8, 1915. Placer Co.: Auburn, May 1939; Newcastle, Apr. 23, 1949; Penryn, July 15, 1939. Plumas Co.: Keddie, June 12, 1941. Sacramento Co.: Sacramento, Apr. 23, 1922. San Benito Co.: June 24, 1933. San Joaquin Co.: Lodi, Apr. 23, 1931; Stockton, May 12, 1933; Tracy, May 4, 1933. San Mateo Co.: Halfmoon Bay, Mar. 16, 1952. Santa Clara Co.: Morgan Hill, May 17, 1922; Mtn. View, May 18, 1941; Palo Alto, May 7, 1920; San Jose, Mar. 2, 1941. Santa Cruz Co.: Santa Cruz Mtns., no date. Shasta Co.: Hat Creek, June 25, 1949, July 25, 1953; Redlands, June 6,

1953. Siskiyou Co.: Yreka, May 10, 1932. Solano Co.: Green Valley Falls, Apr. 26, 1941. Sonoma Co.: Santa Rosa, April 1942; Sobre Vista, May 24, 1910. Stanislaus Co.: Westley, June 8, 1948. Tehama Co.: Red Bluff, Apr. 14, 1928, May 11, 1949; Vina, May 11, 1920; Western, Oct. 30, 1920. Trinity Co.: Carrville, May 17, 1934, May 30, 1934. Tulare Co.: Kaweah; Sequoia Nat. Pk., June 13, 1929, May 25, 1930; Visalia; Wood Lake, Mar. 28–May 3, 1947. Tuolumne Co.: Hardin Flat, May 29, 1955. Yolo Co.: Winters, Apr. 23, 1950. Yuba Co.: Marysville, June 5, 1933. Idaho. Bannock Co.: Lava Hot Springs. Canyon Co.: Parma, May 18, 1930. Lincoln Co.: Shoshone, June 10, 1938. Montana. Lewis and Clark Co.: Wolf Creek, July 4, 1938. Nevada. No other data. Oregon. Baker Co.: Richland, June 14, 1940. Benton Co.: Corvallis, July 2, 1945. Douglas Co.: Drain, May 19, 1914. Harney Co.: June 22, 1912. Jackson Co.: McLeod St. Pk., May 22, 1960; Medford, June 12, 1915, May 14, 1954; Talent, May 4, 1954. Lake Co.: Lakeview, May 27, 1957. Yamhill Co.: June 1913, May 1934. Utah. Cache Co.: June 26, 1954; Lewiston, May; Bear River, Logan, 1925. Juab Co.: Eureka, July 2 (with *l. longulus*). Salt Lake Co.: Apr. 14, 1909; Ft. Douglas, June 7, 1926. Tooele Co.: Stockton, June 22, 1917. Utah Co.: Dividend, June 1921; Provo, June 2, 1939; Provo Cnyn., May 21, 1913. Weber Co.: Roy, July 14, 1957. Washington. Kittitas Co.: Yakima River, 8 mi. south of Ellensburg, July 22, 1959. Walla Walla Co.: Walla Walla, June 1936. Whitman Co.: Pullman, May 13, 1930; Wawawai, May 13, 1944. British Columbia. Oliver, May 22, 1924; Vernon, May 1, 1924; Victoria, June.

The subspecies *longulus* and *oregonensis* are closely related forms, allopatric in distribution (fig. 3). *Longulus* differs from *oregonensis* rather constantly in having a smaller average size, being lighter in color, the nasale better developed, the fovea a little deeper, the antennae less sharply serrate, and the flagellar segments smaller. These features are subject to some variation and a small percentage of specimens possesses characters of the other subspecies. The genitalic characters, on the other hand, seem entirely constant within the ranges of the respective subspecies. Specimens have not been seen which are intermediate between the two subspecies in genitalic characters. A specimen from northern Utah is intermediate in size and color but *oregonensis* on genitalic characters. Perhaps these forms have reached full species status and there is no interbreeding between populations. This is unproven, however, and we have seen few specimens from the borders of the two forms' area. In our opinion, the close relationship and allopatric distribution is best shown by the nomenclatorial rank of subspecies.

Van Dyke (1932) recognized the affinity of *longulus* and *oregonensis* and was the first to group them as subspecies of one species. At the same time he recognized the third subspecies, *franciscanus*. He presents a scheme, that our observations do not support, in which the smaller and lighter *longulus* of southern California gets larger and darker in populations to the north in the Sierra Nevada and the Great Basin. The lowland populations in central California supposedly got still larger and darker and constituted the subspecies *franciscanus.* This suggests a north-south cline from southern California and east-west cline through central California. Our studies show a sharp break between the populations along a line in the Tehachapi Mountains, California, and if there is a north-south cline, it is abrupt and not gradual as outlined by Van Dyke. On the average, specimens from the mountains are smaller and those in the lowlands larger. (Although one of the smallest specimens of *oregonensis* in our material is from Pleasanton, Alameda Co., Calif.) This is most likely a phenotypic expression of a more vigorous climate, shorter summer season, and perhaps less abundant food in the mountains, and we think has nothing to do with the genotypic characters which distinguish the two subspecies. The form *franciscanus* is regarded as merely a larger and darker phenotype of *oregonensis* that enjoys a more favorable environment but does not warrant nomenclatorial recognition.

The species *variolatus* has been synonymized with *longulus* by Van Dyke (1932) on the grounds that it was based on individual variants and in this we concur.

41. *Melanotus gradatus* LeConte

FIGURE 7*g;* PLATE 1*p*

Melanotus gradatus LeConte, 1866, p. 390.—Blatchley, 1910, p. 753.—Thomas, 1941, p. 260.

MALE.—Body color reddish brown, covered with white or yellowish vestiture that grows denser and sometimes nearly velvety posteriorly on pronotum.

Head: Front with pair of shallow anterolateral depressions; margin not strongly protuberant above nasale, evenly rounded or flattened in front when viewed from above; parantennal fovea moderately large, deep, semicircular, foveal tragus small; nasale raised slightly, width from 1¼ to 1½ times height. Mandible with large teardrop-shaped pit. Antenna reddish brown, exceeds tip of hind angle by one-half segment or less, segment 3 nearly as large as 4, 4 about 1½ times as long as maximum width; erect male hairs very short, fine, rather sparse, and easily overlooked.

Pronotum about as wide as long; punctures on anterior two-thirds as large as those on front, and separated by distance equal to less than own diameter, those on posterior one-third grow much smaller and denser, often giving surface granulose appearance; sides of pronotum vary from straight and diverging posteriorly to curved with slight concavity at base of hind angle; hind angles divergent, carina usually extending cephalad of base of hind angle and weakened anteriorly. Genitalia as figured; paramere with apical blade.

Elytron: 7.9–8.2 mm. 3 spec.

FEMALE.—Antenna extends just to tip of hind angle or short of tip by one-half segment; internal genitalia as figured, bursa with 2 patches of tacklike spines, accessory gland slender and shorter than bursa, spermathecal duct branches near its base.

Elytron: 8.5–9.5 mm. 5 spec.

TYPE.—Holotype of *gradatus:* Male, Maryland. Only specimen in type series, not seen by us.

DISTRIBUTION.—Maryland west to Kansas and Arkansas.

ARKANSAS: Lawrence, Washington; April, June. ILLINOIS: Gallatin, Pope, Pulaski, St. Clair; May, June. INDIANA: Clark; June. KANSAS: Douglas; June. OHIO: Hamilton; June.

The fine vestiture and punctures on the posterior part of the pronotum, the short antennae, and moderately large size readily distinguish *M. gradatus* from other North American *Melanotus*.

42. *Melanotus insipiens* (Say)

FIGURES 7*h*, 12*g*

Elater insipiens Say, 1825, p. 267.—1839, p. 184.
Cratonychus insipiens.—LeConte, 1853, p. 480.
Melanotus insipiens.—Candèze, 1860, p. 361.—Fattig, 1951, p. 21.
Cratonychus tenellus Erichson, 1842, p. 114.—LeConte, 1853, p. 480.
Melanotus tenellus.—Candèze, 1860, p. 362.—Fattig, 1951, p. 22.

MALE.—Very small, light to dark reddish brown, species with white or yellowish vestiture.

Head: Front with shallow, narrow anterior depression or lacking entirely; margin dark reddish brown, not strongly protuberant over clypeus, evenly rounded when viewed from above, slightly upturned; parantennal fovea deep, well defined, semicircular; nasale wider than high. Mandible with deep, rounded, or elongate pit. Antenna exceeds tip of hind angle by 2 to 2½ segments, segment 3 intermediate in size between 2 and 4, 4 about 1¾ times as long as maximum width; erect male hairs moderately long and sparse.

Pronotum a little wider than long; punctures at center usually separated by distance equal to about own diameter, slightly smaller than punctures on front; sides of pronotum straight behind small anterior curvature and divergent posteriorly; hind angles divergent, carina extending cephalad of angle base, close to and paralleling sides.

Last visible sternite of abdomen with punctures on posterior half round and considerably larger than on rest of abdominal venter. Genitalia as figured; paramere with apical blade.

Elytron: 3.5±0.2 mm (3.1–4.0). 50 spec.

Female. Antenna exceeds tip of hind angle by one-half segment; internal genitalia as figured, bursa with few tacklike spines, accessory gland and spermathecal duct originate close together at apex of bursa, duct diverticulum very short.

Elytron: 3.6±0.2 mm (3.0–4.3). 50 spec.

TYPES.—Type of *insipiens*: Specimens lost.

Lectotype of *tenellus*: Female, "Amer. Sept." (ZM). Lectotype selected by Quate in 1960.

DISTRIBUTION.—New Jersey to Florida, west to Texas.

ALABAMA: Mobile; June. ARKANSAS: Hempstead; June. FLORIDA: Columbia, Pinellas, Osceola, Volusia, Wakulla; April, May. GEORGIA: Charlton, Houston; May. NEW JERSEY: Burlington, July. NORTH CAROLINA: Bladen, Johnston, Lenoir, Moore, Pender, Richmond, Sampson, Wake, Wayne; May, July. SOUTH CAROLINA: Florence; January. TEXAS: Harrison; May.

The small size is usually sufficient to separate *insipiens* from other North American *Melanotus*. It might be confused with *americanus*, but in that species the pronotal punctures are much smaller and sparser. *M. angustatus* and *prasinus* are also small species of the *americanus* group, but they are larger than *insipiens* and have conspicuously different genitalia.

43. *Melanotus leonardi* (LeConte)

FIGURES 7*k*, 12*h*, *i*

Cratonychus Leonardi LeConte, 1853, p. 475.

Melanotus leonardi.—Candèze, 1860, p. 349.—Thomas, 1941, p. 259.—Dietrich, 1945, p. 56.—Fattig, 1951, p. 20.

MALE.—Head, anterior border of pronotum, elytron, abdomen, and venter black, antenna and legs dark reddish brown and pronotum orange colored.

Head: Front usually with marked, anterior depression; margin scarcely protuberant in front of nasale, rounded or broadly flattened across center when viewed from above; nasale flat, parantennal fovea absent or very shallowly indicated. Mandible without pit. Antenna extends to or beyond tip of hind angle by 1 segment, segment 3 small, little larger than 2, but much smaller than 4; erect male hairs short but dense enough to be seen easily.

Pronotum wider than long, ratio of width/length=1.1–1.2; punctures equal or subequal to those on front, central ones separated by distance equal to about own diameter; sides of pronotum evenly rounded with marked concavity at base of hind angles; hind angles divergent; carina weak, barely extending to hind angle base. Genitalia as figured, apical blade very small.

Elytron: 6.6 mm (5.9–7.3). 16 spec.

FEMALE.—Antenna extends about to tip of hind angle, segment 3 intermediate in size between 2 and 4; internal genitalia as figured, bursa with small cluster of spikelike spines, accessory gland short and thicker than duct, spermathecal duct branches at about basal one-third.

Elytron: 7.1 mm (6.3–7.8). 20 spec.

TYPES.—Lectotype of *leonardi:* Male, labelled with pink circle "prob. Pa." (MCZ). Second specimen of type series selected as lectotype by authors in 1962; second, a male, chosen in preference to first, a female, because males more accurately identified.

DISTRIBUTION.—Quebec to North Carolina, west to Texas.

CONNECTICUT: Litchfield; June. INDIANA: Marion; June. MAINE: Hancock, Oxford, Washington; July. MASSACHUSETTS: Suffolk, Worcester; June. NEW HAMPSHIRE: Cheshire, Strafford; no dates. NEW YORK: Essex, Jefferson; April, June. NORTH CAROLINA: Buncombe; June. TEXAS: Bexar; June. VERMONT: No data. ONTARIO: Mustota Dist., Orrville; June. QUEBEC: Duparquet, Mt. St. Hilaire, Perkins Mills; June, July.

44. *Melanotus taenicollis* (LeConte)

FIGURES 7*l*, 12*j*

Cratonychus taenicollis LeConte, 1853, p. 475.
Melanotus taenicollis: Candèze, 1860, p. 348.—Thomas 1941, p. 259.—Dietrich, 1945, p. 56.

MALE.—Black and orange or reddish brown, body largely black with orange on margins and ventral part of pronotum, on anterior border of elytra, on legs, and over entire, or on margins of, abdominal venter, antenna usually dark reddish brown but lobes of flagellar segments sometimes lighter colored.

Head: Front with anterior depression; margin scarcely protuberant in front of nasale, coming to point in center when viewed from above; nasale flat, parantennal fovea absent. Mandible without pit. Antenna short of tip of hind angle apex by about 1 segment; segment 3 small, little larger than 2, but much smaller than 4, flagellar segments broad; erect male hairs may be sparse but easily seen.

Prontotum wider than long, ratio of width/length=1.15–1.26; punctures subequal to those on front, central ones separated by about own diameter; sides of pronotum evenly rounded with marked concavity at base of hind angles; hind angles parallel or divergent, carina weak, extending just to hind angle base. Genitalia as figured; paramere with apical blade.

Elytron: 6.5±0.3 mm (6.0–6.9). 14 spec.

FEMALE.—Similar to male but less variation in body color; antenna short of tip of hind angle by about 2 segments, segment 3 intermediate in size between 2 and 4; internal genitalia as figured, bursa with cluster of spinelike spines, smaller and more numerous than in *leonardi*.

Elytron: 6.7±0.4 mm (6.1–7.5). 16 spec.

TYPES.—Lectotype of *taenicollis:* Male, labelled with pink circle "Middle States; Pa." (MCZ 2512). First specimen of type series selected as lectotype by authors in 1962; second specimen probably not a type, since only one mentioned in original description.

Distribution.—Eastern U.S.

New Jersey: Essex; no dates. New York: Dutchess; May, June. Pennsylvania: Delaware; June.

M. taenicollis and *leonardi* are the only two North American *Melanotus* with a contrasting, bicolored pattern and are easily distinguished from other species because of this. The black center of the pronotum and orange on the abdominal venter of *taenicollis*, as well as the genitalic structures, readily separate it from *leonardi*.

The *cribricollis* Group

Pronotal punctures large and dense; male paramere short, ends far basad of aedeagus apex.

45. *Melanotus cribricollis* Candèze

Figures 7*j*, 12*l,m*; Plate 1*l*

Melanotus cribricollis Candèze, 1860, p. 358.

Male.—Large, dark reddish species with sparse, short yellowish vestiture.

Head: Front with marked, anteromedian depression; margin scarcely protruding in front of nasale, angulate and concave in center when viewed from above, also sunken or impressed in center; nasale flat, short, and much wider than high; parantennal fovea shallow (1 spec. with deep fovea), circular, or semicircular. Mandible with shallow, elongate pit near lower border. Antenna short, fails to reach tip of hind angle by 4–5 segments, segment 3 intermediate in size and shape between 2 and 4; flagellar segments broad and nearly rectangular, lower angles fulvous; only a few short erect male hairs on base of lower margin, easily overlooked and difficult to distinguish males from females.

Pronotum wider than long, punctures very large and dense, margins nearly contiguous; sides of pronotum straight behind strong anterior curvature, infrequently with concavity at base of hind angle; hind angles subparallel, each with strong carina extending to or little cephalad of hind angle base and sometimes with weak, shorter median carina about two-thirds length of larger one. Genitalia as figured; paramere shorter than aedeagus, ending in broad, apical blade.

Elytron: 7.9 mm (6.5–8.5). 12 spec.

Female.—Internal genitalia as figured, accessory gland large and spherical, bursa with large, dense patch of spikelike spines.

Elytron: 7.9 ± 0.5 mm (7.3–9.0). 18 spec.

Type.—Holotype of *cribricollis:* Female, "Amer. Bor." (BMN). Only specimen in type series.

DISTRIBUTION.—Southwestern U.S., Baja California.

ARIZONA: Cochise, Maricopa, Pima, Pinal; April, September. CALIFORNIA: San Diego; April. BAJA CALIFORNIA: 10 mi. southwest of Comondu, 25 mi. west of LaPaz, 8 mi. northwest of Los Angeles Bay, 22 mi. northwest of Penjamo, St. Bartlme Bay, 10 mi. south of San Jose del Cabo; June, September.

M. cribricollis and *chiricahuae* are readily separable from other North American *Melanotus* by the large pronotal punctures, shallow mandibular pit, short antennae, and peculiar male genitalia. Their divergence from other North American species and distribution in the southwestern U.S. suggests they are of Neotropical origin.

M. cribricollis differs from *chiricahuae* in its shorter antennae, shape of the frontal margin, more rectangular shape of the flagellar segments, better developed parantennal fovea, and different shape of the male genitalia.

46. *Melanotus chiricahuae* Knull

FIGURES 7*i*, 12*k*

Melanotus chiricahuae Knull, 1962, p. 34.

MALE.—Large, dark reddish-brown species with sparse, yellowish vestiture.

Head: Front with marked anterior depression; margin protruding in front of nasale by about twice width of rim, rounded when viewed from above; nasale flat, parantennal fovea very shallow, faintly crescent shaped. Mandible with shallow, elongate pit near lower border. Antenna exceeds tip of hind angle by about ½ segment, segment 3 intermediate in size between 2 and 4, flagellar segments triangular; erect male hairs short, usually dense but may be scarcely visible.

Pronotum wider than long, punctures very large and dense, separated by less than own diameter; sides of pronotum straight behind anterior curvature and usually subparallel but may be divergent posteriorly; hind angles divergent, each with a strong carina extending cephalad of hind angle base and incurved anteriorly and a weak, shorter, median carina about ¾ length of larger one. Genitalia as figured; paramere much shorter than aedeagus, ending in unusual recurved apex.

Elytron: 8.6 ± 0.5 mm (7.6–9.5). 21 spec.

FEMALE.—Similar to male; antenna shorter, extends to tip of hind angle or short of tip by 1 segment; genitalia as figured, bursa with thick patch of simple spines, accessory gland short, originates well before apex and origin of spermathecal duct.

Elytron: 9.2 ± 0.5 mm (8.5–10.5). 16 spec.

DISTRIBUTION.—Southwestern U.S.

ARIZONA: Cochise, Santa Cruz; June–August. NEW MEXICO: Hidalgo; August.

The large pronotal punctures of this species are distinctive, although it might be confused with *similis* in the same area. The punctures of *chiricahuae* are larger than in *similis*, the antennae are shorter, and it has a weak, shallow mandibular pit. The male and female genitalia are easily distinguished from other species.

Species Incertae

Melanotus abdominalis (Erichson)

Cratonychus abdominalis Erichson, 1842, p. 104.—LeConte, 1853, p. 481.
Melanotus abdominalis.—Candèze, 1860, p. 352.

Type.—Holotype: Female, "Amer. Sept." (ZM, 17036). Only specimen in type series.

This species has subequal second and third antennal segments, a jutting frontal margin, fine dense pronotal punctures, and a long, slender, heavily spined female bursa. It is unlike any species which we have encountered in North America and is unfamiliar to us. We suspect that it is not a North American species and the type has been labelled in error.

Melanotus cinereus (Weber)

Elater cinereus Weber, 1801, p. 77.

This species is usually listed as a synonym of *similis* (=*fissilis*) or *communis*, but the types apparently are lost, and we are unable to apply the name to a known species.

Melanotus despectus Candèze

Melanotus despectus Candèze, 1860, p. 343.

We have not seen types of this species, but Mr. Lane (in litt.) states that he saw specimens at the Deutschen Entomologischen Institut, Berlin, which might be the types. According to Lane, these are the same as *ignobilis* and if those specimens can be shown to be types, *despectus* would fall as a synonym of *ignobilis*.

Melanotus effetus Candèze

Melanotus effetus Candèze, 1860, p. 355.

This may be only a small form of *communis* according to Lane (in litt.), who found specimens at the Zoologische Museum der Humboldt-Universität that might be the types.

Literature Cited

Arnett, R. H., Jr.
1955. Supplement and corrections to J. A. Hyslop's genotypes of the elaterid beetles of the world. Proc. U.S. Nat. Mus., vol. 103, no. 3336, pp. 599–619.

Becker, E. C.
1956. Revision of the Nearctic species of *Agriotes* (Coleoptera: Elateridae). Canadian Ent., vol. 88, suppl. 1, pp. 1–101.

Binaghi, G.
1939. I Melanotini della fauna italiana: *Sphenisococomus* Schw. e *Melanotus* Eschs. (Coleoptera: Elateridae). Mem. Soc. Ent. Italiana, vol. **17**, pp. 205–239 (1938).

Blackwelder, R. E.
1939. Fourth supplement to Leng Catalogue of Coleoptera of America, north of Mexico. [Elateridae: pp. 39–42.]

Blackwelder, R. E. and R. M.
1948. Fifth supplement to Leng Catalogue of Coleoptera of America, north of Mexico. [Elateridae: p. 19.]

Blanchard, C. E.
1845. Histoire des insectes, vol. 2.

Blatchley, W. S.
1910. An illustrated descriptive catalogue of the Coleoptera or beetles (exclusive of the Rhynchophora) known to occur in Indiana. [Elateridae: pp. 699–773.]
1920. Canadian Ent. News, vol. 52, pp. 45, 46.
1927. Some new species of Coleoptera from Indiana and Florida. Ent. News, vol. 38, pp. 139–144.
1930. Blatchleyana,

Brooks, A. R.
1960. Canadian Ent., suppl., vol. 20, p. 40.

Candèze, E.
1860. Monographie de Élatéridae, 3. Mém. Soc. Sci. Liege, vol. 15, 512 pp.
1889. Élatérides nouveaux. Ann. Soc. Ent. Belgique, vol. 33, pp. 67–123.

Comstock, J. H., and Shingerland, ?
1891. Cornell Agric. Exp. Sta. Bull., no. 33, p. 262.

Deen, O. T., and Cuthbert, F. P., Jr.
1955. The distribution and relative abundance of wireworms in potato-growing areas of the southeastern states. Journ. Econ. Ent., vol. 48, pp. 191–193.

Dejean, P. S.
1833. Catalogue des Coléoptères de la colleccion . . ., ed. 2, 176 pp.

Dietrich, Henry
1945. The Elateridae of New York State. Cornell Univ. Agric. Exp. Sta. Mem. 269, 79 pp.

Emmons, Ebenezer
1854. Insects of New York. Vol. 5 of pt. 5 (Agriculture) *in* Natural history of New York.

Erichson, W. F.
1842. Ueber die Elateren mit Kammförmig gezähnten Krallen. Germar Zeitschr., vol. 3, pp. 88–129 [1841?].
Eschscholtz, J. F.
1829. *In* T. Thon, Entomologisches Archiv., vol. 2, p. 32.
Fall, H. C.
1934. Journ. New York Ent. Soc., vol. 42, p. 24.
Fattig, P. W.
1951. The Elateridae or click beetles of Georgia. Emory Univ. Mus. Bull., no. 10, 25 pp.
Fenton
1926. Journ. Econ. Ent., vol. 19, p. 502.
Gyllenhal, L.
1817. *In* Schoenherr, Synonymia insectorum, oder: Versuch einer Synonymie aller bisher bekannten Insecten . . ., Appendix, vol. 3, p. 138.
Herbst, J. F. M.
1806. Natursystem aller bekannten in- und auslandischen Insecten, . . ., vol. 10, 285 pp.
Horn, George H.
1874a. Trans. Amer. Phil. Soc., n. s., vol. 10, p. 473.
1874b. Trans. Amer. Ent. Soc., vol. 5, p. 23.
1879. [Communication on the Elateridae.] Trans. Amer. Ent. Soc., vol. 7, pp. xiv–xvi.
Hyslop, J. A.
1915. U.S. Dept. Agric. Bur. Ent. Bull., no. 156, p. 17.
1916. U.S. Dept. Agric. Farmers' Bull., vol. 725, p. 5.
1921. Genotypes of the elaterid beetles of the world. Proc. U.S. Nat Mus., vol. 58, pp. 621–680.
Jeuniaux, Charles
1955. Sur les Elatéroides paléarctiques. Bull. Ann. Soc. Roy. Ent. Belgique, vol. 91, pp. 230–237.
Jewett, H. H.
1946. Identification of some larval Elateridae found in Kentucky. Kentucky Agric. Exp. Sta. Bull., no. 489, 40 pp.
Kirby, W.
1837. Insects. Pt. 4 *in* Richardson, Fauna Boreali-Americana, xxxix+325 pp., 8 col. pls.
Knull, J. N.
1959. Two new species of *Melanotus* (Coleoptera: Elateridae). Ohio Journ. Sci., vol. 59, no. 5, pp. 280–281.
1962. A new *Melanotus* from the Chiricahua Mountains of Arizona (Coleoptera: Elateridae). Ohio Journ. Sci., vol. 62, no. 1, p. 34.
Lane, M. C.
1952. List of Elateridae of British Columbia. Proc. Ent. Soc. British Columbia, vol. 48, pp. 65–67 [1951].
LeConte, J. L.
1853. Revision of the Elateridae of the United States. Trans. Amer. Phil. Soc., n. s., vol. 10, pp. 405–508.
1866. Additions to the coleopterous fauna of the United States, 1. Proc. Acad. Nat. Sci. Philadelphia, vol. 18, pp. 361–394.

LENG, C. W.

1918. Notes on some changes in the list of Coleoptera. Journ. New York Ent. Soc., vol. 26, pp. 201–211.

1920. Catalogue of the Coleoptera of America, north of Mexico, x+470 pp. [Elateridae: pp. 166–175.]

LENG, C. W., and MUTCHLER, A. J.

1927. Supplement to Catalogue of Coleoptera of America, north of Mexico. [Elateridae: p. 29.]

1933. Second and third supplements to Catalogue of Coleoptera of America, north of Mexico. [Elateridae: pp. 27, 83–85.]

McCLURE, H. E.

1933. Ent. News, vol. 44, p. 145.

MELSHEIMER, F. E.

1846. Descriptions of a new species of Coleoptera of the United States. Proc. Acad. Nat. Sci. Philadelphia, vol. 2, pp. 134–160.

PAYKULL, G.

1800. Insecta. Vol. 3 *in* Fauna svecica.

PUTZEYS, JULES

1908. Ann. Soc. Ent. Belgique, vol. 52, p. 294.

REDTENBACHER, L.

1849. Fauna Austriaca, xxviii+883 pp.

SAY, THOMAS

1823. Descriptions of coleopterous insects collected in the late expedition to the Rocky Mountains, performed by order of Mr. Calhoun, Secretary of War, under the command of Major Long. Journ. Acad. Nat. Sci. Philadelphia, vol. 3, pp. 139–216.

1825. Descriptions of new American species of the genera Buprestis, Trachys and Elater. Ann. Lyc. Nat. Hist. New York, vol. 1, pp. 249–268.

1839. Descriptions of new North American insects and observations on some already described. Trans. Amer. Phil. Soc., n. s., vol. 6, pp. 155–190 [1836].

SCHENKLING, S.

1927. Coleopterorum catalogus, Elateridae, 2. No. 88 *in* Junk and Schenkling, pp. 265–636.

SCHWARZ, O.

1892. Revision der paläarktischen Arten der Elateriden-Gattung *Melanotus*, Esch. Deutsche Ent. Zeitschr., pp. 145–164.

SEVERIN, H. C.

1949. The wireworms (Elateridae) of South Dakota. Tech. Bull. South Dakota Agric. Exp. Sta., no. 8, 18 pp.

SNODGRASS, R. E.

1957. A revised interpretation of the external reproductive organs of male insects. Smithsonian Misc. Coll., vol. 135, no. 6, pp. 1–60.

STEPHENS, J. F.

1830. Mandibuta, vol. 3. Illustrations of British Entomology.

SRIVASTAVA

1958. Annals Zool., vol. 2, p. 87.

STONE, M. W., and HOWLAND, A. F.

1944. Life history of the wireworm *Melanotus longulus* (Lec.) in southern California. U.S. Dept. Agric. Tech. Bull. 858, 30 pp.

THOMAS, C. A.
1941. The Elateridae of Pennsylvania. Journ. New York Ent. Soc., vol. 49, pp. 233–263.

VAN DYKE, E. C.
1932. Miscellaneous studies in the Elateridae and related families of Coleoptera. Proc. California Acad. Sci., ser. 4, vol. 20, no. 9, pp. 291–465.

VAN ZWALUWENBURG, R. H.
1921. *Melanotus hyslopi*, new species (Coleoptera). Proc. Ent. Soc. Washington, vol. 23, pp. 210–211.
1922. External anatomy of the elaterid genus *Melanotus* (Coleoptera), with remarks on the taxonomic value of certain characters. Proc. Ent. Soc. Washington, vol. 24, pp. 12–29.

WEBER, FRIEDRICH
1801. Observationes entomologicae, continentes novorum quae condidit generum characteres, . . . xii+116 pp.

WESTWOOD, J. O.
1840. An introduction to the modern classification of insects . . ., vol. 2.

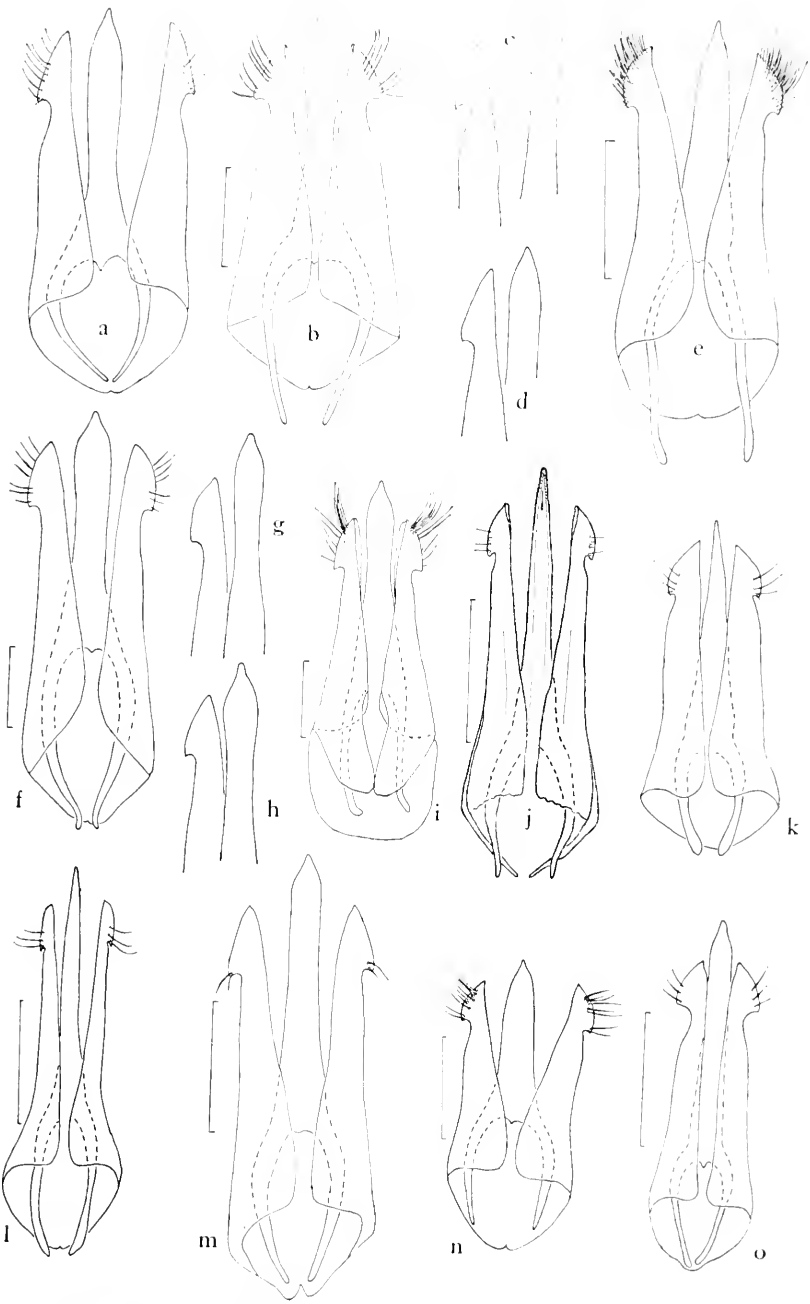


FIGURE 4.—Male genitalia of *Melanotus* species: *a–d*, *similis*; *e*, *spadix*; *f–h*, *decumanus*; *i*, *castanipes*; *j*, *communis*; *k*, *indistinctus*; *l*, *dietrichi*; *m*, *verberans*; *n*, *miscellus*; *o*, *emissus*. (Scale lines=0.5 mm.)

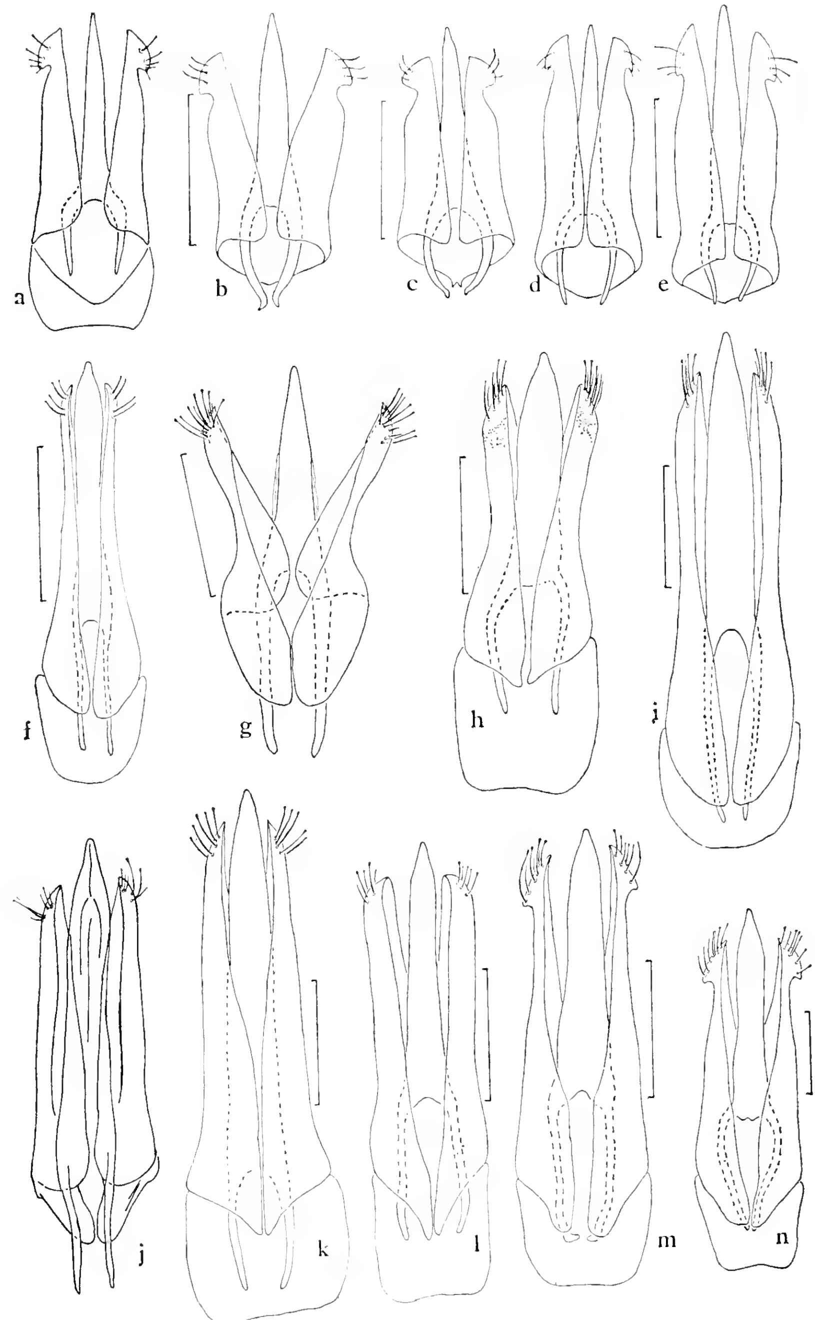


FIGURE 5.—Male genitalia of *Melanotus* species: *a*, *lanei*; *b*, *c*, *pilosus*; *d*, *e*, *opacicollis*; *f*, *clandestinus*; *g*, *ignobilis*; *h*, *morosus*; *i*, *depressus*; *j*, *cribulosus*; *k*, *piceatus*; *l*, *hyslopi*; *m*, *sagittarius*; *n*, *corticinus*. (Scale lines=0.5 mm.)

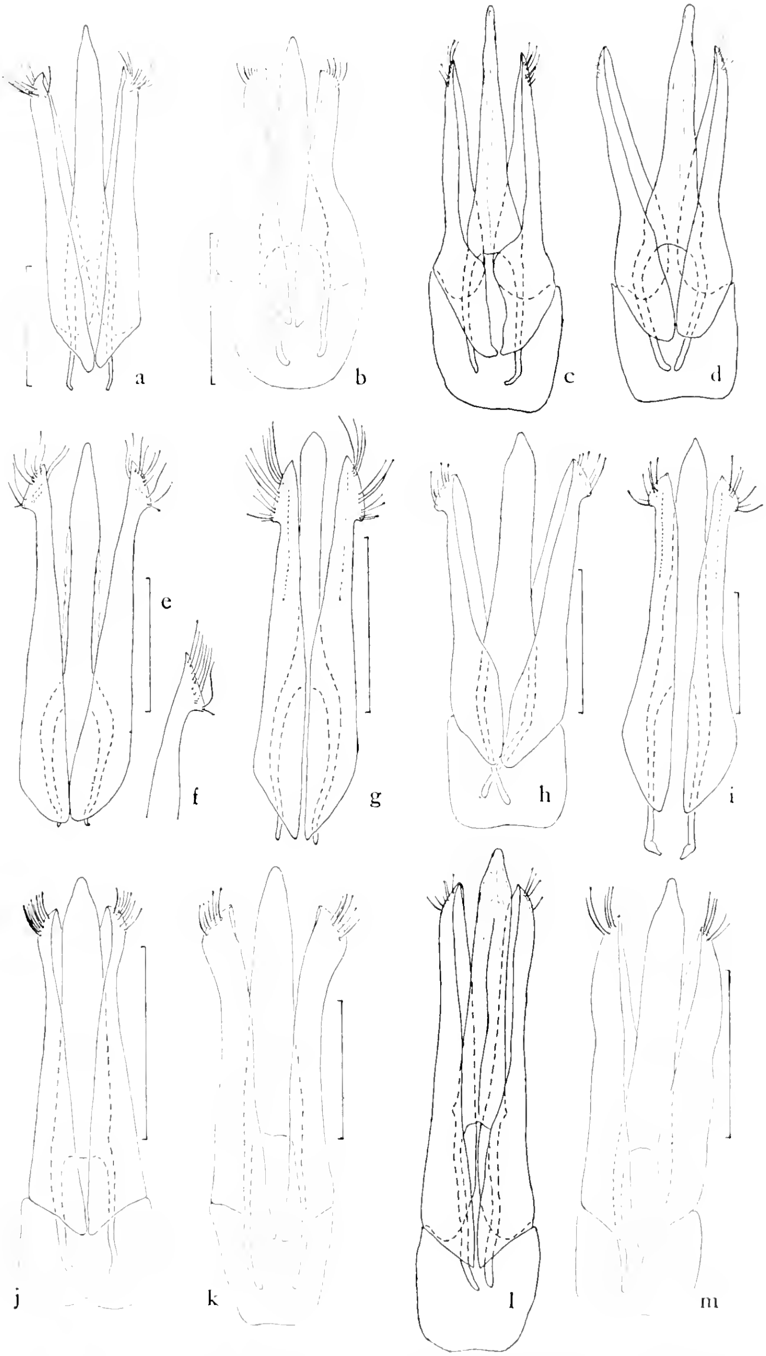


FIGURE 6.—Male genitalia of *Melanotus* species: *a*, *prasinus*; *b*, *testaceus*; *c*, *trapezoideus*; *d*, *tenax*; *e*, *f*, *macer*; *g*, *difficilis*; *h*, *parallelus*; *i*, *infaustus*; *j*, *americanus*; *k*, *cribriventris*; *l*, *pertinax*; *m*, *beameri*. (Scale lines=0.5 mm.)

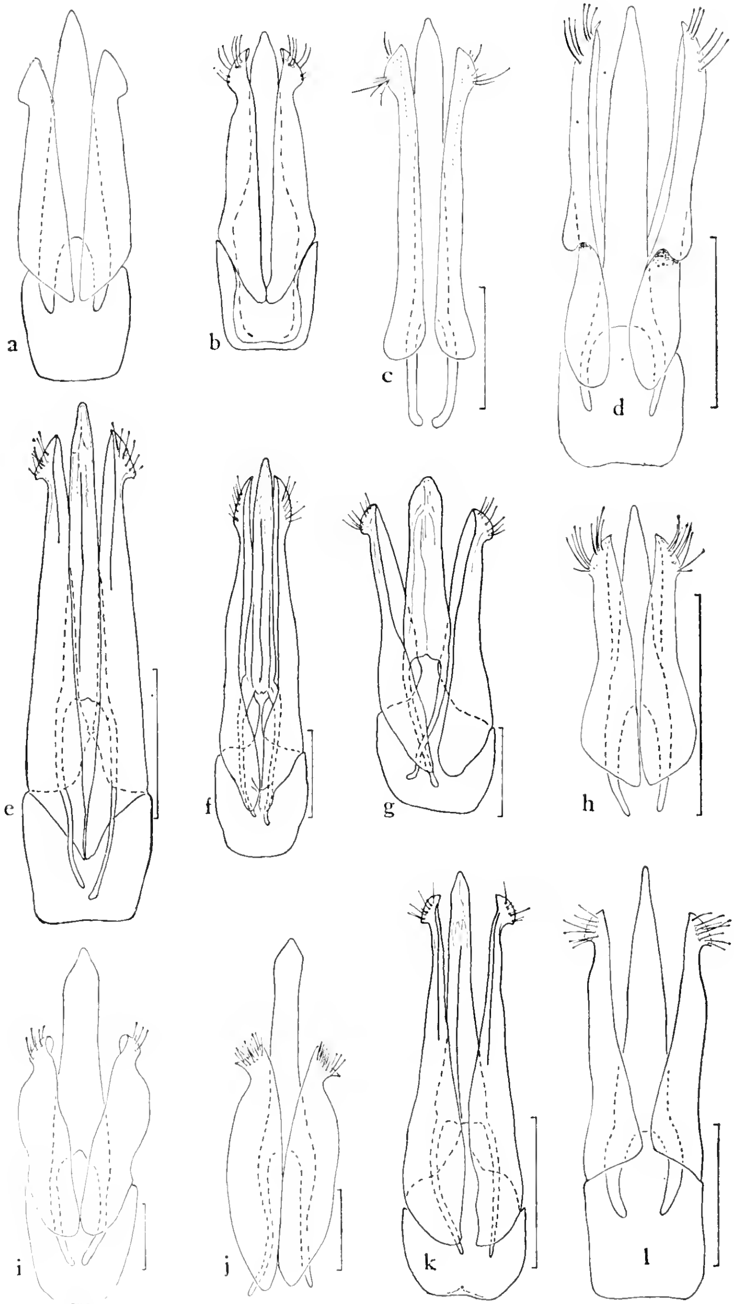


FIGURE 7.—Male genitalia of *Melanotus* species: *a*, *concisus*; *b*, *obscuratus*; *c*, *lanceatus*; *d*, *hamatus*; *e*, *longulus longulus*; *f*, *longulus oregonensis*; *g*, *gradatus*; *h*, *insipiens*; *i*, *chiricahuae*; *j*, *cribricollis*; *k*, *leonardi*; *l*, *taenicollis*. (Scale lines=0.5 mm.)

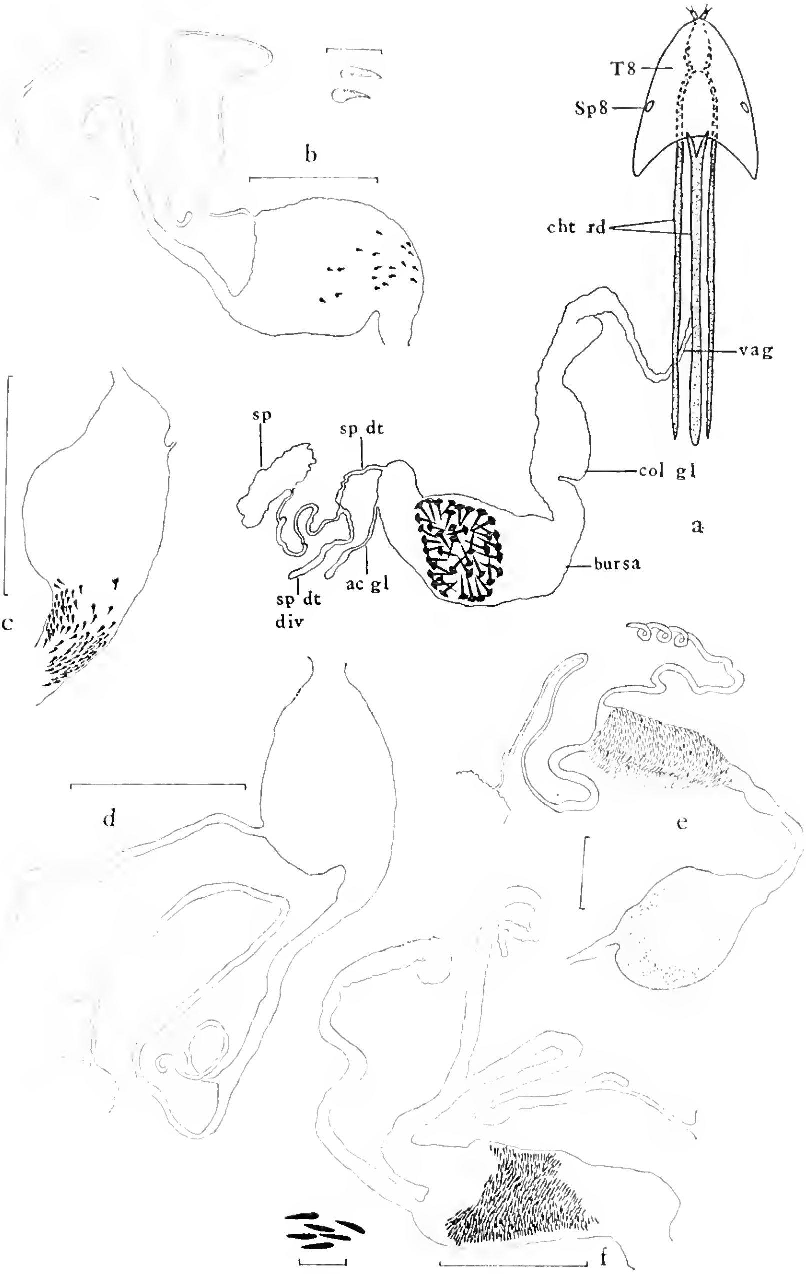


FIGURE 8.—Female genitalia of *Melanotus* species: *a*, hypothetical species with structures labelled; *b*, *similis*, "normal"; *c*, *similis*, "spiny"; *d*, *decumanus*; *e*, *spadix*; *f*, *castanipes*. (Scale lines = 1.0 mm and 0.1 mm.)

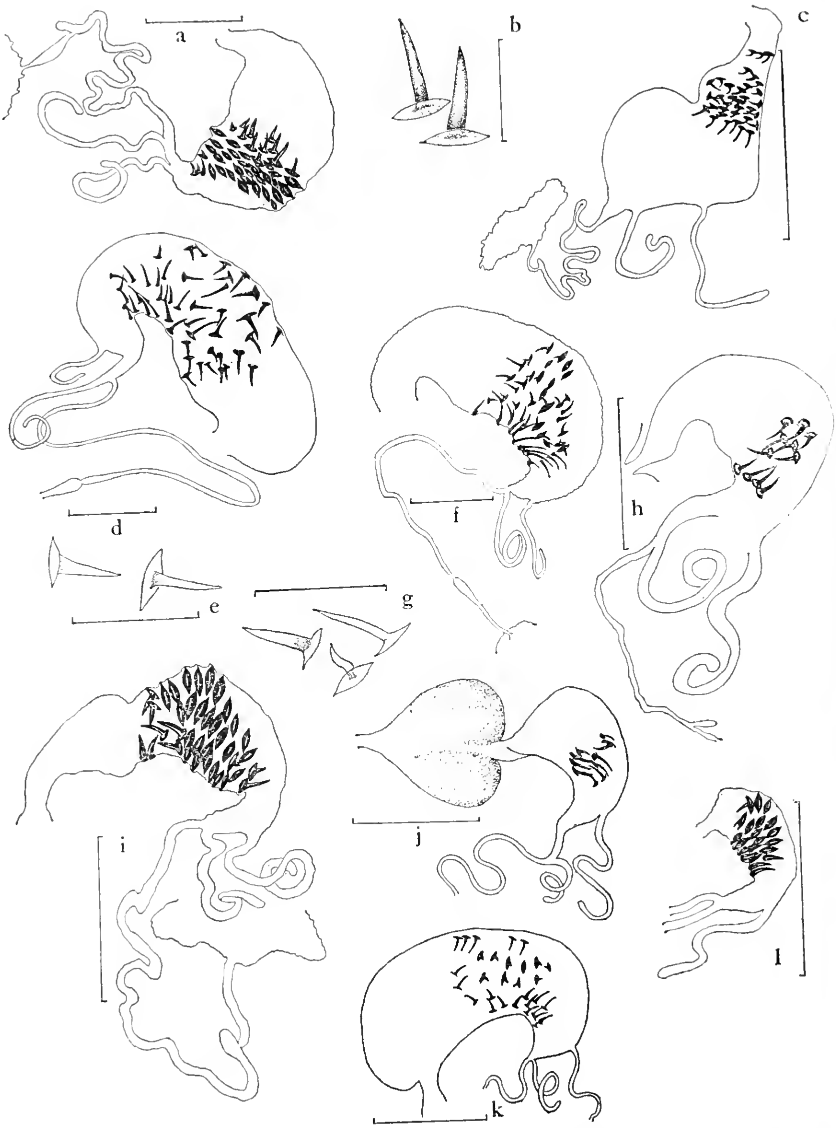


FIGURE 9.—Female genitalia of *Melanotus* species: *a,b, communis; c, miscellus; d,e, dietrichi; f,g, indistinctus; h, lanei; i, verberans; j, opacicollis; k, emissus* (?); *l, pilosus*. (Scale lines= 1.0 and 0.5 mm.)

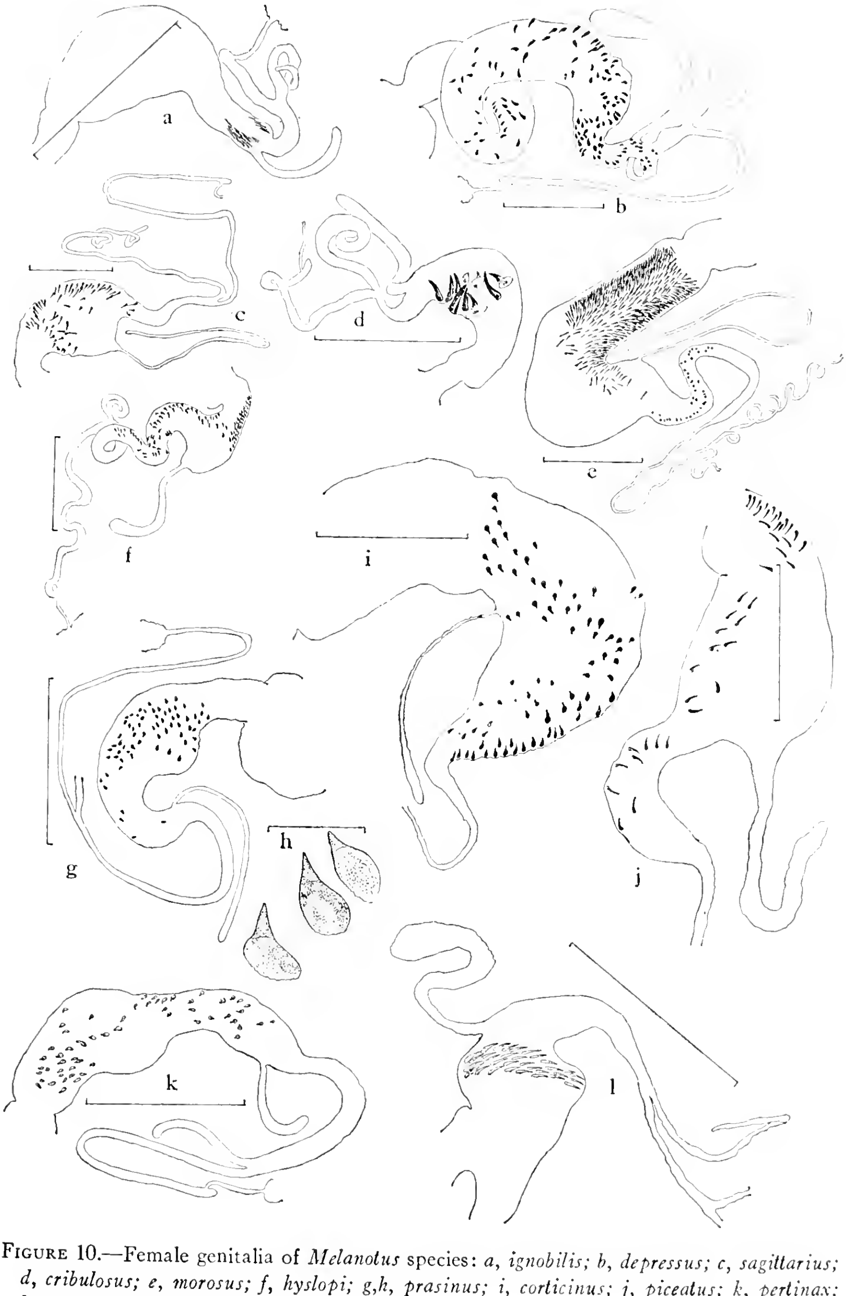


FIGURE 10.—Female genitalia of *Melanotus* species: *a*, *ignobilis*; *b*, *depressus*; *c*, *sagittarius*; *d*, *cribulosus*; *e*, *morosus*; *f*, *hyslopi*; *g,h*, *prasinus*; *i*, *corticinus*; *j*, *piceatus*; *k*, *pertinax*; *l*, *macer*. (Scale lines= 1.0 and 0.05 mm.)

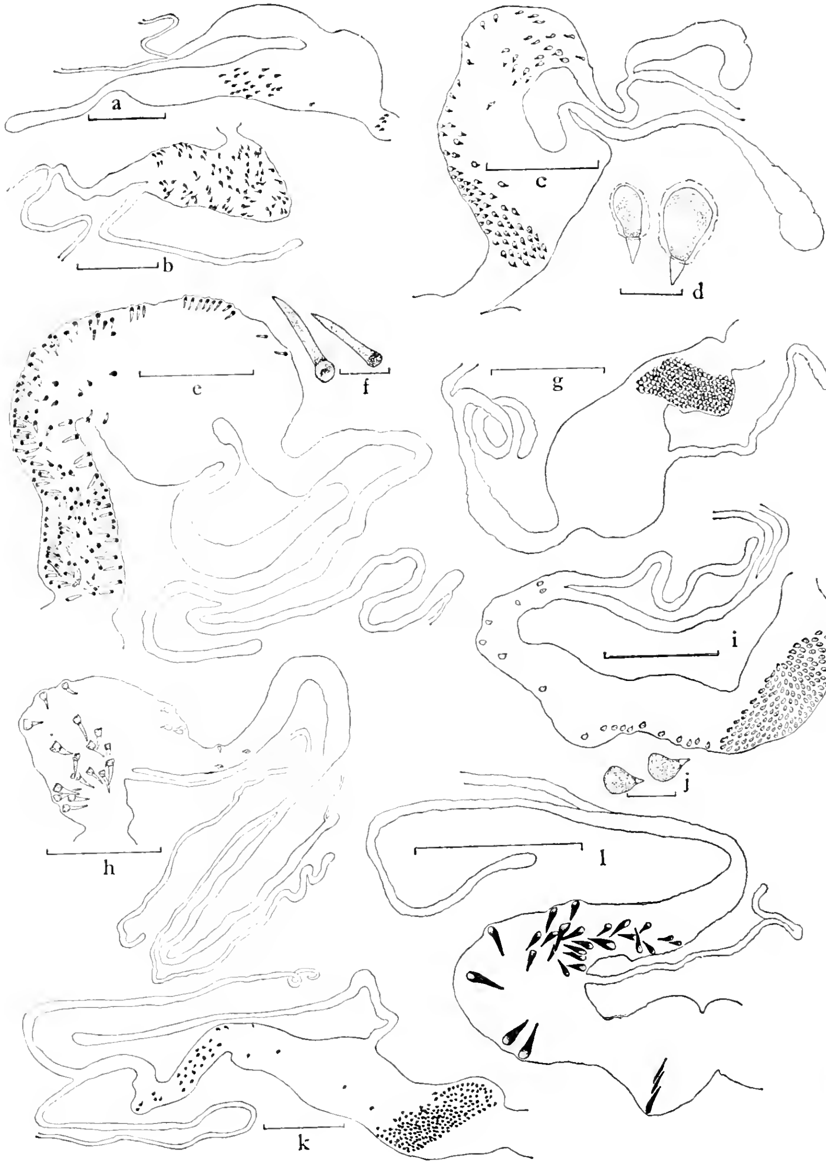
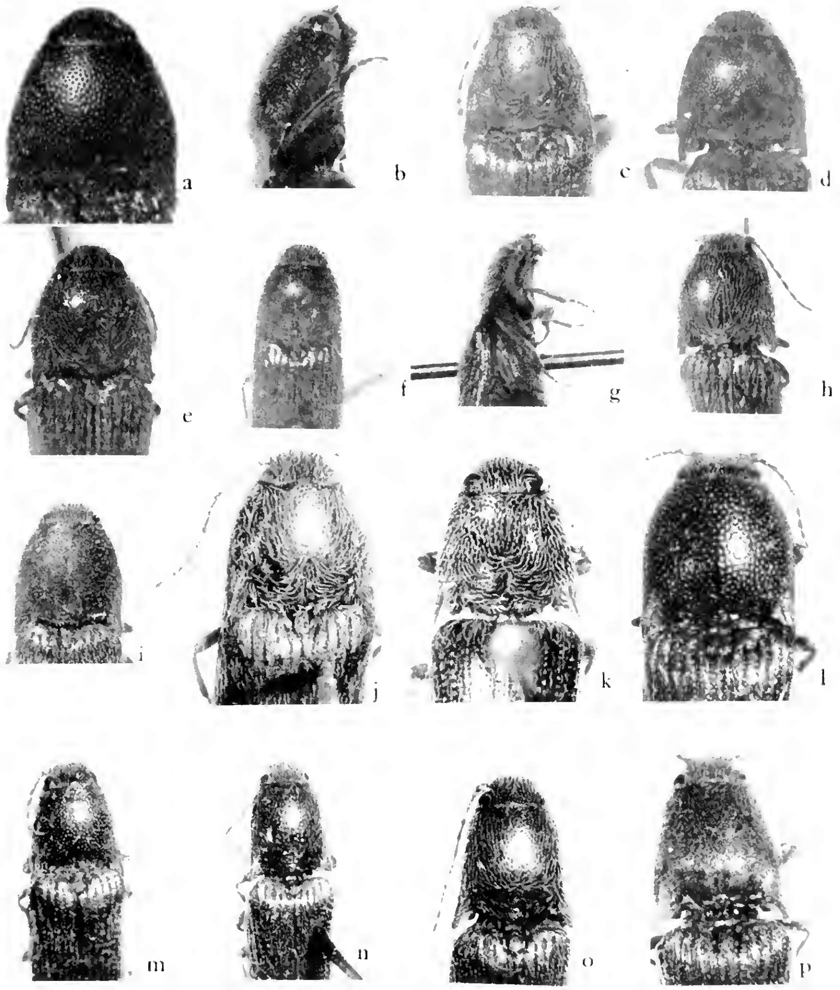


FIGURE 11.—Female genitalia of *Melanotus* species: *a*, *tenax*; *b*, *trapezoideus*; *c,d*, *testaceus*; *e,f*, *americanus*; *g*, *parallelus*; *h*, *cribriventris*; *i,j*, *infaustus* (?); *k*, *gradatus*; *l*, *obscuratus*. (Scale lines=0.5 and 0.05 mm.)

FIGURE 12.—Female genitalia of *Melanotus* species: *a, concisus* (?); *b, lanceatus; c,d, longulus longulus; e,f, longulus oregonensis; g, insipiens; h,i, leonardi; j, taenicollis; k, chiricahuae; l,m ,cribrjcollis.* (Scale lines=0.5 and 0.05 mm.)

U S. GOVERNMENT PRINTING OFFICE: 1967



Heads of *Melanotus* species: *a*, *similis*; *b*, *decumanus*; *c*, *castanipes*; *d*, *communis*; *e*, *verberans*; *f*, *lanei*; *g*, *pilosus*; *h*, *emissus*; *i*, *opacicollis*; *j*, *depressus*; *k*, *sagittarius*; *l*, *cribricollis*; *m*, *tenax*; *n*, *parallelus*; *o*, *infaustus*; *p*, *gradatus*.

Proceedings of the United States National Museum

SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 121 | 1967 | Number 3569

SOLDIER FLY LARVAE IN AMERICA NORTH OF MEXICO[1]

By MAX W. McFADDEN[2]

The Stratiomyidae or soldier flies are represented in America north of Mexico by approximately 237 species distributed through 37 genera. Prior to this study, larvae have been described for only 21 species representing 15 genera. In addition to the lack of adequate descriptions and keys, classification has seldom been attempted and a phylogenetic treatment of the larvae has never been presented.

The present study has been undertaken with several goals in mind: (1) to rear and describe as many species as possible; (2) to redescribe all previously described larvae of North American species; and (3), on the basis of larval characters, to attempt to define various taxonomic units and show phylogenetic relationships within the family and between it and other closely related familes.

Any attempt to establish subfamilial and generic limits must be regarded as tentative. This is especially true in the present study since larvae of so many species of Stratiomyidae remain unknown. Undoubtably, as more species are reared, changes will have to be made in keys and definitions of taxa.

The keys have been prepared chiefly for identification of last instar larvae. If earlier instars are known, they either have been

[1] Modified from a Ph. D. dissertation submitted to the University of Alberta, Edmonton, Canada.

[2] Entomology Research Division, U.S. Dept. Agriculture, Tobacco Insects Investigations, P.O. Box 1011, Oxford, N.C. 27565.

included in the key or a separate description has been given—or both. Because pupation takes place within the last larval skin, the puparium can be identified with the keys to the larvae.

I wish to extend sincere appreciation to Dr. George E. Ball of the University of Alberta, Edmonton, for his excellent direction of the study; to Dr. Maurice T. James of Washington State University, Pullman, for his constant help and advice on many problems; to Dr. Willis W. Wirth of the U.S. Department of Agriculture, Washington, D.C., for his advice and for reviewing the manuscript; and to the University of Alberta and the National Research Council of Canada for their financial assistance.

I also wish to acknowledge with thanks material loaned from the following entomologists and institutions (abbreviations that follow are used throughout this text):

American Museum of Natural History, New York, N.Y. (P. Wygodzinsky)—AMNH
California Academy of Sciences, San Francisco, Calif. (P. Arnaud, Jr.)—CAS
Canada Department of Agriculture, Belleville, Ont. (H. G. James)—CDA
Canadian National Museum, Ottawa, Ont. (G. E. Shewell)—CNC
Clemson College, Clemson, S. C. (R. C. Fox)—CC
Colorado State University, Fort Collins, Colo. (T. O. Thatcher)—CSU
Cornell University, Ithaca, N.Y. (C. O. Berg and H. Dietrich)—CU
Deutches Entomologisches Institut, Berlin, Germany (W. Hennig)—DEI
Illinois Natural History Survey Collection, Urbana, Ill. (L. K. Gloyd)—INHM
Louisiana State University, University Park, La. (H. V. Daly)—LSU
M. W. McFadden Collection—MWM
North Carolina State College, Raleigh, N.C. (R. L. Rabb)—NCSC
Ohio State University, Columbus, Ohio (J. G. Rozen)—OSU
Purdue University, Lafayette, Ind. (L. Chandler)—PU
Rockefeller Foundation, Mexico, D.F., Mexico (J. L. Carrillo S.)—RF
University of California, Berkely, Calif. (P. Ashlock and R. L. Usinger)—UCB
University of Delaware, Newark, Del. (P. P. Burbutis)—UD
University of Kansas, Lawrence, Kans. (W. J. Hanson)—UK
University of Maine, Orono, Maine (G. W. Simpson)—UM
University of Massachusetts, Amherst, Mass. (M. E. Smith)—UMASS
University of Michigan, Ann Arbor, Mich. (T. E. Moore)—UMICH
University of Missouri, Columbia, Mo. (W. R. Enns)—UMO
United States National Museum, Washington, D.C. (W. W. Wirth)—USNM
Washington State University, Pullman, Wash. (M. T. James)—WSU

Methods

A suitable technique for removing larvae from various substrates has been developed (McFadden, 1961). Specimens thus obtained for this study were divided into two groups: one to be reared, the other to be preserved.

Larvae were killed and preserved in 70 percent alcohol without additional treatment. In the case of large specimens, the alcohol was changed after a month's lapse.

Rearing was simplified by collecting in the spring, when larvae were usually in the last instar, about to pupate, or had already pupated. Larvae and pupae held for rearing were placed in 5-dram vials fitted with cotton stoppers. A small amount of the substrate in which the animal was found was placed in the vial before adding the specimen. Distilled water was added occasionally to maintain moist conditions. Larvae and pupae were always reared individually so that emerging adults or parasites could be associated with the respective larval or pupal skin. The adults were then identified and associated with the larvae that had not been reared, and thus the identity of these larvae was determined. This is by no means a foolproof system for identification, but in most instances it can be relied upon because of the gregarious nature of the larvae.

In observing preserved specimens, I frequently found that many morphological characters that are used in distinguishing the various taxa were obscured by deposits of calcium carbonate and environmental debris. The larvae were quickly cleaned of most of the debris by soaking them in 10 percent hydrochloric acid (Lundbeck, 1907, and Johannsen, 1935). Active effervescence always accompanied this treatment.

The head of the larva was prepared for study by removing it from the body and placing it in a test tube containing 2 percent potassium hydroxide. The tube was placed in a beaker of water and boiled slowly for 2 hours. The heads then were washed in glacial acetic acid, dissected, and mounted on a slide. Photomicrographs were prepared using the technique described by Howden (1955).

Historical Résumé

From 1720 to the present, numerous papers have been written on various aspects of stratiomyid natural history as well as on morphology and physiology of the larvae. Rather than attempt to condense a voluminous literature in a few paragraphs here, I shall discuss these works under their appropriate sections of biology, morphology, phylogeny, and classification.

Studies on the biology and systematics of larval Stratiomyidae can be divided into 2 rather distinct periods.

The first period (1720–1868) was devoted to the description of local faunas. In most instances larvae were associated with adults through rearing so that correct identifications were obtained; however, no attempts at classification were made nor were other generalities presented.

The second period, which was initiated by Brauer (1869), was characterized by the incorporation of biological features and the characteristics of the immature stages in classification. Using Schiner's classification (1868) based on adults, Brauer demonstrated that the immature stages of Diptera could be used as a check against an already existing system of classification. Although Brauer did not organize the Stratiomyidae into its component genera, he did recognize that the Stratiomyidae, Tabanidae, Rhagionidae (Leptidae), and Coenomyidae were closely allied and placed them in the tribe Cyclocera under the Orthorrhapha-Brachycera.

Brauer (1883) once again reviewed the characters of dipterous larvae and, on the basis of differences in head capsules, established a new classification in which the Stratiomyidae and Xylophagidae were considered as separate families but were placed together in the Notacantha. In the same paper, Brauer divided the Stratiomyidae into its various genera and listed the larval characters for each genus.

Austen (1899) presented a clear and concise review of the problem regarding the classification of *Solva*, subsequent to which the majority of dipterists have considered the genus to be located in the Xylomyinae (Solvinae), a subfamily within the Stratiomyidae (for further details, see page 13).

Malloch (1917) was the first person to arrange systematically the North American Startiomyidae on the basis of larvae. As might be expected, numerous genera were omitted since many larvae had as yet not been described.

Johannsen (1922, 1935) continued the work of Malloch. He added several new descriptions of larvae and supplied much of the data on biology that we have today.

The most recent contribution to the classification of stratiomyid larvae has come from Willi Hennig. In his outstanding work "Die Larvenformen der Dipteren" (1952) the species are listed for each genus and their distribution given by zoogeographical region. In addition, he has included biological notes for nearly all the species mentioned.

Biology

The following discussion comprises a review of the literature on the biology of the Stratiomyidae along the lines of a general life history, with each study of a particular stage included under its respective heading.

Irwin-Smith (1920, 1921) was the first to achieve some success in rearing in a laboratory the complete life cycle of a species. Although she was able to obtain a cycle from larva to larva, she was unable to determine the duration of the larval stage. More recently, Furman, Young, and Catts (1959) reported that newly hatched larvae of *Hermetia illucens* require 2 weeks or longer to attain full growth under laboratory conditions and that the pupal stage may last from 2 weeks to 5 months. May (1961), also working with *H. illucens*, gave more precise figures for the duration of the various stages in the life cycle and, in addition, was able to complete the life cycle successfully.

EGGS.—Eggs usually are laid in early spring by females that have overwintered as larvae. When first laid, the eggs are pale yellow but become progressively darker as the hatching date approaches. The actual time required for hatching varies from 5 days to 3 weeks.

Hart (1895) mentions that the eggs of *Odontomyia* are "cigar-shaped," but this is not the case throughout the family. Wesenberg-Lund (1943) reports that the eggs may be flattened or highly arched or in the form of a "regular" egg. In addition, he mentions that the eggs usually are placed in a distinct group or clump (the number varying with the species) on vegetation overhanging water, in the case of aquatic forms, or on decaying organic matter, in the case of terrestrial forms. Wesenberg-Lund (1943) also mentions that the eggs of Stratiomyidae are difficult to distinguish from those of Tabanidae.

LARVAE.—Newly hatched larvae were noted by Irwin-Smith (1921) to molt as soon as they emerged from the egg. Active feeding commenced immediately. As stated previously, the duration of the larval state is unknown but the larvae of the majority of the northern Nearctic species appear to be fully mature by fall. These mature larvae are probably the overwintering stage, as pupation does not occur until the following spring.

Larvae in each of the subfamilies exhibit a varying degree of similarity with respect to their feeding habits (James, 1960), but there is considerable variation in habitat selection by species within the subfamilies. Thus we have papers by Packard (1871), Lucas (1879), Griffith and Packard (1882), and Brues (1924, 1928, and 1932) recording the occurrence of larvae in salt water and in hot springs and lakes. Pearson (1883) reported a larva that was found on an exposed part of ocean beach, and Florentin (1899) found a great mass of larvae in excessively saline pools.

The sum of our knowledge on habitats for the larvae of the North American genera of Stratiomyidae is presented in condensed form in table 1. Except for genera such as *Actina*, which are known only from some other part of the world, the references are primarily to North American workers. It is hoped that this table will not only be an aid to collecting larvae but will also be a guide to the needs for future studies within the family. Additional information on biology of the larvae is given under the species descriptions.

Pupae.—The stratiomyid pupa, surprisingly, is much smaller than the puparium, often being only one-third the total length of the latter.

At the onset of pupation the mature larva becomes rigid, the integument hardens, and the apical segments are usally in a distorted position. The pupa itself, enclosed in a silky cocoon secreted by the salivary glands, occupies only the anterior end of the puparium. Miall (1895) reports that earlier workers often mistook the pupa for a parasite that had devoured the larva.

Because of the shrinkage of the pupa, an air space is formed within the puparium, and thus the aquatic pupal stage becomes buoyant. As a result, the pupa floats on the surface of ponds or other bodies of water until eventually it is either blown by the wind or carried by the action of waves to the shore, where it remains with other debris until the adult emerges.

At the time of emergence the puparium splits not only along the dorsomedian line to the second abdominal segment, in the manner of the Nematocera, but also transversely on the second abdominal segment in the manner of the Cyclorrhapha.

Adults.—Malloch (1917) and Johannsen (1935) have stated that adult stratiomyids, of both terrestrial and aquatic forms, may be seen flying about in areas where species of Umbelliferae and Compositae are in flower or resting on vegetation that is close to water. Although there is relatively little information on feeding habits of the adults, the regularity with which they are seen on vegetation correlates with Lundbeck's observation (1907) that the adults feed on "plant juices" (nectar?).

The more commonly seen adults that represent species of *Stratiomys* and *Odontomyia* are robust in appearance and are good fliers, but there are many species in other genera that lack one or both of these attributes. Other species, especially in the genus *Sargus*, are able to hover about vegetation in the manner of a syrphid fly.

Adults may be collected by sweeping in grassy meadows, in bog areas, and in sedges, cattails, and other vegetation along the margins of streams, lakes, and ponds.

Predators and parasites.—Several investigators have observed parasites and/or predators attacking larvae of Stratiomyidae. In table 2, I have presented this information in condensed form and have added my own observations.

Morphology

Several notable investigations on the morphology of the Stratiomyidae have been made and have been concerned with the nervous system, the respiratory system, the head capsule, and the integument.

While the quality of this work is very good, the number of different species investigated leaves much to be desired. In this section, an attempt has been made to incorporate previous work with my own studies in a discussion of the major morphological characteristics of the larvae, both external and internal.

Integument.—The integument of a stratiomyid larva is composed of many facets, some of which are distincly hexagonal while others vary in size and shape. This faceted appearance has caused students of Stratiomyidae to refer to the integument as being "shagreened."[3]

Many early investigators (Miall, 1895; Leydig, 1860; Müller, 1925; and Kruper, 1930) noticed the presence of these facets and explained their appearance as representing the upper surface of the "calcareous nails" that are so evident in a cross section of the integument (fig. 6). These nails are composed of calcium carbonate, but how they are formed is unknown. Earlier workers were of the opinion that the calcium deposits were secreted probably by the malpighian tubules in an unknown manner. Richards (1951), on the contrary, is of the opinion that the calcium deposits are laid down on the external surface of the integument as a result of carbon dioxide diffusing outward through the integument into the calcium-rich medium of water. His theory, however, will not explain the development of the "nails" under the acid conditions in which many species of stratiomyid larvae occur, nor will it explain the development of the "nails" in terrestrial species.

The "nails" provide the larva with a strong but flexible armor. To test its resistence to attack one needs only to try to section it. Flexibility is obtained by the pyramidal shape of the nails, which allows the integument to bend.

Head and appendages.—The total length of the head is always greater than the width. This may seem misleading since the head is permanently retracted approximately one-half of its length into the thorax (fig. 3).

Distinctive eye prominences are situated on the lateral margin of the ocular lobes. Located between the 2 ocular lobes is the clypeus, which is limited by the frontal sutures. At the distal end of the clypeus is the labrum, a structure that is not always clearly defined posteriorly by the clypeolabral suture. The mandibular-maxillary complex is located in the pocket formed by the labrum and the extensions of the ocular lobes. The complex itself is formed by the fusion of the mandibles and the maxillae as the name suggests. It is so articulated that movement is in a plane perpendicular to the long

[3] Derived from the near-eastern word "shagreen," a type of uncured leather prepared in that area. As used here, it doubtless refers to the multifaceted integument that suggests this type of leather.

axis of the body. Cook (1949) states that the mandibular-maxillary complex is used for sweeping food into the oral cavity rather than for chewing.

The 2-segmented antennae are located near the apex of the ocular lobes but the exact position varies with the species as does the size and shape.

On the ventral surface of the head (fig. 4) there is a membranous area that outlines the labium. The large posterior part of the labium is the submentum. Directly anterior to the submentum is the prementum and the palatum. The latter structure, as pointed out by Cook, is apparently an adaptation for rooting up material. Cook also reported that labial palpi and a hypopharynx are lacking in stratiomyid larvae. The arrangement of the previously mentioned structures is shown in figure 5. The most important feature illustrated here is the arrangement of 2 sclerotized plates that are located beneath the pharynx at the posterior end of the head capsule. These structures function as a mortar and pestle, grinding up the food material that is swept into the mouth by the manibular-maxillary complex (Bischoff, 1925; Cook, 1949). The bowl-like mortar is very heavily sclerotized and convoluted while the pestle, which is formed by the floor of the pharynx, is modified in the form of a heavy, corrugated plate and fits into the bowl of the mortar.

If the mortar and pestle do indeed perform the task of grinding the food, it seems inconceivable that stratiomyid larvae could be predaceous on other larvae as has been reported, especially when the size of the oral cavity is taken into consideration.

Thorax.—The thorax is composed of the first 3 body segments posterior to the head. The noteworthy characteristics found here are the prothoracic spiracles, which vary in size and shape, the chaetotaxy, and the shape of the segments, which seem to become broader toward the metathoracic segment. Stratiomyid larvae are without legs or prolegs.

Abdomen.—This tagma consists of the 8 body segments posterior to the metathoracic segment. They are similar in form to the thoracic segments but differ in chaetotaxy and in occurrence of special organs or structures. Several genera can be distinguished by the markings or color patterns that occur on the thoracic and abdominal segments.

The first and second segments are usually the broadest. The remainder of the segments either taper toward the apical segment (aquatic species) or several segments are parallel sided and the remainder taper toward the apical segment (terrestrial species). At the extreme end of the apical segment, which is often much longer than it is wide (fig. 107), especially in the aquatic species, there is located a transverse fissure that houses the spiracular chamber. In the genus

Nemotelus, however, the spiracular chamber is located on the dorsum of this segment.

A few aquatic genera, notably *Euparyphus* and *Odontomyia*, possess strongly curved sclerotized hooks or spines, as they sometimes are called (fig. 122). They are usually on the venter of the seventh abdominal segment, but in the genus *Hedriodiscus* they are on the venter of the sixth segment as well. A remarkable feature of the spines is that they curve forward toward the head. This arrangement would seem to present some difficulty in forward movement, but this has not been observed. Previous workers (Wesenberg-Lund, 1943; Lenz, 1923) have reported that the hooks serve as anchors to keep the larvae from being swept away by fast-flowing currents. This statement may be partially correct, but I have observed this type of larva in shallow pools that had only convection currents.

Digestive system.—The digestive system has little to offer in the way of taxonomic characters other than the characteristic shape of the gut, which is long and highly convoluted. Except for the mortar and pestle, there are no sclerotized areas present in either the foregut or the hindgut.

Malpighian tubules.—The malpighian tubules are filled with a whitish, semiliquid material that is reported to be primarily composed of calcium carbonate. This material may be associated in some manner with the calcium carbonate that is secreted in the integument.

Respiratory system.—Stratiomyid larvae have frequently been described as peripneustic, but it is doubtful that they are functionally so. They appear to be metapneustic or in some cases amphipneustic. The lateral spiracles almost always are minute and difficult to detect, especially in the later instars. The only spiracles that function continually are the terminal or posterior spiracles.

The spiracular chamber contains the ends of the main tracheal trunks. In the aquatic forms, the lips that form the opening to the chamber are fringed with long hydrofuge setae, which enable the larvae to remain suspended from the surface of water for indefinite periods of time while the spiracles are open to the atmosphere. When submerged, these setae also aid respiration by enclosing an air bubble trapped in the process of submerging.

Using the work of Whitten (1959) as a guide, I examined the tracheal system of 4 genera (2 aquatic and 2 terrestrial) for possible taxonomic characters. The tracheal system of each larva has the same general pattern as that given by Whitten for brachycerous larvae and, consequently, cannot be used as a distinguishing character beyond the suborder.

Nervous system.—Although several studies have been made on the nervous system of a few species of stratiomyid larvae, the results appear to have little consequence from a taxonomic standpoint (Viallanes, 1882a, 1882b, 1885; Künckel d'Herculais, 1879; Henneguy and Binet, 1892).

Phylogeny

Handlirsch (1908) postulated that the Stratiomyidae arose in Jurassic times from a primitive tipuloid stock that had evolved to the point where it more closely resembled the Xylophagidae than the Tipulidae. The families most like the Stratiomyidae, the Xylophagidae and the Rhagionidae (Leptidae), are similar to the stratiomyid subfamily Xylomyinae but only in the adult stage (wing venation, spurs on tibiae, etc.). From the Rhagionidae arose the Tabanidae and Therevidae and, in turn, this line of descent led directly to the more advanced Diptera (Handlirsch, 1908; Bischoff, 1925; and Lindner, 1937).

The most primitive subfamily in the Stratiomyidae is the Xylomyinae. Characters occuring in the immature stages of this subfamily that I consider to be primitive are an integument that is only partly shagreened, the generalized type of its mouthparts, an incompletely enclosed pupa, and the type of habitat, which is usually under bark or in rotten logs. Characters of the adults are equally primitive.

From this primitive subfamily 4 lines appear to have evolved, one of which represents a continuation of the basic type with slight modifications in morphology (Xylomyinae, Beridinae, and Pachygastrinae). The other lines represent a divergence toward different ecological zones in the larval stage: one to an aquatic or semiaquatic mode of life (Stratiomyinae and Nemotelinae); another to life in a rich, soft food source such as animal excrement and decaying organic matter (Sarginae and Clitellariinae); and another line, represented by *Altermetoponia rubriceps* (Macquart), which lives in sod (Chiromyzinae).

As previously indicated, the environment in which the larvae live, their feeding habits, and the type of mouthparts are closely allied and provide an insight into the evolution of the family. Table 3 illustrates the distribution of these characters through the subfamilies. In an attempt to show degree of relationship, I have analyzed 11 characters and given them an arbitrary numerical value (for details of this technique, see James, 1953). A list of the characters and their numerical values is as follows:

A. Habitat of larva
   1. aquatic or semiaquatic
   2. terrestrial
   3. terrestrial-arboreal (close association with trees)

B. Food of larva
   1. aquatic microorganisms
   2. plant roots
   3. decaying organic matter (includes microorganisms)
C. Labium of larva
   1. well developed
   2. not well developed
D. Distribution of maxillary setae in larva
   1. setae absent
   2. setae present, located in notch
   3. setae present, other arrangement
E. Types of maxillary setae in larva
   1. cylindrical brushes
   2. cylindrical brushes absent or not cylindrical
F. Transverse series of dorsal setae with accompanying setae in larva
   1. extra setae present
   2. extra setae absent
G. Posterior spiracles of larva
   1. with coronet of setae
   2. without coronet of setae
H. Anal armament of larva
   1. large teeth anterior to anal opening
   2. large teeth absent
I. Body conformation of larva
   1. attenuate
   2. parallel sided
J. Mandibles of larva
   1. well developed
   2. not well developed
K. Posterior spiracles of larva
   1. located at apex of last abdominal segment
   2. located on dorsum of last abdominal segment

These results are presented in graph form in figure 1. The phylogenetic tree in figure 2 represents the sum of the similarities and differences among the subfamilies and indicates the relationships of the extant species.

The Beridinae and succeeding subfamilies of the Stratiomyidae probably arose from a group of the subfamily Xylomyinae that had developed a completely shagreened integument. This separation was no doubt strengthened subsequently by 2 changes in the ecological requirements of beridine larvae: a change in habitat (larvae of Beridinae are not found in the same habitat as larvae of Xylomyinae) and a change in food preference (as evidenced by larvae of *Actina incisuralis*).

The subfamily Pachygastrinae represents an advanced group on the basis of adult characters, but the mouthparts of the larvae are similar to those found in the larvae of Xylomyinae and Beridinae. In addition, pachygastrine larvae are found under the bark of trees as are larvae of Xylomyinae. During the course of time, however, the chaetotaxy and size of the larvae have evolved.

On the basis of similarity of mouthparts, the Clitellariinae and the Pachygastrinae appear to have arisen from a beridine stock. The former represents a radiation into a new ecological zone, and the latter represents evolutionary improvement for living in an already occupied niche. Clitellariine larvae have mouthparts much the same as beridine larvae except for the labium, which has become more sclerotized and spatulate in the former. This change in the labium is probably an adaptation for feeding on the pulpy flesh of succulents.

The Sarginae appear to have arisen from a clitellariine stock, probably closely related to the tribe Hermetiini. The mouthparts of the latter are very similar to those of the Sarginae and both groups live in the same type of enviroment—decaying organic material. Both groups are highly evolved: the mouthparts have degenerated so that the mandibular-maxillary complex is almost indistinguishable.

The subfamily Nemotelinae, although similar in general appearance to the Stratiomyinae, apparently has evolved from a clitellariine stock. This cleavage, however, must have occurred shortly after the Clittellariinae had broken away from the pachygastrine stem since all three taxa are closely related (fig. 2). Both adult and larval characters of the Nemotelinae appear to substantiate the conclusion that the Stratiomyinae and Nemotelinae are not closely related and probably never have been.

The Stratiomyinae have few characters in common with any of the extant subfamilies. Larval characters indicate that the subfamily probably evolved from a beridine stock at a very early period.

Because the Chiromyzinae are represented in North America by only *Altermetoponia rubriceps*—an introduced species—no further consideration need be given to the phylogeny of this subfamily.

Classification

The classification of the Stratiomyidae presented here is based upon opinions and conclusions drawn from the relationships of the subfamilies presented in the previous section. This system differs somewhat from the classification of James (pers. comm.), which is based upon adult characters. A comparison of the 2 systems is as follows (asterisks indicate genera not seen in immature stages and thus not in my classification):

James	McFadden
1.	1. Xylomyinae—*Xylomya, Solva*
2. Chiromyzinae—*Altermetoponia*	2. Chiromyzinae—as in James
3. Beridinae—*Allognosta, Actina, Beris, Exodontha*	3. Beridinae—as in James
4. Sarginae—*Sargus, Ptecticus, Microchrysa, Chloromyia,* Merosargus*	4. Sarginae—as in James
5. Cyphomyiinae—*Cyphomyia, Dicyphoma*	5. Cyphomyiinae—see under Clitellariinae
6. Hermetiinae—*Hermetia*	6. Hermetiinae—see under Clitellariinae
7. Clitellariinae—*Adoxomyia, Dieuryneura, Brachycara,* Euryneura,* Oxycera,* Euparyphus, Caloparyphus, Akronia,* Nemotelus*	7. Clitellariinae—*Dieuryneura* Cyphomyiini—*Cyphomyia, Adoxomyia, Dicyphoma* Hermetiini—*Hermetia*
8. Stratiomyinae—*Stratiomys, Hoplitomyia,* Labostigmina,* Anoplodonta,* Hedriodiscus, Odontomyia, Nothomyia,* Myxosargus*	8. Stratiomyinae—*Stratiomys, Hedriodiscus, Odontomyia, Myxosargus, Euparyphus, Caloparyphus, Aochletus*
9.	9. Nemotelinae—*Nemotelus*
10. Pachygastrinae—*Neopachygaster, Eupachygaster, Pachygaster, Zabrachia, Berkshiria*	10. Pachygastrinae—as in James

There are 2 major points of difference between the present arrangement and that of James. First, the latter includes the genera *Xylomya* and *Solva* in a separate family, the Xylomyidae. Although there is little information in the literature regarding the larva of *Xylomya*, many workers have recorded their thoughts on the larva of *Solva* and its importance in classification; thus, we have papers by Westwood (1840), Osten Sacken (1882), Brauer (1883), Lindner (1937), and Hennig (1952) pointing out that *Solva* should be placed in the Stratiomyidae. In 1899 Austen presented a summation of previous work concerning the classification of *Solva* and came to the conclusion "that *Solva* represents a primitive ancestral form of Stratiomyidae, given off from the common stem after the evolution of the characteristic type of larva and mode of pupation, but before the assumption on the part of the imago of the equally characteristic features (venation, spurless tibiae, etc.) exhibited by the more specialized types of the family." Inasmuch as the larvae of *Xylomya* and *Solva* are almost indistinguishable morphologically, I have extended Austen's discussion to include *Xylomya* and have reorganized the subfamily Xylomyinae.

A second area of disagreement between the 2 systems is in the classification of the Clitellariinae. A study of the mouthparts revealed that there were 3 distinct types present in this 1 subfamily.

One type was found in the genus *Adoxomyia*. The mouthparts of the species in this genus are very similar to those found in the larva of *Cyphomyia*. In addition, the larvae of both genera are known only from wounded or decaying succulents in North America; consequently, *Cyphomyia* and *Dicyphoma* have been transferred to the Clitellariini (Cyphomyinae of James) along with *Adoxomyia*.

A second tribe, the Hermetiini (Hermetiinae of James), has been transferred to this subfamily on the basis of similarities in morphological and ecological characters of both adults and larvae of *Hermetia* to the clitellariine genera *Adoxomyia*, *Cyphomyia*, and *Dicyphoma*.

The genus *Dieuryneura* has been placed in this subfamily also but not in either tribe. A comparison of larval mouthparts shows it to be more closely related to the Hermetiini than to the Clitellariini, but a more definite attempt at classification is impossible at this time.

The larvae of the remaining genera in the Clitellariinae of James are either aquatic or semiaquatic and the mouthparts are similar to the genera originally placed in the Stratiomyinae. These 2 facts by themselves give sufficient cause to unite the genera in a single subfamily; in addition, all of the genera except *Nemotelus* that were removed from the Clitellariinae possess ventral hooks. These curious structures may represent a clinging device for living in fast-flowing water. *Stratiomys* larvae lack these structures but they are present on larvae of *Odontomyia*. It is possible that the hooks have evolved twice but it seems more likely that the genera are more closely related than they were previously thought to be.

Larvae of *Nemotelus* pose a special problem. In addition to lacking the ventral hooks, the orifice of the spiracular chamber is on the dorsal surface of the last abdominal segment and possesses a cornet of hydrofuge setae as contrasted with the terrestrial larvae that lack this feature and as contrasted with other aquatic larvae that also possess a coronet of hydrofuge setae but have the spiracular chamber at the apex of the last segment. This combination of characters is rather unique and provides the basis for elevating this genus to subfamilial status.

Key to Suborders, Divisions, and Principal Families of Brachycera-Orthorrhapha Based on Larval Characters

1. Head complete, or the posterior portion with deep longitudinal incisions; mandibles capable of horizontal movement; body consisting of 13 segments in addition to head; with 9 pairs of spiracles . . Suborder NEMATOCERA

   Head incomplete, frontal region not strongly arched; mandibles capable of vertical movement; body comprising fewer than 13 segments and only exceptionally with as many as 9 pairs of spiracles.
   Suborder BRACHYCERA 2

2. Free cephaloskeleton present; head very poorly developed, completely unsclerotized dorsally; antennae poorly developed or absent, when present situated on a membranous surface; mandibles short and hooklike, usually capable of protrusion much beyond the poorly developed maxillae; maxillary palpi rarely visible . . . . Division CYCLORRHAPHA

No free cephaloskeleton within the head capsule, the exoskeleton of the head at least dorsally indicated; antennae well developed, situated on the upper surface of the lateral lobe or on the slightly arched, sclerotized frontal plate; mandibles normally sickle shaped, not protruding much beyond apices of the well-developed maxillae, often much shorter, maxillary palpi distinct. Division ORTHORRHAPHA 3

3. Posterior spiracles situated within a terminal or subterminal cleft or chamber, usually concealed, or with a terminal breathing tube; pupa free or enclosed in last larval skin 4

Posterior spiracles visible, situated on apical, penultimate or antepenultimate segment, body not shagreened or visibly striated; pupa free 5

4. Body 12-segmented, cylindrical, not shagreened, usually longitudinally striated, abdomen with a girdle of pseudopods on each segment; head retractile; spiracular fissure vertical . . . . TABANIDAE

Body 11-segmented, bristly, surface finely shagreened, without pseudopods; head not retractile; spiracular fissure transverse, sometimes rather small; peripneustic or amphipneustic . . . . STRATIOMYIDAE

5. Posterior spiracles situated on penultimate or antepenultimate segment. THEREVIDAE, SCENOPINIDAE, MYDAIDAE, ASILIDAE, BOMBYLIIDAE

Posterior spiracles situated on apical segment 6

6. Last abdominal segment obliquely truncate and with projecting processes; projecting portion of head and the flattened apical plate of last abdominal segment heavily sclerotized, the former cone shaped . . XYLOPHAGIDAE (including Rhachiceridae and Coenomyidae)

Last abdominal segment lacking projecting processes; projecting portion of head not pointed cone shaped; last abdominal segment without a heavily sclerotized flattened terminal plate . . . . NEMESTRINIDAE, EMPIDIDAE, DOLICHOPODIDAE, RHAGIONIDAE, ACROCERIDAE.

Family Stratiomyidae

In addition to the characters given in the key to families, stratiomyid larvae may be readily distinguished from other dipterous larvae (except for psychodid larvae) by the presence of calcium carbonate deposits on the integument (see p. 7).

Family diagnosis.—Head elongate and narrow except for ocular prominences; not retractile; antennae usually located anterolaterally but varying among species; setae on dorsum of head variable; body 11-segmented; prothoracic segment with functional spiracles, that segment wider than the head; segment posterior to prothorax either parallel with the lateral margins of the prothorax or tapering in a posterior direction from the second abdominal segment as in *Stratiomys* (fig. 105); posterior spiracles located in a transverse cleft on last abdominal segment; with or without a fringe of hydrofuge setae;

pseudopods lacking, but strong curved hooks may be present on venter of penultimate and/or antepenultimate segment.

Key to Larvae of Subfamilies of Stratiomyidae of America North of Mexico

1. Last abdominal segment with a coronet of plumose or pinnate setae at the apex . . . . STRATIOMYINAE
   Last abdominal segment with coronet of plumose or pinnate setae absent from apex 2
2. Last abdominal segment with a coronet of plumose or pinnate setae on dorsum . . . . NEMOTELINAE
   Last abdominal segment lacking a coronet of plumose or pinnate setae . . 3
3. Pro- and mesothoracic segments with a smooth field on dorsum; anus bordered anteriorly by a transverse row of strong, posteriorly directed teeth. XYLOMYINAE
   Pro- and mesothoracic segments with normal shagreened pattern on dorsum; anus not bordered anteriorly by teeth 4
4. Mouthparts highly sclerotized and foreshortened, mandibles well developed, no setae or bristles present on mouthparts (fig. 15); recorded from San Francisco area only . . . . CHIROMYZINAE
   Mouthparts with a different combination of characters than those listed above; occurring in San Francisco area or elsewhere 5
5. Dorsal row of transverse setae surrounded by smaller setae; mouthparts as in figure 16; uniformly colored larvae . . . . BERIDINAE
   Dorsal row of transverse setae not surrounded by smaller setae; mouthparts different than above; larvae uniformly colored or with a pattern 5
6. Larva with a well-developed labium (fig. 19); primarily restricted to southwestern United States, where found in *Opuntia* or *Agave* species. CLITELLARIINAE, Tribe CLITELLARIINI
   Larva lacking a well-developed labium; occurring in southwestern United States and elsewhere; not recorded from hosts given above 7
7. Small larva, under 10 mm in length; mouthparts similar to those of Beridinae (fig. 18); found under bark of trees . . . . PACHYGASTRINAE
   Larva over 10 mm in length; mouthparts lacking sclerotized areas 8
8. Mouthparts simple, setae restricted to a linear patch on inner margin of mandibular-maxillary complex (fig. 21); large, robust, color uniform. CLITELLARIINAE, Tribe HERMETIINI
   Mouthparts more elaborate, setae present on mandibular-maxillary complex, in addition to setae restricted to notch on inner margin of complex (fig. 17); smaller, usually with a vittate pattern . . . . SARGINAE

Subfamily Xylomyinae

This subfamily is represented in North America by the 2 genera *Xylomya* Rondani and *Solva* Walker. It is considered the most primitive group of the Stratiomyidae because it shares at least 1 character of the adult stage with the corresponding stage of the generally more primitive Xylophagidae.

Subfamilial characters.—Mouthparts as in figure 14. Other characters as given in key to subfamilies.

HABITAT OF LARVAE.—The few records available indicate that the larvae live under the bark of trees and in rotting logs.

Key to Genera of Xylomyinae

Prothoracic segment of larva with a tubercle anterior to the spiracle giving a cleft appearance to margin (fig. 10); apical abdominal segment with a transverse row of tubercles on dorsum . . . . **Solva** Walker

Prothoracic segment of larva lacking cleft appearance of margin; no tubercles present on dorsum of apical abdominal segment . . . . **Xylomya** Rondani

Genus *Xylomya* Rondani, 1861

Of the 7 species listed by James (pers. comm.) for this genus, the larvae of only 2 species have been collected and 1 lacks a specific determination.

GENERIC CHARACTERS.—As given in key to genera.

Xylomya americana (Wiedemann), 1821

FIGURES 149, 150

DESCRIPTION.—Puparium: length (head capsule lacking) 15.2 mm; width 4.1 mm. Other characters as given in key to genera.

BIOLOGY.—Larvae of this species were removed from a hole in a sycamore tree.

MATERIAL EXAMINED.—Virginia: Alexandria, Oct. 14, 1951, W. W. Wirth, 1 puparium (USNM).

Xylomya species

FIGURES 7, 11, 25

DESCRIPTION.—Mature larva: length 13 mm; width 3.2 mm. Other characters as given in key to genera.

BIOLOGY.—No data available for this species.

MATERIAL EXAMINED.—Massachusetts: Amherst, 1945, M.E.S., 1 larva, MSC.

Genus *Solva* Walker, 1860

James (pers. comm.) lists 3 species for this genus but the larva of only 1 species, *Solva pallipes* (Loew), has been collected.

Lindner (1938) and Hennig (1952) include the species of *Xylomya* in this genus, but Steyskal (1947) has demonstrated that the adults of these 2 genera can be distinguished. This shows that the immature stages can also be differentiated.

GENERIC CHARACTERS.—As given in key to genera.

Solva pallipes (Loew), 1863

FIGURES 8–10, 12–14

DESCRIPTION.—Mature larva: length 7–8 mm, mean 7.8 mm; width 1.75–2.0 mm, mean 1.85 mm. Other characters as given in key to species.

Pupa (after Greene, 1926): Very thin, shining, transparent, with a yellowish tinge. Antennal capsules large, pointing outward, faintly annulated to the tip; just posterior to the base of these are 3 faint ocellar punctures. Thorax slightly longer than wide, smooth; wing pads smooth, reaching to the apex of the third abdominal segment; thoracic spiracles situated on a small elevation; the spiracular entrance is golden yellow, sinuous, and contains a great number of short radiating slits. Abdomen cylindrical, composed of 8 segments; first and last segment without any spines; segments 2–7 with a transverse, dorsal row of reddish-yellow spines just posterior to the middle of the segment; segments 1–7 have a spiracle on the anterolateral surface; spiracle small, golden yellow, slightly elevated; last segment rounded at apex and entirely smooth. Length 6.0 mm; diameter of thorax 1.85 mm; diameter of abdomen 1.75 mm.

BIOLOGY.—Larvae have been collected from the following trees: *Ulmus* species, *Populus* species, *Robinia* species, and *Liriodendron tulipifera*. The larvae seem to prefer trees on which the bark has become loosened. Malloch (1917) intimates that he found the larva of *Solva* to be predaceous on the larvae of *Euxesta, Lonchaea*, and *Heterominga*. Greene (1926) states that the larvae may be predaceous but are usually scavengers.

As the larva of *Solva* matures, it forms a pupa within the last larval skin as is the case with all other stratiomyid larvae; however, before emergence, the puparium splits dorsally down the median line and the pupa forces itself about two-thirds of the way out of the puparium and remains there until the adult emerges. The emergence of the pupa causes the head of the puparium to become loose and often completely separated as in the higher flies. Adults of *Solva* can be found on tree trunks in June, July, and August.

MATERIAL EXAMINED.—Illinois: Rock Island, Apr. 5, 1932, C. O. Mohr, 2 larvae, INHM. Pennsylvania: Blain, Aug. 6, 1955, F. Craighead, lot no. 55 11825, 6 larvae, 7 puparia from oak, USNM. Wisconsin: Madison, July 1938, Dodge, 23 larvae, 6 puparia from under elm bark, OSU.

Subfamily Chiromyzinae

Although the genus *Altermetoponia* Miller has been placed in this subfamily, there is some doubt as to whether it should be left here or placed in a subfamily of its own as Hennig (1952) has done. Because of a scarcity of specimens in related genera within the subfamily, it has been impossible to make a comparison of characters. Raff (1931) has provided a vague description of the larva of *Chiromyza* *australis* Macquart, the only published information available on the larvae of this subfamily.

The subfamily is represented in North America only by *Altermetoponia rubriceps* (Macquart).

SUBFAMILIAL CHARACTERS.—As given in key to subfamilies.

HABITAT OF LARVAE.—The only species of Chiromyzinae for which habitat data are available is *A. rubriceps*.

Genus *Altermetoponia* Miller, 1945

FIGURES 15, 25, 33, 34

DESCRIPTION.—Mature larva: length 8.8–9.8 mm, mean 9.27 mm; width 1.8–2.0 mm, mean 1.87 mm. Body segments yellow; head brown, darkest at apex.

BIOLOGY.—It is quite probable that this species will assume economic importance in the area around San Francisco, just as it has come to be considered a pest in Australia, where it causes extensive damage to lawns. Other than evidence it lives in sod as a larva, nothing is known about its life history in North America.

MATERIAL EXAMINED.—California: San Francisco, Mission Park, Nov. 20, 1959, T. R. Haig, 35 larvae, 3 puparia, CAS.

Subfamily Beridinae

Of the 5 genera that represent this subfamily in North America, the larvae of only 2 are known: *Allognosta* and *Exodontha;* however, larvae of 2 of the remaining genera are known from other geographical areas and descriptions of these species have been included.

SUBFAMILIAL CHARACTERS.—As given in the key to subfamilies.

HABITAT OF LARVAE.—The larvae in this subfamily are terrestrial but may be associated with semiaquatic environments; e.g., Fuller (1934) found larvae of *Actina* in and on the carcass of a dead sheep, Johannsen (1922) reported larvae of *Allognosta* from decaying organic material, and the larvae of *Beris* have been found in decaying leaves. In addition to being the center of the larvae's food source, the semiaquatic medium facilitates their movement and ingestion.

Key to Genera of Beridinae

1. Larva robust, greater than 10 mm in length . . . . . . **Exodontha** Rondani
   Larva smaller, less than 10 mm in length 2
2. Abdominal segments with lateral margin bilobed, the anterior smaller than the posterior one . . . . **Allognosta** Osten Sacken
   Abdominal segments with lateral margin smooth 3
3. Last abdominal segment broadly indented at distal end and fringed with fine setae . . . . **Beris** Latreille
   Last abdominal segment not indented at distal end; fringe lacking **Actina** Meigen

Genus *Allognosta* Osten Sacken, 1883

There are 4 species recognized in this genus, but only the larva of *Allognosta fuscitarsis* (Say) has been reported (Johannsen, 1922).

Generic characters.—As given in the key to genera.

Allognosta fuscitarsis (Say), 1823

Figures 31, 36–38

Description.—Mature larva: length 9.5 mm; width 3.5 mm. Prothoracic spiracle located in a distinct marginal notch. Other characters as given in key to genera.

Biology.—Little is known of the biology and life history of this species. Malloch's (1917) specimen was obtained from woods near Urbana, Ill., while Johannsen's report (1922) stated that his specimens were found in decaying organic matter.

Material examined.—Rhode Island: Kingston, Aug. 20, 1942, H. Knutson, 1 early instar larva from glass of milk, MSC. New York: Ithaca, C. Hamilton, 2 larvae, 1 puparium, CU; Ithaca, 2 early instar larvae collected with larvae of *Fannia* species, CU. North Carolina: Great Smoky Mountain National Park, Oct. 4, 1951, J. S. Ayars, acc. no. 49768, 11 larvae, NCS.

Genus *Actina* Meigen, 1804

Only 1 species of this genus is known from North America, the immature stages of which have never been reported.

The characteristics that are given below are taken from a paper by Fuller (1934) in which she described the immature stages of an Australian species, *Actina incisuralis* Macquart.

Generic characters.—As given in key to genera.

Actina incisuralis Macquart, 1847

Figures 40, 41, 45

Description.—Mature larva (?): length 9 mm. Color varying between greyish brown and brown.

> Head elongated, narrow and pointed. Body strongly constricted between the segments giving the larva a scalloped appearance along the sides. Dorso-laterally the integument between each abdominal segment, and between the third thoracic and first abdominal, is produced into a small papilla projecting outwards. The thoracic segments become broader passing from the head, the abdominal segments are of uniform width and length, with the exception of the eighth, which is narrower and longer than the others, more flattened and produced into two blunt projections at the posterior corners (Fuller, 1934, p. 191).

Setal arrangement typical for family and subfamily.

Biology.—Fuller (1934) reported that larvae of this species "were found in abundance on the undersurface of a sheep carcass" and "on the earth under masses of rotting grass" (p. 190). Larvae were also present in soil among the roots and stems of growing grasses. Pupae were obtained 7–8 months after the larvae were collected.

MATERIAL EXAMINED.—No larvae of this species were examined.

Genus *Beris* Latreille, 1802

Three species are recorded for this genus in North America but the larvae or pupae have never been reported. The larval stages of a few European species of *Beris* have been described (Lenz, 1923). The larva described below was loaned to me by W. Hennig.

GENERIC CHARACTERS.—As given in key to genera.

Beris vallata Forster, 1771

FIGURES 23, 26, 28

DESCRIPTION.—Mature larva (?): length 7–8 mm; width 2 mm. Head and body segments yellow; body of larva extremely flattened dorsoventrally; prothoracic spiracle elevated but relatively inconspicuous; body segments from second thoracic to seventh abdominal with a distinct papilla at intersegmental fold.

BIOLOGY.—Nothing is known about the biology of the North American species. Lenz (1923) reports that larvae of *Beris vallata* and 2 other species of this genus were found under the bark of a fallen tree, which was lying in a marshy area between fallen leaves (presumably wet) and at the margins of springs.

MATERIAL EXAMINED.—Two larvae borrowed from the Deutsches Entomologisches Institut; no collecting data.

Genus *Exodontha* Rondani, 1856

According to James (pers. comm.), 2 species occur in North America, but larvae and pupae of only *Exodontha luteipes* (Williston) have been found.

GENERIC CHARACTERS.—As given in key to genera.

Exodontha luteipes (Williston), 1885

FIGURES 29, 30, 35

DESCRIPTION.—Mature larva: length 11.7–15+ mm, mean 13.23 mm; width 3.8–4.5 mm, mean 4.77 mm. Head and body segments pale yellow.

BIOLOGY.—Larvae of this species were found in moist rotting wood under large boulders on a mountainside at an elevation of approximately 6000 feet. Adults emerged on June 27, 1960, in the laboratory.

MATERIAL EXAMINED.—Alberta: Banff National Park, Mt. Ishbel, June 13, 1960, Ball, Madge and McFadden, 1 larva, 4 puparia MWM.

Subfamily Sarginae

Of the 6 genera listed for this subfamily by James (pers. comm.), larvae have been described for only the following 4 genera: *Sargus*, *Ptecticus*, *Microchrysa*, and *Merosargus*.

The keys to the genera of this subfamily will work for mature larvae only, but, where earlier instars are known, descriptions of these forms are included.

Subfamilial characters.—As given in key to subfamilies.

Habitat of larvae.—Larvae of the Sarginae are terrestrial scavengers. They have been collected from various types of manures, rotting vegetation—especially garden refuse—and from other types of decaying organic matter.

Key to Genera of Sarginae

1. Venter of sixth abdominal segment with sternal patch extending almost the length of that segment; venter of fifth abdominal segment with a smaller sternal patch (fig. 50) . . . . **Ptecticus** Loew
   Venter of sixth abdominal segment with a shorter sternal patch; sternal patch lacking on venter of fifth abdominal segment 2
2. Dorsolateral margin of segments 1–10 with a series of large, dark plaques arranged in a circular pattern; segments 1–3 with a transverse band of these plaques connecting the 2 lateral circles; 5 vittae on dorsum, the mesal vitta much broader than the others . . . . **Sargus (Pedicellina)** James
   Dorsolateral margin of segments 1–10 lacking markings described above . . 3
3. Lateral margin of head lacking a protruding tubercle; no constriction of head posterior to eye prominence . . . **Sargus** Fabricius (sensu stricto, in part)
   Lateral margin of head with a protruding tubercle; head constricted posterior to tubercle 4
4. Eye prominence anterior to protruding lateral tubercle . **Merosargus** Loew
   Eye prominence on protruding lateral tubercle 5
5. Width of head at tubercle not more than 0.5 mm . . . **Microchrysa** Loew
   Width of head at tubercle 0.8–1.0 mm.
   Sargus Fabricius (sensu stricto, in part)

Genus *Sargus* Fabricius, 1798

Larvae of this genus are almost impossible to identify to species unless they are fully mature specimens. Earlier instars lack the characteristic patterns of the species and the head capsule apparently varies from instar to instar.

Generic characters.—As given in key to genera.

Subgenus *Pedicellina* James, 1952

Sargus (*Pedicellina*) *lucens* Loew, 1866

Figures 49, 56, 61

Description.—Mature larva: length 9.2–11 mm, mean 10.1 mm; width 2.5–3.3 mm, mean 2.85 mm. Other characters as given in key to genera.

BIOLOGY.—Larvae of this species have been collected from leaf axils of cattails only where the axils were above the waterline.

MATERIAL EXAMINED.—New York: Ithaca, Apr. 8, 1921, P. W. Claasen and O. A. Johannsen, 5 larvae, 15 puparia collected from leaf axils of cattails, CU; Ithaca, July (?), 2 larvae from leaf axils of cattails, CU.

Subgenus *Sargus* Fabricius, 1798

Key to Species of Subgenus *Sargus*

1. Body segments lacking vittae; prothoracic spiracle on stalk like structure. **elegans** Loew
   Body segments with alternating dark and light vittae; prothoracic spiracle sessile 2
2. Dorsal surface of body segments with 3 dark vittae . . . . **decorus** Say
   Dorsal surface of body segments with more than 3 dark vittae 3
3. Median light band between inner 2 dark vittae parallel sided. **bipunctatus** Scopoli
   Median light band between inner 2 vittae geniculate; each of inner pair of setae located in a dark patch in median light band . . . . . **viridis** Say

Sargus (Sargus) elegans Loew, 1866

FIGURES 52, 53, 61

DESCRIPTION.—Mature larva: length 7.8 mm, width 2.4 mm; head not restricted posterior to eye prominence, ratio of width of head at eye prominence to width at neck 1.0. Other characters as given in keys to genera and subgenera.

Instar no. ?: length 4.5–5.2 mm, mean 4.96 mm; width 1.4–2.0 mm, mean 1.68 mm; differ from mature larvae since they lack the stalked prothoracic spiracle.

BIOLOGY.—Larvae of this species have been collected only from under horse manure.

MATERIAL EXAMINED.—Ontario: Marmora, June 19, 1952, J. R. Vockeroth, 2 puparia, larvae collected from under horse dung in woods, CNC. Virginia: Alexandria, June 24, 1951, W. W. Wirth, 15 larvae (early instar), from under horse dung, USNM.

Sargus (Sargus) decorus Say, 1824

FIGURES 55, 58, 59

DESCRIPTION.—Mature larva: length 4.0–4.2 mm, mean 4.1 mm; width 3.0–3.3 mm, mean 3.13 mm; width of head at eye prominence 0.81–0.94 mm, mean 0.87; width of head at neck 0.48–0.59 mm, mean 0.52 mm, mean ratio of width of head at eye prominence to width at neck 1.67. Other characters as given in key to species.

BIOLOGY.—Larvae of this species have been collected from rotting leaves and cow manure.

Material examined.—Saskatchewan: Saskatoon, Aug. 1, 1949, A. R. Brooks, 14 puparia from cow manure, CNC. Washington: Seattle, Sept. 15, 1942, lot no. 42–11571, det. by C. T. Greene, 4 larvae, 5 puparia from rotting leaves, USNM.

Sargus (Sargus) bipunctatus Scopoli, 1763

Figures 48, 54, 57

Description.—Mature larvae: length 9 mm; width 3 mm. Other characters as given in key to species.

Instar no. ?: length 6.5 mm; width 2.4 mm. Differs from mature larva since it lacks the vittae.

Biology.—Larvae of this species have been collected from cow manure. Malloch (1917) reported the larvae as being very sluggish.

Material examined.—Maryland: Braddock Heights, Oct. 1, 1921, A. N. Caudell Collection, 1 larva (early instar), USNM.

Discussion.—All data regarding description of the mature larva and notes on its biology have been taken from Malloch.

Sargus (Sargus) cuprarius (Linnaeus), 1758

Figures 17, 62–64

Description.—Instar no. ?: length 6.5–7.4 mm, mean 7.04 mm; width 1.7–2.0 mm, mean 1.84 mm. Similar to *S. decorus* in this stage but much smaller.

Biology.—Larvae of this species have been collected from under cow manure.

Material examined.—Nebraska: Dunbar, Sept. 13, 1950, W. W. Wirth, 39 larvae from cow manure (early instars), USNM.

Genus *Ptecticus* Loew, 1855

Of the two species listed by James (1960) for this genus, only the larvae of *P. trivittatus* Say have been collected north of Mexico.

Generic characters.—As given in key to genera.

Ptecticus trivittatus (Say), 1829

Figures 43, 47, 50, 51

Description.—Mature larva: length 11.2–13.2 mm, mean 12.68 mm; width 3.5–3.9 mm, mean 3.76 mm; apical segment with 2 setae at each corner of spiracular opening; no anal spines present; other characters as given in key to species.

Antepenultimate instar: length 12.2–15.1 mm, mean 13.67 mm; width 3.0–4.5 mm, mean 3.67 mm; larvae testaceous, no visible pattern; body setae short, partially hidden by fine pubescence that covers body; anal spines present.

Biology.—Larvae of this species have been collected from a corn compost pile, from decaying tomatoes, decaying garbage, rotting paper, decaying fruit, and from watermelon rinds. Larvae have also been collected from a fungus (*Laetiporus speciosus*).

Material examined.—Georgia: Silver Lake, Bradley, 7 larvae from decaying garbage and rotting paper, CU. Illinois: Urbana, Aug. 3, 1942, H. H. Ross, 14 larvae, INHS. Maryland: Cabin John Bridge, July 31, 1913, Barber and Shannon, 11 larvae from fungus (*Laetiporus speciosus*), USNM. North Carolina: Faison, Aug. 25, 1950, P. O. Richter, 5 larvae from watermelon, NCS; Faison, Oct. 14, 1952, Dogger and Howden, 1 larva from decaying vegetables, NCS; McCulley's, Jan. 20, 1951, Weisman, 3 larvae from watermelon rinds, NCS. Ohio: O.A.E.S., dump, Aug. 22, 1943, 17 larvae from decaying tomatoes, OSU.

Ptecticus sackenii Williston, 1885

Description.—Mature larva: length 11 mm; width 4.5 mm.

Biology.—No data available.

Material examined.—Mexico: No other data, 2 larvae collected by A. Herrana, AMNH.

Discussion.—According to W. W. Wirth of the U.S. Department of Agriculture, this species does not occur in Mexico. The 2 larvae examined by the author were indistinguishable from the antepenultimate instar of *P. trivittatus*. The identification is made less creditable by the fact that both larvae were neither reared nor associated with adult flies in the collection.

Genus *Microchrysa* Loew, 1855

James (pers. comm.) lists 2 species for this genus but only the larvae of *Microchrysa polita* (Linnaeus) have been collected to date.

Generic characters.—As given in key to genera.

Microchrysa polita (Linnaeus), 1758

Figures 42, 44, 46

Description.—Mature larva: length 5.2–7.1 mm, mean 6.68 mm; width 1.6–2.0 mm, mean 1.84 mm; width of head at eye prominence 0.45–0.50 mm, mean 0.47 mm; width of head at neck 0.32–0.42 mm, mean 0.36 mm; mean ratio of width of head at eye prominence to width at neck 1.32; venter of sixth abdominal segment with the setae on each side of the sternal patch reduced; anal spines lacking.

Biology.—Larvae of this species have been collected from cow manure and from decaying vegetation.

Material examined.—Colorado: Woodland Park, Station 4, Aug. 4, 1943, J.A.R. and H. H. Ross, 3 larvae from cattle droppings, UC. Massachusetts: Amherst, July 10, 1942, M. E. Smith, 15 larvae, 2 puparia from decaying vegetation, MSC. New York: Ithaca, July 8, 1915, 4 larvae from cow manure, CU; Ithaca, July 1917, 5 larvae, 3 puparia from decaying rhubarb, CU; Ithaca, July 1919, 9 larvae, CU. North Carolina: Rowan County, Dec. 14, 1955, C. E. Jernigan, 1 larva from woods trash, NCS.

Genus *Merosargus* Loew, 1855

Of the 2 species listed by James (pers. comm.) for this genus, only the larvae of *Merosargus caerulifrons* (Johnson) have been collected to date.

Generic characters.—As given in key to genera.

Merosargus caerulifrons (Johnson), 1900

Figure 151

Description.—Puparium: length 5.6 mm (head capsule and prothorax lacking); width 2.3 mm; head capsule similar to that of *Sargus lucens* but differing in key characters.

Biology.—A puparium of this species was collected from debris at the base of a squirrel's nest.

Material examined.—Maryland: Linnieville, Jan. 1, 1914, R. C. Shannon, 1 puparium with head capsule detached, USNM.

Subfamily Clitellariinae

A study of both adults and larvae of the subfamilies Cyphomyiinae and Hermetiinae (James, pers. comm.) has shown that these two taxa are closely related to the Clitellariinae as defined by me (p. 13). For this reason, I have combined the Cyphomyiinae with the genus *Adoxomyia* to form the tribe Clitellariini and have reduced the subfamily Hermetiinae to tribal status.

The genus *Dieuryneura* has not been placed in either tribe due to a lack of characters, but it appears to be more closely allied to the Hermetiini than to the Clitellariini.

Subfamilial characters.—As given in key to subfamilies.

Habitat of larvae.—All larvae of this subfamily are terrestrial scavengers and, as such, have been reported from a great variety of habitats, the most common of which is decaying organic matter.

Tribe Clitellariini

This tribe includes 3 genera: *Adoxomyia, Cyphomyia,* and *Dicyphoma.* Their range extends from South America through the southwestern region of the United States. It is interesting to note that 2 species of *Adoxomyia, lata* and *rustica,* have extended their range as far north as Oregon and Washington on the west coast and a third species, *subulata*, is found throughout many of the Eastern States. Fourteen species have been collected from the southwest as adults, but the genus *Adoxomyia*, which contains 11 of the 14 species, is known only from 3 puparia that lack the head capsule.

HABITAT OF LARVAE.—All specimens collected to date have been taken from decaying or wounded cactus. Larvae of an unknown species of *Cyphomyia* have been reported as occurring under the bark of cedar logs in Honduras.

Key to Genera of Clitellariini

1. Head without a distinct notch posterior to eye prominence; dorsal seta on median line of first abdominal segment shorter than outer 2 setae (fig. 77); all 3 setae set on a line perpendicular to the body axis . **Adoxomyia** Kertesz
   Head with a distinct notch posterior to eye prominence 2
2. Median seta on dorsum of first abdominal segment longer than setae on either side of it (fig. 84); all 3 setae set on a line diagonal to the body axis. **Cyphomyia** Wiedemann
   Median seta no longer than setae on either side of it (fig. 78); all 3 setae set on a line diagonal to the body axis . . . . **Dicyphoma** James

Genus *Cyphomyia* Wiedemann, 1819

James (pers. comm.) recognizes 2 species in this genus: *Cyphomyia bicarinata* Williston and *C. marginata* Loew. Larvae have been collected for both species, but because the specimens of *C. bicarinata* are an early instar, pin mounted, and in poor condition, I have substituted the description of a neotropical species, *C. pilosissima* Gerstaecker.

Cyphomyia marginata Loew, 1866

FIGURES 152–154

DESCRIPTION.—Puparium: length 20.1 mm; width 2.9 mm; other characters as given in key to genera.

BIOLOGY.—Larvae of this species have been collected from papaya in Florida.

MATERIAL EXAMINED.—Florida: Miami, July 11, 1917, T. E. Snyder, 1 puparium, USNM.

Cyphomyia pilosissima Gerstaecker, 1857

FIGURES 83–85

DESCRIPTION.—Mature larva: length 21 mm; width 5 mm; dorsally the anterior and posterior margins of the thoracic and of the first 7 abdominal segments somewhat elevated with low transverse ridges occupying approximately the anterior and posterior fourth or fifth of the segment; ventrally these areas are only slightly elevated.

BIOLOGY.—Larvae of *C. bicarinata* as well as larvae of *C. pilosissima* have been taken from wounds in cacti, *C. bicarinata* from prickly pear (*Opuntia* species), and *C. pilosissima* from maguey (*Agave* species). No other data are available.

Genus *Dicyphoma* James, 1937

Only 1 species, *Dicyphoma schaefferi* (Coquillett), occurs in the Nearctic area. It is restricted to the southwestern states, where it has been taken from wounded and decaying cacti.

GENERIC CHARACTERS.—As given in key to genera.

Dicyphoma schaefferi (Coquillett), 1904

FIGURES 78, 81, 82

DESCRIPTION.—Mature larva: length 14.0–15.8 mm, mean 15.2 mm; width 3.6–4.1 mm, mean 3.87 mm.

BIOLOGY.—Larvae have been collected from *Opuntia* (*Platyopuntia*) species and *Myrtillocactus geometrizans* in Mexico.

MATERIAL EXAMINED.—Mexico: 54 miles north of San Luis Potosi, S.L.P., Aug. 4, 1960, Ryckman, Ryckman and Christianson, ADM 61, 2 larvae, WSU; 8 miles south of Aguascalientes, June 19, 1960, ADM 46, Ryckman, Ryckman and Christianson, 1 larva WSU. Texas: El Paso, Aug. 12, 1908, F. C. Pratt, 1 headless puparium, USNM.

DISCUSSION.—Except for the key characters, there appears to be little difference between the larva of *D. schaefferi* and that of *C. pilosissima.*

Genus *Adoxomyia* Bezzi, 1908

James (pers. comm.) lists 11 species for this genus, all of which (except *A. subulata*, *A. lata*, and *A. rustica*) are confined to the southwestern and western states. Unfortunately, this group of species is represented by only 3 puparia, all of which lack the head capsule; however, in an attempt to present a complete analysis of the generic characters, I have included the description of an Indian species, *Adoxomyia heminopla* (Wiedemann).

GENERIC CHARACTERS.—As given in key to genera.

Adoxomyia rustica (Osten Sacken), 1877

FIGURES 155, 156

DESCRIPTION.—Puparium: length 19.6 mm (head capsule missing); width 2.8 mm. Other characters as given in key to genera.

BIOLOGY.—No data available for *A. rustica* but larvae of *A. claripennis* have been collected from decaying cacti.

Material examined.—Washington: Tampico, Mar. 1, 1931, A. R. Rolfs, 1 puparium, USNM.

Discussion.—In addition to the specimens described above, the author has examined 2 puparia of *A. claripennis* that were collected in Pima County, Ariz., Dec. 27, 1951, by Ryckman, Ames, and Arakawa USNM. Both specimens lacked the head capsule but were in agreement with other key characters of *A. rustica.*

Adoxomyia heminopla (Wiedemann), 1819

Figures 74, 77, 80

Description.—Mature larva: the characters that appear to be of generic significance are given in the key to genera. Specific characters are unimportant since the species does not occur within the geographic range covered in this paper.

Biology.—Larvae of this species were collected from *Kaempferia* species, a tuberous-rooted plant. It has also been reported from papaya by Brunetti (1923).

Material examined.—India: Calcutta, May 26, 1955, HO–19477, lot no. 55–11257, 10 larvae, 5 puparia, USNM.

Tribe Hermetiini

Composed of the single genus *Hermetia,* this tribe is represented in North America by 8 species. Seven of them appear to be restricted to the southwestern United States. One species, *Hermetia illucens* (Linnaeus), has been recorded from as far north and east as Maryland and Delaware.

Tribal characters.—As given in key to subfamilies.

Habitat of larvae.—Hermetiine larvae are terrestrial scavengers. They have been reported from excrement (mammal and avian), decaying vegetable matter, wax in beehives, and a cadaver (Dunn, 1916). *H. illucens* has been involved in the human disease enteric myiasis (James, 1947).

Key to Species of *Hermetia* Latrielle

1. Lateral and transverse setae (dorsal and ventral) very prominent; body segments with dense yellow pubescence especially on apical segment and on lateral margins . . . . **illucens** (Linnaeus)

   Lateral and transverse setae not prominent; dense yellow pubescence lacking or, if present on dorsum of thorax, then divided into 2 patches by a bare median line 2

2. Posteroventral region of head with coarse yellow pubescence; 2 setae in prothoracic leg group . . . . species

   Bib on venter of head lacking (fig. 108); more than 2 setae in prothoracic leg group 3

3. Labrum barely extending beyond ocular lobes; point not drawn out, blunt appearance . . . . **concinna** Williston
Labrum extending beyond ocular lobes, end portion drawn out into a tapering point . . . . **aurata** Bellardi

Genus *Hermetia* Latreille, 1804

I have seen larvae or puparia of 4 of the 8 species listed by James (pers. comm.) for this genus. One species, however, remains unnamed.

Hermetia illucens (Linnaeus), 1758

FIGURES 21, 65, 75, 79

DESCRIPTIONS.—Mature larva: length 14.5–21.5 mm, mean 18.6 mm; width 4.8–6.5 mm, mean 5.8 mm; head and body segments reddish brown; spiracles present on lateral margin of segments 3–10, accompanied by a small papilla on segments 2–5; anus not armed with spines; no transverse series of short spines.

Penultimate instar: length 19.0–25.5 mm, mean 18.6 mm; width 4.0–5.5 mm, mean 4.8 mm; body segments white to creamy yellow, head and prothoracic spiracles almost black; anus armed with spines; all abdominal segments with a transverse series of darkly pigmented spines on venter near anterior margin.

BIOLOGY.—Larvae of *H. illucens* are terrestrial scavengers. They have been reported from beehives (Copello, 1926), decaying crabs (Buxton and Hopkins, 1927), decaying fruits and vegetables, catsup, animal cadavers, waste material in beehives, and from privies (James, 1947). May (1961) reported that large numbers of *H. illucens*, living and dead larvae, pupae, and some dead adults, were found in covered crocks containing tuna remains preserved in a solution of 10 percent formaldehyde. Furman, Young, and Catts (1959) have shown that large numbers of larvae of *H. illucens* will prevent development of larvae of the housefly *Musca domestica* (Linnaeus) in poultry manure.

A detailed life history has been presented by May (1961) in which she reports on the time required for the egg, larval and pupal stadia, number of instars, and the morphological changes associated with each of the 6 larval instars.

In North America this species appears to be limited to one generation per year with the adults emerging in the spring after a winter of dormancy. Copello (1926) mentioned that mating takes place during flight and later the females oviposit at the edge of decaying organic material.

MATERIAL EXAMINED.—Arkansas: Fayetteville, Sept. 27, 1927, W. J. Baerg, 3 larvae from kraut. California: 10 miles east of

Rosario Cirio, June 29, 1938, Ross and Michelbacher, 12 larvae. Delaware: Magnolia, October 1958, P.P.B., 10 larvae from polluted water, UD; Primehood Neck, M.S.C., 8 larvae from lima bean cull pile, UD; Thompsonville, Oct. 24, 1957, M.S.C., 1 larva from lima bean refuse pile, UD. Florida: Collection 1884 from USNM, 5 larvae, 1 pupa, USNM. Georgia: Bissel, Sept. 15, 1938, 1 larva from rotten potatoes; Camp Stewart, Sept. 21, 1944, E. R. Willis, 8 larvae taken from pit latrine; Camp Stewart, Dec. 6, 1944, E. R. Willis, 31 larvae taken from pit latrine. Louisiana: Baton Rouge, Sept. 30, 1959, H. V. Daley, 13 larvae from chicken manure, LSU. Maryland: Beltsville, Aug. 9, 1957, J. C. Hwang, 4 larvae from turkey manure, USNM. Missouri: St. Louis, July 20, 1960, C. W. Robinette, 4 larvae, UMO. New Mexico: Roswell, Aug. 30, 1957, 7 larvae taken from worm bed. North Carolina: Clay County, Oct. 15, 1954, extension service, 5 larvae from silo, NCSC; Clayton County, July 5, 1959, W. Brooks, 6 larvae from corn pile, NCSC; Faison, Aug. 14, 1952, Dogger and Howden, 9 larvae from rotting pumpkin, NCSC; Fuguay, Sept. 12, 1950, 5 larvae from manure, NCSC; Long Beach, Sept. 5, 1951, 1 larva from refuse, NCSC; Onslow County, Sept. 18, 1956, H. E. Scott, 2 larvae from poultry litter, NCSC; Raleigh, Aug. 4, 1941, 8 larvae from garbage, NCSC; Raleigh, July 1, 1953, D. M. Weisman, 3 larvae from ensilage, NCSC; Raleigh, Sept. 4, 1954, W. Spink, 5 larvae, NCSC; Rockingham, Oct. 25, 1955, M. Farrier, 4 larvae from under caged hens, NCSC. South Carolina: Clemson, Nov. 18, 1959, Schroeder and Skelton, 2 larvae from lab culture (dung), CC; Clemson, Nov. 19, 1959, 1 larva from manure, CC; Clemson, 30 larvae (no data), CC; Wild Cat Creek, Six Mile, Sept. 29, 1959, D. H. Peterson, 1 larva, CC. Tennessee: Knoxville, Harwood, 1 pupal case. Washington: Everett, June 22, 1957, F. Johansen, 10 larvae from soy beans in freight car, origin unknown, WSU.

Hermetia concinna Williston, 1900

Figures 66, 69, 72

Description.—Puparium: length 17.3 mm; width 4.8 mm; head and body segments testaceous; no spines in transverse series on any segments.

Biology.—The puparium studied was taken from decayed sotol (*Dasylirion* species). No other data are available.

Material examined.—Arizona: Sierita Mountains, 30 miles southwest of Tucson, Nov. 27, 1913, E. A. Schwarz, 1 larva, 1 puparium, USNM.

***Hermetia* species**

FIGURES 68, 70, 76

DESCRIPTION.—Mature larva: length 17.5 mm; width 5.5 mm; head and body segments orange yellow, head more darkly pigmented at distal end; eyespots not distinct; transverse row of small spines present on segments 1–7 near anterior margin.

BIOLOGY.—Same as noted for *H. concinna.*

MATERIAL EXAMINED.—Three larvae with same data as for *H. concinna.*

DISCUSSION.—There may be some doubt as to the validity of this species because the specimens used to describe it were found with those of *H. concinna.*

***Hermetia aurata* Bellardi, 1859**

FIGURES 67, 71, 73

DESCRIPTION.—Puparium: length 17.8–22.3 mm, mean 20.05 mm; width 5.1–6.0 mm, mean 5.55 mm. Other characters as given in key to species.

BIOLOGY.—Larvae have been collected from prickly pear (*Opuntia occidentalis*).

MATERIAL EXAMINED.—California: San Dimas Canyon, Pomona, Los Angeles County, Dec. 4, 1960, A.D.M. 72, Ryckman and Olsen, two puparia, WSU.

Genus *Dieuryneura* James, 1937

***Dieuryneura obscura* (Coquillett), 1902**

FIGURES 16, 24, 27, 32

DESCRIPTION.—Mature larva: length 14.9 mm; width 4.0–4.3 mm, mean 4.1 mm; head and body segments dark brown.

BIOLOGY.—Larvae of this species were collected from a decaying sotol plant stem (*Dasylirion* species).

MATERIAL EXAMINED.—Texas: 12 miles north of Presidio, Apr. 18, 1952, 52-6319-Presidio-3119-L, 1 larva, 11 puparia, USNM.

Subfamily Stratiomyinae

This subfamily is composed of the species of Stratiomyidae, whose larvae are aquatic or semiaquatic. The larvae vary in size from a few millimeters to 50 millimeters. One commonly finds larvae of this subfamily as representatives of this family in general collections of immature stages. This can be explained best by the fact that the aquatic species are more numerous and, therefore, easier to locate than the terrestrial species.

Subfamilial characters.—As given in key to subfamilies.

Habitat of larvae.—Stratiomyine larvae have been collected from almost every conceivable type of aquatic environment, ranging from hot springs and fast-flowing brooks to ocean shores. Although larvae in the genus *Stratiomys* are at home in water depths of several feet, larvae in most of the remaining genera prefer to remain hidden in naturally occurring vegetation along the shore or margin of the water. Quite frequently these larvae are found in and under shore debris such as boards, logs, cans, cardboard boxes, weeds, and other types of decaying organic matter.

Key to Genera of Stratiomyinae

1. Seventh abdominal segment of larva with curved sclerotized hooks on venter (fig. 122) 5
   Seventh abdominal segment without curved sclerotized hooks on venter . 2
2. Antenna located at apex of ocular lobe (fig. 126) 4
   Antenna not located at apex of ocular lobe . **Caloparyphus** James (in part)
3. Integument of larva covered with minute, peltate scales (fig. 91).
   Odontomyia Meigen, subgenus **Catasina**
   Integument lacking peltate scales . . . . **Stratiomys** Geoffroy
4. Sclerotized hooks present on venter of each of the first 7 abdominal segments, those on the seventh larger than the others . . . . **Aochletus** Osten Sacken
   Sclerotized hooks absent from each of the first 6 segments; those on the seventh present 5
5. Hydrofuge setae on last abdominal segment attaching to 2-lobed structures on lower lip of spiracular cleft (fig. 88); prothoracic spriacles located at anterior corner of that segment . . . . **Myxosargus** Brauer
   Hydrofuge setae attaching to straight edge of lower lip, lobed structures absent; prothoracic spiracle not located in anterior corner of prothorax . . 6
6. Antenna dorsal, not at apex of ocular lobe; prothoracic spiracles elevated or stalked 7
   Antenna at apex of ocular lobe; prothoracic spiracles neither elevated nor stalked 8
7. Apical segment with lateral margin straight; distance from antenna to eye prominence greater than twice length of antenna.
   Caloparyphus James (in part)
   Lateral margin of apical segment tapering basally toward median line; distance from antenna to eye prominence approximately equal to length of antenna . . . . **Euparyphus** Gerstaecker
8. Venter of sixth and seventh abdominal segments with sclerotized hooks . . 9
   Venter of only seventh abdominal segment with sclerotized hooks.
   Odontomyia Meigen, subgenus **Odontomyiina**
9. Body segments with broad dorsal vittae or body segments with fine white pubescence or multiple hooks.
   Odontomyia Meigen, subgenus **Odontomyia**
   Without the above combination of characters . . . **Hedriodiscus** Enderlein

Genus *Stratiomys* Geoffroy, 1762

This is one of the largest genera of soldier flies that occurs in North America. Of the 21 species listed by James (pers. comm.), I have seen associated larvae or puparia of 7 species.

Generic characters.—As given in key to species

Key to Species of *Stratiomys* Geoffroy

(Although associated puparia of 7 species were available, I was able to separate only 1 species (*S. discaloides* Curran) from the remaining 6).

Length of last abdominal segment approximately 2 times the basal width of that segment . . . . **discaloides** Curran

Length of last abdominal segment greater than 2 times the basal width of that segment . . . . **adelpha** Steyskal, **badia** Walker, **barbata** Loew, **meigenii** Wiedemann, **norma** Wiedemann, **normula** Loew.

Stratiomys discaloides Curran, 1922

Figure 119

Description.—Puparium: length 31 mm, width 6.8 mm; head and body segments dark brown; faint dark markings at basal margin of body segments. Other characters as given in key to species.

Biology.—No data are available for this species.

Material examined.—Montana: Harlan Gulch, Rav. County, Jan. 9, 1932, C. B. Philip, 1 broken puparium, WSU.

Stratiomys species

Figures 20, 105–109

Description.—Puparium: length 31.3–41.0 mm; width 4.9–6.0 mm; color varying from grey brown to dark brown; markings same as for *S. discaloides*. Other characters as given in key to species.

Biology.—See biology section in this paper.

Material examined.—*Stratiomys adelpha* Steyskal: New York: Ithaca, Decker Pond, Mar. 27, 1950, H. H. Schwardt, 1 puparium, WSU. Saskatchewan: Watson, May 15, 1956, M. E. Taylor, 5 puparia, MWM. *Stratiomys badia* Walker: Alberta: 4 miles north of Devon, May 16, 1961, G. Pritchard, 1 puparium, MWM; Banff National Park, Mt. Ishbel, June 14, 1960, Ball, Madge and McFadden, 1 larva, 1 puparium from under moss, elevation approximately 6000 ft., MWM. *Stratiomys barbata* Loew: Manitoba: Churchill, July 16, 1949, 2 puparia, CNC. Alberta: Banff National Park, Mt. Ishbel, June 14, 1960, Ball, Madge and McFadden, 1 puparium, elevation approximately 6000 ft., MWM. *Stratiomys meigenii* Wiedemann: Kansas: Manhatten, Feb. 8, 1936, H. H. Schwardt, 2 puparia, WSU. *Stratiomys norma* Wiedemann: Wisconsin: T9N Knapps Creek, Richland County, R2W, June 10, 1954, R. H. Jones, 4 puparia, WSU.

Stratiomys normula Loew: Louisiana: Baton Rouge (?), 2 puparia, LSU.

Genus *Myxosargus* Brauer, 1882

Four species of *Myxosargus* occur in North America but only the puparium of *Myxosargus nigricornis* Green is known.

Generic characters.—As given in key to genera.

Myxosargus nigricornis Green, 1918

Figures 88, 92, 93

Description.—Puparium: length 6.7–7.0 mm (less head and prothorax), mean 6.85 mm; width 2.0–2.1 mm, mean 2.05 mm.

Biology.—No data are available for this species.

Material examined.—Missouri: 5 miles north of Vichy, June 15, 1955, P. J. Spangler, 2 puparia, WSU.

Genus *Euparyphus* Gerstaecker, 1857

James (pers. comm.) divided this genus into 2 subgenera as follows: *Euparyphus* (11 species) and *Aochletus* (3 species). Of the 11 species listed for *Euparyphus*, only the larvae of *E. limbrocutris* Adams have been collected. *Aochletus* has been elevated to full generic status.

Generic characters.—As given in key to genera.

Euparyphus limbrocutris Adams, 1903

Figures 94, 95, 99

Description.—Mature larva: length 10.6–11.2 mm, mean 10.9 mm; width 2.3–2.5 mm, mean 2.4 mm; prothoracic spiracles located on a medial-lateral projection and extending at least halfway to the dorsomedian line of that segment.

Penultimate instar: length 9.2–10.6 mm, mean 9.9 mm; width 2.0–2.1 mm, mean 2.05 mm; differs from mature larva since prothoracic spiracles are elevated as high as their basal diameter.

Biology.—No data are available for this species.

Material examined.—Washington: O'Sullivan Dam, Grant County, May 7, 1955, J. A. Quist, 2 mature and 2 penultimate instar larvae, WSU.

Genus *Aochletus* Osten Sacken, 1886

On the basis of adult characters, James (pers. comm.) considered *Aochletus* to be a subgenus of *Euparyphus*; however, the difference or degree of difference between the larvae of *Aochletus* and *Euparyphus* is so great that I feel full generic status should be given to *Aochletus*.

Of the 3 species listed by James (pers. comm.) for this taxon, larvae have been collected for the following 2: *A. cinctus* Osten Sacken and *A. brevicornis* Loew.

GENERIC CHARACTERS.—As given in key to genera.

Key to Species of *Aochletus* Osten Sacken

Prothoracic spiracles distinctly stalked . . . . **cinctus** Osten Sacken
Prothoracic spiracles almost flush with integument . . . . . . **brevicornis** Loew

Aochletus cinctus Osten Sacken, 1866

DESCRIPTION.—Puparium: length 9.5–10.5 mm, mean 10.0 mm; width 2.7–2.8 mm, mean 2.73 mm. Other characters as given in key to species.

BIOLOGY.—No data are available for this species.

MATERIAL EXAMINED.—California: Topanga Canyon, Los Angeles County, May 10, 1953, 3 puparia, WSU; Sespe Creek, Ventura County, June 15, 1948, W. W. Wirth, 1 puparium, USNM.

Aochletus brevicornis Loew, 1866

FIGURES 96, 97, 101

DESCRIPTION.—Instar no. ?: length 4.5–5.3 mm, mean 4.93 mm; width 1.3–1.7 mm, mean 1.50 mm; other characters as given in key to species.

BIOLOGY.—Larvae have been collected from springs in Yellowstone National Park. No mention is given regarding the type of spring other than the location.

MATERIAL EXAMINED.—Wyoming: Mammoth, Yellowstone National Park, Jan. 25, 1956, J. R. Murphy, 3 early instar larave from a cavern spring, WSU; Mammoth, Yellowstone National Park, June 20, 1956, J. R. Murphy, 6 larvae from hillside springs, WSU.

Genus *Caloparyphus* James, 1939

On the basis of male genitalia, both James (pers. comm.) and Quist (Thesis) consider *Caloparyphus* to merit generic status. The larvae, however, do not seem to corroborate this. In fact, it is rather difficult to distinguish between the larvae of *Caloparyphus* and those of *Euparyphus* (see key to genera, p. 33). This seems to suggest that perhaps *Caloparyphus* should be returned to its former status as a subgenus of *Euparyphus*.

James (pers. comm.) lists 11 species for this genus in North America. Associated larvae or puparia have been collected for 5 species, including 1 unidentified species.

GENERIC CHARACTERS.—As given in key to genera.

Key to Species of *Caloparyphus* James

1. Venter of seventh abdominal segment without strong sclerotized hooks. species
   Venter of seventh abdominal segment with strong sclerotized hooks . . . 2
2. Sclerotized hooks half the length of seventh abdominal segment. **amplus** (Coquillett)
   Sclerotized hooks less than half the length of the seventh abdominal segment 3
3. Prothoracic spiracle oval shaped, diameter at widest point twice that of the elevation; 4 setae in mesothoracic leg group . . . . . **major** (Hine)
   Prothoracic spiracle varying in shape but elevation approximately equal to basal diameter; number of setae in mesothoracic leg group other than 4 . 4
4. Three setae in mesothoracic leg group . . . . **tetraspilus** (Loew)
   Five setae in mesothoracic leg group . . . . . . **crotchi** (Osten Sacken)

Caloparyphus species

FIGURES 112, 115, 118

DESCRIPTION.—Puparium: length 12.4–13.4 mm, mean 12.88 mm; width 2.5–3.2 mm, mean 2.90 mm; other characters as given in keys to genera and species.

BIOLOGY.—Larvae of this species were collected from a sphagnum bog located part way up a mountain (elevation approximately 6000 ft.).

MATERIAL EXAMINED.—Alberta: Banff National Park, Mt. Ishbel, Apr. 14, 1960, Ball, Madge and McFadden, 5 puparia, MWM.

Caloparyphus amplus (Coquillett), 1902

FIGURES 122, 127, 128, 131

DESCRIPTION.—Mature larva: length 7 mm or under; width 1.0–1.4 mm, mean 1.2 mm; dorsum of body segments with short blunt setae; other characters as given in key to species.

BIOLOGY.—No data are available for this species.

MATERIAL EXAMINED.—California: Sespe Creek, Ventura County, June 15, 1948, W. W. Wirth, 20 larvae, USNM.

DISCUSSION.—Accurate measurements of length were unobtainable due to improper preservation of the specimens.

Caloparyphus major (Hine), 1901

FIGURES 111, 114, 117

DESCRIPTION.—Mature larva: length 9.6–12.1 mm, mean 10.94 mm; width 2.7–2.9 mm, mean 2.8 mm; other characters as given in key to species.

BIOLOGY.—Larvae of this species were collected from moss on a large floating board in a cold, spring-fed roadside pool.

MATERIAL EXAMINED.—British Columbia: Pole no. 187/18, Route 3, June 9, 1960, Ball, Madge, and McFadden, 5 larvae, 3 puparia, MWM.

Caloparyphus tetraspilus (Loew), 1866

FIGURES 110, 113, 116

DESCRIPTION.—Mature larva: length 9.5–11.0 mm, mean 10.25 mm; width 1.8–2.3 mm, mean 2.05 mm; other characters as given in key to species

BIOLOGY.—Larvae of this species were collected on a sandy lake beach under decaying vegetation and other debris at the water's edge.

MATERIAL EXAMINED.—Alberta: Dilberry Lake, 54°34′30″ N lat., 110°60′45″ W long., June 5, 1960, Ball, Madge and McFadden, 2 larvae, MWM.

Caloparyphus crotchi (Osten Sacken), 1877

FIGURES 125, 129, 132

DESCRIPTION.—Puparium: length (specimen broken, impossible to measure accurately but close to 15 mm); width 3.4 mm; other characters as given in key to species.

BIOLOGY.—No data are available for this species.

MATERIAL EXAMINED.—Colorado: Fort Collins, Aug. 4, 1910, 1 puparium, WSU.

Genus *Hedriodiscus* Enderlein, 1914

James (pers. comm.) lists 7 species for this genus in North America. Only the larva of *H. vertebratus* (Say) is known.

Hedriodiscus vertebratus (Say), 1824

FIGURES 87, 91

DESCRIPTION.—Puparium: length 19 mm, width 2.7 mm; other characters as given in key to genera

BIOLOGY.—James (pers. comm.) reported that larvae of this species live among floating vegetation in small streams. They feed on microorganisms, algae, and the soft parts of plants.

MATERIAL EXAMINED.—Locality (?); July 1, 1938, larva from weedy lake, 1 puparium, WSU.

Genus *Odontomyia* Meigen, 1803

James (pers. comm.) has divided this taxon into 3 subgenera as follows: *Catasina* (9 species), *Odontomyiina* (7 species) and *Odontomyia* (14 species). The character combinations of the immature stages seem to support this classification.

Subgenus *Catasina* Enderlein, 1914

Odontomyia (*Catasina*) *pubescens* (Day), 1882

FIGURES 86, 89, 90

DESCRIPTION.—Puparium: length 13.8–17.0 mm, mean 15.80 mm; width 2.7–3.6 mm, mean 3.1 mm; other characters as given in key to genera.

BIOLOGY.—Larvae of this species have been collected from moss-covered logs (in boggy areas), from under stones at water's edge, and from the margins of marshy areas.

MATERIAL EXAMINED.—Alberta: Beaverhills Lake near Tofield, May 21, 1960, G. E. Ball, 1 puparium, MWM; Flatbush, May 12, 1960, M. W. McFadden, 1 larva, 1 puparium, MWM; Dilberry Lake, 54°34′30″ N lat., 110°60′45″ W long., June 5, 1960, Ball, Madge, and McFadden, 1 puparium, MWM. Saskatchewan: Saskatoon, May 15, 1949, A. R. Brooks, 1 puparium, CNC.

Subgenus *Odontomyiina* Enderlein, 1930

Odontomyia (*Odontomyiina*) *virgo* (Wiedemann), 1830

FIGURES 98, 102

DESCRIPTION.—Puparium: length 15 mm (less head and prothorax); width 3.50 mm; 4 white vittae on dorsal surface of body segments, inner 2 narrow; penultimate segment half as long as apical segment; other characters as given in key to genera.

BIOLOGY.—Larvae of this species were collected from shore debris at the edge of a small pond.

MATERIAL EXAMINED.—Alberta: 4 miles north of Devon, May 10, 1961, M. W. McFadden, 1 puparium, 1 early instar larva, MWM.

Subgenus *Odontomyia* Meigen, 1803

Key to Species of *Odontomyia* Meigen

1. Venter of sixth and seventh abdominal segments with multiple hooks. **occidentalis** James
   Venter of sixth and seventh abdominal segments with a single pair of hooks . 2
2. Dorsum with 2 broad vittae extending length of body but dividing into 4 vittae on apical segment . . . . **cincta** Olivier
   Vittae in different pattern; body segments with fine white pubescence. **communis** James

Odontomyia (Odontomyia) occidentalis James, 1936

Figures 135, 136, 138

Description.—Puparium: length 20 mm; width 3.5 mm; other characters as given in key to species.

Biology.—Larvae of this species have been collected from hot springs.

Material examined.—Sleeping Child Hot Springs, reared June 28, 1930, 2 puparia, WSU.

Discussion.—The mensural data given above were taken directly from the puparia. These specimens had the apical segments turned up in the typical manner making accurate measurements an impossibility.

Odontomyia (Odontomyia) cincta Olivier, 1811

Figures 126, 130, 133

Description.—Mature larva: length 18.5–20.0 mm, mean 19.25 mm; width 3.5–3.9 mm, mean 3.7 mm; other characters as given in key to species.

Biology.—Larvae of this species have been collected from a peat bog and from a pool of unidentified type.

Material examined.—Ohio: Delaware County, July 29, 1940, 1 larva, OSU. Wisconsin: Dane County, University of Wisconsin Arboretum, May 22, 1954, R. H. Jones, 1 puparium, WSU.

Odontomyia (Odontomyia) communis James, 1939

Figures 140, 142

Description.—Mature larva: length 19–21 mm, mean 20 mm; width 2.9–3.6 mm, mean 3.25 mm; other characters as given in key to species.

Biology.—Larvae of this species have been collected from 5 percent saline water in Death Valley.

Material examined.—California: Bad Water, Death Valley, May 1, 1958, D. P. Furman, 2 larvae, WSU.

Subfamily Nemotelinae

James (pers. comm.) placed the genus *Nemotelus* in the Stratiomyinae solely on the basis of adult characters; however, when both adult and larval characters are taken together and compared with similar characters of other members of that subfamily, the differences observed are great enough to warrant separation. For this reason I have erected the new subfamily Nemotelinae.

Subfamilial characters.—As given in key to subfamilies.

Genus *Nemotelus* Geoffroy, 1762

In North America this genus contains 33 species that are divided into 2 subgenera: *Nemotelus* (12 species) and *Camptopelta* (21 species). I have seen puparia of 2 species of *Camptopelta* and larvae of a single species of *Nemotelus*.

GENERIC CHARACTERS.—As given in key to genera.

Subgenus *Nemotelus* Geoffroy, 1762

The specimens representing this taxon consisted of 3 headless puparia in poor condition.

Nemotelus (Nemotelus) kansensis Adams, 1903

FIGURES 120, 123

DESCRIPTION.—Puparium: length 7.2 mm (less head and prothorax); width 2.6 mm

BIOLOGY.—Larvae of this species were collected from a salt spring (probably from the margin)

MATERIAL EXAMINED.—Missouri: Petersburg, June 1, 1955, P. J. Spangler, 3 puparia, WSU.

DISCUSSION.—The pattern on the dorsum of the body segments and the arrangement and placement of setae both agree very closely with that of *Nemotelus canadensis* Loew

Subgenus *Camptopelta* Williston, 1917

Key to Species of *Camptopelta* Williston

Larva less than 4 mm in length; dorsum of body segments lacking vittae and plaques . . . . **centralis** Hanson

Larva 5 mm or more in length; dorsum of body segments with vittae and plaques (fig. 121) . . . . **canadensis** Loew

Nemotelus (Camptopelta) centralis Hanson, 1958

FIGURES 100, 103, 104

DESCRIPTION.—Mature larva: length 3.5–3.7 mm, mean 3.6 mm; width 0.8–1.0 mm, mean 0.9 mm; head light brown, body white; prothoracic spiracles dark.

BIOLOGY.—No data are available for this species.

MATERIAL EXAMINED.—Michigan: Cheboygan County, Aug. 17, 1957, W. J. Hanson, 3 larvae, lab reared, KU

Nemotelus (Camptopelta) canadensis Loew, 1863

FIGURES 121, 124, 134

DESCRIPTION.—Puparium: length 7.7–8.3 mm, mean 8.0 mm; width 1.8–2.0 mm, mean 1.9 mm; other characters as given in key to species.

Biology.—Larvae of this species have been collected from under cow manure and rotting vegetation at the edge of highly alkaline lakes (pH 8.6).

Material examined.—Alberta: Chappice Lake, 18 miles north of Medicine Hat, June 7, 1960, Ball, Madge and McFadden, 3 puparia, MWM; Gooseberry Lake Provincial Park, 9 miles north of Consort, June 5, 1960, Ball, Madge and McFadden, 8 puparia, MWM.

Subfamily Pachygastrinae

In their recent revision of this subfamily, Kraft and Cook (1961) have presented an up-to-date resumé of the biology and taxonomy of both adults and larvae. Keys were presented for distinguishing between larvae in each of the 5 genera and within the 2 genera *Zabrachia* and *Eupachygaster*.

I have found variation in the measurements given by Kraft and Cook as compared with those taken by myself. In one species, *Eupachygaster henshawi* Malloch, this variation is one millimeter and represents an error of 25 percent. In spite of this, I do not believe that these mensural variations represent specific differences but, rather, indicate a small sample that may have been taken from a limited geographic area. I have placed the measurements given by Kraft and Cook in brackets and have presented my own measurements including range and mean.

Subfamilial characters.—As given in key to subfamilies.

Habitat of larvae.—Pachygastrine larvae have been found under the bark of both deciduous and coniferous trees. Oviposition usually occurs on wounded or dead trees but in either case there must be enough moisture present in the host for the larvae to be able to obtain nourishment. Host trees mentioned by Kraft and Cook are: apple, quaking aspen, dwarf elm, American elm, cottonwood, hickory, white pine, Douglas fir, Engelmann spruce, and shore pine.

The larvae are gregarious (I have collected approximately 100 larvae beneath the bark of a single log), extremely slow moving, and feed on the sap or microorganisms that occur in the moist areas beneath the bark. Malloch (1917) has suggested that pachygastrine larvae are predatory on other insect larvae but this has not been observed.

Key to Genera of Subfamily Pachygastrinae

(modified after Kraft and Cook, 1961)

1. Teeth along anal opening prominent; setae on margin of last segment short, no longer than one-fourth width of last segment (fig. 141) 2

   No prominent teeth along anal opening; setae on margin of last segment long, at least one-third as long as width of last segment (fig. 140) 3

2. Midventral line of abdominal segment 6 with a round sternal patch, located anterior to transverse row of setae; 8 or more pairs of conspicuous plaques along dorsal midline of last segment . . . . . . **Berkshiria** Johnson
   Sternal patch on midventral line of abdominal segment 6 oval, located between setae of transverse row; no more than 3 or 4 pairs of conspicuous plaques along dorsal midline of last segment . . . . **Neopachygaster** Austen
3. Each thoracic leg group with 2 setae (fig. 140) . . . **Eupachygaster** Kertesz
   Each thoracic leg group with 3 setae (fig. 142) 4
4. Abdominal segments 1–7 each with 18 setae (fig. 148). . **Pachygaster** Meigen
   Abdominal segments 1–7 each with 20 setae (fig. 142). **Zabrachia** Coquillett

Genus *Berkshiria* Johnson, 1914

This genus contains the single species *Berkshiria albistylum*, the larva of which has been collected from beneath the bark of deciduous trees only. As Kraft and Cook (1961) have pointed out, it resembles *Neopachygaster* but can be readily distinguished on the basis of the form of the sternal patch.

Generic characters.—As given in key to genera.

Berkshiria albistylum Johnson, 1914

Figure 142

Description.—Mature larva: length (5.0–7.2 mm) 5.0–5.9 mm, mean 5.3 mm; width (1.6–2.0 mm) 2.0–2.4 mm, mean 2.2 mm.

Biology—Larvae of *B. albistylum* have been collected from under the bark of poplar (*Populus deltoides*) and elm (*Ulmus pumila*). Cook (1953) reported that the larvae have at least 4 instars that apparently do not form distinct size groups. He also mentioned that the pupal period lasted from 8 to 10 days and that the adults did not live for more than 5 days in the laboratory.

Material examined.—Eight larvae from the Ohio State University collection with the following data: Dec. 5, 1942, under bark of dead poplar.

Genus *Zabrachia* Coquillett, 1901

Of the 11 species listed for this genus by Kraft and Cook (1961), the larvae of only 2 species have been found. Both species were taken from beneath the bark of coniferous trees.

Generic characters.—As given in key to genera.

Key to Species of *Zabrachia* Coquillett

(after Kraft and Cook, 1961)

Ventral surface of abdominal segment 6 with 18 large plaques . **politum** Coquillett
Ventral surface of abdominal segment 6 with 16 large plaques.
plicatum Kraft and Cook

Zabrachia politum Coquillett, 1901

Figure 145

Description.—Mature larva: length 4.3 mm; width 1.0 mm; other characters as given in key to species.

Biology—No data are available for this species.

Material examined.—No larvae of this species were examined.

Zabrachia plicatum Kraft and Cook, 1961

Figure 142

Description.—Mature larva: length 4.0–5.0 mm, mean 4.7 mm; width 0.7–1.0 mm, mean 0.5 mm; other characters given in key to species.

Biology.—Larvae have been collected from beneath the bark of *Pinus contorta*, *P. ponderosa*, *Picea engelmanni*, and *Pseudotsuga mucronata*.

Material examined.—North Carolina: Raleigh, 1941–1942, 9 larvae from fallen pine, NCSC.

Discussion.—In keying out this species, I found it necessary to slide-mount the integument in order to be sure of the number of plaques on segment 6.

Genus *Neopachygaster* Austen, 1901

Kraft and Cook (1961) recognize 4 species in this genus. The larvae have been collected from both coniferous and deciduous trees.

Generic characters.—As given in key to genera.

Key to Species of *Neopachygaster* Austen

Kraft and Cook (1961) were unable to differentiate between the larvae of the species in this genus. Because of a lack of material, I am also unable to contribute toward the identification of these species.

Neopachygaster occidentalis Kraft and Cook, 1961

Figure 147

Description.—Larva: length 5.58 mm; width 1.69 mm; tufts of setae of thoracic leg group with 2 inner seate of equal length, outer seta much shorter; otherwise indistinguishable from other larvae of this genus.

Biology.—Larvae were taken from under bark of *Pinus ponderosa*.

Material examined.—No larvae of this species were examined.

Discussion.—All data presented for this species are taken directly from Kraft and Cook (1961).

Neopachygaster maculicornis (Hine), 1902

FIGURES 18, 146

DESCRIPTION.—Mature larva: length (5.50–6.00 mm) 6.0–6.5 mm, mean 6.17 mm; width (1.40–1.50 mm) 1.1–1.50 mm, mean 1.27 mm; tufts of setae in thoracic leg group same as in *N. occidentalis*.

BIOLOGY.—Larvae have been collected from beneath the bark of a fallen poplar (*Populus* species).

MATERIAL EXAMINED.—Alberta: Medicine Hat, South Saskatchewan River, June 7, 1960, Ball, Madge, and McFadden, approximately 100 specimens of larvae and puparia, MWM.

DISCUSSION.—Adults of this species were reared from larvae and the measurements outside of the parentheses are based on these specimens.

Neopachygaster vitrea Hull, 1930

DESCRIPTION.—According to Kraft and Cook (1961), the larva of this species is essentially the same as the larva of *N. maculicornis*.

BIOLOGY.—No data are available for this species.

MATERIAL EXAMINED.—No larvae of this species were examined.

Neopachygaster reniformis Hull, 1942

DESCRIPTION.—Larva: length 4.93 mm; width 1.45 mm; very similar to larvae of *N. maculicornis;* tufts of thoracic leg setae with the middle setae longest, inner seta next longest.

BIOLOGY.—No data are available for this species.

MATERIAL EXAMINED.—No larvae of this species were examined.

DISCUSSION.—All data presented for this species were taken directly from Kraft and Cook (1961).

Genus *Euphachygaster* Kertesz, 1911

Kraft and Cook (1961) recognize 3 species in this genus. The larvae have been collected from beneath the bark of both deciduous and coniferous trees.

GENERIC CHARACTERS.—As given in key to genera.

Key to Species of *Eupachygaster* Kertesz

(modified after Kraft and Cook, 1961)

1. Abdominal terga 1–7 of approximately equal length with setae in transverse rows . . . . **punctifer** Malloch
   Setae in transverse rows with the outermost setae much shorter than the others in the row 2

2. Transverse row of 6 setae on abdominal sterna 1–7 with all setae of approximately equal length . . . . **henshawi** Malloch
   Setae in transverse row with outermost setae much longer than others. **fusca** Kraft and Cook

Eupachygaster punctifer Malloch, 1915

Figure 143

Description.—Mature larva: length (6.2 mm) 5.0–6.5 mm, mean 5.8 mm; width (1.7 mm) 1.0–1.3 mm, mean 1.2 mm; other characters as given in key to species.

Biology.—Larvae have been collected from under the bark of *Carya*, *Populus*, and an unknown species of *Pinus*.

Material examined.—Delaware: Sussex County, 1952, W. A. Connell, 6 larvae from under bark, UD. North Carolina: Auburn, Nov. 2, 1956, Bowden and Wright, 3 larvae from under bark of oak log, NCSC; Herring, August 23, 1956, C. G. Wright, 1 larva from under bark of oak log, NCSC; West End, July 14, 1941, 12 larvae from under bark of pine log, NCSC.

Eupachygaster fusca Kraft and Cook, 1961

Figure 140

Description.—Mature larva: length (5.85 mm) 4.2–7.0 mm, mean 6.0 mm; width (0.169 mm) 0.9–1.7 mm, mean 1.5 mm; other characters as given in key to species

Biology.—The only recorded host for this species is the willow (*Salix* species).

Material examined.—North Carolina: Rocky Mountain, Mar. 25, 1954, D. M. Weisman, 20 larvae from under bark of log, NCSC. Ohio: Wooster, Apr. 22, 1940, H. R. Dodge, 5 larvae from under willow bark, NCSC.

Eupachygaster henshawi Malloch, 1917

Figure 144

Description.—Mature Larva: length (4.95 mm) 5.7–6.9 mm, mean 6.5 mm; width (1.44 mm) 1.2–1.3 mm, mean 1.23 mm; other characters as given in key to species

Biology.—Larvae have been collected from under the bark of apple, elm, and oak trees.

Material examined.—North Carolina: Auburn, Jan. 8, 1956, C. G. Wright, 3 larvae from under bark of oak log, NCSC; Auburn, Aug. 25, 1956, C. G. Wright, 3 larvae from under bark of oak tree, NCSC.

Genus *Pachygaster* Meigen, 1803

Kraft and Cook (1961) list 3 species for this genus but larvae of only *Pachygaster pulchra* have been found.

GENERIC CHARACTERS.—As given in key to genera.

Pachygaster pulchra Loew, 1863

FIGURE 148

DESCRIPTION.—Larva: length 4.82 mm; width 0.94 mm; narrow, dirty white, dorsal setae knobbed at tips; only 9 pairs of setae on abdominal segments 1–7.

BIOLOGY.—Larvae of this species have been collected from tree crotch debris, treeholes, and hollow trees.

MATERIAL EXAMINED.—No larvae of this species were examined.

DISCUSSION.—All data presented for this species were taken directly from Kraft and Cook (1961).

Literature Cited

AUSTEN, E. E.

1899. On the preliminary stages and mode of escape of the imago of the dipterous genus *Xylomyia* Rondani (*Subula* Meigen *et auct.*) with special reference to *Xylomyia maculata* F., and on the systematic position of the genus. Ann. Mag. Nat. Hist., vol. 3, no. 7, pp. 181–190.

BAKER, C. F.

1895. Biological notes on some Colorado Diptera. Ent. News, vol. 6, no. 6, p. 6.

BELING, T.

1883. Beitrag zur Metamorphose zweiflügeliger Insekten aus den Familien Tabanidae, Leptidae, Asilidae, Empidae, Dolichopidae, und Syphidae. Arch. Nat., vol. 48, pp. 186–240.

BELLARDI, L.

1861. Saggio di Ditterologia Messicana. Mem. Reale Accad. Sci. Torino, vol. 19, pp. 201–278.

BERG, C. O.

1952. Biology and metamorphosis of some Solomon Islands Diptera, 2: *Solva bergi* James (Erinnidae), with a comparison of related species. Pan-Pacific Ent., vol. 28, no. 4, pp. 203–215.

BERTRAND, H.

1948. Note sur deux larves du genre *Hermione* Meigen. Bull. Soc. Ent. France, vol. 53, pp. 55–58.

BISCHOFF, W.

1925. Ueber die Kopfbildung der Dipterenlarven, 3: Die Köpfe der Orthorrhapha-Brachycera-Larven. Arch. Naturg., vol. 90, pp. 1–105.

BORGMEIER, T.

1930. Ueber das Vorkommen der Larven von *Hermetia illucens* L. in den Nestern von Meliponiden. Zool. Anz., vol. 90, pp. 225–235.

BOUCHÉ, P. F.

1834. Naturgeschichte der Insekten besonders in Hinsicht ihrer ersten Zustande als Larven und Puppen.

BRAUER, F.

1869. Kurze Characteristik der Dipteren-Larven zur Bekraftigung des neuen von Dr. Schiner entwerfenen Dipterensystemes. Verh. Zool.-Bot. Ges. Wien, vol. 19, pp. 843–852.

1883. Die Zweiflüger des Kaiserlichen Museums zu Wien, 3: Systematatische Studien auf Grundlage der Dipterenlarven, nebst einer Zusammenstellung von Beispielen aus der Literatur über dieselben und Beschreibung neuer Formen. Denkschr. Kais. Akad. Wiss. Wien, vol. 47, pp. 1–100.

BREML

1846. Beitrag zur Kunde der Dipteren. Isis Oken, vol. 3, pp. 164–175.

BRINDLE, A.

1959. Notes on the larvae of the British Rhagionidae and Stratiomyidae. Ent. Rec., vol. 71, pp. 126–133.

BRONGNIART, C. J. E.
1881. Note sur les tufs quarternaires de Bernouville, pres Gisors (Eure). Bull. Soc. Geol. France, vol. 8, no. 3, p. 419.

BRUES, C. T.
1924. Observations on animal life in the thermal waters of Yellowstone Park, with a consideration of the thermal environment. Proc. American Acad. Arts Sci., vol. 59, pp. 371–437.
1928. Studies on the fauna of hot springs in the Western United States and the biology of thermophilous animals. Proc. American Acad. Arts Sci., vol. 63, pp. 139–228.
1932. Further studies on the fauna of North American hot springs. Proc. American Acad. Arts Sci., vol. 67, pp. 185–303.

BUXTON, P. A.
1929. A note on the larvae of four species of Stratiomyidae. *In* Insects of Samoa, vol. 6, pp. 141–150.

BUXTON, P. A., and HOPKINS, G. H. E.
1927. Researches in Polynesia and Melanesia. London: London School of Hygiene and Tropical Medicine, pts. 1–4, pp. 51, 65.

COLLART, A.
1937. Contribution à l'étude des diptères de Belgique (3° note). Bull. Ann. Soc. Ent. Belgique, vol. 77, pp. 306–317.

COOK, E. F.
1949. The evolution of the head in the larvae of Diptera. Microentomology, vol. 14, pp. 1–57.
1953. On the early stages of *Neopachygaster maculicornis* (Hine) and *Berkshiria aldrichi* (Malloch). Ann. Ent. Soc. America, vol. 46, pp. 293–299.

COPELLO, A.
1926. Biologia de *Hermetia illucens* Latr. Rev. Soc. Ent. Argentina, vol. 1, no. 2, pp. 22–26.

CORNELIUS, C.
1860. Zur Ernahrung und Entwicklung der Larven von *Sargus formosus* Schrank. Stettiner Ent. Zeit., vol. 21, pp. 202–204.

CROS, A.
1911. Notes sur les larves de *Stratiomys anubis* Wiedemann. Feuill. Jeun. Nat., vol. 41, pp. 91–103.

CURRAN, C. H.
1934. The families and genera of North American Diptera, pp. 135–145.

DAMIANITSCH, R.
1868. Ueber die Metamorphose des *Xylophagus ater* (Fab.). Verh. Zool.-Bot. Ges. Wien, vol. 18, pp. 117–118.

DUFOUR, L.
1841. Note sur la larve du *Pachygaster mesomelas*. Ann. Sci. Nat., vol. 16, no. 2, pp. 264–266.
1846a. Note sur la *Fulgora obliqua*, la *Brachyopa bicolor* et le *Subularia citripes*. Bull. Soc. Ent. France, vol. 4, p. 47.
1846b. Sur une colonie d'insectes vivant dan l'ulcére de l'ormeau. Compt. Rend. Acad. Sci. Paris, vol. 22, pp. 318–319.
1847. Histoire des metamorphoses du *Subula citripes* et quelques autres especes de ce genre des diptères. Ann. Sci. Nat., vol. 7, no. 3 pp. 5–14.

DUNN, L. H.
1916. *Hermetia illucens* breeding in a human cadaver. Ent. News, vol. 27, pp. 59–61.

DUSEK, J., and ROZKOSNY, R.
1963. Revision Mitteleuropaischer Arten der Familie Stratiomyidae (Diptera) mit besonderer Berucksichtigung der Fauna der CSSR. Act. Soc. Ent. Cechosloveniae, vol. 60, no. 3, pp. 202–221.

ENGEL, E. O.
1916. Beitrage zur kenntnis einiger Dipteren larven. Mitt. Münchener Ent. Ges., vol. 7, pp. 68–76.

ENGEL, E. O., and CUTHBERTSON, A.
1937. On the biology of some Rhodesian Diptera together with descriptions of three species of Asilidae new to science. Trans. Rhodesia Sci. Assoc., vol. 35, pp. 1–15.

ENGELHARDT, G. P.
1928. Notes on the breeding of *Hermetia aurata* Bell. Bull. Brooklyn Ent. Soc., vol. 23, p. 122.

FANTHOM, H. B., and PORTER, A.
1913. *Herpetomonas stratiomyiae* n. sp., a flagellate parasite of the flies *Stratiomyia chamaeleon* and *Stratiomyia potamida*, with remarks on the biology of the hosts. Ann. Trop. Med. Parasit., vol. 7, pp. 609–620.

FARGEAU, S., and SERVILLE, J. G.
1825. Les larves du *Vappo* Latr. Fabr. (*Pachygaster* Meig., Macq.). *In* vol. 10 *of* Encyclopedie medthodique, p. 779.

FLORENTIN.
1899. Études sur la fauna des mares salees de Lorraine. Ann. Sci. Nat., pp. 274–276.

FREIDENFELS, E.
1880. Ueber *Artemia salina* und andere Bewohner der Soolenteiche in Salzburg. Verh. Mitth. Siebenbürgischer Ver. Naturwiss. (Hermannstadt), vol. 30, pp. 112–178.

FRISCH, J. L.
1720. Beschreibung von allerly Insecten in Teutsch-Land, nebst nutzlichen Anmerckungen . . . vondiesem . . . inlandischen Gewürme vol. 1, no. 5, p. 10.

FROGGAT, W. E.
1896. The entomology of the grass tree (*Xanthorrhoea*). Proc. Linn. Soc. New South Wales, vol. 21, pp. 74–87.

FULLER, M.
1934. The early stages of *Actina incisuralis*. Proc. Linn. Soc. New South Wales, vol. 59, pp. 190–196.

FURMAN, D. P.; YOUNG, R. D.; and CATTS, P. E.
1959. *Hermetia illucens* (Linnaeus) as a factor in the natural control of *Musca domestica* (Linnaeus). Journ. Econ. Ent., vol. 52, no. 5, pp. 917–921.

GANIN, M.
1876. Materialen zur Kenntniss der post embryonalen Entwickelungsgeschichte der Insekten: Protokolle der Sitzungen der Sektion für die Zoologie und vergleichende Anatomy der S. Versammlung russischer Naturforscher und Aerzte in Warschaw, Sept. Mitgeteilt von Hoyer.

Geer, C. De
1778. Mémoires pour servir a l'histoire des insectes, 7 vols.
Goidanich, A.
1939. Gli straziomiidi mancati nemici del riso. Risicoltura, vol. 29, pp. 221–230.
Goureau, C.
1867. A note on *Subula*. Ann. Soc. Ent. France, ser., 4. vol. 7, pp. 87–88.
Greene, C. T.
1917. A contribution to the biology of North American Diptera. Proc. Ent. Soc. Washington, vol. 19, pp. 146–161.
1926. Descriptions of larvae and pupae of two-winged flies belonging to the family Leptidae. Proc. U.S. Nat. Mus., art. 2, vol. 70, pp. 1–20.
Griffith, H. G., and Packard, A. S.
1882. Larvae of *Stratiomyia* sp. found in a hot spring in Colorado. American Nat., vol. 16, pp. 599–600.
Grünberg, K.
1910. Diptera. No. 2A *in* Brauer, Die Süsswasserfauna Deutschlands, iv+312 pp.
Haliday, A. H.
1857a. On some remaining blanks in the natural history of the native Diptera (larvae). Nat. Hist. Rev., vol. 4, pp. 177–196.
1857b. List of the genera and species of British Diptera, the earlier stages of which are more or less perfectly known, with references to the principal authorities. Nat. Hist. Rev., vols. 3–4, pp. 180–195.
Handlirsch, A.
1883. Beiträge zur Biologie der Diptera. Verh. Zool.-Bot. Ges. Wien, vol. 33, pp. 243–245.
Handlirsch, A.
1908. Die Fossilen Insekten und die Phylogenie der rezenten Formen; ein Handbuch für Paläontologen und Zoologen, 1430 pp., 51 pls.
Hanson, W. J.
1958. A revision of the subgenus *Melanonemotelus* of America north of Mexico. Univ. Kansas Sci. Bull., vol. 38, no. 19, pp. 1351–1391.
Hart, C. A.
1895. On the entomology of the Illinois River and adjacent waters, 1. Bull. Illinois St. Lab. Nat. Hist., vol. 4, pp. 247–266.
Heeger, E.
1853. Beitrage zur Naturgeschichte der Insekten: Als Beitrage zur Fauna Oesterreichs: Sitzungsberichte der Kais. Akad. Wiss. Wien, vol. 10, pp. 7–30, 161–178, 460–481.
1856. Neue Metamorphosen einiger Dipteren: Sitzungsberichte der Kais. Akad. Wiss. Wien, vol. 20, pp. 335–350.
1858. Neue Metamorphosen einiger Dipteren: Sitzungsberichte der Kais. Akad. Wiss. Wien, vol. 31, pp. 295–309.
Henneguy, F., and Binet, A.
1892. Contribution a l'étude microscopique du systeme nerveux larvaire de *Stratiomys longicornis*. Ann. Soc. Ent. France, vol. 41, pp. 309–316.
Hennig, W.
1952. Die Larvenformen der Dipteren, pt. 3.
Howard, L. O.
1904. The insect book, xxvii+429 pp., 48 col. pls., text-figs.

HOWDEN, H. F.

1955. Descriptions of a new Peruvian *Athyreus* with notes on the method of illustration. Ent. Arb. Mus. G. Frey, vol. 6, no. 2, pp. 667–673.

HRBÂCEK, J.

1945. Notes on the Stratiomyidae of Central Europe. Act. Soc. Ent. Cechosloveniae, vol. 42, pp. 95–100.

HUDSON, G. V.

1951. Fragments of New Zealand entomology, 188 pp.

IRWIN-SMITH, V.

1920. Studies in life histories of Australian Diptera Brachycera, 1: Stratiomyidae, no. 1: *Metoponia rubriceps* Macquart. Proc. Linnaean Soc. New South Wales, vol. 45, pp. 505–530.

1921. Studies in life histories of Australian Diptera Brachycera, 1: Stratiomyidae, no. 2: Further experiments in the rearing of *Metoponia rubriceps*. Proc. Linnaean Soc. New South Wales, vol. 46, pp. 252–255.

1923. Studies in life histories of Australian Diptera Brachycera, 1: Stratiomyidae, no. 3: On the structure of the mouthparts and pharynx of the larval *Metoponia rubriceps*. Proc. Lin. Soc. New South Wales, vol. 46, pp. 425–432.

JAENNICKE, F.

1866. Beitrage zur Kentniss der europaischen Stratiomyiden, Xylophagiden und Coenomyiden, sowie Nachtrag zu den Tabaniden. Berliner Ent. Zeitschr., vol. 10, pp. 217–237.

JAMES, M. T.

1935. The genus *Hermetia* in the United States. Bull. Brooklyn Ent. Soc. vol. 30, pp. 165–170.

1936. Some evolutionary trends in the Stratiomydae. Ann. Ent. Soc. America, vol. 29, pp. 624–626.

1947. The flies that cause myiasis in man. U.S. Dept. Agric. Misc. Publ., vol. 631, pp. 1–175.

1953. An objective aid in determining generic limits. Syst. Zool., vol. 2, no. 3, pp. 136–137.

1957. The larva of *Cyphomyia* and its significance in classification. Ann. Ent. Soc. America, vol. 50, pp. 639–641.

1960. The soldier flies or Stratiomyidae of California. Bull. California Ins. Surv., vol. 6, no. 5, pp. 79–122.

1962. The genus *Dicyphoma* James. Ann. Ent. Soc. America, vol. 55, no. 1, pp. 15–20.

JOHANNSEN, O. A.

1921. *Oxycera tenuicornis* or *Euparyphus tenuicornis*? Ent. Monthly Mag., vol. 57, pp. 140–141.

1922. Stratiomyid larvae and puparia of the northeastern states. Journ. New York Ent. Soc., vol. 30, pp. 14–153.

1935. Aquatic Diptera, 2: Orthorrhapha-Brachycera and Cyclorrhapha. Mem. Cornell Univ. Agric. Exp. Sta., vol. 177, pp. 7–11.

JOHNSON, C. W.

1895. A review of the *Stratiomyia* and *Odontomyia* of North America. Trans. American Ent. Soc., vol. 22, p. 229.

1906. Notes on some dipterous larvae. Psyche, vol. 13, pp. 1–4.

JUSBASCHJANZ, S.

1910. Zur Kenntnis der nach embryonalen Entwickelung der Stratiomyiden. Jenaische Zeitschr. Naturw., vol. 46, pp. 681–736.

KAWALL, J. H. C.
1867. Miscellanea entomologica. Stettiner Ent. Zeit., vol. 28, pp. 117–124.

KILPATRICK, J. W., and SCHOOF, H. F.
1959. Interrelationship of water and *Hermetia illucens* breeding to *Musca domestica* production in human excrement. American Journ. Trop. Med. Hyg., vol. 8, pp. 597–602.

KRAFT, K. J., and COOK, E. F.
1961. A revision of the Pachygasterinae of America north of Mexico. Misc. Publ. Ent. Soc. America, vol. 3, no. 1, pp. 1–24.

KRUPER, F.
1930. Über Verkalkungerscheinungen bei Dipterenlarven und ihrer Ursachen. Arch. Hydrob., vol. 22, pp. 185–220.

KÜNCKEL D'HERCULAIS, J.
1879. Recherches morphologiques et zoologiques sur le systeme nerveux des insectes diptères. Compt. Rend. Acad. Sci. Paris, vol. 89, pp. 491–494.

KUSTER, K. C.
1935. A study of the general biology, morphology of the respiratory system, and respiration of certain aquatic *Stratiomyia* and *Odontomyia* larvae. Pap. Michigan Acad. Sci. Arts Lett., vol. 19, pp. 605–658.
1936. Distributional variation of the ganglionic tracheae in the larva of *Odontomyia cincta*. Pap. Michigan Acad. Sci. Arts Lett., vol. 21, pp. 639–650.

LAXER, A. G.
1880. Larvae of *Stratiomys* in winter. Entomologist, vol. 13, pp. 167–168.

LENZ, F.
1923. Stratiomyiden larven aus Quellen: Ein Beitrag zur Metamorphose der Stratiomyiden. Arch. Naturg., part A, vol. 89, pp. 39–62.
1926. Stratiomyiden larven aus dem Salzwasser. Mitt. Geogr. Ges. Naturh. Mus. Lübeck, vol. 31, no. 2, pp. 170–175.

LEYDIG, F.
1860. Ueber Kalkablagerung in der Haut der Insekten. Arch. Naturg., vol. 26, pp. 157–160.

LINDER, E.
1928. Dr. L. Zürchers Dipteren-Ausbeute aus Paraguay: Stratiomyiden. Arch. Naturg., part A, vol. 92, no. 12, pp. 94–103.
1936–1938. Stratiomyidae. Part. 18 *in* Die Fliegen der Paläarktischen Region, 218 pp.

LUCAS, H.
1879. Larvae of *Stratiomys* sp. living in hot water in Euboea, and very tenacious of life. Bull. Soc. Ent. France, vol. 9, no. 5, pp. 142–143.

LUNDBECK, W.
1907. Diptera danica, genera, and species of flies hitherto found in Denmark, 1: Stratiomyidae, Xylophagidae, Coenomyidae, Tabanidae-Leptidae, Acroceridae, 114 pp.

LYONET, P.
1832. Recherches sur l'anatomie et les métamorphoses de différentes espèces d'insectes, 580 pp. [Posthumous work, published by W. de Haan.]

MALLOCH, J. R.
1915. A revision of the North American Pachygasterinae with unspined scutellum. Ann. Ent. Soc. America, vol. 8, pp. 305–320.

MALLOCH, J. R.

1917. A preliminary classification of the Diptera, exclusive of the Pupipara, based upon larval and pupal characters, with keys to the imagines in certain families. Bull. Illinois St. Lab. Nat. Hist. art. 3, vol. 12, pp. 161–410.

MARKEL, F.

1844. Ueber die larve von *Clitellaria ephippium*. Germar Zeitschr. Ent. vol. 5, pp. 478–480.

MATHUR, R. N.

1933. Notes on the bionomics of *Odontomyia cyanea* Brunetti. Indian Journ. Agric. Sci., vol. 3, pp. 369–376.

MAY, B. M.

1961. The occurrence in New Zealand and the life-history of the soldier fly *Hermetia illucens* (L.). New Zealand Journ. Sci., vol. 4, pp. 55–65.

McFADDEN, M. W.

1961. An improved technique for using the Berlese funnel. Ent. News, vol. 72, no. 6, pp. 150–152.

MEIJERE, J. C. H. DE

1911. Studien über südostasiatische Dipteren, 6. Tijdschr. Ent., vol. 54, pp. 258–432.

1916. Beiträge zur Kenntnis der Dipterenlarven und -puppen. Zool. Jahrb., vol. 40, pp. 177–322.

MIALL, L. C.

1895. The natural history of aquatic insects, 389 pp.

MIK, J.

1896. Dipterologische Miscellen, 7: Ueber die Fruchtbarkeit von *Stratiomys chamaeleon* Deg. Wiener Ent. Zeit., vol. 15, pp. 106–114.

MÜLLER, G. W.

1925. Kalk in der Haut der Insekten und die Larve von *Sargus cuprarius* L. Zeitschr. Morph. Ökol. Tiere, vol. 3, pp. 542–566.

MYERS

1920. New Zealand Journ. Sci. Techn., vol. 3, no. 2, p. 117.

NEEDHAM, J. G., and BETTEN, G.

1901. Aquatic insects in the Adirondacks. New York St. Mus. Bull., vol. 47, pp. 576–577.

OSTEN SACKEN, C. R.

1882. On Professor Brauer's paper: Versuch einer Characteristik der Gattungen der Notocanthen, 1882. Berliner Ent. Zeitschr., vol. 26, pp. 363–380.

PACKARD, A. S.

1871. The larvae of an unknown *Stratiomys* found in salt water, Clear Lake, California. American Journ. Sci. Arts, vol. 7, no. 3, p. 102.

PEARSON, A. W.

1883. American Nat., vol. 17, p. 1287.

PERRIS, E.

1870. Histoire des insectes du pin maritime, Diptères. Ann. Soc. Ent. France, vol. 10, no. 4, pp. 210–211.

PETERSON, A.

1951. Larvae of insects: An introduction to Nearctic species, part 2, 416 pp.

PLOTNIKOW,
1904. Ueber die Hautung und über einige Elemente der Haut bei den Insekten. Zeitschr. Wiss. Zool., p. 76.

QUIST, J.
1958. A revision and variation analysis of *Euparyphus* and related genera. Unpublished Ph.D. dissertation, Washington State University.

RAFF, J. W.
1931. Notes on *Chiromyza australis* Macq. Victorian Nat., vol. 47, pp. 213–214.

RÉAUMUR, R. A. F. DE
1742. Mémoires pour servir à l'histoire des insectes, 4 vols.

RICARDO, G.
1929. Stratiomyidae, Tabanidae and Asilidae. Fasc. 3 *in* part 6 *of* Insects of Samoa, pp. 109–122.

RICHARDS, A. G.
1951. The integument of arthropods, 411 pp.

RILEY, C. V., and HOWARD, L. O.
1899. *Hermetia muscens*, larva infesting beehives. Insect Life, vol. 1, pp. 353–354.

ROSER, C. L. F. VON
1828. Beitrag zur Naturgeschichte der Insekten Gattung, *Xylophagus* Meig. Naturw. Abh. Würtemberg, vol. 2, p. 188.
1834. Verzeichniss der in Würtemberg verkommenden zweiflüglichen Insekten. Würtemb. Landw. Ver. Stuttgart Corresp., vol. 1, p. 267.

SCHILLING, P. S.
1829. Beiträge zur Entomologie, vol. 1, p. 94.

SCHINER, J. R.
1864. Fauna Austriaca: Die Fliegen, 2 vols.
1863. Diptera. No. 6 *in* vol. 2 *of* Zoologischer Theil *in* Reise der Österreichischen Fregatte Novara um die Erde . . ., vi + 388 pp., 4 pls.

SCHMIDT, R.
1913. Die Salzwasserfauna Westfalens, 70 pp., 6 tables.

SCHOLZ, H.
1848. Ueber den Aufenhalt der Dipteren während ihrer ersten Stände. Ent Ver. Breslau Zeitschr., vol. 2, pp. 1–24.

SCHRANK, F.
1793. Beiträge zur Naturgeschichte von *Stratiomys chamaeleon*. Naturf. Stück, vol. 27, pp. 7–25.

SCHREMMER, P.
1951a. Zur Biologie der Larve von *Hermione* (*Oxycera*) *calceata* und *Hermione* meigeni Staeg: Zugleich ein Beitrag zur Fauna hygropetrica. Österreichische Zool. Zeitschr., vol. 3, pp. 126–139.
1951b. Die Mundteile der Brachycerenlarven und der Kopfbau der Larve von *Stratiomys chamaeleon* L. Österreichische Zool. Zeit., vol. 3, pp. 326–397.

SEGUY, E.
1926. Diptera (Brachycera). Vol. 13 *in* Faune de France, 308 pp.

Sparrman, A.

1806. Rön och anmärkningar om Fluge-mask eller Fluge-Larver som inästla sig: lefvande människors innanmäten, jämte afteckningar pa okände species deraf. Svenska Vetensk. Akad. Handl., vol. 27, pp. 239–248.

Steyskal, G. C.

1947. A revision of the nearctic speies of *Xylomyia* and *Solva* (Diptera: Erinnidae). Pap. Michigan Acad. Sci. Arts Lett., vol. 31, pp. 181–189.

Swammerdam, J.

1737. Biblia naturae, 2 vols. and atlas. [Latin and Dutch in parallel columns.]

Tragardh, I.

1914. Skogsentomologiska bidrag, 1–5. Ent. Tidskr., vol. 35, pp. 188–209.

Townsend, C. H. T.

1893. The puparium and pupa of *Subula pallipes* Loew. Ent. News, vol. 4, pp. 163–165.

Vaillant, F.

1951. Les larves d'*Hermione*. Trav. Lab. Hydrob. Pisci. Grenoble, vols. 43–44, pp. 23–38.

1952. Les larves d'*Hermione* d'Algérie. Bull. Soc. Hist. Nat. Afrique Nord, vol. 43, pp. 8–15.

Vaillant, F., and Delhom, M.

1956. Les formes adaptatives de l'appareil bucco-pharyngien chez les larves de Stratiomyidae. Bull. Soc. Hist. Nat. Afrique Nord, vol. 47, pp. 217–250.

Vaney, C.

1900. Note sur les tubes de Malpighi des larves de *Stratiomys*. Bull. Soc. Ent. France, p. 360.

Verrall, G. H.

1909. Stratiomyidae and succeeding families of the Diptera Brachycera of Great Britain. Vol. 5 *in* British flies, 780 pp.

Viallanes, H.

1882a. Note sur les terminaisons nerveuses sensitives des insectes. Bull. Sci. Soc. Phil. Paris, vol. 6, no. 7, pp. 94–98.

1882b. Recherches sur l'histologie des insectes, et sur les phènoménes histologiques qui accompagnent le developpement postembryonnaire de ces animaux. Ann. Sci. Nat., vol. 14, pp. 1–348.

1885. Études histologiques et organologiques sur les centres nerveux et les organes des sens des animaux articulés. Troisième mémoire: Le ganglion optique de quelques larves de Diptères (*Musca, Eristalis, Stratiomys*). Ann. Sci. Nat., art. 4, vol. 19, no. 6, pp. 1–34.

Vimmer, A.

1925. Larvy a kukly duojkridleho hmyzu stredoeuropskeho se zulastnim zretelem na skudce rostlin kultur nich.

Walker, F.

1851. Diptera. Vol. 1 *in* Insecta Britannica.

Wesenberg-Lund, C.

1943. Biologie der Süsswasserinsekten, 655 pp.

WESMAEL, C.
1837. Notice sur la métamorphose d'un xylophage. Bull. Soc. Ent. France, p. 89.
WESTWOOD, J. O.
1840. An introduction to the modern classification of insects, vol. 2.
WHITTEN, J. M.
1959. The tracheal system as a systematic character in larval Diptera. Syst. Zool., vol. 8, no. 3, pp. 130–139.
WILLISTON, S. W.
1908. Manual of North American Diptera, ed. 3, 455 pp.
WIRTH, W. W.
1956. *In* Usinger, Aquatic insects of California, 508 pp.
ZELLER, P. C.
1842. Dipterologische Beiträge. Isis von Oken, vol. 11, pp. 807–847.
ZETTERSTEDT, J. W.
1851. Diptera scandinaviae disposita et descripta, 14 vols.

221-533—66——5

TABLE 1.—*Habitats of stratiomyid larvae occurring in America north of Mexico* (genera arranged by subfamily as given on p. 13)

Genus	Habitat	Reference
Xylomya	Terrestrial; in crotch of tree	New record
Solva	Terrestrial; under bark of trees; in rotted logs	Townsend, 1893; Malloch, 1917; Johannsen, 1922; Greene, 1926; Peterson, 1951; Hennig, 1952
Altermetoponia	Terrestrial; in sod	Irwin-Smith, 1920
Allognosta	Terrestrial; in decaying organic material	Malloch, 1917; Johannsen, 1922
Actina	Terrestrial; in decaying plant and animal material	Fuller, 1934
Beris	Terrestrial; in decaying leaves; under bark of fallen trees; in moss?	Williston, 1908; de Meijere, 1916; Lenz, 1923
Exodontha	Terrestrial; in rotten wood under large rocks	New record
Sargus	Terrestrial; in decaying plant and animal material; in excrement	Westwood, 1840; Lundbeck, 1907; Williston, 1908; Malloch, 1917; Johannsen, 1922; Peterson, 1951; Hennig, 1952
Ptecticus	Terrestrial; in decaying organic material	Lindner, 1928; Hennig, 1952
Microchrysa	Terrestrial; in decaying organic material; in garden soil; in excrement	Lundbeck, 1907; Malloch, 1917; Johannsen, 1922; Seguy, 1926; Hennig, 1952
Merosargus	Terrestrial; in debris at base of squirrel's nest	New record
Chloromyia	Terrestrial; in decaying organic material	Brauer, 1883; Cornelius, 1860; Lundbeck, 1907; Seguy, 1926
Cyphomyia	Terrestrial; in decaying plant material	James, 1957
Dicyphoma	Terrestrial; in decaying plant material	James, 1962
Adoxomyia	Terrestrial; in decaying plant material	New record
Hermetia	Terrestrial; in decaying organic material; in excrement	Williston, 1908; Malloch, 1917; Johannsen, 1922; Copello, 1926; James, 1935; James, 1497; James, 1957
Dieuryneura	Terrestrial; in decaying plant material	New record
Oxycera	Aquatic; on margins of lakes, ponds, and streams	Heeger, 1856; Lundbeck, 1907; Johannsen, 1922; Lenz, 1923; Johannsen, 1935; Wesenberg-Lund, 1943

TABLE 1.—Continued

Genus	Habitat	Reference
Euparyphus	Aquatic; on margins of aquatic environments; usually associated with mossy conditions	Johannsen, 1922; Johannsen, 1935; Wesenberg-Lund, 1943; Peterson, 1951; James, 1960
Caloparyphus	Aquatic; in bog or swamp areas; usually associated with mossy conditions	Quist (thesis); James, 1960
Stratiomys	Aquatic; on margins of aquatic environments; usually associated with *Typha* spp.; occasionally in hot springs or saline habitats	Hart, 1895; Johnson, 1895; Miall, 1895; Lundbeck, 1907; Williston, 1908; Malloch, 1917; Johannsen, 1922, 1935; Peterson, 1951; James, 1960b
Hedriodiscus	Aquatic; on margins of lakes and ponds	James, 1960b
Odontomyia	Aquatic; in much the same habitat as given for *Stratiomys*	Hart, 1895; Johson, 1895; Lunbeck, 1907; Williston, 1908; Malloch, 1917; Johannsen, 1922, 1935; Peterson, 1951; James, 1960b
Myxosargus	Aquatic; no specific data available	New record
Nemotelus	Aquatic; under debris at margins of lakes and ponds; frequently in saline habitats	Haliday, 1857a; Lunbeck, 1907; Malloch, 1917; Johannsen, 1922; Lenz, 1923; Johannsen, 1935; Wesenberg-Lund, 1943; Hanson, 1958; James, 1960
Berkshiria	Terrestrial; under bark of trees	Kraft and Cook, 1961; Cook, 1953
Zabrachia	Terrestrial; under bark of coniferous trees	Malloch, 1915; Malloch, 1917; Kraft and Cook, 1961
Neopachygaster	Terrestrial; under bark of trees	Malloch, 1917; Cook, 1953; Kraft and Cook, 1961
Eupachygaster	Terrestrial; under bark of trees	Malloch, 1917; Kraft and Cook, 1961
Pachygaster	Terrestrial; in tree holes; in crotch debris and in hollow trees	Kraft and Cook, 1961

TABLE 2.—*Predators and parasites of stratiomyid larvae in America north of Mexico*

Parasite or predator	Host	Reference
Coleoptera		
Coccinellidae		
Megilla maculata	Egg mass of *Odontomyia* species	Hart, 1895
Hymenoptera		
Pteromalidae		
Rhicnocoelia, new species[1]	*Odontomyia* species	New record
Genus species	*Stratiomys* species	
	Chloromyia formosa	Lundbeck, 1907
Eulophidae		
Tetrastichus species	*Microchrysa polita*	Lundbeck, 1907
Chalcidae		
Chalcis barbara	*Stratiomys norma*	Hart, 1895
Chalcis microgaster	*Odontomyia cincta*; *Odontomyia* species; *Odontomyia vertebrata*; egg mass of *Odontomyia* species	Hart, 1895
Ichneumonidae		
New genus, new species[2]	*Stratiomys* species	New record
Genus, new species	*Nemotelus* species	Lundbeck, 1907
Genus, species	*Sargus* species	Lundbeck, 1907

[1] Taxonomic status as given by B. D. Burks, U.S. National Museum.
[2] Taxonomic status as given by L. H. Walkeiy, U.S. National Museum.

TABLE 3.—*Ecological and morphological specializations in stratiomyid larvae*

Subfamily	Environment	Nutrition	Mouthparts
Xylomyinae	terrestrial-arboreal	micropantophagous	cylindrical brushes present
Chiromyzinae	terrestrial	phytophagous	brushes and setae absent
Beridinae	terrestrial	micropantophagous	cylindrical brushes present
Sarginae	terrestrial	copraphagous, sapronecrophytophagous	degenerate, cylindrical brushes reduced
Clitellariinae	terrestrial	copraphagous, sapronecrophytophagous	variable, degenerate to well developed
Stratiomyinae	aquatic	micropantophagous	cylindrical brushes absent
Nemotelinae	terrestrial	micropantophagous	cylindrical brushes absent
Pachygastrinae	terrestrial-arboreal	micropantophagous	cylindrical brushes present

○ = 0 - 1
▲ = 2 - 3
■ = 4 - 5
● = 6 - 7

	Xylomyinae	Chiromyzinae	Beridinae	Sarginae	Clitellariinae	Stratiomyinae	Nemotelinae	Pachygastrinae
Xylomyinae		▲	○	○	▲	■	○	○
Chiromyzinae			○	▲	■	▲	▲	▲
Beridinae				▲	▲	▲	○	▲
Sarginae					○	■	○	○
Clitellariinae						●	▲	○
Stratiomyinae							■	●
Nemotelinae								▲
Pachygastrinae								

FIGURE 1.—Subfamily relationships of the Stratiomyidae. Each symbol represents a range of numerical value, which is the sum of the differences in 11 characters (25 variates) between a pair of subfamilies. Maximum values indicate maximum differences and distant relationships; minimum values indicate minimum differences and close relationships.

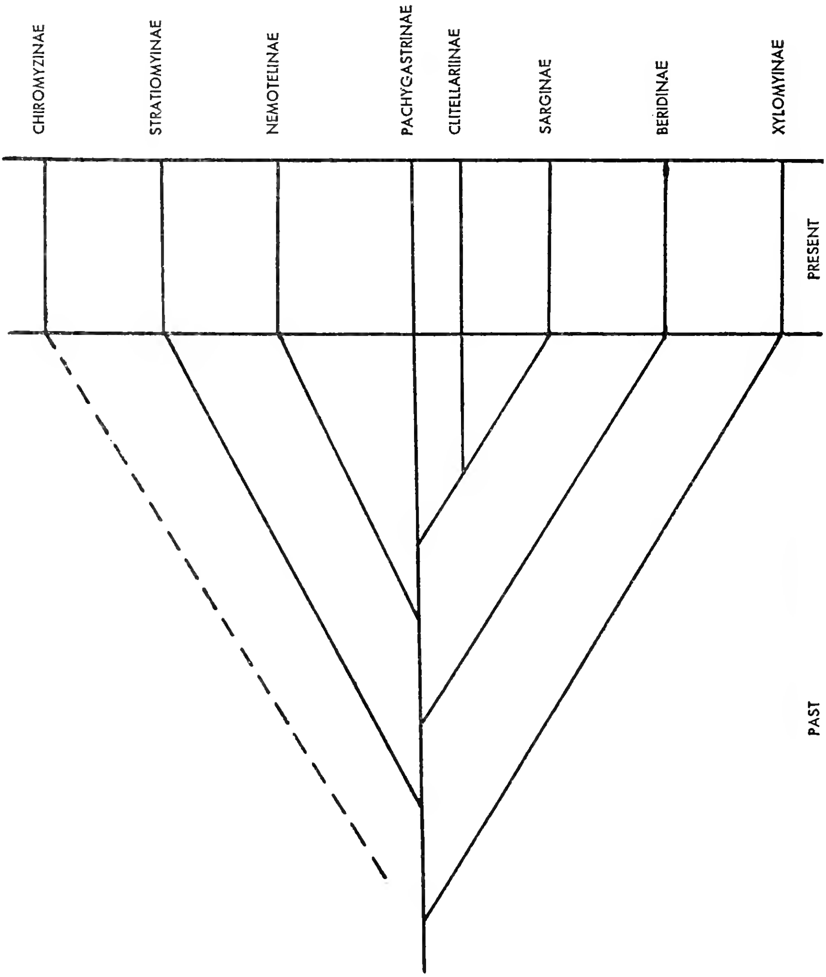
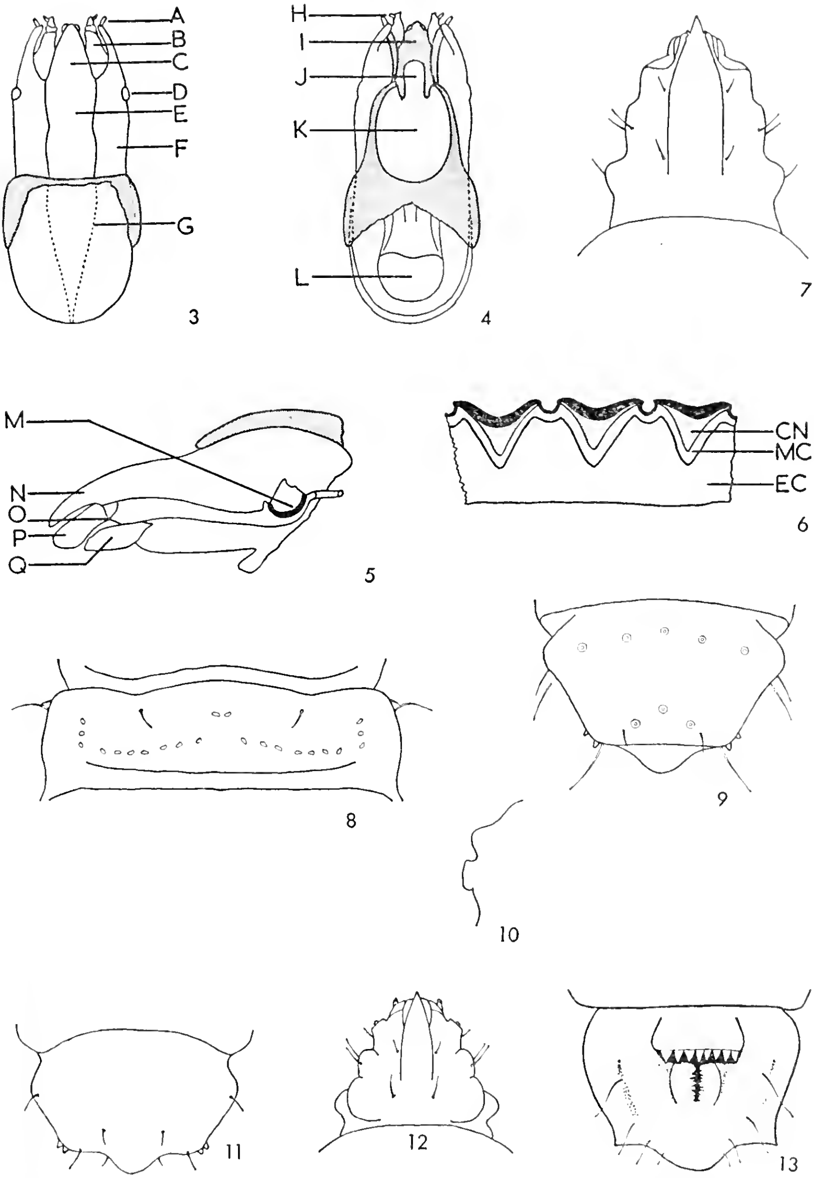
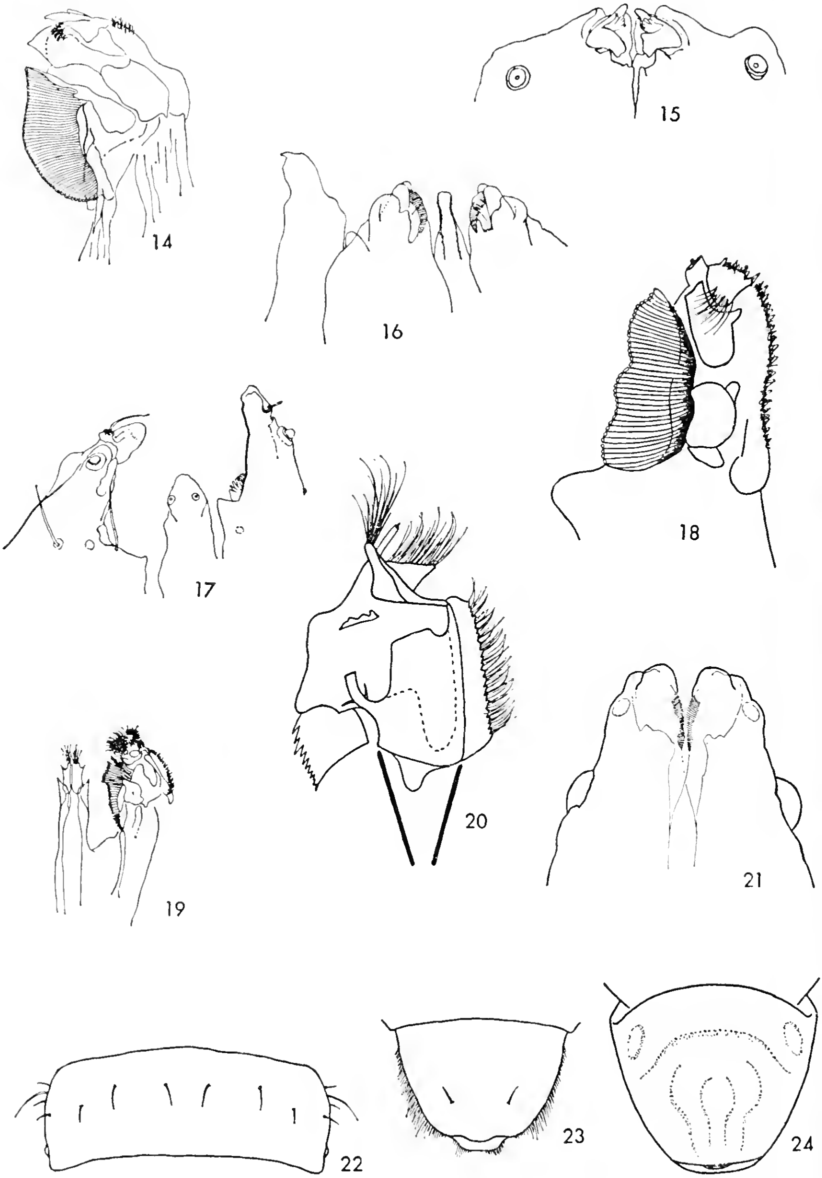


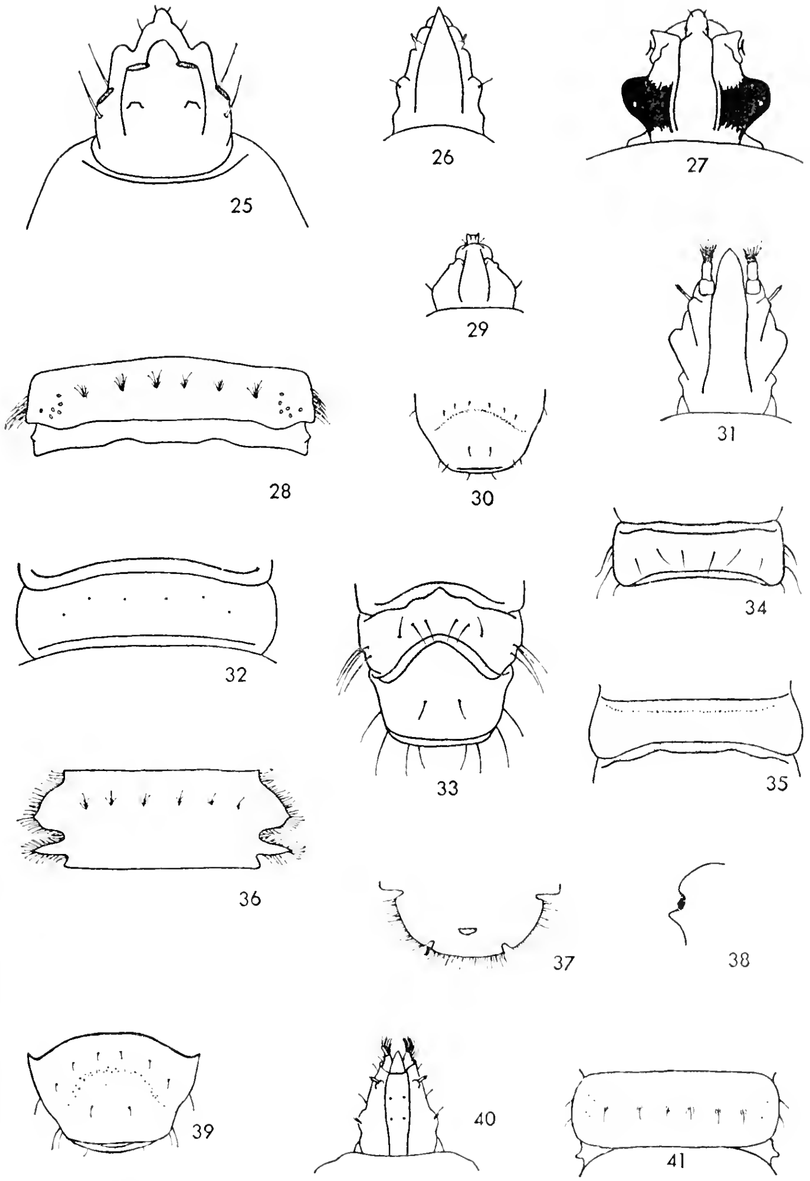
FIGURE 2.—Proposed phylogeny for the eight stratiomyid subfamilies.



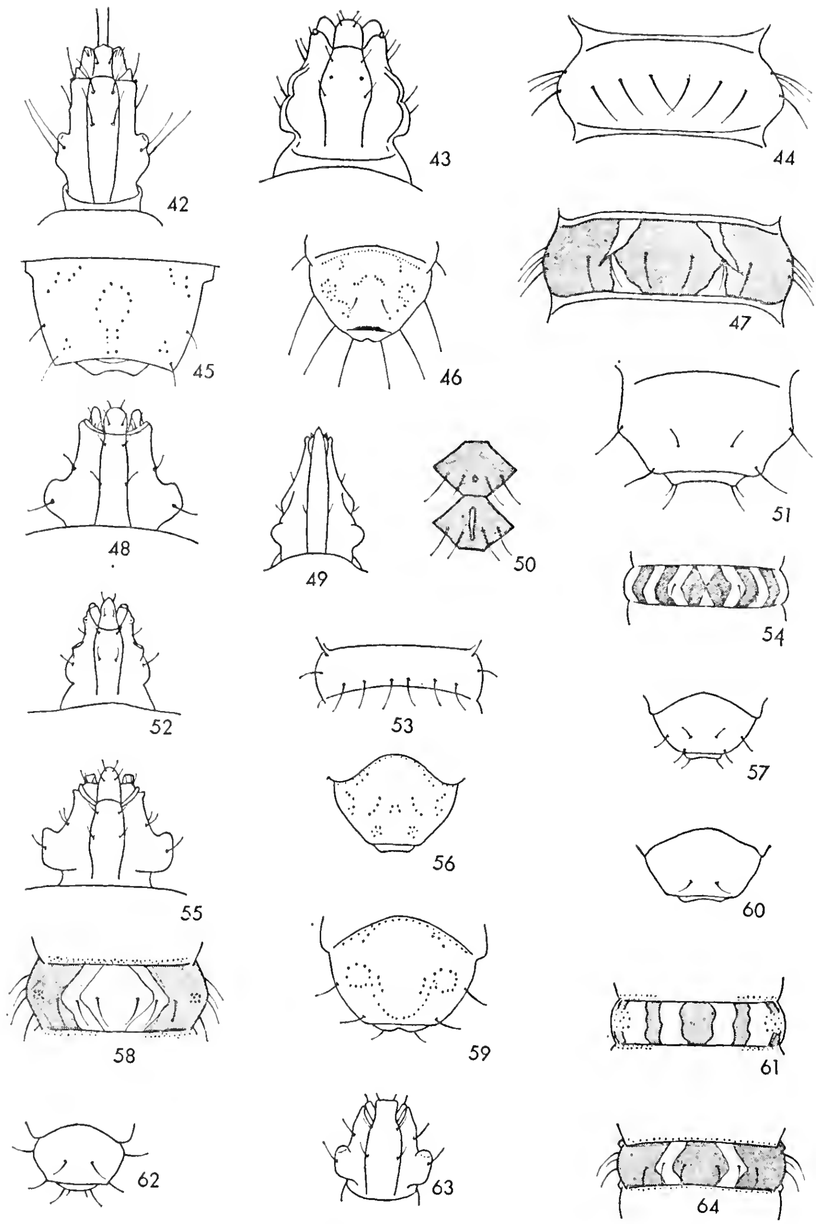
FIGURES 3–13.—3, *Odontomyia* species, head, dorsal view (after Cook, 1949; A=antenna, B=mandibular-maxillary complex, C=labrum, D=eye, E=clypeus, F=ocular lobe, G=frontal suture); 4, *Odontomyia* species, head, ventral view (after Cook, 1949; H=maxillary palp, I=palatum, J=prementum, K=submentum, L=pharynx); 5, *Odontomyia* species, head, lateral view (after Cook, 1949; M=pestle, N=labrum, O=mandibular articulation, P=mandibular-maxillary complex, Q=labium); 6, *Odontomyia* species, integument, cross-section (CN=calcareous nail, MC=mesocuticle, EC=endocuticle); 7, *Xylomya* species, head, dorsal view; 8, *Solva pallipes*, first abdominal segment, dorsal view; 9, *S. pallipes*, apical segment, dorsal view; 10, *S. pallipes*, outline of prothoracic segment, dorsal view; 11, *Xylomya* species, apical segment, dorsal view; 12, *S. pallipes*, head, dorsal view; 13, *S. pallipes*, apical segment, ventral view.



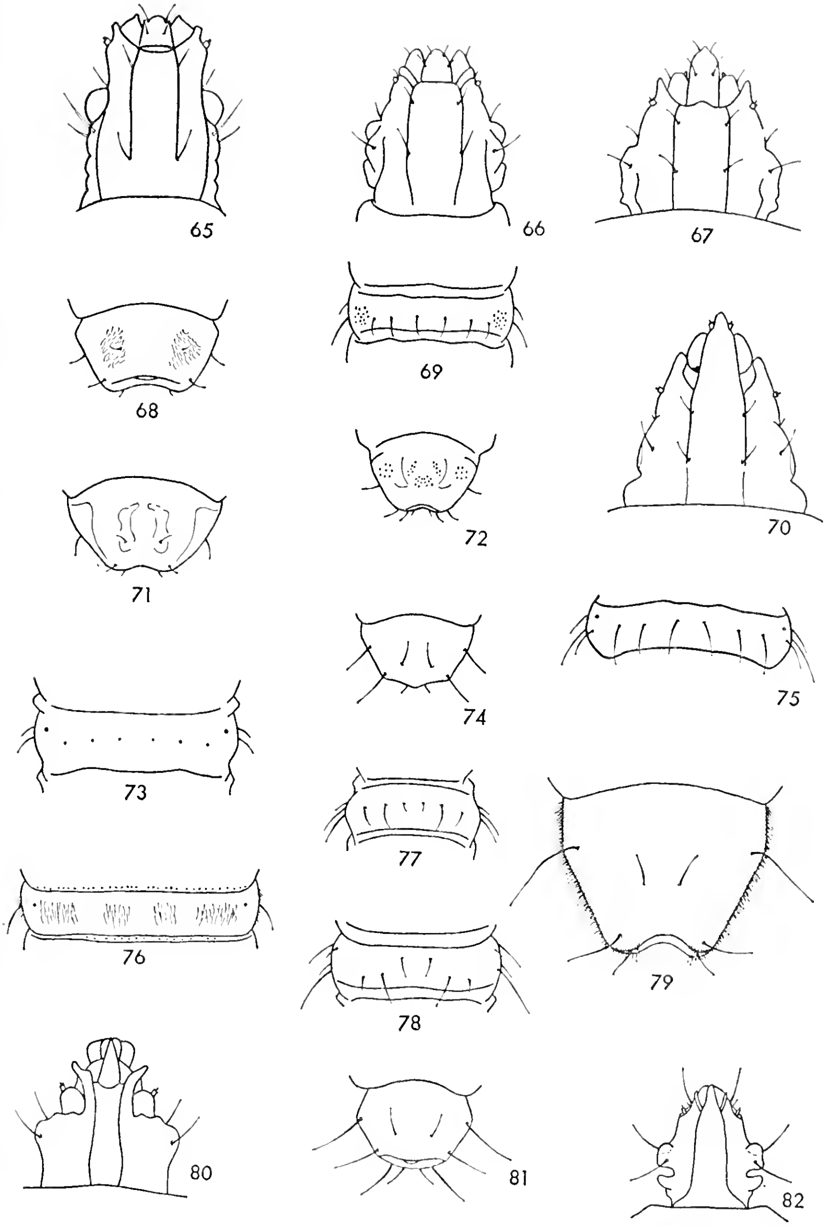
FIGURES 14–24.—Dorsal view: 14, *Solva pallipes*, mandibular-maxillary complex; 15, *Altermetoponia rubriceps*, mouthparts; 16, *Dieuryneura obscura*, mouthparts; 17, *Sargus cuprarius* mouthparts; 18, *Neopachygaster maculicornis*, mandibular-maxillary complex; 19, *Cyphomyia bicarinata*, labium and mandibular-maxillary complex; 20, *Stratiomys norma*, mandibular-maxillary complex (after Malloch, 1917); 21, *Hermetia illucens*, mouthparts (labrum removed); 22, *Xylomya* species, first abdominal segment; 23, *Beris vallata*, apical segment; 24, *D. obscura*, apical segment.



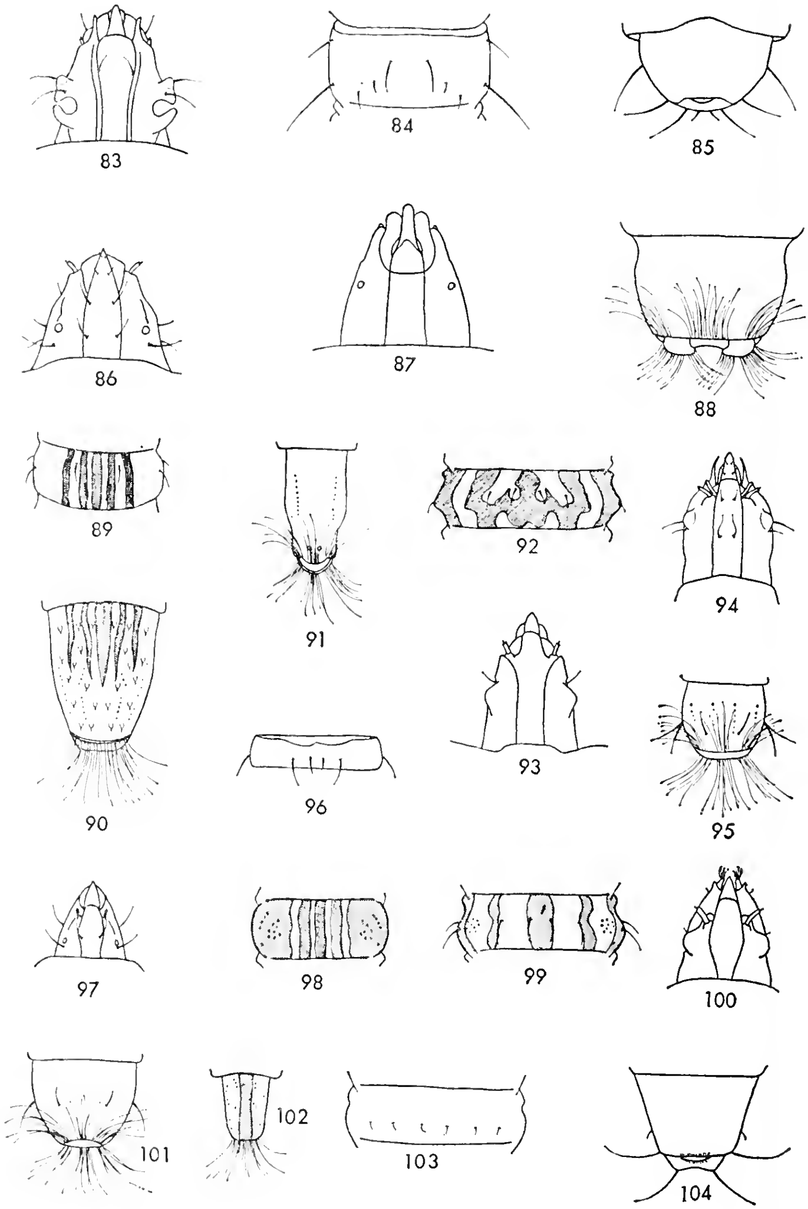
FIGURES 25–41.—Dorsal view: 25, *Altermetoponia rubriceps*, head; 26, *Beris vallata*, head; 27, *Dieuryneura obscura*, head; 28, *B. vallata*, first abdominal segment; 29, *Exodontha luteipes*, head; 30, *E. luteipes*, apical segment; 31, *Allognosta fuscitarsis*, head; 32, *D. obscura*, first abdominal segment; 33, *Altermetoponia rubriceps*, apical segments; 34, *A. rubriceps*, first abdominal segment; 35, *E. luteipes*, first abdominal segment; 36, *A. fuscitarsis*, first abdominal segment; 37, *A. fuscitarsis*, apical segment; 38, *A. fuscitarsis*, outline of prothoracic segment; 39, *D. obscura*, apical segment; 40, *Actina incisuralis*, head; 41, *A. incisuralis*, first abdominal segment.



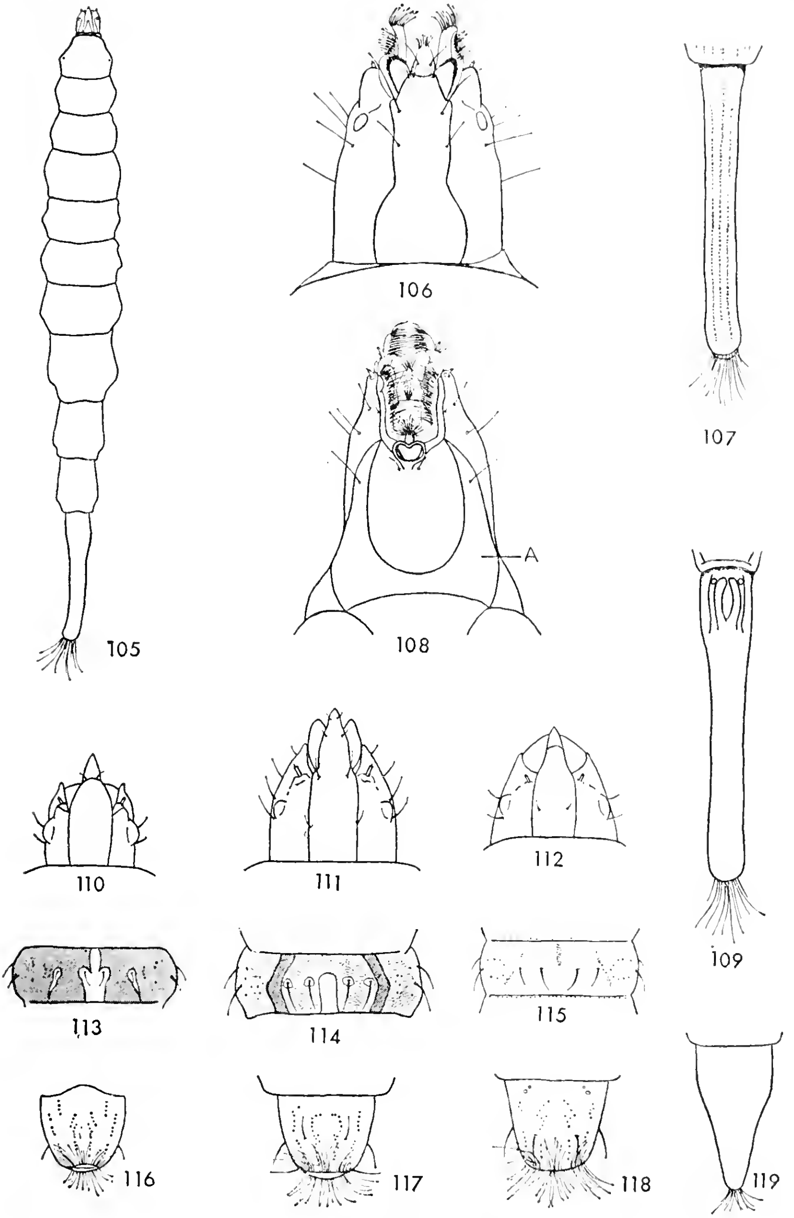
FIGURES 42–64.—Dorsal view: 42, *Microchrysa polita*, head; 43, *Ptecticus trivittatus*, head; 44, *M. polita*, first abdominal segment; 45, *Actina incisuralis*, apical segment; 46, *M. polita*, apical segment; 47, *P. trivittatus*, first abdominal segment; 48, *Sargus bipunctatus*, head; 49, *S. lucens*, head; 50, *P. trivittatus*, sixth and seventh abdominal segments (ventral view); 51, *P. trivittatus*, apical segment; 52, *S. elegans*, head; 53, *S. elegans*, first abdominal segment; 54, *S. bipunctatus*, first abdominal segment; 55, *S. decorus*, head 56, *S. lucens*, apical segment; 57, *S. bipunctatus*, apical segment; 58, *S. decorus*, first abdominal segment; 59, *S. decorus*, apical segment; 60, *S. elegans*, apical segment; 61, *S. lucens*, first abdominal segment; 62, *S. cuprarius*, apical segment; 63, *S. cuprarius*, head; 64 *S. cuprarius*, first abdominal segment.



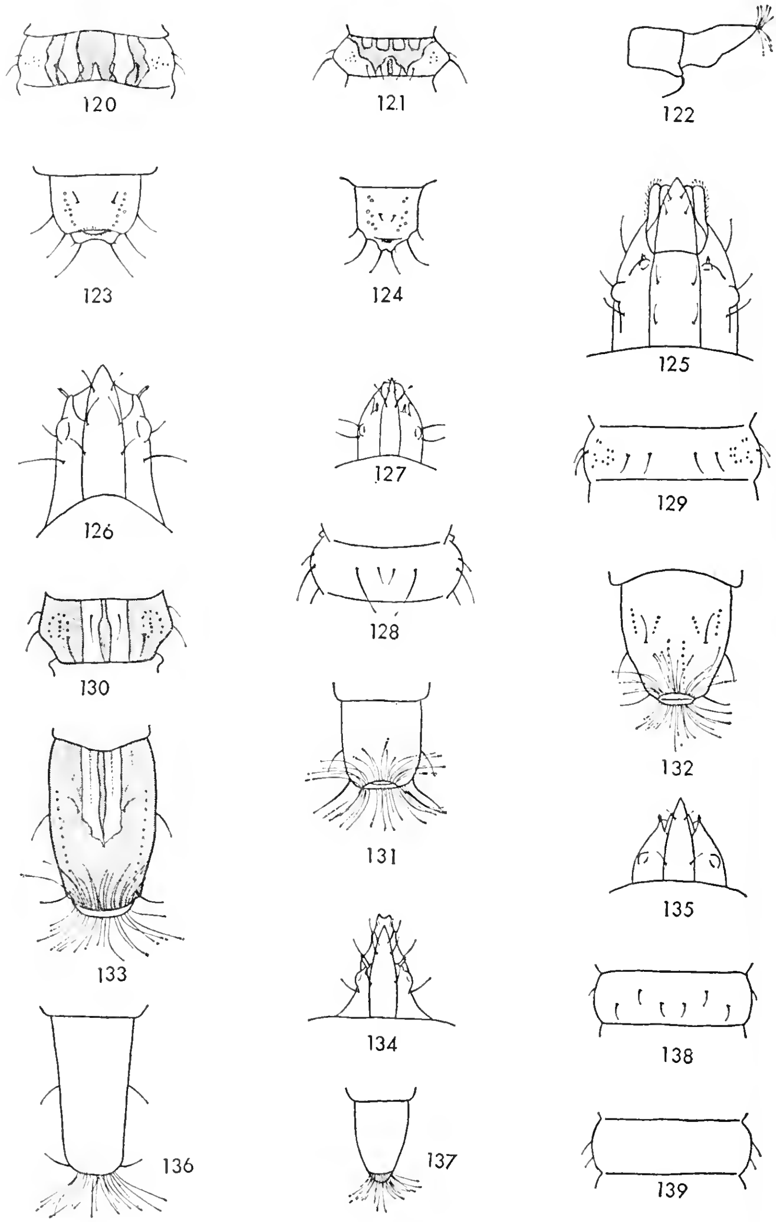
FIGURES 65–82.—Dorsal view: 65, *Hermetia illucens*, head; 66, *H. concinna*, head; 67, *H. aurata*, head; 68, *Hermetia* species, apical segment; 69, *H. concinna*, first abdominal segment; 70, *Hermetia* species, head; 71, *H. aurata*, apical segment; 72, *H. concinna*, apical segment; 73, *H. aurata*, first abdominal segment; 74, *Adoxomyia heminopla*, apical segment; 75, *H. illucens*, first abdominal segment; 76, *Hermetia* species, first abdominal segment; 77, *A. heminopla*, first abdominal segment; 78, *Dicyphoma schaefferi*, first abdominal segment; 79, *H. illucens*, apical segment; 80, *A. heminopla*, head; 81, *D. schaefferi*, apical segment; 82, *D. schaefferi*, head.



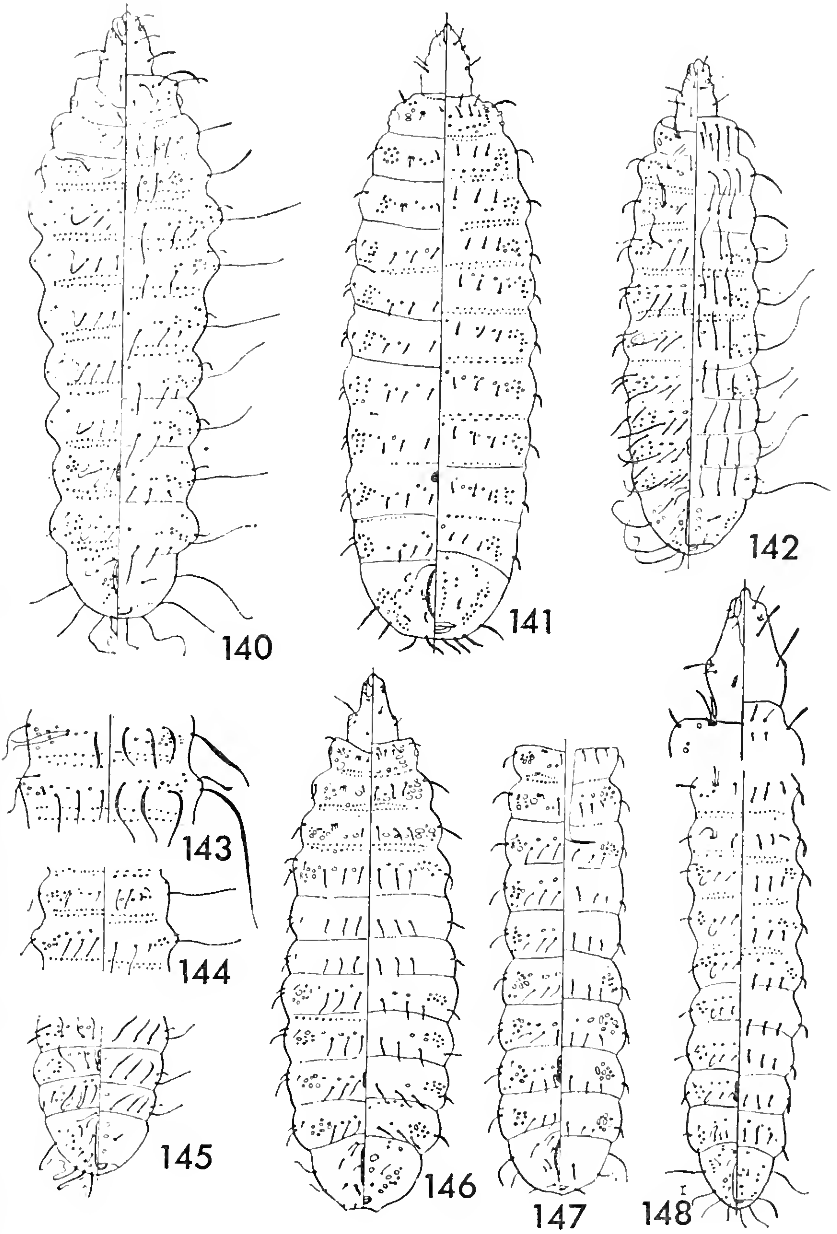
Figures 83–104.—Dorsal view: 83, *Cyphomyia pilosissima*, head; 84, *C. pilosissima*, first abdominal segment; 85, *C. pilosissima*, apical segment; 86, *Odontomyia pubescens*, head; 87, *Hedriodiscus vertebratus*, head; 88, *Myxosargus nigricornis*, apical segment; 89, *O. pubescens*, first abdominal segment; 90, *O. pubescens*, apical segment; 91, *H. vertebratus*, apical segment; 92, *M. nigricornis*, first abdominal segment; 93, *M. nigricornis*, head; 94, *Euparyphus limbrocutris*, head; 95, *E. limbrocutris*, apical segment; 96, *Aochletus brevicornis*, first abdominal segment; 97, *A. brevicornis*, head; 98, *O. virgo*, first abdominal segment; 99, *E. limbrocutris*, first abdominal segment; 100, *Nemotelus centralis*, head; 101, *A. brevicornis*, apical segment; 102, *O. virgo*, apical segment; 103, *N. centralis*, first abdominal segment; 104, *N. centralis*, apical segment.



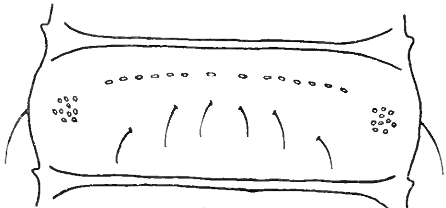
FIGURES 105–119.—Dorsal view: 105, *Stratiomys norma;* 106, *S. norma*, head; 107, *S. norma*, apical segment; 108, *S. norma*, head (ventral view; Abib); 109, *S. norma*, apical segment (ventral view); 110, *Caloparyphus tetraspilus*, head; 111, *C. major*, head; 112, *Caloparyphus* species, head; 113, *C. tetraspilus*, first abdominal segment; 114, *C. major* first abdominal segment; 115, *Caloparyphus* species, first abdominal segment; 116, *C. tetraspilus*, apical segment; 118, *C. major*, apical segment; 118, *Caloparyphus* species, apical segment; 119, *S. discaloides*, apical segment.

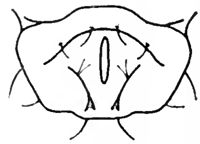


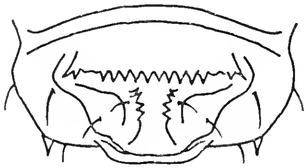
FIGURES 120–139.—Dorsal view: 120, *Nemotelus kansensis*, first abdominal segment; 121, *N. canadensis*, first abdominal segment; 122, *Caloparyphus amplus*, ventral hooks (lateral view); 123, *N. kansensis*, apical segment; 124, *N. canadensis*, apical segment; 125, *C. crotchi*, head; 126, *Odontomyia cincta*, head; 127, *C. amplus*, head; 128, *C. amplus*, first abdominal segment; 129, *C. crotchi*, first abdominal segment; 130, *O. cincta*, first abdominal segment; 131, *C. amplus*, apical segment; 132, *C. crotchi*, apical segment; 133, *O. cincta*, apical segment; 134, *N. canadensis*, head; 135, *O. occidentalis*, head; 136 *O. occidentalis*, apical segment; 137, *O. communis*, apical segment; 138, *O. occidentalis*, first abdominal segment; 139, *O. communis*, first abdominal segment.

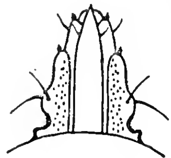


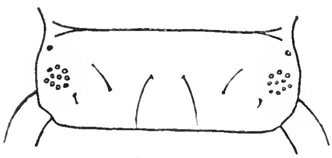
FIGURES 140–148.—140, *Eupachygaster fusca*, dorsal view on right; 141, *Berkshiria albistylum*, dorsal view on right; 142, *Zabrachia plicatum*, dorsal view on right; 143, *E. punctifer*, abdominal terga; 144, *E. henshawi*, abdominal sterna; 145, *Z. politum*, terminal segments; 146, *Neopachygaster maculicornis*, dorsal view on right; 147, *N. occidentalis*, dorsal view on right; 148, *Pachygaster pulchra*, dorsal view on right. (After Kraft and Cook, 1961.)

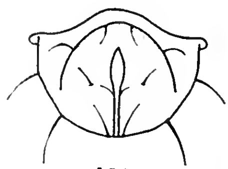

149

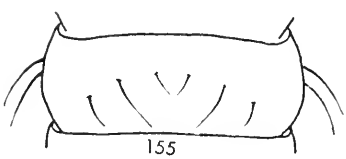

151

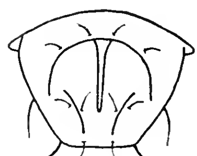

150


152


153


154


155


156

FIGURES 149–156.—149, *Xylomya americana*, first abdominal segment, dorsal view; 150, *X. americana*, apical segment, ventral view; 151, *Merosargus caerulifrons*, apical segment, ventral view; 152, *Cyphomyia marginata*, head, dorsal view; 153, *C. marginata*, first abdominal segment, dorsal view; 154, *C. marginata*, apical segment, ventral view; 155, *Adoxomyia rustica*, first abdominal segment, dorsal view; 156, *A. rustica*, apical segment, ventral view.

U.S. GOVERNMENT PRINTING OFFICE: 1967

Proceedings of the United States National Museum

SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 121 | 1967 | Number 3570

REVISION OF THE FAMILY PANDARIDAE (COPEPODA: CALIGOIDA)[1]

By Roger Cressey
Associate Curator, Division of Crustacea

In 1907, C. B. Wilson published a revision of the subfamily Pandarinae as part of a series of papers dealing with caligoid copepods. We now recognize that much of this work was superficial, containing descriptions of species often incomplete and inadequately figured; nevertheless, it served to focus attention on a group of parasites, caligoid copepods, which were then and are still today poorly known in most cases.

Between 1960 and 1965 I collected and solicited material of the family Pandaridae from as many different areas as possible. As a result of this accumulation of material and data, I feel that a revision of the family is in order. Ecological relationships are now more evident than before.

Because of inadequate species descriptions that exist for most members of this family, positive identification of material is often difficult. This results in the publication of records that obscure our understanding of existing host-parasite relationships. I believe that, in most cases, I have examined enough samples of members of this

[1] Modified from a Ph. D. dissertation submitted to Boston University, Boston, Mass.

group to be able to draw a clearer picture. Also, as a result of these collections, I have been able better to define important taxonomic characters and to discount others on which new species descriptions have often been based. It is with the foregoing in mind that I have made the following family revision. The Pandaridae as defined here is composed of 12 genera and 33 species.

The material examined was preserved in 10 percent formalin or 70 percent ethyl alcohol. For detailed examination of the appendages, the copepods were dissected in lactic acid and mounted in Hoyer's mounting medium. Whole specimens were often treated with 5 percent potassium hydroxide to render them more transparent. No distortion was noticed by this method.

All drawings were made with the aid of a camera lucida. The letter following the explanation of the figure refers to the scale at which it was drawn. In all text tabulations, Roman numerals refer to spines, Arabic numerals to setae.

All specimens are deposited in the U.S. National Museum unless otherwise designated.

I wish to acknowledge the constant encouragement and helpful advice offered by Dr. Arthur Humes, Boston University, during the course of this study.

I also wish to acknowledge the following persons who generously donated or loaned to me material for study: Dr. Thomas E. Bowman and Dr. Robert Gibbs, U.S. National Museum; Dr. Eugenie Clark, Cape Haze Marine Laboratory, Fla.; Dr. Richard Gooding, University of Singapore; Mr. Ju Shey Ho, Boston University; Miss Leonie Joubert, Oceanographic Research Institute, South Africa; Mr. Susumu Kato, California Fish and Wildlife Service; and Dr. Jan Stock, Zoological Museum, Amsterdam.

A portion of this work was supported by the National Science Foundation as a part of the U.S. Program in Biology, International Indian Ocean Expedition.

Family Pandaridae Milne-Edwards, 1840

Female.—Body caligiform, usually with dorsal plates. First thoracic segment fused with cephalon. Thoracic segments 2–4 free. Genital segment conspicuous. Abdomen of 1 or 2 segments with or without dorsal plates. Oral area with or without adhesion pads. First antenna 2-segmented. Mandible in form of stylet with 10–12 apical teeth. Mandible inserted within mouth tube. Maxilliped with terminal claw. Legs 1–4 biramose. Leg 5 reduced. Egg strings consisting of long strings of eggs arranged in linear series.

Male.—Body caligiform, without dorsal plates. First thoracic segment fused with cephalon. Thoracic segments 2–4 free. Oral area generally as in female. Legs 1–4 biramose, rami always with long plumose setae. Legs 5 and 6 present. Abdomen 1- or 2-segmented. Caudal rami large.

Discussion.—Members of the family Pandaridae are generally considered to be parasites of elasmobranch fishes. Occasionally investigators report these copepods from teleost fish, but occurrence on such hosts is undoubtedly accidental and does not indicate the true host. The copepods are found on the body surface, cloacal aperture, gills and gill arches, mouth, and nasal passages. Those which are found on the body surface are often heavily pigmented; those in more protected areas are devoid of pigment.

These parasites are well adapted for attachment to the host, the female more so than the male. The principal attachment structure is the maxilliped. In the case of *Perissopus* the maxilliped becomes cemented to the host. Adhesion pads scattered over the ventral surface of the parasite seem to help resist its sliding over the surface of the host. The pads do not actually attach to the host but rather have surface striations for increased friction.

Locomotion is usually restricted to the males. The swimming legs of the females are often lamelliform (bearing reduced setae) and probably afford increased area for respiration with a reduction in the swimming function. Males are not so modified and undoubtedly move much more freely than the female.

The life history of pandarid copepods is still unknown. Wilson (1907) has outlined a composite life history of this group based on fragments of information from various representative caligoids. In general, the life history includes the following stages: egg, nauplius, copepodid, chalimus, and adult. The number of molts between stages is completely unknown for this group. The nauplius is of the usual copepod form with 3 pairs of anterior appendages. This stage is apparently free in the plankton and undoubtedly of short duration. The copepod attaches to the host as a copepodid (="metanauplius," Wilson 1907). The second antenna of this stage is greatly enlarged and projects anteriorly. The body of the copepodid is divided into a cephalon, 2 thoracic segments, and a fused genital segment-abdomen with rami attached distally. It is not clear whether this stage lasts for more than 1 molt. The chalimus assumes a body form similar to the adult. Wilson (1907) describes the chalimus stage as seen in *Perissopus dentatus*. The chalimus stage of caligoid copepods is characterized by the presence of a frontal filament. This is produced by glands in the anterior portion of the cephalon and serves to attach the copepod to the host. Wilson's description includes this structure. I have collected occasional chalimus stages in the genera *Pandarus* and *Echthrogaleus* and have not observed this filament. More material will eventually show the true nature of this structure in pandarid copepods. The chalimus apparently undergoes a series of molts, increasing the segmentation until the adult form is reached. Lewis (1963) has described the life history stages of *Lepeophteirus dissimulatus* Wilson. This copepod includes the following stages in its life history: nauplius (first and second), copepodid (1 stage), chalimus (6 stages), and adult. The life history of pandarids is probably quite similar. Heegaard (1947) described 2 copepodid stages for *Caligus curtus* (Muller).

The family Pandaridae is composed of 2 well-defined groups on the basis of external characters of both sexes. These characters are included in the key below. Group I includes the following genera: *Pandarus, Pseudopandarus, Phyllothyreus, Gangliopus, Perissopus,* and *Pannosus.* Group II includes: *Dinemoura, Demoleus, Pagina, Echthrogaleus, Nesippus,* and *Paranesippus.* Keys to the genera of females of the 2 groups also are provided below (not enough information is available to construct a key to the males).

Key to Groups and Genera of Pandaridae

FEMALES

Dorsal thoracic plates present on segments 2–4; penultimate segment of second maxilla with 2 prominent distal spines . . . . GROUP I

Dorsal thoracic plates, if present, on segment 4 only; penultimate segment of second maxilla with 1 spine and a patch of spinules or setules . GROUP II

MALES

Outer distal corner of last endopod segment of leg 3 smooth . . . . GROUP I

Outer distal corner of last endopod segment of leg 3 modified with roughened areas and short spines . . . . GROUP II

GENERA OF GROUP I FEMALES

1. Dorsal thoracic plates of segment 3 extending beyond plates of segment 3 . 3
   Dorsal thoracic plates of segment 3 not extending beyond plates of segment 2 2
2. Abdomen and caudal rami hidden dorsally . . . . **Perissopus**
   Abdomen and caudal rami visible dorsally . . . . **Pandarus**
3. Plates of segment 2 large, overlapping those of segment 3 4
   Plates of segment 2 reduced and lateral to those of segment 3 5
4. Maxilliped with spatulate tip . . . . **Pannosus**
   Maxilliped with pointed tip . . . . **Phyllothyreus**
5. Maxilliped with pointed tip, genital segment less than ½ body length. **Gangliopus**
   Maxilliped with spatulate tip, genital segment at least ½ body length. **Pseudopandarus**

GENERA OF GROUP II FEMALES

1.	Abdomen 2-segmented	2
	Abdomen 1-segmented	3
2.	Fourth leg lamelliform	**Dinemoura**
	Fourth leg not lamelliform	**Pagina**
3.	Fourth leg lamelliform	**Echthrogaleus**
	Fourth leg not lamelliform	4
4.	Abdomen with large dorsal plate	**Demoleus**
	Abdomen without dorsal plate	5
5.	Exopods of legs 1–3 3-segmented	**Paranesippus**
	Exopods of legs 1–3 2-segmented	**Nesippus**

Genus *Pandarus* Leach, 1816

Pandarus Leach, 1816, p. 405. [Type-species: *P. bicolor.*]
Caligus.—Lamarck, 1818, p. 137. [Refers to *C. bicolor* only.]
Nogagus Leach, 1819, p. 536.

FEMALE.—Frontal plate distinctly separate. First thoracic segment fused with cephalon. Thoracic segments 2–4 free, bearing dorsal plates. Dorsal plates of segment 3 never extending beyond plate of segment 2. Plates of segment 4 fused basally. Abdomen 1-segmented with dorsal plate. Abdomen (or its plate) visible dorsally and attached to distal end of genital segment. Caudal rami lateral to abdomen. First antenna 2-segmented. Adhesion pads present on cephalon in association with first and second antennae and maxilliped; pads also located on ventral surface of posterior corners of cephalon. Claw of maxilliped spatulate. Legs 1–4 biramose, rami of legs 1–3 2-segmented. Rami of leg 4 1-segmented. Leg 5 present. Egg strings long and straight.

MALE.—No dorsal plates present. Cephalic appendages in general like those of female. Legs 1–4 biramose, all rami 2-segmented and bearing plumose setae. Fifth and sixth legs present. Leg 3 endopod unmodified.

DISCUSSION.—Since 1816, 29 species have been described and assigned to this genus. Only 10 of these remain valid today. The synonymies are discussed with the species descriptions. I propose to designate each of the following 4 species described by Hesse in 1883 as a nomen dubium on the basis that the descriptions and figures are so poor that it is impossible to assign these to any known taxon: *Pandarus mustelilaevis*, *Pandarus unicolor*, *Pandarus spinaciiachantias*, and *Pandarus carchiiglaucus*.

Members of the genus *Pandarus* are parasites on the body surface of the host. They have been reported from both pelagic and inshore species and are the most frequently encountered pandarid copepod. The females of some species are heavily pigmented and those of others show some signs of pigmentation. They frequently occur in clusters of more than 100 individuals on the fins of the shark.

Members of this genus can easily be separated from other genera on the basis of the arrangement of the dorsal thoracic plates and the nature of the caudal rami.

Key to Adult Females of *Pandarus*

1. Dorsal plate of thoracic segment 2 extending only as far as the posterior edge of the plate of segment 3 . . . . BICOLOR GROUP. 2
   Dorsal plate of thoracic segment 2 extending well beyond posterior edge of plate of segment 3 . . . . CRANCHII GROUP. 4
2. Cephalon only ⅓ of total body length; caudal rami small, scarcely visible dorsally . . . . **bicolor**
   Cephalon about ½ of total body length; caudal rami easily visible dorsally . 3
3. Caudal rami long, about 3 times as long as dorsal abdominal plate and extending well beyond it; posterior edge of plate of segment 4 without conspicuous sinus . . . . **niger**
   Caudal rami only about 1½ times as long as dorsal abdominal plate and extending only slightly beyond it; posterior edge of plate of segment 4 with deep sinus . . . . **carcharhini**
4. Caudal rami with the inner basal half expanded to broad lobe . . **smithii**
   Caudal rami without such a lobe 5
5. Caudal rami not extending more than ⅔ length of dorsal abdominal plate. **satyrus**
   Caudal rami extending at least to tip of dorsal abdominal plate or well beyond it 6
6. Dorsal plates of thoracic segments 3 and 4 fused and with broad posterior sinus 7
   Dorsal plates of thoracic segments 3 and 4 divided by deep sinus into 2 nearly separate lobes 9
7. Dorsal abdominal plate subtriangular; eye spots separated in fully pigmented forms . . . . **cranchii**
   Dorsal abdominal plate subcircular; body may or may not be darkly pigmented 8
8. Most of body darkly pigmented but eye spots connected by median posterior line . . . . **sinuatus**
   Body only slightly pigmented with pigment usually confined to anterior portion of cephalon and plate of fourth thoracic segment . . . **floridanus**
9. Thoracic plate of segment 2 extending to posterior tip of thoracic plate of segment 4 . . . . **zygaenae**
   Thoracic plate of segment 2 extending to middle of thoracic plate of segment 4 . . . . **katoi**

Pandarus satyrus Dana, 1852

FIGURES 1–26

Pandarus satyrus Dana, 1852–3, p. 1368.—Brady, 1883, p. 134.—Bassett-Smith, 1899, p. 467.—Wilson, 1907, p. 415; 1914, p. 71.—Yamaguti, 1936, p. 5.—Bere, 1936, p. 595.—Shiino, 1957, p. 364; 1959a, p. 315; 1959b, p. 352; 1960b, p. 493.—Ho, 1963, p. 90.

Specimens studied.—All collections from *Prionace glauca* (Linnaeus). Twenty-six collections made in the western North Atlantic Ocean between latitudes 30°N to 49°N and longitudes 60°W to 72°W. Six collections in the Indian Ocean (0°58′N, 55°E; 0°14′S, 55°04′E; 6°37′S, 55°00′E; 34°32′S, 74°48′E; 33°11′S, 54°58′E; 02°06′S, 75°10′E. Three collection in Pacific Ocean (3°18′N, 101°54′W; 1°00′S, 101°40′W; 9°56′N, 135°16′W).

Female.—Body form as in figure 1. Length 8.2 mm and width (measured at widest point) 4.4 mm based on average of 10 specimens.

First thoracic segment fused with head. Dorsal thoracic plates present on segments 2–4. Plates on segment 2 separate, extending laterally beyond tip of plate of segment 3. Plates of segment 3 fused at base, divided by a broad median distal sinus in middle of distal margin. Plates of segment 4 extending over the genital segment, fused, and with distal median sinus. Genital segment 1.8 mm long and 2.7 mm wide. Abdomen 1-segmented and joined broadly to genital segment ventrally. Abdomen covered by dorsal plate (1.8 by 1.5 mm), longer than wide, extending beyond tips of rami. Caudal rami (fig. 2) long, slender, widest at base, tapering distally (990μ by 228μ), bearing 4 short spines. Rami extend only to about middle of abdominal plate.

Oral area (fig. 3). Adhesion pads present at bases of first antennae, second antennae, and maxillipeds. Pads also present at posterior corners of cephalon. First antenna (fig. 4) 2-segmented. First segment bearing 26 setae, 4 setae small and plumose, remainder stout and armed as in figure. Second segment bearing 12 naked setae. Second antenna (fig. 5) 3-segmented. Terminal segment bearing large terminal spine and 2 setae. Mouth tube (figs. 6, 7) of usual caligoid type. Labrum with pari of subterminal processes within tube and fringed at its tip. Labium somewhat expanded at tip and with fringe as in figure 7. Mandible (fig. 8) composed of basal podomere bearing long slender shaft with serrate tip. Mandibular process extending within tube as in figure 6. First maxilla (fig. 6) 2-segmented. Basal segment bearing 3 short setae. Terminal segment with small seta and large terminal spine. Second maxilla (fig. 9) with 3 segments. Basal segment unarmed. Second segment with 2 distal spines, longer one fringed, shorter plumose. Terminal segment bearing large claw with rows of spinules and apical patch of spinules. Maxilliped (fig. 10) 2-segmented. Basal segment stout, bearing an adhesion pad. Terminal segment in shape of a claw, with 1 seta. Tip of claw bilobed, with an adhesion area that, when closed, is in contact with adhesion pad of basal segment. Legs 1–4 biramose with spine and setal formula as follows:

	leg 1 exp.	leg 1 end.	leg 2 exp.	leg 2 end.	leg 3 exp.	leg 3 end.	leg 4 exp.	leg 4 end.
seg. 1	I:0	0:0	I:0	0:0	I:0	0:0	VI	0
seg. 2	VI	III	X	IV	VI	II	–	–

Leg 1 (fig. 11) with both rami 2-segmented. Leg 2 (fig. 12) with both rami 2-segmented. Inner 7 spines on last segment of exopodite not articulated. Leg 3 (fig. 13) with both rami 2-segmented. Two inner spines on last segment of exopodite not articulated. Leg 4 (fig. 14) with both rami 1-segmented. Endopodite without spines. Legs 1–4 with patches of spinules and adhesion pad as in figures. Leg 5 (fig. 15) consisting of outer plumose seta and inner lobe with single terminal spine.

Egg strings long and slender, extending several times length of body, not recurved. Eggs disc shaped.

Color of adult female dark brown to black with eye spots separated as in figure 1.

MALE.—Body form as in figure 16. Length (not including setae on caudal rami) 10.3 mm and width (measured at widest point) 5.6 mm based on an average of 10 specimens. Cephalon rounded when viewed dorsally with head and first thoracic segment fused. Thoracic segments 2–4 free, without dorsal plates except for lateral winglike plates on segment 2. Genital segments 2.3 mm by 2.3 mm, with posterior corners attenuated, terminating in inwardly directed tip. Spermatophores (fig. 17) often visible through genital segment. Abdomen 2-segmented. First segment 432μ long. Second segment 576μ long. Caudal ramus (fig. 18) 1050μ by 665μ, bearing 4 long and 2 short setae. Outermost long seta 1365μ long, innermost 910μ long, and 2 median setae 1500μ long. Oral area as in female except as follows: second antenna (fig. 19) with last segment in form of large claw, not subdivided as in female; maxilliped (fig. 20) terminating in pointed claw whereas female claw terminating as spatulate tip.

Legs 1–4 biramose, each ramus of 2 segments, with spine and setal formula as follows:

	leg 1 exp.	leg 1 end.	leg 2 exp.	leg 2 end.	leg 3 exp.	leg 3 end.	leg 4 exp.	leg 4 end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	I:1	0:1
seg. 2	IV:3	3	IV:6	8	IV:5	6	IV:5	5

All setae densely plumose. Leg 1 as in figure 21. First segment of endopod with prominent inner adhesion pad. Leg 2 as in figure 22. Leg 3 (fig. 23) with bilobed outer edge on first segment of exopodite. No modified setae on last endopodite segment. Leg 4 (fig. 24) also possessing bilobed outer edge on exopodite first segment. Leg 5 (fig. 25) borne on genital segment as lateral projection with 4 setae and 1 stout terminal spine (see also fig. 16). Leg 6 (fig. 26) consisting of single plumose seta and stout spine borne on genital segment near origin of abdomen (see also fig. 16).

Color in life whitish yellow and generally devoid of darker pigment.

Discussion.—*Pandarus satyrus* is a widely distributed copepod nearly always found associated with *Prionace glauca*. Reports in the literature of this copepod from other hosts are probably the result of misidentification of the copepod or even of the host shark. It is closely related to *Pandarus cranchii* Leach and was placed in synonymy with it by Shiino (1954). I have examined a great number of specimens of both of these species and conclude that both are valid species. The principal differences between them are discussed under the description of *Pandarus cranchii*.

This copepod is parastic on the body surface of the host and is often found in large clusters near the posterior edge of the fins. Generally the number of females far exceeds the number of males.

Pandarus cranchii Leach, 1819

Figures 27–33

Pandarus cranchii Leach 1819, p. 535.—Burmeister, 1833, p. 331.—Krøyer, 1837, p. 202.—Steenstrup and Lütken, 1861, p. 390.—Rathbun, 1884, p. 488; 1886, p. 317.—Beneden, 1892, p. 221.—Wilson, 1907, p. 403; 1908, p. 453; 1932, p. 435; 1936, p. 333.—Brian, 1908, p. 4; 1912, p. 14.—Leigh-Sharpe, 1934a, p. 27.—Pesta, 1934, p. 30.—Oorde and Schuurmans Stekhoven, 1936, p. 141.—Heegaard, 1943b, p. 27.—Barnard, 1948, p. 249; 1955, p. 258.—Capart, 1953, p. 660; 1959, p. 98.—Markevitch, 1956, p. 151.

Nogagus latreilli Leach, 1819, p. 536.

Pandarus carchariae Leach, 1819, p. 535.

Pandarus concinnatus Dana, 1852, p. 59.

Pandarus pallidus Milne-Edwards, 1840, p. 468.

Pandarus vulgaris Milne-Edwards, 1840, p. 468.

Pandarus dentatus Milne-Edwards, 1840, p. 469.—Heller, 1868, p. 206.—Thomson, 1889, p. 363.—Bassett-Smith, 1899, p. 466.

Pandarus armatus Heller, 1868, p. 202.—Thomson, 1889, p. 363.—Bassett-Smith, 1899, p. 467.—Wilson, 1907, p. 448.—Stebbing, 1910, p. 558.—Capart, 1953, p. 659.—Barnard, 1955, p. 258.

Specimens studied.—Eighteen collections from *Pterolamiops longimanus* (Poey) between latitudes 30°N to 49°N and longitudes 60°W to 72°W. Two collections from *Eulamia falciformis* (Müller and Henle) (30°49′N, 64°02′W; 57°44′N, 65°42′W). Two collections from *Eulamia obscura* (Lesueur) (34°45′N, 73°41′W; 36°42′N, 70°00′W). Ten collections from *Eulamia floridanus* (Bigelow and Schroeder) between latitudes 30°N to 49°N and longitudes 60°W to 72°W. All above collections in the North Atlantic Ocean. Indian Ocean: 8 collections from *P. longimanus* (07°17′N, 55°00′E; 02°25′N, 55°04′E; 00°14′S, 55°04′E; 06°37′S, 55°00′E; 11°08′S, 55°04′E;

12°38′S, 54°40′E; 04°09′S, 74°58′E; 03°54′N, 74°59′E). Two collections from *E. floridanus* (07°17′N, 55°00′E; 00°14′S, 55°04′E). Pacific Ocean: from *Carcharinus malpeloensis* (Fowler) (9°42′N, 85°46′W), *Carcharinus galapagensis* (14°3′N, 92°8′W) and *Sphyrna zygaena* (Linnaeus) off Formosa. Also 1 collection from *P. longimanus* from Durban, South Africa, and 4 collections from this host in the Gulf of Mexico. Two collections from *Galeocerdo cuvier* (Lesueur), 1 from Formosa and the other from Pointe Noire, West Africa.

FEMALE.—Body form as in figure 27. Length 8.4 mm and width (measured at the widest part) 4.6 mm. Based on an average of 10 specimens.

In general, dorsal view and arrangement of thoracic plates of female is same as *P. satyrus* with the following exception: caudal ramus (fig. 28) of *P. cranchii* always extends to distal tip of abdominal plate and often even beyond while ramus of *P. satyrus* is much shorter in relation to abdominal plate (see fig. 2). Ramus of *P. cranchii* measures 1.4 mm in length.

Oral area as in *P. satyrus* except that maxilliped (fig. 29) of *P. cranchii* possesses a larger basal segment. Leg 1–4 with spine and setal formula as *P. satyrus*. Endopodite of leg 2 of *P. cranchii* (fig. 30) with patch of more rugose spines along outer edge than that of *P. satyrus*. Leg 5 (fig. 31) as in *P. satyrus*. Eggs and egg strings as in *P. satyrus*.

Color as in *P. satyrus*.

MALE.—Body form as in *P. satyrus*. Total length 10.4 mm. Greatest width 5.2 mm, based on an average of 10 specimens. Male of *P. cranchii* differs from *P. satyrus* as follows: second antenna of *P. cranchii* (fig. 32) with smaller claw; posterior corners of genital segment of *P. cranchii* attenuated but not curved inwardly as in *satyrus* (see fig. 33).

DISCUSSION.—This copepod appears to be closely related to *P. satyrus* but the two species are easily separated on the basis of the caudal rami. The rami of *P. cranchii* extend at least to the tip of the abdominal plate (often beyond) whereas the rami of *P. satyrus* extends only about half the length of the abdominal plate. The legs of *P. cranchii* have the same spine and setal formula but the patches of spinules are much heavier in *P. cranchii*.

Pandarus cranchii seems to be confined primarily to carcharinid sharks. It is also common on the tiger shark, *Galeocerdo cuvier*. The parasite is found on the body surface of the host and like other members of the genus is sometimes found in large clusters on the fins. It is worldwide in distribution.

Shiino (1954) has described and figured both sexes of this species under the name of *P. satyrus*.

Pandarus smithii Rathbun, 1886

FIGURES 34–35

Pandarus smithii Rathbun, 1886, p. 315.—Wilson, 1907, p. 410; 1932, p. 158.—Leigh-Sharpe, 1934, p. 27.—Bere, 1936, p. 595.—Carvalho, 1940, p. 281; 1945, p. 110; 1951, p. 139.—Brian, 1944, p. 202.—Barnard, 1948, p. 249; 1955, p. 259.—Causey, 1955, p. 6.—Shiino, 1959b, p. 353.

Pandarus lugubris Heller, 1868, p. 205.—Bassett-Smith, 1899, p. 467.—Brian, 1902, p. 8; 1906, p. 56.—Wilson, 1907, p. 395.—Rose and Vaissiere, 1953, p. 86.

Pandarus marcusi Carvalho, 1940, p. 284; 1951, p. 140.

SPECIMENS STUDIED.—Two collections from *Isurus oxyrhynchus* Rafinesque (42°18′N, 64°02′W; 35°00′N, 70°00′W). Two collections from *Eulamia obscurus* (Lesueur) (36°42′N, 70°00′W; 34°45′N, 73°41′W). Three collections from *Eulamia floridanus* Bigelow and Schroeder (36°07′N, 73°25′W; 38°00′N, 68°00′W; 40°25′N, 62°35′W). All above in North Atlantic Ocean. From the Indian Ocean 2 collections from *Alopias vulpinus* (Bonneterre) (9°24′N, 54°58′E; 07°17′N, 55°00′E). Single collections from *Isurus oxyrhynchus* (16°13′N, 63°29′E) and *Eulamia floridanus* (07°17′N, 55°00′E). From the Pacific Ocean 2 collections from *Carcharinus azureus* (9°52′N, 85°29′W; 10°09′N, 86°04′W). Single collections from *Carcharinus galapagensis* (9°45′N, 85°34′W), *Carcharinus malpeloensis* (Fowler) (Très Madres Island), *Carcharinus limbatus* Müller and Henle, off San Pedro, Calif. Also single collections from *Hypoprion signatus* Poey in the Gulf of Mexico, *Carcharodon carcharias* (Linnaeus) off Cape Cod, Mass., and *Sphyrna zygaena* (Linnaeus) off the coast of Brazil.

FEMALE.—Body form as in figure 34. Length 8.2 mm and width 4.6 mm based on an average of 10 specimens. Dorsal thoracic plates similar to those of *P. satyrus* and *P. cranchii* except that plates of segment 2 extend only to about middle of plate of segment 4. Genital segment 2.2 mm long and 3.0 mm wide. Abdomen 1-segmented as in *P. satyrus*. Dorsal plate of abdomen nearly round (see fig. 35). Caudal rami (figs. 35, 36) 1.78 mm long and with an inner lobe extending ventrally below abdomen. In some specimens lobes extending toward midline almost touching and thus forming shelflike structure bridging the rami.

Oral area similar to that of *P. satyrus*. Second antenna (fig. 37) and maxilliped (fig. 38) are illustrated to show minor differences in shapes of segments and lengths of spines. Legs 1–4 modified as in *P. satyrus* and with the following spine and setal formula:

	leg 1 exp.	*leg 1* end.	*leg 2* exp.	*leg 2* end.	*leg 3* exp.	*leg 3* end.	*leg 4* exp.	*leg 4* end.
seg. 1	I:0	0:0	1:0	0:0	I:0	0:0	VI	I or 0
seg. 2	VI	III	X	IV	VI	I or II		

Formula like that of *P. satyrus* and *P. cranchii* except in variation of numbers of spines on last podemere of expodite of legs 3 and 4 (fig. 39).

Leg 5 (fig. 40) with inner lobe in form of large claw. Egg strings as in other *Pandarus* species. Color dark brown to black in pigmented areas (see fig. 34). Eye spots joined at midline and not separated as in *P. satyrus*.

Male.—Body form as in figure 41. Length 9.4 mm (not including setae on caudal rami) and width (measured at widest point) 4.4 mm based on an average of 10 specimens. General configuration similar to other *Pandarus* species. Genital segment (fig. 42) 2.0 mm by 1.8 mm with posterior corners not produced as in *P. satyrus* and *P. cranchii*. Spermatophore visible through genital segment. Oral area as in *P. satyrus*. Legs 1.4 biramose with spine and setal formula as in *P. satyrus*. Leg 1 (fig. 43) showing minor differences in adhesion areas and length of setae when compared with *P. satyrus*. Leg 2 (fig. 44) with papillose area on outer corner of coxopodite rather than patch of fine setules as in *P. satyrus*. Leg 5 (fig. 45) with 3 plumose setae and 1 small spine and borne laterally on genital segment as in *P. satyrus*. Leg 6 consisting of 1 short spine and a single seta located at junction of genital segment and abdomen.

Color in life whitish yellow and generally devoid of darker pigment.

Discussion.—*Pandarus smithii* is a widely distributed copepod found on a number of hosts and often occurring with *Pandarus cranchii* on carcharinid sharks. *P. smithii* can be easily distinguished from the other species of the *cranchii* group on the basis of the caudal ramus and eye spots in pigmented females. Males can be separated from *cranchii* and *satyrus* on the basis of the shape of the genital segment and nature of leg 5.

In 1940 Carvalho described a new species, *Pandarus marcusi*. I have examined material identified by Carvalho as this new species from Brazil and have concluded that it is in fact a synonym of *P. smithii*. The sole basis for separating *marcusi* from *smithii* was the shape of the dorsal plate of the abdomen. *P. marcusi* had a plate with a deep median sinus. This irregularity in the shape of plates is not uncommon in the genus. I have observed these irregularities in collections of *Pandarus* that show an epiphyte (algal or fungal) growing on the surface of the copepod. The "roots" of the epiphyte seem to have a corrosive action on the integument and often leave the area malformed.

Pandarus floridanus, new species

Figures 46–66

Specimens studied.—Thirty-two females and 1 male collected from *Carcharodon carcharias* (Linnaeus) caught at Dennis, Mass. Holotype female, allotype male, and 10 paratype females in alcohol deposited in the U.S. National Museum, 10 paratype females in alcohol deposited in the British Museum (Natural History) and the remaining paratypes in the author's collection. Other specimens studied: 3 collections from *Carcharodon carcharias* (USNM 107299, Miami, Fla.) (USNM 101876, off Cape Lookout, N.C.) (USNM 104859, St. Augustine, Fla.); a single collection (USNM 32765) from *Lamna nasus* (Bonneterre) Woods Hole, Mass.

FEMALE.—Body form as in figure 46. Total length (based on an average of 5 specimens) 7.5 mm. Greatest width (measured at widest part of cephalon) 3.8 mm. Cephalon widest posteriorly narrowed anteriorly, measuring 3.5 by 3.8 mm. First thoracic segment fused to head. Dorsal thoracic plates present on segments 2–4. Plates of segment 2 extending well beyond those of segment 3 to about middle of lateral edge of plate of segment 4. Plates of segments 3 and 4 fused at bases. Genital segment nearly square measuring 2.8 mm long and 2.6 mm wide. Dorsal posterior border of genital segment has broad sinus to accommodate dorsal abdominal plate. Abdomen 1-segmented with a dorsal plate (see fig. 47) slightly wider than long (7.9 by 7.2 mm). Caudal ramus of usual generic type, bearing 4 setae (see fig. 47) and 0.6 mm long.

Oral area as in figure 48. First antenna 2-segmented. First segment 490μ long bearing 25 spines and setae. Spines and setae armed as in the figure. Second segment 168μ long bearing 11 naked setae. Second antenna (fig. 48) 3-segmented. Terminal segment in form of claw and bearing 2 spines. Mouth tube with associated mandible and first maxilla as in other members of genus. Second maxilla with usual fringed clawlike tip. Short plumose seta (fig. 49) near base of terminal segment. Maxilliped of the usual type (see fig. 48).

Head appendages, except maxilliped, as in female. Maxilliped with distinct claw at tip as in *P. satyrus* (see fig. 20).

Legs 1–4 not modified as in female and with spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	I:1	0:1
seg. 2	IV:3	3	IV:6	8	IV:5	6	IV:5	5

Legs 1–4 biramose and each ramus 2-segmented. All setae plumose. Leg 1 (fig. 61) with adhesion pads as indicated in figure. Leg 2 (fig. 62) exopod with first segment bearing long hairs along outer edge and outer distal corner. Leg 3 (fig. 63) with no modifications for holding on last endopod segment. Leg 4 as in figure 64. Leg 5 (fig. 65) consisting of 3 short plumose setae and one short, stout spine located on midlateral margin of genital segment. Leg 6 (fig. 66) located at junction of genital segment and abdomen, consisting of a spinelike process with stout plumose seta near base.

Color in life cream and generally devoid of pigmentation.

Legs 1–4 biramose, with spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:0	0:0	I:0	0:0	VI	0
seg. 2	VI	III	IX	V	VI	II		

Leg 1 (fig. 52) with both rami 2-segmented. First exopod segment with outer spine. Last exopod segment with 6 spines, outer 3 naked, inner 3 finely plumose. First endopod segment with adhesion pad. Last endopod segment with 3 inner spines. Basipod having an inner and outer spine with 1 adhesion pad. Leg 2 (fig. 53) with both rami 2-segmented. First exopod segment with 1 outer spine and patch of fine spinules on outer distal half. Last segment with 9 spines, outer 4 spinose and inner 5 naked. First endopod segment unarmed. Second endopod segment with 5 short spines at tip. Leg 3 (fig. 54) with both rami 2-segmented. First exopod segment with spine on outer distal corner. Second segment with 6 short spines. First endopod segment unarmed. Second segment with 2 short terminal spines. Leg 4 (fig. 55) with both rami 1-segmented. Exopod segment with 6 spines. One spine placed at midpoint of outer edge suggesting a 2-segmented ramus. Endopod unarmed. Leg 5 (fig. 56) consisting of naked spine and separate plumose seta. Leg 5 located near point of attachment of spermatophores (see fig. 56). Area of spermatophore attachment located at junction of abdomen to genital segment and composed of a heavily sclerotized area with shelf to receive neck of spermatophores, attaching in these areas with necks crossing to opening of seminal receptacle on opposite side. Egg strings long and of usual generic type.

Color in life creamy yellow with light brown pigmentation as indicated in figure 46.

Male.—Body form as in figure 57. Total length based on 1 specimen, 9.5 mm, including caudal ramus but not setae. Greatest width 4.5 mm, measured at widest part of cephalon. Cephalon rounded, slightly longer than wide (4.9 by 4.4 mm).

First thoracic segment fused with head. Segments 2–4 free without dorsal plates. Genital segment longer than wide, 2.2 by 1.7 mm with spermatophore visible within. Abdomen of 2 segments. First segment 360μ long. Second segment 612μ long. Caudal ramus (fig. 58) bearing 6 setae, inner 4 long and plumose, inner margin of caudal ramus bearing row of hairs.

Oral area similar to that of female. In adult male adhesion pad associated with second antenna only about one-half length of pad of first antenna (264:576μ) (see fig. 59). Collected with this mature male was also a young male (7.1 mm) with spermatophores developing within genital segment (by itself, this might have been mistaken for fully developed male). Examination of its appendages showed it to be identical with its larger counterpart, except pad of second antenna is about as long as pad of first antenna (408:420μ) (see fig. 60). Other species of this genus with same reduction of adhesion pad of second antenna in mature males.

Discussion.—*Pandarus floridanus* is closely related to *P. sinuatus* but the females can be readily separated on the basis of the following differences. The dorsal abdominal plate of *P. floridanus* is considerably longer than the dorsally exposed caudal ramus while in *P. sinuatus* they are about equal in length (see table 1). In *P. floridanus* the

Table 1.—Comparison of the length of the dorsal abdominal plates with the length of dorsally exposed caudal ramus in some specimens of *Pandarus floridanus* with *P. sinuatus* (CHML=Cape Haze Marine Laboratory, Fla.)

Specimens	Plate	Ramus
P. floridanus		
ex *Carcharodon carcharias* (avg. of 4) Dennis, Mass.	702μ	450μ
" " (avg. of 2) USNM 107299	810μ	576μ
" " (1 spec.) USNM 101876	720μ	540μ
ex *Lamna cornubica* (1 spec.) USNM 32765	720μ	360μ
P. sinuatus		
ex *Negaprion brevirostris* (avg. of 2) CHML	495μ	468μ
ex *Carcharinus leucas* (avg. of 2) CHML	621μ	630μ

dorsal thoracic plate of segment 2 extends beyond the middle of the plate of segment 4 while in *P. sinuatus* the plate of segment 2 does not extend to the middle of the plate of segment 4. *P. floridanus* is not so heavily pigmented as *P. sinuatus*. Young females of *P. sinuatus* first show pigmentation in the lateral areas of the cephalon (see fig. 66), whereas *P. floridanus* is not pigmented in this area at all (its young females showing first areas of pigmentation to be the anterior margin of the cephalon).

From Latin, the word *floridanus* refers to the fact that the species was seen first on a shark from Florida.

Pandarus floridanus can be separated from all other species of the *cranchii* group on the basis of the spine and setal formula. The male of *P. floridanus* is similar to that of *P. sinuatus*. Since only 1 mature male of the new species was available, a more detailed comparison could not be made.

This species seems to be a well-established parasite on the body surface of *Carcharodon carcharias* since it was recovered from that host on four different occasions in the Western Atlantic. It should also be noted as having been collected from *Lamna nasus* as well.

Pandarus sinuatus Say, 1817

FIGURES 67, 68

Pandarus sinuatus Say, 1817, p. 436.—Milne-Edwards, 1840, p. 470.—Smith, 1874, p. 283.—Rathbun, 1886, p. 310.—McClendon, 1906, p. 44; 1907, p. 114; 1910, p. 229.—Wilson, 1907, p. 417; 1932, p. 437.—Bere, 1936, p. 595.—Carvalho, 1940, p. 283; 1945, p. 111; 1951, p. 139.—Pearse, 1952a, p. 27; 1952b, p. 213.—Causey, 1953, p. 12; 1955, p. 6.

Pandarus affinis Beneden, 1892a, p. 224.—Bassett-Smith, 1899, p. 467.—Wilson, 1907, p. 394.—Capart, 1953, p. 660.

SPECIMENS STUDIED.—Two collections from *Carcharinus leucas* Müller and Henle from Sarasota, Fla. From the same locality a single collection from *Negaprion brevirostris* (Poey). In addition to these, I examined 88 collections from the U.S. National Museum collected at various localities along the eastern coast of the United States. These collections are from a wide variety of shark hosts generally restricted to inshore species.

FEMALE.—Body form as in figure 67. Total length (based on an average of 5 specimens) 6.5 mm. Greatest width (measured at widest part of cephalon) 3.2 mm. Appendages of this species inseparable from those of *P. floridanus* except last segment of exopod of leg 2 bears 10 spines instead of 9 as in *P. floridanus*. Since a description of appendages of this species would only duplicate that of *P. floridanus*, none will be given here. Only those features that separate it from *P. floridanus* will be emphasized.

Dorsal plate of segment 2 extending only to anterior third of plate of segment 4. Abdominal plate small and rounded, only about as long as exposed caudal ramus (see table 1). Color dark brown to black with eye spots fused and continuous with median unpigmented line from posterior edge of eye spots to posterior margin of cephalon. Young females (fig. 68)with pigment first developing in lateral areas of cephalon.

MALE.—As in *P. floridanus*.

DISCUSSION.—*P. sinatus* is apparently found only on sharks inhabiting coastal waters of the western North Atlantic Ocean. It occurs only on the body surface of the host usually in clusters on the fins as do other members of the genus. It is closely related to *P. floridanus* but is easily separated from it on the basis of the above characteristics. Superficially, this copepod also may be confused with *P. bicolor* because of the pigmentation, but it can be easily distinguished from this species on the basis of the thoracic plates. The dorsal plates of segment 2 of *P. bicolor* do not extend beyond the plate of segment 3.

Pandarus katoi, new species

FIGURES 69–96

SPECIMENS STUDIED.—Thirty females and 10 males from *Carcharinus malpeloensis* (Fowler) from the Pacific (09°55′N, 85°51′W). Holotype female, allotype male, and 14 paratypes (10♀♀ and 4♂♂) in alcohol deposited in the U.S. National Museum. Fourteen paratypes (10♀♀ and 4♂♂) deposited in the British Museum (Natural History) and the remaining paratypes in the author's collection. Additional specimens studied: 4 collections from *C. malpeloensis* from the Pacific Ocean (09°42′N, 85°51′W; 21°20′N, 106°50′W; 10°03′N, 85°53′W; 08°25′N, 83°45′W), 2 collections from *C. azureus* from the Pacific (9°52′N, 85°29′W; 10°09′N, 86°04′W), and a single collection from the Cocos Islands from *C. platyrhynchus*.

FEMALE.—Body form as in figure 69. Total length (based on an average of 5 specimens) 5.6 mm. Greatest width (measured at the widest part of the cephalon) 3.8 mm. Cephalon somewhat rounded, 3.0 by 3.8 mm. First thoracic segment fused to head. Dorsal thoracic plates present on segments 2–4. Plates of segment 2 extending beyond those of segment 3 and to about middle of plates of segment 4. Plates of segment 2 are generally slightly divergent. Plates of segments 3 and 4 fused at their bases. Genital segment 2.3 by 2.3 mm. Abdomen 1-segmented (fig. 70), with dorsal plate. Dorsal plate 3.0 by 2.3 mm, slightly longer than wide. Caudal ramus (see fig. 70) 720μ long and 270μ wide bearing 4 spines and 2 plumose setae.

Oral area as in other members of genus. Adhesion pads associated with first antennae, second antennae, maxillipeds, and a pair at ventral distal corners of cephalon. First antenna (fig. 71) 2-segmented. First segment 600μ long and bearing 13 naked setae (fig. 72). Second antenna (fig. 73) 3-segmented. Terminal segment with 2 spines, in form of stout claw. Figure 73 shows adhesion pad (dotted line) in relation to second antenna. Mouth tube of typical pandarid type. Mandible (fig. 74) within tube. First maxilla (fig. 75) with a terminal claw, 3 short setae, and located near base of mouth tube. Second maxilla (fig. 76) armed as in figure. Maxilliped (fig. 77) terminal claw with spatulate tip and opposed by 1 large adhesion pad on basal segment.

Legs 1–4 biramose, with spine and setal formula as follows:

	leg 1 exp.	end.	*leg 2* exp.	end.	*leg 3* exp.	end.	*leg 4* exp.	end.
seg. 1	I:0	0:0	I:0	0:0	I:0	0:0	VII	I
seg. 2	VI	III	X	IV	VI	II		

Leg 1 (fig. 78) with both rami 2-segmented. First exopod segment with outer fringed spine. Last exopod segment with 6 terminal spines. First endopod segment with adhesion pad. Last endopod segment with 3 inner spines. Leg 2 (fig. 79) with both rami 2-segmented. First exopod segment with outer spine. Last exopod segment with 10 spines (outer 4 articulated, inner 6 not). First endopod segment unarmed. Last endopod segment with 4 naked spines. Leg 3 (fig. 80) with both rami 2-segmented. First exopod segment with outer spine. Last exopod segment with 6 spines. First endopod segment unarmed. Last endopod segment with 2 terminal spines (all spines on rami of leg 3 naked). Leg 4 (fig. 81) with both rami 1-segmented. Exopod with 7 spines. Endopod with 1 short spine. All spines naked. Leg 5 (fig. 82) with outer single spine and inner lobe with 3 spines. Leg 5 located near point of attachment of abdomen (see fig. 70). Area of attachment of spermatophore at junction of abdomen and genital segment, composed of a heavily sclerotized area with shelf to receive neck of spermatophore. Spermatophores crossing with neck penetrating opening of the seminal receptacle of opposite side. Egg strings long and composed of single strands of eggs.

Color in life creamy yellow with light brown pigmentation as in figure 69.

Male.—Body form as in figure 83. Total length, based on 5 specimens, 7.4 mm. Greatest width 4.2 mm measured at widest part of cephalon. First thoracic segment fused with head. Segments 2–4 free and without dorsal plates. Genital segment somewhat longer than wide, 1.98 by 1.72 mm with spermatophores visible within. Abdomen 2-segmented. First segment 300μ long. Second segment 410μ long. Caudal ramus (fig. 84) with 6 setae, the inner 4 long and plumose. Inner margin of caudal ramus bearing row of hairs.

Oral area similar to that of female. As in *P. floridanus*, adhesion pad of second antenna considerably smaller than one associated with first antenna (204:516μ) (see fig. 85). First antenna (fig. 86) as in female except spines more heavily barbed. Second antenna (fig. 87) 4-segmented with adhesion pad on basal segment. Terminal segment in form of claw with 2 median spines. Mouth tube and mandible as in female. First maxilla (fig. 88) similar to that of female except terminal claw has a more striated surface. Second maxilla (fig. 89) as in female. Maxilliped (fig. 90) with terminal claw pointed rather than spatulate as in female. Opposing adhesion area composed of 3 pads instead of 1 as in female.

Legs 1–4 not modified as in female and with spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	I:1	0:1
seg. 2	IV	3	III:6	8	IV:5	6	IV:5	5

Legs 1–4 biramose and each ramus 2-segmented. All setae plumose. Leg 1 (fig. 91) with adhesion areas as in the figure. Leg 2 (fig. 92)

with outer edge of exopod first segment with long hairs and short spinules. Leg 3 (fig. 93) with outer edge of exopod first segment bilobed. Leg 4 (fig. 94) with outer edge of exopod first segment similar to that of leg 3. Leg 5 (fig. 95) situated on midlateral margin of genital segment and consisting of a lobe bearing 4 spines, 1 naked and 3 smaller and plumose. Leg 6 (fig. 96) situated at point of attachment of abdomen to genital segment and consisting of lobe bearing 3 spines (1 plumose and 2 naked). Color in life cream, generally devoid of pigment.

Discussion.—This species thus far has been collected only from carcharinid sharks of the western central Pacific Ocean. It is closely related to *P. zygaenae* but can be separated from this species by the nature of the dorsal thoracic plates. The plates of the second thoracic segment of *P. katoi* extend only to about the middle of the plate of the fourth segment, whereas in *P. zygaenae* these plates extend to the distal end of the plate of segment 4. Since the appendages of these 2 species are identical, it seems probable that they have evolved from a common ancestor and thus are very closely related. Because I was able to examine several collections of each species (10 collections of *P. katoi*, 4 collections of *P. zygaenae*), a good sample for comparison was available. In each case the copepods are separated easily on the aforementioned characters.

I have named this species for Mr. Susumu Kato, who originally collected the type material and who has generously collected in the Pacific area for me.

Pandarus zygaenae Brady, 1883

Figures 97–99

Pandarus zygaenae Brady, 1883, p. 134.—Bassett-Smith, 1899, p. 467.—Wilson, 1907, p. 416.

Specimens studied.—Collections from the following areas: Off São Paulo, Brazil, from *Sphyrna zygaena* (Linnaeus); Pacific (9°47′ N, 85°48′ W) from *Sphyrna* species; Pacific (18°31′ N, 109°34′ W) from *Sphyrna zygaena*.

Female.—Body form as in figure 97. Total length (based on an average of 2 specimens) 7.6 mm. Greatest width (measured at the widest part of the cephalon) 3.9 mm. Cephalon somewhat truncated and measuring 3.7 by 3.9 mm, somewhat wider than long. Thoracic plates present on segments 2–4. Plates of segment 2 extending beyond those of segment 3 and to distal border of plate of segment 4. Genital segment somewhat longer than wide (2.7 by 2.3 mm). Abdomen 1-segmented and with dorsal plate. Caudal rami as in *P. katoi* except that they are generally held parallel to each other.

Oral area and all appendages like those of *P. katoi* with the following 2 exceptions: tip of maxilliped of *P. zygaenae* (fig. 98) shaped somewhat differently; endopod of *P. zygaenae* unarmed; spine and setal formula, otherwise, same as *P. katoi*.

Color in preserved material creamy white except for some light brown pigmentation in mature females as indicated in figure 97.

Male.—Body form as in figure 99. Male indistinguishable from male of *P. katoi*. Only 1 male of each species was collected. More material of both species might show some differences between the males of these 2 species. Total length of male of *P. zygaenae* (based on a single specimen) 8.1 mm (length not including setae on caudal rami). Greatest width 4.6 mm.

Discussion.—Brady described this species in 1883 from *Zygaena malleus* collected near Cape Verde Islands. In 1907 Wilson placed the species in synonomy with *Pandarus satyrus*. Wilson examined 2 females from Brady's original collection but noted that the copepods were so covered with "fish slime" as to be difficult to study. I received 2 collections of copepods from the same host with enough material to ascertain that these were not *P. satyrus* but clearly a separate species. A comparison of this new material with Brady's original description and figures prove his species to be valid. The figure of the female by Brady appears to be of an immature form but shows some features consistent with my recent collections, namely, the relative lengths of the dorsal thoracic plates and the fact that the caudal rami are generally held parallel to each other rather than divergent as in most other members of the genus (in preserved specimens).

This species is closely related to *P. katoi* but can be distinguished from it by the relationship of the plates of segment 2 to those of segment 4. *P. zygaenae* so far has been found only on the genus *Zygaena* and may well be confined to species of hammerhead sharks.

Pandarus bicolor Leach, 1816

Figures 100–108

Pandarus bicolor Leach, 1816, p. 405; 1819, p. 535.—Desmarest, 1825, p. 339.—Burmeister, 1833, p. 331.—Krøyer, 1837, p. 202; 1838, p. 34; 1863, p. 261.—Milne-Edwards, 1840, p. 470.—Baird, 1850, p. 288.—Beneden, 1851a, p. 94; 1861, p. 148.—Norman, 1868, p. 301.—Olsson, 1868, p. 21.—Richiardi, 1880, p. 149.—Carus, 1885, p. 362.—Bassett-Smith, 1896, p. 156; 1899, p. 466.—Brian, 1898a, p. 12; 1899, p. 3; 1906, p. 55; 1914b, p. 7; 1940, p.11.—Scott, T., 1900, p. 157.—Scott, A., 1904, p. 40.—Norman and Scott, T., 1906, p. 211.—Wilson, 1907, p. 400; 1932, p. 436; 1935b, p. 778.—Scott, T., and Scott, A., 1913, p. 95.—Hansen, 1923, p. 36.—Scott, A., 1929, p. 95.—Leigh-Sharpe, 1934b, p. 112.—Pesta, 1934, p. 29.—Oorde and Schuurmans Stekhoven, 1936, p. 141.—Stephensen, 1940, p. 5.—Rose and Vaissiere, 1953, p. 86.—Barnard, 1955, p. 257.—Nunes-Ruivo, 1956, p. 17.—Causey, 1960, p. 331.—Heegaard, 1962, p. 177.

Pandarus boscii Leach, 1816, p. 406; 1819, p. 535.—Guérin-Meneville, 1829–1843, p. 41.—Burmeister, 1833, p. 331.—Desmarest, 1825, p. 339.—Krøyer, 1837, p. 202.—Baird, 1850, p. 289.
Caligus bicolor.—Lamarck, 1818, p. 137.
Pandarus fissifrons.—Milne-Edwards, 1840, p. 470.
Pandarus lividus.—Frey and Leuckart, 1847, p. 166.

Specimens studied.—Three collections of females from *Squalus acanthias* Linnaeus caught at the following locations: in the North Sea, eastern North Atlantic (53°04′ N, 04°02′ E), and off the coast of the Netherlands.

Female.—Body form as in figure 100. Total length (based on an average of 2 specimens) 9.1 mm. Greatest width (measured at the widest part of the cephalon) 3.8 mm. Cephalon only about one-third body length, measuring 3.6 by 3.8 mm. Dorsal thoracic plates present on segments 2–4. Plates of segment 2 short and not extending beyond the posterior edge of plates of segment 3. Plate of segment 4 fully exposed. Abdomen 1-segmented (see fig. 101) and covered by broad dorsal plate. Caudal ramus (fig. 101) broad and much shorter than in other species of genus. Caudal rami not obvious in dorsal view. Each ramus armed with 5 short spines.

Oral area as in other members of genus. Since this species has been well reported and amply figured in the literature, only salient features included here. Second antenna (fig. 102) with short claw at tip separated from last segment. In other species of genus these 2 elements are often fused. Maxilliped (fig. 103) with spatulate process at tip of claw.

Legs 1–4 biramose with spine and setal formula as follows:

	leg 1 exp.	end.	*leg 2* exp.	end.	*leg 3* exp.	end.	*leg 4* exp.	end.
seg. 1	I:0	0:0	I:0	0:0	I:0	0:0	VI	I
seg. 2	VI	III	VIII	V	VI	II		

Legs not notably different from other species of genus with exception of reduction in number of spines on last segment of exopod of leg 2 (8 instead of 10) and elongated nature of exopod of leg 4. Legs 1–4 as in figures 104–107. Leg 5 (fig. 108) with outer single spine and inner lobe with 3 spines.

Color cream yellow to dark brown in pigmented areas. Cephalon usually heavily pigmented with eye spots not separated and often joined by median clear stripe extending distally.

Male.—No material available for study. Apparently male of this species is rare, as no collection examined contained one. It is interesting to note that males of *P. carcharini* and *P. niger* (probably closely related to *P. bicolor*) are unknown.

T. and A. Scott (1913) illustrate male of *P. bicolor* and their figures show it to be much the same as other males of the genus.

Spine and setal formula (based on T. and A. Scott's illustrations) are as follows:

	leg 1 exp.	end.	*leg 2* exp.	end.	*leg 3* exp.	end.	*leg 4* exp.	end.
seg. 1	I:0	0:0	I:1	0:1	(not illustrated by the Scotts)			
seg. 2	IV:3	3	IV:6	8				

REMARKS.—This copepod seems to be limited to the waters of the eastern Atlantic and is the primary species of *Pandarus* found in the coastal waters of Europe. It seems to be restricted to smaller inshore species of sharks and, as far as recorded in the literature, is found only on the body surface of its host.

Pandarus bicolor can be easily separated from the other known species of the genus on the basis of the caudal rami. The relative lengths of the dorsal thoracic plates of segments 2 and 3 separate it from all species of the *cranchii* group. This copepod has twice been confused by American authors (Wilson, 1932, and Causey, 1960) with *P. sinuatus* because of the presence of a median stripe from the eye spots to the distal border of the cephalon of both species. I have examined specimens in the U.S. National Museum identified by Wilson as *P. bicolor* and they are clearly *P. sinuatus*.

Finally, I have placed *Pandarus lividus* Frey and Leuckart in synonymy with *P. bicolor*. Wilson (1907) commented that it was impossible to separate the 2 species on the basis of Frey's and Leuckart's description but he did not place it in synonymy. Frey and Leuckart gave no figures of *P. lividus*.

***Pandarus niger* Kirtesinghe, 1950**

FIGURES 109–118

Pandarus niger Kirtesinghe, 1950, p. 83.

SPECIMENS STUDIED.—A female paratype loaned to me by Kirtesinghe, and a single collection of 6 females from *Galeorhinus* species in Formosa.

FEMALE.—Since this species has been described recently by Kirtesinghe (1950), I will be concerned with only those features taxonomically important to the genus. Body form as in figure 109. Total length 8.2 mm (based on an average of 2 specimens). Greatest width (measured at the widest part of the cephalon) 3.8 mm. Cephalon somewhat truncated only about one-half as wide across anterior third as across posterior third. First thoracic segment fused to head. Dorsal thoracic plates present on segments 2–4. Plates of segments 2 and 3 fused basally with posterior borders more or less in a straight line across proximal portion of plate of segment 4. Plate of segment 4 with posterior border nearly straight with only a very slight medial indentation. Genital segment as in other species of genus. Abdomen

1-segmented and with dorsal plate. Dorsal plate small, extending only slightly beyond posterior border of abdomen (see fig. 110). Caudal ramus (fig. 110) long (1.8 mm) and well exposed dorsally.

Oral area as in other members of genus. First antenna (fig. 111) 2-segmented, bearing 22 spines on first segment and 10 naked setae on second segment. Second antenna (fig. 112) with tip produced into a short claw similar to that of *P. bicolor*. First maxilla (fig. 113) with group of short spines on basal third composed of only 2 spines rather than usual 3. Second maxilla (fig. 112) with distal setae in form of fringed claw.

Legs 1–4 (figs. 115–118) biramose and with spine and setal formula as follows:

	leg 1 exp.	end.	*leg 2* exp.	end.	*leg 3* exp.	end.	*leg 4* exp.	end.
seg. 1	I:0	0:0	I:0	0:0	I:0	0:0	VII	II
seg. 2	VI	III	X	VII	VI	III		

Leg 5 (see fig. 110) with an inner lobe and an outer long seta.

Color dark brown except where unpigmented. Eye spots separated in older females.

MALE.—Unknown. Kirtesinghe (1950) illustrates and briefly describes an immature male but not enough is shown to be of value in an analysis of the adult.

REMARKS.—So far this copepod has not been reported from areas other than Ceylon and Formosa. It may well be a parasite restricted to the Indian Ocean and western Pacific. Not enough is known to ascertain its host preferences but inshore carcharinid sharks seem to be preferred hosts.

This copepod is closely related to *P. bicolor*, but the nature of the caudal ramus separates it easily from all other members of the genus. Kirtesinghe (1950) notes the relationship between this species and *P. bicolor;* he also suggests an affinity with *P. satyrus* on the basis of the caudal ramus. A comparative survey of the genus shows this not to be so, especially on that basis since the caudal ramus of *P. satyrus* does not extend beyond the tip of the abdominal plate.

Pandarus carcharini Ho, 1960

FIGURES 119–124

Pandarus carcharini Ho, 1963, p. 93.

SPECIMENS STUDIED.—Paratype female from Formosa loaned to me by Ho. Also 2 more collections of females from Formosa from *Galeorhinus* species and *Carcharinus gangeticus*. Three collections from Nosy Bé, Madagascar, from *Carcharinus leucas*, *C. sorrah*, and *C. limbatus*. A single collection from Durban, South Africa, from *C. leucas*.

Female.—A full description of this species will not be given here since it has been well described recently by Ho (1960). Body form as in figure 119. Total length 9.8 mm (based on an average of 3 specimens). Greatest width 4.9 mm (measured at the widest part of the cephalon). Cephalon somewhat truncated but not as narrowed anteriorly as *P. niger*. First thoracic segment fused with head. Dorsal thoracic plates on segments 2–4 with plates of segments 2 and 3 fused basally, posterior borders forming a straight line as in *P. bicolor* and *P. niger*. Some of the salient features have been figured for the sake of comparison. Caudal rami (fig. 120) intermediate between that of *P. bicolor* and *P. niger*, measuring 1.26 mm in length and extending posteriorly only about as far as the dorsal abdominal plate.

Oral area as in *P. niger*. Appendages of cephalon as in *P. niger* except that first antenna (fig. 121) has 24 spines on first segment and 10 naked setae on last.

Legs 1–4 biramose, with spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:0	0:0	I:0	00:	VIII	I
seg. 2	VI	III	X	VI	VII	II		

Legs 2–4 as in figs. 122–124. Leg 5 as in *P. niger*.

Color creamy yellow with dark brown pigmentation as in figure 119. Eye spots fused. Egg strings of usual type.

Male.—Unknown.

Remarks.—This species described by Ho (1960) from Formosa has been collected by the author in Nosy Bé, Madagascar, from carcharinid sharks. Its range may well be the same as *P. niger* but not enough material has been collected on which to base a definitive conclusion; nevertheless, from what is known, it appears to be a parasite of inshore species of sharks in the Indian Ocean and western Pacific coast.

Pandarus carcharini may be separated from its closely related species (*P. bicolor* and *P. niger*) on the basis of the caudal ramus and the spine and setal formula. Ho (1960) has already cited the similarities between those 3 species. His comparison and description implies the presence of a ventral abdominal plate. I could find no evidence of a ventral plate and, after personal communication with Ho, he agrees that this is synonomous with the abdomen and that the use of the term "plate" is invalid in this case.

Genus *Phyllothereus* Norman 1903

Phyllophora Milne-Edwards, 1840, p. 471. [Type-species: *P. cornutus*.]
Nogagus.—Steenstrup and Lutken, 1861, p. 386. [Refers to *N. grandis* only.]
Laminifera Poche, 1902. [Cite Wilson, 1907, p. 361.]

Phyllothereus Norman, 1903, p. 368.
Parapandarus Wilson, 1924a, p. 7.

FEMALE.—Frontal plate distinctly separate. First thoracic segments 2–4 free and possessing dorsal plates. Dorsal plate of segment 3 extending well beyond distal margin of plates of segment 2. Plates of segment 4 separated. Abdomen 1-segmented and with a dorsal plate. Abdomen or its plate visible dorsally and attached to distal end of genital segment. Caudal rami lateral to abdomen. First antenna 2-segmented. Claw of maxilliped pointed at tip. Adhesion pads absent or much reduced. Legs 1–4 biramose, rami of legs 1–3 2-segmented, those of leg 4 1-segmented. All legs without plumose setae. Leg 5 present. Egg sacs long and straight.

MALE.—No dorsal plates present. Cephalic appendages in general like those of female. Legs 1–4 biramose, all rami 2-segmented bearing plumose setae. Fifth and sixth legs present. Leg 3 endopod unmodified. Abdomen 2-segmented. Caudal rami held at distal end of abdomen. Adhesion pad with first antenna.

DISCUSSION.—A great deal of confusion has existed over the synonymy of this genus. The genus was first described by Milne-Edwards in 1840 as *Phyllophora* with *P. cornutus* as the type-species. Later, in 1861, Steenstrup and Lutken described the male as *Nogagus grandis*. Norman (1903) cited the fact that *Phyllophora* is thrice preoccupied and changed the generic name to *Phyllothereus*. Wilson (1907) discussed the preoccupation of the name *Phyllophora* and stated that Poche in 1902 suggested changing the name to *Laminifera*. This reference to Poche (1902) is in error since there is no reference to the name *Laminifera* by this author in 1902 or in subsequent works (see Brian, 1946). Brian synonymized his *Laminifera doello-juradoi* with *P. cornutus* in 1946; consequently, the valid name of the genus should be *Phyllothereus* as proposed by Norman in 1903. Wilson in 1932 states that his *Parapandarus* is so close to *Phyllothereus* that the 2 may be identical. I have examined Wilson's types of *Parapandarus* and have concluded that they are indeed the same; consequently, *P. nodosus* Wilson 1924 is synonymous with *Phyllothereus cornutus* (Milne-Edwards, 1840).

Phyllothereus cornutus (Milne-Edwards, 1840)

FIGURES 125–138

Phyllophora cornuta Milne-Edwards, 1840, p. 372.
Nogagus grandis Steenstrup and Lutken, 1861, p. 386.
Phyllophorus cornutus—Bassett-Smith, 1899, p. 465.
Phyllothereus cornutus—Norman, 1903, p. 368.—Norman and Scott, 1906, p. 212.—Scott, T., and Scott, A., 1913, p. 92.—Wilson, 1932, p. 440.—Monod and Dollfus, 1938, p. 196.—Brian, 1946, p. 142.
Parapandarus nodosus Wilson, 1924a, p. 7.
Laminifera doello-juradoi Brian, 1944, p. 193; 1946, p. 142.

SPECIMENS STUDIED.—Three collections from *Prionace glauca* in the Indian Ocean (0°58′N, 55°00′E; 0°14′N, 55°00′E; 6°37′S, 55°00′E). Five collections from *Prionace glauca* at various points in the western North Atlantic.

FEMALE.—Body form as in figure 125. Average length of North Atlantic specimens 14.6 mm (based on an average of 5 specimens). Greatest width of North Atlantic specimens 10.3 mm. Average length of Indian Ocean specimens 10.3 mm (based on 4 specimens). Greatest width of Indian Ocean specimens 5.6 mm. Dorsal thoracic plates on segments 2–4. All thoracic plates paired and often greatly inflated in preserved specimens. Genital segment (fig. 126) pear shaped, being widest in posterior third. Abdomen 1-segmented, large, and bearing a dorsal plate that does not cover it when viewed dorsally. Caudal rami as in figure 126 with 4 short spines.

Oral area without adhesion pads. First antenna 2-segmented, first segment with 22 naked spines and last segment with 12 naked spines. Second antenna (fig. 127) with long terminal claw. When second antenna is flattened against oral area, claw extends posteriorly to maxillipeds. Terminal claw bearing 2 short spines. First maxilla (fig. 128) with short stout terminal spine and group of 3 short setae on basal third. Second maxilla (fig. 129) with usual fringed claw and 2 setae at base, 1 large and fringed, other shorter and plumose at tip. Maxilliped (fig. 130) bearing terminal claw with pointed tip and opposed on penultimate segment by a ridge.

Legs 1–4 (fig. 131–134) biramous with rami of legs 1–3 2-segmented and those of leg 4 1-segmented. Spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:0	0:0	I:0	0:0	VIII	III
seg. 2	VII	III	VII	VII	VIII	IV		

Leg 5 (fig. 135) consisting of an inner lobe and single outer seta.

Egg strings long and each composed of a single strand of disclike eggs.

Color whitish yellow.

MALE.—Since the male of this copepod has been well figured and described by Monod and Dollfus (1938), only a few salient features will be mentioned here. Body form as in figure 136. Oral area as in female with the following differences: second antenna smaller, in relation to rest of oral area, than in female; maxilliped with a claw at tip but opposed by 2 adhesive areas rather than 1 as in female (see Monod and Dollfus, 1938, p. 198, fig. 5).

Legs 1–4 biramose and not as highly modified as in female. Spine and setal formula as follows:

	leg 1 exp.	leg 1 end.	leg 2 exp.	leg 2 end.	leg 3 exp.	leg 3 end.	leg 4 exp.	leg 4 end.
seg. 1	I:0	0:0	I:0	0:1	I:0	0:1	I:1	0:1
seg. 2	IV:3	3	IV:6	8	IV:5	6	IV:5	5

Leg 5 (fig. 137) located at beginning of distal third of genital segment and consisting of a ventral lobe bearing 1 outer plumose seta, a group of 2 plumose setae and a naked spine at distal end of lobe. Leg 6 (fig. 138) located on posterior border of genital segment near junction of abdomen and consisting of an outer plumose seta and an inner naked spine.

Discussion.—*Phyllothereus cornutus* is a parasite on the gills and gill arches of a number of species of sharks, but it is most commonly found associated with *Prionace glauca.* It is cosmopolitan in distribution and has been collected by the author in both the Indian Ocean and the North Atlantic. The Indian Ocean specimens were smaller than those collected in the North Atlantic, but a detailed examination of their appendages showed no important differences. Since the same host was involved in both cases, I have concluded that they are of the same species. More collections in intermediate areas might well yield intermediate sizes. The nature of the inflated dorsal plates seems to be a function of the preserving fluid (70 percent alcohol or 10 percent formalin) as this condition has not been observed by me in life.

Genus *Gangliopus* Gerstaecker, 1854

Gangliopus Gerstaecker, 1854, p. 189. [Type-species: *G. pyriformis.*]

Female.—Frontal plate distinctly separate. First thoracic segment fused with cephalon. Thoracic segments 2–4 free and possessing dorsal plates. Dorsal plates of segment 2 small. Plate of segment 3 extending beyond tip of plate of segment 2. Plates of segment 4 partially separated. Abdomen 1-segmented, with a dorsal plate. Abdomen or its plate visible dorsally and attached to distal end of genital segment. Caudal rami lateral to abdomen. First antenna 2-segmented. Claw of maxilliped pointed at tip. Adhesion pads of the first and second antenna absent or reduced. Pad of maxilliped well developed. Legs 1–4 biramose, rami of legs 1–3 2-segmented, those of leg 4 1-segmented. All legs without plumose setae. Leg 5 present. Egg sacs long and held straight.

Male.—No dorsal plates present. Cephalic appendages like those of female. Adhesion pad with first antenna. Legs 1–4 biramose, all rami 2-segmented and bearing plumose setae. Fifth and sixth legs present. Leg 3 endopod unmodified. Caudal rami held at distal end of abdomen.

Gangliopus pyriformis Gerstaecker, 1854

FIGURES 139–146

Gangliopus pyriformis Gerstaecker, 1854, p. 192.—Wilson, 1907, p. 350.—Monod and Dollfus, 1938, p. 204.

Nogagus angustulus Gerstaecker, 1854, p. 193.

Gangliopus tetrapturi Yamaguti and Yamasu, 1960, p. 142.

SPECIMENS STUDIED.—Three collections from *Prionace glauca* in the Indian Ocean (0°58′N, 55°00′E; 0°14′N, 55°00′E; 6°37′S, 55°00′E). One collection from the same host in the North Atlantic (39°32′N, 28°02′W).

FEMALE.—Body form as in figure 139. Total length 9.1 mm (based on an average of 3 specimens). Greatest width 4.9 mm (measured at widest part of the cephalon). Dorsal thoracic plates on segments 2–4. Plates of segment 2 small and not extending to tip of plates of segment 3. Plates of segments 3 and 4 each with a deep median incision. Genital segment nearly square. Abdomen 1-segmented and joining genital segment at posterior border. Abdomen with a small dorsal plate. Caudal rami small and held at lateral angles of abdomen.

Oral area of usual pandarid type. No adhesion pad with first antenna. Adhesion pad of second antenna small and inconspicuous. Adhesion pad of maxilliped large and L-shaped (fig. 140).

Monod and Dollfus (1938) have given a detailed description of female appendages.

Legs 1–4 biramose with spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:0	0:0	I:0	0:0	VII	II
seg. 2	VII	III	X	VI	VIII	III		

Leg 5 (fig. 141) consisting of a single finger-like spine with 2 short setae. Fifth leg near junction of abdomen and genital segment.

Egg strings long and each composed of a single strand.

Color in life pale yellow and without pigment.

MALE.—Body form as in figure 142. Total length 7.4 mm (based on 1 specimen). Greatest width 3.5 mm (measured at widest part of cephalon). Thoracic segments without dorsal plates except for a winglike expansion on the posterolateral corners of segment 2. These extend nearly to end of segment 3. Genital segment (fig. 143) nearly square, 1.75 mm long by 1.85 mm wide. Genital segment with each posterior corner produced into broad lobe. Abdomen 2-segmented. Caudal rami prominent, with 4 long plumose setae and 2 smaller ones at each distal corner.

Oral area as in female except a small adhesion pad associated with first antenna. Adhesion pad of maxilliped small and inconspicuous. Cephalic appendages like those of female except for maxilliped (fig. 144).

Legs 1–4 biramose and with spine and setal formula as follows:

	leg 1 exp.	*leg 1* end.	*leg 2* exp.	*leg 2* end.	*leg 3* exp.	*leg 3* end.	*leg 4* exp.	*leg 4* end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	I:1	0:1
seg. 2	IV:3	3	IV:6	8	IV:5	6	IV:5	5

Leg 5 (fig. 145) located on midlateral edges of genital segment and consisting of 3 plumose setae and 1 short stout spine. Leg 6 (fig. 146) located near junction of abdomen and genital segment and composed of a single plumose seta and a short spine.

Remarks.—*Gangliopus pyriformis* is apparently cosmopolitan in distribution and occurs commonly on the gills of the blue shark, *Prionace glauca*. In 1960 Yamaguti and Yamasu described a new species *Gangliopus tetrapteri*. Since they do not refer to the work of Monod and Dollfus (1938), it is assumed that they were not aware of it. They based their new species on morphological differences which do not exist. Gerstaecker originally described the female as having a 2-segmented abdomen. His original description was very superficial. Monod and Dollfus (1938) updated the work and provided a working description. *Gangliopus tetrapteri* does not differ from this later description nor from my own collections in the Indian Ocean. The male was described under the name *Nogagus angustulus* by Gerstaecker at the same time as the female. No description of the male has appeared since then. I have added salient features to this original description.

Genus *Pseudopandarus* Kirtesinghe, 1950

Pseudopandarus Kirtesinghe, 1950, p. 84. [Type-species: *P. gracilis*.]
Pandarus.—Gnanamuthu, 1951a, p. 1245. [Refers to *P. longus* only.]

Female.—Frontal plate distinctly separate. First thoracic segment fused with cephalon. Thoracic segments 2–4 free and possessing dorsal plates. Dorsal plates of segment 2 small and widely separated. Plate of segment 3 extending beyond tip of plates of segment 2. Abdomen incompletely divided into 2 segments and with a dorsal plate. Abdomen completely or partially concealed beneath genital segment. Abdomen attached to genital segment ventrally. Caudal rami attached terminally to abdomen. First antenna 2-segmented. Claw of maxilliped with a spatulate tip. Adhesion pads present on cephalon. Legs 1–4 biramose. Rami of legs 1–3 2-segmented, those of leg 4 1-segmented. Leg 5 present and consisting of a free segment. Egg sacs long and straight.

Male.—I had no material of the male of this genus to study but the male has been described by Gnanamuthu (1951) and my diagnosis is based on this description.

Body form of typical pandarid configuration. Cephalic appendages like those of female except setae on first antenna are more plumose in male. Legs 1–4 biramose with each ramus composed of 2 segments. All setae plumose. Legs 5 and 6 present. Abdomen 2-segmented. Caudal rami attached distally.

REMARKS.—This genus is known only from the Indo-Pacific area and consists of 2 species from the body surface of sharks of the genera *Carcharinus* and *Triakis*. This genus may well be restricted to inshore sharks.

Key to Females of Genus *Pseudopandarus*

Abdomen concealed in dorsal view, genital segment with posterior corners produced into long pointed processes . . . . **gracilis**

Abdomen partially visible in dorsal view, genital segment with posterior corners rounded and not greatly produced . . . . **longus**

Pseudopandarus gracilis Kirtesinghe, 1950

FIGURES 147–150

Pseudopandarus gracilis Kirtesinghe, 1950, p. 84.
Pseudopandarus scyllii Yamaguti and Yamasu, 1959, p. 124.

SPECIMENS STUDIED.—Paratypes on loan from P. Kirtesinghe. 6 females ex *Scoliodon palasorrah*, Nosy Bé, Madagascar.

FEMALE.—Body form as in figure 147. Total length 4.8 mm (based on an average of 3 specimens). Greatest width 1.75 mm (measured at widest part of the cephalon). Thoracic segments 2–4 with dorsal plates. Plates of segments 2 and 3 fused basally. Plates of segment 2 small and entirely lateral to those of segment 3. Plates of segment 4 covering proximal part of genital segment and fused basally. Posterior edges of plates of segments 3 and 4 often irregular in shape (I noticed this in both samples from Ceylon and Madagascar) Genital segment long (3 mm) and posterior border produced to form 2 lateral projections and median finger-like process. Abdomen (fig. 148) joined ventrally to genital segment and concealed in dorsal view. Abdomen indistinctly divided into 2 segments. A small dorsal plate present on first segment of abdomen and not extending beyond distal tip of second segment. Caudal ramus triangular in shape, widest at distal end, bearing 3 terminal naked spines and outer plumose seta. Two naked subterminal spines located at distal corners (see fig. 148).

Since this species has been well described by Kirtesinghe (1950) and Yamaguti and Yamasu (1959), only a few taxonomically important features of the appendages will be discussed here.

Oral area with prominent adhesion pads with first and second antenna. Adhesion pad of maxilliped small. Second maxilla (fig. 149) with shortest spine feathered at tip. Maxilliped (fig. 150) spatulate at tip.

Legs 1–4 biramose and with spine and setal formula as follows:

	leg 1		leg 2		leg 3		leg 4	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:0	0:0	I:0	0:0	V:3	2
seg. 2	VI	3	IV:5	7	IV:4	3		

Surface of segments of legs 1–4 generously covered with patches of spinules. Leg 5 (see fig. 148) consisting of a free segment bearing 4 naked setae (in one specimen the 2 innermost setae were fused to form a thick spine).

Egg strings long and straight.

Color in preserved specimens cream white with no pigmentation.

Male.—Unknown.

Remarks.—*Pseudopandarus gracilis* was described in 1950 by P. Kirtesinghe and was not reported again until 1959 by Yamaguti and Yamasu. They determined their species to be new, based primarily on the structure of the tip of the maxilliped. Unfortunately, Kirtesinghe's figure of this was misleading. I was fortunate to be able to examine type material of *P. gracilis*, in which I found that there actually were no differences between the two species on this or any other basis and thus have placed *P. scyllii* in synonymy. Yamaguti and Yamasu define the fourth leg as having 2-segmented rami. Their figure shows no articulation between segments. I have interpreted the rami as being 1-segmented. They also refer to the plate of the fourth segment as the structure that I have called the genital segment. The plate of segment 4 actually covers the proximal portion of the genital segment and is the same plate referred to by them as the plate of segment 3. The plates of segments 2 and 3 referred to as one plate belong to segment 2. A careful study of the copepod shows this interpretation to be in error and not consistent with the usual pandarid situation.

To date, this parasite has been found in the Indo-Pacific area only (Madagascar, Ceylon, Japan), parasitic on the body surface of small inshore sharks (*Carcharinus* and *Triakis*).

Pseudopandarus longus **(Gnanamuthu, 1951)**

Figures 151–161

Pandarus longus Gnanamuthu, 1951a, p. 1245.—Kurian, 1955, p. 114.

Specimens studied.—Four females ex *Carcharinus obesus*, 2 females ex *Rhizoprionodon acutus*, both sharks caught off Durban, South Africa.

Female.—Body form as in figure 151. Total length 4.3 mm (based on 1 specimen). Greatest width 1.5 mm. Thoracic plates on segments 2–4. Plates of segment 2 small and extending only to about middle of plates of segment 3. Plate of segment 4 covering proximal end of genital segment. Genital segment long (2.6 mm), over one-half the length of body. Posterior border of genital segment with a broad midian sinus. Abdomen (fig. 152) joined ventrally to genital segment and partially concealed dorsally. Abdomen consisting of 2 incompletely separated segments. Caudal rami held at distal end of abdomen and bearing 4 terminal setae and 2 subterminal setae on outer corners. Outer terminal seta finely plumose.

Oral area with prominent adhesion pads associated with first and second antennae. Adhesion pad of maxilliped evident but somewhat reduced. First antenna (fig. 153) 2-segmented and of typical pandarid type. First segment with 24 spines, most of which are plumose. Last segment with 13 naked setae. Second antenna (fig. 154) with small claw at tip and a large adhesion pad. Mouth tube, mandible, and first maxilla of usual type. Second maxilla (fig. 155) with usual 3 spines at or near tip. Maxilliped (fig. 156) of usual type and with broad spatulate tip on last segment.

Abdomen composed of 2 segments. Caudal rami attached distally.

Remarks.—This copepod was first described by Gnanamuthu in 1951 and assigned to the genus *Pandarus*. On the basis of the diagnostic features of the genus *Pandarus* I have removed this species and placed it in the genus *Pseudopandarus* Kirtesinghe, 1950. A comparison of *P. gracilis* Kirtesinghe and *P. longus* (Gnanamuthu) shows the following common features: the arrangement of the dorsal thoracic plates, the spatulate process of the maxilliped, the prominent first and second antennal adhesion pads with a reduction of the maxilliped pad, the nature of the abdomen and its position in relation to the genital segment, and the free segment of leg 5.

This species, like *P. gracilis*, seems to be Indo-Pacific in distribution (Ceylon and Durban, South Africa). So far, it has been reported only from carcharinid sharks.

Pannosus, new genus

Type-species: *Gangliopus japonicus* (Shiino, 1960).

Female.—Frontal plate distinctly separate. First thoracic segment fused with cephalon. Thoracic segments 2–4 free and possessing dorsal plates. Dorsal plate of segment 3 extending well beyond plates of segment 2. Plates of segment 4 extends well beyond end of plate of segment 3. Plates of segments 3 and 4 fused basally. Abdomen 1-segmented. Caudal rami held laterally on abdomen. Adhesion pads of cephalon well developed. First antenna 2-segmented. Claw of maxilliped spatulate. Legs 1–4 biramose, rami of legs 1–3 2-segmented, those of leg 4 1-segmented. Egg sacs long and straight.

MALE.—Unknown.

REMARKS.—This copepod was described by Shiino in 1960 from a single ovigerous female taken off a hammerhead shark (*Sphyrna zygaenae*) by him. He assigned this new species to the genus *Gangliopus*. After a redescription of the generic diagnosis of this genus, it became apparent that this new copepod did not belong to that genus. Since I have had no material of this species to work with, no further diagnosis of Shiino's species can be made. I have removed this species from the genus *Gangliopus* for the following reasons: (1) Shiino's species show well-developed adhesion pads associated with the first and second antennae; (2) the dorsal thoracic plates of the second segment are well formed in *Pannosus;* (3) the maxilliped of *japonicus* has a spatulate tip whereas in *Gangliopus* the tip is pointed. Shiino does not mention the presence of fifth legs but more material would probably reveal their nature.

Since this copepod does not conform to any known genus, I propose placing it in a new genus *Pannosus*.

The name *Pannosus*, from Latin, meaning "covered with rags," refers to the appearance of the dorsal plates.

Genus *Perissopus* Steenstrup and Lütken, 1861

Perissopus Steenstrup and Lütken, 1861, p. 393. [Type-species: *P. dentatus*.]
Chlamys Beneden, 1892a, p. 227.
Achtheinus Wilson, 1908, p. 450.

FEMALE.—Frontal plate not distinctly separate. First thoracic segment fused with cephalon. Thoracic segments 2–4 free and possessing dorsal plates. Dorsal plate of segment 2 extending to posterior border of plates of segment 3. Plates of segment 4 covering anterior portion of genital segment. Abdomen 1-segmented and attached ventrally to genital segment. Caudal rami rudimentary. First antenna 2-segmented. Second antenna armed with teeth at tip. Mouth parts of typical pandarid type. Adhesion pads present. Maxilliped with small claw and large adhesion pad. Legs 1–4 biramose but much reduced. Rami of legs 1 and 2 2-segmented. Rami of legs 3 and 4 1-segmented. All legs without plumose setae. Legs 5 and 6 present. Egg strings long and straight.

MALE.—Frontal plate separate. No dorsal plates present. Oral area similar to female but with adhesion pads reduced. Maxilliped with a strong terminal claw. Legs 1–4 biramose with each ramus 2-segmented. All setae plumose. Fifth and sixth legs present. Leg 3 endopod unmodified. Abdomen 2-segmented. Caudal rami attached distally to abdomen.

Discussion.—This genus is represented by two species, *Perissopus dentatus* Steenstrup and Lütken 1861 and *P. oblongatus* (Wilson, 1908). A discussion of the history of the synonomy of these species is included in the species descriptions.

Perissopus oblongatus (Wilson, 1908)

Achtheinus oblongatus Wilson, 1908, p. 450.
Achtheinus dentatus Wilson, 1911, p. 630.
Achtheinus pinguis Wilson, 1912, p. 235.
Achtheinus japonicus Wilson, 1922, p. 4.
Achtheinus parvideus Wilson, 1923, p. 7.
Achthcinus intermedius Kurtz, 1924, p. 614.
Achtheinus galeorhini Yamaguti, 1936, p. 11.
Achtheinus platensis Thomsen, 1949, p. 20.
Achtheinus chinesis Thomsen, 1949, p. 23.
Achthcinus impenderus Shen and Wang, 1958, p. 27.

Discussion.—In 1908 Wilson described a new copepod and erected for it a new genus, *Achtheinus*. Since then, 10 species assigned to this genus have been described. A comparison of the description and figures of these species show that they should be included in the genus *Perissopus*. This is apparent when one compares the appendages of the two groups. In both, the second antenna has a hoodlike process bearing spines. The maxillipeds of each bears a reduced claw and the basal segment is in the form of a flattened pad. Legs 1–4 are much reduced in both and are similar in form.

I have grouped all species described in the genus *Achtheinus* as one species. These had been separated on the basis of overall form and not on details of the appendages. It is apparent that we have here a situation like that found in *Perissopus dentatus*—a single species with variation in body form. I have examined Wilson's material of *A. oblongatus*, *A. dentatus*, and *A. pinguis*, and I could find no good basis for keeping them as separate species. On the basis of the descriptions of other species, there is no valid evidence to justify more than one species. Probably the best description of the appendages of this species can be found in Yamaguti's (1936) description of *A. galeorhini*.

This species can be separated from *P. dentatus* on the basis of 2 characters. In *P. dentatus* the posterior corners of the genital segment are sharply angular whereas in *P. oblongatus* they are rounded. In *P. dentatus* the endopods of legs 1–4 are unarmed. In *P. oblongatus* the endopods of legs 1 and 2 and sometimes 3 are armed with short setae.

I did not collect this copepod and more material would certainly be desirable to clarify this situation. It may be that future descriptions will warrant resurrecting some of the previously described species but, on the basis of existing descriptions, this is not justified.

So far, this species has been reported from a number of inshore species of sharks, especially of the genera *Triakis* and *Acanthias*. It is a parasite on the body surface of its host.

Perissopus dentatus Steenstrup and Lütken, 1861

FIGURES 162–189

Perissopus dentatus Steenstrup and Lütken, 1861, p. 393.—Richiardi, 1880, p. 148.
Perissopus communis Rathbun, 1887, p. 560.
Chlamys incisus Beneden, 1892a, p. 227.
Perissopus crenatus Leigh-Sharpe, 1930, p. 7.
Perissopus manuelensis Gnanamuthu, 1951a, p. 1252.
Perissopus travancosiensis Kurian, 1955, p. 108.
Perissopus serratus Heegaard, 1962, p. 175.

SPECIMEN STUDIED.—Five females and 1 male ex *Carcharinus milberti* from Sarasota, Fla., 1 female ex *C. leucas*, Sarasota, Fla., 4 females ex *C. maculipinnis*, Sarasota, Fla., and 3 females ex "shark" from Siboga Expedition, 2 females ex *Mustelus* species Durban, South Africa.

All descriptions and figures refer to specimens from *Carcharinus milberti* unless otherwise stated.

FEMALE.—Body form as in figures 162, 187, 188, and 189. Total length 4.9 mm (based on 1 specimen). Greatest width 3.8 mm (measured at widest part of cephalon). Frontal plate not completely separated from cephalon. First thoracic segment fused with cephalon. Thoracic segments 2–4 free and with dorsal plates. Plates of segment 2 widely separated and extending only to distal tip of plates of segment 3. Plates of segment 4 extending only slightly over proximal portion of genital segment. Genital segment large, comprising about one-half total body length. Shape of genital segment variable (see figs. 162, 187, 188, 189). Abdomen (fig. 163) 1-segmented, nearly hidden in dorsal view. No dorsal plate evident. Caudal rami joined distally to abdomen, articulated on dorsal surface only. Each ramus with 7 short spines along posterior border.

Oral area of usual pandarid type. Adhesion pads moderately developed and associated with first and second antenna and maxilliped. No pad on outer distal corners of cephalon. First antenna (fig. 164) 2-segmented. First segment with 18 spines, armed as in figure. Second segment with 11 naked setae. Second antenna (fig. 165) with small adhesion pad at base, last segment in form of claw with very small spine near base. Tip of claw (fig. 166) with curious hooded appearance. Mouth tube of usual type, labium fringed at tip (fig.

167). Mandible of usual form. First maxilla (fig. 168) consisting of broad basal lobe with short spine at tip and group of 3 short setae. Second maxilla with tip armed as in figure 169. Maxilliped (fig. 170) large. Terminal spine small but opposed by a very broad adhesion area. Surface of adhesion area shows imprint of host denticles suggesting a secretion of a cement-like substance on surface of the maxilliped. The maxilliped can be easily pulled off the copepod when removing the parasite from the host.

Legs 1–4 (figs. 171–174) biramose. Spine and setal formula as follows:

	leg 1 exp.	end.	*leg 2* exp.	end.	*leg 3* exp.	end.	*leg 4* exp.	end.
seg. 1	I:0	0:0	I:0	0:0	IV	0	IV	0
seg. 2	IV	0	IV	0				

Legs 1–4 small and weakly developed. Endopod of all legs unarmed except for patches of spinules. Segmentation reduced in legs 3 and 4. Leg 5 (fig. 175) consisting of a single lobe with 4 naked setae, situated near the ventral distal corner of genital segment (see fig. 163). Leg 6 (fig. 176) consisting of 2 unarmed lobes located near junction of abdomen and genital segment (see fig. 163).

Egg strings long and straight.

Color in life cream white without pigmentation.

MALE.—Body form as in figure 177. Total length 2.9 mm (based on 1 specimen). Greatest width 1.4 mm (measured at widest point of cephalon). Cephalon rounded. Frontal plate distinctly separate. Thoracic segments 2–4 free. No dorsal plates present. Genital segment longer than wide with posterior corners rounded and scarcely projecting posteriorly. Spermatophores visible within. Abdomen 2-segmented. Caudal ramus (fig. 178) about as long as wide with 4 long terminal plumose setae and 2 short subterminal ones on distal corners of each ramus. Four terminal setae all nearly equal in length.

Oral area similar to that of female. Adhesion pads reduced. First antenna as in female. Second antenna as in figure 179. Oral appendages as in female. Maxilliped (fig. 180) with a strong terminal claw opposed by an area of heavy ridges on basal segment.

Legs 1–4 biramose. Spine and setal formula as follows:

	leg 1 exp.	end.	*leg 2* exp.	end.	*leg 3* exp.	end.	*leg 4* exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	I:1	0:1
seg. 2	III:4	3	III:6	8	II:6	6	III:5	4

Leg 1 (fig. 181) with each ramus 2-segmented but exopod only weakly divided into 2 segments. Legs 2–4 (figs. 182–184) with each ramus strongly divided into 2 segments. All setae plumose. Leg 5 (fig.

185) located on midlateral edge of genital segment and consisting of a group of 3 setae and 1 stout spine. All setae naked, spine finely barbed. Leg 6 (fig. 186) located near junction of abdomen and genital segment and consisting of a single naked seta and a finely barbed stout spine.

Color in life cream white, no pigment.

REMARKS.—To date, 7 species of *Perissopus* have been described. I have examined material of this genus from several hosts and noted wide variation in body form. A closer examination of the appendages showed no differences between one form and another. Unfortunately, I had only a few specimens of each type available. Figure 187 shows an adult female from *Carcharinus leucas*, Sarasota, Fla. Its measurements are 4.4 by 2.2 mm. Figure 188 is an adult female from *Carcharinus maculipinnis*, Sarasota, Fla. (3.9 by 2.4 mm). Figure 189 is an adult female from the Siboga Expedition to the Indo-Pacific, host recorded only as a "shark." It measures 3.8 by 2.2 mm. A cursory examination of these would indicate more than one species, but I must, on the basis of the few specimens available, concur with Capart (1953), who noticed this same variation and concluded that they should be treated as 1 species.

More material from these and other hosts may favor splitting the genus into a number of species but, in the face of so small a sample, I do not feel justified in doing this at the moment. One would expect to find at least minor differences in the finer details if they are indeed separate species. None seem to exist. I have thus placed all known species in synonymy as *Perissopus dentatus*. Apparently Heegaard (1962) did not know of the new species of Gnanamuthu or Kurian when he described *Perissopus serratus*.

Perissopus dentatus seems to be a parasite of inshore species of sharks. The copepod is often found externally attached near the nares and less often near the posterior border of the fins. It is the only pandarid that attaches to its host by the use of cement. As pointed out above, the maxilliped of the female bears a very large pad that, upon removal of the copepod from the host, often shows denticles or the impression of denticles adhering to the surface of this pad. This adaption may be due to the rather hazardous area of attachment on the host (nose). Undoubtedly the nose of the host is often bumped, thus requiring an effective hold-fast structure if the parasite is to remain on the host.

The male is described here for the first time. It was attached to a female when found.

Genus *Dinemoura* Latreille, 1829

Caligus Müller, 1785, p. 132. [Refers to *C. productus* only.]
Dinemoura Latreille, 1829, p. 197. [Type-species: *D. producta*.]
Binoculus Nordman, 1832, p. 38.
Dinematura Burmeister, 1833, p. 284.
Pandarus.—Baird, 1850, p. 286. [Refers to *P. lamnae* only.]
Nogagus.—Milne-Edwards, 1840, p. 460. [Refers to *N. gracilis* only.]

FEMALE.—Frontal plate distinctly separate. Thoracic segments 2–4 free. Dorsal thoracic plates on segment 4. Genital segment large. Abdomen 2-segmented and joined to genital segment ventrally. Caudal rami broad. Oral area with or without adhesion pads. Adhesion pad of first antenna double when present. Second maxilla with a patch of long setules at base of terminal claw. Maxilliped with small terminal claw. Legs 1–4 biramose. Rami of leg 1 2-segmented. Rami of legs 2 and 3 3-segmented. Rami of leg 4 1-segmented and in form of broad lamellae. Egg strings long and straight or folded.

MALE.—Body form of usual pandarid type. Dorsal plate of segment 4 reduced. Abdomen 2-segmented. Caudal rami large. Oral area as in female. Legs 1–4 biramose. Legs as in female with the following exceptions: terminal segment of endopod of leg 3 modified; leg 4 rami 2-segmented; legs 5 and 6 present.

DISCUSSION.—The genus *Dinemoura* occurs on the body surface of large pelagic sharks. The genus is represented by 4 valid species.

There has been much confusion in the literature over the generic name of this group. In 1829 Latreille separated *Caligus productus* Müller from the genus *Caligus* and assigned it to a new genus, *Dinemoura*. In 1832 Nordman used the name *Binoculus* but this was preoccupied by Geoffroy in 1792 for a phyllopod genus. Burmeister changed the name *Dinemoura* to *Dinematura* in 1833 because the etymology of the word *Dinemoura* was incorrect. Since then, the 2 names have appeared with almost equal frequency. Yamaguti (1963) suggested that the original name be the proper one. According to Article 33a of the "International Code of Zoological Nomenclature," this viewpoint is correct. Burmeister's change was an "unjustified emendation" and cannot stand. Not enough is known of the males of the 4 species on which to base a key, but one is provided below for the females.

Key to Females of Genus *Dinemoura*

1. Adhesion pads conspicuous on oral area 2
   Adhesion pads absent or reduced on oral area 3
2. Genital segment about ½ body length. Dorsal plates of segment 4 wider than long . . . . **latifolia**
   Genital segment about ⅔ body length. Dorsal plates of segment 4 longer than wide . . . . **producta**

3. Posterior corners of genital segment not greatly produced and rounded. **ferox**
Posterior corners of genital segment greatly produced and truncated. **discrepans**

Dinemoura producta (Müller, 1785)

FIGURES 190, 191

Caligus productus Müller, 1785, p. 132.
Dinemoura producta.—Latreille, 1829, p. 197.—Krøyer, 1837, p. 202.—Scott, T., 1901, p. 124.—Scott, T., and Scott, A., 1913, p. 86.—Norman and Scott, T., 1906, p. 211.—Norman and Brady, 1910, p. 404.—Fage, 1923, p. 281.—Pesta, 1934. p. 27.—Oorde and Schuurmans Stekhoven, 1936, p. 139.—Matthews and Parker, 1950, p. 568.—Barnard, 1955, p. 262.—Delamare-Deboutteville and Nunes-Ruivo, 1958, p. 223.
Binoculus productus.—Nordman, 1832, p. 38.
Dinematura gracilis Burmeister, 1833, p. 284.
Dinematura producta.—Burmeister, 1833, p. 331.—Steenstrup and Lütken, 1861, p. 370.—Norman, 1868, p. 301.—Bassett-Smith, 1899, p. 463.—Scott, T., 1900, p. 156.—Brian, 1906, p. 52; 1911, p. 197; 1944, p. 202.—Wilson, 1907, p. 380; 1923, p. 8; 1932, p. 431.—Hansen, 1923, p. 35.—Scott, A., 1929, p. 95—Pesta, 1934, p. 27.—Heegaard, 1943b, p. 26; 1945, p. 15.—Delamare-Deboutteville, 1948, p. 446.—Matthews and Parker, 1950, p. 568.—Rose and Vaissiére, 1953, p. 86.—Yamaguti, 1963, p. 117.
Pandarus lamnae Johnston, 1835, p. 203.
Nogagus gracilis.—Milne-Edwards, 1840, p. 460.
Dinemoura lamnae Baird, 1850, p. 286.
Nogagus productus.—Gerstaecker, 1853, p. 63.
Dinematura lamnae.—Krøyer, 1863, p. 179.
Dinematura affinis Thomsen, 1949, p. 14.—Shiino, 1957, p. 365.

SPECIMENS STUDIED.—Single collections from each of the following hosts: *Isurus oxyrhynchus* Rafinesque (35 00′N, 70 00′W), *Prionace glauca* (Linnaeus) (39 32′N, 28 02′W), *Carcharodon carcharias* (Linnaeus) off Boothbay Harbor, Maine, *Cetorhinus maximus* (Gunnerus) on loan from Zoological Museum in Amsterdam.

FEMALE.—A good description of the female of this species has been given as recently as 1957 by Shiino. His description is of *Dinematura affinis* but, since this is synonymous with *Dinemoura producta*, the figures and description apply. I will therefore only point out salient features.

Body form as in figure 190. Total length (based on an average of 2 specimens) 18.5 mm. Greatest width 8.0 mm. Dorsal thoracic plates, present only on segment 4 fused basally and covering the anterior third of the genital segment. Genital segment about ⅔ body length. Caudal rami broad and with setae placed laterally. (Wilson, 1907, showed them as terminal, but in all specimens I examined they are laterally displaced.) Oral area as in figure 191. First antenna 2-segmented and bearing stout spinose spines on first segment and short naked setae on terminus of last segment. Second antenna with a stout claw, sharply bent at tip. Mandible of usual type with 12 teeth on tip and projecting within mouth tube as in other members of group. First maxilla of 2 segments with a palplike process bearing 3 short setae on first segment. Second maxilla with usual fringe claw at tip, a stout subterminal spine and a subterminal patch of long hairs. Maxilliped with a short claw at tip.

Legs 1–4 biramose. Rami of leg 1 2-segmented. Rami of legs 2 and 3 3-segmented. Rami of leg 4 1-segmented and modified to form broad lamellae. Spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	V	0
seg. 2	IV:3	3	I:1	0:2	I:1	0:2		
seg. 3	–	–	III:5	6	III:5	4		

Leg 5 consisting of a small process bearing 2 short spines, outer plumose the inner naked. Leg 5 located near junction of abdomen and genital segment.

Egg strings long and straight.

Color in life cream, generally devoid of pigment.

MALE.—The male of this species was first described by Wilson (1923). Because I had no material of the male of this genus, I am unable to expand Wilson's work. He failed to mention any modification of the endopod of leg 3. Based on evidence in other members of the genus, this modification should be present. On the basis of Wilson's work the male appendages appear to be very similar to those of the female, except that the fourth leg of the male is not modified into broad lamellae as in the female but rather each ramus is 2-segmented and bears spines and setae.

REMARKS.—This copepod has a very long and confusing history. It has been described or recorded under 11 different names. Many of the synonyms have been noted in the literature previously (mainly Wilson, 1907) but I have, in addition to these, placed *D. affinis*, Thomsen, 1949, in synonymy with *D. producta*. Shiino (1957) described and illustrated *D. affinis* from Japan. These descriptions agree with material I have collected and identified as *D. producta* from the Atlantic from 4 different hosts, including the same host from which Thomsen described *D. affinis*. In view of this, I feel certain that only one species of copepod is involved here.

D. producta is found on several species of pelagic sharks but is most commonly associated with sharks of the genera *Lamna* and *Isurus*. It is probably worldwide in distribution.

Dinemoura ferox (Krøyer, 1838)

FIGURES 192, 193

Dinematura ferox Krøyer, 1838, p. 40.—Steenstrup and Lütken, 1861, p. 376.—Olsson, 1868, p. 17.—Meirs, 1880, p. 71.—Bassett-Smith, 1899, p. 463.—Wilson, 1907, p. 377; 1920, p. 7.—Hansen, 1923, p. 33.—Stephensen, 1940, p. 5.—Yamaguti, 1963, p. 117.
Dinemoura ferox.—Milne-Edwards, 1840, p. 465.
Dinemoura elongatus Beneden, 1857, p. 226.
Dinematura carcharodonti Thomson, 1889, p. 360.

SPECIMENS STUDIED.—Two collections from the U.S. National Museum: USNM 12036 from a shark caught off Iceland, USNM 37783 (no collection data).

FEMALE.—Body form as in figure 192. Total length 32 mm (based on 1 specimen). Greatest width 10 mm. The female of this species has been well illustrated by Krøyer (1838) and Steenstrup and Lütken (1861) so that I will not repeat the figures here. Dorsal thoracic plates on segment 4. Plates extending slightly over proximal portion of genital segment. Genital segment large, about one-half body length. Abdomen 2-segmented. First segment bearing lateral wing-like projections. Caudal rami large and with 4 short spines along distal margin. Oral area as in figure 193. No adhesion pads associated with first and second antenna. A small pad with maxilliped. Oral appendages as in *D. producta*. The claw of the maxilliped is larger in *D. ferox* than in *D. producta*.

Legs 1–4 as in figure 193. Spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	IV	IV
seg. 2	IV:3	3	I:1	0:2	I:1	0:2		
seg. 3			III:5	6	III:5	4		

Legs 5 and 6 represented by a series of lobes on posterior ventral surface of genital segment (see fig. 193). Lobes nearest to attachment of abdomen probably represent leg 6. Single most posterior lobe undoubtedly represents leg 5.

Egg strings long and straight.

Color in preserved specimens cream yellow and lacking pigment.

MALE.—Hansen (1932) described a copepod identified by Krøyer as the male of *D. ferox*. He did not mention the presence of spermatophores which should be the foremost character relating to its sex. The fourth legs are not modified as in the female. The description in general is insufficient; that this is actually the male of *D. ferox* is inconclusive. It appears to be of the genus, however. Consequently, the male of this species still remains poorly known and perhaps even yet to be described.

Discussion.—*Dinemoura ferox* is the largest pandarid copepod yet described. It is almost twice as long as its next largest relative. This alone easily separates it from other members of the group. It has been reported only from sharks from the North Atlantic in the area of Greenland. The known hosts are *Somniosus microcephalus* (Bloch and Schneider), reported by Wilson (1920), and *Centrophorus squamosus* Müller and Henle, reported by Hansen (1923). Miers (1880) reported this copepod taken off the "Greenland shark" and noted that the copepods were usually but not always found attached to the eyes of the host.

Dinemoura latifolia (Steenstrup and Lutken, 1861)

Figures 194–196

Dinematura latifolia Steenstrup and Lütken, 1861, p. 378.—Heller, 1868, p. 199.—Richiardi, 1880, p. 148.—Valle, 1880, p. 60.—Carus, 1884, p. 390.—Brian, 1898b, p. 14; 1899, p. 4; 1902, p. 17; 1906, p. 52; 1944, p. 201.—Bassett-Smith, 1899, p. 463.—Wilson, 1907, p. 383; 1923, p. 15; 1932, p. 432; 1935b, p. 778.—Yamaguti, 1936, p. 9; 1963, p. 117.—Shiino, 1954, p. 318; 1957, p. 365.—Delamare-Deboutteville and Nunes-Ruivo, 1954, p. 204.—Barnard, 1955, p. 263.—Heegaard, 1962, p. 177.

Specimen studied.—Two collections from *Isurus oxyrinchus* Rafinesque in the North Atlantic (42°18′N, 64°02′W; 35°00′N, 70°00′W). A single collection from the same host in the Indian Ocean (8°55′S, 55°08′E).

Female.—Body form as in figure 194. Total length 14.5 mm (based on an average of 5 specimens). Greatest width 8.2 mm. Dorsal thoracic plates on segment 4 projecting posteriorly over the anterior portion of genital segment. Genital segment about one-half body length. Abdomen 2-segmented, each segment with a dorsal plate. Caudal rami large, each bearing 4 setae. Oral area as in figure 195.

Since the female of this species has been well described and figured by Yamaguti (1936) and Shiino (1954), I will only discuss salient features. Adhesion pads associated with first and second antenna and maxilliped. Oral appendages similar to those of *D. producta*.

Legs 1–4 biramose with spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:0	V	0
seg. 2	IV:3	3	I:1	0:2	I:1	0:2		
seg. 3			III:5	6	III:5	4		

Shiino (1947) stated that the fifth legs are still undiscovered. I have figured the posteroventral surface of the genital segment (fig. 196). This region shows 2 areas representing legs 5 and 6. I have interpreted the single, broad, spatulate process as belonging to leg 5 and the curved, clawlike process at the junction of the genital segment and abdomen as leg 6.

MALE.—The male of this species has been described with some figures by Wilson (1907). Because I had no material of the male of this species, I am unable to amplify this description. Wilson did show some modification on the endopod of leg 3 (Wilson, 1907, p. xxv, fig. 103) which supports my contention that this is characteristic of the males of the entire group II of the family. The figures and description are incomplete and more material would certainly be desirable to complete the male description of this species. He stated that the fourth legs are not laminate as in the female but each ramus is 2-jointed and bearing spines and setae. He did not figure this appendage.

DISCUSSION.—This is a fairly common species occurring on the body surface of a number of pelagic sharks of the genera *Isurus*, *Lamna*, and *Carcharodon*. These 3 genera of sharks compose the family *Isuridae* (after Bigelow and Schroeder, 1948). The parasite may well be restricted to that group. It is easily separated from members of the genus by the shape of the dorsal thoracic plates.

Dinemoura discrepans, new species

FIGURES 197–217

SPECIMENS STUDIED.—Eighteen females and 13 males from the body surface of *Alopias vulpinus* (Bonneterre) from the Indian Ocean (9°24′N, 54°58′E). Holotype female (USNM 113592), allotype male, and 10 paratypes (5♀♀, 5♂♂) deposited in alcohol in the U.S. National Museum, 10 paratypes (5♀♀, 5♂♂) in the British Museum (Natural History), and the remaining paratypes in the author's collection.

Other specimens studied: a single collection from *Alopias vulpinis* in the Indian Ocean (7°17′N, 55°00′E); a single collection from *Alopias superciliosus* (Lowe) from Nosy Bé, Madagascar; a single collection from *Alopias superciliosus* from the Pacific Ocean (0°38′N, 124°23′W).

FEMALE.—Body form as in figure 197. Total length 13.9 mm (based on an average of 5 specimens). Greatest width 6.7 mm (measured at widest part of cephalon). Cephalon rounded, 6.7 mm by 6.2 mm, slightly wider than long. Thoracic segments 2–4 free. Posterior corners of segment 2 produced to form winglike expansions. Dorsal plates present on segment 4. Plate of segment 4 extending only slightly over anterior portion of genital segment with their posterior borders serrate. Plates widely separated. Genital segment longer than wide (5.7 by 3.9 mm). Posterior corners of genital segment produced and truncated. Abdomen 2-segmented. Each segment bearing a dorsal plate. Plate of segment 1 bilobed. Plate of segment 2 single. Caudal ramus large (1.6 by 0.8 mm) and bearing 6 short, naked spines.

Oral area as in figure 198. Adhesion pads reduced. First antenna (fig. 199) 2-segmented. First segment with 29 short, stout spines (majority of the spines covered with spinules). Second segment with 14 naked setae. Second antenna (fig. 200) with a terminal claw recurved at tip, with 2 short spines along outer edge. Small adhesion areas on the penultimate segment. Mandible (fig. 201) of the usual type with 11 teeth at tip (fig. 202). First maxilla (see fig. 201) a broad lobe with a group of 3 setae near base and a broad terminal spine. Second maxilla (fig. 202) with terminal claw subdivided into 2 segments (fig. 204). Terminal segment with short rows of fringe. Penultimate segment with group of broad bladelike setae on inner distal corner and surface of segment covered with stout setules. Antepenultimate segment with large spine and patch of hairs at inner distal corner. Maxilliped (fig. 205) with strong terminal claw.

Legs 1–4 biramose. Spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:0	4	0
seg. 2	IV:3	3	I:1	0:2	IV:6	0:2		
seg. 3			III:5			4		

Leg 1 (fig. 206) with both rami 2-segmented. No adhesion pads on the rami. Leg 2 (fig. 207) with each ramus 3-segmented. Outer edge of first exopod segment striated as an adhesion area. Outer edges of other exopod segments serrated. Leg 3 (fig. 208) with exopod of only 2 clearly separated segments. Terminal segment shows some evidence of being subdivided but indicates a fusion of last 2 segments. Leg 4 with each ramus in shape of a broad lamella (see fig. 198). Exopod bearing 4 short spines. Endopod unarmed. Leg 5 (see fig. 209) a single lobe with 1 small setae. Leg 6 (see fig. 219) located near junction of abdomen and genital segment and composed of 2 spatulate processes projecting under lateral extensions of first abdominal segment. Two sclerotized areas located on the midline of genital segment. These probably function in attachment of spermatophores.

Egg strings long and folded (fig. 210) forming 3 strands.

Color in life cream and without pigmentation.

Male.—Body form as in figure 211. Total length 9.7 mm (based on an average of 2 specimens). Greatest width 5.1 mm (measured at the widest part of the cephalon). Cephalon about one-half body length. Dorsal thoracic plates present on segment 4 and similar to those of female. Genital segment with posterior corners produced to form lobes serrate on posterior border (see fig. 212). Genital segment slightly longer than wide (2.8 by 2.3 mm). Abdomen 2-segmented and without dorsal plates. Caudal rami as in female.

Oral area as in female. Legs 1–3 as in female except for a modification on endopod of leg 3 (fig. 213). This appendage may be used in the transfer of spermatophores to female. Leg 4 (fig. 214) with rami 2-segmented and not modified in form of lamellae. Spine and setal formula of legs 1–4 as follows:

	eg 1		*leg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:0	I:0	0:1
seg. 2	IV:3	3	I:1	0:2	IV:6	0:2	VI	III
seg. 3		III:5	6	6		4		

Leg 5 (fig. 215) located at the midpoint of the lateral margin and composed of an outer lobe with 2 setae (outer plumose, inner naked) and an inner lobe with a single naked setae. Leg 6 (fig. 216) near junction of abdomen and genital segment and consisting of a small process bearing a single naked spine.

Spermatophores (fig. 217) attach to female and cross to opposite seminal receptacle as in other members of the family. It is less obvious in this group since the spermatophores lie side by side in close proximity to each other. Figure 217 shows one spermatophore removed to reveal neck of the other spermatophore crossing to receptacle of other side.

Color cream white as in female and devoid of pigmentation.

Discussion.—This parasite seems to be specific to sharks of the genus *Alopias*. I have examined material from the Indian Ocean and Pacific and it may well be found throughout the range of the host genus. This species is easily separated from the known members of the genus by the shape of the genital segment and nature of the dorsal thoracic plates. It is found on the body surface of the host and, from my own experience, seems to favor the undersurface of the host in the region of the cloaca. The description of the male should give pertinent information regarding the nature of the lesser known males of other species of this genus. The modification of the endopod of leg 3 is quite distinct. It is interesting to note that the male and female are much more alike than in members of group I of this family. This may prove to be a consistent difference between these two groups.

The word *discrepans* is from Latin, meaning "to differ."

Genus *Demoleus* Heller, 1865

Caligus.—Otto, 1821, p. 15. [Refers to *C. heptatus* only.]
Binoculus.—Nordman, 1832, p. 32. [Refers to *B. sexsetaceus* only.]
Dinematura.—Burmeister, 1833, p. 331. [Refers to *D. sexsetaceus* only.]
Nogagus.—Gerstaecker, 1853, p. 63. [Refers to *N. productus* only.]
Demoleus.—Heller, 1868, p. 199. [Type-species: *D. paradoxus*.]

FEMALE.—Frontal plate distinctly separate. Thoracic segments 2–4 free. Dorsal thoracic plates on segment 4 only. Abdomen 1-segmented and with a dorsal plate. Caudal rami large. Oral area with adhesion pads associated with first and second antenna, maxilliped and an additional pad between bases of the maxillipeds. Oral appendages of usual type. The second antenna with terminal hook-like spine reduced. Penultimate segment of second maxilla with large spine and patch of stout setules on distal corner. Legs 1–4 biramose; all rami 2-segmented. Legs 5 and 6 present. Egg strings folded.

MALE.—Body form of usual type. No dorsal plates present. Oral area similar to that of female. Appendages similar to female except for a modification on endopod of third leg of male. Males of this genus are poorly known.

DISCUSSION.—At present there are 2 species in this genus. *D. heptatus*, female, is well known and is amply recorded in the literature principally as an external parasite of *Hexanchus*. *D. latus* is reported by Shiino (1954) from *Acanthidium eglantina* (Jordan and Snyder) and I have examined material from *Squalus acutipinnis* Regan. Both of these hosts are members of the family Squalidae.

The adhesion process between bases of maxillipeds is not found in any other genus in this family. This character alone sets it apart from other pandarid copepods.

Key to Females of Genus *Demoleus*

Genital segment covering the dorsal abdominal plate. Egg strings exposed. **heptatus**

Genital segment only covering about ½ of the dorsal abdominal plate. Egg strings hidden . . . . **latus**

Demoleus heptatus (Otto, 1821)

FIGURES 218–237

Caligus heptatus.—Otto, 1821, p. 15.
Caligus paradoxus Otto, 1828, p. 352.
Binoculus sexsetaceus Nordman, 1832, p. 32.
Dinematura sexsetaceus.—Burmeister, 1833, p. 331.
Nogagus productus Gerstaecker, 1853, p. 64.

Demoleus paradoxus.—Heller, 1868, p. 199.—Carus, 1884, p. 361.—Bassett-Smith, 1899, p. 460.—Pearson, 1905, p. 166.—Brian, 1906, p. 50.—Wilson, 1907, p. 349; 1935b, p. 778.—Scott, T., and Scott, A., 1913, p. 79.—Rose and Vaissiere, 1953, p. 85.

Demoleus heptatus.—Dollfus, 1943, p. 1.—Yamaguti, 1963, p. 115.

Specimens studied.—Eleven females and 1 male USNM 60465 from *Hexanchus* species from Monterey Bay, California.

Female.—Body form as in figure 218. Total length 12.5 mm (based on a single specimen). Greatest width 4.5 mm (measured at widest part of cephalon). Carapace rounded about as long as wide. Dorsal thoracic plates present on segment 4. Plates extending only slightly over anterior portion of genital segment. Genital segment 5.8 mm long and 3.1 mm wide, about one-half body length. Posterior corners produced dorsally and extending as rounded lobes over abdomen and caudal rami. Abdomen (see fig. 219) 1-segmented and with a large dorsal plate. Caudal rami large (2.6 by 1.3 mm), joined to the abdomen distally (see fig. 219). Each ramus with 6 naked setae, innermost and outermost very short.

Oral area (fig. 220) with adhesion pads associated with first and second antenna and maxilliped. Adhesion pads small and not well developed. A padlike process located between bases of maxillipeds (fig. 221). This process is directed posteriorly and has a pad at tip. Pad is divided by a median line suggesting a fusion of 2 pads. First antenna (fig. 222) 2-segmented. First segment with 28 spines and setae armed as in figure. Last segment with 9 naked setae. Second antenna (fig. 223) small. Terminal claw not well developed. Adhesion area near base. Mouth tube of the usual form. Mandible with 12 teeth at tip. First maxilla (fig. 224) composed of a lobe with articulated process at tip and basal process bearing 3 short spines. Second maxilla of usual form. Terminal claw (fig. 225) subdivided. Distal segment with rows of fringes as in figure. Subterminal segment with patch of spines. Penultimate segment bearing prominent spinose spine and group of long hairs. Maxilliped (fig. 226) with terminal claw opposed by sclerotized protuberances on basal segment.

Legs 1–4 (figs. 227–230) biramose. Spine and setal formula as follows:

	leg 1 exp.	end.	*leg 2* exp.	end.	*leg 3* exp.	end.	*leg 4* exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	I:1	0:1
seg. 2	IV:3	3	IV:5	8	IV:5	6	IV:5	5

Leg 5 (fig. 231) located on ventral surface of genital segment near lateral margin (see fig. 219) and composed of single lobe with 2 naked spines. Leg 6 (fig. 232) at area of spermatophore attachment and modified to assist in this function.

Egg strings folded to form 3 strands.

MALE.—Body form as in figure 233. Total length 9 mm (based on 1 specimen). Greatest width 3.4 mm. No dorsal plates present. Oral area as in female. First antenna as in female. Second antenna (fig. 234) with clawlike tip. Penultimate segment with stout hooklike spine at midpoint. Other oral appendages as in female. Maxilliped (fig. 235) with long terminal claw opposed by 4 adhesive areas on preceding segments. Legs 1–4 as in female except for modification of last segment of endopod of leg 3 (fig. 236). Leg 5 single lobe with 2 or 3 setae. In the only specimen I was able to observe one leg was broken and the other was not clear. Leg 5 located along margin of genital segment near midpoint. Leg 6 (fig. 237) located near junction of abdomen and genital segment and composed of a single lobe with 2 naked setae.

DISCUSSION.—*Demoleus heptatus* has been described and its synonymy considered recently by Dollfus (1943). The male is poorly known and has been elaborated here on the basis of a single specimen. This parasite seems to be most common on sharks of the genus *Hexanchus*.

Wilson designates *Nogagus grandis* Steenstrup and Lütken as the male. This has been shown to be the male of *Phyllothyreus cornutus* Milne-Edwards. The true male is not well known and the single specimen that I studied may be the first record of the true male of this species.

Demoleus latus Shiino, 1954

FIGURES 238–242

Demoleus latus Shiino, 1954, p. 325.

SPECIMENS STUDIED.—A single collection of 12 females from the *Discovery* Collections, collected off Cape Trawler, July 8, 1927, from *Squalus acutipinnis*.

FEMALE.—This species has been well described and figured by Shiino (1954). Except for the inclusion of a few details omitted in the original description, I will only present a superficial overall descripton here.

Body form as in figure 238. Total length 9.2 mm. (based on an average of 3 specimens). Greatest width 3.1 mm. (measured at widest part of genital segment). Dorsal thoracic plates present on segment 4. Genital segment about one-half body length. Abdomen 1-segmented and with broad dorsal plate. Caudal ramus broad, with 4 terminal naked setae.

Oral area (fig. 239) and associated appendages well described by Shiino except that it is worth noting that there is an adhesive pad between the bases of the maxillipeds as in *D. heptatus*.

Legs 1–4 biramose, with spine and setal formula as follows:

	leg 1 exp.	leg 1 end.	leg 2 exp.	leg 2 end.	leg 3 exp.	leg 3 end.	leg 4 exp.	leg 4 end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	I:1	0:1
seg. 2	IV:3	3	IV:5	8	IV:5	5	III:5	4

Leg 5 (fig. 240) located ventrally near outer distal corner of genital segment and composed of a signle lobe bearing a short plumose seta. Leg 6 (fig. 241) located near junction of abdomen and genital segment and represented by a finger-like lobe.

Egg strings coiled and not protruding (fig. 242), remaining hidden between dorsal abdomen plate and abdomen.

Color in preserved specimens cream and devoid of pigmentation.

MALE.—Unknown.

DISCUSSION.—I have been able to supplement the original description on a few points, particularly the nature of the 5th and 6th legs and the egg strings. The specimens I received were still attached to pieces of fin from the host shark. I noticed that the copepods were attached to the lighter pigmented surface (presumably lower) of the fin. This would indicate that in this instance the pectoral or pelvic fins were involved.

This is only the second record of this copepod; consequently, too little is known about the species to draw any conclusions regarding its host specificity or geographic distribution.

This species is easily separated from *D. heptatus* by the nature of the abdomen and general configuration of the body.

Genus *Pagina* Cressey, 1964

Pagina Cressey, 1964, p. 285. [Type-species: *P. tunica*.]

FEMALE.—Frontal plate distinctly separate. First thoracic segment fused with cephalon. Thoracic segments 2–4 free. Second and third thoracic segments without dorsal plates. Fourth segment with a dorsal plate. Abdomen 2-segmented, each segment with a dorsal plate. Abdomen attached to distal end of genital segment and visable dorsally. Cephalic appendages of typical pandarid type. Legs 1–4 biramose; rami of leg 1 2-segmented, those of legs 2–4 3-segmented; all bearing plumose setae. Fifth and sixth legs present. Egg sacs long.

MALE.—Body of typical pandarid form. No dorsal plates present. Appendages with same generic characters as the female.

The name *Pagina*, from Latin, meaning "a page," refers to the relationship of the abdominal plates to each other.

Pagina tunica Cressey, 1964

FIGURES 243–267

Pagina tunica Cressey, 1964, p. 285.

SPECIMENS STUDIED.—21 specimens (18 females and 3 males) collected from *Alopias superciliosus* (Lowe) caught at Majunga, Madagascar. Holotype female, allotype male, and 8 paratype females in alcohol deposited in the U.S. National Museum, 3 paratype females in alcohol deposited in the Collection of the Centre d'Oceanographic et des Peches de Nosy Bé, Madagascar, and the remaining paratypes in the author's collection.

OTHER SPECIMENS STUDIED.—A single collection from *Alopias superciliosus* from Nosy Bé, Madagascar; a single collection from the same host in the Pacific (0°38′N, 124°23′W).

FEMALE.—Body form as in figures 243 and 244. Total length, based on an average of 4 specimens, including caudal rami but not setae, 17.9 mm. Greatest width (measured at the widest part of cephalon) 5.8 mm.

Cephalon nearly round, slightly longer than wide, measuring 6.0 by 5.8 mm (measurements including marginal fringe). Posterior corners of cephalon projecting distally. First thoracic segment fused with head. Second segment distinct with 2 lateral lobes extending to posterior margin of third thoracic segment, thus incorporating the smaller third segment within its posterior border. Fourth thoracic segment with dorsal plate consisting of 2 conspicuous winglike lobes. The distal corner of this plate extends only slightly over anterior corner of genital segment. Genital segment large, its greatest length 4.6 mm and its greatest width at the posterior corners 3.8 mm. Posterior corners produced to form 2 short lobes. Abdomen 2-segmented, both segments possessing a conspicuous dorsal plate. From the dorsal aspect abdominal plates covering rest of abdomen. Ventrally the first abdominal segment (fig. 248) as wide as long, measuring 1.5 by 1.5 mm. Dorsal plate of this segment extending over rest of abdomen and with a deep median sinus dividing it into 2 long lobes (see figs. 243, 244). Second abdominal segment also as long as wide and measuring ventrally 2.1 by 2.1 mm. Its dorsal plate composed of only a single lobe and extending over proximal ends of caudal rami (see figs. 243, 245). Caudal ramus (fig. 245) large, comprising almost one-fourth of total body length. Each ramus about 4 times as long as wide measuring 4.2 by 1.3 mm. Distal end of ramus bearing 6 setae. The outermost and innermost small and naked, but median 4 plumose and all nearly equal in length, longest measuring 0.4 mm. Outer border heavily sclerotized while inner only weakly so and often appearing wrinkled in preserved specimens.

Oral area as in figure 246. A single pair of adhesion pads near base of first antenna. First antenna (fig. 247) 2-segmented. First segment 0.77 mm long and bearing 23 stout setae along anterior distal border, all of which are covered with spinules. Four smaller finely plumose setae internal to outer spines. Terminal segment 0.42 mm long and bearing 13 naked setae. Second antenna (fig. 249) 3-segmented. Terminal segment in form of a stout, heavily sclerotized claw bearing 2 setae, 1 basal and the other median. No adhesion pad associated with this appendage. Mouth tube (fig. 250) about twice as long as basal width with labium extending beyond tip of labrum. Tip of labrum somewhat expanded and weakly trilobed with a pair of subterminal processes projecting within tube (fig. 251). The labium expanded at tip and fringed as in figure 251. The mandible attached to head near base of tube (see fig. 250) and bearing a long process with extends between labrum and labium. Distal end of mandibular process with an inner row of about 11 teeth (fig. 252). First maxilla (fig. 253) indistinctly divided into 2 segments. Proximal segment with a group of 3 setae near base. Distal segment short and terminating as a blunt process. Second maxilla (fig. 254) 3-segmented. Second segment bearing a group of stout setules and a single seta at inner distal corner. Third segment short, with 2 transverse rows of setules and bearing a claw ornamented on proximal two-thirds of concave margin with transverse rows of spinules and on convex surface with longitudinal rows of spines. Maxilliped (fig. 255) apparently 4-segmented. First segment bearing padlike process on anteroventral surface, which undoubtedly serves as an adhesion pad. Third segment bearing a heavily sclerotized spinelike process opposed by claw of fourth segment, thus forming a chela. Fourth segment bearing a single seta near base of claw.

Legs 1–4 biramose, with spine and setal formula as follows:

	leg 1		*eg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	I:1	0:1
seg. 2	III:4	3	I:1	0:2	I:1	0:2	I:1	0:2
seg. 3	–	–	III:5	6	III:5	4	III:5	3

Leg 1 (fig. 256) with both rami 2-segmented. First exopod segment outwardly greatly inflated and bearing a single outer spine. Last exopod segment with 3 outer spines and 4 inner setae. First endopod segment with no setae but second segment bearing 3 setae. Basipodite bearing a short outer seta; inner margin naked except for a short seta. No setae on coxopodite. Leg 2 (fig. 257) with both rami 3-segmented. First exopod segment with an outer spine and an inner seta. Second segment same. Third segment with 3 outer spines and 5 terminal setae. First endopod segment with an inner seta. Second segment with 2 inner setae. Third segment with 6 terminal setae. Basipodite with only an outer seta; inner margin with a row of hairs. Coxopodite seta stout and densely plumose. Leg 3 (fig. 258) with both rami 3-segmented. First and second exopod segments with an outer spine and an inner seta. Third segment with 3 outer spines and 5 terminal setae. First endopod segment with an inner seta. Second segment with 2 inner setae. Third segment with 3 terminal setae. Inner portion of basipodite expanded with a marginal fringe as in figure. No seta on the coxopodite. All setae on legs 1–4 plumose and all spines fringed. Leg 5 located on ventral surface near posterior corner of genital segment (see fig. 248), bearing 3 naked spines. Leg 6 modified to form a hooklike process that holds spermatophores in place (see fig. 248). Egg strings long, 1.5 times as long as body.

MALE.—Body form as in figure 260. Total length, based on an average of 2 specimens, including caudal ramus but not setae 11.7 mm. Greatest width 4.6 mm measured at widest part of cephalon. Cephalon nearly round somewhat wider than long (4.6 by 4.2 mm) with posterior corners projecting. Lateral dorsal edge of segment 2 bearing on each side a clear membrane that extends posteriorly to fourth segment. Fourth segment with only a suggestion of winglike plate found in female. Genital segment (fig. 261) 2.6 by 2.1 mm, somewhat longer than wide. Spermatophores visable through posterior half of genital segment. Abdomen 2-segmented, without dorsal plates. First segment measuring 0.88 by 0.88 mm. Second segment longer than wide (1.4 by 1.08 mm) with widest part in distal portion of segment. Caudal ramus armed as in female; about 4 times as long as wide (1.9 by 0.49 mm). Inner margin bearing a row of short hairs.

Oral area as in female. First antenna like that of female. Second antenna (fig. 262) 4-segmented. Second segment with striated areas as shown in figure. Claw shorter and stouter than in female and composed of 2 segments (in the female these segments are fused to form 1). Other oral appendages like those of female. Maxilliped (figs. 263, 264) heavily sclerotized with a chela at tip. When chela is closed, claw of last segment fits into a bifurcation on tip of spinelike process on penultimate segment. A bossed area present between these claws. In addition to claw, last segment bearing a single seta (see fig. 264). Adhesion process near base of maxilliped as in female.

Legs 1–4 as in female except for last endopod segment of leg 3 (fig. 265). Ventral surface of this segment bearing a heavily sclerotized process that extends out over an embossed area near edge (this seems to be modified for holding, but exact function is yet unknown). In addition to ventral process, a more weakly sclerotized dorsolateral process. Leg 5 (fig. 266) located ventrolaterally in middle of genital segment (see fig. 261) and bearing 4 setae, 3 plumose and 1 fringed with spinules. Outer seta not greatly displaced from other 3, as in female. Leg 6 (fig. 267) located internal to distal corner of genital segment and consisting of a small process bearing short setae.

DISCUSSION.—The genus *Pagina* is closely related to *Dinemoura* Latreille, 1829, of which there are 4 known species. These 2 genera have the following characteristics of the female in common: a wing-like dorsal plate on the fourth thoracic segment; a 2-segmented abdomen, each abdominal segment bearing a dorsal plate, the first of which is bilobed and the second single-lobed, and legs 1–3 similar and relatively unmodified. *Pagina* can be separated from *Dinemoura* by the fact that in *Dinemoura* the fourth leg is broad and conspicuously lamelliform, whereas the fourth leg of *Pagina* is unmodified.

Pagina is unlike all other known genera of this family in having the rami of legs 2–4 3-segmented.

Genus *Echthrogaleus* Steenstrup and Lütken, 1861

Dinemoura.—Guerin-Meneville, 1837, pl. 35. [Refers to *D. alata* only.]
Dinematura.—Dana, 1852, p. 60. [Refers to *D. braccata* only.]
Echthrogaleus Steenstrup and Lütken, 1861, p. 380. [Type-species: *E. coleoptratus.*]
Pandarus.—Thomson, 1889, p. 363. [Refers to *P. armatus* only.]

FEMALE.—Frontal plate distinctly separate. First thoracic segment fused with cephalon. Dorsal thoracic plates on segment 4. Abdomen 1-segmented. Abdomen concealed beneath genital segment. Caudal rami joined to abdomen terminally. Oral adhesion pads present but somewhat reduced. First antenna 2-segmented. Legs 1–4 biramose. Leg 4 lamelliform. Legs 5 and 6 present. Egg strings long and straight.

MALE.—No dorsal thoracic plates present. Abdomen 2-segmented Legs 1–4 biramose. Leg 3 with modification on endopod. Leg 4 not lamelliform. Legs 5 and 6 present and not as reduced as in female. Other oral and thoracic appendages as in the female.

DISCUSSION.—This genus is cosmopolitan as a parasite on the body surface of elasmobranch fishes. *E. coleoptratus* and *denticulatus* may be restricted to larger pelagic sharks whereas *torpedinis* has been reported only from the ray, *Torpedo occidentalis.* The copepod is parasitic on the body surface of the host.

This genus is closely related to *Dinemoura* but differs from it principally in having a 1-segmented abdomen. The males of this genus have not been well described. The descriptions of *coleoptratus* and *denticulatus* males have been amplified here.

In 1899 Thomson described a copepod under the name of *Dinematura hamiltoni.* This is obviously a member of the genus *Echthrogaleus,* but the figures and description are too poor to assign it to any species.

Key to Females of Genus *Echthrogaleus*

1. Posterior border of dorsal thoracic plate smooth. Leg 5 concealed in dorsal view . . . . **coleoptratus**
   Posterior border of dorsal thoracic plate serrate 2
2. Leg 5 visible in dorsal view. Dorsal thoracic plate covering not more than ½ genital segment . . . . **denticulatus**
   Leg 5 concealed in dorsal view. Dorsal thoracic plate covering at least ⅔ genital segment . . . . **torpedinis**

Echthrogaleus coleoptratus (Guerin-Meneville, 1837)

Figures 264–280

Dinemoura alata Guerin-Meneville, 1837, p. 42.
Dinemoura coleoptrata Guerin-Meneville, 1837, p. 42.
Dinemoura affinis Milne-Edwards, 1840, p. 465.
Dinematura braccata Dana, 1852, p. 60.
Echthrogaleus coleoptratus Steenstrup and Lütken, 1861, p. 380.—Olsson, 1868, p. 20.—Norman, 1868, p. 301.—Rathbun, 1884, p. 488.—Brian, 1899, p. 4; 1902, p. 8; 1906, p. 53; 1908, p. 4; 1912, p. 12; 1914b, p. 148; 1944, p. 202.—Bassett-Smith, 1899, p. 464.—Scott, T., 1900, p. 156; 1901, p. 125; 1902, p. 292.—Scott, T., and Scott, A., 1913, p. 89.—Norman and Scott, T., 1906, p. 214.—Wilson, 1907, p. 367; 1908, p. 452; 1920, p. 12; 1922, p. 5; 1923, p. 13; 1932, p. 427.—Norman and Brady, 1910, p. 404.—Stebbing, 1910, p. 559.—Hansen, 1923, p. 33.—Marukawa, 1925, p. 1242; 1947, p. 926.—Yamaguti, 1936, p. 7; 1963, p. 119.—Oorde and Schuurmans Stekhoven, 1936, p. 139.—Rose and Vaissiere, 1953, p. 86.—Shiino, 1954, p. 291; 1957, p. 364.—Delamare-Deboutteville and Nunes-Ruivo, 1954, p. 204.—Barnard, 1955, p. 264.—Capart, 1959, p. 97.—Stuardo and Fagetti, 1961, p. 58.—Heegaard, 1962, p. 177.
Echthrogaleus braccatus.—Heller, 1868, p. 197.—Thomson, 1889, p. 361.—Norman and Scott, 1906, p. 213.—Wilson, 1907, p. 366.
Nogagus lutkenii Norman, 1868, p. 300.
Echthrogaleus perspicax Olsson, 1868, p. 18.—Wilson, 1907, p. 457.
Echthrogaleus lutkenii.—Norman and Scott, 1906, p. 213.—Scott, T., and Scott, A., 1913, p. 90.—Oorde and Schuurmans Stekhoven, 1936, p. 139.
Echthrogaleus affinis.—Brady, 1883, p. 133.—Bassett-Smith, 1899, p. 465.—Wilson, 1907, p. 363.

Specimens studied.—Twenty-six collections from *Prionace glauca* from the western North Atlantic (35°–45°N, 20°–80°W). A single collection from *Lamna ditropis* Hubbs and Fallett sent to me by Dr. P. Gilbert from the North Pacific. Four collections from *Prionace glauca* from the Indian Ocean (42°23′S, 74°56′E) and 2 collections from *Lamna nasus* (Bonnaterre) at the same locality.

This copepod has been extensively collected and reported in the literature. The female has been well described and figured (most recently by Shiino, 1954); however, the male is poorly known and will be dealt with here in more detail.

Female.—Body form as in figure 268. Total length 9.7 mm (based on an average of 10 specimens). Greatest width 4.8 mm. Dorsal thoracic plates on segment 4. Oral area and associated appendages described by Shiino (1954). First maxilla as in figure 269. Adhesion pads present but small.

Leg 1–4 biramose with spine and setal formula as follows:

	leg 1		leg 2		leg 3		leg 4	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	X	IV
seg. 2	IV:3	3	I:0	8	I:1	6		
seg. 3			III:5		III:5			

Leg 1 endopod (fig. 270) with usual 3 setae but inner and outer short. Sternal plate between legs 1 with a bilobed adhesion pad (fig. 271). Leg 5 (fig. 272) a single lobe with 3 stout spines near tip. Leg 6 incorporated into area of spermatophore attachment and not a separate element.

Egg strings long and straight.

Color in life cream with light brown pigment on cephalon.

Male.—Body form as in figure 273. Total length 6.4 mm (based on an average of 2 specimens). Greatest width 3.6 mm (measured at widest part of the cephalon). Cephalon rounded, about as long as wide. No dorsal plates present. Genital segment (fig. 274) 1.6 by 1.4 mm, slightly longer than wide. Posterior corners not markedly produced. Abdomen 2-segmented. Caudal ramus with 4 moderately long, plumose setae and plumose along inner margin.

Oral area and associated appendages as in the female. Adhesion pads somewhat smaller.

Legs 1–4 biramose. Spine and setal formula as follows:

	leg 1		leg 2		leg 3		leg 4	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	I:1	0:1
seg. 2	IV:3	3	I:1	8	I:1	II:6	I:1	5
seg. 3			III:5		III:5		II:5	

Leg 1 (fig. 275) as in the female except that setae on endopod are of equal length in male. Leg 2 (fig. 276) as in female but without patches of stout spinules. Leg 3 with a modification of last endopod segment (fig. 277). Leg 4 as in figure 278.

Leg 5 (fig. 279) located on midlateral margin of genital segment and consisting of a single lobe with 1 stout spine and 3 plumose setae. Leg 6 (fig. 280) situated near junction of genital segment and abdomen and represented by a single spine and plumose seta.

Color in life cream, devoid of pigment.

Discussion.—*Echthrogaleus coleoptratus* is a widely distributed species of copepod and has been reported from a wide variety of sharks. It is generally found on pelagic rather than inshore varieties. It occurs on the body surface of the host, commonly on the fins.

The male shows the modified endopod of leg 3 placing this copepod in group II.

***Echthrogaleus denticulatus* Smith, 1874**

FIGURES 281–290

Echthrogaleus denticulatus Smith, 1874, p. 282.—Rathbun, 1884, p. 488.—Wilson, 1907, p. 369; 1932, p. 428.—Shiino, 1954, p. 297; 1959b, p. 352.
Dinematura neozealanica Thomson, 1889, p. 359.—Bassett-Smith, 1899, p. 464.—Wilson, 1907, p. 363.
Pandarus armatus Thomson, 1889, p. 363. [*Nogagus* male.]

SPECIMENS STUDIED.—A single large collection from *Alopias pelagicus* Nakamura from Majunga, Madagascar. Three collections from *Alopias vulpinus* from the Indian Ocean (16°13′N, 63°29′E; 9°24′N, 54°58′E; 7°17′N, 55°00′E). A single collection from *Eulamia floridanus* from the Indian Ocean (14°36′N, 55°23′E). Two collections from *Alopias vulpinus* from the Pacific Ocean (7°47′N, 102°37′W; 11°15′N, 113°26′W).

FEMALE.—Body form as in figure 281. Total length 7.8 mm (based on an average of 5 specimens). Greatest width 4.3 mm (measured at the widest part of cephalon). The female of this species has been recently redescribed and figured by Shiino (1954) and a complete description will not be repeated here. Oral area of usual type, adhesion pads present. Cephalic appendages as shown by Shiino except terminal claw of second maxilla (fig. 282) is indistinctly subdivided.

Legs 1–4 biramose with spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	X	VI
seg. 2	IV:3	3	I:1	0:2	I:1	6		
seg. 3			IV:4	6	III:5			

Leg 5 (fig. 283) a long process projecting beyond distal corners of genital segment, bearing a stout terminal spine and 2 subterminal setae. Leg 6 (fig. 284) located at junction of abdomen and genital segment and composed of a bilobed process. Leg 6 covered by abdomen in ventral view.

Egg strings long and straight.

Color in life cream, no pigmentation.

MALE.—Body as in figure 285. Total length 5.2 mm (based on an average of 2 specimens). Greatest width 2.8 mm (measured at widest point of cephalon). Frontal plate separate. Cephalon rounded, somewhat wider than long. No dorsal thoracic plates. Genital segment (fig. 286) with posterior corners produced only slightly. Two patches of spinules on ventral surface of segment. Genital segment longer than wide (1.2 by 1.0 mm). Abdomen 2-

segmented. First segment 218μ long. Second segment 360μ long. Caudal rami long, measuring 720μ by 144μ (about 5 times as long as wide). Each ramus bearing 4 plumose terminal setae and 2 shorter subterminal ones. Each ramus plumose along inner edge.

Oral area as in female. Setae on first and second antennae slightly longer than in female.

Legs 1–4 biramose with spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	I:1	0:1
seg. 2	IV:3	3	I:1	8	I:1	II:6	I:1	5
seg 3			III:5		III:5		III:4	

Leg 1 as in female. Leg 2 endopod of only 2 segments. Leg 3 with modification as in figure 287. Leg 4 (fig. 288) bearing a prominent spine on outer distal corner of first exopod segment. Leg 5 (fig. 289) located on posterior corners of genital segment, composed of a process bearing a stout terminal spine and 3 setae on inner margin. Distal 2 setae plumose. Proximal one naked. Leg 6 (fig. 290) located at junction of abdomen and genital segment, composed of an inner stout spine and an outer plumose seta.

Color in life cream and devoid of pigment.

Discussion.—This copepod was recently redescribed by Shiino (1954). He described a male of this species also, but a closer examination shows this to be actually the male of *Pandarus satyrus*. A comparison of his description and figures leaves no doubt as to its true identity. He comments that there is "a remarkable dimorphism found between the sexes." This is not the case when one considers the true male of this species, described here for the first time. The modification on the third leg is well formed, establishing the position of this species in group II. I have synonymized *D. neozealanica* Thomson, 1889, with this species since Thomson's original description fits in every way.

This copepod is found generally on the body surface of a wide variety of pelagic sharks. It is occasionally recovered from the gills also. I collected large numbers of this species from *Alopias vulpinus* in the Indian Ocean. On this host the copepod often occurred in great clusters (200–300 copepods) around the opening of the cloaca. Females far outnumber the males in such cases. This copepod has been reported from the Atlantic (Smith, 1874), North Pacific (Shiino, 1954), and I have collected it from the Indian Ocean and received material from the Central Pacific. This seems to indicate a cosmopolitan distribution. It is apparently a common parasite of the genus *Alopias*.

Echthrogaleus torpedinis Wilson, 1907

FIGURES 291–294

Echthrogaleus torpedinis Wilson, 1907, p. 371; 1932, p. 429.

SPECIMENS STUDIED.—USNM 11350, syntypes. 3 females from *Torpedo occidentalis* from Provincetown, Mass.

The only material available for study were type specimens from the U.S. National Museum. Because I did not dissect any of these types, a complete redescription is not possible here. This will have to wait until more material can be collected; nevertheless, I have figured some details and have added here to the original description.

FEMALE.—Body form as in figure 291. Total length 12.8 mm (based on a single specimen). Greatest width 8.2 mm (measured at widest part of the dorsal thoracic plates). Cephalon rounded, about as wide as long (6.2 by 6.2 mm). Dorsal thoracic plates on segment 4. These plates very conspicuous and serrated along their posterior borders. Plates extending over the proximal two-thirds of the genital segment. Genital segment with its posterior corners produced to form inwardly directed lobes. Abdomen 1-segmented, hidden in dorsal view. A small dorsal plate with abdomen. Caudal ramus (fig. 292) bearing 6 naked setae on posterior border. Rami with fine spinules along inner margins.

Oral area with adhesion pads reduced. Pad associated with maxilliped in form of a posteriorly directed process. Oral appendages like those of *E. denticulatus*.

Legs 1–4 (fig. 293) biramose with spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	IX	IV
seg. 2	IV:3	3	I:1	7	I:1	6		
seg. 3			IV:4		IV:4			

Leg 4 lamelliform as in figure. Leg 5 (fig. 294) a process not projecting beyond tip of genital segment, bearing a single stout spine and 3 setae armed as in figure. Leg 6 as in *E. denticalatus*.

Color in preserved specimens cream tan, devoid of heavy pigmentation.

Egg strings long and straight.

MALE.—Unknown.

DISCUSSION.—This species seems closely related to *E. denticulatus*, but it can be separated from that species by the nature of the dorsal thoracic plates of segment 4, by the relative length of leg 5, and by the differences in the armature of the legs. This copepod has been collected twice from *Torpedo occidentalis* off the coast of Massachusetts. Further collecting would be necessary before concluding that it is specific to that host. It was reported by Wilson (1907) from the pectoral and ventral fins of the host.

Genus *Nesippus* Heller, 1868

Nesippus Heller, 1868, p. 193. [Type-species: *N. orientalis*.]
Nogagus.—Beneden, 1892b, p. 246. [Refers to *N. augustatus* only.]

Female.—Frontal plate distinctly separate. First thoracic segment fused with cephalon. Thoracic segments 2–4 free. Dorsal plate may or may not be present on segment 4. Abdomen 1-segmented and joined to genital segment ventrally. Caudal rami attached distally to abdomen. Adhesion pads present on cephalon. First antenna 2-segmented. Oral appendages of usual pandarid type. Maxilliped with a claw pointed or rounded at tip. Legs 1–4 biramose. Rami of legs 1–3 2-segmented, those of leg 4 1-segmented. Leg 5 reduced to 1 or 2 setae. Leg 6 absent. Egg strings straight.

Male.—The same generic characters of female with following exceptions. A reduced modification on endopod of leg 3. Leg 6 present but much reduced. Abdomen 1-segmented. The males of this genus can be separated from all other pandarids by the 1-segmented abdomen.

Discussion.—Members of this genus seem to be restricted to inshore species of sharks and are generally not found on the body surface of the host. The usual sites of infestation are the mouth, gill arches, and nasal passages.

Three species of copepods have been described and assigned to the genus *Nesippus* that are now certainly not members of this genus: *Nesippus curticaudis* Dana, 1852, *N. borealis* Steenstrup and Lutken, 1861, and *N. bengalensis*, Gnanamuthu, 1949. These are described as males of this genus. On the basis of the descriptions of the males of 2 species of *Nesippus* in this paper, it has been shown that the above 3 species are not males of this genus. None of these species shows any indication of sexual maturity. None has been reported in copulation with a female. All have been reported from the plankton. These 3 species, therefore, should be removed from this genus. Their taxonomic position remains in doubt owing to the fact that they appear to be immature. It cannot be established that they are even members of the family Pandaridae.

Key to Adult Females of Genus *Nesippus*

1. Endopod of leg 4 unarmed 2
   Endopod of leg 4 with long setae 3
2. Genital segment conspicuously narrowed anteriorly, caudal rami with prominent setae . . . . **crypturus**

Genital segment not conspicuously narrowed anteriorly, caudal rami with small reduced setae . . . . **tigris**

3\. Fourth thoracic segment with alate plates . . . . **orientalis**

Fourth thoracic segment without plates . . . . **vespa**

Nesippus orientalis **Heller, 1868**

Figures 295–304

Nesippus orientalis Heller, 1868, p. 194.—Bassett-Smith, 1899, p. 459.—Brian, 1906, p. 49; 1924, p. 33.—Wilson, 1907, p. 457.—Capart, 1953, p. 658; 1959, p. 96.—Rose and Vaissiere, 1953, p. 86.—Barnard, 1955, p. 265.—Nunes-Ruivo, 1956, p. 22.—Yamaguti, 1963, p. 123.

Nogagus angustatus Beneden, 1892b, p. 245.

Nesippus alatus Wilson, 1905, p. 130; 1907, p. 426; 1932, p. 438.—Bere, 1936, p. 595.—Heegaard, 1943b, p. 27.—Pearse, 1952b, p. 213.—Capart, 1953, p. 659.—Rose and Vaissiere, 1953, p. 86.—Barnard, 1955, p. 265.—Yamaguti, 1963, p. 123.

Nesippus ornatus Thomsen, 1949, p. 17.—Yamaguti, 1963, p. 124.

Nesippus incisus Heegaard, 1962, p. 179.

Nesippus australis Heegaard, 1962, p. 178.

Specimens studied.—Five collections from Sarasota, Fla., from the following hosts: *Ginglymostomum cirratum*, *Galeocerdo cuvier*, *Carcharinus leucas*, and *Carcharinus maculipinnis*. A single collection from *Sphryna zygaenae* from Durham, South Africa. From Nosy Bè, Madagascar, the following: 8 collections from *Carcharinus maculipinnis*, 4 collections from *Sphyrna lewini*, 4 collections from *Carcharinus leucas*, 1 collection from *Galeocerdo cuvier*, and 1 collection from *Scoliodon palasorrah*.

Female.—Body form as in figure 295. Total length 5.6 mm (based on an average of 5 specimens). Greatest width 3.1 mm (measured at widest point of cephalon). Cephalon rounded about as long as wide. Thoracic segments 2–4 free with dorsal plates on segment 4. Plates extending posteriorly slightly over anterior portion of genital segment. Genital segment 2.1 mm long and 1.5 mm wide. Genital segment of equal width throughout with posterior border trilobed. Abdomen (fig. 296) 1-segmented. Caudal rami (see fig. 296) with 6 terminal setae, inner 4 plumose.

Oral area with adhesion pads associated with first and second antennae and maxilliped. The pad of first antenna with posterior margin produced to form a hooklike process (fig. 297). First antenna 2-segmented (see fig. 297). Second antenna clawlike; of usual pandarid form. Mandible with 11 teeth at tip and of usual type. First maxilla (fig. 298) with a broad process on outer distal corner. Second maxilla (fig. 299) with tip produced to form a clear bulblike tip. A short plumose spine and a small patch of hairs near base of claw. Maxilliped (fig. 300) with a short blunt claw.

Legs 1–4 biramose with spine and setal formula as follows:

	leg 1 exp.	leg 1 end.	leg 2 exp.	leg 2 end.	leg 3 exp.	leg 3 end.	leg 4 exp.	leg 4 end.
seg. 1	I:0	0:0	I:1	0:1	I:0	0:1	V:4	4
seg. 2	IV:3	3	IV:5	7	IV:5	4		

Leg 1 (fig. 301) with an interpodal adhesion pad as in figure. Leg 2 (fig. 302) armed as in figure. Leg 3 (fig. 303) with innermost seta of last exopod segment reduced. Leg 4 (fig. 304) with each ramus 1-segmented and armed as in figure. Leg 5 small process bearing 2 short setae (see fig. 296). Leg 6 absent.

Egg strings long and straight.

Color in life cream.

MALE.—Wilson in 1905 described a male of *Nesippus alatus* (=*orientalis*). I have examined this type specimen and have concluded that it is immature and does not indicate the nature of the adult male; consequently, the true adult male of this species is unknown.

DISCUSSION.—This copepod has been reported from a number of sharks and is probably cosmopolitan in distribution. It seems to be restricted to inshore species and is usually found in the mouth and gill arches of the host.

Capart (1953) states that more material will eventually show *alatus* and *angustatus* to be synonymous with *orientalis*. As a result of my collections and the material I have examined, I am convinced that this interpretation is correct and have placed the two former in synonymy. *Nesippus ornatus* described by Thomsen in 1949 is also the same as *orientalis*. Heegaard described 2 new species (*incisus* and *australis*) in 1962. He noted the similarity to *alatus* and *orientalis* and I believe that these 2 species should be placed in synonymy. I have examined material from the North Atlantic, Caribbean, and Indian Ocean and conclude that my own collections represent a single cosmopolitan species that is found on a wide variety of hosts. The exact shape of the dorsal thoracic plates of segment 4 should not be regarded by itself as a specific character. The presence of this plate separates it from the other known species. It also differs from other species in the nature of the adhesion pad of the first antenna.

Nesippus crypturus Heller, 1868

FIGURES 305–324

Nessipus crypturus Heller, 1868, p. 196.—Bassett-Smith, 1899, p. 459.—Wilson, 1907, p. 425; 1935a, p. 3.—Barnard, 1955, p. 265.—Yamaguti, 1963, p. 124.
Nesippus occultus Wilson, 1924b, p. 214.—Yamaguti, 1963, p. 124.
Nesippus costatus Wilson, 1924b, p. 213.—Yamaguti, 1963, p. 124.
Nesippus gracilis Wilson, 1935a, p. 4.—Bere, 1936, p. 595.—Yamaguti, 1963, p. 124.

Specimens studied.—Single collections from Sarasota, Fla., from the following hosts: *Sphryna mokarran*, *Galeocerdo cuvier*, *Carcaharinus milberti*, and *Carcharinus leucas*. A single collection from Socorro Island (Pacific) from *Carcharinus galapagensis*. From Nosy Bé Madagascar: *Sphyrna lewini* (4 collections), *Carcharinus maculipinnis* (8 collections), *C. leucas* (4 collections), *Scoliodon palasorrah* (1 collection), and *Galeocerdo cuvier* (1 collection).

Female.—Body form as in figure 305. Total length 6.8 mm (based on an average of 5 specimens). Greatest width 3.5 mm (measured at widest part of cephalon). Cephalon rounded, somewhat wider than long (2.5 by 2.7 mm). Thoracic segment 2 expanded laterally. Segment 3 small. Segment 4 expanded laterally somewhat but no plates present. Genital segment 2.6 mm long and narrowed anteriorly; posterior border with deep median sinus. Abdomen (fig. 306) 1-segmented Caudal rami (see fig. 306) attached to abdomen distally and with 6 terminal setae, inner 4 plumose and longer than outer 2

Oral area with adhesion pads associated with first and second antennae and maxilliped (see fig 307). First antenna (fig. 308) 2-segmented, armed as in figure. Adhesion pad produced to form a hooklike process. Second antenna (see fig. 307) of usual form. Mandible and mouth tube of usual form. First maxilla (fig. 309) a broad lobe with a small outer spine and an anterior group of 3 setae. Second maxilla of usual type. Maxilliped (fig. 310) with a short terminal claw rounded at tip. Tip of claw is opposed by a raised area with a central crater-like depression.

Legs 1–4 biramose with the spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	V	0
seg. 2	IV:3	3	IV:5	7	IV:4	4		

Terminal exopod segments of legs 1–3 (figs. 311–313) with spines armed as in figures. Setae of these legs pinched near base and often broken off at this point (see figs. 311–313). Leg 4 (fig. 314) with each ramus of 1 joint. Endopod unarmed. Leg 5 (fig. 315) consisting of 2 short setae, 1 naked, the other with a serrate fringe. Leg 5 located lateral to caudal rami on ventral surface of genital segment (see fig. 306). Leg 6 absent.

Egg strings long and straight.

Color in life cream.

Male.—Body form as in figure 316. Total length 5.4 mm (based on an average of 2 specimens). Greatest width 3.1 mm (measured at widest part of cephalon). Lateral margins of thoracic segment 2 somewhat alate. No dorsal plates present. Genital segment slightly longer than wide. Abdomen 1-segmented. Caudal rami (fig. 317) with 4 terminal setae and 2 subterminal. Each ramus joined distally to abdomen.

Oral area with adhesion pads as in female. First antenna as in female. Second antenna (fig. 318) with terminal hook more recurved than in female. An adhesion area present on antepenultimate segment. Remaining oral appendages as in female. Maxilliped with tip of terminal claw produced as in figure 319. Legs 1–4 (figs. 320–323) biramose with spine and setal formula as follows:

	leg 1 exp.	*leg 1* end.	*leg 2* exp.	*leg 2* end.	*leg 3* exp.	*leg 3* end.	*leg 4* exp.	*leg 4* end.
seg. 1	I:0	0:0	I:0	0:1	I:1	0:1	IV:4	4
seg. 2	IV:3	3	IV:5	7	IV:4	4		

Leg 5 (fig. 324) located near outer distal corner of genital segment and consisting of 2 short, naked setae. Leg 6 absent.

Discussion.—This species, like *N. orientalis,* seems to be cosmopolitan in distribution and occurs in the mouth and gill arches of a variety of inshore species of sharks.

The copepod was originally described by Heller in 1865 and has since been redescribed as *N. occultus*, *N. costatus*, and *N. gracilis* by C. B. Wilson (1924; 1924b; 1935). I have examined Wilson's types of *N. gracilis* and determined this to be the same as *N. crypturus*. *Nesippus occultus* from the published description also appears to be synonymous. *Nesippus costatus* was described from an immature female and was collected together with the material described as *N. occultus* by Wilson. It appears to be merely a young female of the type described as *N. occultus*.

This copepod is characterized by a lack of dorsal plates, the nature of the fourth leg of the female, and the deep median sinus on the posterior portion of the female genital segment. The form of the male maxilliped should separate this sex from other species of the genus.

Nesippus tigris, new species

Figures 325–345

Specimens studied.—Twelve females and 4 males from *Galeocerdo cuvier* from Sarasota, Fla. Holotype female, allotype male, 3 paratypes (2♀♀, 1♂) deposited in alcohol in the U.S. National Museum. Four paratypes (females) deposited in the British Museum (Natural History). Remaining paratypes in the author's collection. Additional specimens studied from *Galeocerdo cuvier* from Nosy Bé, Madagascar (6♀♀).

Female.—Body form as in figure 325. Total length 8.2 mm (based on an average of 2 specimens). Greatest width 4.3 mm (measured at widest part of cephalon). Cephalon rounded, slightly wider than long (4.1 by 4.3 mm). Thoracic segments 2–4 free. No dorsal plates present but lateral margins of segments 2 and 4 expanded laterally somewhat. Genital segment 3.9 by 2.9 mm, widest at its midpoint, its lateral margins somewhat irregular. Genital segment with a median sinus posteriorly. Abdomen (fig. 326) 1-segmented. Caudal rami (see fig. 326) round, bearing 3 weak spines as in figure.

Oral area with adhesion pads associated with first and second antennae and maxilliped. First antenna (figs. 327, 328) 2-segmented.

Each segment armed as in figures. All spines and setae of first antenna naked. Adhesion pad of first antenna produced to form a sharp, posteriorly directed spine (see fig. 327). Second antenna (fig. 329) of usual form with 2 short setae on distal claw. Mouth tube and mandible as in other members of genus. First maxilla (fig. 330) with a median short, stout spine and an anterior group of 3 short setae. Second maxilla (fig. 331) with a short terminal claw bearing rows of fringe. The penultimate segment with a stout distal spine and a small patch of setae. Maxilliped (fig. 332) with a stout terminal claw opposed by a raised area with a central depression on penultimate segment. Maxilliped with an adhesion pad near base. Pad produced in form of a sharp, posteriorly directed process (fig. 333). This process seemingly subdivided.

Legs 1–4 biramose with spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	IV	0
seg. 2	IV:3	3	IV:5	7	IV:4	4		

Leg 1 (fig. 334) with both rami 2-segmented. Setae constricted near their bases as in *N. crypturus*. First exopod segment with an outer spine. Last exopod segment with 4 outer spines and 3 inner setae. First endopod segment unarmed. Last endopod segment with 3 terminal setae. Leg 2 (fig. 335) with both rami 2-segmented. First exopod segment with an outer spine and an inner seta. Last exopod segment with 4 outer spines and 5 inner setae. First endopod segment with an inner seta. Last endopod segment with 7 terminal setae. Leg 3 (fig. 336) with both rami 2-segmented. First exopod segment with an outer spine and an inner seta. Last exopod segment with 4 outer spines and 4 inner setae. First endopod segment with an inner seta. Last endopod segment with 4 terminal setae. Leg 4 (fig. 337) with both rami 1-segmented. Exopod with 4 terminal spines. Endopod unarmed. Leg 5 a single seta located on ventral surface of genital segment near posterior corner (see fig. 326).

Egg strings long and straight.

Color in life cream.

Male.—Body form as in figure 338. Total length 5.7 mm (based on an average of 2 specimens). Greatest width 3.6 mm (measured at widest part of cephalon). No dorsal plates. Posterior corners of segment 2 produced. Genital segment about as long as wide (1.6 by 1.6 mm). Abdomen 1-segmented. Caudal ramus (fig. 339) somewhat rounded with 4 terminal plumose setae and 2 short subterminal ones. Inner margin with short hairs.

Oral area as in female. Appendages of cephalon as in female except for maxilliped. Maxilliped (fig. 340) with tip of claw papillose (fig. 341). Adhesion areas as in figure 340. Adhesive pad of maxilliped (fig. 342) not pointed as in female but with posterior portion produced as a rounded process with heavy striations as in figure.

Legs 1–4 biramose with spine and setal formula as follows:

	leg 1 exp.	*leg 1* end.	*leg 2* exp.	*leg 2* end.	*leg 3* exp.	*leg 3* end.	*leg 4* exp.	*leg 4* end.
seg 1	I:0	0:0	I:1	0:1	I:1	0:1	IV:3	4
seg 2	IV:3	3	IV:5	7	IV:5	4		

Legs 1 and 2 as in female. Leg 3 with a modification on last endopod segment as in figure 343. This is consistent with group II males, although this modification is much reduced in this species. Leg 4 (fig. 344) with each ramus 1-segmented but not as reduced as the female. Leg 5 (see fig. 345) a single short seta on margin of genital segment. Leg 6 (see fig. 345) a single short seta near junction of genital segment and abdomen.

Discussion.—This species has been collected twice from *Galeocerdo cuvier*. The specimens from Nosy Bé were recovered from the nasal passages of the host. Those from Sarasota were not collected by the author, and there is no information as to their location on the host.

This species may be separated from *N. orientalis* by the nature of the fourth legs of the females. It seems to be more closely related to *N. crypturus* but can be separated from it on the basis of the caudal rami and by the fact that in *N. crypturus* the genital segment is considerably narrowed anteriorly whereas in *N. tigris* it is not markedly so.

The name *tigris*, from Latin, meaning "tiger," refers to the host, the tiger shark.

Nesippus vespa Kirtesinghe, 1964

Figures 346–356

Nessipus vespa Kirtesinghe, 1964, p. 91.

Specimens studied.—Eleven females form *Rynchobatus djeddensis* (Forskal) from Nosy Bé, Madagascar.

Female.—Body form as in figure 346. Total length 3.8 mm (based on an average of 2 specimens). Greatest width 1.5 mm (measured at widest part of cephalon). Cephalon rounded, slightly wider than long (1.2 by 1.5 mm). Thoracic segments 2 and 3 indistinctly divided in dorsal view. No dorsal plates present. Genital segment globose, about as long as wide (1.3 mm long by 1.2 mm wide). Genital segment deeply incised posteriorly. Abdomen (fig. 347) joined distally to abdomen and bearing 6 terminal setae, inner 4 long and plumose. Inner margin of ramus with a row of hairs.

Oral area with adhesion pads as in other species of genus. Pad associated with first antenna not produced to form a hooklike process as in other species of the genus (see fig. 348). First antenna (fig. 348) 2-segmented, armed as in figure, and bearing only 12 spines on first segment and 6 setae on the second. Second antenna (fig. 349) of usual form. The 2 setae near base of claw longer than in other species of genus. Mouth tube and mandible of usual pandarid type. First maxilla (fig. 351) with a short spine and a small patch of setules near base of the claw. Claw with rows of fringe as in figure. Maxilliped (fig. 352) bearing a blunt terminal claw opposed by a crater-like area on opposite segment.

Legs 1–4 biramose with spine and setal formula as follows:

	leg 1 exp.	*leg 1* end.	*leg 2* exp.	*leg 2* end.	*leg 3* exp	*leg 3* end.	*leg 4* exp.	*leg 4* end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	IV:3	4
seg. 2	IV:3	3	IV:5	7	IV:4	4		

Leg 1 (fig. 353) with both rami 2-segmented. First exopod segment with an outer spine. Last exopod segment with 4 outer spines and 3 inner setae. First endopod segment unarmed. Last endopod segment with 3 terminal setae. Leg 2 (fig. 354) with both rami 2-segmented. First exopod segment with an outer spine and an inner seta. Last exopod segment with 4 outer spines and 5 inner seta. First endopod segment with an inner seta. Last endopod segment with 7 terminal setae. Leg 3 (fig. 355) with each ramus 2-segmented. First segment of the exopod with an outer spine and an inner seta. Last exopod segment with 4 outer spines and 4 inner setae. First endopod segment with an inner seta. Last endopod segment with 4 terminal setae. Leg 4 (fig. 356) with each ramus 1-segmented. Exopod with 4 outer spines and 3 inner setae. Endopod with 4 setae. Setae on legs 1–4 constricted near their bases (see fig. 355) and often broken off at this point. Leg 5 (see fig. 347) a single plumose seta located ventrally near distal margin of genital segment. Leg 6 absent.

Egg strings long and straight.

Color in life cream.

Discussion.—This copepod has been collected only from *Rhynchobatus djeddensis* in Madagascar and Ceylon. It was found in the mouth of the host in Madagascar and on the body surface of the Ceylon host.

This species can be separated from *N. orientalis* by the lack of the dorsal plate on fourth segment. It can be separated from *N. crypturus* by the nature of adhesion pads of the cephalon and the nature of the fourth leg of the female. It differs from *N. tigris* by the nature of the fourth thoracic segment (wide in *N. tigris*, narrow in *N. vespa*) and also by the nature of the caudal rami.

Genus *Paranesippus* Shiino, 1955

Paranesippus Shiino, 1955, p. 340. [Type-species: *P. incisus*.]

In 1955 Shiino described a new genus and species of parasitic copepod on the basis of a single female specimen taken from the body surface of *Acanthidium eglantina* (Jordan and Snyder).

In general, this copepod appears to be a member of group II and, as the name implies, seems to be more closely related to *Nesippus* than to other members of the family. Since Shiino has provided a good description with illustrations, I shall not repeat his description here. Because I had no material to study, I cannot add any more details to the existing description.

Adhesion pads are associated with first and second antennae and maxilliped.

The spine and setal formula of legs 1–4 (based on Shiino, 1955) as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exp.	end.	exp.	end.	exp.	end.	exp.	end.
seg. 1	I:0	0:0	I:1	0:1	I:1	0:1	I:1	0:1
seg. 2	IV:3	3	I:1	0:2	I:1	0:2	I:1	5
seg. 3			III:5	6	III:4	4	III:4	

It is interesting to note that the egg strings remain recurved and hidden beneath the genital segment as in some other members of group II (*Demoleus latus* and *Dinemoura discrepans*).

The male is unknown.

Comparative External Morphology and Taxonomic Relationships Within the Family Pandaridae

It seems appropriate to examine the family Pandaridae as a group and discuss the taxonomic features on a comparative basis. During the course of the study, it became apparent that certain features were quite stable, while others showed variations that should be pointed out. In some cases these variations can be explained reasonably on the basis of the ecology of the parasite.

Body form: The body of the adult is composed of a cephalon (head and first thoracic segment fused together), 3 free thoracic segments (nos. 2–4), a genital segment (thoracic segments 5 and 6 fused), and an abdomen (of 1 or 2 segments) that bears 2 caudal rami. In general, the body of the female is more compact than that of the male. The thoracic segments tend to be more broadly joined to each other, making the females less flexible and adapted for a more sedentary existence. The male is not modified in this way and is more mobile than the female (compare figs. 1 and 16).

Cephalon: The cephalon is usually rounded in both sexes and concave on the ventral surface. This configuration is quite stable and found in most caligoid copepods. This is an obvious modification to aid in attaching to the host, the cephalon forming a sucking disc. The lateral borders usually bear a membrane. This thin flexible membrane further enhances the holding ability of the cephalon.

Thoracic segments: In all cases in both sexes segment 1 is fused to the head and segments 2–4 are free. The thoracic segments of the female may bear dorsal plates in one of two arrangements, plates present on segments 2–4 as in *Pandarus, Pseudopandarus, Gangliopus, Phyllothereus, Perissopus,* and *Pannosus,* or plates present on segment 4 only as in *Echthrogaleus, Demoleus, Pagina, Dinemoura, Nesippus,* and *Paranesippus.* This feature separates the females easily into 2 distinct groups.

Genital segment: The genital segment in both sexes is well formed. In the female the genital segment may comprise more than one-half of the total length (as in *Pseudopandarus*) and in all cases is at least one-third of the total length of the copepod.

Abdomen: The abdomen of the female is 1-segmented in all genera except *Pagina* and *Dinemoura.* The segments of the abdomen bear dorsal plates except in the genera *Nesippus* and *Paranesippus.* The abdomen may be joined to the genital segment ventrally or terminally. In the male the abdomen is of 2 segments except in the genus *Nesippus,* in which there is only 1. None of the males have dorsal abdominal plates.

Caudal rami: There is a great deal of variation in the form of the rami in the females of this family. In the genus *Pandarus* the rami are attached laterally to the abdomen and are often strongly sclerotized and elongated, terminating in a point (see figs. 2, 28, 35, 110). In *Pandarus bicolor* (see fig. 101) the rami are not elongated but are attached laterally to the abdomen.

It is interesting to note that the 2 genera *Phyllothereus* and *Gangliopus,* which are found only on gill filaments of the hosts, show a great reduction in adhesion pads. *Dinemoura ferox* and *D. discrepans* also have no adhesion pads. Both these species are found on the body surface, and the loss of pads is unexplained in these cases.

First antenna: In both sexes of all members of this family the first antenna is 2-segmented. The first segment bears terminally a number of spines that are often covered with spinules or hairs.

The last segment bears a smaller number of naked setae in all cases. This appendage is not of great taxonomic importance on the generic or specific level.

Second antenna: This appendage is well developed in all members and serves as a principal means of attachment. The tip is always in the form of a claw and this reaches its greatest development in the females of the genera *Phyllothereus* and *Gangliopus* (see fig. 127). These genera, as previously pointed out, show a reduction in adhesion pads and also are the only pandarids found routinely on the gill filaments. In view of this location on the host, adhesion pads would not be as

TABLE 2.—Arrangement of female cephalic adhesion pads in genera of the family Pandaridae (+=present, −=absent)

Genus	Cephalic Adhesion Pads				
	A1	A2	base of Mxpd	between Mxpd	distal corner of cephalon
Pandarus	+	+	+	−	+
Pseudopandarus	+	+	+	−	+
Perissopus	+	+	+	−	−
Paranesippus	+	+	+	−	−
Pannosus	+	+	+	−	−
Nesippus	hooklike	+	+	−	−
Dinemoura (part)	double	+	+	−	−
Demoleus	+	+	+	+	−
Pagina	+	−	−	−	−
Echthrogaleus	+	+	hooklike	−	−
Phyllothereus	−	−	−	−	−
Dinemoura (part)	−	−	−	−	−
Gangliopus	−	−	+	−	−

useful whereas a well-developed claw to envelope the gill filament would be. The terminal claw always bears 2 setae.

Mouth tube: The mouth tube is composed of the labrum and labium, forming a conelike structure, within which is housed the stylus of the mandible. The tip of the labium is fringed (see figs. 6, 167, 251). The labium extends beyond the tip of the labrum. The labrum bears 2 accessory spinelike structures at its tip (see fig. 251).

Mandible: The mandible is composed of a basal segment located near the base of the mouth tube and a long stylet projecting within the tube. The tip of the stylet is armed with 10–12 teeth. This appendage is of little taxonomic value and shows little variation from species to species in both sexes.

First maxilla: This appendage is attached laterally to the base of the mandible (see fig. 6) and is composed of a basal segment bearing a group of 3 short setae anteriorly and a posteriorly directed process. Within the family this appendage takes 2 basic forms. In members of group I, plus *Nesippus*, the first maxilla is represented by a basal segment fused to the cephalon along its entire length and bearing a group of 3 short setae and a more prominent spine, generally directed posteriorly. The appendage does not appear to have much mobility (see figs. 6, 75, 113, 128, 168). In the genera *Pagina*, *Echthrogaleus*, *Dinemoura*, and *Demoleus* (all of group II), the first maxilla is attached to the cephalon at the anterior margin of the basal segment and gives the appearance of greater freedom of movement (see figs. 224, 253, 269).

Second maxilla: The second maxilla in all species bears a clawlike tip that usually bears rows of fringe or spinules. Group I can be separated from group II by the nature of this appendage. In group I there are 2 prominent spines near the base of the claw (see figs. 9, 76, 129, 149, 169). In group II the smaller spine is replaced by a patch of setules or spinules (see figs. 204, 225, 254, 282). This distinction is present in both sexes.

Maxilliped: The maxilliped is in all species a strongly developed appendage. It undoubtedly aids in holding the copepod to the host or is used by the male to hold the female during copulation. It is interesting to note that, in group I, 3 genera found on the body surface of the host possess a maxilliped with a spatulate tip on the claw (*Pandarus*, *Pseudopandarus*, and *Pannosus*). This modification would seem to enable the parasite to grip the denticles of the host better. The remaining genus (*Perissopus*) of group I found on the body surface of the host attaches by cementing the maxilliped to the host. The 2 genera of group I found on the gills have pointed claws on the maxilliped. All members of group II have sharply pointed or rounded tips on the claw of the maxilliped. None are spatulate.

Leg 1: This appendage is relatively stable in pandarid copepods, but 2 genera can be separated from the rest of the family on the basis of the endopod. In *Pandarus* the endopod is 1-segmented. In all other known members of the family the endopod is 2-segmented. In *Perissopus* the endopod is unarmed. In all other members of the family the endopod bears 3 setae.

Leg 2: In group I the exopod of all species is 2-segmented. In group II all genera have 3-segmented exopods except *Demoleus* and *Nessipus*, which have only 2.

Leg 3: The situation regarding this appendage is like that of leg 2. All members of group II (except *Demoleus*, with only 2) have 3-segmented exopods. Copepods of group I have a 2-segmented exopod except *Perissopus*, which has only 1.

Leg 4: In many genera of both groups this leg in the female is lamelliform (*Pandareus*, *Phyllotherus*, *Echthrogaleus*, and *Dinemoura*). The females of these genera can be separated from other female members of the family on this basis alone. In the male the leg is not modified and is of more usual form.

Leg 5: This leg is reduced in both sexes and is represented by a group of 2–4 setae. This appendage is not useful in separating members of the family.

Leg 6: This leg is incorporated in the female into the area of spermatophore attachment and is more obvious in group II species (see figs. 209, 284). In the male this leg is represented by 2 setae located near the union of the abdomen and genital segment in all members of the family in which the male is known.

It should be noted here that certain observations were made regarding the determination of adult males. It was noted (see page 14) that often, in collections, 2 sizes of males showing spermatophores were present. A closer examination indicated that the larger was more mature than the smaller (based on relative development of the spermatophores). It was obvious that in a collection where only the smaller ones were present that these might be erroneously considered as mature. I found that in the larger forms the pad of the second antenna was only about one-half the size of the pad of the first antenna. In the smaller forms they are of about equal size. The opinion is therefore presented that this difference may be a method of determining sexual maturity of the male since the spermatophore is seen in earlier stages and is not a dependable criterion. It was observed that in mature males of other species of *Pandarus* this reduction of the pad of the second antenna was also present (see figs. 59, 60).

A List of Sharks Examined with the Pandarid Copepods Recovered from Them

(Number in parenthesis indicates collections made)

Hexanchus species
- *Demoleus paradoxus* (1)

Isurus oxyrhynchus
- *Pandarus smithii* (3)
- *Dinemoura producta* (1)
- *Dinemoura latifolia* (3)
- *Echthrogaleus denticalatus* (3)

Lamna nasus
- *Pandarus floridanus* (1)
- *Echthrogaleus colcoptratus* (1)

Lamna ditropis
- *Echtrogaleus coleoptratus* (1)

Carcharodon carcharias
- *Pandarus smithii* (1)
- *Pandarus floridanus* (4)
- *Dinemoura producta* (1)

Cetorhinus maximus
- *Dinemoura producta* (1)

Alopias superciliosus
- *Dinemoura discrepans* (2)
- *Pagina tunica* (3)

Alopias pelagicus
- *Echthrogaleus denticulatus* (1)

Alopias vulpinus
- *Pandarus smithii* (2)
- *Dinemoura discrepans* (2)
- *Echthrogaleus denticulatus* (3)

Ginglymostomum cirratum
- *Nesippus orientalis* (1)

Mustelus species
- *Perissopus dentatus* (1)

Carcharinus milberti
- *Perissopus dentatus* (1)
- *Nesippus orientalis* (1)
- *Nesippus crypturus* (1)

Carcharinus maculipinnus
- *Perissopus dentatus* (1)
- *Pandarus sinuatus* (2)
- *Pandarus carcharini* (2)
- *Nesippus orientalis* (5)
- *Nesippus crypturus* (1)

Carcharinus leucas
- *Perissopus dentatus* (1)
- *Pandarus sinuatus* (2)
- *Pandarus carcharini* (2)
- *Nesippus orientalis* (5)
- *Nesippus crypturus* (1)

Carcharinus gangeticus
- *Pandarus carcharini* (1)

Carcharinus sorrah
- *Pandarus carcharini* (1)

Carcharinus limbatus
- *Pandarus smithii* (1)
- *Pandarus carcharini* (1)

Carcharinus obesus
- *Pseudopandarus longus* (1)

Carcharinus malpeloensis
- *Pandarus cranchii* (1)
- *Pandarus smithii* (1)
- *Pandarus katoi* (5)

Carcharinus galapagensis
- *Pandarus cranchii* (1)
- *Pandarus smithii* (1)
- *Nesippus crypturus* (1)

Carcharinus azureus
- *Pandarus smithii* (2)
- *Pandarus katoi* (2)

Carcharinus platyrhynchus
- *Pandarus katoi* (1)

Pterolamiops longimanus
- *Pandarus cranchii* (27)

Eulamia floridanus
- *Pandarus cranchii* (12)
- *Pandarus smithii* (4)
- *Echthrogaleus denticulatus* (1)

Eulamia falciformis
- *Pandarus cranchii* (2)
- *Pandarus smithii* (2)

Eulamia obscura
- *Pandarus cranchii* (2)

Hypoprion signatus
- *Pandarus smithii* (1)

Prionace glauca
- *Pandarus satyrus* (35)
- *Echthrogaleus coleoptratus* (30)
- *Phyllothereus cornutus* (8)
- *Gangliopus pyriformis* (4)
- *Dinemoura producta* (1)

Galeocerdo cuvier
- *Pandarus cranchii* (2)
- *Nesippus tigris* (2)
- *Nesippus orientalis* (2)
- *Nesippus crypturus* (2)

Negaprion brevirostris
Pandarus sinuatus (1)
Galeorhinus species
Pandarus niger (1)
Pandarus carcharini (1)
Scoliodon palasorrah
Pseudopandarus gracilis (1)
Nesippus orientalis (1)
Nesippus crypturus (1)
Rhizoprionodon acutus
Pseudopandarus longus (1)
Sphyrna mokarran
Nesippus crypturus (1)
Sphyrna lewini
Nesippus orientalis (4)
Nesippus crypturus (4)
Sphyrna zygaenae
Pandarus cranchii (1)
Pandarus smithii (1)
Pandarus zygaenae (3)
Nesippus orientalis (1)
Squalus acutipinnus
Demoleus latus (1)
Squalus acanthias
Pandarus bicolor (1)
Rhynchobatus djeddensis
Nesippus nana (1)

Literature Cited

Baird, W.
1850. The natural history of the British Entomostraca, 348 pp.
Barnard, K. H.
1948. New records and descriptions of new species of parasitic Copepoda from South Africa. Ann. Mag. Nat. Hist., ser. 12, vol. 1, no. 4, pp. 242–254.
1955. South African parasitic Copepoda. Ann. South African Mus., vol. 41, pt. 5, pp. 223–312.
Bassett-Smith, P. W.
1896. A list of the parasitic Copepoda of fish obtained at Plymouth. Mar. Biol. Assoc., vol. 4, no. 2, pp. 155–163.
1899. A systematic description of parasitic Copepoda found on fishes, with an enumeration of the known species. Proc. Zool. Soc. London, pt. 2, pp. 438–507.
Beneden, P. J. van
1851a. Recherches sur quelques crustacés inférieurs. Ann. Sci. Nat., vol. 16, no. 3, pp. 71–131.
1851b. Note sur un crustacé parasite nouveau, avec l'énumeration des espèces de cette classe qu'on observe sur les poissons du littoral de Belgique. Bull. Acad. Roy. Belgique, vol. 18, pt. 1, pp. 286–290.
1857. Sur un nouveau *Dinemoure* provenant du *Scimnus glacialis*. Bull. Belgique, year 26, ser. 2, vol. 1, pp. 226–235.
1861. Recherches sur les crustacés du littorale de Belgique. Bull. Belgique year 26, ser. 2, vol. 1, no. 3, 174 pp.
1892a. Le male de certain caligides et un nouveau genre de cette famille. Bull. Belgique, year 62, ser. 6, vol. 23, no. 3, pp. 220–235.
1892b. Quelques nouveaux caligides de la côte d'Afrique et de l'archipel des Acores. Bull. Belgique, year 62, ser. 6, vol. 23, no. 3, pp. 241–262.
Bere, R.
1936. Parasitic copepods from Gulf of Mexico fish. American Midl. Nat., vol. 17, no. 3, pp. 577–625.
Brady, G. S.
1883. Copepoda. Pt. 23 *of* vol. 8 *in* Zoology *in* Report on the scientific results of the voyage of H.M.S. *Challenger* . . . 1873–76 . . . , 142 pp., 55 pls.

BRIAN, A. G. G.

1898a. Note préliminaire sur les copépodes parasites des poissons. Bull. Inst. Océanogr., no. 110, 19 pp.

1898b. Catalogo di copepodi parassiti dei pesci della Liguria. Atti Soc. Lig. Sci. Nat. Geogr., vol. 9, pp. 5–31.

1899. Crostacei parassiti dei pesci dell'Isola d'Elba (II contribuzione). Bull. Mus. Zool. Anat. Comp. Univ. Genova, vol. 4, no. 85, pp. 1–11.

1902. Note su alcuni crostacei parassiti dei pesci del Mediterraneo. Atti Soc. Lig. Sci. Nat. Geogr., vol. 13, pp. 30–45.

1906. Copepoda parassiti dei pesci d'Italia, 191 pp., 21 pls.

1908. Note préliminaire sur les copépodes parasites des poissons provenent des campagnes scientifiques de S.A.S. le Prince Albert Ier de Monaco ou déposés dans les collections du Musée océanographique. Bull. Inst. Océanogr., no. 110, pp. 1–19.

1911. Descrizione del maschio della *Dinematura producta* Muller (copepode parassita). Monit. Zool. Italiano, vol. 22, no. 8, pp. 197–202.

1912. Copépodes parasites des poissons et des échinides provenent des campagnes scientifiques de S.A.S. le Prince Albert Ier de Monaco (1886–1910). Vol. 38 *in* Résultats des Campagnes Scientifiques . . . Albert Ier Prince . . . Monaco, 58 pp., 12 pls.

1914a. Copépodes parasites provenant des récentes campagnes scientifiques de S.A. le Prince Albert Ier de Monaco ou déposés dans les collections du Musée océanographique. No. 286 *of* vol. 38 *in* Résutats . . . Monaco, pp. 1–14.

1914b. Nuove aggiunte al catalogo dei copepodi parassiti dei pesci viuenti nel Mare Ligustico, pp. 144–148.

1924. Parasitologia mauritanica, 1: Copepoda. Bull. Com. Etud. Hist. Sci. Afrique Occid. Française, no. d, Sept., pp. 1–66.

1940. Sur trois copépodes parasites des poissons de côtes Algériennes. Bull. Stat. Aquicult. Algérie, n.s., vol. 1, pp. 9–18.

1944. Copepodos parasitos de pesces y cetaceos del Museo Argentino de Ciencias Naturales. Ann. Mus. Argentino Cienc. Nat., vol. 41, pp. 193–220.

1946. Sulla inesistenza del gen. *Laminifera* "Franz Poche" (fide Ch. Br. Wilson 1907) e sulla sinominia della sp. *Laminifera doello-jaradoi* Brian (1944) colla sp. *Phyllothreus cornutus* (M. Edw. 1840). Monit. Zool. Italiano, vol. 55, pp. 142–143.

BURMEISTER, H.

1833. Beschreibung einiger neuen oder weniger bekannten Schmarotzerkrebse, nebst allgemeinen Betrachtungen über die Gruppe, welcher sie angehören. Act. Verh. Leopoldinische-Carolinischen Akad. Naturf., vol. 17, pt. 1, pp. 269–336.

CAPART, A.

1953. Quelques copépodes parasites des poissons marins de la région de Daker. Bull. Inst Français Afrique Noire, vol. 15, no. 2, pp. 647–670, figs. 1–10.

1959. Copépodes parasites. Fasc 5 *of* vol. 3 *in* Expédition océanographique belge dans les eaux côtières africaines de l'Atlantique Sud (1948–1949), pp. 57–126.

CARCUS, J. V.

1885. Prodromus faunae mediterraneae . . . , vol. 1, xi+525 pp.

Carvalho, J.
1940. Notas sobre alguns Caligoida, com a descricao de *Pandarus marcusi* sp. nov. Zoologia (Univ. São Paulo), no. 4, pp. 271–289.
1945. Copepodos de Caiobá e Baía de Guaratúba. Arq. Mus. Paranaese, vol. 4, no. 3, pp. 83–116, pls. 6–12.
1951. Notas sôbre alguns copépodos parasitos de peixes marítimos da costa do estado de São Paulo. Bol. Inst. Paulista Oceanogr., vol. 2, fasc. 2, pp. 135–144.

Causey, D.
1953. Parasitic Copepoda of Texas coastal fishes. Publ. Inst. Mar. Sci., vol. 3, pp. 7–16.
1955. Parasitic Copepoda from Gulf of Mexico fish. Occas. Pap. Mar. Lab. Louisiana State Univ., no. 9, pp. 1–9.
1960. Parasitic copepoda from Mexican coastal fishes. Bull. Mar. Sci. Gulf and Caribbean, vol. 10, pp. 323–337.

Cressey, R.
1964. A new genus of copepods (Caligoida, Pandaridae) from a thresher shark in Madagascar. Cah. O.R.S.T.O.M. (Océanogr., ser. Nosy Bé, vol. 2, no. 6, pp. 285–297.

Dana, J. D.
1852–53. Crustacea, pts. 1 and 2. Vol. 13 *in* United States exploring expedition . . . 1838–42 . . . pt. 1 (1852), viii+685 pp.; pt. 2 (1853), pp. 686–1618.

Delamare-Deboutteville, C.
1948. Sur quelques copépodes parasites du squale pelerin *Cetorhinus maximus* (Gunner). Bull. Mus. Nat. Hist. Paris, ser. 2, vol. 20, no. 5, pp. 446–447.

Delamare-Deboutteville, C., and Nuñes-Ruivo, L.
1954. Copépodes parasites des poissons méditerranées. Vie et Milieu, ser. 3, vol. 4, no. 2, pp. 201–218.
1958. Copépodes parasites des poissons méditerranées. Vie et Milieu, ser. 4, vol. 9, no. 2, pp. 215–235.

Desmarest, A. G.
1825. Considérations générales sur le classe des crustacés . . . , xix+446 pp., 5 tbls., 56 pls.

Dollfus, R. Ph.
1943. Sur un copépode (gen. *Demoleus* C. Heller) parasite d'*Hexanchus*. Bull. Inst. Océanogr., no. 851, pp. 1–10.

Fage, L.
1923. Sur deux copépodes *Dinemoura producta* (Muller) et *Nemesis lamna* (Risso) parasites due pélerin, *Cetorhinus maximus* (Gunner). Bull. Soc. Zool. France, vol. 48, nos. 6 and 7, pp. 280–287.

Frey, H., and Leuckart, R.
1847. Beiträge zur Kenntniss wirbelloser Thiere mit besonderer Berücksichtigung der Fauna des Norddeutschen Meeres, 170 pp.

Gerstaecker, A. D.
1853. Ueber eine neue und eine weniger gekannte Siphostomen-Gattung. Arch. Naturg., vol. 19, pp. 58–70.
1854. Beschreibung zweier neuer Siphonostomen-Gattungen. Arch. Naturg., vol. 20, pp. 185–195.

GNANAMUTHU, C. P.

1951a. New copepod parasites of sharks. Ann. Mag. Nat. Hist., ser. 12, vol. 4, no. 48, pp. 1236–1256.

1951b. *Perissopus manuelensis* n. sp.: A pandarine copepod parasitic on *Mustelus manazo* Bleeker. Spolia Zeylanica, vol. 26, pt. 1, pp. 9–12.

GUÉRIN-MENEVILLE, F. E.

1837. Crustacés. Vol. 26 *in* Iconographie du regne animal. [1829–1843: plates; 1844: text.]

HANSEN, H. J.

1923. Crustacea Copepoda, 2. *In* Copepoda parasitica and hemiparasitica Danish *Ingolf* expedition, vol. 3, no. 7, pp. 1–92.

HEEGAARD, P.

1943a. Some new caligids from the Gilbert Islands. Ark. Zool., vol. 34A, no. 16, pp. 1–12.

1943b. Parasitic copepods mainly from tropical and antarctic seas. Ark. Zool., vol. 34A, no. 18, pp. 1–37.

1945. Some parasitic copepods from fishes in the Upsala University Collections. Ark. Zool., vol. 35A, no. 18, pp. 1–27.

1962. Parasitic Copepoda from Australian waters. Rec. Australian Mus., vol. 25, no. 9, pp. 149–233.

HELLER, C.

1868. Crusteceen. No. 8 *in* vol. 2 *of* Zoologischer Theil *in* Reise der Oesterreichischen Fregatte Novara . . . , 280 pp., 25 pls. [The plates were printed in 1865, but the text and plates were published in 1868.]

HESSE, C. E.

1880. Description de deux crustacés nouveaux male et femelle du genre *Dinematura*, decrits et peints sur des individus vivants. Rev. Sci. Nat. Montpellier, vol. 2, no. 2, pp. 5–15.

1883. Crustacés rares ou nouveaux des cotes de France. Ann. Sci. Nat. Zool., vol. 14, no. 3, pp. 1–48, pls. 4–6.

HO, J.

1963. On five species of Formosan parasitic copepods belonging to the suborder Caligoida. Crustaceana, vol. 5, pp. 81–98.

JOHNSTON, G.

1835. *Pandarus alatus* and *lamnae*. Mag. Nat. Hist., vol. 8, pp. 202–205.

KIRTISINGHE, P.

1950. Parasitic copepods of fish from Ceylon, 3. Parasitology, vol. 40, nos. 1 and 2, pp. 77–86.

1964. A review of the parasitic copepods of fish recorded from Ceylon with descriptions of additional forms. Bull. Fish. Res. Sta. Ceylon, vol. 17, no. 1, pp. 45–132.

KRØYER, H.

1837–38. Om snyltekrebsene, isaer med Hensyn til den Danske Fauna. Naturh. Tidsskr., vol. 1, no. 2, pp. 172–208; no. 3, pp. 252–304; no. 5, pp. 476–506; no. 6, pp. 605–628; (1838), vol. 2, pp. 8–52, 131–157.

1863. Bidrag til Kundskab om Snyltekrebsene. Naturh. Tidsskr., vol. 3, pt. 2, pp. 75–426.

KURIAN, C. V.

1955. Parasitic copepods of Travancore-Cochin. Bull. Cent. Res. Inst. Univ. Travancore Trivandrum, vol. 4, no. 1, pp. 103–116.

Kurtz, H.

1924. *Philodopus* (*Achtheinus*) *intermedius* und *Dissonus glaber*, zwei neuv Arten aus der Familie der Caligidae. Sit. Akad. Wissen. Wien, vol. 133, p. 10, pp. 613–624.

Lamarck, G. B. P. de

1818. Histoire naturelle des animaux sans vertebres, vol. 5, 612 pp. [Reference not seen.]

Latreille, P. A.

1829. Crustacés . . . . Vol. 4 *in* Cuvier, Le Règne Animal, ed. 2.

Leach, W. E.

1816. Crustaceology: Suppl. Annulosa. *In* Edinburg Encyclopedia, pp. 401–453, pls. 20–26.

1819. Entomostraca. *In* Dictionnaire des Sciences Naturelles . . . , vol. 14, pp. 524–543.

Leigh-Sharpe, W. H.

1930. Parasitic Copepoda. Fasc. 2 *of* vol. 3 *in* Resultats scientifiques du voyage aux Indes Orientales Néerlandaises . . . , pp. 1–11.

1934a. The Copepoda of the Siboga-Expedition, 2: Commensal and parasitic Copepoda. Monogr. 29b (vol. 123) *in* Weber, Siboga-Expeditie, 40 pp.

1934b. A third list of parasitic Copepoda of Plymouth with notes. Parasitology, vol. 26, no. 1, pp. 112–113.

Lewis, A. G.

1963. Life history of the caligid copepod *Lepeophtheirus dissimulatus* Wilson, 1905 (Crustacea Caligoida). Pacific Sci., vol. 17, no. 2, pp. 195–242.

Markewitsch [Markevich], A. P.

1957. Parasitic Copepoda of fish of USSR, 259 pp. [In Russian; reference not seen.]

Marukawa, H.

1925. Illustrated encyclopedia of the fauna of Japan. [Reference not seen.]

1947. Revised edition of illustrated encyclopedia of the fauna of Japan, exclusive of Insecta. [Reference not seen.]

Matthews, L., and Parker, H. W.

1950. Notes on the anatomy and biology of the basking shark. Proc. Zool. Soc. London, vol. 120, pp. 535–576, 15 figs., 8 pls.

McClendon, J. F.

1906. On the development of parasitic copepods, 1 and 2. Biol. Bull., vol. 12, no. 1, pp. 37–52; no. 2, pp. 53–88.

1907. The spermatogenesis of *Pandarus sinuatus* Say. Biol. Bull., vol. 13, pp. 114–119.

1910. Further studies on the gametogenesis of *Pandarus sinuatus*. Arch. Zellf., vol. 5, no. 2, pp. 229–234, 1 illustr., 1 tbl.

Miers, E. J.

1880. On a small collection of Crustacea made by Edward Whymper, Esq., chiefly in the N. Greenland Seas. Journ. Linn. Soc., vol. 15, pp. 59–73.

Milne-Edwards, H.

1840. Histoire naturelle des crustacéa, comprenant l'anatomie, la physiologie et la classification de ces animaux, 638 pp., 42 pls.

Monod, T., and Dollfus, R.
1938. Pandarins peu connus (Generes *Phyllothyreus* Norman 1903 et *Gangliopus* Gerstaecker 1854). Ann. Parasit. Hum. Comp., vol. 16, no. 3, pp. 196–209.

Muller, O. F.
1785. Entomostraca, seu Insecta testacea quae in aquis Daniae et Norvegiae reperit, descripsit, et inconibus illustravit, 134 pp. [Reference not seen.]

Nordmann, Alexander von
1832. Mikrographische Beiträge zur Naturgeschichte der wirbellosen Thiere, xvi+150 pp., 10 pls.

Norman, A. M.
1868. Last report on dredging among the Shetland Isles. *In* Report of the British Association for the Advancement of Science for 1868, p. 301.

1903. New generic names for some Entomostraca and Cirripedia. Ann. Mag. Nat. Hist., ser. 7, vol. 11, pp. 367–369.

Norman, A. M., and Brady, G. S.
1910. The crustacea of Northumberland and Durham. Trans. Nat. Hist. Soc. Northumberland, Durham and Newcastel-upon-Tyne, n. s., vol. 3, no. 2, pp. 252–417.

Norman, A. M., and Scott, T.
1906. Crustacea of Devon and Cornwall, 232 pp.

Nuñes-Ruivo, L.
1956. Copepodes parasitas de peixes dos mares de Angola. Anais Junta Investig. Ultramar., vol. 9, no. 2 (1954), pp. 9–45.

Olsson, P.
1868–69. Prodromus faunae copepodorum parasitantium Scandinaviae. Acta Univ. Lundensis, no. 8, 49 pp., 2 pls.

Oorde de Lint, G. M. van, and Schuurmans Stekhoven, J. H., Jr.
1936. Copepoda parasitea. Tierw. Nord-Ostee (Gimpe und Wagler), no. 31, pp. 73–198.

Otto, A. W.
1821. Conspectus animalium quorundam maritimorum nondum editorum . . ., 20 pp.

Otto, A. W.
1828. Beschreibung einiger neuen, in den Jahren 1818 und 1819 im mittellandischen Meer gefundener Crustaceen. Nov. Act. Acad. Leopold-Carol., vol. 14, no. 1, pp. 331–354, pls. 20–22.

Pearse, A. S.
1952a. Parasitic Crustacea from the Texas coast. Inst. Mar. Sci. Port Arkansas, Texas, vol. 2, no. 2, pp. 5–42.

1952b. Parasitic crustaceans from Alligator Harbor, Florida. Quart. Journ. Florida Acad. Sci., vol. 15, no. 4, pp. 187–243.

Pearson, J.
1905. A list of the marine copepoda of Ireland, 1: Litoral forms and fish parasites. Rep. Sea and Inl. Fish. Ireland (1904), pt. 2, pp. 143–170.

Pesta, Otto
1934. Krebstiere oder Crustacea, 1: Ruderfüsser oder Copepoda, 6: Caligoida. Pt. 29 *in* Dahl, Die Tierwelt Deutschlands, 68 pp.

Poche, F.
1902. Bemerkungen zu der Arbeit des Herrn Bassett-Smith: "A systametic description of parasitic Copepoda found on fishes, with an enumeration of the known species." Zool. Anz., vol. 26, pp. 8–20. [Reference not seen.]

Rathbun, R.
1884. Annotated list of the described species of parasitic Copepoda (Siphonostoma) from American waters contained in the United States National Museum. Proc. U.S. Nat. Mus., vol. 7, no. 31, pp. 483–492.
1886. Description of parasitic Copepoda belonging to the genera *Pandarus* and *Chondracanthus*. Proc. U.S. Nat. Mus., vol. 9, pp. 310–324.
1887. Description of new species of parasitic copepods belonging to the genera *Trebius, Perissopus,* and *Lernanthropus*. Proc. U.S. Nat. Mus., vol. 10, pp. 559–571.

Richiardi, S.
1880. Contribution alla fauna d'Italia: Catalogo sistematico dei crostacei che vivono sul corpo degli animali aquatici. *In* Catalogo degli Espositori, pp. 147–152.

Rose, M., and Vaissiere, R.
1952a. Catalogue préliminaire des copépodes de l'Afrique du Nord, 1. Bull. Soc. Hist. Nat. Afrique Nord, vol. 43, pp. 113–136.
1952b. Catalogue préliminaire des copépodes de l'Afrique du Nord, 2. Bull. Soc. Hist. Nat. Afrique Nord, vol. 43, pp. 164–176.
1953. Catalogue préliminaire des copépodes de l'Afrique du Nord, 3. Bull. Soc. Hist. Nat. Afrique Nord, vol. 44, pp. 83–99.

Say, T.
1817. An account of the Crustacea of the United States. Journ. Acad. Nat. Sci. Philadelphia, vol. 1, 458 pp.

Scott, A.
1904. Some parasites found on fishes in the Irish Sea. Trans. Biol. Soc. Liverpool, vol. 18, pp. 33–45.
1929. The copepod parasites of Irish Sea Fishes. Rep. Lancahire Sea-Fish. Lab., no. 37, pp. 81–118.

Scott, T.
1900. Notes on some crustacean parasites of fishes. 18th Ann. Rep. Fish. Bd. Scotland, pp. 144–188.
1901. Notes on some parasites of fishes. 19th Ann. Rep. Fish. Bd. Scotland, pp. 120–153.
1902. Notes on some parasites of fishes. 20th Ann. Rep. Fish. Bd. Scotland, pp. 288–299.
1904. On some parasites of fishes new to Scottish marine fauna. 22d Ann. Rep. Fish. Bd. Scotland, pp. 275–278.

Scott, T., and Scott, A.
1913. The British Copepoda, 1: Copepoda parasitic on fishes. Ray Soc. London, vol. 2, 72 pls., 256 pp.

Shen, C. J., and Wang, K. N.
1958. A new parasitic copepod, *Achtheinus impenderus* (Caligoida, Pandaridae) from a shark taken at Peitaiho, Hopei Province. Tung Wu Hseuh Pao, vol. 10, no. 1, pp. 27–31. [In Chinese with English summary.]

Shiino, S. M.
1954. Copepods parasitic on Japanese fishes, 5: Five species of the family Pandaridae. Rep. Fac. Fish. Pref. Univ. Mie, vol. 1, no. 3, pp. 291–332.
1955. *Paranesippus incisus* n. gen., n. sp.: A new parasitic copepod of the family Pandaridae. Pacific Sci., vol. 9, no. 3, pp. 349–353.
1957. Copepods parasitic on Japanese fishes, 13: Parasitic copepods collected off Kesennuma, Miyagi Prefecture. Rep. Fac. Fish. Pref. Univ. Mie, vol. 2, no. 3, pp. 359–375.
1959a. Ostpazifische parasitierende Copepoden. Rep. Fac. Fish. Pref. Univ. Mie, vol. 3, no. 2, pp. 267–333.
1959b. Sammlung der parasitischen Copepoden in der Prafekturuniversitat von Mie. Rep. Fac. Fish. Pref. Univ. Mie, vol. 3, no. 2, pp. 334–374.
1960a. Copepods parasitic on fishes from Seto, Province Kii, Japan. Rep. Fac. Fish. Pref. Univ. Mie, vol. 3, no. 3, pp. 501–517.
1960b. Copepods parasitic on the fishes collected on the Coast of Province Shima, Japan. Rep. Fac. Fish. Pref. Univ. Mie, vol. 3, no. 3, pp. 471–500.

Smith, S. I.
1874. Invertebrate animals of Vineyard Sound. Rep. Comm. Fish and Fisher. 1871 and 1872, 478 pp., 38 pls.

Stebbing, T. R. R.
1910. General catalogue of South African Crustacea. Ann. South African Mus., vol. 6, no. 5, pp. 281–593.

Steenstrup, J. J. S., and Lütken, C. F.
1861. Bidrag til Kundskab om det aabne Havs Snyltekrebs og Lernaeer samt om nogle andre nye eller hidtil kun ufuldstaen digt kjendte parasitiske Copepoder, vol. 5, pp. 341–342.

Stephenson, K. H.
1940. Parasitic and semiparasitic Copepoda. Zool. Iceland, vol. 3, no. 34, pp. 1–24.

Stuardo, J., and Fagetti, E.
1961. Copepodos parasitos chilenos, 1: Una lista de las especies conocidas y descripcion de tres especies nuevas. Rev. Chilena Hist. Nat., vol. 55, pp. 55–82.

Thomsen, R.
1949. Copepods parasitos de los pesces marinos des Uruguay. Comm. Zool. Mus. Hist. Nat. Montevideo, vol. 3, no. 54, pp. 1–41.

Thomsen, G. M.
1889. Parasitic Copepoda of New Zealand. Trans. New Zealand Inst., vol. 22, pp. 353–376.

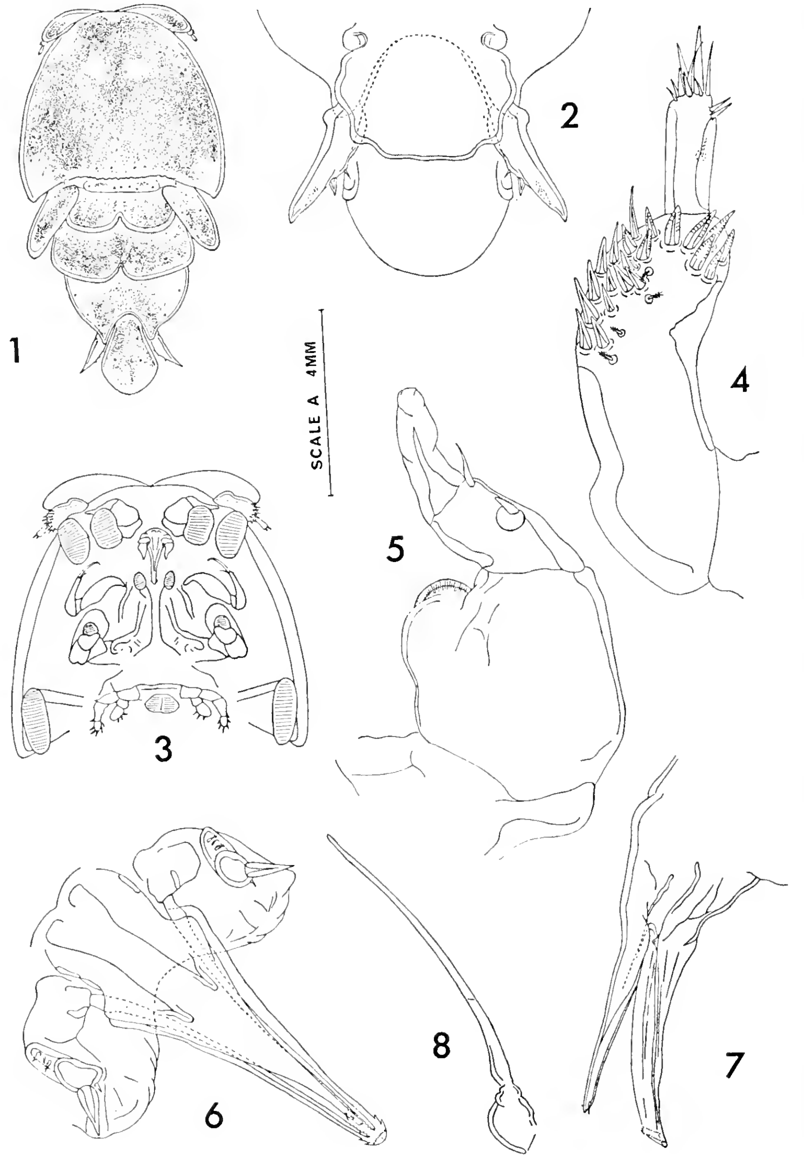
Valle, A. D.
1880. Crostacei parassiti dei pesci del mare Adriatico. Boll. Soc. Adriat. Sci. Nat., vol. 6, pp. 55–90.

Wilson, C. B.
1905. New species of parasitic copepods from Massachusetts coast. Proc. Biol. Soc. Washington, vol. 18, pp. 127–131.
1907. North American parasitic copepods belonging to the family Caligidae, 3 and 4: A revision of the Pandarinae and the Cecropinae. Proc. U.S. Nat. Mus., vol. 33, pp. 323–490, pls. 17–43.
1908. North American parasitic copepods: A list of those found upon the fishes of the Pacific coast, with descriptions of new genera and species. Proc. U.S. Nat. Mus., vol. 35, pp. 431–481.

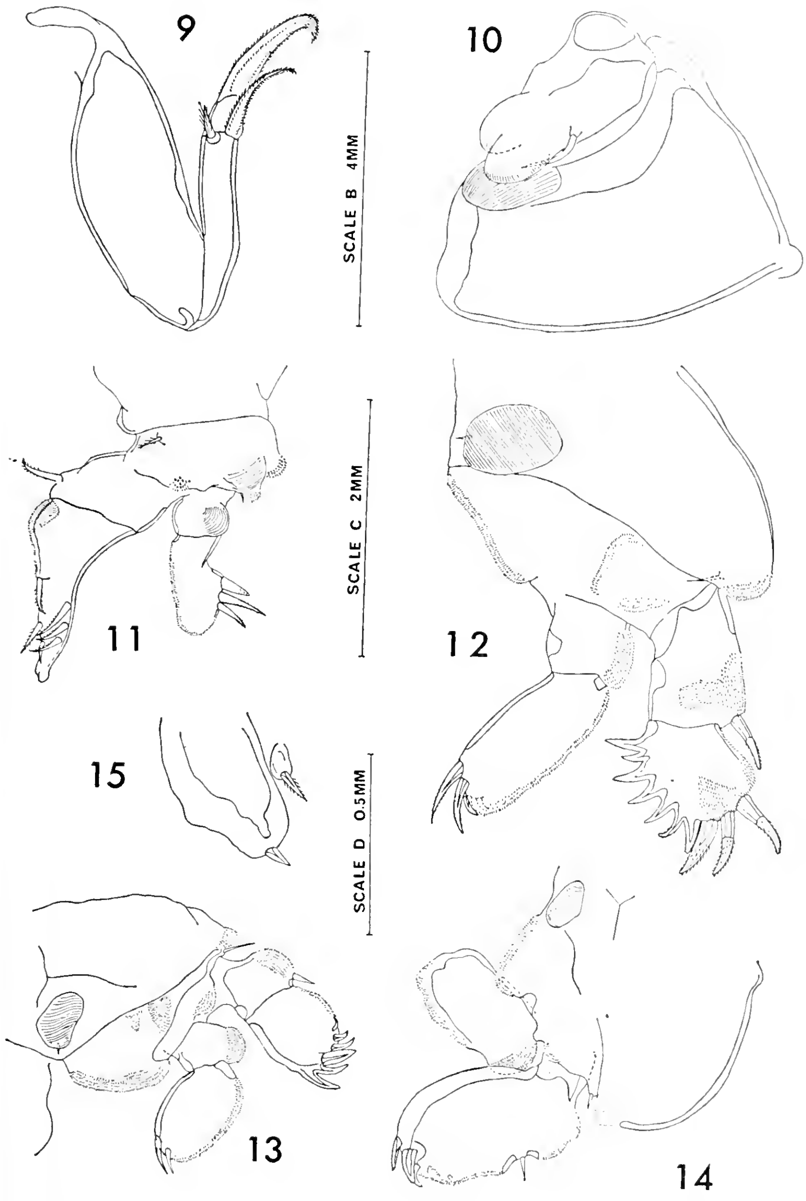
WILSON, C. B.
1911. North American parasitic copepods: Description of new genera and species. Proc. U.S. Nat. Mus., vol. 39, pp. 625–634.
1912. Description of new species of parasitic copepods in the collections of the U.S. National Museum. Proc. U.S. Nat. Mus., vol. 42, pp. 233–243.
1914. The male of *Pandarus satyrus* Dana. Sci. Bull. Mus. Brooklyn Inst. Arts and Sci., vol. 2, no. 4, pp. 71–72.
1920. Report on the parasitic Copepoda collected during the Canadian Arctic Expedition, 1913–18. Rep. Canadian Arctic Exped. 1913–18, vol. 7, pt. L, pp. 3–16.
1922. Parasitic Copepoda in the collection of the Zoological Museum, Kristiania. Medd. Zool. Mus. Kristiania, no. 4, pp. 1–7.
1923. Parasitic copepods in the collection of the Riksmuseum at Stockholm. Ark. Zool., vol. 15, no. 3, pp. 1–15.
1924a. New North American parasitic copepods, new hosts and note on copepod nomenclature. Proc. U.S. Nat. Mus., vol. 64, no. 2507, art. 17, pp. 1–22.
1924b. Parasitic copepods from the William Galapagos Expedition. Zoologica, Sci. Contr. New York Zool. Soc., vol. 5, no. 19, pp. 211–217.
1932. The copepods of the Woods Hole region, Massachusetts. U.S. Nat. Mus. Bull. 158, 635 pp.
1935a. New parasitic copepods (Reports on the collections obtained by the first Johnson-Smithsonian deep sea expedition to the Puerto Rican deep). Smithsonian Misc. Coll., vol. 91, no. 3298, art. 19, pp. 1–9.
1935b. Parasitic copepods from the Pacific Coast. American Midl. Nat., vol. 16, no. 5, pp. 776–797.
1936. Parasitic copepods from the Dry Tortugas. *In* Papers from the Tortugas Laboratory. Carnegie Inst. Washington Publ. 452, vol. 29, no. 12, pp. 327–347.

YAMAGUTI, S.
1936. Parasitic copepods from fishes of Japan, 3: Caligoida, 2, 21 pp.
1963. Parasitic copepods and Branchiura of fishes, 390 pp.

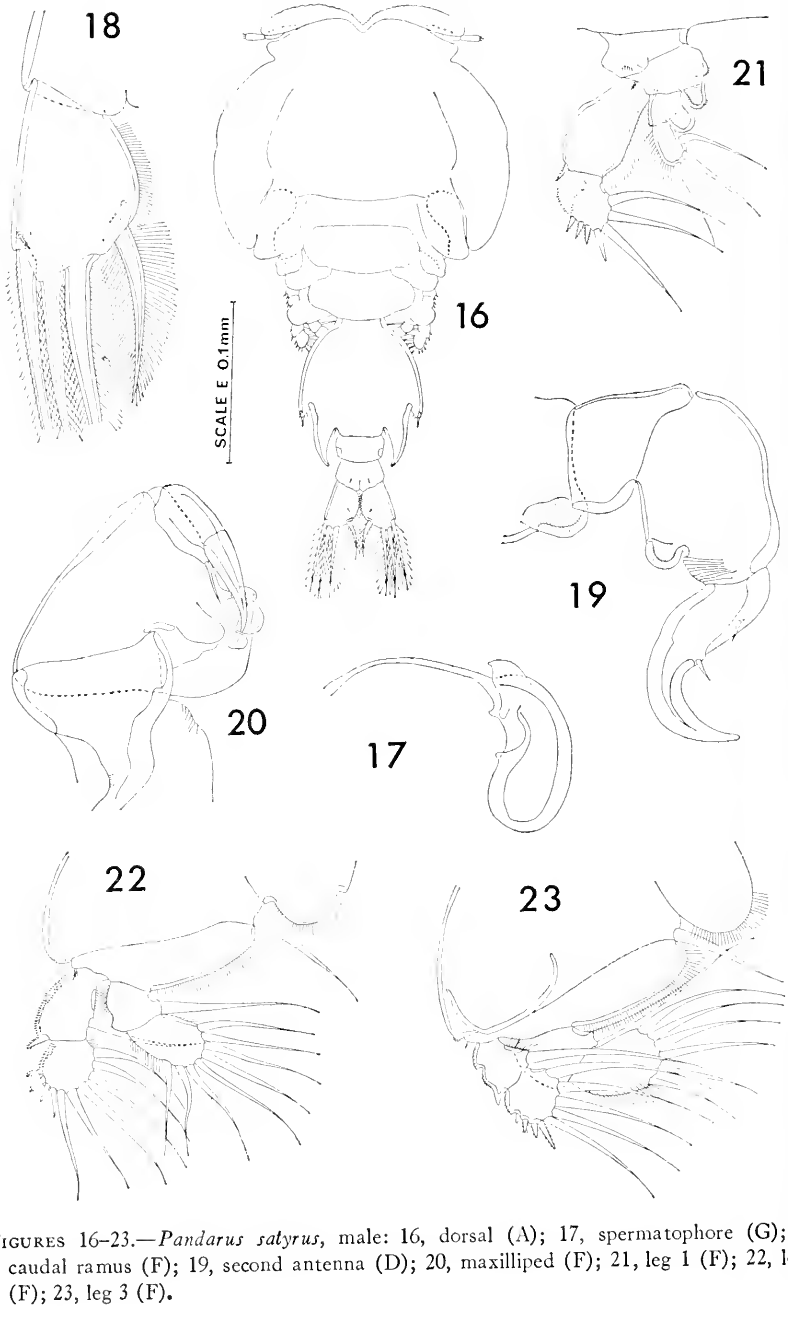
YAMAGUTI, S., and YAMASU, T.
1960. New parasitic copepods from Japanese fishes. Publ. Seto Mar. Biol. Lab., vol. 8, no. 1, pp. 141–152.



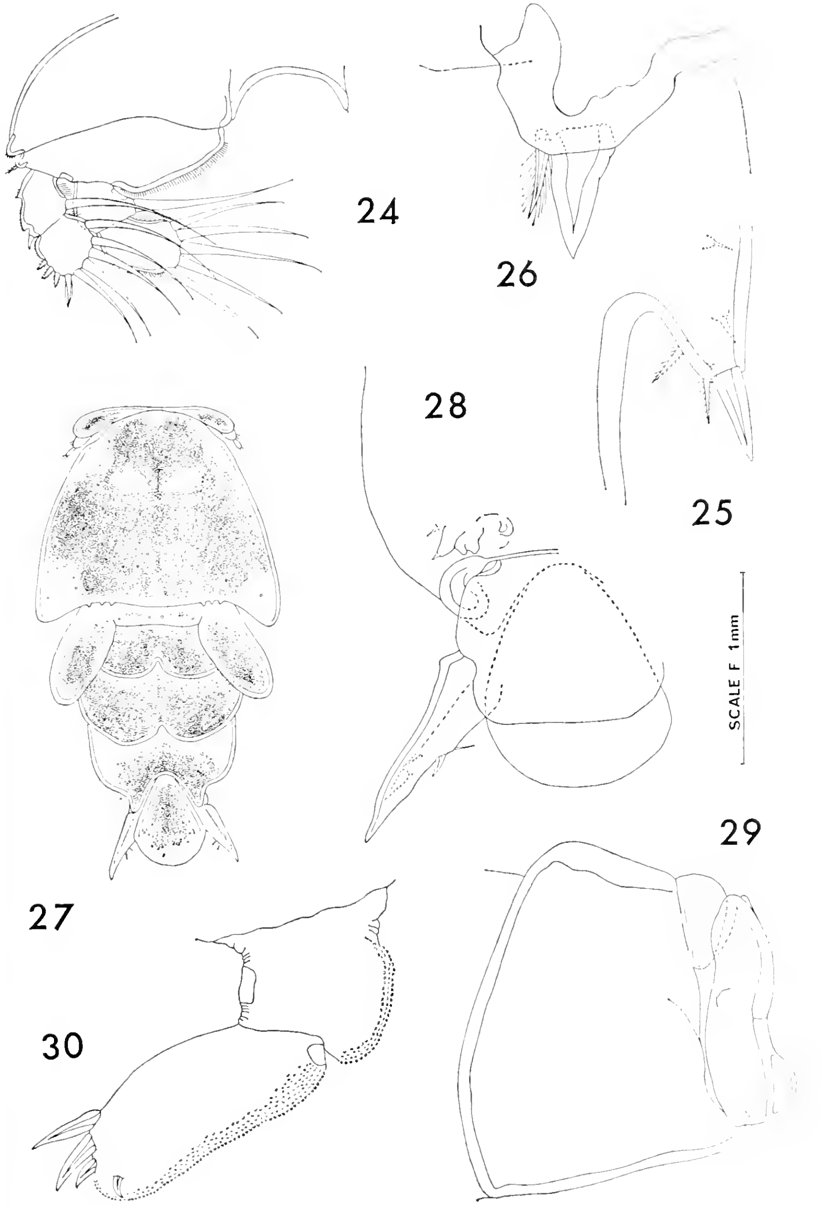
FIGURES 1–8.—*Pandarus satyrus*, female: 1, dorsal (A); 2, abdomen and caudal rami ventral (D); 3, oral area, ventral (B); 4, first antenna (G); 5, second antenna (G); 6, mouth tube and first maxilla (G); 7, mouth tube, lateral (G); 8, mandible (G).



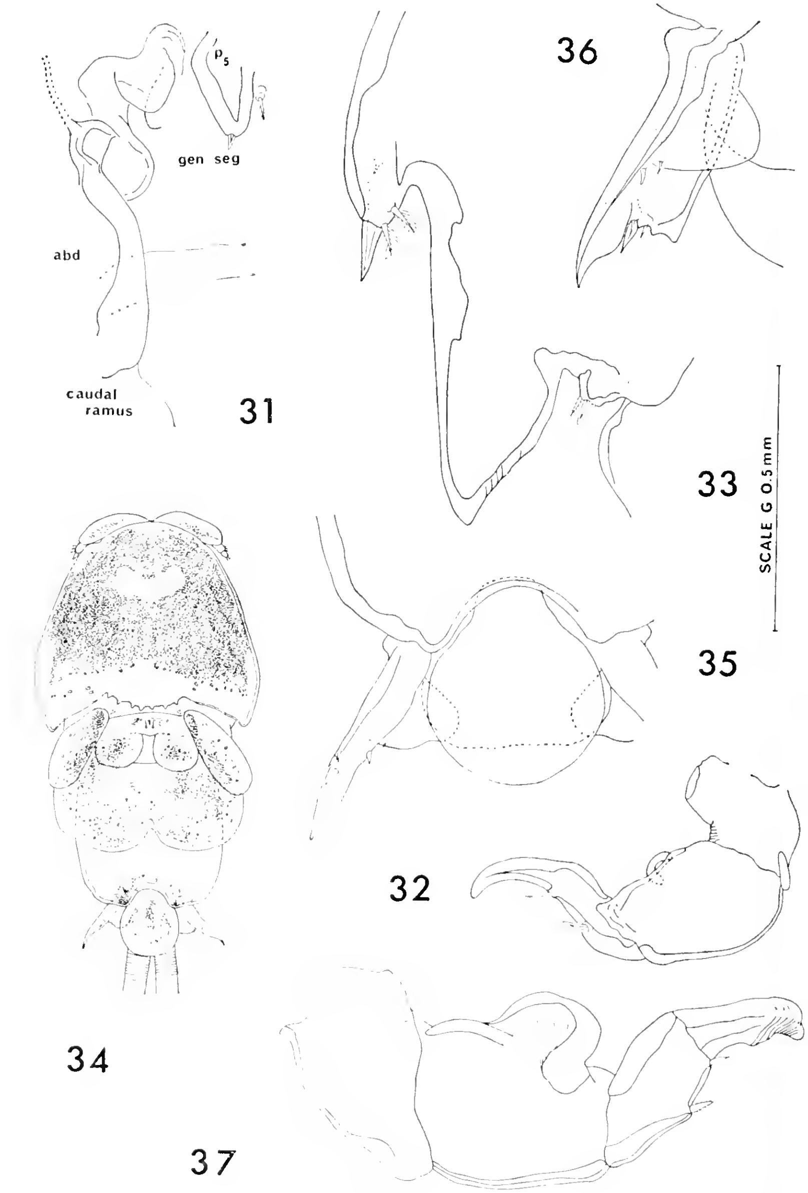
FIGURES 9–15.—*Pandarus satyrus*, female: 9, second maxilla (D); 10, maxilliped (D); 11, leg 1 (D); 12, leg 2 (D); 13, leg 3 (F); 14, leg 4 (F); 15, leg 5 (G).



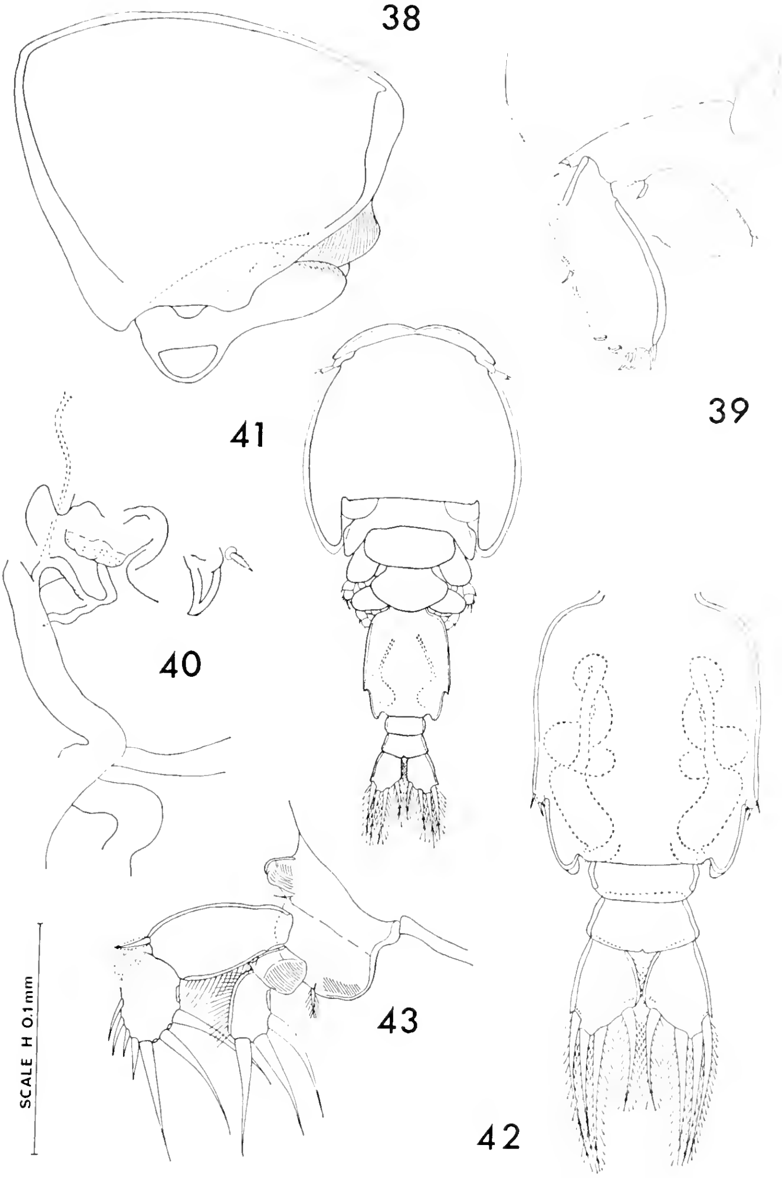
FIGURES 16–23.—*Pandarus satyrus*, male: 16, dorsal (A); 17, spermatophore (G); 18, caudal ramus (F); 19, second antenna (D); 20, maxilliped (F); 21, leg 1 (F); 22, leg 2 (F); 23, leg 3 (F).



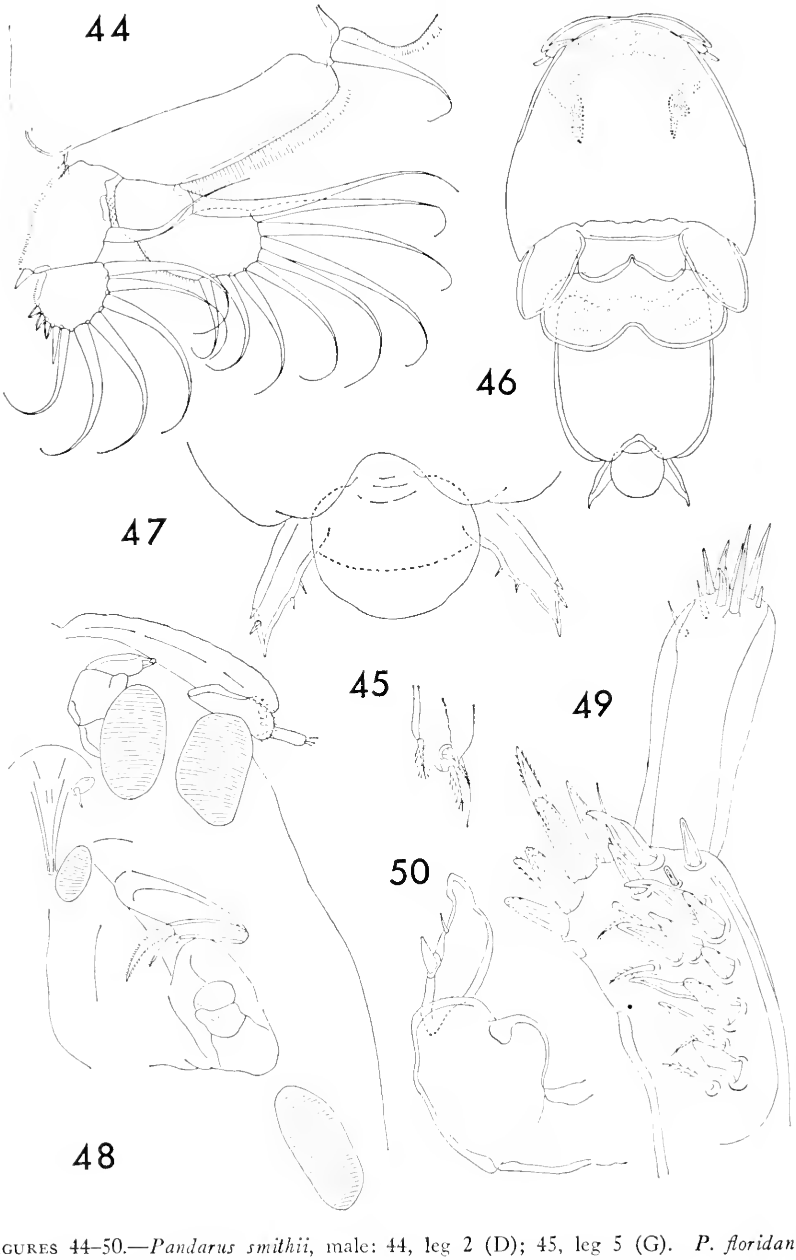
FIGURES 24–30.—*Pandarus satyrus*, male: 24, leg 4 (F); 25, leg 5 (G); 26 leg 6 (E). *P. cranchii*, female: 27, dorsal (A); 28, abdomen and caudal ramus (C); 29, maxilliped (D); 30, endopod of second leg (G).



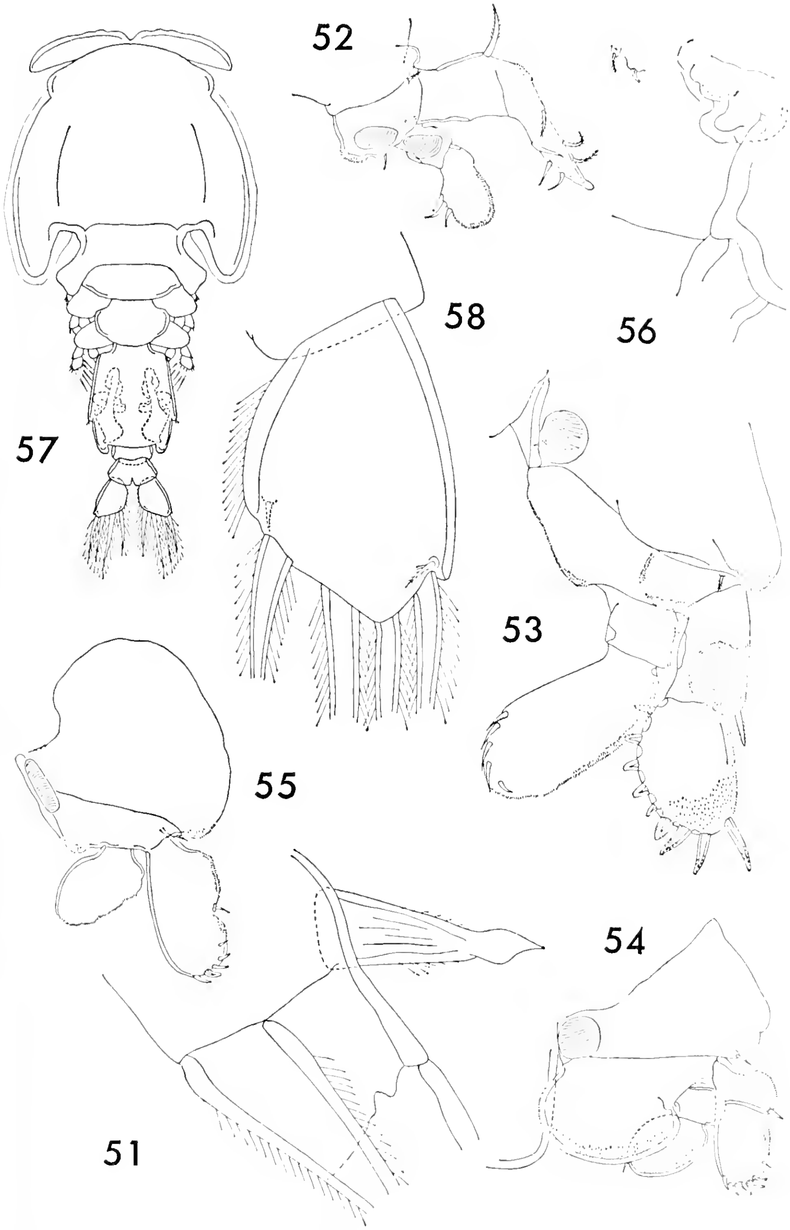
FIGURES 31–37.—*Pandarus cranchii*, female: 31, area of spermatohpore attachment (D); male: 32, second antenna (D); 33, posterior corner of genital segment (D). *P. smithii*, female: 34, dorsal (A); 35, abdomen and caudal ramus (D); 36, caudal ramus, ventrolateral (F); 37, second antenna (G).



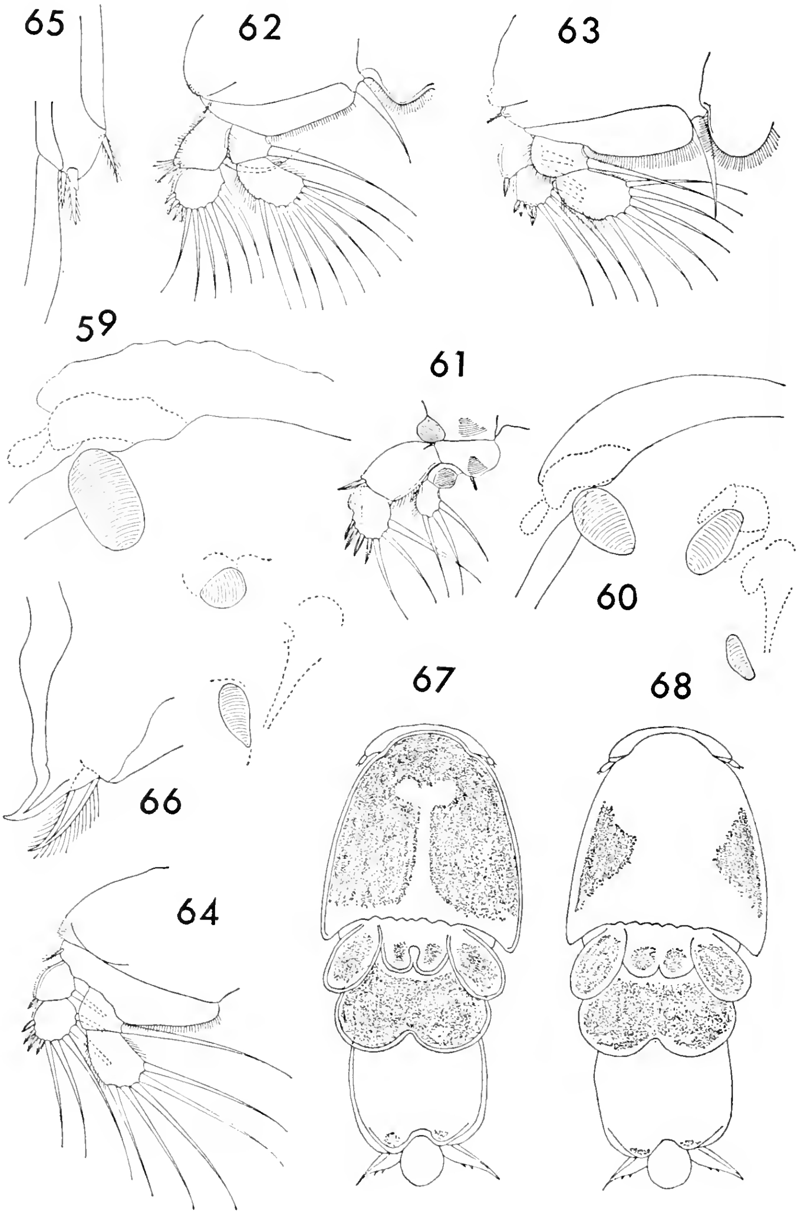
FIGURES 38–43.—*Pandarus smithii*, female: 38, maxilliped (D); 39, leg 4 (F); 40, area of spermatophore attachment (D); male: 41, dorsal (A); 42, genital segment and abdomen (C); 43, leg 1 (D).



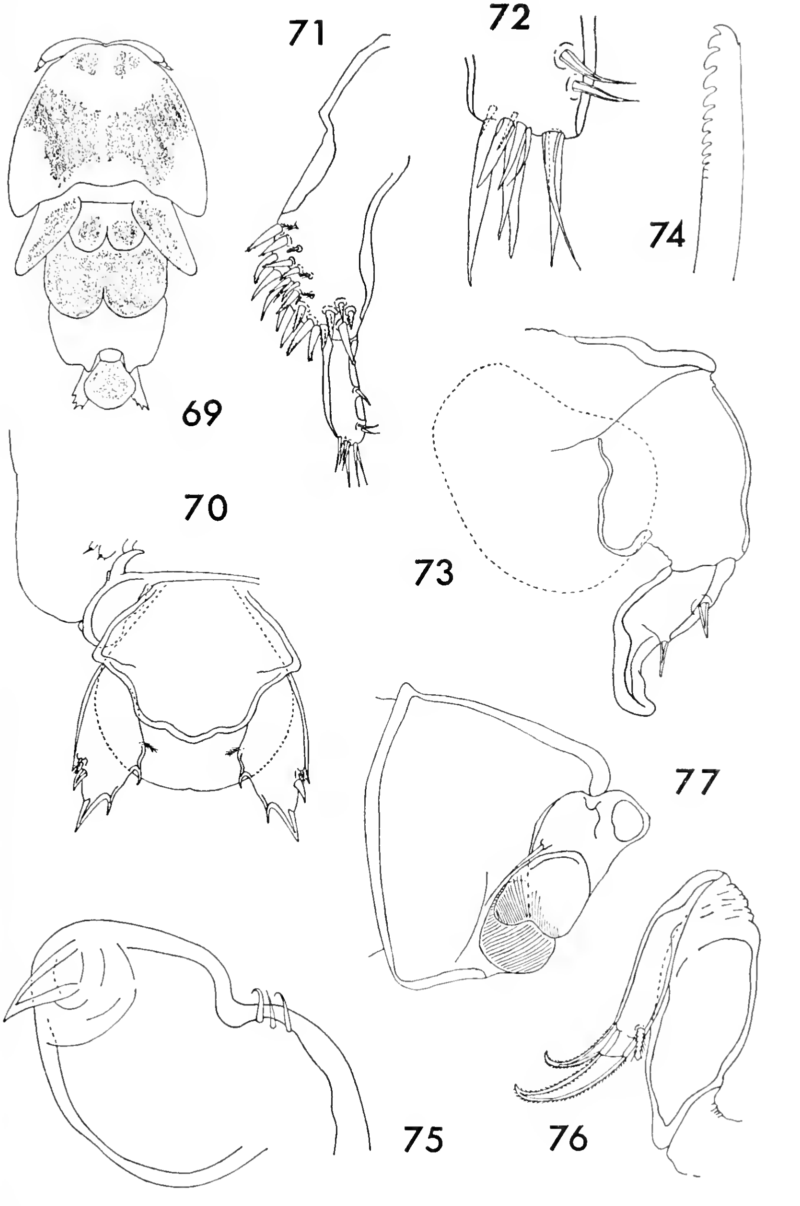
Figures 44–50.—*Pandarus smithii*, male: 44, leg 2 (D); 45, leg 5 (G). *P. floridanus*, new species, female: 46, dorsal (B); 47, dorsal abdominal plate and rami (F); 48, oral area (F); 49, first antenna (E); 50, second antenna (G).



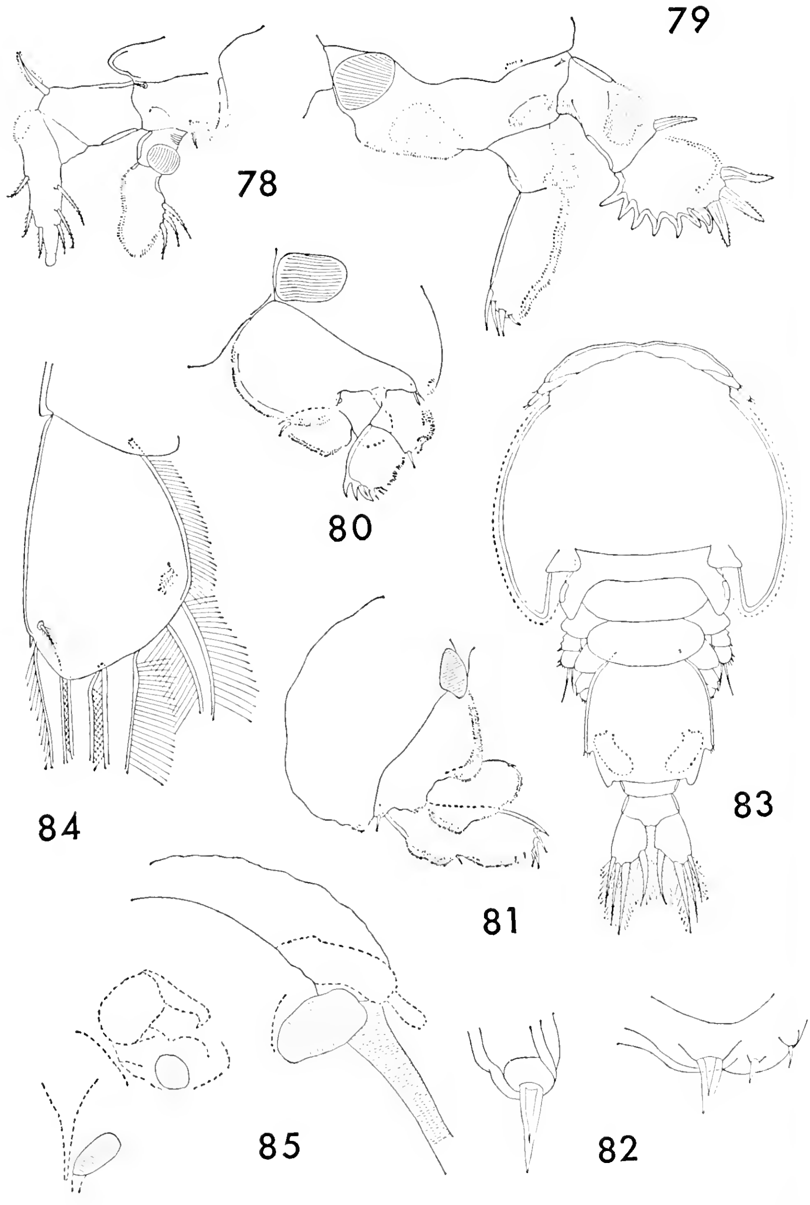
FIGURES 51–58.—*Pandarus floridanus*, new species, female: 51, subterminal spine on second maxilla (H); 52, leg 1 (D); 53, leg 2 (D); 54, leg 3 (F); 55, leg 4 (F); 56, area of spermatophore attachment (D). Male: 57, dorsal (C); 58, caudal ramus (G).



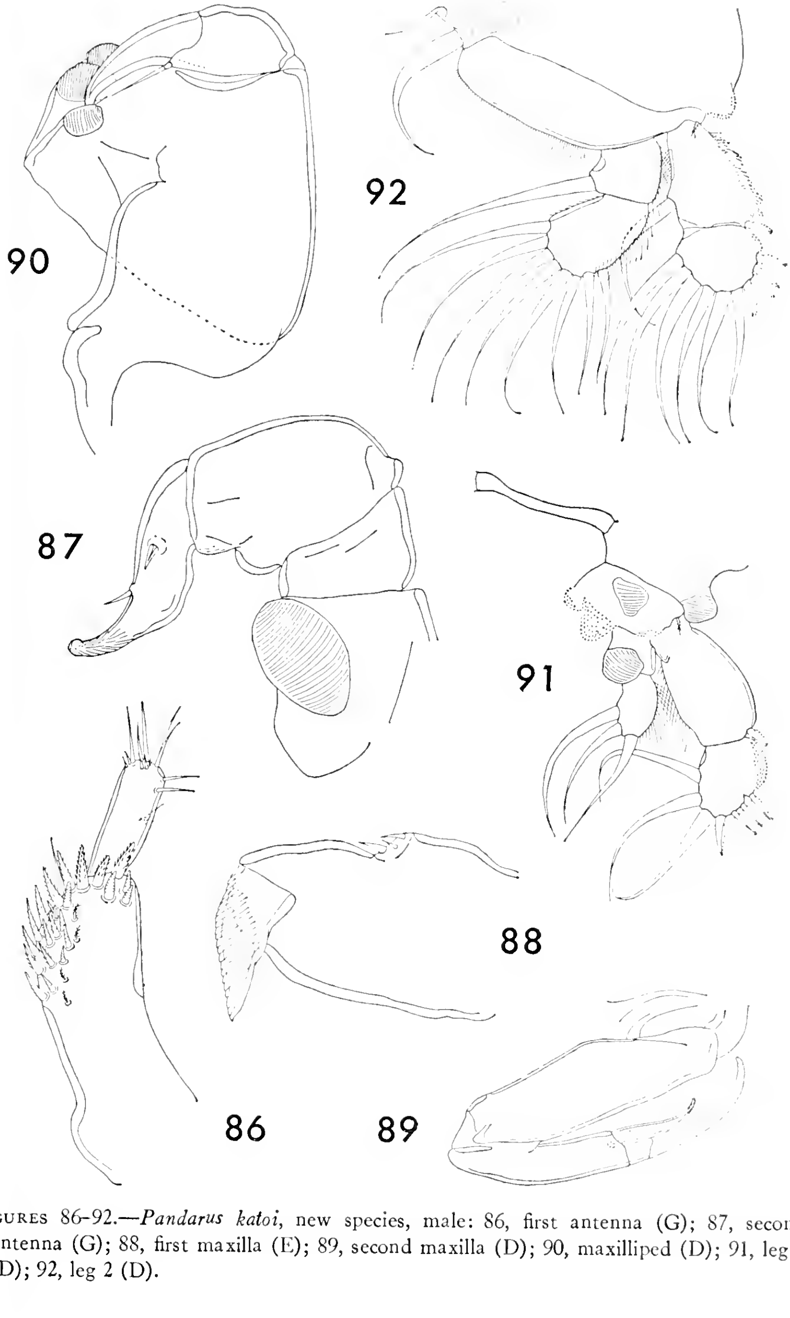
FIGURES 59–68.—*Pandarus floridanus*, new species, male: 59, adhesion pads, adult (F); 60, adhesion pads, young male (F); 61, leg 1 (F); 62, leg 2 (F); 63, leg 3 (F); 64, leg 4 (F); 65, leg 5 (G); 66, leg 6 (H). *P. sinuatus*, female: 67, dorsal, adult female (B); 68, dorsal, young female (B).



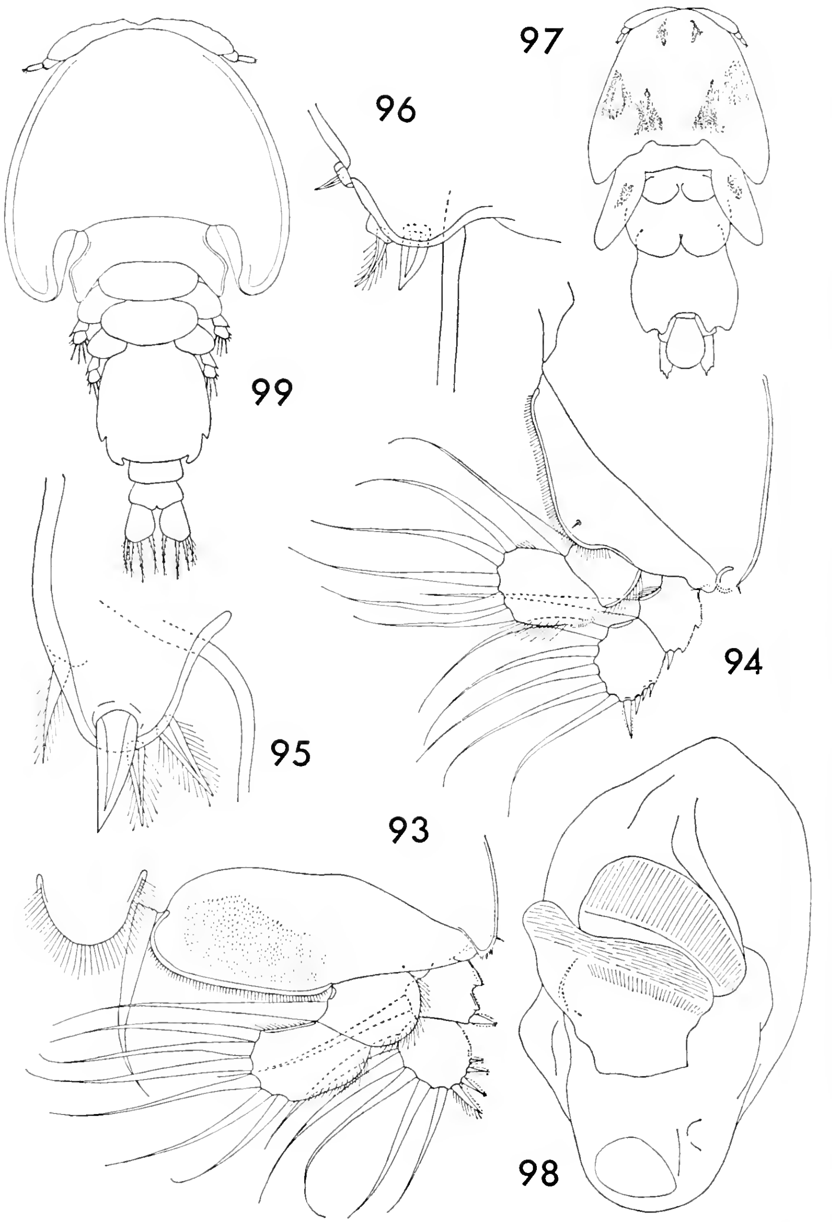
FIGURES 69-77.—*Pandarus katoi*, new species, female: 69, dorsal (A); 70, abdomen and caudal ramus (F); 71, first antenna (G); 72, detail of last segment of first antenna (H); 73, second antenna (G); 74, tip of mandible (?); 75, first maxilla (H); 76, second maxilla (D); 77, maxilliped (D).



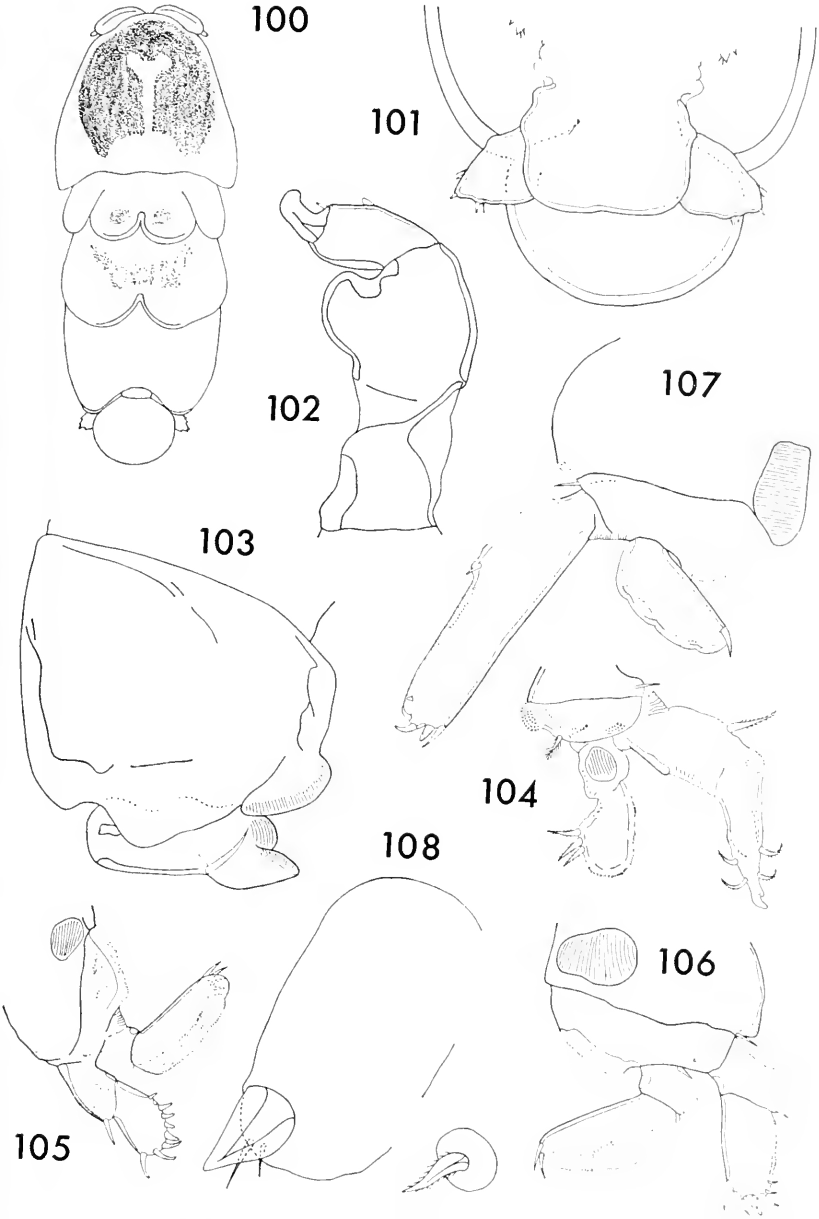
FIGURES 78–85.—*Pandarus katoi*, new species, female: 78, leg 1 (D); 79, leg 2 (D); 80, leg 3 (F); 81, leg 4 (F); 82, leg 5 (H). Male: 83, dorsal (B); 84, caudal ramus (D); 85, adhesion pads, oral area (F).



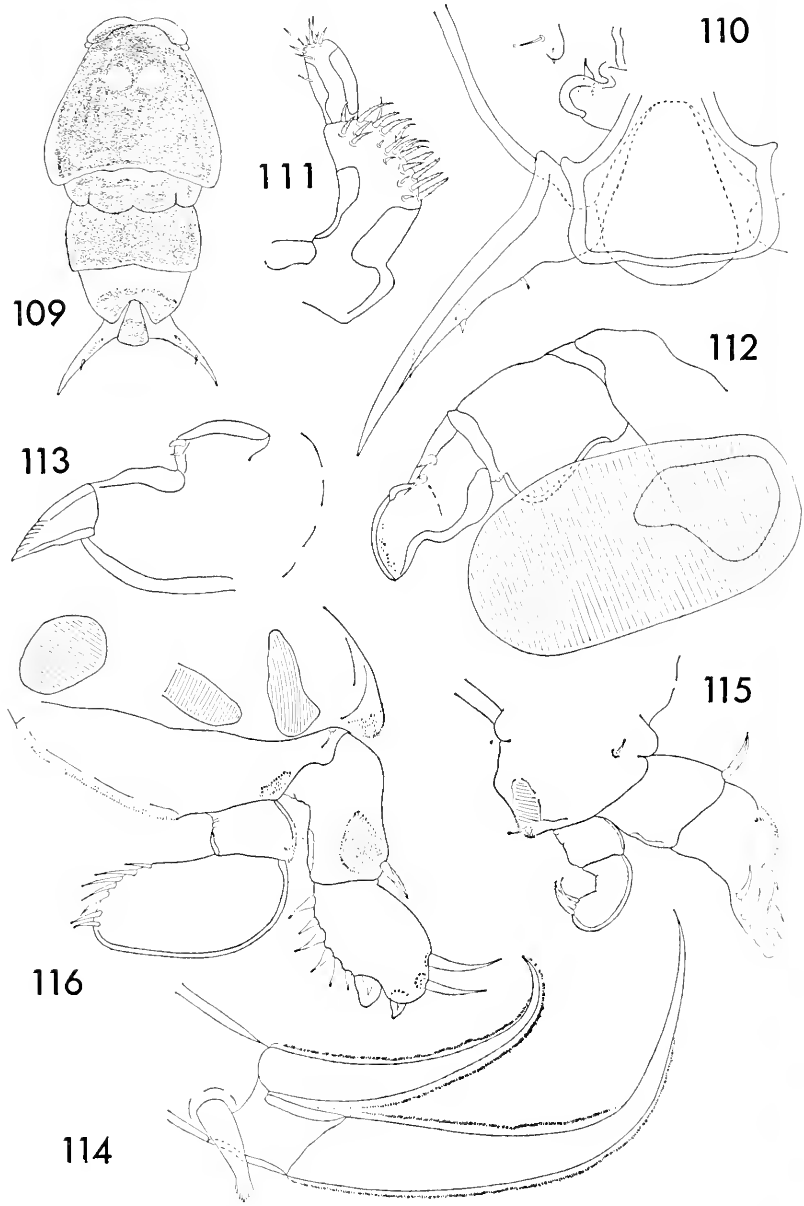
FIGURES 86-92.—*Pandarus katoi*, new species, male: 86, first antenna (G); 87, second antenna (G); 88, first maxilla (E); 89, second maxilla (D); 90, maxilliped (D); 91, leg 1 (D); 92, leg 2 (D).



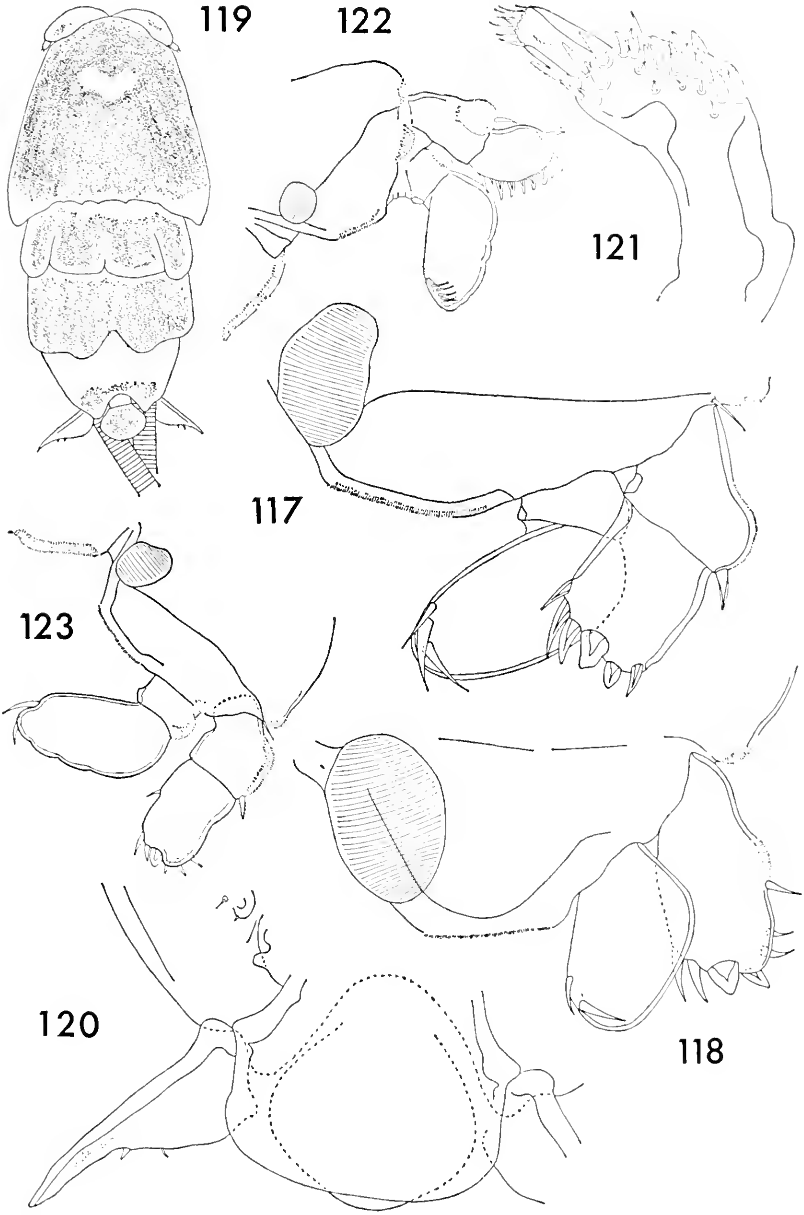
FIGURES 93–99.—*Pandarus katoi*, new species, male: 93, leg 3 (D); 94, leg 4 (D); 95, leg 5 (E); 96, leg 6 (E). *P. zygaenae*, female: 97, dorsal (A); 98, maxilliped (G); male: 99, dorsal (B).



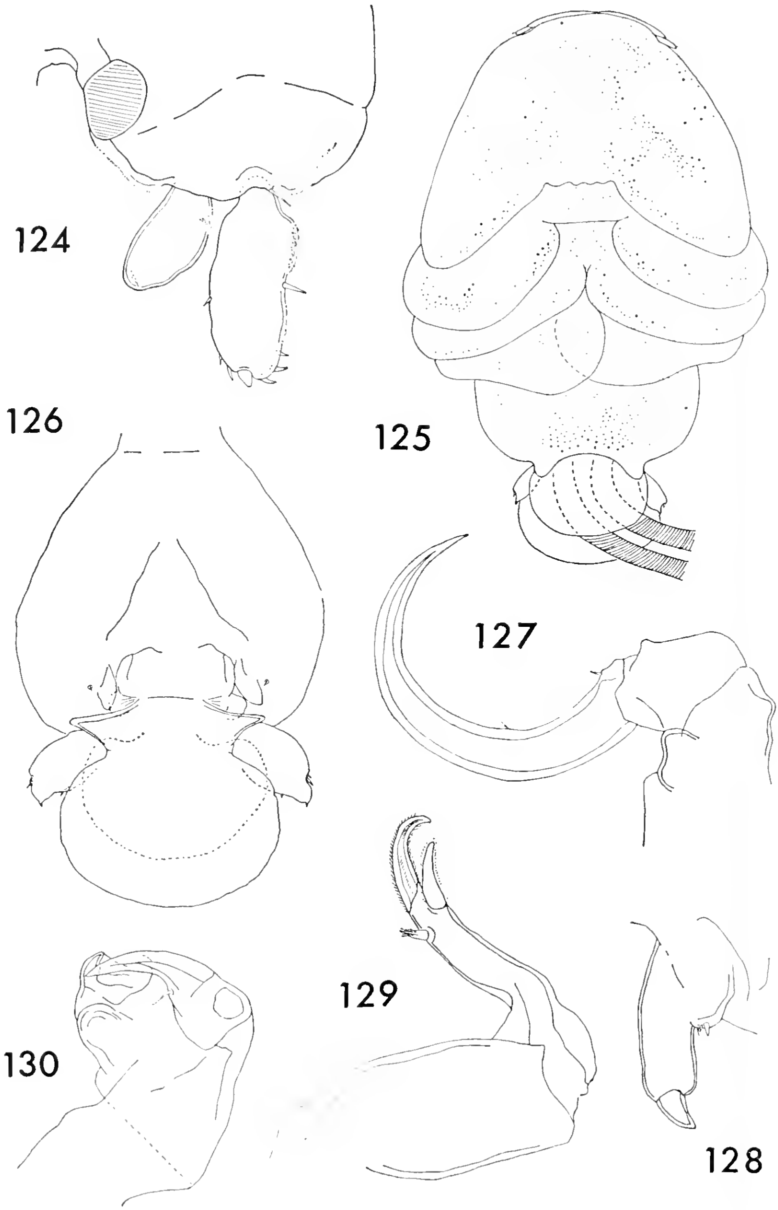
FIGURES 100–108.—*Pandarus bicolor*, female: 100, dorsal (A); 101, abdomen and caudal rami, ventral (C); 102, second antenna (G); 103, maxilliped (D); 104, leg 1 (D); 105, leg 2 (F); 106, leg 3 (G); 107, leg 4 (F); 108, leg 5 (H).



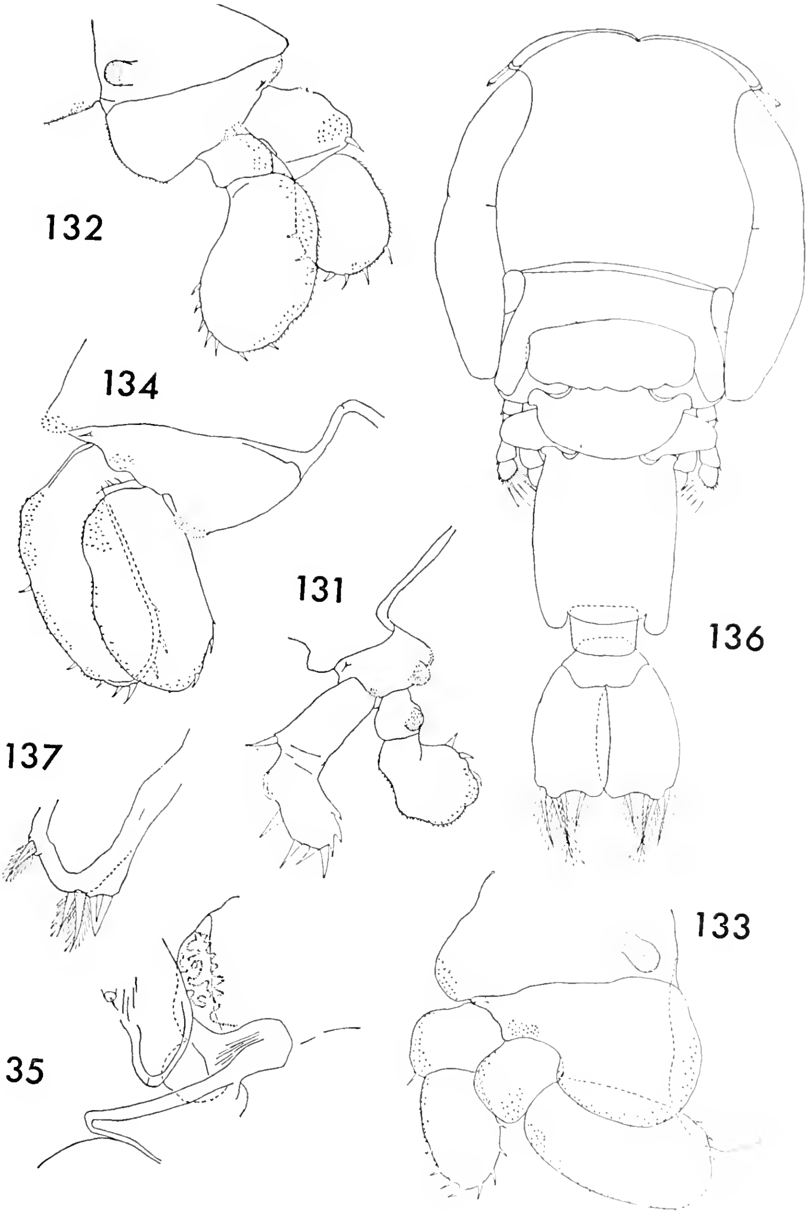
FIGURES 109–116.—*Pandarus niger*, female: 109, dorsal (A); 110, abdomen and caudal ramus, ventral (F); 111, first antenna (G); 112, second antenna (G); 113, first maxilla (E); 114, tip of second maxilla (E); 115, leg 1 (G); 116, leg 2 (G).



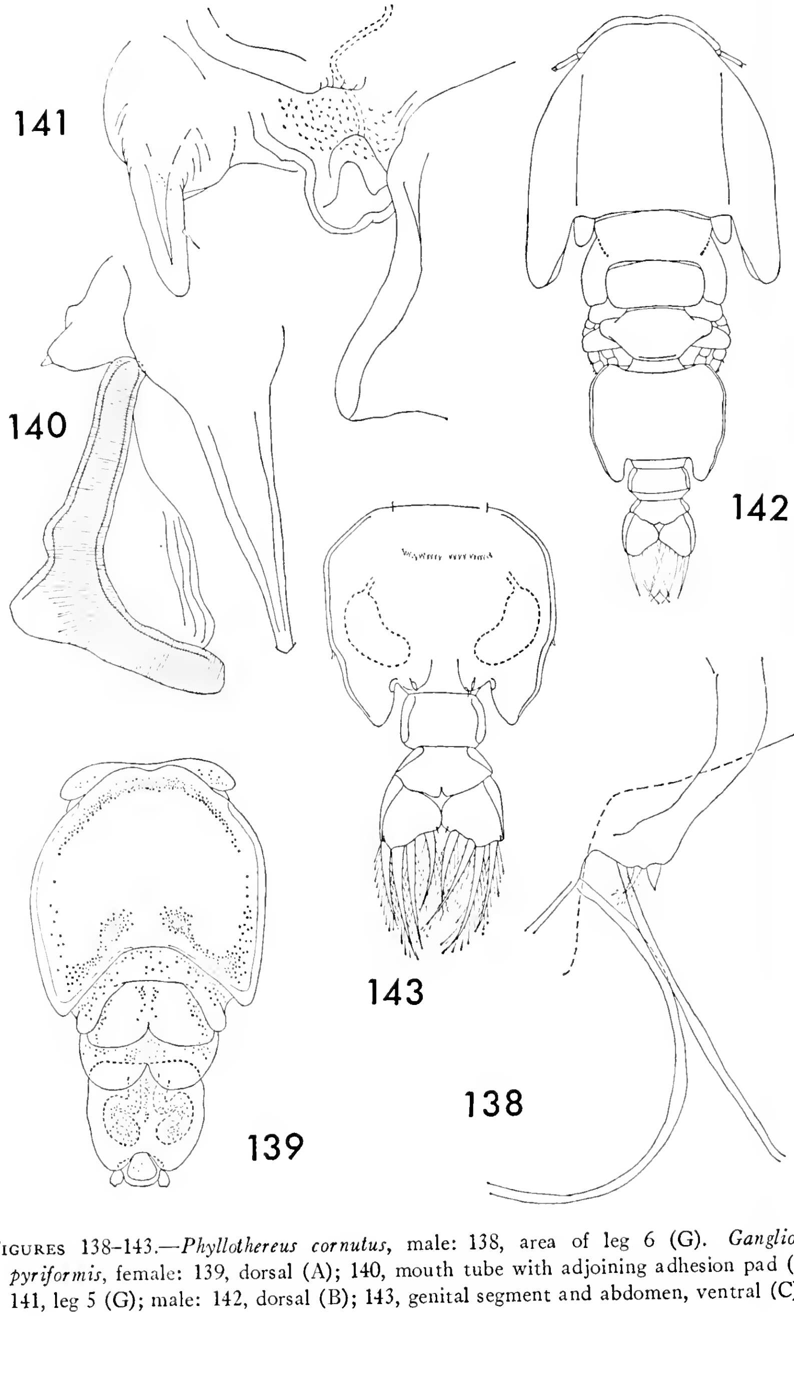
FIGURES 117–123.—*Pandarus niger*, female: 117, leg 3 (G); 118, leg 4 (G). *P. carcharini*, female: 119, dorsal (A); 120, abdomen and caudal ramus, ventral (F); 121, first antenna (G); 122, leg 2 (F); 123, leg 3 (F).



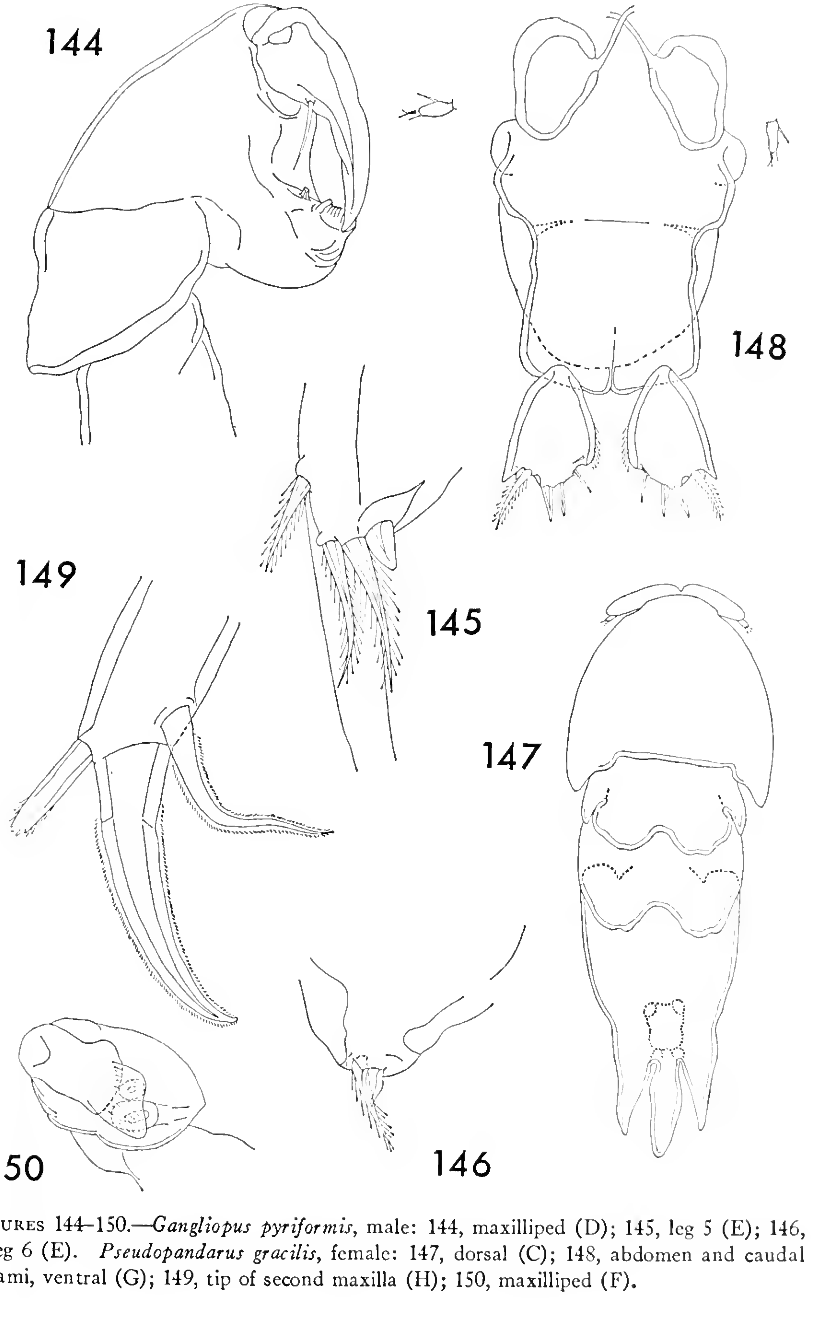
FIGURES 124–130.—*Pandarus carcharini*, female: 124, leg 4 (F). *Phyllothereus cornutus*, female: 125, dorsal (A); 126, genital segment, abdomen, and caudal rami, ventral (B); 127, second antenna (C); 128, first maxilla (G); 129, second maxilla (F); 130, maxilliped (F).



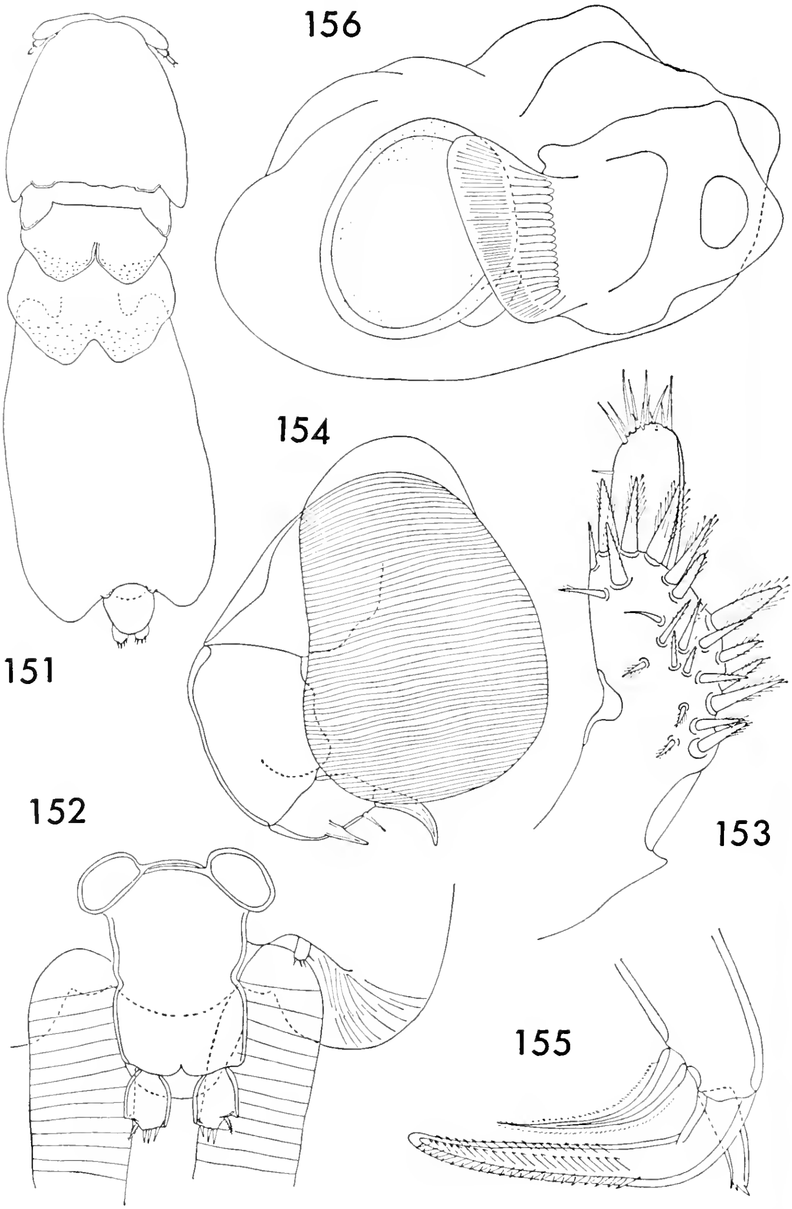
Figures 131–137.—*Phyllothereus cornutus*, female: 131, leg 1 (F); 132, leg 2 (C); 133, leg 3 (C); 134, leg 4 (C); 135, area of leg 5 (F). Male: 136, dorsal (A); 137, leg 5 (G).



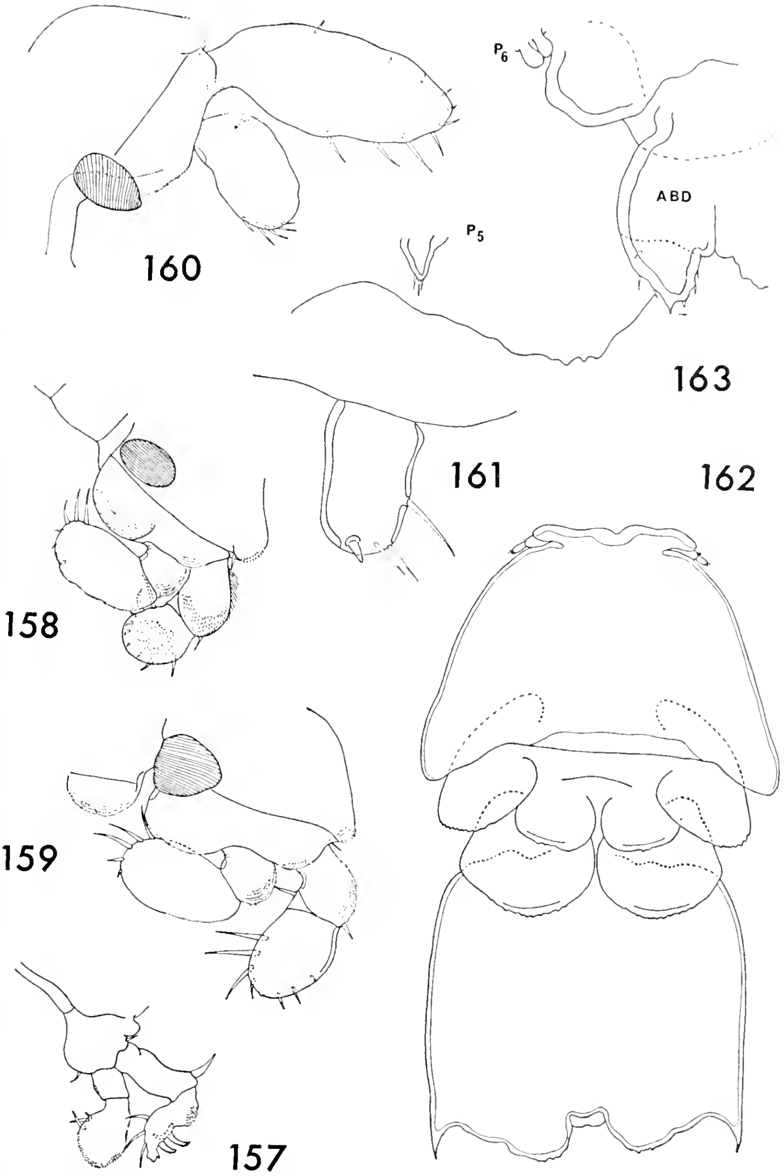
FIGURES 138–143.—*Phyllothereus cornutus*, male: 138, area of leg 6 (G). *Gangliopus pyriformis*, female: 139, dorsal (A); 140, mouth tube with adjoining adhesion pad (D); 141, leg 5 (G); male: 142, dorsal (B); 143, genital segment and abdomen, ventral (C).



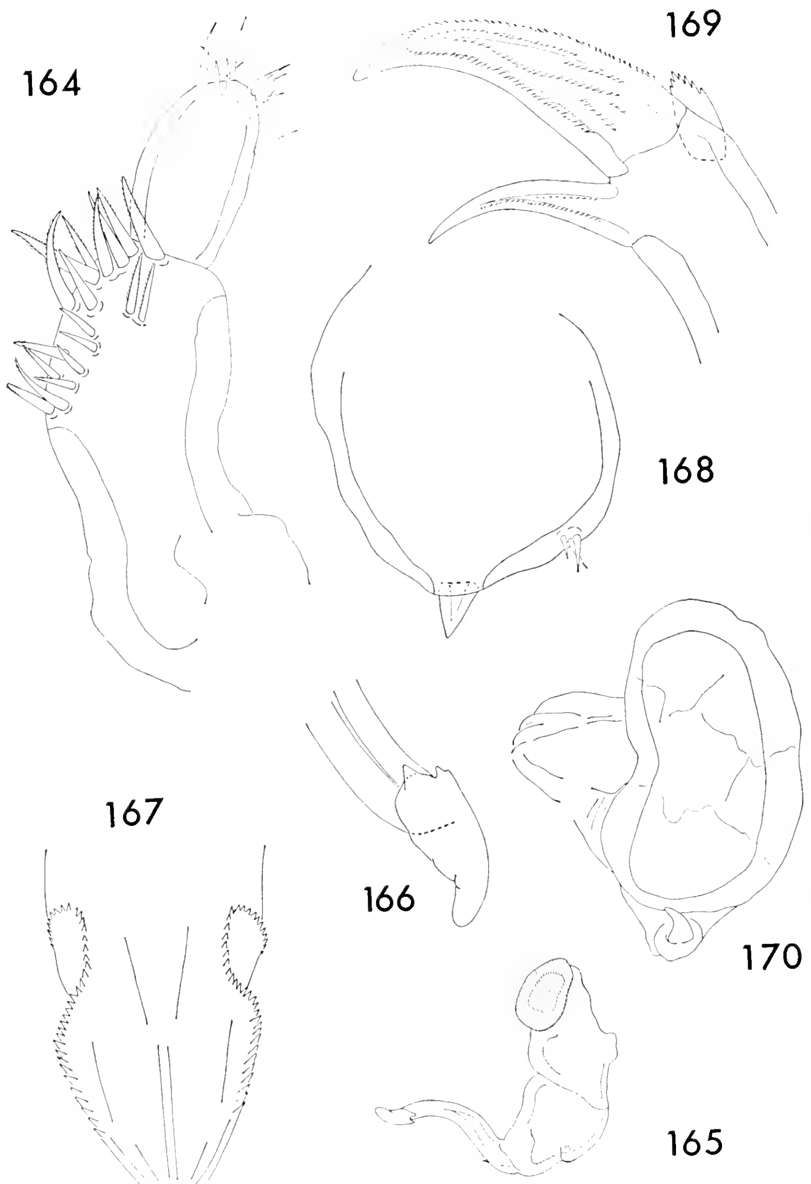
FIGURES 144–150.—*Gangliopus pyriformis*, male: 144, maxilliped (D); 145, leg 5 (E); 146, leg 6 (E). *Pseudopandarus gracilis*, female: 147, dorsal (C); 148, abdomen and caudal rami, ventral (G); 149, tip of second maxilla (H); 150, maxilliped (F).



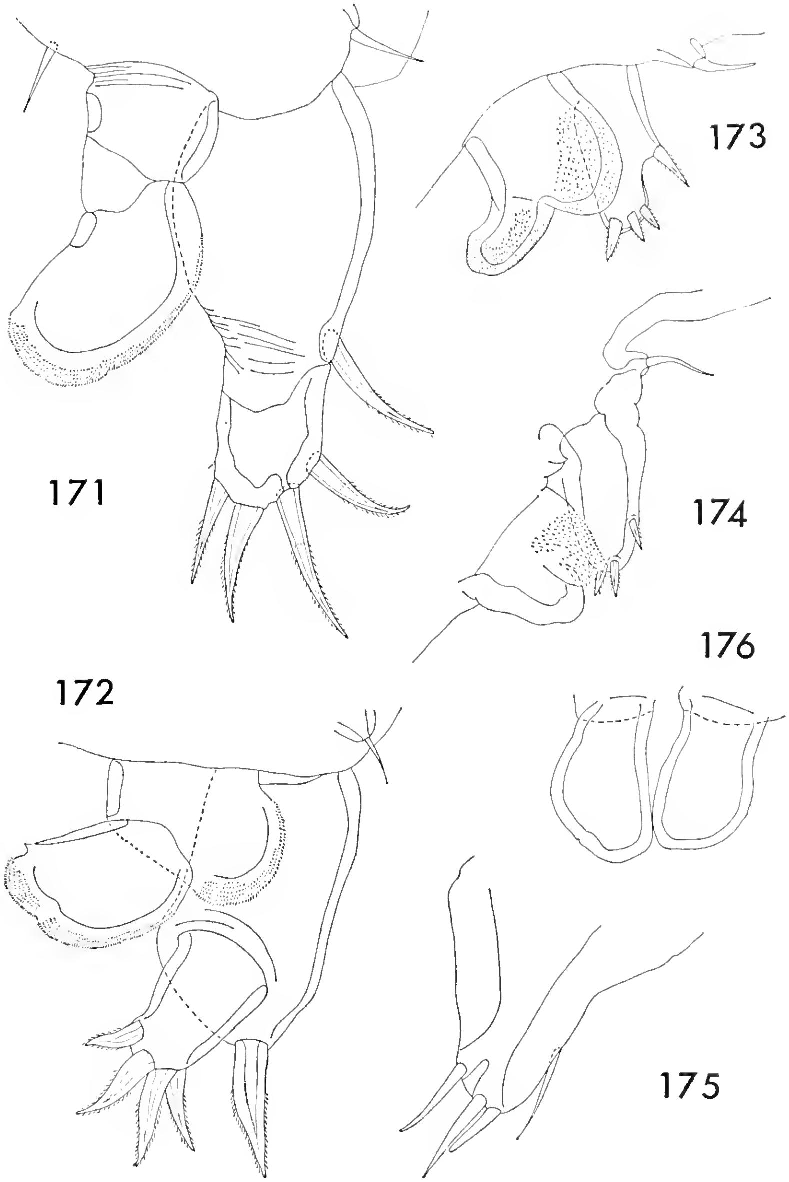
FIGURES 151–156.—*Pseudopandarus longus*, female: 151, dorsal (C); 152, abdomen and caudal rami, ventral (C); 153, first antenna (E); 154, second antenna (E); 155, tip of second maxilla (H); 156, maxilliped (D).



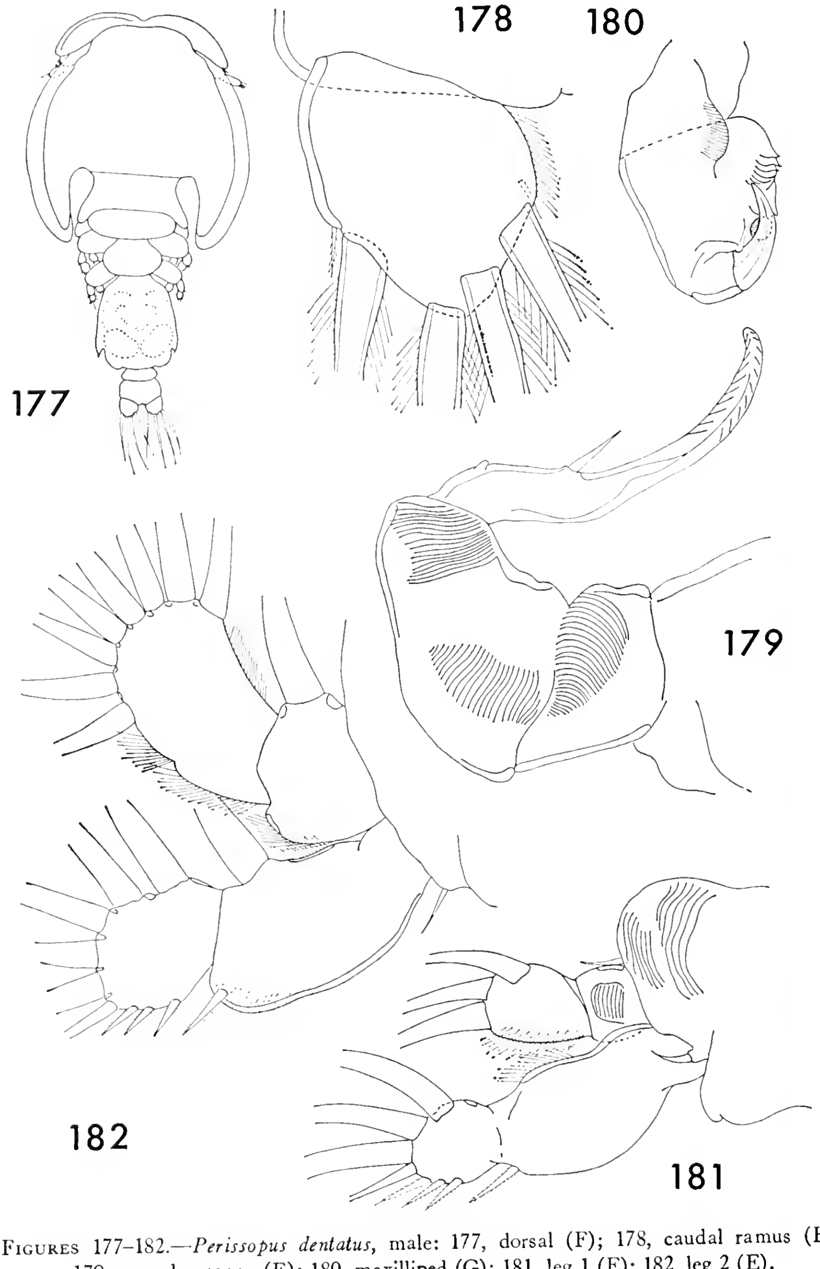
Figures 157–163.—*Pseudopandarus longus*, female: 157, leg 1 (G); 158, leg 2 (G); 159, leg 3 (G); 160, leg 4 (G); 161, leg 5 (H). *Perissopus dentatus*, female: 162, dorsal (C); 163, abdomen and adjacent area, ventral (D).



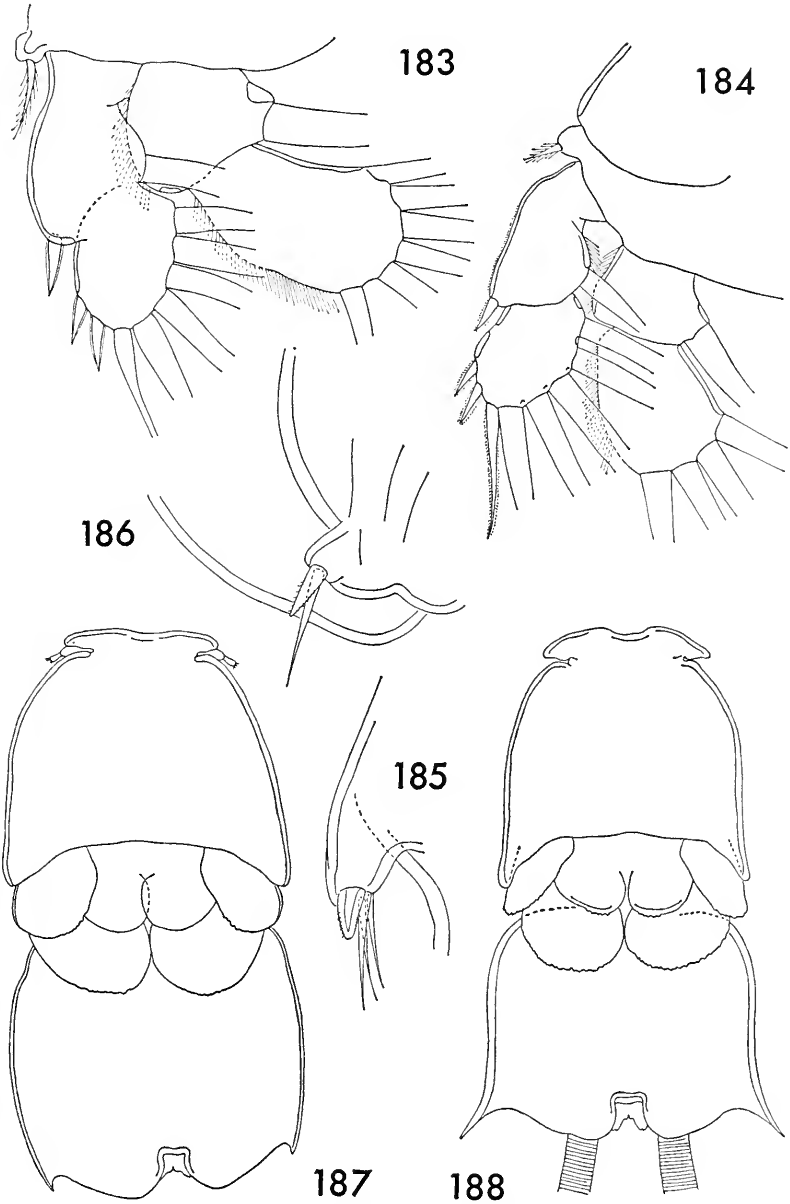
FIGURES 164–170.—*Perissopus dentatus*, female: 164, first antenna (E); 165, second antenna (G); 166, tip of second antenna (H); 167, tip of labium (I); 168, first maxilla (E); 169, tip of second maxilla (H); 170, maxilliped (D).



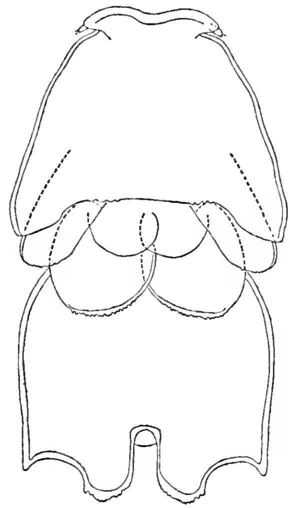
FIGURES 171–176.—*Perissopus dentatus*, female: 171, leg 1 (E); 172, leg 2 (E); 173, leg 3 (E); 174, leg 4 (E); 175, leg 5 (H); 176, leg 6 (H).



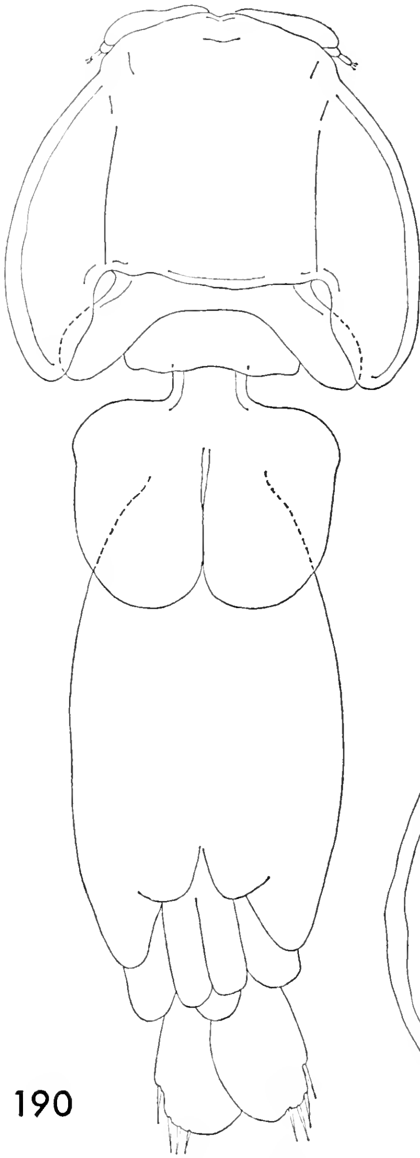
Figures 177–182.—*Perissopus dentatus*, male: 177, dorsal (F); 178, caudal ramus (E); 179, second antenna (E); 180, maxilliped (G); 181, leg 1 (E); 182, leg 2 (E).



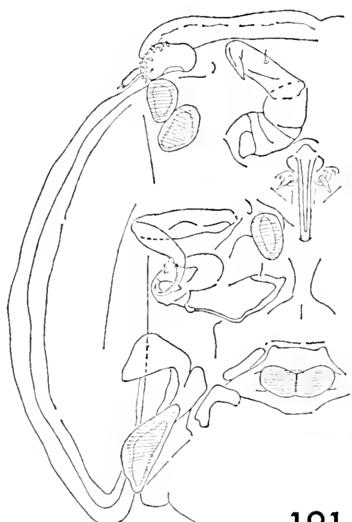
FIGURES 183–188.—*Perissopus dentatus*, male, 183, leg 3 (E); 184, leg 4 (E); 185, leg 5 (H); 186, leg 6 (H). Female: 187, dorsal (C); 188, dorsal (C).



189

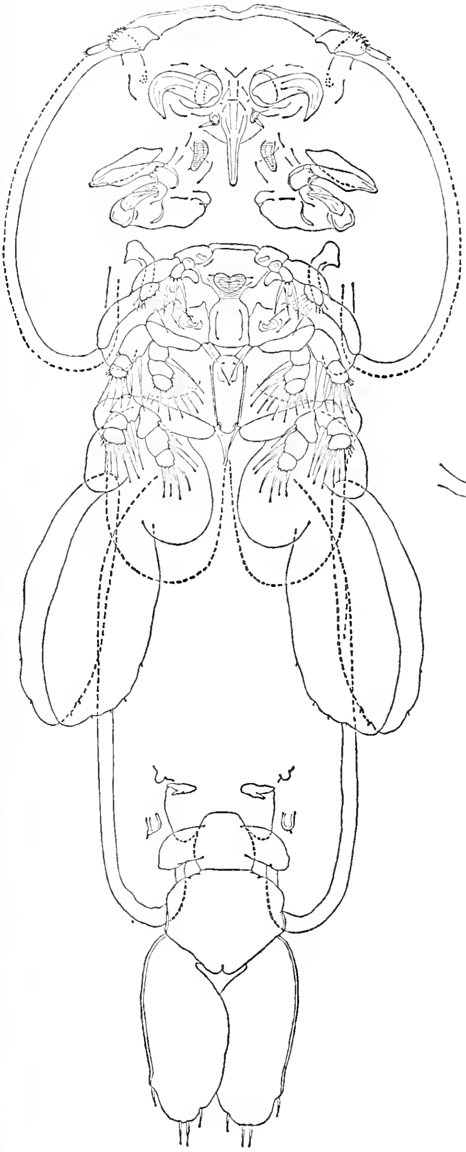


190



191

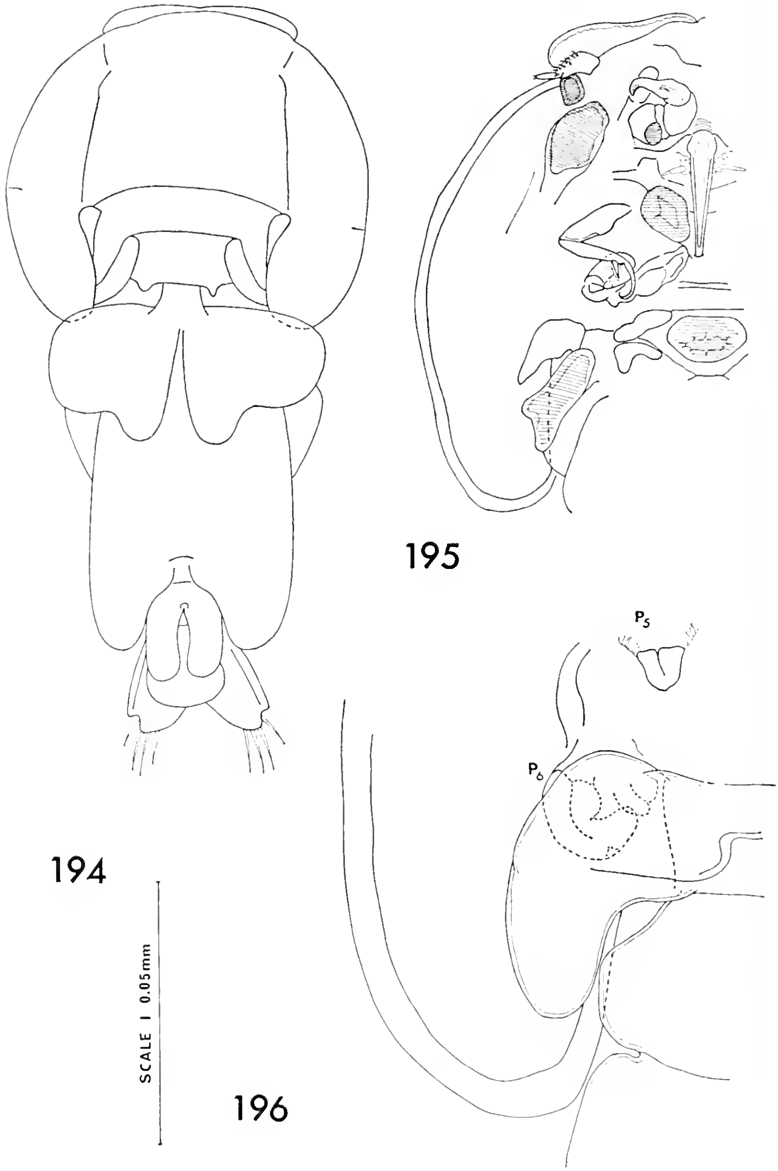
Figures 189–191.—*Perissopus dentatus*, female: 189, dorsal (C). *Dinemoura producta*, female: 190, dorsal (A); 191, oral area (B).



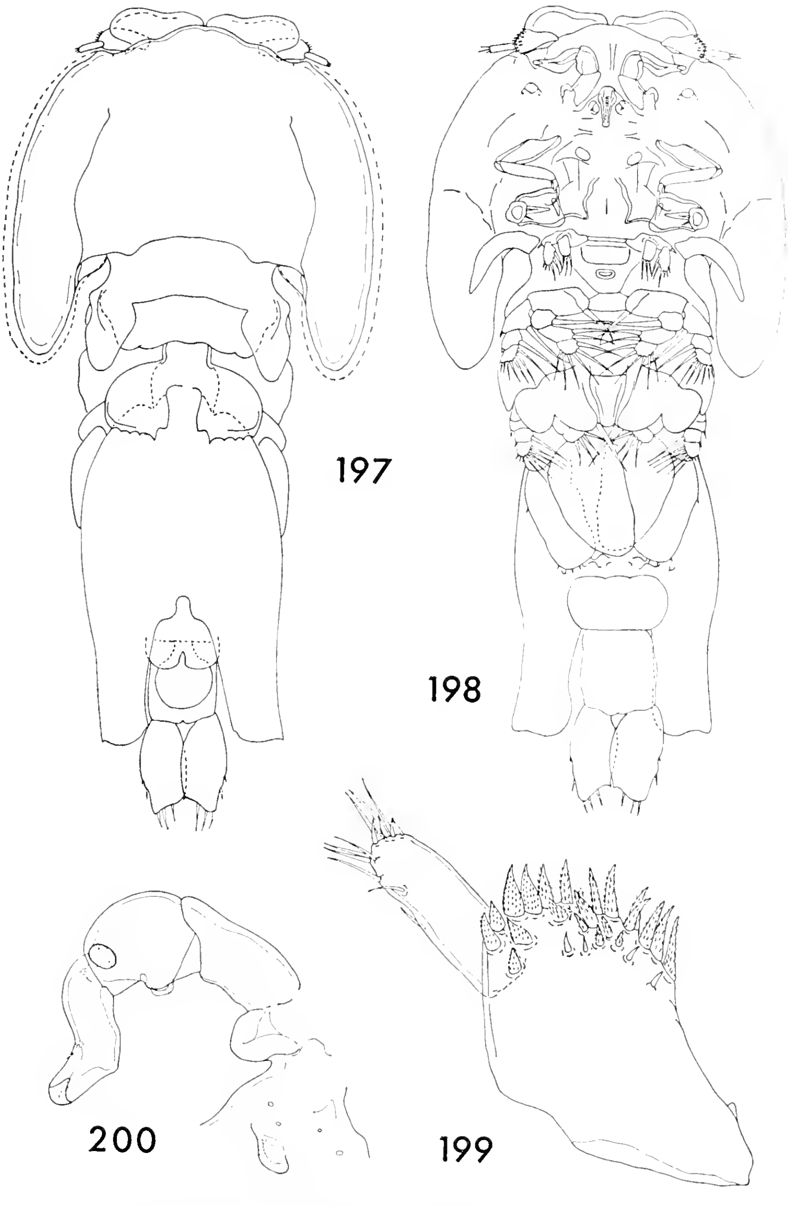
193

192

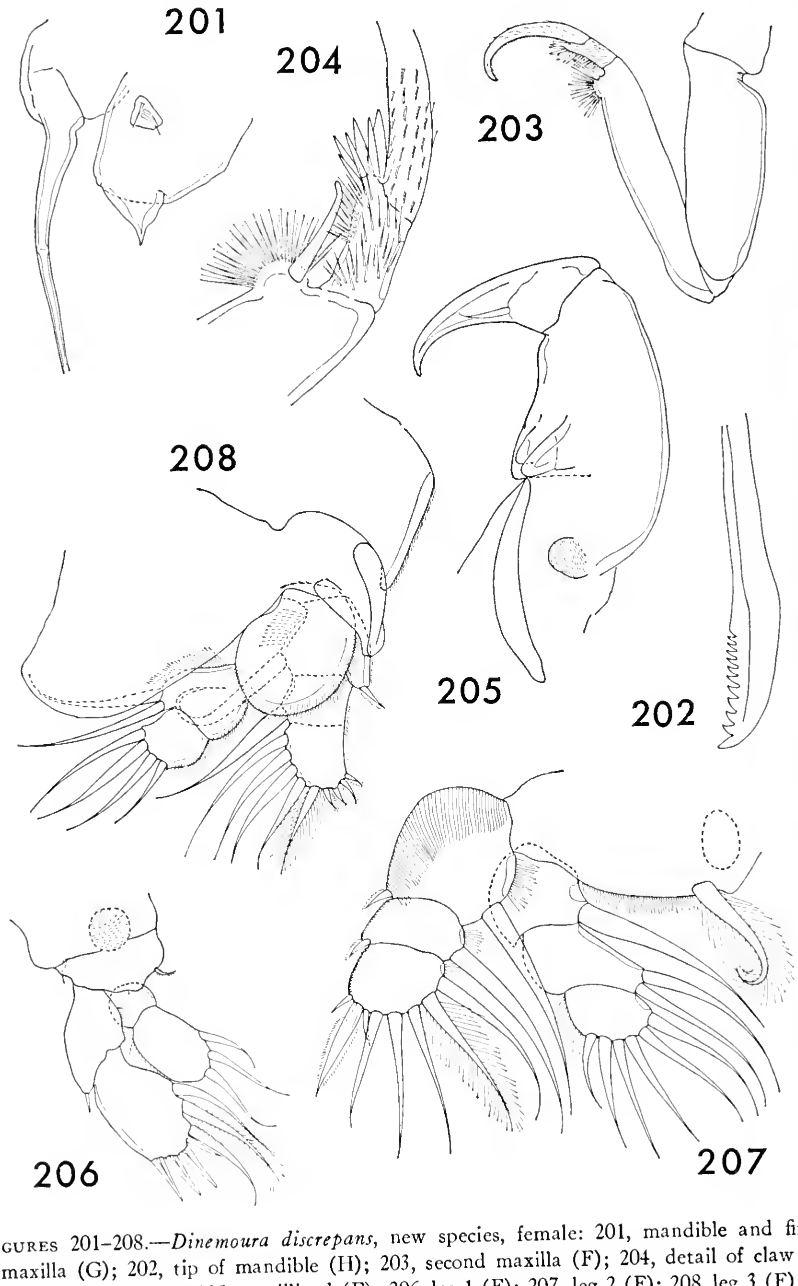
FIGURES 192–193.—*Dinemoura ferox*, female: 192, dorsal (J); 193, ventral (J).



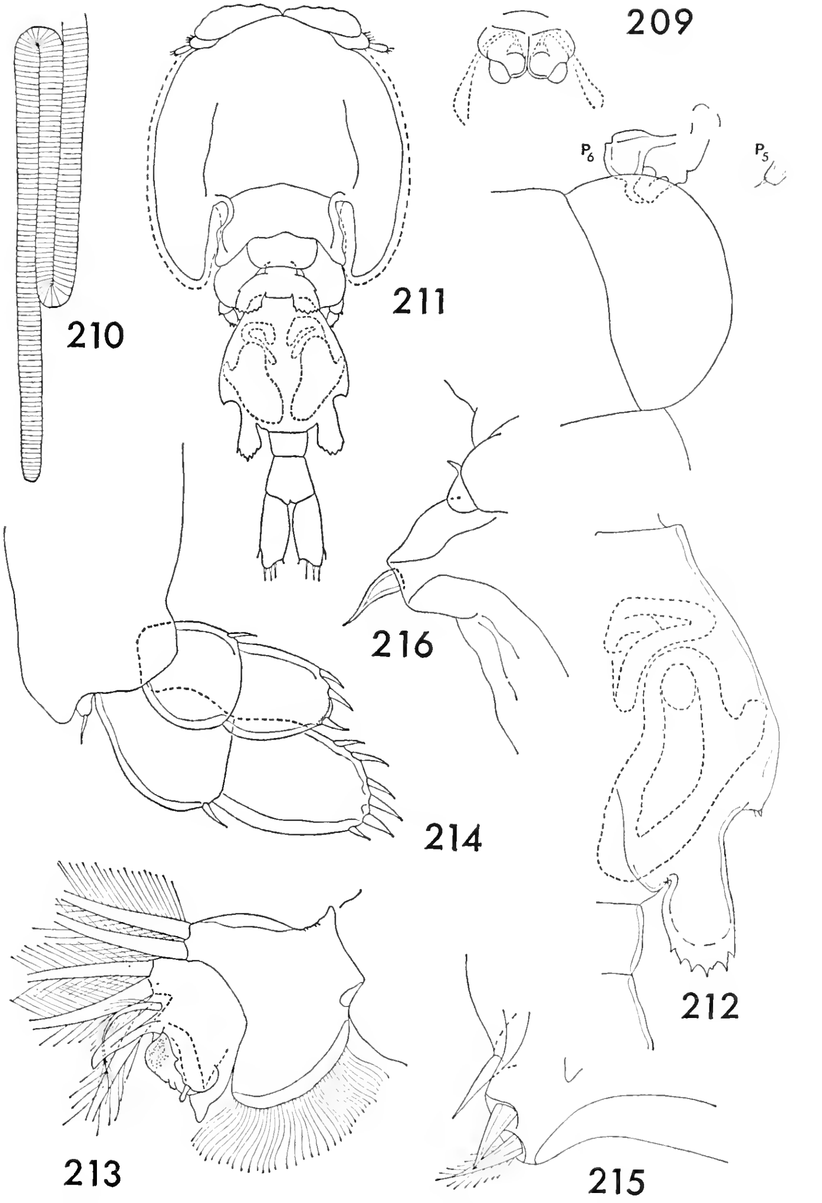
FIGURES 194–196.—*Dinemoura latifolia*, female: 194, dorsal (A); 195, oral area (B); 196, area of legs 5 and 6 (F).



FIGURES 197–200.—*Dinemoura discrepans*, new species, female: 197, dorsal (A); 198, ventral (A); 199, first antenna (D); 200, second antenna (F).



FIGURES 201–208.—*Dinemoura discrepans*, new species, female: 201, mandible and first maxilla (G); 202, tip of mandible (H); 203, second maxilla (F); 204, detail of claw of second maxilla (G); 205, maxilliped (F); 206, leg 1 (F); 207, leg 2 (F); 208, leg 3 (F).



Figures 209–216.—*Dinemoura discrepans*, new species, female: 209, area of legs 5 and 6 (F); 210, egg string (no scale) (10X). Male: 211, dorsal (A); 212, genital segment, ventral (C); 213, endopod of leg 3 (G); 214, leg 4 (G); 215, leg 5 (H); 216, leg 6 (E).

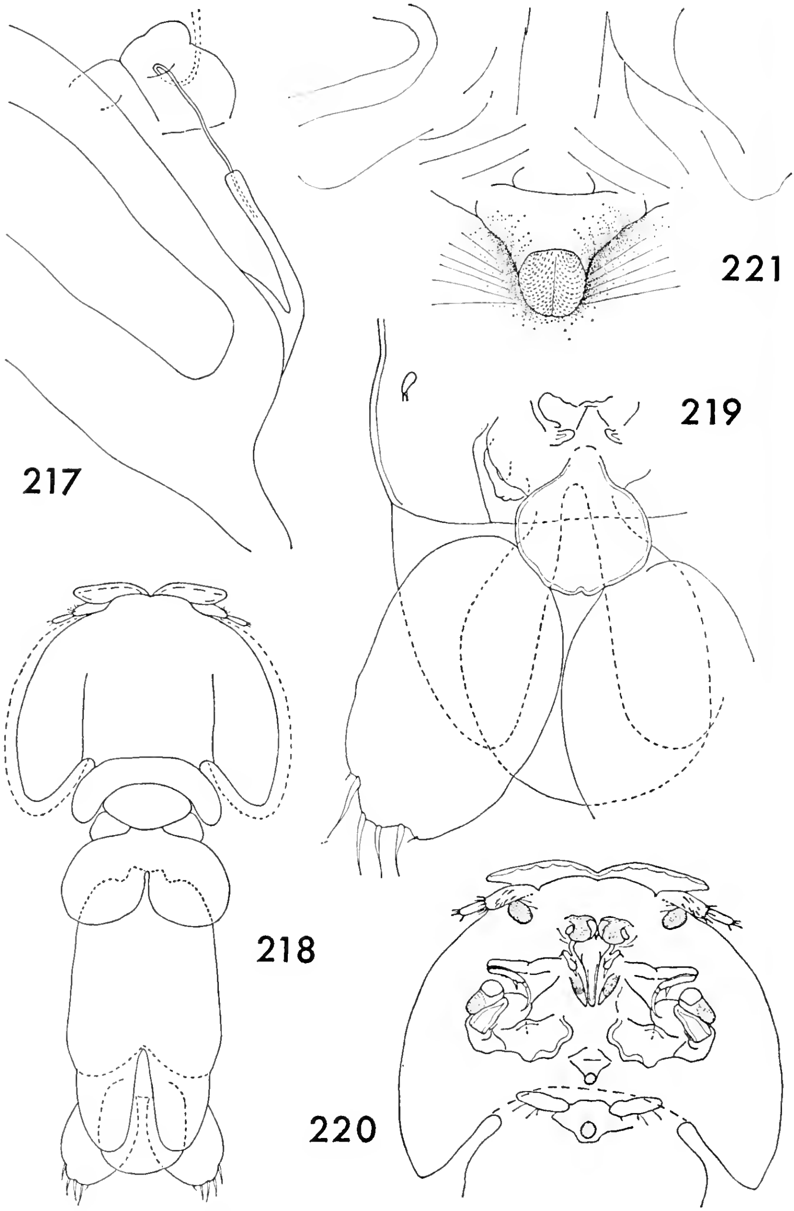
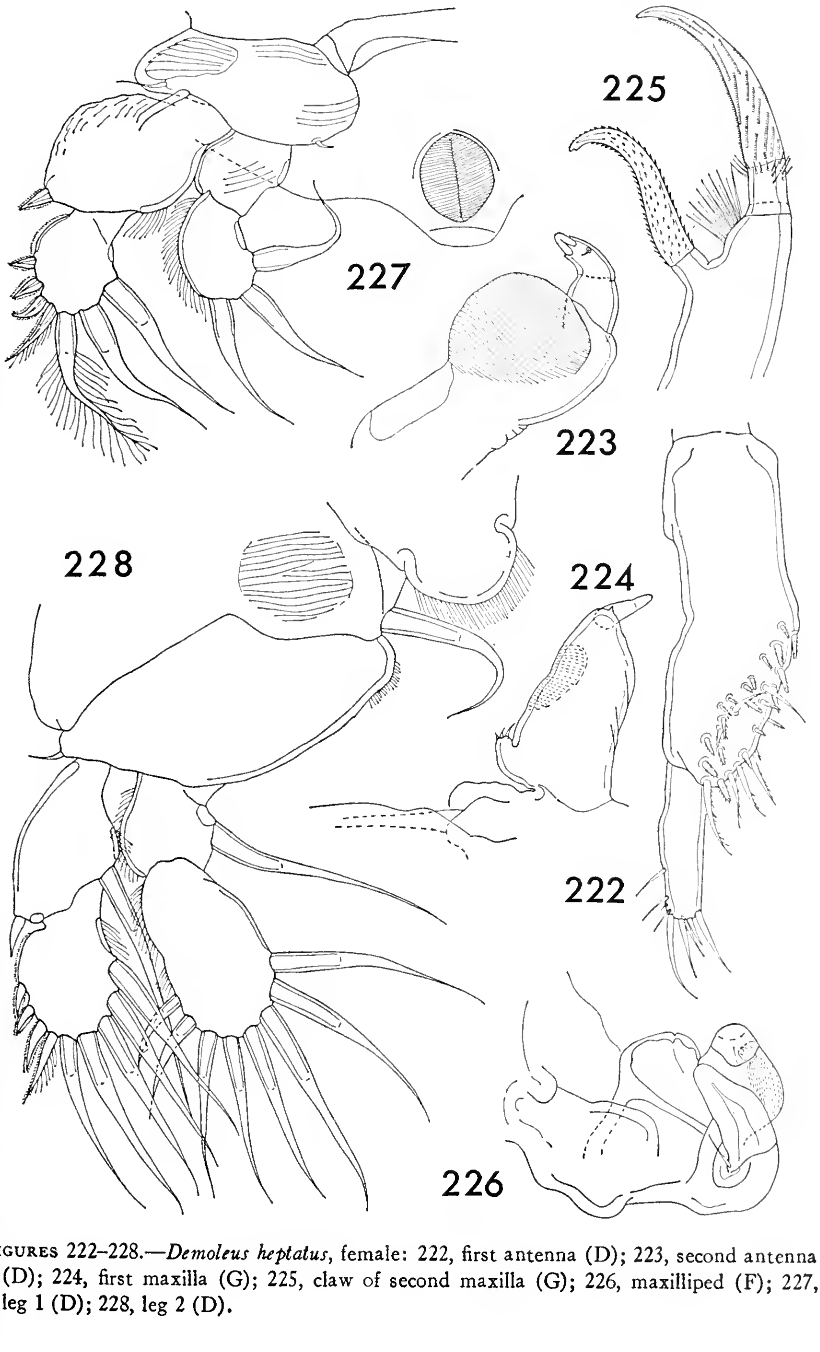
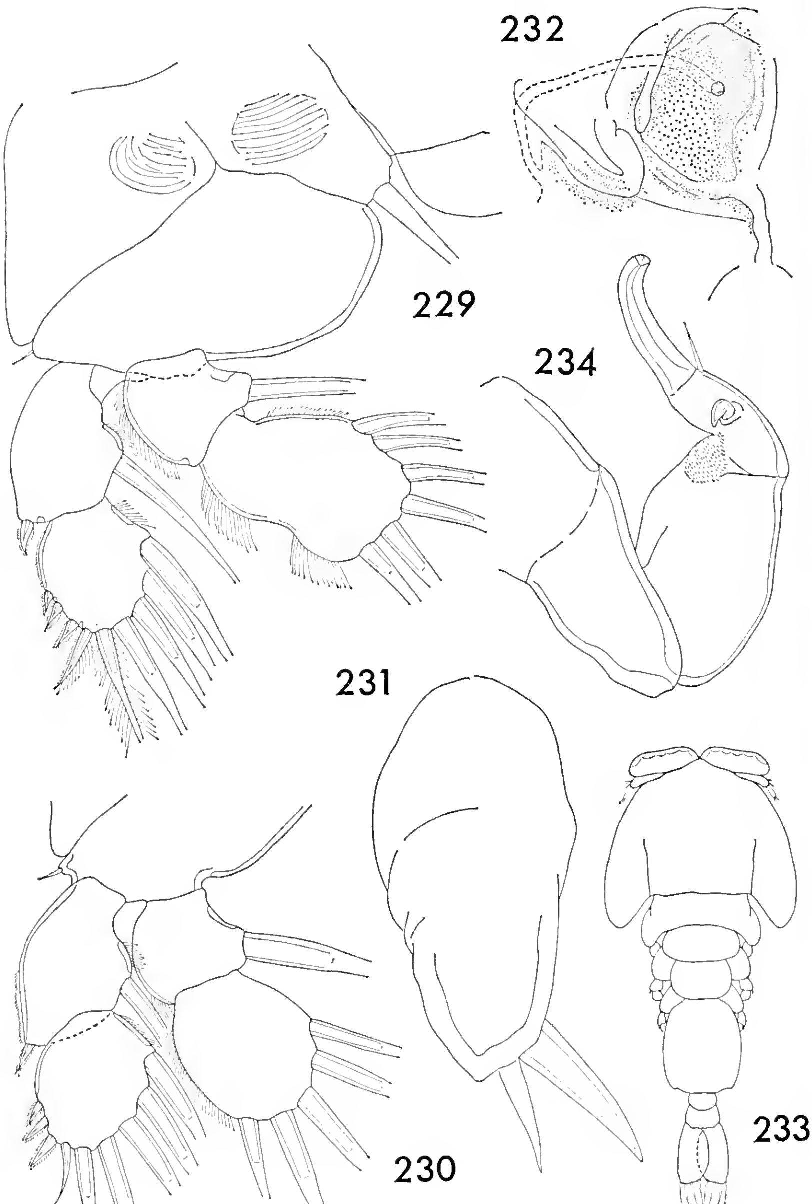


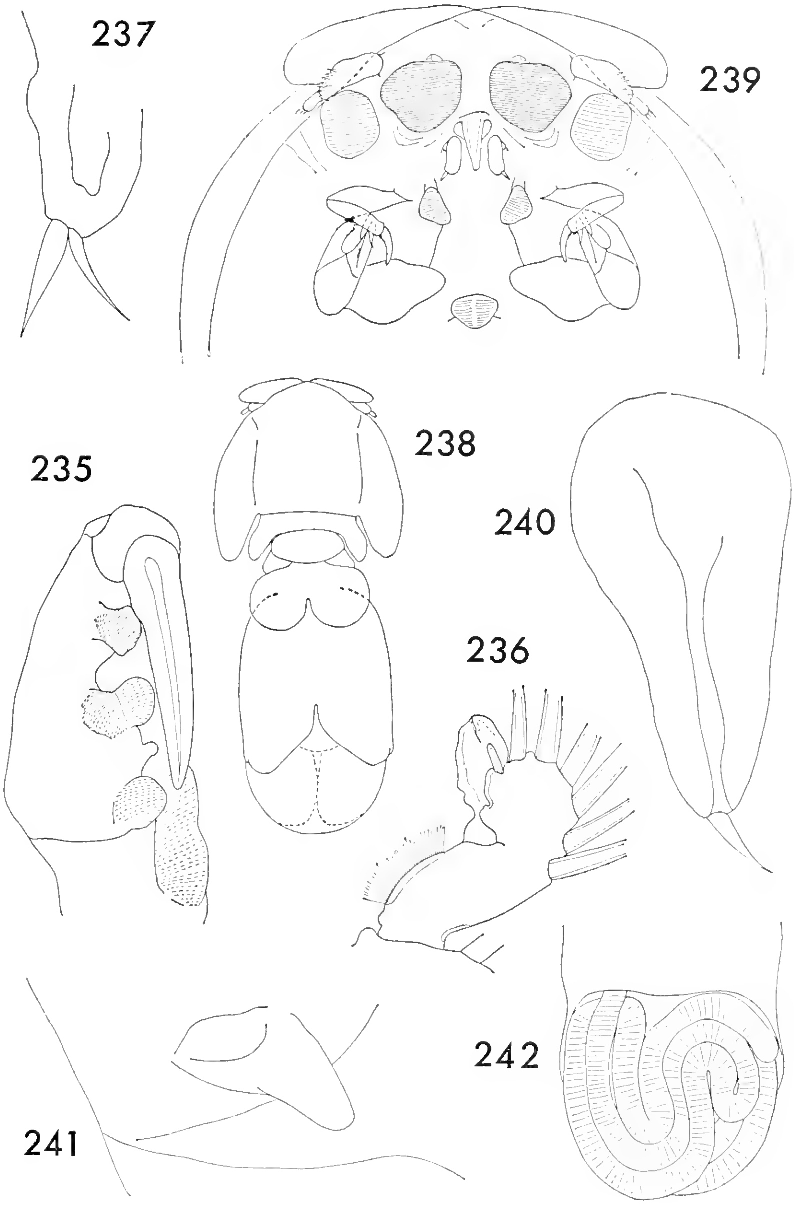
FIGURE 217–221.—*Dinemoura discrepans*, new species, male: 217, attachment area of spermatophore (E). *Demoleus heptatus*, female: 218, dorsal (A); 219, abdomen and caudal rami (C); 220, oral area (A); 221, process between maxillipeds (D).



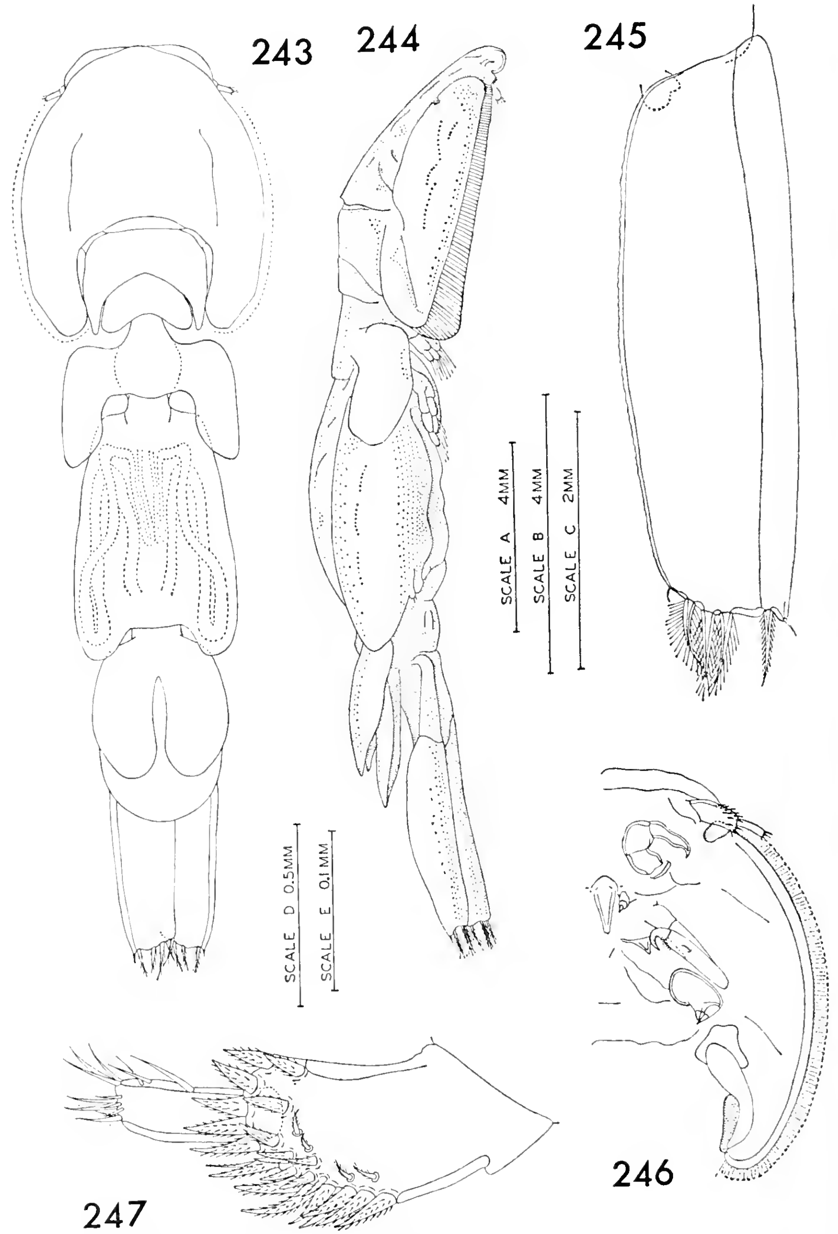
FIGURES 222–228.—*Demoleus heptatus*, female: 222, first antenna (D); 223, second antenna (D); 224, first maxilla (G); 225, claw of second maxilla (G); 226, maxilliped (F); 227, leg 1 (D); 228, leg 2 (D).



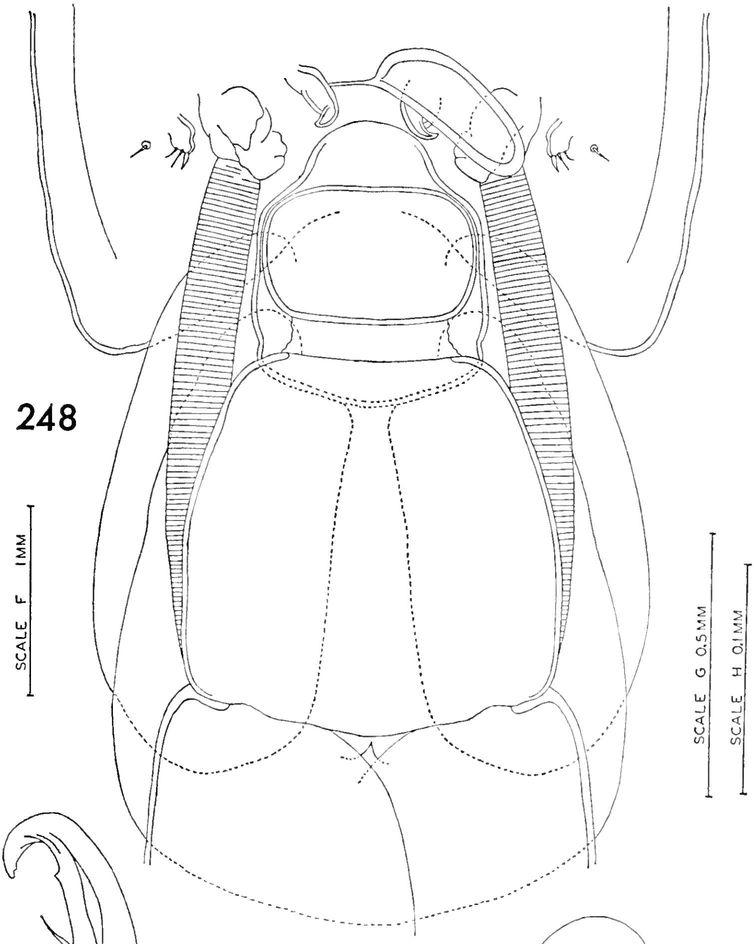
FIGURES 229–234.—*Demoleus heptatus*, female: 229, leg 3 (D); 230, leg 4 (D); 231, leg 5 (G); 232, leg 6 (G).



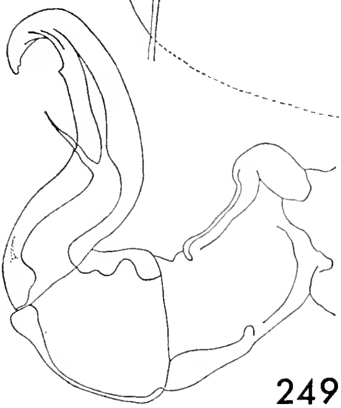
FIGURES 235–242.—*Demoleus hepta us*, male: 235, maxilliped (D); 236, endopod of leg 3 (D); 237, leg 6 (H). *D. latus*, female: 238, dorsal (A); 239, oral area (C); 240, leg 5 (E); 241, leg 6 (E); 242, egg strings, abdomen removed (B).



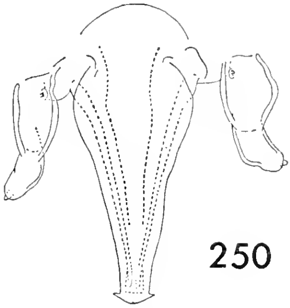
FIGURES 243–247.—*Pagina tunica*, female: 243, dorsal (A); 244, lateral (A); 245, caudal ramus (C); 246, oral area, ventral (D); 247, first antenna (E).



248

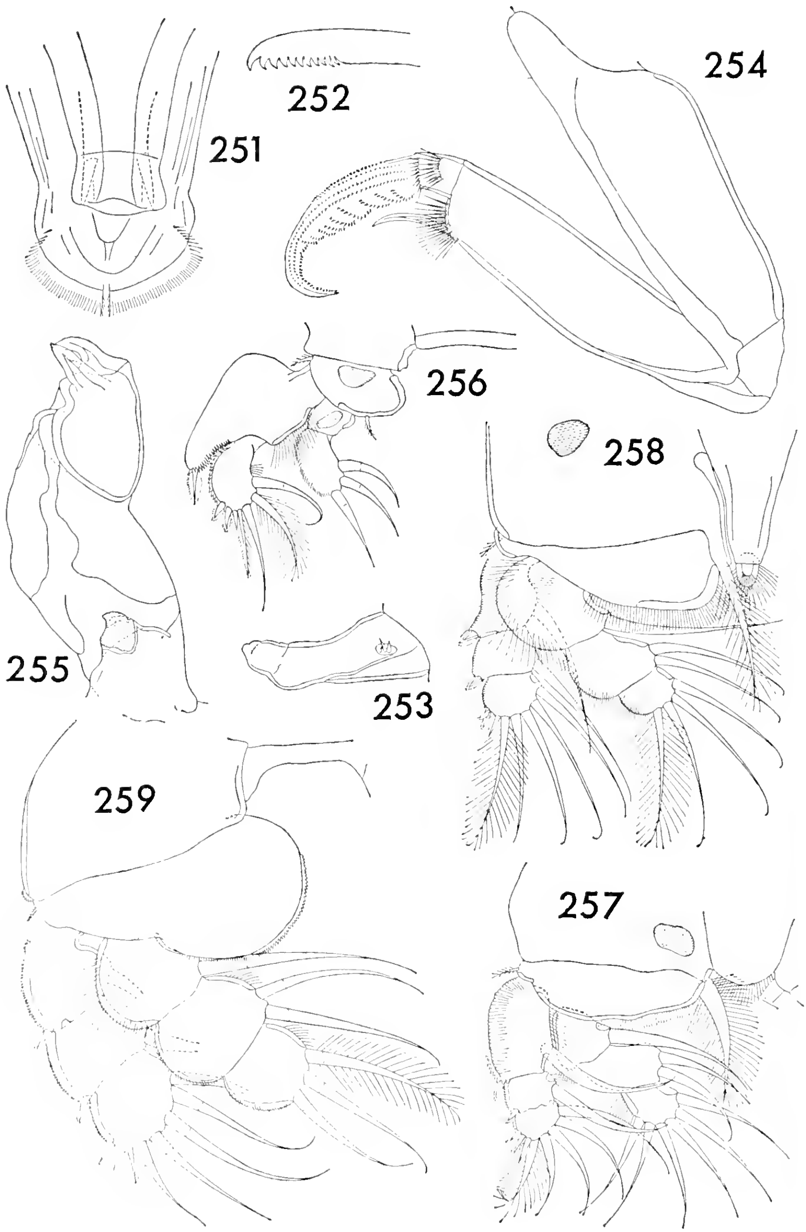


249

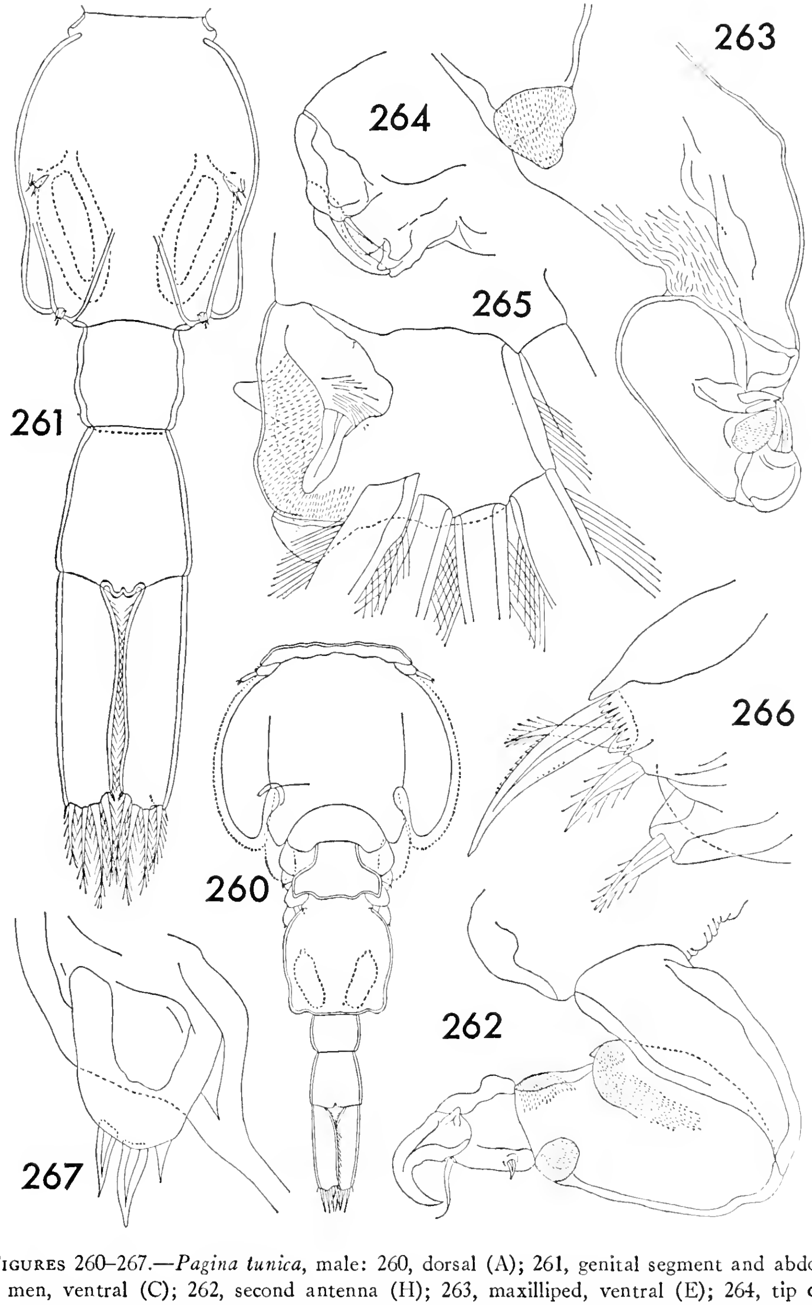


250

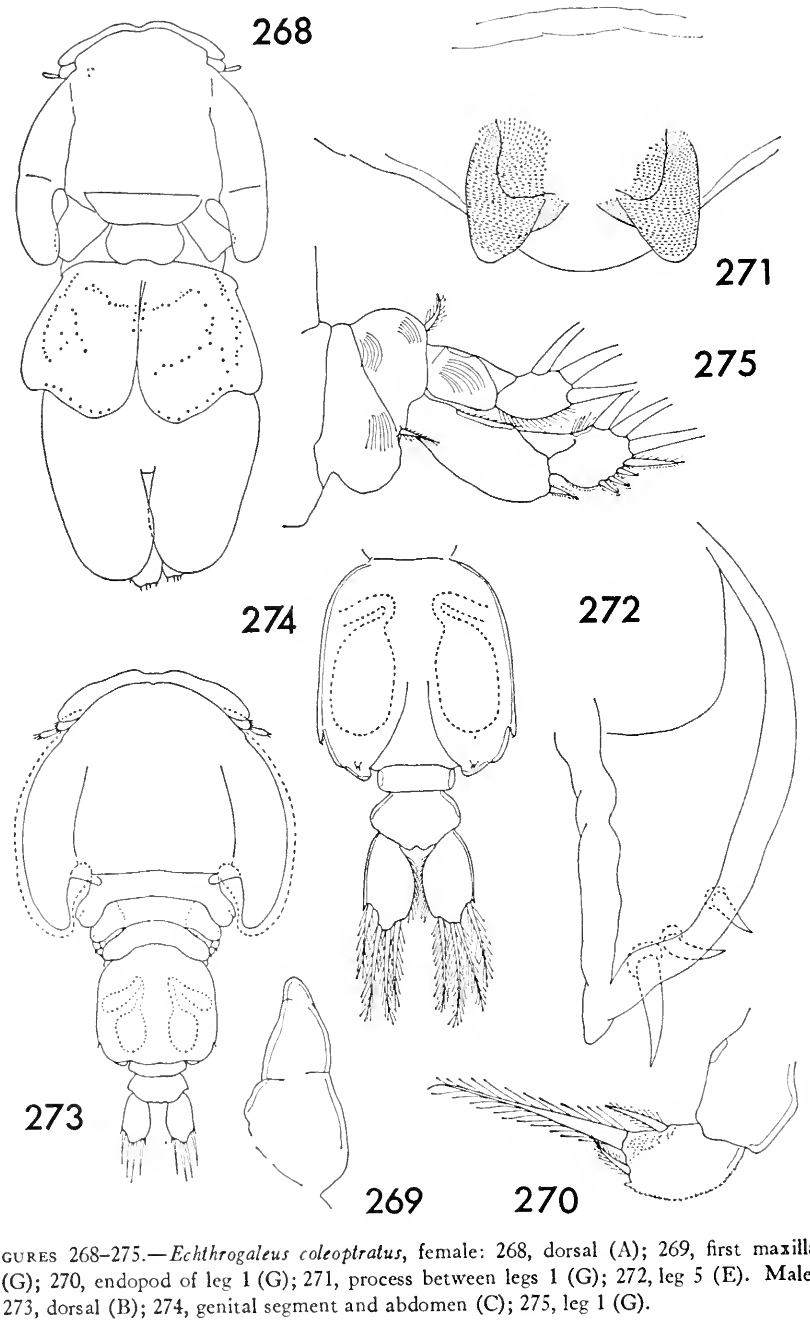
FIGURES 248–250.—*Pagina tunica*, female: 248, posterior end of genital segment and abdomen, ventral (B); 249, second antenna (E); 250, mouth tube and adjacent appendages, postero-lateral (E).



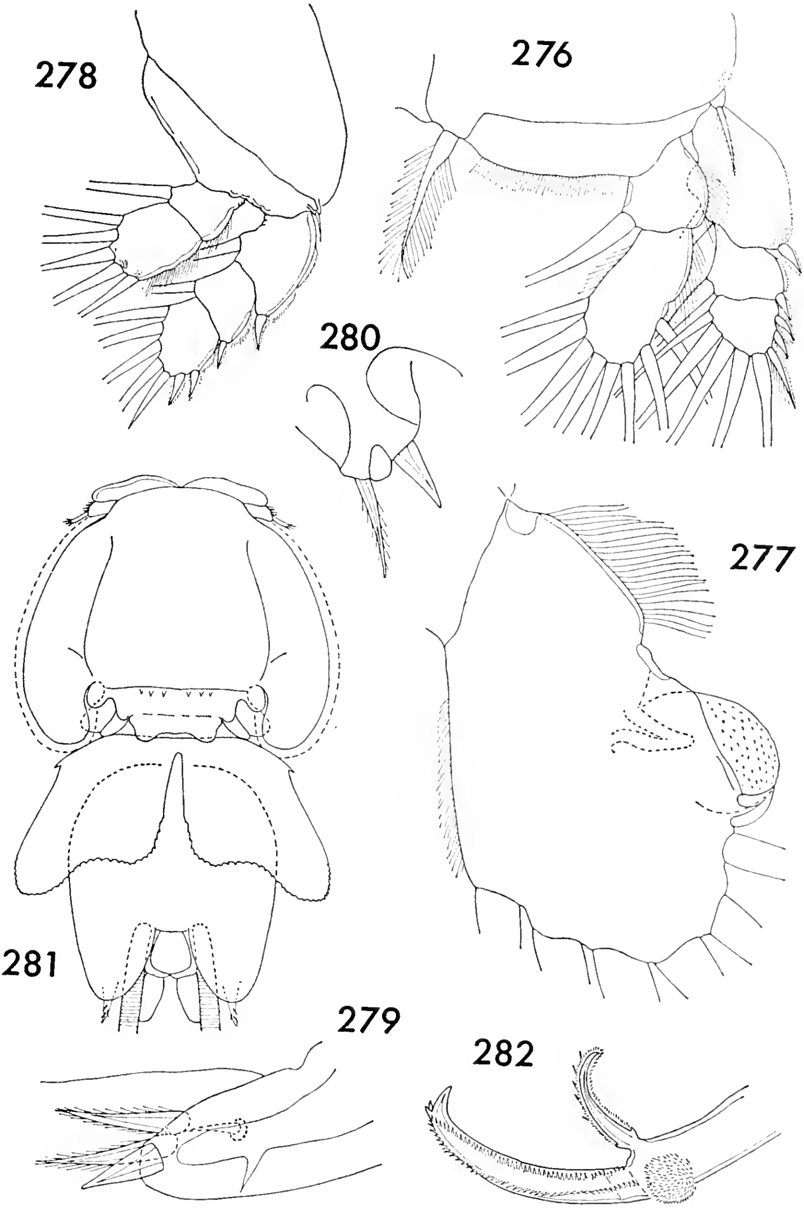
FIGURES 251-259.—*Pagina tunica*, female: 251, tip of mouth tube, antero-ventral (F); 252, tip of mandible (G); 253, first maxilla (H); 254, second maxilla (E); 255, maxilliped (B); 256, leg 1 (B); 257, leg 2 (B); 258, leg 3 (B); 259, leg 4 (B).



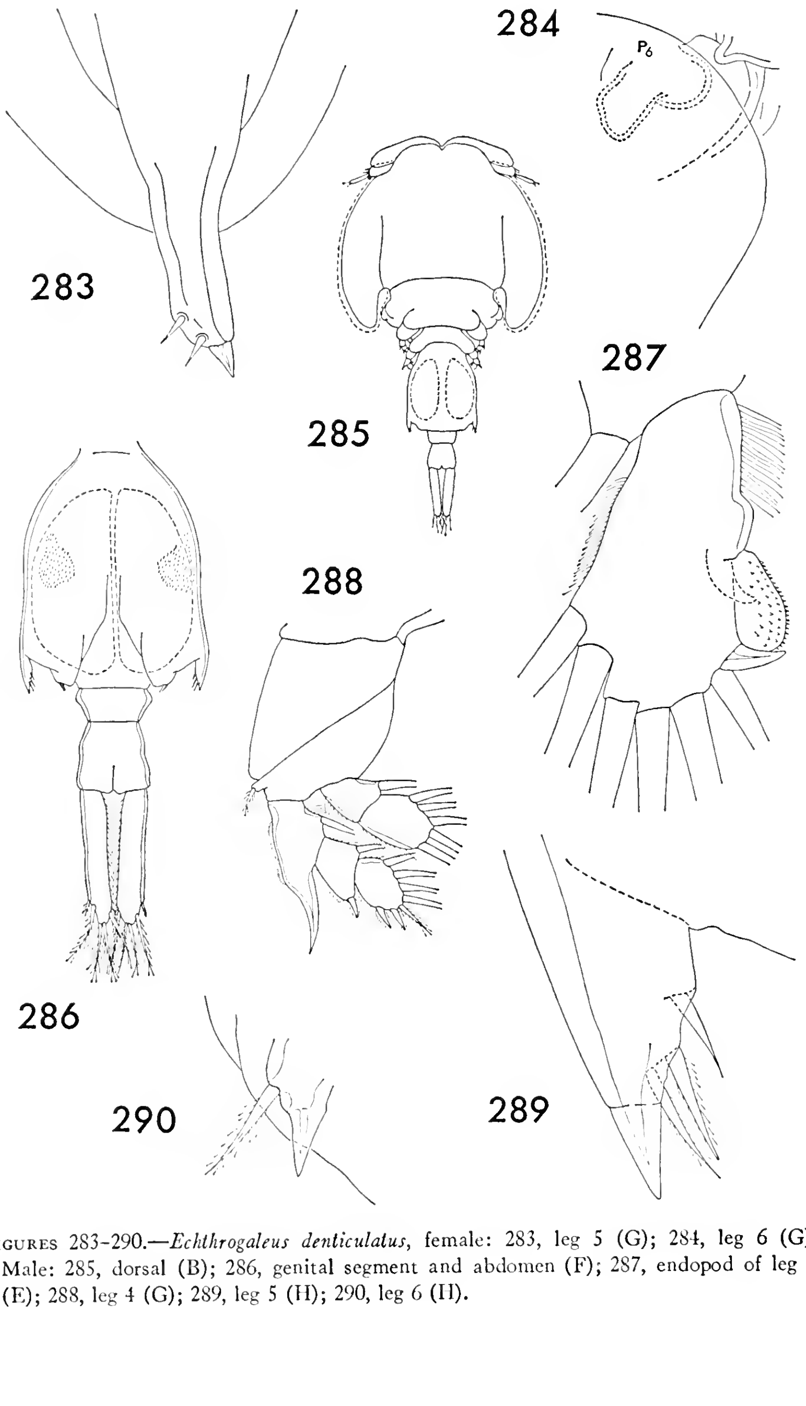
FIGURES 260–267.—*Pagina tunica*, male: 260, dorsal (A); 261, genital segment and abdomen, ventral (C); 262, second antenna (H); 263, maxilliped, ventral (E); 264, tip of maxilliped, dorsal (H); 265, leg 3, endopod, 3rd segment, ventral (F); 266, leg 5, left side (G); 267, leg 6 (G).



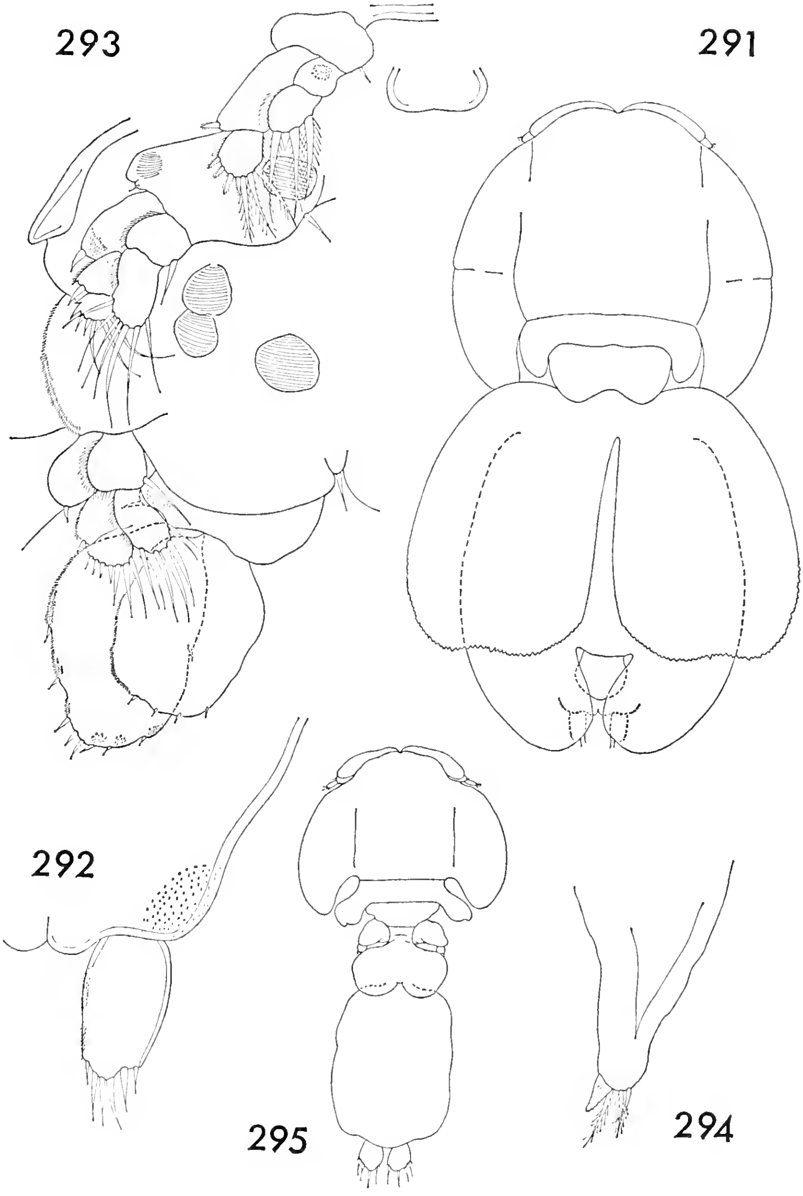
FIGURES 268–275.—*Echthrogaleus coleoptratus*, female: 268, dorsal (A); 269, first maxilla (G); 270, endopod of leg 1 (G); 271, process between legs 1 (G); 272, leg 5 (E). Male: 273, dorsal (B); 274, genital segment and abdomen (C); 275, leg 1 (G).



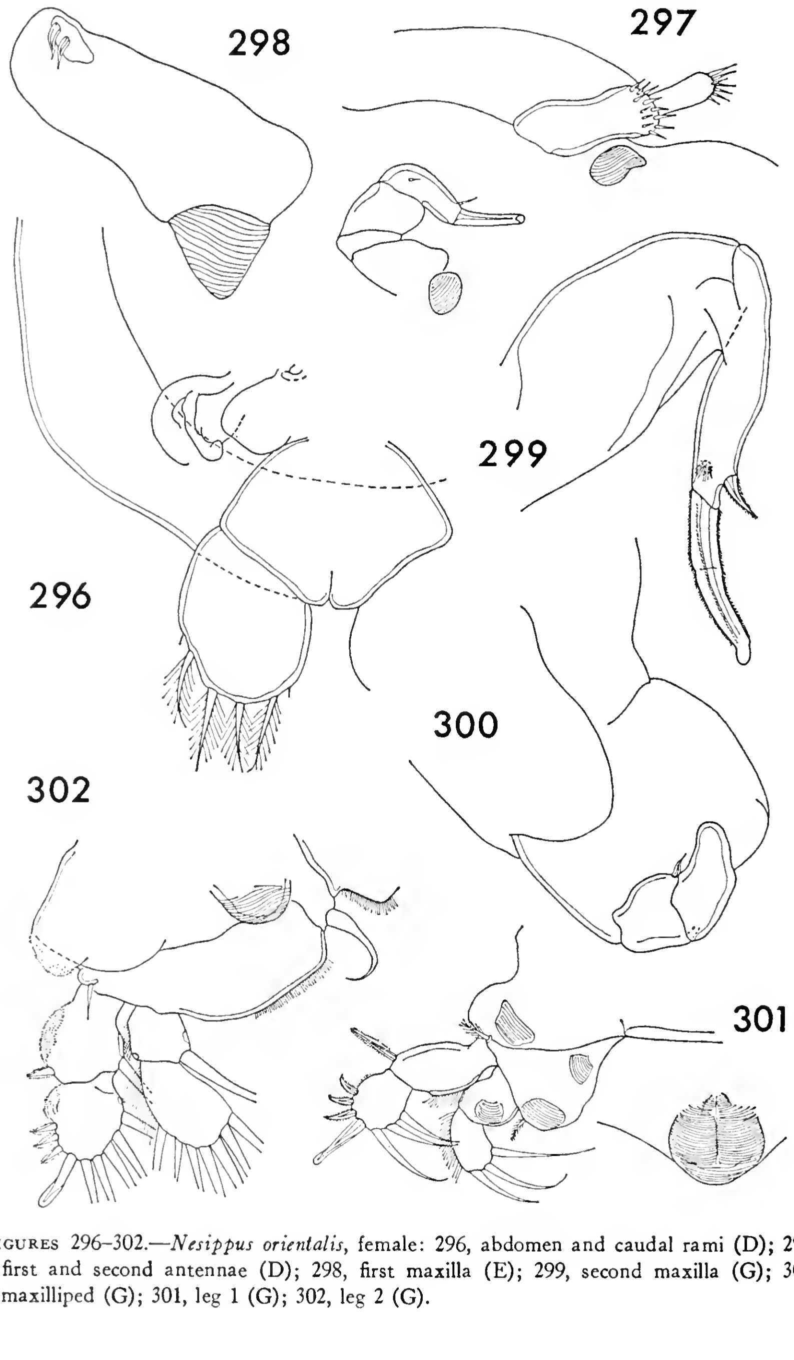
FIGURES 276–282.—*Echthrogaleus coleptratus*, male: 276, leg 2 (G); 277, endopod of leg 3 (E); 278, leg 4 (G); 279, leg 5 (H); 280, leg 6 (H). *E. denticulatus*, female: 281, dorsal (B); 282, second maxilla (G).



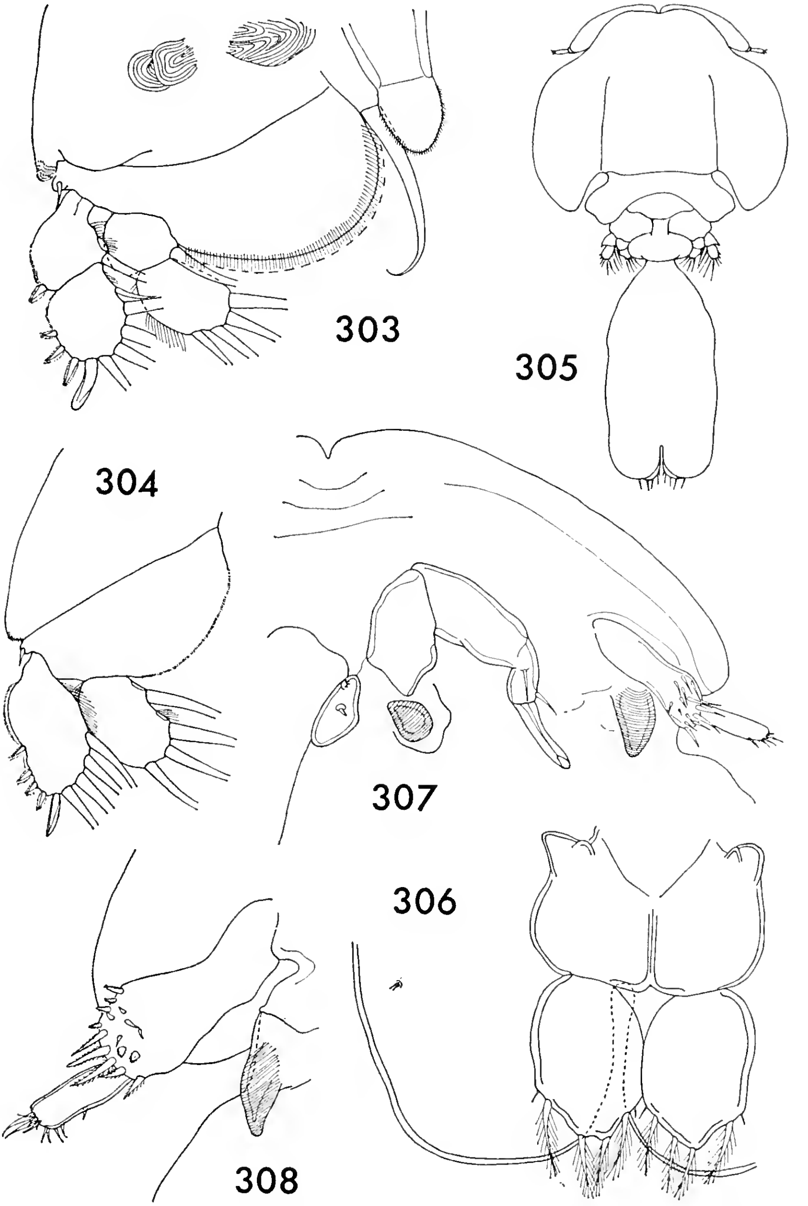
FIGURES 283-290.—*Echthrogaleus denticulatus*, female: 283, leg 5 (G); 284, leg 6 (G). Male: 285, dorsal (B); 286, genital segment and abdomen (F); 287, endopod of leg 3 (E); 288, leg 4 (G); 289, leg 5 (H); 290, leg 6 (H).



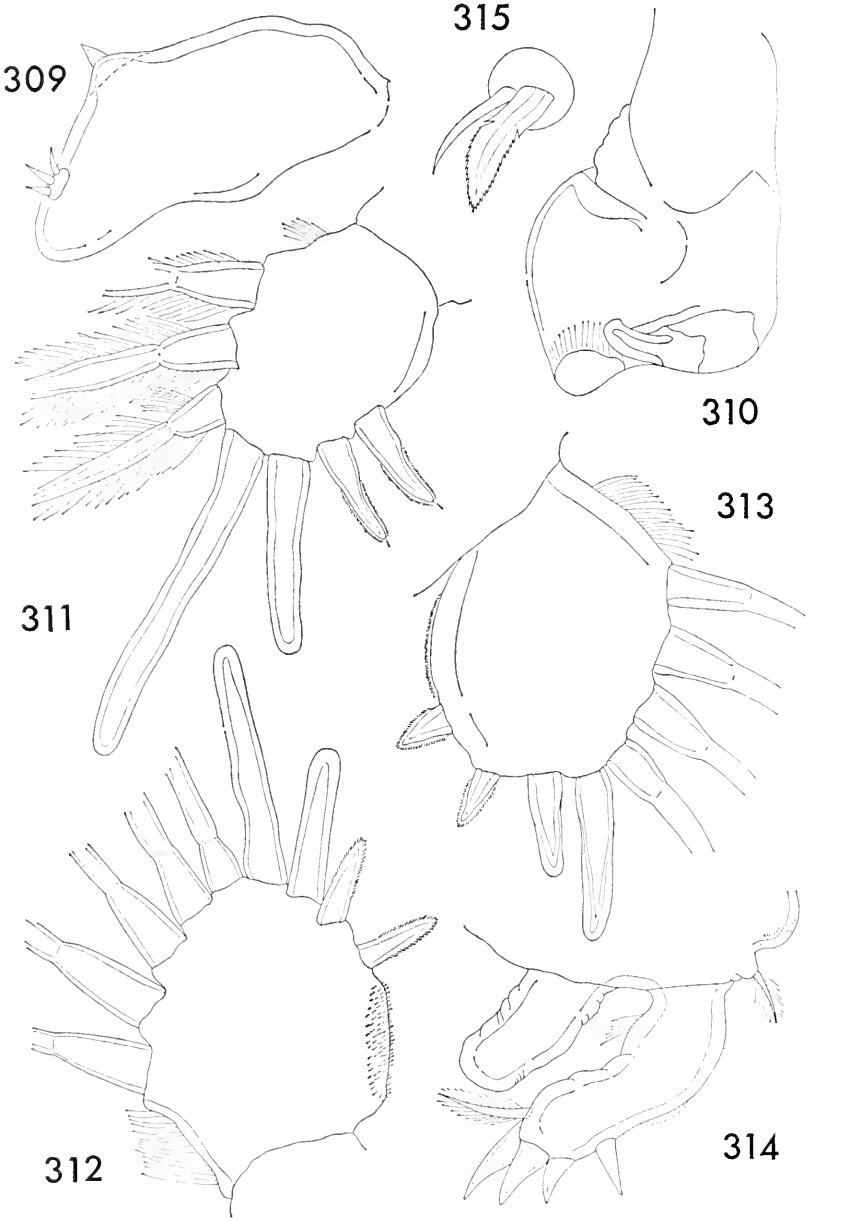
FIGURES 291–295.—*Echthrogaleus torpedinis*, female: 291, dorsal (A); 292, caudal ramus (F); 293, legs 1–4 (F); 294, leg 5 (G). *Nesippus orientalis*, female: 295, dorsal (B).



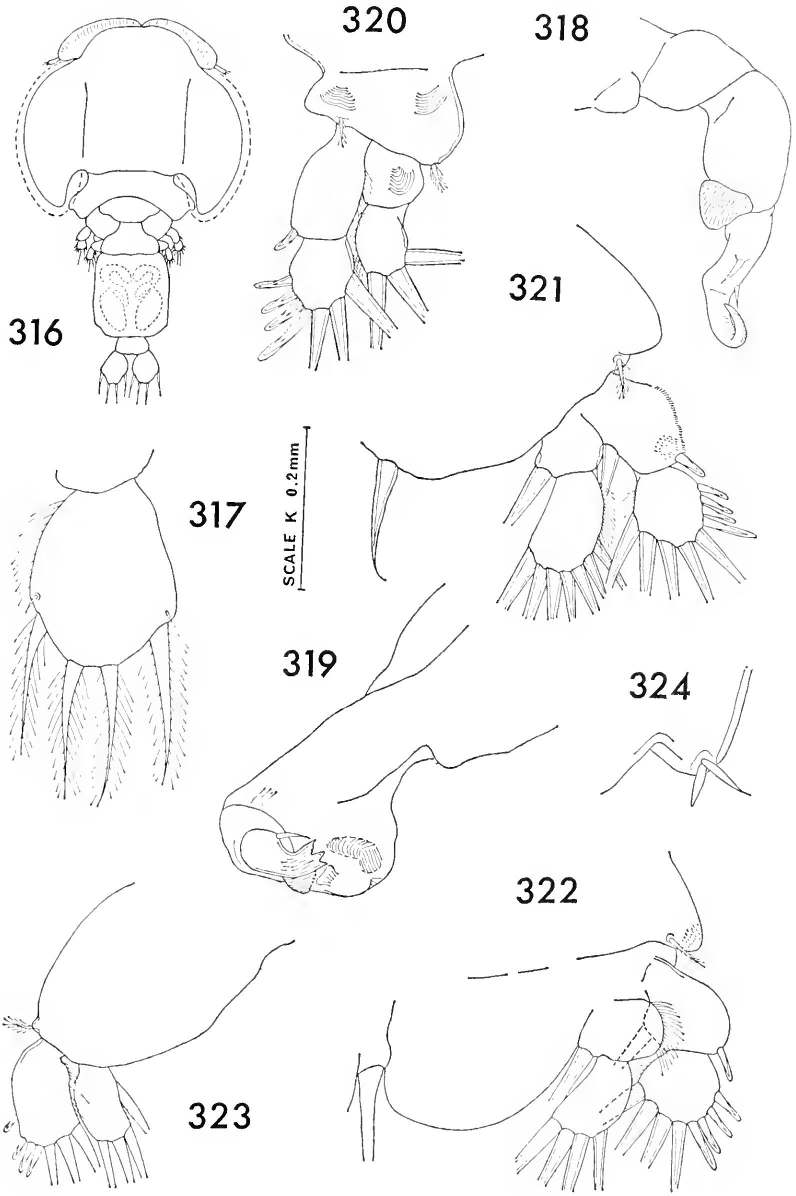
FIGURES 296–302.—*Nesippus orientalis*, female: 296, abdomen and caudal rami (D); 297, first and second antennae (D); 298, first maxilla (E); 299, second maxilla (G); 300, maxilliped (G); 301, leg 1 (G); 302, leg 2 (G).



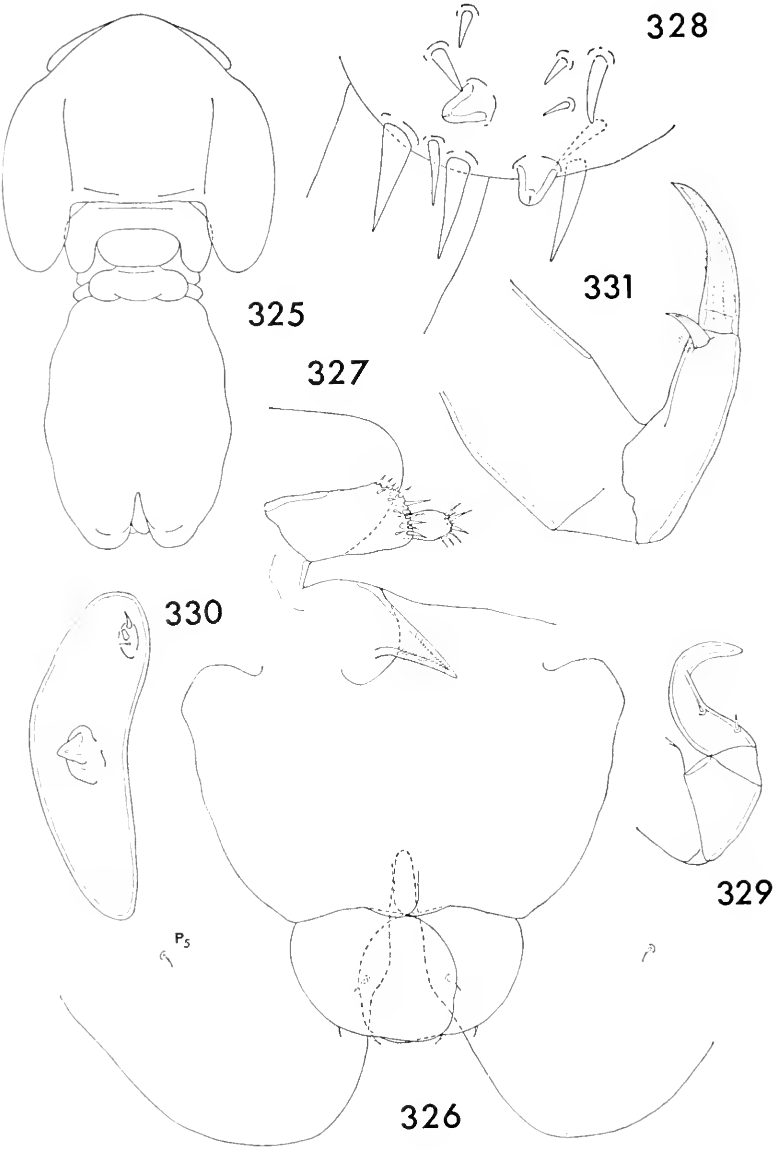
FIGURES 303–308.—*Nesippus orientalis*, female: 303, leg 3 (G); 304, leg 4 (G). *N. crypturus*, female: 305, dorsal (B); 306, abdomen and caudal rami (D); 307, first and second antennae (C); 308, first antenna (G).



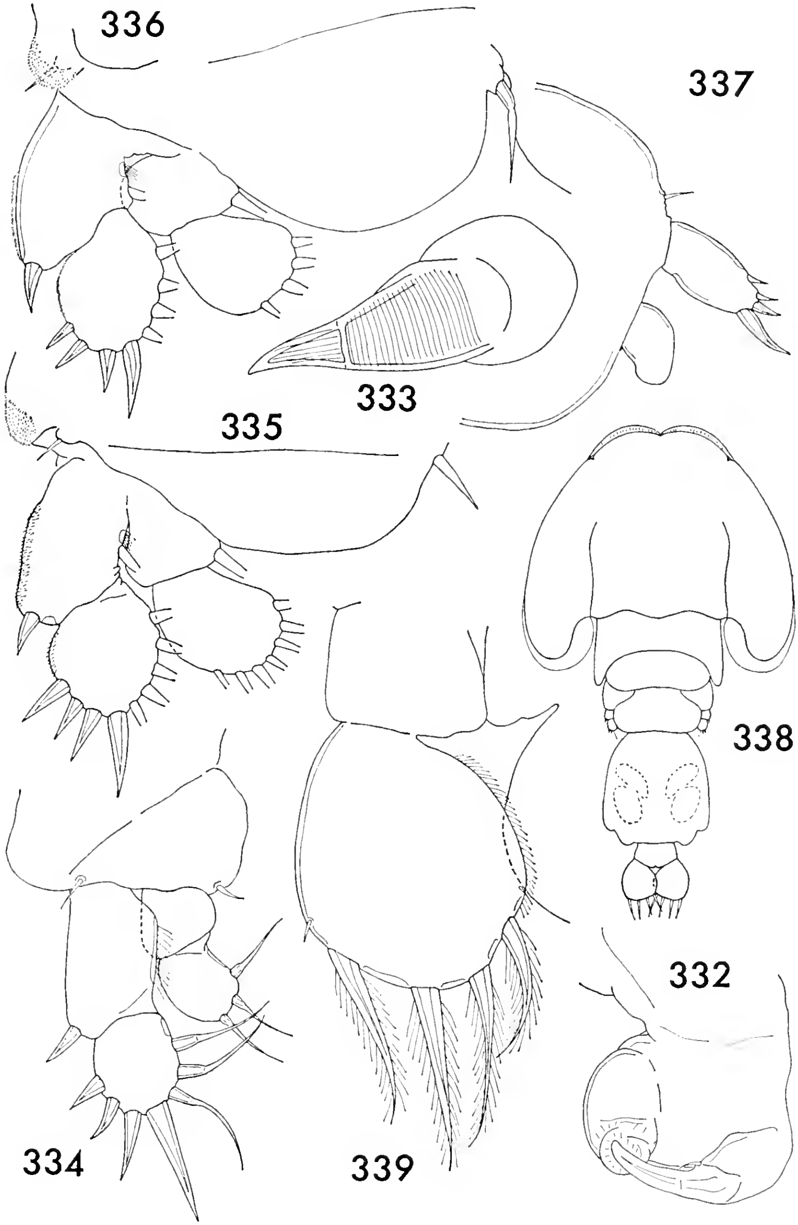
Figures 309–315.—*Nesippus crypturus*, female: 309, first maxilla (E); 310, maxilliped (G); 311, leg 1, last endopod segment (E); 212, leg 2, last endopod segment (E); 313, leg 3, last endopod segment (E); 314, leg 4 (E); 315, leg 5 (I).



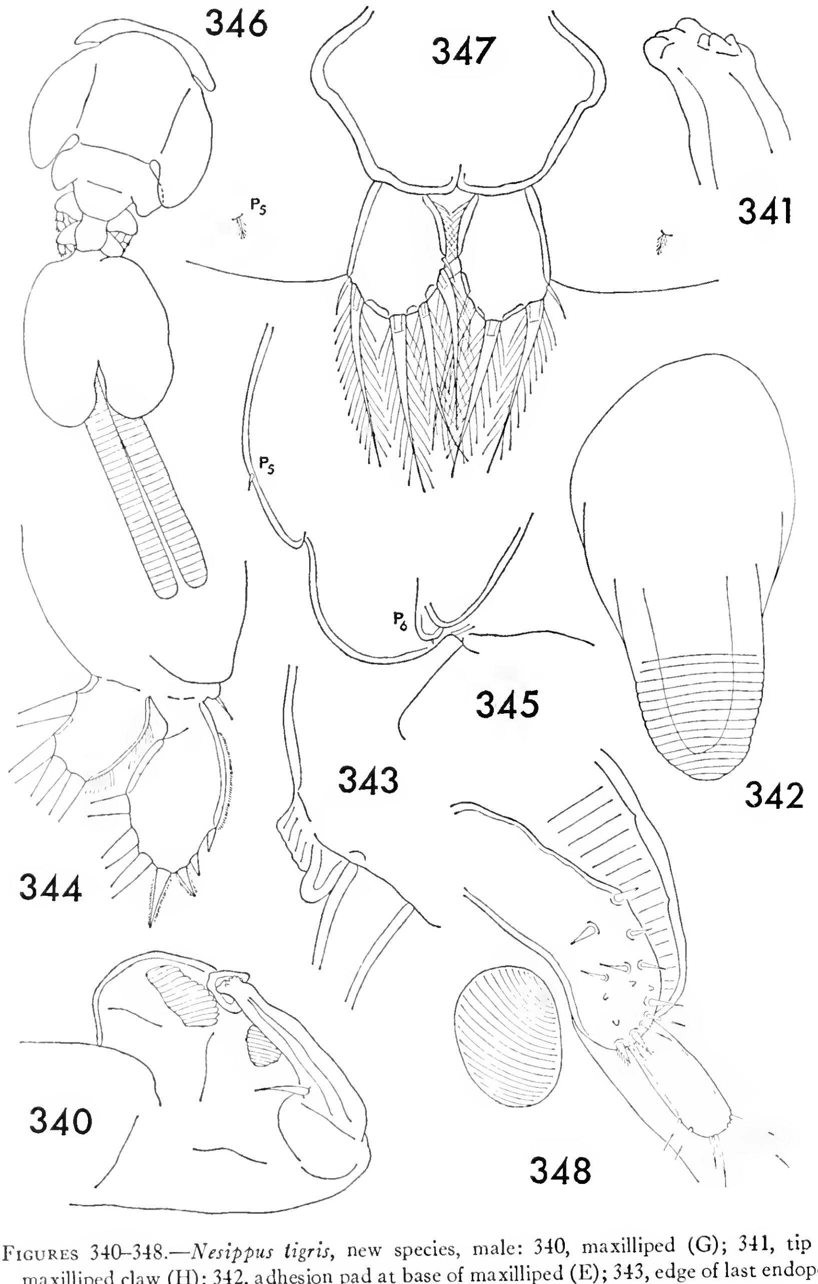
FIGURES 316–324.—*Nesippus crypturus*, male: 316, dorsal (B); 317, caudal ramus (G); 318, second antenna (G); 319, maxilliped (G); 320, leg 1 (K); 321, leg 2 (K); 322, leg 3 (K); 323, leg 4 (K); 324, leg 5 (H).



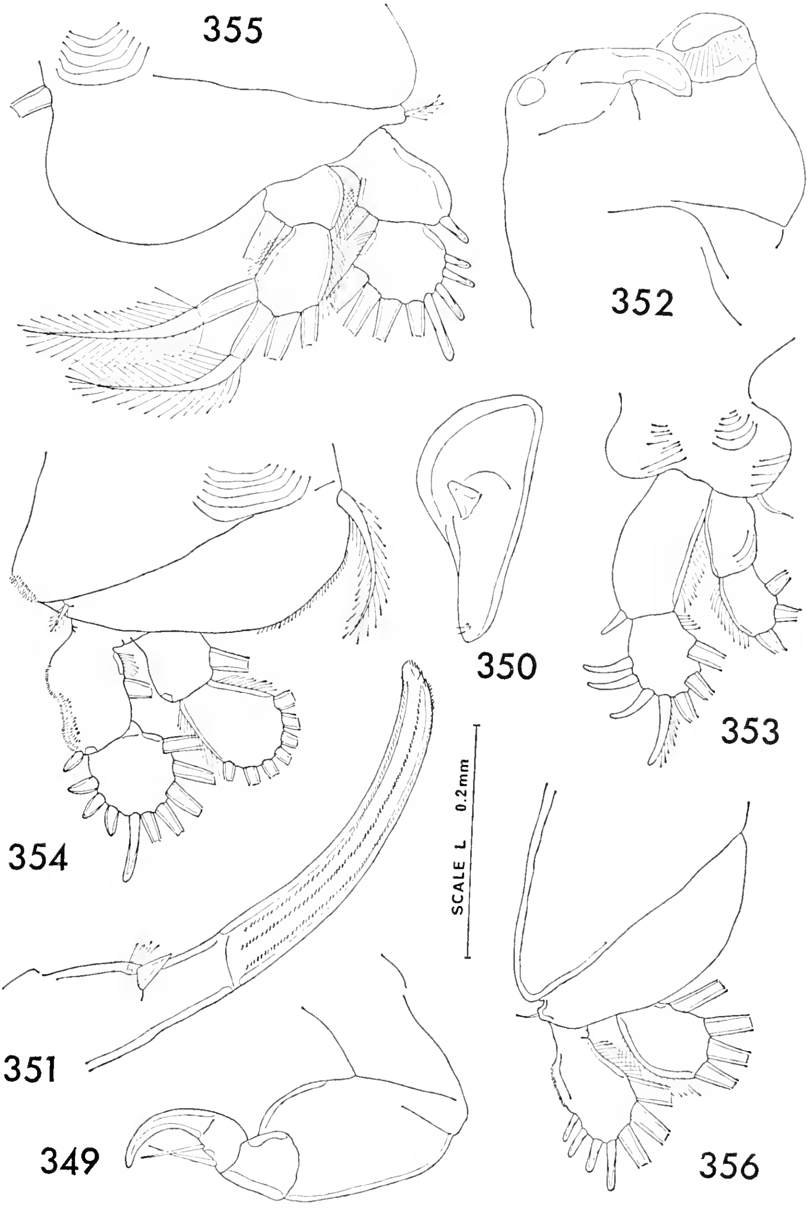
FIGURES 325-331.—*Nesippus tigris*, new species, female: 325, dorsal (B); 326, abdomen and caudal rami, ventral (D); 327, first antenna (D); 328, detail of first antenna (H); 329, second antenna (F); 330, first maxilla (L); 331, second maxilla (D).



FIGURES 332–339.—*Nesippus tigris*, new species, female: 332, maxilliped (D); 333, adhesions pad at base of maxilliped (K); 334, leg 1 (G); 335 leg 2 (G); 336, leg 3 (G); 337, leg 4 (G). Male: 338, dorsal (B); 339, caudal ramus (G).



FIGURES 340–348.—*Nesippus tigris*, new species, male: 340, maxilliped (G); 341, tip of maxilliped claw (H); 342, adhesion pad at base of maxilliped (E); 343, edge of last endopod segment of leg 3 (H); 344, leg 4 (G); 345, area of legs 5 and 6 (G). *N. vespa*, female: 346, dorsal (C); 347, abdomen and caudal rami (K); 348, first antenna (L).



FIGURES 349–356.—*Nesippus vespa*, female: 349, second antenna (L); 350, first maxilla (H); 351, claw of second maxilla (H); 352, maxilliped (L); 353, leg 1 (L); 354, leg 2 (L); 355, leg 3 (L); 356, leg 4 (L).

U.S. GOVERNMENT PRINTING OFFICE: 1967

Proceedings of the United States National Museum

SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 121 1967 Number 3571

SUPPLEMENTARY DESCRIPTIONS OF TWO MYODOCOPID OSTRACODS FROM THE RED SEA

By Louis S. Kornicker
Associate Curator, Division of Crustacea

This study is based on ostracods collected on the *Pola* Expedition to the Red Sea in 1896 and described by Dr. Herbert Graf (1931). In the original description of *Philomedes polae* (=*Euphilomedes polae*), Graf (1931) did not designate a holotype and omitted some details of carapace and appendage morphology. Graf's description may have been based on more than one species. The species, therefore, is redescribed herein and a lectotype selected from the available type-series. Specimens designated as *Philomedes* species by Graf (1931) have been identified as females of *E. polae* and are described as such. A single specimen included by Graf in the type-series of *Philomedes polae* has been identified as *Euphilomedes arostrata* Kornicker (1967); this identification is documented with a description and illustrations of the Red Sea specimen.

The following material was obtained through the courtesy of Dr. Gerhard Pretzmann from the Naturhistorisches Museum, Vienna, Austria: (1) One bottle, containing one vial with 3 males, with red label marked: "*Philomedes polae*, n. sp. ♂; Rotes Meer: Gulf von Suez;

Coll: 'Pola' 1895/8; Dr. Graf det." (2) One bottle with white label marked: "*Philomedes* sp. ♀; Rotes Meer: Stat. 90; Coll. 'Pola' 1895/8; Dr. Graf det." This bottle contained one vial with 2 females containing eggs that had not yet been extruded into the brood chamber and with a label that had been marked "*Philomedes* sp. ♀ (A)."

Since Dr. Graf had not designated a holotype of *Philomedes polae* Graf, Dr. Pretzmann suggested that I select a lectotype from the type material. Examining the material, I found 2 specimens in the first bottle that I could equate with *Philomedes polae* Graf, using primarily as a basis for identification the distinctive secondary appendage described and figured for this species by Graf (1931, p. 37, fig. 5i). The third specimen in the first bottle I identify as *Euphilomedes arostratus* Kornicker, recently described for the first time from the Maldive Islands, Indian Ocean.

The 2 specimens in the second bottle I equate to specimens described by Graf (1931) as *Philomedes* species on his page 38 and illustrated in his figure 6. The similarity of the distribution of primary and secondary claws on the caudal rami of the specimens at hand with the published description of *Philomedes* species makes it certain that this identification is correct. After studying these specimens, I have concluded that they are females of *Philomedes polae* Graf.

I acknowledge with thanks the assistance of Dr. Gerhard Pretzmann in obtaining specimens for study from the Naturhistorisches Museum, Vienna, Austria, and of Miss Caroline Bartlett, who inked the final illustrations. I would like also to thank Mr. I. G. Sohn and Doctors Raymond B. Manning and W. Duane Hope for reviewing the manuscript.

Family Cypridinidae Baird, 1850

Subfamily Philomedinae G. W. Müller, 1912

Genus *Euphilomedes* Poulsen, 1962

Type-species.—*Euphilomedes nodosus* Poulsen, 1962, by subsequent designation, Kornicker (1967).

Euphilomedes polae (Graf, 1931)

Figures 1–5

Philomedes polae Graf, 1931, p. 37, fig. 5.
Philomedes species.—Graf, 1931, p. 38, fig. 6.

Lectotype.—Specimen designated as specimen B on slide. Naturhistorisches Museum, Zoologische Abteilung, Vienna, Austria.

Sex.—Male.

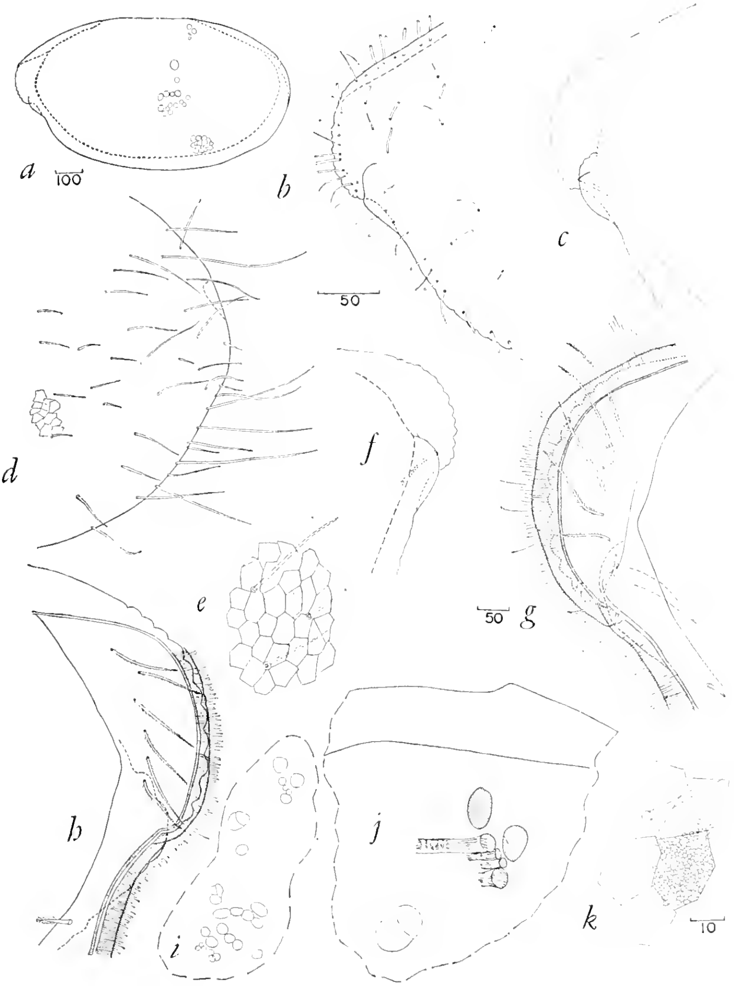


Figure 1.—*Euphilomedes polae*, male, specimen C (except *a* and *h*, spec. B): *a*, lateral view left valve showing some muscle scars, surface reticulation shown only near posteroventral margin of valve; *b*, lateral view anterior end of left valve showing surface and marginal hairs; *c*, lateral view anterior end of left valve showing flap over antennal sinus, and linear sclerotized area visible in transmitted light; *d*, lateral view posterior end of left valve showing surface hairs and some reticulations; *e*, medial view of part of shell posterior showing reticulations, normal pore canals and surface hairs; *f*, lateral view anterior end of right valve showing marginal denticulations around rostrum, flap over antennal sinus and linear sclerotized area; *g*, medial view anterior end of right valve; *h*, medial view anterior end of left valve; *i*, medial view of middle section of right valve showing adductor muscle scars below and dorsal muscle scars above; *j*, medial view of dorsal muscle scars below anterior hinge element and oval lucid area below muscle scars; *k*, medial view right valve showing minute reticulations within large reticulations on surface of valve. (Same scale, in microns: *b,c,d,f,i, e,g,h,j*.)

PARALECTOTYPE.—1 male designated as specimen C, Naturhistorisches Museum.

ADDITIONAL SPECIMENS.—2 females from the type-locality designated as specimens 1 and 2 on slides, Naturhistorisches Museum.

TYPE-LOCALITY.—Graf (1931) reported 4 specimens of *Philomedes polae* from *Pola* Expedition Station 90 and 1 specimen from Station 89; both stations are in the Gulf of Suez; all specimens are males. The vial containing specimens of *P. polae* did not bear a station number; however, as 3 specimens were in the vial, it is probable that all, and at least 2 of them, are from Station 90 rather than 89. Station 90, therefore, is considered here to be the type-locality; since Stations 89 and 90 are close to each other, however, whether the lectotype was collected at one or the other is not of major significance. Females of *P. polae*, designated by Graf as *Philomedes* species, were collected at Station 90. Data concerning the stations are as follows:

station	*latitude*	*longitude*	*collecting depth*	*date collected*
89	28°40′N	32°57′E	surface	March 31, 1896
90	28°00′N	33°36′E	surface	April 1, 1896

DESCRIPTION OF MALE.—Shell (figs. 1, 2*a*–*e*): oval, elongate with greatest height near middle, prominent rostrum and shallow rostral incisure (fig. 1*a*); anterior margin of rostrum and anteroventral margin of shell with scalloped outline formed by cresent-like marginal denticulations; alate shield projecting laterally and anteroventrally from behind rostral incisure, partly covering incisure, flap strongly sclerotized anteriorly (figs. 1*c*,*f*). Surface of valves with irregular polygons; polygons with pebbly texture appearing as minute polygons under high magnification (figs. 1*e*,*k*). Posterior dorsal margin with linear hinge depressed below outline of shell (figs. 2*b*,*c*); hinge not visible in lateral view except by transmitted light. Posterior hinge element of each valve consisting of angular sclerotized process (figs. 2*c*,*d*); medial hinge element straight; anterior hinge element not prominent. Left valve broadly overlapping right valve along anterodorsal margin. About 20 individual muscle scars (partly obscured by muscles in specimen examined) clustered behind and below middle of valve; small scar and large oval hyaline spot situated some distance above others; 2 large and 4 smaller scars situated below anterior hinge element (figs. 1*a*,*i*,*j*). Inner lamella broad with vestibule; no parallel striations or line of concrescence observed on inner lamella. Selvage with wide, corrugated, lamellar prolongation having fringe of slender spines along outer margin. Six long hairs bearing secondary spines, forming row on inner lamella behind rostrum (figs. 1*g*,*h*); inner lamella ventral to rostral incisure with small plumose hair, followed by wide space and then about 5 plumose hairs (fig. 2*a*); about 30 hairs on posteroventral part of inner lamella (figs. 2*d*,*e*).

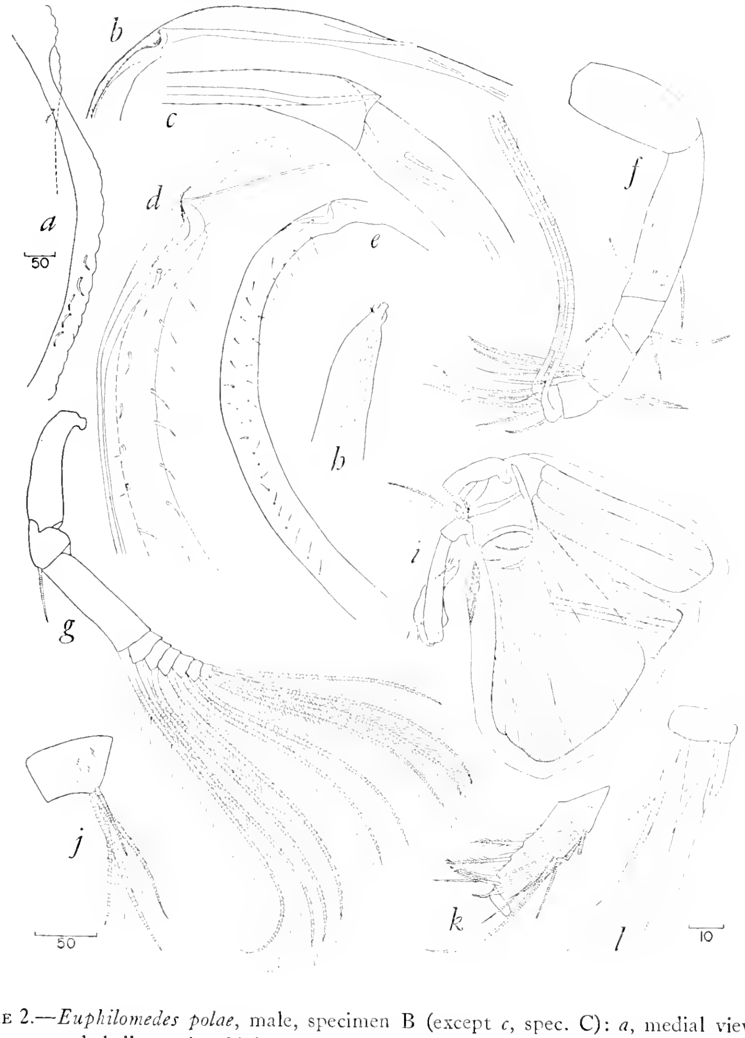


FIGURE 2.—*Euphilomedes polae*, male, specimen B (except *c*, spec. C): *a*, medial view of anteroventral shell margin of left valve showing medial hairs; *b*, medial view of left valve hinge area (anterior on right); *c*, medial view of posterior hinge element on right valve; pustules along middle hinge element are dotted because they could not be seen with certainty on specimen C and were not observed on specimen B; *d*, medial view marginal area at posterior end of left valve showing medial hairs; *e*, medial view posteroventral and posterodorsal margin showing medial hairs; *f*, lateral view of right 1st antenna (only proximal part of c- and f-bristles shown); *g*, exopodite of 2nd antenna; *h*, distal end 3rd joint of endopodite of 2nd antenna; *i*, protopodite and endopodite of 2nd antenna; *j*, medial view 1st endopodite joint of left mandible, distal bristles are on ventral margin (joint foreshortened by oblique position of joint in mounting medium); *k*, medial view 2nd endopodite joint of left mandible, dorsal margin to right; *l*, lateral view end joint of right mandible, all bristles not shown. (Same scale, in microns: *a,b,e,f,g,i; c,d,j,k; h,l.*)

Hairs with either pointed or blunt ends distributed on rostral surface (fig. 1*b*), some forming row near margin of shell; slender hairs with pointed ends on posterior surface of shell, some forming row near posterior margin (fig. 1*d*); a long tapered hair projecting from base immediately behind posterior hinge element of each valve (figs. 2*c–e*); all hairs coming through normal pore canals; radial pore canals not observed.

Dimensions: Lectotype (specimen B) greatest length 1.12 mm, greatest height 0.63 mm; paralectotype (specimen C) greatest length 1.12 mm, greatest height 0.63 mm. Graf (1931, p. 38) gives length of this species as 1.05 mm and height 0.60 mm.

First antenna (fig. 2*f*): First joint with faint clusters of short hairs on medial surface. Second joint with clusters of long hairs on medial surface, and distally, a dorsal, ventral, and lateral bristle; all bristles bare or with short hairs, none with wreaths of long hairs. Third joint with a few clusters of short hairs on medial surface, and 1 ventral and 2 dorsal bristles, the longer dorsal bristle provided with wreaths of long hairs near middle and short hairs distally; other dorsal bristle and ventral bristle with short hairs. Fourth joint with 2 dorsal bristles, each with wreaths of long hairs and the more proximal bristle with short hairs distally, and 4 long ventral bristles subterminally, latter bristles bare or with short hairs distally. Fifth joint, inferred to be inserted ventrally between 4th and 6th joints, bearing sensory bristle with broad base and provided with numerous filaments. Sixth joint with single bristle on 1 limb and without bristle on other limb (bristle may have been broken off during dissection). End joints with 5 slender bristles and 2 long stout c- and f-bristles.

Second antenna (figs. 2*g–i*): Protopodite triangular with transparent rim (fig. 2*i*). Exopodite (fig. 2*g*): 1st joint elongate; 2nd joint about ⅓ length of 1st; 3rd joint about same length as 1st; distal margins of joints 2–8 with comb of short spines (not shown on fig. 2*g*); basal spines not observed. Bristle of 2nd joint about ½ length of 3rd joint, bearing short marginal spines. Bristles of joints 3–8 bearing natatory hairs, without marginal spines. End joint with 4 stout bristles with natatory hairs and 2 short slender bristles. Endopodite 3-jointed (figs. 2*h,i*); 1st joint with 5 bare short bristles and 1 long distal bristle with wreaths of long hairs near middle and short spines distally; 2nd joint elongate, with 2 subterminal bristles provided with short spines; 3rd joint elongate, broad proximally, with 1 short proximal bristle and 2 longer subterminal bristles; tip with short spine and about 5 serrate ridges.

Mandible (figs. 2*j–l*, 3*a*, *b*): No coxale endite observed. Basale (fig. 3*b*): ventral margin with 3 short slender spinous bristles, and 2

FIGURE 3.—*Euphilomedes polae*, male, specimen B: *a*, medial view of exopodite and 1st endopodite joint without distal bristles of left mandible; *b*, lateral view of basale and exopodite of right mandible; *c*, maxilla, all bristles not shown; *d*, 5th limb, hairs not shown on all epipodial bristles; *e*, endites and exopodite of 5th limb, all bristles not shown; *f*, 6th limb; *g*, 7th limb (1 bristle in distal group broken); *h*, distal end of 7th limb; *i*, frontal organ and median eye; *j*, lateral view of right furcal lamella; *k*, copulatory organ; *l*, detail of distal tip of copulatory organ; *m*, lateral eye. (Same scale, in microns: *a, e, h, l*; *b, f, i, m*; *c, g*; *d, j, k*.)

long bristles with wreaths of long hairs and short spines distally. Dorsal margin with 3 bristles, 1 near middle and 2 subterminally. Medial surface with about 5 short bristles proximally near ventral corner and 1 longer bristle near ventral margin at middle of joint. Exopodite reaching middle of 1st endopodite joint, with 2 subequal terminal bristles with short marginal spines (fig. 3*a*); tip of joint with blunt hirsute process bearing short spine. Endopodite: First joint (fig. 2*j*) with 1 short spinous bristle and 3 long hirsute posterior bristles distally. Second joint (fig. 2*k*) anterior margin with proximal group of 3 bristles and distal group of 5 bristles, all bristles bare or with short spines; posterior margin with 2 spinous bristles distal and 1 short annulated bristle and 2 clawlike bristles subterminally. End joint (fig. 2*l*) with 2 large subequal claws, 1 short anterior claw, and 3 annulated bristles. Medial surface of basale and 1st and 2nd joints of endopodite provided with groups of hairs.

Maxilla (fig. 3*c*): Very small. It seems to have a structure typical of the genus, but because of its size I have not attempted to describe it fully.

Fifth limb (figs. 3*d, e*): Epipodial appendage with about 47 plumose bristles. Outer lobe of 3rd exopodite joint with 2 stout plumose bristles.

Sixth limb (fig. 3*f*): First endite with 3 bristles, 2nd endite with 4 bristles, 3rd endite with 6 bristles, 4th endite with 6 bristles, 2nd joint of exopodite with 14 bristles, joint not produced posteriorly; epipodial appendage represented by 2 short bare bristles. Surface of second joint of exopodite with clusters of short hairs.

Seventh limb (figs. 3*g, h*): Cleaning bristles: 4 in distal group, each with 4 or 5 bells; 3 in proximal group, each with 1 to 3 bells; surface hairs not observed on bristles. Terminal comb with about 7 marginal teeth, some with marginal spines. Two long curved pegs opposing comb.

Copulatory organ (figs. 3*k, l*): Long, slender, divided into 3 lobes, each with 2 annulated bristles; 1 lobe with large curved sclerotized tip.

Furca (fig. 3*j*): Each lamella with 12 to 13 claws: primary claws number 1, 2, 6, 10; secondary claws 3, 4, 5, 7, 8, 9, 11, 12, 13 (13th claw not always present). Primary claws 1 and 2 separated from lamella, 6 and 10 joined to lamella; secondary claws all separated from lamella; all claws with double row of spines. Primary claws decrease in length proximally on lamella. Lamella near claws 1 and 2 with clusters of long hairs. (One specimen has 13 claws on each lamella, another specimen has 13 claws on the right lamella and only 12 on the left lamella.)

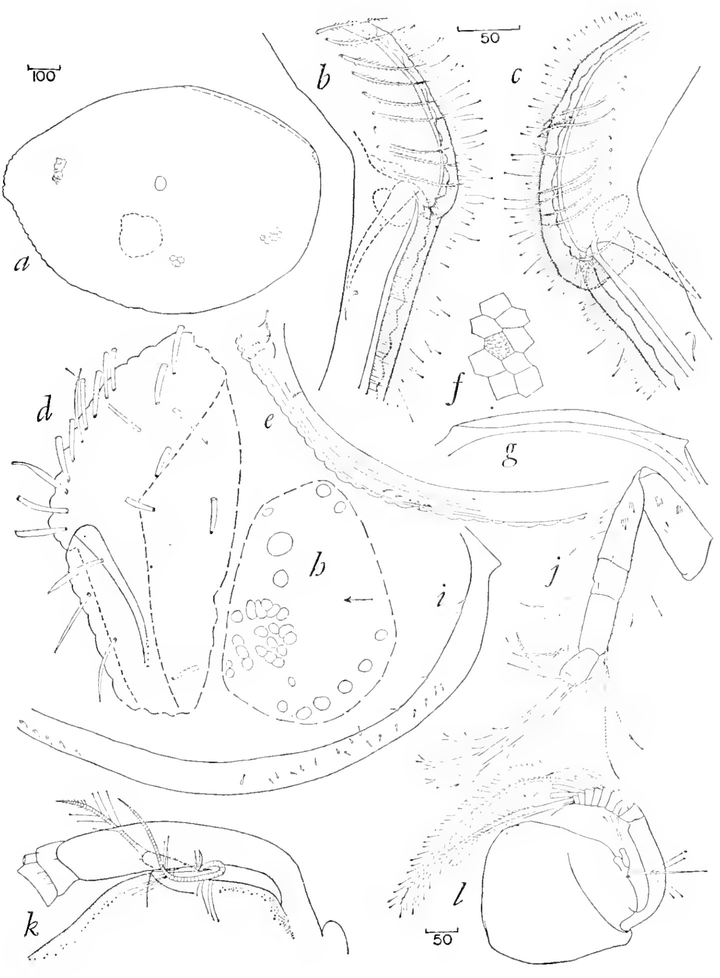


FIGURE 4.—*Euphilomedes polae*, female, specimen 2 (except *a–d*, *j–l*, spec. 1): *a*, lateral view left valve, dashed area near valve middle contains adductor muscle scars, not all surface polygons shown; *b*, medial view of anterior end of left valve, sclerotized areas stippled; *c*, medial view anterior of right valve, sclerotized areas stippled; *d*, lateral view of anterior end of left valve showing surface and marginal hairs; *e*, medial view of antero-ventral margin of right valve showing distribution of hairs on inner lamella; *f*, medial view of valve near posterior showing large and small reticulations; *g*, medial view hinge element of right valve (anterior end on right); *h*, medial view of muscle scars on right valves, adductor muscle scars clustered at lower left of figure, anterior of valve to left; *i*, medial view of posterior and ventral marginal area of right valve showing distribution of hairs on inner lamella; *j*, lateral view of left 1st antenna; *k*, lateral view of endopodite, first 3 joints of exopodite and distal margin of protopodite of left 2nd antenna; *l*, medial view of right 2nd antenna, ends of some bristles of exopodite not shown. (Same scale, in microns: *b–d*, *f*, *k*; *e*, *g–j*, *l*.)

Eyes: Lateral eyes large; about 19 ommatophores visible in side view, all except 2 divided by a suture into 2 parts (fig. 3*m*). Medial eye large, pigmented (fig. 3*i*).

Frontal organ (fig. 3*i*): Elongate, 2-jointed with short spines on distal half of 2nd joint and subterminally on basal joint.

Description of female.—Shell (figs. 4*a–i*): lateral outline more ovoid than male (fig. 4*a*); hinge structure (fig. 4*g*) selvage similar to male; adductor muscle scars (figs. 4*a,h*) more anteriorly and ventrally located on shell than on male; rostrum narrower and incisure shallower than on male; irregular polygons on surface of shell subdivided by minute polygons larger than on male shell and visible under low magnification (fig. 4*f*). Inner lamella with parallel striations on anteroventral part; 9 long hairs with secondary spines forming row on inner lamella behind rostrum (figs. 4*b,c*); inner lamella below rostral incisure with small hair followed by wide space and then 5 hairs (fig. 4*e*); posteroventral part of inner lamella with at least 21 hairs (fig. 4*i*); lateral surface of rostrum and anterior part of shell with numerous hairs with blunt ends (fig. 4*d*).

Dimensions: Specimen no. 1 greatest length 1.06 mm, greatest height 0.86 mm; specimen no. 2 greatest length 1.03 mm, greatest height 0.73 mm. Graf (1931, p. 38) gives length as 0.90 mm and 1.00 mm and height as 0.70 mm.

First antenna (fig. 4*j*): First and 2nd joints with surface hairs. Second joint with 3 bristles, 1 dorsal, 1 ventral, and 1 lateral. Third joint with 1 ventral bristle distally and 1 short bare bristle and 1 long hirsute bristle on dorsal margin; ventral margin with short spines. Fourth joint with 2 dorsal subterminal bristles and 1 short and 3 long ventral subterminal bristles; ventral margin with short spines. Fifth joint with stout ventral terminal bristle with filaments. Sixth joint with medial bristle distally. End joints with 1 short bristle and 2 long bristles without filaments and 4 long bristles with filaments.

Second antenna (figs. 4*k, l*): Protopodite subtriangular without transparent rim. Exopodite (fig.4*l*) with 9 joints; 1st joint elongate with small medial spine; 2nd to 9th joints trapezoidal without basal spines; distal margins of 2nd to 5th joints with comb of slender spines; 2nd and 3rd joints with bristles without natatory hairs or marginal denticulations; 4th to 8th joints with bristles having natatory hairs and marginal denticulations; 9th joint with 2 short bare bristles and 2 subequal long bristles with natatory hairs and marginal denticulations. Endopodite (figs. 4*k,l*) with 2 joints; basal joint with long stout bristle with wreath of long hairs near middle, and 3 to 5 short bare bristles; distal joint elongate with small spine at tip and long stout terminal bristle with wreaths of long hairs near middle and short distal spines.

FIGURE 5.—*Euphilomedes polae*, female, specimen 1: *a*, medial view right mandible (surface hairs not shown); *b*, lateral view left maxilla, all bristles not shown; *c*, posterior view left 5th limb; *d*, medial view right 6th limb; *e*, 7th limb; *f*, distal end of 7th limb; *g*, distal end frontal organ; *h*, frontal organ and medial eye; *i*, medial view right lamella of furca; *j*, lateral view left lamella of furca. (Same scale, in microns: *b,d,e,h–j*; *c,f,g*.)

Mandible (fig. 5*a*): Coxale endite large, bifurcate, with rows of spines. Basale: ventral margin with 4 short bristles followed by 1 longer bristle near distal end; dorsal margin with 3 bristles, 1 near middle and 2 at distal end; medial surface with 1 bristle at middle and 5 shorter bristles proximally, all near ventral margin. Exopodite short with 2 bristles and triangular process at tip, inner bristle with wreath of long hairs near middle. Endopodite: distal end of 1st joint with 1 short and 3 long bristles ventrally; anterior margin of 2nd joint with proximal group of 4 and distal group of 5 bristles; posterior margin with 2 subterminal bristles and terminally with 1 short annulate bristle and 2 clawlike bristles; distal joint with 2 long stout claws of subequal length and 3 bristles. Surface of basale and 2nd joint of exopodite hirsute.

Maxilla (fig. 5*b*): Precoxa and coxa with fringe of fine hair along dorsal margin; coxa with short bare bristle on dorsal margin; basale with 3 distal bristles; 1st endopodite joint with marginal hairs, a hirsute bristle terminal on anterior margin and about 5 bristles on distal margin; distal end of endopodite joint provided with numerous bristles; exopodite with 2 long and 1 short bristle. Three endites: 1st endite with about 8 bristles; 2nd endite with about 4 bristles; 3rd endite with about 6 distal and 1 proximal bristle (bristles not shown in illustration).

Fifth limb (fig. 5*c*): Epipodial appendage with about 49 bristles. Triangular tooth anterior to main tooth of 1st exopodite joint about same size as distal tip of 2nd exopodite joint. Distal anterior margin of 1st joint with 2 centrally located bristles. Large curved tooth of 2nd exopodite joint without bristle at distal lateral corner.

Sixth limb (fig. 5*d*): First endite with 3 bristles; 2nd endite with 4 bristles; 3rd endite with 7 bristles; 4th endite with 6 bristles; epipodial appendage represented by 2 short bristles. Second joint of exopodite not produced posteriorly, distal margin with 13 to 14 bristles, medial and lateral surfaces hirsute.

Seventh limb (figs. 5*e,f*): Five cleaning bristles in distal group, 3 in proximal group, each bristle with 1 to 5 terminal bells. Terminal comb with about 9 teeth, secondary teeth at base (all teeth not shown in illustration); 2 elongate pegs opposing comb.

Furca (figs. 5*i,j*): Each lamella with 4 primary claws and 10 to 12 secondary claws. Primary claws 1 and 2 separated from lamella, 7 and 12 (or 11) joined to lamella. Primary claws decrease in length proximally on lamella. Secondary claws 3 to 6 about same length, shorter than claw 7, longer than claw 8; claws 8 to 12 (or 11) decrease in size proximally. Primary claw 12 (or 11) about same size or longer than preceding secondary claw and longer than following secondary claw. Lamella near basis of claws with long hairs. Primary claws 1 and 2 with double row of teeth, claws 7 and 12 without teeth; secondary claws with marginal spines. Distribution of primary and secondary furcal claws on 2 specimens is as follows:

	claw number															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
specimen 1																
right	p	p	s	s	s	s	p	s	s	s	s	p	s	s	s	s
left	p	p	s	s	s	s	p	s	s	s	p	s	s	s		
specimen 2																
right	p	p	s	s	s	s	p	s	s	s	s	p	s	s	s	
left	p	p	s	s	s	s	p	s	s	s	s	p	s	s		

Eyes: Large medial eye (fig. 5*h*); lateral eyes not observed.

Frontal organ (figs. 5*g,h*): 2-jointed with distal joint 3 times length of proximal joint; tip rounded; surface of 2nd joint and distal end of 1st joint with fine spines.

Remarks.—Extreme sexual dimorphism among some species of ostracods creates inherent difficulties in relating males and females with certainty. Carapace morphology in the region of the rostrum and rostral incisure between males and females of *Euphilomedes polae* identified herein is sufficiently similar to warrant considering them as conspecific in spite of some differences in appendage morphology. Both males and females were collected in the same area. The male and female of *E. arostratus* Kornicker, a closely related species, have similar dimorphism.

Some differences in morphology between males and females of *E. polae* and *E. arostratus* are compared as follows:

	E. polae		*E. arostratus*	
	male	female	male	female
number of secondary furcal claws	8–9	10–12	7	9
cleaning bristles in distal group of 7th limb	4	5	4	5
number of hairs in row on inner lamella behind rostrum	6	9	9–11*	11

*The male of *E. arostratus* described from the Maldive Islands (Kornicker, 1967) has 9 to 10 hairs, whereas the Red Sea form described in this paper has 11.

Comparisons.—*Euphilomedes polae* is closely related to *E. arostratus* Kornicker but may be differentiated from that species by the shallower rostral incisure with a lateral shield, the subterminal location of bristles on the 2nd joint of the endopodite of the 2nd antenna of the male, and the lower number of bristles on the anteroventral part of the inner lamella of the carapace: 5 compared to 16–21 on *E. arostratus*.

Euphilomedes arostratus Kornicker, 1967

FIGURE 6

Euphilomedes arostrata Kornicker, 1967, p. 2.

HOLOTYPE.—USNM 112658. Sex: female. Male Atoll, Maldive Islands, Indian Ocean.

LOCALITY.—Gulf of Suez, Red Sea. Specimen probably from Station 90 but could be from Station 89. Data concerning the stations is given under "Type-locality" of *E. polae*. This specimen was in vial containing specimens identified as *Philomedes polae* by Dr. Herbert Graf.

DESCRIPTION OF MALE.—Shell (figs. 6*a–e, h*): oval, elongate with greatest height near middle, prominent rostrum and antennal sinus (figs. 6*a, b, e*); anterior margin of rostrum and anteroventral margin of shell with scalloped outline formed by crescent-like marginal denticulations. Surface of valves with distinct irregular polygons (fig. 6*h*); polygons with pebbly texture appearing as minute polygons under high magnification. Posterior dorsal margin with linear hinge depressed below outline of shell; posterior hinge element of each valve consisting of angular sclerotized process; medial hinge element straight; anterior hinge element not prominent. Left valve broadly overlapping right valve along anterodorsal margin. Numerous adductor muscle scars (partly obscured by muscles in specimen examined) clustered behind and below middle of valve; 2 small scars and large oval hyaline spot situated some distance above other; additional scars below anterior hinge element (fig. 6*h*). Inner lamella broad with vestibule; selvage with wide, corrugated lamellar prolongation having fringe of slender spines along outer margin. Eleven long hairs with a few secondary spines forming row on inner lamella behind rostrum (fig. 6*b*); inner lamella below rostrum with small hair followed by wide space and then 20 hairs on right valve and 21 on left valve (figs. 6*c, d*); about 34 hairs on posteroventral part of inner lamella. Hair with either pointed or blunt ends distributed on rostral surface, some forming row near margin of shell; slender hairs with pointed ends on posterior surface of shell, some forming row near posterior margin; a long tapered hair projecting from base immediately behind posterior hinge element of each valve.

Dimensions: Greatest length 1.23 mm, greatest height 0.73 mm. Specimen is larger than male reported by Kornicker (1967) from the Maldives, length 1.00 mm, height 0.60 mm.

First antenna: First joint with medial hairs. Second joint with medial hairs and, distally, a dorsal, ventral, and lateral bristle, all bristles bare or with short hairs distally. Third joint with few medial hairs and 1 ventral and 2 dorsal bristles, all with short hairs, the

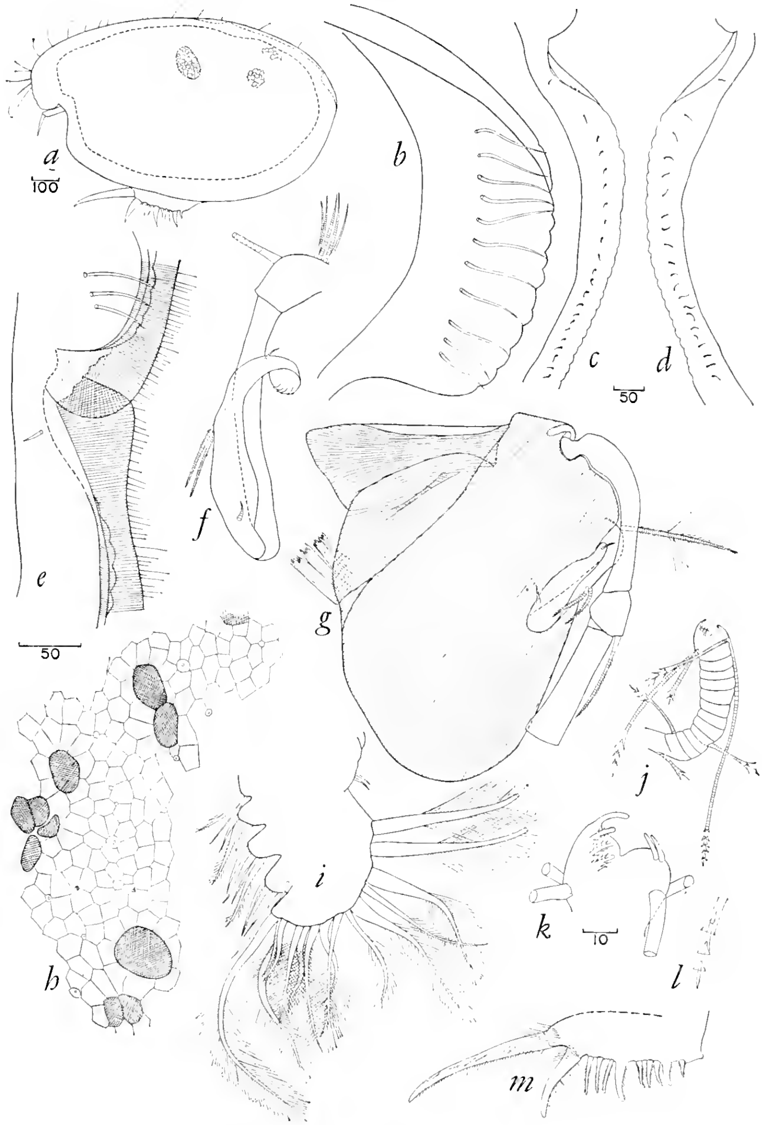


FIGURE 6.—*Euphilomedes arostratus*, male, specimen A: *a*, lateral view of complete carapace showing position of lateral eye and some reticulations; *b*, medial view rostrum left valve; *c*, medial view of anteroventral margin of left valve; *d*, medial view of anteroventral of margin of right valve; *e*, medial view of antennal sinus area of left valve; *f*, endopodite of left 2nd antenna; *g*, lateral view protopodite, endopodite, and 1st 3 joints of exopodite of 2nd antenna; *h*, medial view of reticulations, normal pores, and muscle scars (cross-hatched) located dorsal to adductor muscle scars on left valve, anterior to right, upper scars are located below anterior hinge element; *i*, medial view right 6th limb (surface hairs not shown); *j*, distal part of 7th limb; *k*, distal tip of 7th limb; *l*, detail of distal end of bristle of 7th limb; *m*, lateral view left caudal lamella. (Same scale, in microns: *b,e,f,h–j; c,d,g,m; k,l.*)

longer dorsal bristle also provided with wreaths of long hairs near middle. Fourth joint with 2 dorsal bristles, each with wreaths of long hairs, and 4 long ventral bristles subdistally; bristles bare or with short hairs distally. Fifth joint, inferred to be inserted ventrally between 4th and 6th joints, bearing sensory bristle with broad base and numerous filaments. Sixth joint with single dorsal bristle distally having short spines. End joint with 1 short dorsal bristle with short spines, 2 slender bristles with filaments, 2 bristles with filaments, and usual long, stout c- and f-bristles.

Second antenna (figs. 6*f,g*): Protopodite triangular without transparent rim (fig. 6*g*). Exopodite: first joint elongate; 2nd joint about ¼ length of 1st; 3rd joint about ⅔ length of 1st; distal margins of joints 2–8 with comb of short spines; basal spines not observed. First joint without bristle; bristle of 2nd joint about ¾ length of 3rd joint (fig. 6*g*), bearing short marginal spines. Bristles of joints 3–8 bearing natatory hairs, without marginal spines. End joint with 4 stout bristles with natatory hairs and 2 short slender bristles without hairs. Endopodite (fig. 6*f*) 3-jointed; 1st joint with 5 bare short bristles and 1 long distal bristle with wreaths of long hairs near middle and short spines distally; 2nd joint elongate, with 2 bristles near middle, bristles provided with short spines; 3rd elongate with 1 proximal and 1 distal short bristle, tip with serrated ridges (tip of appendage partly obscured with the result that presence or absence of spine at tip could not be ascertained).

Mandible: No coxale endite observed. Basale: ventral margin with 4 short slender bristles and 2 long bristles with wreaths of long hairs and short spines distally. Dorsal margin with 3 bristles. Medial surface with about 5 short bristles proximally near ventral corner and 1 longer bristle near ventral margin at middle of joint. Exopodite reaching middle of 1st endopodite joint, with 2 subequal terminal bristles; tip of joint with blunt hirsute process. Endopodite: first joint with 1 short and 3 long ventral bristles distally. Second joint of anterior margin with proximal group of 3 and distal group of 5 bristles; posterior margin with 2 distal spinous bristles and 1 short annulated bristle and 2 clawlike subterminal bristles. End joint with 2 large subequal claws, 1 short posterior claw, and 3 annulated bristles. Medial surface of basale and 1st and 2nd joints of endopodite provided with groups of hairs.

Maxilla: Very small. It seems to have a structure typical of the genus, but because of its small size I have not attempted to describe it fully.

Fifth limb: Epipodial appendage with 45 plumose bristles. Outer lobe of 3rd exopodite joint with 2 stout plumose bristles.

Sixth limb (fig. 6*i*): First endite with 3 bristles, 2nd endite with 4 bristles, 3rd endite with 7 bristles; 2nd joint of exopodite with 14 or 15 bristles, joint not produced posteriorly; epipodial appendage represented by 2 short bare bristles. Surface of 2nd joint of exopodite with clusters of short hairs (not shown on illustration).

Seventh limb (figs. 6*j*–*l*): Cleaning bristles: 4 in distal group, each with 2 to 4 bells; 3 proximal bristles, each with 1 to 3 bells; some bristles with short marginal spines. Terminal comb with about 7 marginal teeth, some with spines. Two long curved pegs opposing comb.

Copulatory organ: Long slender, divided into 3 lobes with bristles.

Furca (fig. 6*m*): Each lamella with 11 claws: primary claws number 1, 2, 6, 10; secondary claws 3, 4, 5, 7, 8, 9, 11. Primary claws 1 and 2 and all secondary claws separated from lamella; all claws with double row of spines. Primary claws decrease in length proximally on lamella. Lamella near claws 1 and 2 with clusters of long hairs.

Frontal organ: Elongate, 2-jointed with short spines on surface of end joint and distal end of basal joint.

REMARKS.—Although I have identified the Red Sea specimen as *Euphilomedes arostratus*, some differences between this form and that described from the Maldive Islands (Kornicker, 1967) creates doubt concerning their conspecificity. A difference of possible significance is that the Red Sea form has 2 bristles in place of the epipodial appendage on the 6th limb as contrasted to 3 in this position on the male of *E. arostratus* described from the Maldives. The female of *E. arostratus* from the Maldives, however, has only 2 bristles, suggesting that the species may have either 2 or 3 epipodial bristles. Also, whereas the male of *E. arostratus* from the Maldives has 9 to 10 bristles on the inner lamella behind the rostrum, the Red Sea form has 11, the same number as the female from the Maldives. This suggests that the number of bristles in this position might vary from 9 to 11 for the species. The Red Sea specimen is also larger than the Maldive form. In most characters, the Red Sea and Maldive Island forms are so similar that it seems best at this time to include them in the same species.

Literature Cited

Baird, W.

1850. The natural history of the British Entomostraca, 364 pp., 36 pls. [Ostracoda: pp. 138–182, pls. 18–23.]

Graf, H.

1931. Expedition S.M.S. "Pola" in das Rote Meer: Die Cypridinidae des Roten Meeres. Denkschr. Akad. Wiss. Wiener Math. Naturw. Klasse, vol. 102, pp. 32–46, figs. 1–10.

Kornicker, L. S.

1967. *Euphilomedes arostrata*, a new myodocopid ostracod from the Maldive Islands, Indian Ocean. Proc. U.S. Nat. Mus., vol. 120, no. 3563, pp. 1–21.

Müller, G. W.

1912. Ostracoda. Pt. 31 *in* Das Tierreich, 434 pp., 92 figs.

Poulsen, E. M.

1962. Cypridiniformes-cypridinidae. Pt. 1 *in* Ostracoda-Myodocopa, 414 pp. [Dana-Report No. 57.]

U.S. GOVERNMENT PRINTING OFFICE: 1967

Proceedings of the United States National Museum

SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 121 1967 Number 3571

SUPPLEMENTARY DESCRIPTIONS OF TWO MYODOCOPID OSTRACODS FROM THE RED SEA

By Louis S. Kornicker
Associate Curator, Division of Crustacea

This study is based on ostracods collected on the *Pola* Expedition to the Red Sea in 1896 and described by Dr. Herbert Graf (1931). In the original description of *Philomedes polae* (=*Euphilomedes polae*), Graf (1931) did not designate a holotype and omitted some details of carapace and appendage morphology. Graf's description may have been based on more than one species. The species, therefore, is redescribed herein and a lectotype selected from the available type-series. Specimens designated as *Philomedes* species by Graf (1931) have been identified as females of *E. polae* and are described as such. A single specimen included by Graf in the type-series of *Philomedes polae* has been identified as *Euphilomedes arostrata* Kornicker (1967); this identification is documented with a description and illustrations of the Red Sea specimen.

The following material was obtained through the courtesy of Dr. Gerhard Pretzmann from the Naturhistorisches Museum, Vienna, Austria: (1) One bottle, containing one vial with 3 males, with red label marked: "*Philomedes polae*, n. sp. ♂; Rotes Meer: Gulf von Suez;

Coll: 'Pola' 1895/8; Dr. Graf det." (2) One bottle with white label marked: "*Philomedes* sp. ♀; Rotes Meer: Stat. 90; Coll. 'Pola' 1895/8; Dr. Graf det." This bottle contained one vial with 2 females containing eggs that had not yet been extruded into the brood chamber and with a label that had been marked "*Philomedes* sp. ♀ (A)."

Since Dr. Graf had not designated a holotype of *Philomedes polae* Graf, Dr. Pretzmann suggested that I select a lectotype from the type material. Examining the material, I found 2 specimens in the first bottle that I could equate with *Philomedes polae* Graf, using primarily as a basis for identification the distinctive secondary appendage described and figured for this species by Graf (1931, p. 37, fig. 5i). The third specimen in the first bottle I identify as *Euphilomedes arostratus* Kornicker, recently described for the first time from the Maldive Islands, Indian Ocean.

The 2 specimens in the second bottle I equate to specimens described by Graf (1931) as *Philomedes* species on his page 38 and illustrated in his figure 6. The similarity of the distribution of primary and secondary claws on the caudal rami of the specimens at hand with the published description of *Philomedes* species makes it certain that this identification is correct. After studying these specimens, I have concluded that they are females of *Philomedes polae* Graf.

I acknowledge with thanks the assistance of Dr. Gerhard Pretzmann in obtaining specimens for study from the Naturhistorisches Museum, Vienna, Austria, and of Miss Caroline Bartlett, who inked the final illustrations. I would like also to thank Mr. I. G. Sohn and Doctors Raymond B. Manning and W. Duane Hope for reviewing the manuscript.

Family Cypridinidae Baird, 1850

Subfamily Philomedinae G. W. Müller, 1912

Genus *Euphilomedes* Poulsen, 1962

Type-species.—*Euphilomedes nodosus* Poulsen, 1962, by subsequent designation, Kornicker (1967).

Euphilomedes polae (Graf, 1931)

Figures 1–5

Philomedes polae Graf, 1931, p. 37, fig. 5.
Philomedes species.—Graf, 1931, p. 38, fig. 6.

Lectotype.—Specimen designated as specimen B on slide. Naturhistorisches Museum, Zoologische Abteilung, Vienna, Austria.

Sex.—Male.

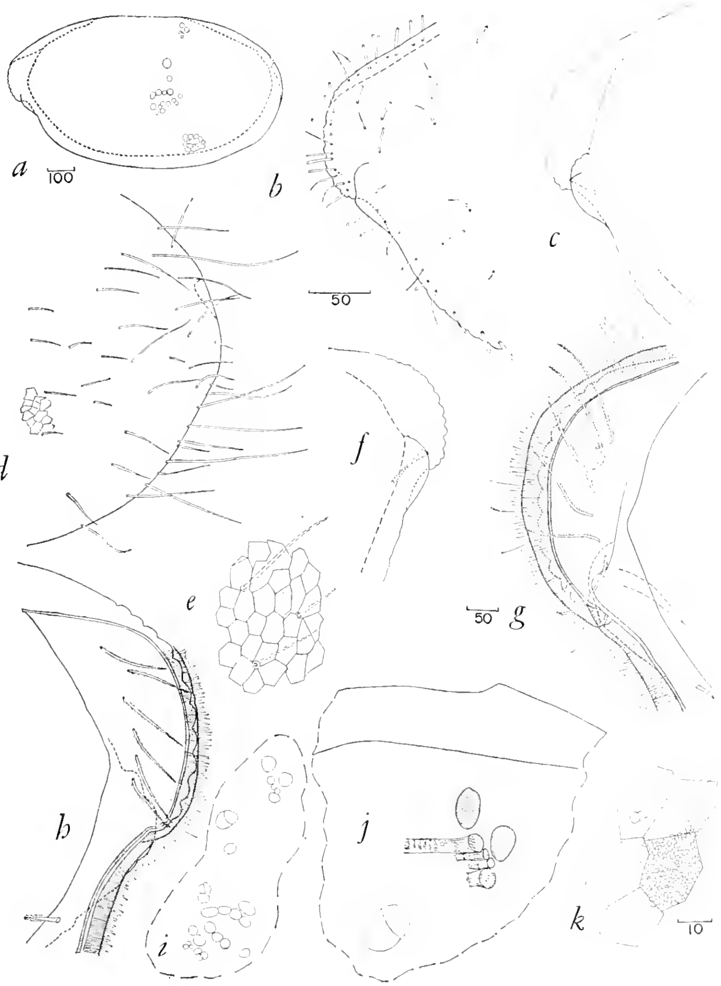


FIGURE 1.—*Euphilomedes polae*, male, specimen C (except *a* and *h*, spec. B): *a*, lateral view left valve showing some muscle scars, surface reticulation shown only near posteroventral margin of valve; *b*, lateral view anterior end of left valve showing surface and marginal hairs; *c*, lateral view anterior end of left valve showing flap over antennal sinus, and linear sclerotized area visible in transmitted light; *d*, lateral view posterior end of left valve showing surface hairs and some reticulations; *e*, medial view of part of shell posterior showing reticulations, normal pore canals and surface hairs; *f*, lateral view anterior end of right valve showing marginal denticulations around rostrum, flap over antennal sinus and linear sclerotized area; *g*, medial view anterior end of right valve; *h*, medial view anterior end of left valve; *i*, medial view of middle section of right valve showing adductor muscle scars below and dorsal muscle scars above; *j*, medial view of dorsal muscle scars below anterior hinge element and oval lucid area below muscle scars; *k*, medial view right valve showing minute reticulations within large reticulations on surface of valve. (Same scale, in microns: *b,c,d,f,i, e,g,h,j*.)

Paralectotype.—1 male designated as specimen C, Naturhistorisches Museum.

Additional specimens.—2 females from the type-locality designated as specimens 1 and 2 on slides, Naturhistorisches Museum.

Type-locality.—Graf (1931) reported 4 specimens of *Philomedes polae* from *Pola* Expedition Station 90 and 1 specimen from Station 89; both stations are in the Gulf of Suez; all specimens are males. The vial containing specimens of *P. polae* did not bear a station number; however, as 3 specimens were in the vial, it is probable that all, and at least 2 of them, are from Station 90 rather than 89. Station 90, therefore, is considered here to be the type-locality; since Stations 89 and 90 are close to each other, however, whether the lectotype was collected at one or the other is not of major significance. Females of *P. polae*, designated by Graf as *Philomedes* species, were collected at Station 90. Data concerning the stations are as follows:

station	*latitude*	*longitude*	*collecting depth*	*date collected*
89	28°40′N	32°57′E	surface	March 31, 1896
90	28°00′N	33°36′E	surface	April 1, 1896

Description of male.—Shell (figs. 1, 2*a–e*): oval, elongate with greatest height near middle, prominent rostrum and shallow rostral incisure (fig. 1*a*); anterior margin of rostrum and anteroventral margin of shell with scalloped outline formed by cresent-like marginal denticulations; alate shield projecting laterally and anteroventrally from behind rostral incisure, partly covering incisure, flap strongly sclerotized anteriorly (figs. 1*c,f*). Surface of valves with irregular polygons; polygons with pebbly texture appearing as minute polygons under high magnification (figs. 1*e,k*). Posterior dorsal margin with linear hinge depressed below outline of shell (figs. 2*b,c*); hinge not visible in lateral view except by transmitted light. Posterior hinge element of each valve consisting of angular sclerotized process (figs. 2*c,d*); medial hinge element straight; anterior hinge element not prominent. Left valve broadly overlapping right valve along anterodorsal margin. About 20 individual muscle scars (partly obscured by muscles in specimen examined) clustered behind and below middle of valve; small scar and large oval hyaline spot situated some distance above others; 2 large and 4 smaller scars situated below anterior hinge element (figs. 1*a,i,j*). Inner lamella broad with vestibule; no parallel striations or line of concrescence observed on inner lamella. Selvage with wide, corrugated, lamellar prolongation having fringe of slender spines along outer margin. Six long hairs bearing secondary spines, forming row on inner lamella behind rostrum (figs. 1*g,h*); inner lamella ventral to rostral incisure with small plumose hair, followed by wide space and then about 5 plumose hairs (fig. 2*a*); about 30 hairs on posteroventral part of inner lamella (figs. 2*d,e*).

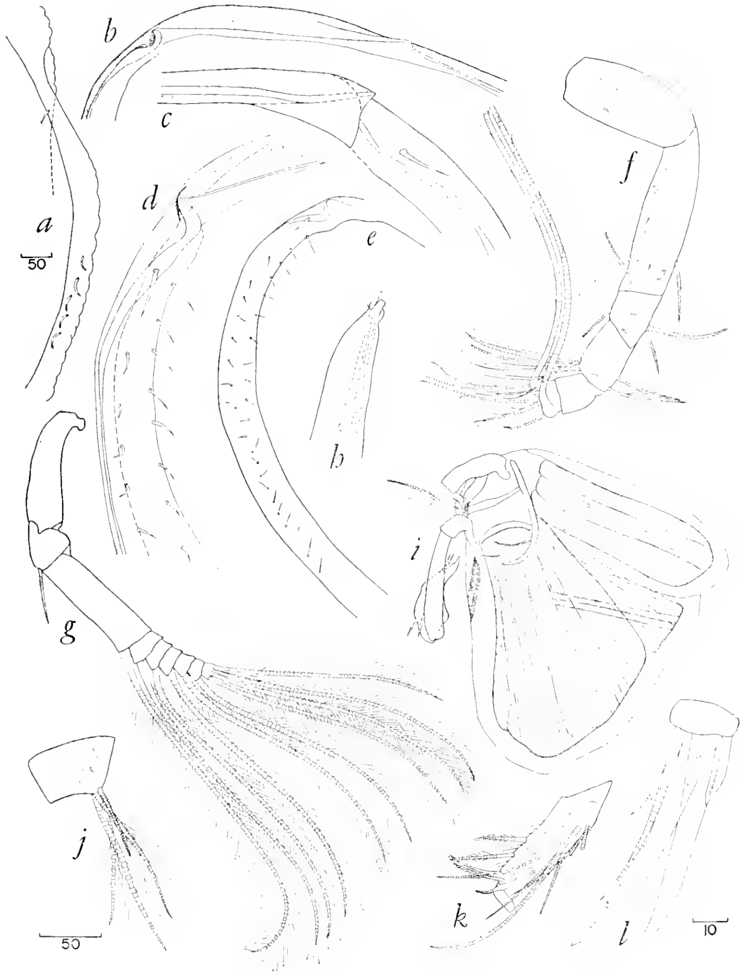


FIGURE 2.—*Euphilomedes polae*, male, specimen B (except *c*, spec. C): *a*, medial view of anteroventral shell margin of left valve showing medial hairs; *b*, medial view of left valve hinge area (anterior on right); *c*, medial view of posterior hinge element on right valve; pustules along middle hinge element are dotted because they could not be seen with certainty on specimen C and were not observed on specimen B; *d*, medial view marginal area at posterior end of left valve showing medial hairs; *e*, medial view posteroventral and posterodorsal margin showing medial hairs; *f*, lateral view of right 1st antenna (only proximal part of c- and f-bristles shown); *g*, exopodite of 2nd antenna; *h*, distal end 3rd joint of endopodite of 2nd antenna; *i*, protopodite and endopodite of 2nd antenna; *j*, medial view 1st endopodite joint of left mandible, distal bristles are on ventral margin (joint foreshortened by oblique position of joint in mounting medium); *k*, medial view 2nd endopodite joint of left mandible, dorsal margin to right; *l*, lateral view end joint of right mandible, all bristles not shown. (Same scale, in microns: *a,b,e,f,g,i; c,d,j,k; h,l.*)

Hairs with either pointed or blunt ends distributed on rostral surface (fig. 1*b*), some forming row near margin of shell; slender hairs with pointed ends on posterior surface of shell, some forming row near posterior margin (fig. 1*d*); a long tapered hair projecting from base immediately behind posterior hinge element of each valve (figs. 2*c–e*); all hairs coming through normal pore canals; radial pore canals not observed.

Dimensions: Lectotype (specimen B) greatest length 1.12 mm, greatest height 0.63 mm; paralectotype (specimen C) greatest length 1.12 mm, greatest height 0.63 mm. Graf (1931, p. 38) gives length of this species as 1.05 mm and height 0.60 mm.

First antenna (fig. 2*f*): First joint with faint clusters of short hairs on medial surface. Second joint with clusters of long hairs on medial surface, and distally, a dorsal, ventral, and lateral bristle; all bristles bare or with short hairs, none with wreaths of long hairs. Third joint with a few clusters of short hairs on medial surface, and 1 ventral and 2 dorsal bristles, the longer dorsal bristle provided with wreaths of long hairs near middle and short hairs distally; other dorsal bristle and ventral bristle with short hairs. Fourth joint with 2 dorsal bristles, each with wreaths of long hairs and the more proximal bristle with short hairs distally, and 4 long ventral bristles subterminally, latter bristles bare or with short hairs distally. Fifth joint, inferred to be inserted ventrally between 4th and 6th joints, bearing sensory bristle with broad base and provided with numerous filaments. Sixth joint with single bristle on 1 limb and without bristle on other limb (bristle may have been broken off during dissection). End joints with 5 slender bristles and 2 long stout c- and f-bristles.

Second antenna (figs. 2*g-i*): Protopodite triangular with transparent rim (fig. 2*i*). Exopodite (fig. 2*g*): 1st joint elongate; 2nd joint about ⅓ length of 1st; 3rd joint about same length as 1st; distal margins of joints 2–8 with comb of short spines (not shown on fig. 2*g*); basal spines not observed. Bristle of 2nd joint about ½ length of 3rd joint, bearing short marginal spines. Bristles of joints 3–8 bearing natatory hairs, without marginal spines. End joint with 4 stout bristles with natatory hairs and 2 short slender bristles. Endopodite 3-jointed (figs. 2*h,i*); 1st joint with 5 bare short bristles and 1 long distal bristle with wreaths of long hairs near middle and short spines distally; 2nd joint elongate, with 2 subterminal bristles provided with short spines; 3rd joint elongate, broad proximally, with 1 short proximal bristle and 2 longer subterminal bristles; tip with short spine and about 5 serrate ridges.

Mandible (figs. 2*j–l*, 3*a*, *b*): No coxale endite observed. Basale (fig. 3*b*): ventral margin with 3 short slender spinous bristles, and 2

FIGURE 3.—*Euphilomedes polae*, male, specimen B: *a*, medial view of exopodite and 1st endopodite joint without distal bristles of left mandible; *b*, lateral view of basale and exopodite of right mandible; *c*, maxilla, all bristles not shown; *d*, 5th limb, hairs not shown on all epipodial bristles; *e*, endites and exopodite of 5th limb, all bristles not shown; *f*, 6th limb; *g*, 7th limb (1 bristle in distal group broken); *h*, distal end of 7th limb; *i*, frontal organ and median eye; *j*, lateral view of right furcal lamella; *k*, copulatory organ; *l*, detail of distal tip of copulatory organ; *m*, lateral eye. (Same scale, in microns: *a, e, h, l*; *b, f, i, m*; *c, g*; *d, j, k*.)

long bristles with wreaths of long hairs and short spines distally. Dorsal margin with 3 bristles, 1 near middle and 2 subterminally. Medial surface with about 5 short bristles proximally near ventral corner and 1 longer bristle near ventral margin at middle of joint. Exopodite reaching middle of 1st endopodite joint, with 2 subequal terminal bristles with short marginal spines (fig. 3*a*); tip of joint with blunt hirsute process bearing short spine. Endopodite: First joint (fig. 2*j*) with 1 short spinous bristle and 3 long hirsute posterior bristles distally. Second joint (fig. 2*k*) anterior margin with proximal group of 3 bristles and distal group of 5 bristles, all bristles bare or with short spines; posterior margin with 2 spinous bristles distal and 1 short annulated bristle and 2 clawlike bristles subterminally. End joint (fig. 2*l*) with 2 large subequal claws, 1 short anterior claw, and 3 annulated bristles. Medial surface of basale and 1st and 2nd joints of endopodite provided with groups of hairs.

Maxilla (fig. 3*c*): Very small. It seems to have a structure typical of the genus, but because of its size I have not attempted to describe it fully.

Fifth limb (figs. 3*d, e*): Epipodial appendage with about 47 plumose bristles. Outer lobe of 3rd exopodite joint with 2 stout plumose bristles.

Sixth limb (fig. 3*f*): First endite with 3 bristles, 2nd endite with 4 bristles, 3rd endite with 6 bristles, 4th endite with 6 bristles, 2nd joint of exopodite with 14 bristles, joint not produced posteriorly; epipodial appendage represented by 2 short bare bristles. Surface of second joint of exopodite with clusters of short hairs.

Seventh limb (figs. 3*g, h*): Cleaning bristles: 4 in distal group, each with 4 or 5 bells; 3 in proximal group, each with 1 to 3 bells; surface hairs not observed on bristles. Terminal comb with about 7 marginal teeth, some with marginal spines. Two long curved pegs opposing comb.

Copulatory organ (figs. 3*k, l*): Long, slender, divided into 3 lobes, each with 2 annulated bristles; 1 lobe with large curved sclerotized tip.

Furca (fig. 3*j*): Each lamella with 12 to 13 claws: primary claws number 1, 2, 6, 10; secondary claws 3, 4, 5, 7, 8, 9, 11, 12, 13 (13th claw not always present). Primary claws 1 and 2 separated from lamella, 6 and 10 joined to lamella; secondary claws all separated from lamella; all claws with double row of spines. Primary claws decrease in length proximally on lamella. Lamella near claws 1 and 2 with clusters of long hairs. (One specimen has 13 claws on each lamella, another specimen has 13 claws on the right lamella and only 12 on the left lamella.)

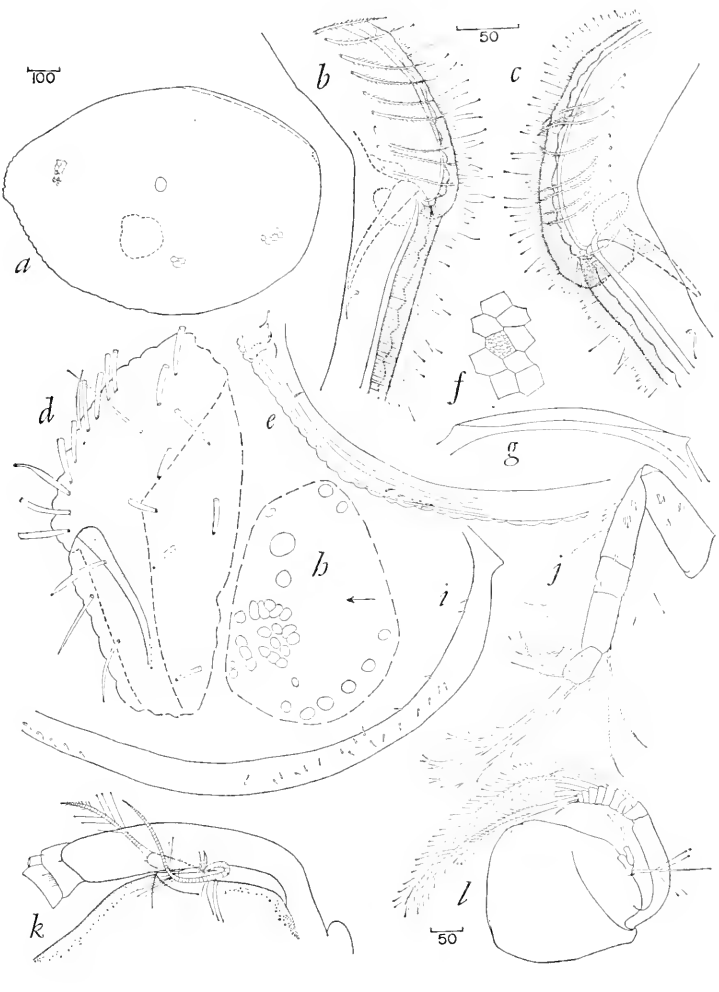


FIGURE 4.—*Euphilomedes polae*, female, specimen 2 (except *a–d*, *j–l*, spec. 1): *a*, lateral view left valve, dashed area near valve middle contains adductor muscle scars, not all surface polygons shown; *b*, medial view of anterior end of left valve, sclerotized areas stippled; *c*, medial view anterior of right valve, sclerotized areas stippled; *d*, lateral view of anterior end of left valve showing surface and marginal hairs; *e*, medial view of antero-ventral margin of right valve showing distribution of hairs on inner lamella; *f*, medial view of valve near posterior showing large and small reticulations; *g*, medial view hinge element of right valve (anterior end on right); *h*, medial view of muscle scars on right valves, adductor muscle scars clustered at lower left of figure, anterior of valve to left; *i*, medial view of posterior and ventral marginal area of right valve showing distribution of hairs on inner lamella; *j*, lateral view of left 1st antenna; *k*, lateral view of endopodite, first 3 joints of exopodite and distal margin of protopodite of left 2nd antenna; *l*, medial view of right 2nd antenna, ends of some bristles of exopodite not shown. (Same scale, in microns: *b–d, f, k*; *e, g–j, l*.)

Eyes: Lateral eyes large; about 19 ommatophores visible in side view, all except 2 divided by a suture into 2 parts (fig. 3*m*). Medial eye large, pigmented (fig. 3*i*).

Frontal organ (fig. 3*i*): Elongate, 2-jointed with short spines on distal half of 2nd joint and subterminally on basal joint.

Description of female.—Shell (figs. 4*a–i*): lateral outline more ovoid than male (fig. 4*a*); hinge structure (fig. 4*g*) selvage similar to male; adductor muscle scars (figs. 4*a,h*) more anteriorly and ventrally located on shell than on male; rostrum narrower and incisure shallower than on male; irregular polygons on surface of shell subdivided by minute polygons larger than on male shell and visible under low magnification (fig. 4*f*). Inner lamella with parallel striations on anteroventral part; 9 long hairs with secondary spines forming row on inner lamella behind rostrum (figs. 4*b,c*); inner lamella below rostral incisure with small hair followed by wide space and then 5 hairs (fig. 4*e*); posteroventral part of inner lamella with at least 21 hairs (fig. 4*i*); lateral surface of rostrum and anterior part of shell with numerous hairs with blunt ends (fig. 4*d*).

Dimensions: Specimen no. 1 greatest length 1.06 mm, greatest height 0.86 mm; specimen no. 2 greatest length 1.03 mm, greatest height 0.73 mm. Graf (1931, p. 38) gives length as 0.90 mm and 1.00 mm and height as 0.70 mm.

First antenna (fig. 4*j*): First and 2nd joints with surface hairs. Second joint with 3 bristles, 1 dorsal, 1 ventral, and 1 lateral. Third joint with 1 ventral bristle distally and 1 short bare bristle and 1 long hirsute bristle on dorsal margin; ventral margin with short spines. Fourth joint with 2 dorsal subterminal bristles and 1 short and 3 long ventral subterminal bristles; ventral margin with short spines. Fifth joint with stout ventral terminal bristle with filaments. Sixth joint with medial bristle distally. End joints with 1 short bristle and 2 long bristles without filaments and 4 long bristles with filaments.

Second antenna (figs. 4*k, l*): Protopodite subtriangular without transparent rim. Exopodite (fig. 4*l*) with 9 joints; 1st joint elongate with small medial spine; 2nd to 9th joints trapezoidal without basal spines; distal margins of 2nd to 5th joints with comb of slender spines; 2nd and 3rd joints with bristles without natatory hairs or marginal denticulations; 4th to 8th joints with bristles having natatory hairs and marginal denticulations; 9th joint with 2 short bare bristles and 2 subequal long bristles with natatory hairs and marginal denticulations. Endopodite (figs. 4*k,l*) with 2 joints; basal joint with long stout bristle with wreath of long hairs near middle, and 3 to 5 short bare bristles; distal joint elongate with small spine at tip and long stout terminal bristle with wreaths of long hairs near middle and short distal spines.

FIGURE 5.—*Euphilomedes polae*, female, specimen 1: *a*, medial view right mandible (surface hairs not shown); *b*, lateral view left maxilla, all bristles not shown; *c*, posterior view left 5th limb; *d*, medial view right 6th limb; *e*, 7th limb; *f*, distal end of 7th limb; *g*, distal end frontal organ; *h*, frontal organ and medial eye; *i*, medial view right lamella of furca; *j*, lateral view left lamella of furca. (Same scale, in microns: *b,d,e,h–j*; *c,f,g*.)

Mandible (fig. 5*a*): Coxale endite large, bifurcate, with rows of spines. Basale: ventral margin with 4 short bristles followed by 1 longer bristle near distal end; dorsal margin with 3 bristles, 1 near middle and 2 at distal end; medial surface with 1 bristle at middle and 5 shorter bristles proximally, all near ventral margin. Exopodite short with 2 bristles and triangular process at tip, inner bristle with wreath of long hairs near middle. Endopodite: distal end of 1st joint with 1 short and 3 long bristles ventrally; anterior margin of 2nd joint with proximal group of 4 and distal group of 5 bristles; posterior margin with 2 subterminal bristles and terminally with 1 short annulate bristle and 2 clawlike bristles; distal joint with 2 long stout claws of subequal length and 3 bristles. Surface of basale and 2nd joint of exopodite hirsute.

Maxilla (fig. 5*b*): Precoxa and coxa with fringe of fine hair along dorsal margin; coxa with short bare bristle on dorsal margin; basale with 3 distal bristles; 1st endopodite joint with marginal hairs, a hirsute bristle terminal on anterior margin and about 5 bristles on distal margin; distal end of endopodite joint provided with numerous bristles; exopodite with 2 long and 1 short bristle. Three endites: 1st endite with about 8 bristles; 2nd endite with about 4 bristles; 3rd endite with about 6 distal and 1 proximal bristle (bristles not shown in illustration).

Fifth limb (fig. 5*c*): Epipodial appendage with about 49 bristles. Triangular tooth anterior to main tooth of 1st exopodite joint about same size as distal tip of 2nd exopodite joint. Distal anterior margin of 1st joint with 2 centrally located bristles. Large curved tooth of 2nd exopodite joint without bristle at distal lateral corner.

Sixth limb (fig. 5*d*): First endite with 3 bristles; 2nd endite with 4 bristles; 3rd endite with 7 bristles; 4th endite with 6 bristles; epipodial appendage represented by 2 short bristles. Second joint of exopodite not produced posteriorly, distal margin with 13 to 14 bristles, medial and lateral surfaces hirsute.

Seventh limb (figs. 5*e,f*): Five cleaning bristles in distal group, 3 in proximal group, each bristle with 1 to 5 terminal bells. Terminal comb with about 9 teeth, secondary teeth at base (all teeth not shown in illustration); 2 elongate pegs opposing comb.

Furca (figs. 5*i,j*): Each lamella with 4 primary claws and 10 to 12 secondary claws. Primary claws 1 and 2 separated from lamella, 7 and 12 (or 11) joined to lamella. Primary claws decrease in length proximally on lamella. Secondary claws 3 to 6 about same length, shorter than claw 7, longer than claw 8; claws 8 to 12 (or 11) decrease in size proximally. Primary claw 12 (or 11) about same size or longer than preceding secondary claw and longer than following secondary claw. Lamella near basis of claws with long hairs. Primary claws 1 and 2 with double row of teeth, claws 7 and 12 without teeth; secondary claws with marginal spines. Distribution of primary and secondary furcal claws on 2 specimens is as follows:

claw number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
specimen 1																
right	p	p	s	s	s	s	p	s	s	s	s	p	s	s	s	s
left	p	p	s	s	s	s	p	s	s	s	p	s	s	s		
specimen 2																
right	p	p	s	s	s	s	p	s	s	s	s	p	s	s	s	
left	p	p	s	s	s	s	p	s	s	s	s	p	s	s		

Eyes: Large medial eye (fig. 5*h*); lateral eyes not observed.

Frontal organ (figs. 5*g,h*): 2-jointed with distal joint 3 times length of proximal joint; tip rounded; surface of 2nd joint and distal end of 1st joint with fine spines.

Remarks.—Extreme sexual dimorphism among some species of ostracods creates inherent difficulties in relating males and females with certainty. Carapace morphology in the region of the rostrum and rostral incisure between males and females of *Euphilomedes polae* identified herein is sufficiently similar to warrant considering them as conspecific in spite of some differences in appendage morphology. Both males and females were collected in the same area. The male and female of *E. arostratus* Kornicker, a closely related species, have similar dimorphism.

Some differences in morphology between males and females of *E. polae* and *E. arostratus* are compared as follows:

	E. polae		*E. arostratus*	
	male	female	male	female
number of secondary furcal claws	8–9	10–12	7	9
cleaning bristles in distal group of 7th limb	4	5	4	5
number of hairs in row on inner lamella behind rostrum	6	9	9–11*	11

*The male of *E. arostratus* described from the Maldive Islands (Kornicker, 1967) has 9 to 10 hairs, whereas the Red Sea form described in this paper has 11.

Comparisons.—*Euphilomedes polae* is closely related to *E. arostratus* Kornicker but may be differentiated from that species by the shallower rostral incisure with a lateral shield, the subterminal location of bristles on the 2nd joint of the endopodite of the 2nd antenna of the male, and the lower number of bristles on the anteroventral part of the inner lamella of the carapace: 5 compared to 16–21 on *E. arostratus*.

***Euphilomedes arostratus* Kornicker, 1967**

FIGURE 6

Euphilomedes arostrata Kornicker, 1967, p. 2.

HOLOTYPE.—USNM 112658. Sex: female. Male Atoll, Maldive Islands, Indian Ocean.

LOCALITY.—Gulf of Suez, Red Sea. Specimen probably from Station 90 but could be from Station 89. Data concerning the stations is given under "Type-locality" of *E. polae.* This specimen was in vial containing specimens identified as *Philomedes polae* by Dr. Herbert Graf.

DESCRIPTION OF MALE.—Shell (figs. 6*a–e, h*): oval, elongate with greatest height near middle, prominent rostrum and antennal sinus (figs. 6*a, b, e*); anterior margin of rostrum and anteroventral margin of shell with scalloped outline formed by crescent-like marginal denticulations. Surface of valves with distinct irregular polygons (fig. 6*h*); polygons with pebbly texture appearing as minute polygons under high magnification. Posterior dorsal margin with linear hinge depressed below outline of shell; posterior hinge element of each valve consisting of angular sclerotized process; medial hinge element straight; anterior hinge element not prominent. Left valve broadly overlapping right valve along anterodorsal margin. Numerous adductor muscle scars (partly obscured by muscles in specimen examined) clustered behind and below middle of valve; 2 small scars and large oval hyaline spot situated some distance above other; additional scars below anterior hinge element (fig. 6*h*). Inner lamella broad with vestibule; selvage with wide, corrugated lamellar prolongation having fringe of slender spines along outer margin. Eleven long hairs with a few secondary spines forming row on inner lamella behind rostrum (fig. 6*b*); inner lamella below rostrum with small hair followed by wide space and then 20 hairs on right valve and 21 on left valve (figs. 6*c, d*); about 34 hairs on posteroventral part of inner lamella. Hair with either pointed or blunt ends distributed on rostral surface, some forming row near margin of shell; slender hairs with pointed ends on posterior surface of shell, some forming row near posterior margin; a long tapered hair projecting from base immediately behind posterior hinge element of each valve.

Dimensions: Greatest length 1.23 mm, greatest height 0.73 mm. Specimen is larger than male reported by Kornicker (1967) from the Maldives, length 1.00 mm, height 0.60 mm.

First antenna: First joint with medial hairs. Second joint with medial hairs and, distally, a dorsal, ventral, and lateral bristle, all bristles bare or with short hairs distally. Third joint with few medial hairs and 1 ventral and 2 dorsal bristles, all with short hairs, the

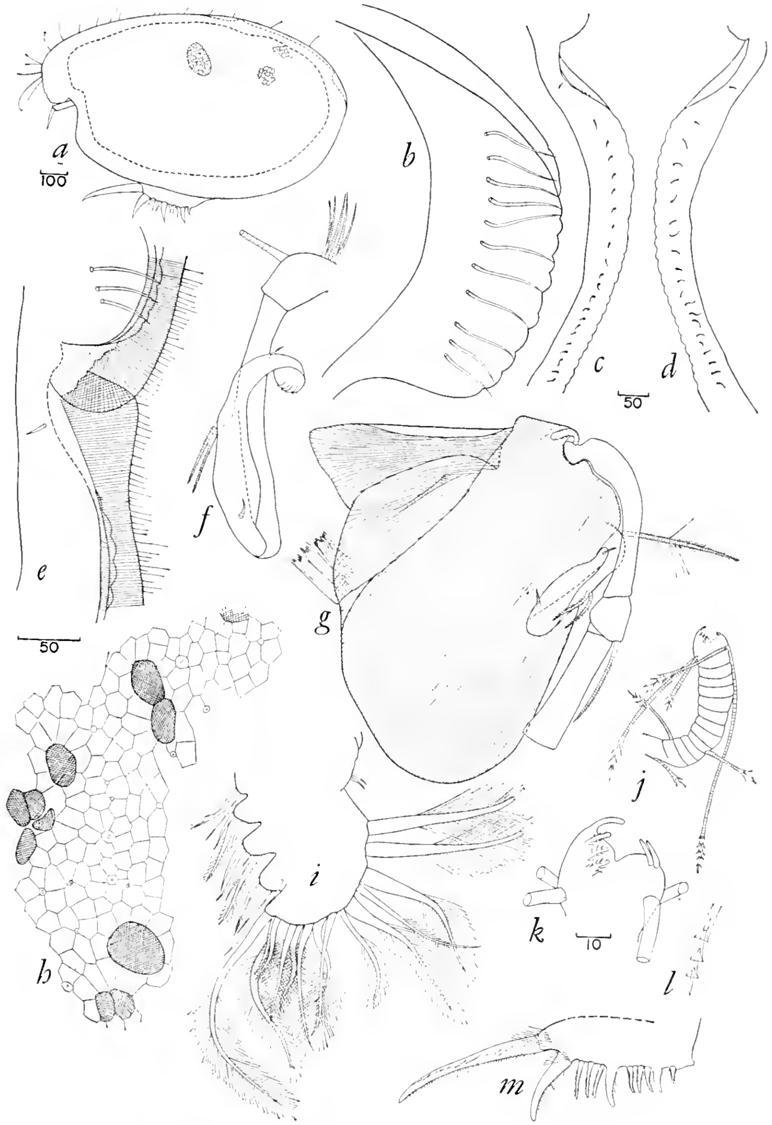


FIGURE 6.—*Euphilomedes arostratus*, male, specimen A: *a*, lateral view of complete carapace showing position of lateral eye and some reticulations; *b*, medial view rostrum left valve; *c*, medial view of anteroventral margin of left valve; *d*, medial view of anteroventral of margin of right valve; *e*, medial view of antennal sinus area of left valve; *f*, endopodite of left 2nd antenna; *g*, lateral view protopodite, endopodite, and 1st 3 joints of exopodite of 2nd antenna; *h*, medial view of reticulations, normal pores, and muscle scars (cross-hatched) located dorsal to adductor muscle scars on left valve, anterior to right, upper scars are located below anterior hinge element; *i*, medial view right 6th limb (surface hairs not shown); *j*, distal part of 7th limb; *k*, distal tip of 7th limb; *l*, detail of distal end of bristle of 7th limb; *m*, lateral view left caudal lamella. (Same scale, in microns: *b,e,f,h–j*; *c,d,g,m*; *k,l*.)

longer dorsal bristle also provided with wreaths of long hairs near middle. Fourth joint with 2 dorsal bristles, each with wreaths of long hairs, and 4 long ventral bristles subdistally; bristles bare or with short hairs distally. Fifth joint, inferred to be inserted ventrally between 4th and 6th joints, bearing sensory bristle with broad base and numerous filaments. Sixth joint with single dorsal bristle distally having short spines. End joint with 1 short dorsal bristle with short spines, 2 slender bristles with filaments, 2 bristles with filaments, and usual long, stout c- and f-bristles.

Second antenna (figs. 6*f,g*): Protopodite triangular without transparent rim (fig. 6*g*). Exopodite: first joint elongate; 2nd joint about ¼ length of 1st; 3rd joint about ⅔ length of 1st; distal margins of joints 2–8 with comb of short spines; basal spines not observed. First joint without bristle; bristle of 2nd joint about ¾ length of 3rd joint (fig. 6*g*), bearing short marginal spines. Bristles of joints 3–8 bearing natatory hairs, without marginal spines. End joint with 4 stout bristles with natatory hairs and 2 short slender bristles without hairs. Endopodite (fig. 6*f*) 3-jointed; 1st joint with 5 bare short bristles and 1 long distal bristle with wreaths of long hairs near middle and short spines distally; 2nd joint elongate, with 2 bristles near middle, bristles provided with short spines; 3rd elongate with 1 proximal and 1 distal short bristle, tip with serrated ridges (tip of appendage partly obscured with the result that presence or absence of spine at tip could not be ascertained).

Mandible: No coxale endite observed. Basale: ventral margin with 4 short slender bristles and 2 long bristles with wreaths of long hairs and short spines distally. Dorsal margin with 3 bristles. Medial surface with about 5 short bristles proximally near ventral corner and 1 longer bristle near ventral margin at middle of joint. Exopodite reaching middle of 1st endopodite joint, with 2 subequal terminal bristles; tip of joint with blunt hirsute process. Endopodite: first joint with 1 short and 3 long ventral bristles distally. Second joint of anterior margin with proximal group of 3 and distal group of 5 bristles; posterior margin with 2 distal spinous bristles and 1 short annulated bristle and 2 clawlike subterminal bristles. End joint with 2 large subequal claws, 1 short posterior claw, and 3 annulated bristles. Medial surface of basale and 1st and 2nd joints of endopodite provided with groups of hairs.

Maxilla: Very small. It seems to have a structure typical of the genus, but because of its small size I have not attempted to describe it fully.

Fifth limb: Epipodial appendage with 45 plumose bristles. Outer lobe of 3rd exopodite joint with 2 stout plumose bristles.

Sixth limb (fig. 6*i*): First endite with 3 bristles, 2nd endite with 4 bristles, 3rd endite with 7 bristles; 2nd joint of exopodite with 14 or 15 bristles, joint not produced posteriorly; epipodial appendage represented by 2 short bare bristles. Surface of 2nd joint of exopodite with clusters of short hairs (not shown on illustration).

Seventh limb (figs. 6*j–l*): Cleaning bristles: 4 in distal group, each with 2 to 4 bells; 3 proximal bristles, each with 1 to 3 bells; some bristles with short marginal spines. Terminal comb with about 7 marginal teeth, some with spines. Two long curved pegs opposing comb.

Copulatory organ: Long slender, divided into 3 lobes with bristles.

Furca (fig. 6*m*): Each lamella with 11 claws: primary claws number 1, 2, 6, 10; secondary claws 3, 4, 5, 7, 8, 9, 11. Primary claws 1 and 2 and all secondary claws separated from lamella; all claws with double row of spines. Primary claws decrease in length proximally on lamella. Lamella near claws 1 and 2 with clusters of long hairs.

Frontal organ: Elongate, 2-jointed with short spines on surface of end joint and distal end of basal joint.

REMARKS.—Although I have identified the Red Sea specimen as *Euphilomedes arostratus*, some differences between this form and that described from the Maldive Islands (Kornicker, 1967) creates doubt concerning their conspecificity. A difference of possible significance is that the Red Sea form has 2 bristles in place of the epipodial appendage on the 6th limb as contrasted to 3 in this position on the male of *E. arostratus* described from the Maldives. The female of *E. arostratus* from the Maldives, however, has only 2 bristles, suggesting that the species may have either 2 or 3 epipodial bristles. Also, whereas the male of *E. arostratus* from the Maldives has 9 to 10 bristles on the inner lamella behind the rostrum, the Red Sea form has 11, the same number as the female from the Maldives. This suggests that the number of bristles in this position might vary from 9 to 11 for the species. The Red Sea specimen is also larger than the Maldive form. In most characters, the Red Sea and Maldive Island forms are so similar that it seems best at this time to include them in the same species.

Literature Cited

Baird, W.

1850. The natural history of the British Entomostraca, 364 pp., 36 pls. [Ostracoda: pp. 138–182, pls. 18–23.]

Graf, H.

1931. Expedition S.M.S. "Pola" in das Rote Meer: Die Cypridinidae des Roten Meeres. Denkschr. Akad. Wiss. Wiener Math. Naturw. Klasse, vol. 102, pp. 32–46, figs. 1–10.

Kornicker, L. S.

1967. *Euphilomedes arostrata*, a new myodocopid ostracod from the Maldive Islands, Indian Ocean. Proc. U.S. Nat. Mus., vol. 120, no. 3563, pp. 1–21.

Müller, G. W.

1912. Ostracoda. Pt. 31 *in* Das Tierreich, 434 pp., 92 figs.

Poulsen, E. M.

1962. Cypridiniformes-cypridinidae. Pt. 1 *in* Ostracoda-Myodocopa, 414 pp. [Dana-Report No. 57.]

U.S. GOVERNMENT PRINTING OFFICE: 1967

Proceedings of the United States National Museum

SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 121 1967 Number 3572

CALIGOID COPEPODS PARASITIC ON SHARKS OF THE INDIAN OCEAN

By ROGER F. CRESSEY
Associate Curator, Division of Crustacea

During the International Indian Ocean Expedition, 35 species of caligoid copepods were collected from 29 species of sharks. The author collected during Cruise 5 of the R.V. *Anton Bruun* and also at Nosy Bè, Madagascar (Malagasy Republic). In addition, several other participants collected copepods and donated the material to the author for inclusion in this study.

Of the 35 species of copepods collected, 8 of them were new. Four of these new species, all members of the Eudactylinidae, are described here. Two of the others represented new genera (*Pagina* and *Bariaka*) and each has been described separately elsewhere. The remaining 2 new species are members of the Pandaridae and are being described in a paper currently in press revising the entire family.

A map of the Indian Ocean showing points of collection is included (fig. 54). All station numbers refer to points on the various cruise tracks of the R.V. *Anton Bruun*. In text tabulations, Roman numerals refer to spines, Arabic to setae.

I would like to thank the following persons for their efforts on my behalf: Dr. Richard Gooding, University of Singapore; Miss Sherril

Kite, Woods Hole Oceanographic Institution; Dr. Alan Lewis, University of British Columbia; Mr. Richard Shomura, Bureau of Commercial Fisheries; Dr. Marta Vannucci, University of São Paulo; and Miss Leonie Joubert, University of Natal, who sent a number of collections from sharks caught near Durban, South Africa, that I have included in this paper.

I would like to acknowledge the support of the National Science Foundation-U.S. Program in Biology for the field portion of this work.

All material has been deposited in the U.S. National Museum.

Family Pandaridae Milne-Edwards, 1840

Pandarus cranchii Leach, 1819

Collections: From 22 specimens of *Carcharinus longimanus* (Poey) at stations 108, 109, 113, 118, 139, 141, 144, 147, 289, 291, 293, 295, 297, 298, 323, 326, 411, 415, 417, and 418; from 1 specimen of the same host off Durban, South Africa; from 4 specimens of *Carcharinus floridanus* (Bigelow and Schroeder) at stations 111, 289, 293, and 326; from 1 specimen of *Alopias vulpinus* at station 115; from 1 specimen of *Carcharodon carcharias* from Durban.

Habitat: Body surface and fins.

Pandarus smithii Rathbun, 1886

Collections: From 2 specimens of *Alopias vulpinus* (Bonneterre) at stations 288 and 289; from 1 specimen of *Isurus oxyrinchus* Rafinesque at station 282; from 1 specimen of *Carcharinus floridanus* at station 144.

Habitat: Body surface and fins.

Pandarus satyrus Dana, 1852

Collections: From 6 specimens of *Prionace glauca* (Linnaeus) at stations 124, 292, 295, 306, 311, and 324.

Habitat: Body surface and fins.

Pandarus carcharini Ho, 1963

Collections: From 3 specimens of *Carcharinus maculipinnis* (Poey) from Nosy Bé, Madagascar; from 2 specimens of *Carcharinus leucas* (Valenciennes) from Nosy Bé and 1 specimen of the same host from Durban.

Habitat: Body surface and fins.

Pandarus niger Kirtesinghe, 1950

Collections: From 10 specimens of *Carcharinus* species at stations 408 and 409; from 1 specimen of *Carcharinus spallanzani* (Boneparte) at station 407.

Habitat: Body surface and pectoral fins.

Pseudopandarus gracilis Kirtesinghe, 1950

Collections: From 1 specimen of *Scoliodon palasorrah* (Bleeker) from Nosy Bé; from 1 specimen of *Scoliodon* species at station 412.

Habitat: Body surface and fins.

Pseudopandarus longus (Gnanamuthu, 1951)

Collections: From 7 specimens of *Rhizoprionodon* species at station 402 (Beira Harbor); from 2 specimens of *Carcharinus tjutjot* at the same location; from 1 specimen of *Carcharinus obesus* and *Rhizoprionodon acutus* both from Durban.

Habitat: Body surface.

This copepod was originally assigned to the genus *Pandarus* by Gnanamuthu, but I have placed it in the genus *Pseudopandarus*. A discussion of this species together with my reasons for the change can be found in my paper (1966b) revising the Pandaridae.

Gangliopus pyriformis Gerstaecker, 1854

Collections: From 2 specimens of *Prionace glauca* at stations 292 and 295; from 3 specimens of *Alopias vulpinus* at stations 106, 109, and 115.

Habitat: Gill filaments.

Phyllothereus cornutus (Milne-Edwards, 1840)

Collections: From 2 specimens of *Prionace glauca* at stations 292 and 306.

Habitat: Gill filaments.

Perissopus dentatus Steenstrup and Lütken, 1861

Collections: From 1 specimen of *Carcharinus tjutjot* at station 402; from 1 specimen of *Mustelus* species, from 1 specimen of *Carcharinus obscurus*, from 1 specimen of *Carcharinus leucas*, all from Durban.

Habitat: Caudal fin and right clasper.

Echthrogaleus coleoptratus (Guerin, 1837)

Collections: From 5 specimens of *Prionace glauca* at stations 131, 132, 306, and 309; from 2 specimens of *Lamna* species (mackerel shark) at stations 132 and 309.

Habitat: Body surface.

Echthrogaleus denticulatus Smith, 1874

Collections: From 3 specimens of *Alopias vulpinus* at stations 106, 109, 110, 115, 288, and 289; from 2 specimens of *Isurus oxyrinchus* Rafinesque at stations 106, 108, 123, and 282.

Habitat: Body surface, sometimes in large clusters around vent of female.

Dinemoura latifolia (Steenstrup and Lütken, 1861)

Collections: From 2 specimens of *Isurus oxyrinchus* at stations 123, 139, 296, and 310; from 1 specimen of *Isurus glaucus* from Durban.

Habitat: Body surface.

Dinemoura species

Collections: From 2 specimens of *Alopias vulpinus* at stations 289 and 295; from 1 specimen of *Alopias superciliosus* (Lowe) at Nosy Bé and station 119.

Habitat: Ventral body surface.

This new species is described in detail in my paper (1967) revising the Pandaridae.

Pagina tunica Cressey, 1964

Collections: From 2 specimens of *Alopias superciliosus* from Nosy Bé and Majunga, Madagascar, and station 119.

Habitat: Body surface (usually ventral).

Nesippus orientalis Heller, 1868

Collections: From 6 specimens of *Carcharinus maculipinnis*, 4 specimens of *Sphyrna lewini* (Griffith), 3 specimens of *Carcharinus leucas*, 1 specimen of *Galcocerdo cuvier* (Peron and LeSueur), 1 specimen of *Rhizoprionodon acutus*, 1 specimen of *Scoliodon palasorrah*, all from Nosy Bé; from 1 specimen of *Sphyrna mokarran* (Rüppell) at station 409; from 1 specimen of *Sphyrna zygaena* (Linnaeus) from Durban; from 2 specimens of *Carcharodon carcharias* from Durban.

Habitat: Roof of mouth and gill arches.

Nesippus crypturus Heller, 1865

Collections: From 13 specimens of *Carcharinis maculipinnis*, 5 specimens of *Sphyrna lewini*, 5 specimens of *Carcharinus leucas*, 1 specimen of *Galeocerdo cuvier*, all from Nosy Bé; from 1 specimen of *Carcharinus longimanus* at station 291; from 1 specimen of *Carcharinus leucas* at station 409; from 1 specimen of *Sphyrna mokarran* at station 409; from 1 specimen of *Carcharinus* species (*floridanus*?) at station 412.

Habitat: Roof of mouth and gill arches.

Nesippus species

Collections: From 1 specimen of *Galeocerdo cuvier* from Nosy Bé; from 1 specimen of the same host caught off Comores Island (Zaudsi).

Habitat: Nasal cavities.

This new species is described in detail in my paper (1967) revising the Pandaridae.

Family Euryphoridae Wilson, 1905

Alebion gracilis Wilson, 1905

Collections: From 1 specimen of *Carcharinus albimarginatus* at station 400; from 1 specimen of *Carcharinus leucas* at station 409; from 1 specimen of *Carcharinus* species at station 381; from 1 specimen of *Carcharinus* species at station 412; from 1 specimen of *Galeocerdo cuvier* from Comores Island; from 1 specimen of *Carcharinus longimanus* at station 291; from 1 specimen of *Carcharinus obscurus* from Durban.

Habitat: Body surface and fins (dorsal surface usually).

Alebion alatus Gnanamuthu, 1951

Collection: From 1 specimen of *Carcharinus limbatus* from Nosy Bé.

Habitat: Body surface.

This copepod was originally described from a carcharinid shark of India and this new record is only the second record of this species.

Alebion elegans Capart, 1953

Collection: From 1 specimen of *Sphyrna mokarran* at station 409.

Habitat: Caudal fin.

This copepod has previously been reported from the west coast of Africa (Capart, 1953, and Vaissière, 1959). This record extends the known range to the east coast of Africa.

Paralebion elongatus Wilson, 1911

Collections: From 7 specimens of *Carcharinus leucas* from Nosy Bé; from 1 specimen of the same host from Durban.

Habitat: Mouth and gill arches.

This parasite is probably worldwide in its distribution. I have collections from the Atlantic and Pacific as well as the Indian Ocean. It is the only euryphorid that is routinely found in the mouth of the host.

Family Anthosomatidae Dana, 1853

Anthosoma crassum (Abildgaard, 1794)

Collection: From 1 specimen of *Isurus* species caught off East London, South Africa; from 1 specimen of *Isurus oxyrinchus* at station 139.

Habitat: Near base of teeth of the host.

This copepod has been reported many times and apparently is worldwide in distribution.

Family Eudactylinidae Yamaguti, 1963

Nemesis lamna Risso, 1826

Collections: From 2 specimens of *Isurus oxyrinchus* at stations 296 and 310; from 2 specimens of *Isurus* species and 1 specimen of *Carcharodon carcharias* from Durban.

Habitat: Gill filaments.

Nemesis versicolor Wilson, 1913

Collections: From 12 specimens of *Carcharinus maculipinnis* from Nosy Bé.

Habitat: Gill filaments.

Nemesis robusta (Beneden, 1851)

Collections: From 1 specimen of *Sphyrna mokarran* at station 409; from 2 specimens of *Sphyrna lewini* and 4 specimens of *Carcharinus leucas* from Nosy Bé.

Habitat: Gill filaments.

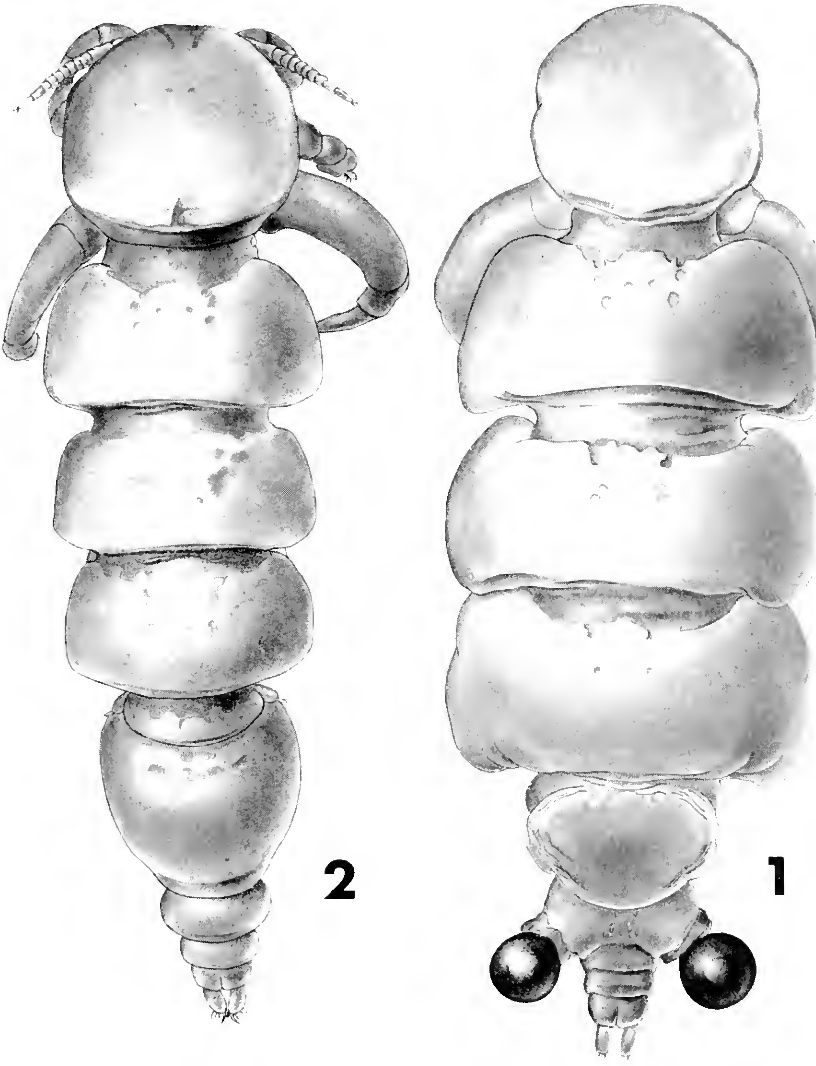
Nemesis aggregatus, new species

Figures 1, 2, 6–20

Collections: From 5 specimens of *Alopias vulpinus* at stations 109, 110, 115, 288, and 289. Material from station 288 designated as types. Holotype, female, USNM 113291. Allotype, male, USNM 113292. Paratypes female and male USNM 113293.

Female.—Body form as in figure 1. Total length 4.5 mm. Greatest width 1.5 mm. Cephalon slightly longer than wide (1.3 by 1.2 mm), comprising nearly one-third of body length. First pedigerous segment (2nd thoracic segment) fused with head. Thoracic segments 3–5 free, about equal in length (0.85 mm). Thoracic segment bearing leg 5 free, not combined to form genital segment (fig. 6). Genital segment wider than long (0.7 by 0.4 mm), often with spermatophores attached at posterior corners (fig. 6). Abdomen 3-segmented, segments measuring 140μ, 103μ, and 140μ respectively. Caudal rami (fig. 7) about twice as long as wide (85μ by 40μ), each with 6 posterior setae. All setae of about equal length, 2 broad and blunt as in figure.

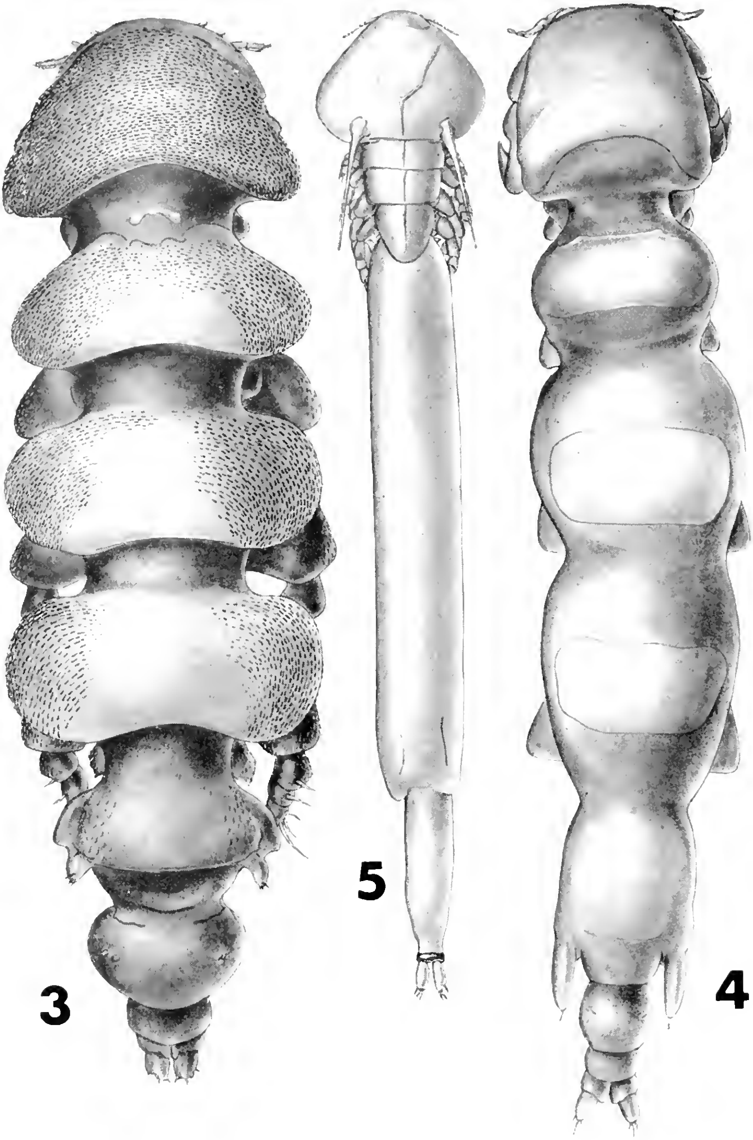
First antenna (fig. 8) of 12 segments, bearing short setae. Second antenna (fig. 9) in form of claw, terminal segment with 2 short setae. Second segment with patch of 10–12 short, broad, spinules on inner surface. Mouth tube and mandible as in other members of genus. First maxilla (fig. 10) biramose, each ramus with 2 terminal setae. Second maxilla, in general, as in other members of genus. Tip armed as in figure 11. Maxilliped (fig. 12) in form of stout claw.



2

1

FIGURES 1–2.—*Nemesis aggregatus*, new species, dorsal view: 1, female; 2, male.

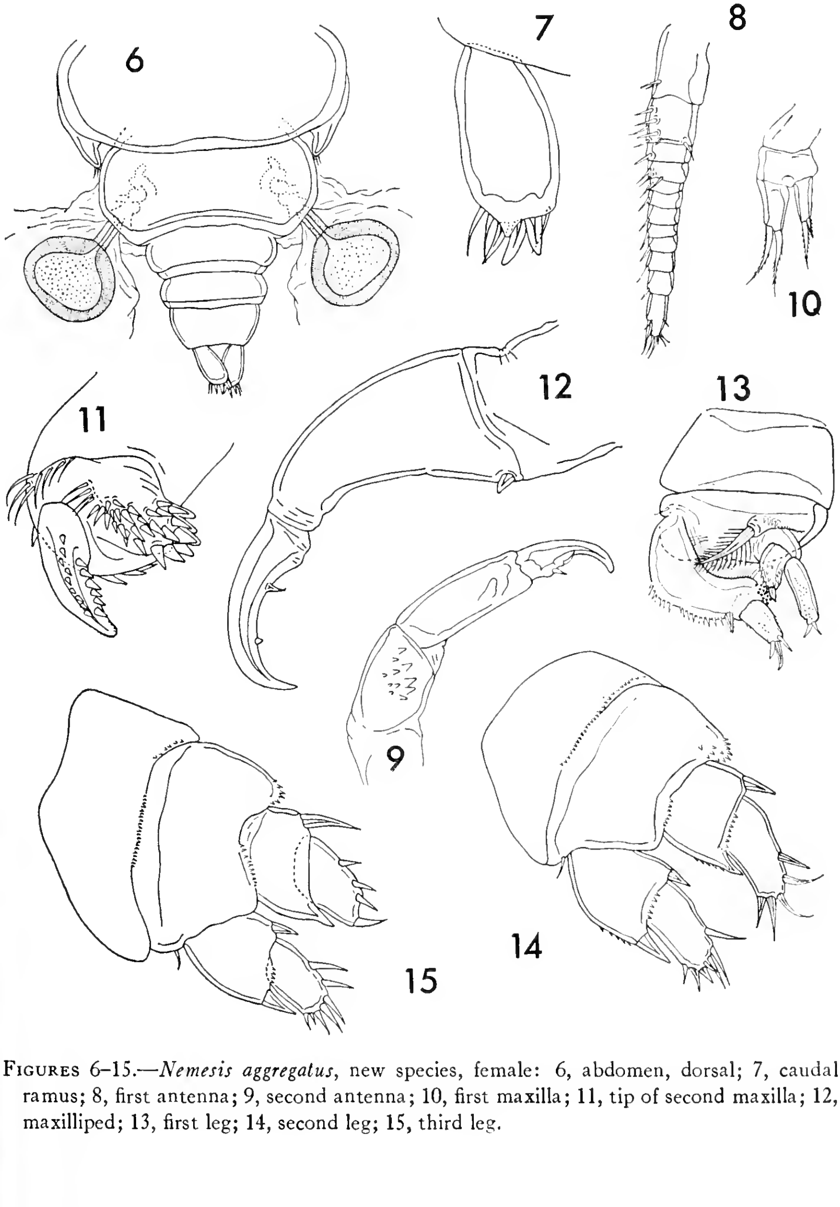


FIGURES 3–5.—*Eudactylina pusilla*, new species: 3, dorsal view, female. *Eudactylina pollex*, new species: 4, dorsal view, female. *Kroyeria gemursa*, new species: 5, dorsal view, female.

Legs 1–4 (figs. 13–16) biramose, all rami 2-segmented. Spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exo.	end.	exo.	end.	exo.	end.	exo.	end.
seg. 1	I:0	0:I	I:I	0:I	I:I	0:I	I:I	0:I
seg. 2	III	II	VII	V	VII	IV	VIII	IV

Leg 1 with endopod turned so that inner edge faces exopod. First segment of exopod curved toward endopod forming chela-like struc-



Figures 6–15.—*Nemesis aggregatus*, new species, female: 6, abdomen, dorsal; 7, caudal ramus; 8, first antenna; 9, second antenna; 10, first maxilla; 11, tip of second maxilla; 12, maxilliped; 13, first leg; 14, second leg; 15, third leg.

ture. Legs 2–4 with rows of spinules as indicated in figures. Leg 5 (see fig. 6) a lobe on posterior corner of thoracic segment 5 bearing 3 short setae. Leg 6 absent.

Egg strings uniseriate, long.

MALE.—Body form as in figure 2. Total length 4.0 mm. Greatest width 1.0 mm. Genital segment as long as wide (0.8 mm). Configuration of body otherwise as in female. Caudal rami as in female.

Oral area and cephalic appendages as in female.

Legs 1–4 biramose. All rami 2-segmented. Spine and setal formula as follows:

	leg 1 exo.	*leg 1* end.	*leg 2* exo.	*leg 2* end.	*leg 3* exo.	*leg 3* end.	*leg 4* exo.	*leg 4* end.
seg. 1	I:0	0:I	I:1	0:1	I:1	0:1	I:1	0:1
seg. 2	III	II	IV:3	6	III:4	5	III:5	5

Legs 2–4 (figs 17, 18, and 19) armed as in figures. Terminal endopod segment of leg 3 bearing a modified seta as shown in figure 18. Terminal endopod segment of leg 4 also with modified seta but differing from that of leg 3 (compare figs. 18 and 19). Leg 5 a lobe with 3 setae along distal border and 1 seta near base of lobe. Segment bearing leg 5 small and inconspicuous. Leg 6 (fig. 20) a broad lobe on ventrodistal corner of genital segment bearing 3 setae, innermost twice as long as outer 2.

REMARKS.—This species differs from *N. pallida* Wilson, *N. vermi* Scott, *N. robusta* (van Beneden), *N. atlantica* Wilson, *N. pilosa* Pearse, and *N. macrocephalus* Shiino by the nature of the spinules on segment 2 of the second antenna. In *N. aggregatus* there is a patch of 10–12 prominent spinules on this segment whereas in the above-mentioned species this patch is composed of 25–40 small spinules. *Nemesis tiburo* and *N. versicolor* differ from *N. aggregatus* in the presence of a row of fine spinules on segment 3 of second antenna in addition to those on segment 2.

Habitat: The parasites were found attached to the free end of each gill filament nearest to the gill slit. The tissue at the site of attachment was swollen and pale in color (normally red). Each gill filament could carry as many as 8 copepods on its tip.

The name *aggregatus* from Latin, meaning "clustered or united," refers to the appearance of the species.

Eudactylina aspera Heller, 1865

Collections: From 8 specimens of *Carcharinus maculipinnis;* from 2 specimens of *Rhizoprionodon acutus;* from 1 specimen of *Sphyrna lewini;* all from Nosy Bé.

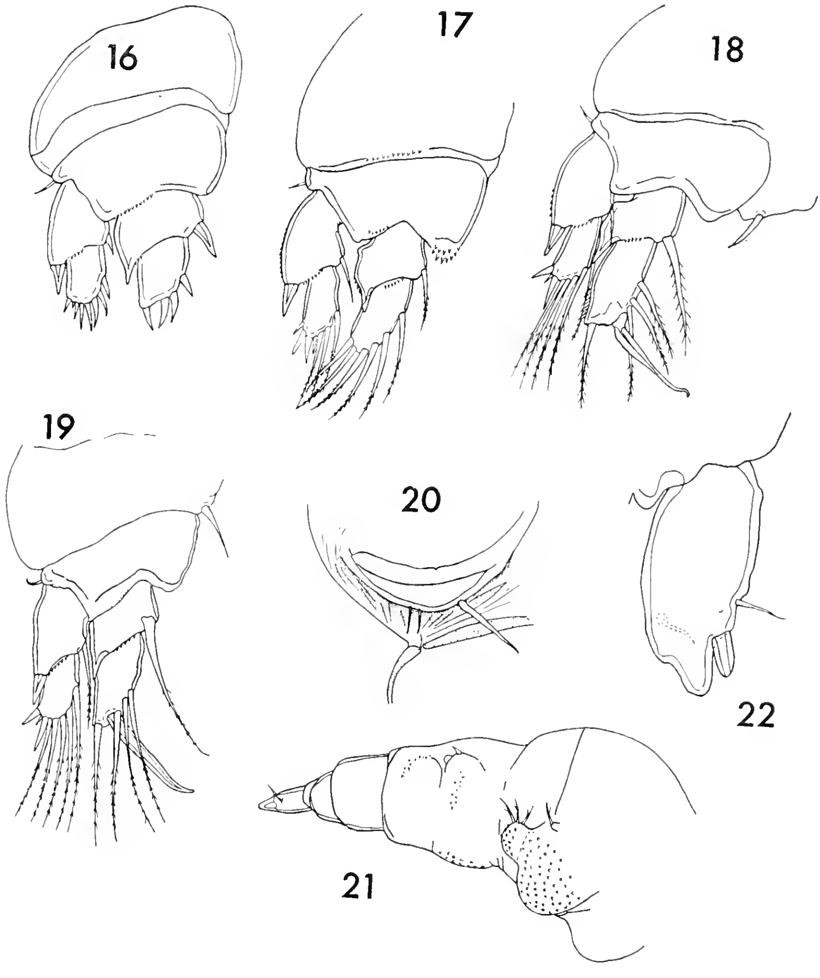
Habitat: Gill filaments.

Eudactylina pusilla, new species

FIGURES 3, 21–30

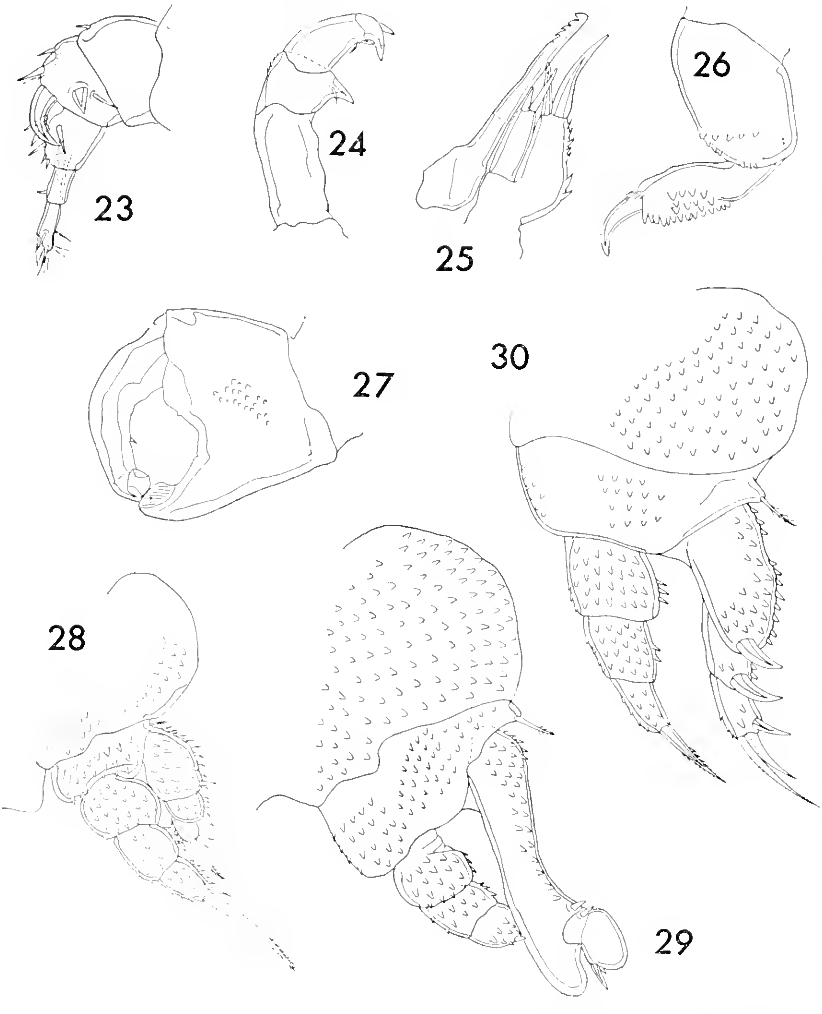
Collection: 3 females from 1 specimen of *Galeocerdo cuvier* from Nosy Bé. Holotype USNM 113299. Paratype USNM 113300. One specimen dissected for study.

FEMALE.—Body form as in figure 3. Dorsal surface of body covered with broad spinules. Total length 4.6 mm. Greatest width 1.3 mm. Cephalon wider than long (1.3 by 0.8 mm), widest posterolaterally. First pedigerous thoracic segment fused with head.



FIGURES 16–22.—*Nemesis aggregatus*, new species, male: 16, fourth leg; female: 17, second leg; 18, third leg; 19, fourth leg; 20, sixth leg. *Eudactylina pusilla*, new species, female: 21, abdomen and genital segment, lateral; 22, caudal ramus.

Thoracic segments 3–5 free. Thoracic segment bearing leg 5 free, not combined to form genital segment. Genital segment (fig. 21) somewhat wider than long (0.8 by 0.7 mm). Abdomen 2-segmented. Caudal ramus (fig. 22) terminating in blunt process with accessory spine and 2 subterminal setae.



FIGURES 23–30.—*Eudactylina pusilla*, new species, female: 23, first antenna; 24, second antenna; 25, mandible and first maxilla; 26, second maxilla; 27, maxilliped; 28, first leg; 29, second leg; 30, fourth leg.

First antenna (fig. 23) 5-segmented, second segment with stout clawlike spine on outer distal corner. Other segments armed as in figure. Second antenna (fig. 24) 3-segmented, second segment with sclerotized process on inner border. Terminal segment with clawlike spine at tip. Mandible and first maxilla (fig. 25) as in other members of genus. Mandible with 5 terminal teeth. Second maxilla (fig. 26) with terminal claw, segment bearing claw with patch of prominent spinules. Maxilliped (fig. 27) chelate, tip of movable process bearing broad scalelike spine opposed by process on preceding segment.

Legs 1–4 biramose, covered with stout spinules. Spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exo.	end.	exo.	end.	exo.	end.	exo.	end.
seg. 1	I:0	0:0	I:0	0:0	I:0	0:0	I:0	0:0
seg. 2	I:0	0:0	I:0	0:0	I:0	0:0	I:0	0:0
seg. 3	3	2	II	I	III	1	III	1

Leg 1 (fig. 28) with 1 long and 1 short seta at tip. Outer edges of segments on exopod and endopod with rows of pointed spines as in figure. Leg 2 (fig. 29) exopod elongate as in figure, terminal exopod segment bearing 2 short inner spines. Second exopod segment reduced. First exopod segment with prominent lobe on inner distal corner. Endopod without spines and setae except for very small spine at tip. Leg 3 (fig. 30) exopod with well-developed spines on outer corners of segments. Endopod unarmed except for terminal seta. Leg 4 same as leg 3. Leg 5 (see fig. 21) broad lobe with 3 distal setae and 1 basal seta. Lobe covered with spinules. Leg 6 (see fig. 21) reduced to single short spine on genital segment at area of egg string attachment.

Egg strings uniseriate.

Male.—Unknown.

Remarks.—This species can be distinguished from all other members of the genus by the prominent lobe on the inner distal corner of the first exopod segment of leg 2. It is further characterized by the conspicuous spinules on the rami of legs 1–5.

Habitat: Gill filaments.

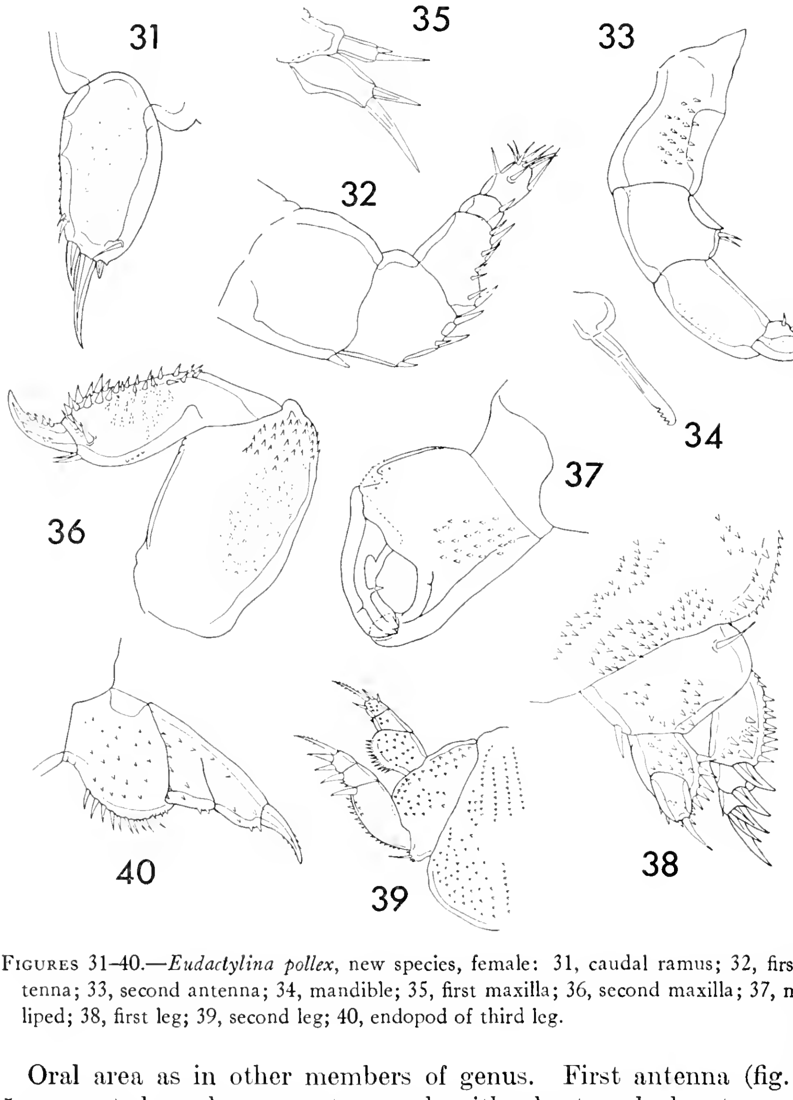
The name *pusilla,* from Latin, meaning "small," refers to the size of the species.

Eudactylina pollex, new species

Figures 4, 31–42

Collection: 23 females from 1 specimen of *Sphyrna mokarran* at station 409. Holotype female USNM 113297. Paratypes (21 females) USNM 113298. One specimen dissected for study.

Female.—Body form as in figure 4. Dorsal surface of body smooth. Total length 3.6 mm. Greatest width 0.8 mm. Cephalon slightly longer than wide (0.72 by 0.66 mm). First pedigerous thoracic segment fused with head. Thoracic segments 3–5 free, measuring 360μ, 600μ, and 960μ, respectively. Thoracic segment bearing leg 5 free, not combined to form genital segment. Genital segment somewhat wider than long (300μ by 340μ). Abdomen 2-segmented, segments measuring 141μ and 118μ, respectively. Caudal rami (fig. 31) about twice as long as wide (132μ by 75μ), bearing 3 terminal spines and 3 subterminal setae. Rami covered with spinules on dorsal surface.



FIGURES 31–40.—*Eudactylina pollex*, new species, female: 31, caudal ramus; 32, first antenna; 33, second antenna; 34, mandible; 35, first maxilla; 36, second maxilla; 37, maxilliped; 38, first leg; 39, second leg; 40, endopod of third leg.

Oral area as in other members of genus. First antenna (fig. 32) 5-segmented, each segment armed with short, naked setae as in figure. Second antenna (fig. 33) 4-segmented. Terminal segment in form of short claw bearing 3 spines. Second segment with 2 short setae on inner margin. Mandible (fig. 34) styliform process projecting with mouth tube, armed with 4 teeth at tip. Second maxilla (fig. 36) with patches of stout spinules as in figure. Maxilliped (fig. 37) chelate. Movable process of maxilliped opposed by immovable dactylate process on preceding segment. Immovable process with distal depression into which tip of movable process fits.

Legs 1–4 biramose with spine and setal formula as follows:

	leg 1		*leg 2*		*leg 3*		*leg 4*	
	exo.	end.	exo.	end.	exo.	end.	exo.	end.
seg. 1	I:0	0:0	I:0	0:0	I:0	0:0	I:0	0:0
seg. 2	I:0	1	I:0	0:0	I:0	0:0	I:0	1
seg. 3	III		III	4	III	1	III	

Leg 1 (fig. 38) bearing stout spinules on both rami. Exopod 3-segmented. Endopod 2-segmented. Leg 2 (fig. 39) with both rami 3-segmented, small spinules on both rami. Leg 3 similar to leg 4 except endopod last segment incompletely divided (fig. 40). Leg 4 (fig. 41) endopod 2-segmented. Exopod 3-segmented. Exopods of legs 2–4 with few spinules on first segment only. Leg 5 (fig. 42) a lateral lobe on thoracic segment 6, bearing 2 terminal setae, 1 subterminal seta. Leg 6 represented by short spine incorporated into area of egg string attachment.

Egg strings uniseriate.

MALE.—Unknown.

REMARKS.—This new species can be separated from all known species of the genus (except *E. acanthii* Scott, *E. turgipes* Bere, and *E. corrugata* Bere) by the exopod of leg 2. In all other species the exopod is unusually long and somewhat recurved (compare figs. 29 and 39). *E. pollex* can be separated from the other 3 species by the segmentation of the legs. In *E. acanthii* and *E. corrugata* the exopods of legs 1–4 are 2-segmented. In *E. pollex* the exopods of legs 2 and 3 are 3-segmented. The endopod of leg 4 of *E. turgipes* is 3-segmented. It is 2-segmented in *E. pollex*.

Habitat: Gill filaments.

The name *pollex*, from Latin, meaning "thumb," refers to the shape of the endopods of legs 2–4.

Kroyeria gracilis Wilson, 1932

Collections: From 3 specimens of *Carcharinus leucas* from Nosy Bé; from 1 specimen of the same host from station 409; from 1 specimen of *Carcharinus longimanus* from station 291.

Habitat: Gill filaments.

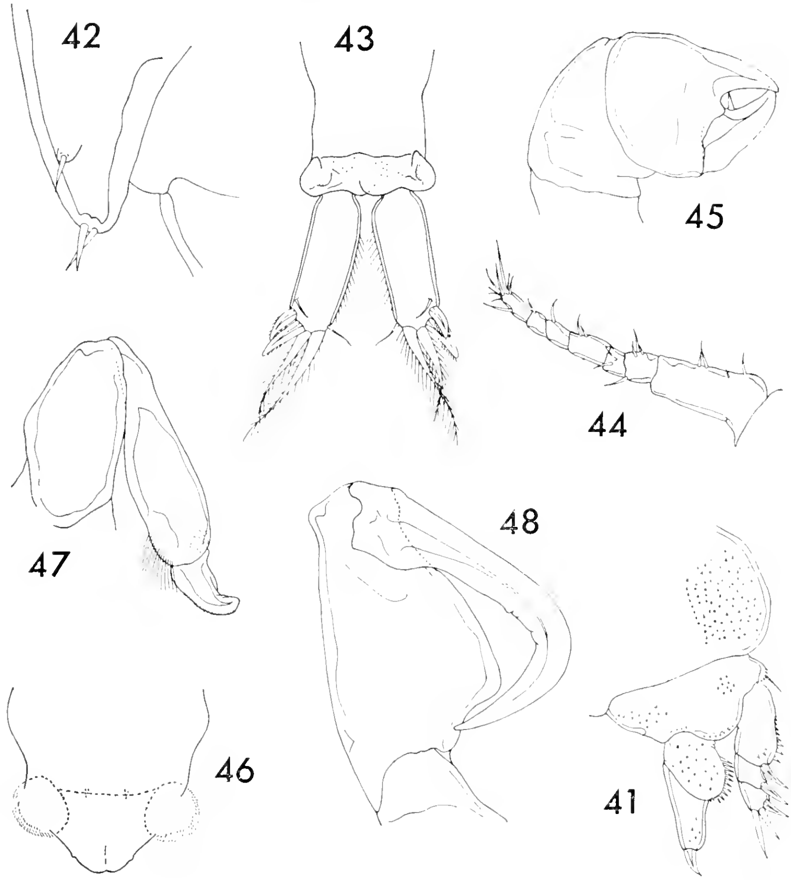
This copepod has been reported from a wide range of hosts and is probably cosmopolitan in distribution.

Kroyeria dispar Wilson, 1935

Collections: From 3 specimens of *Galeocerdo cuvier* from Nosy Bé.

Habitat: Gill filaments.

The only previous report of this copepod is the original description from Puerto Rico from *Squalus*.



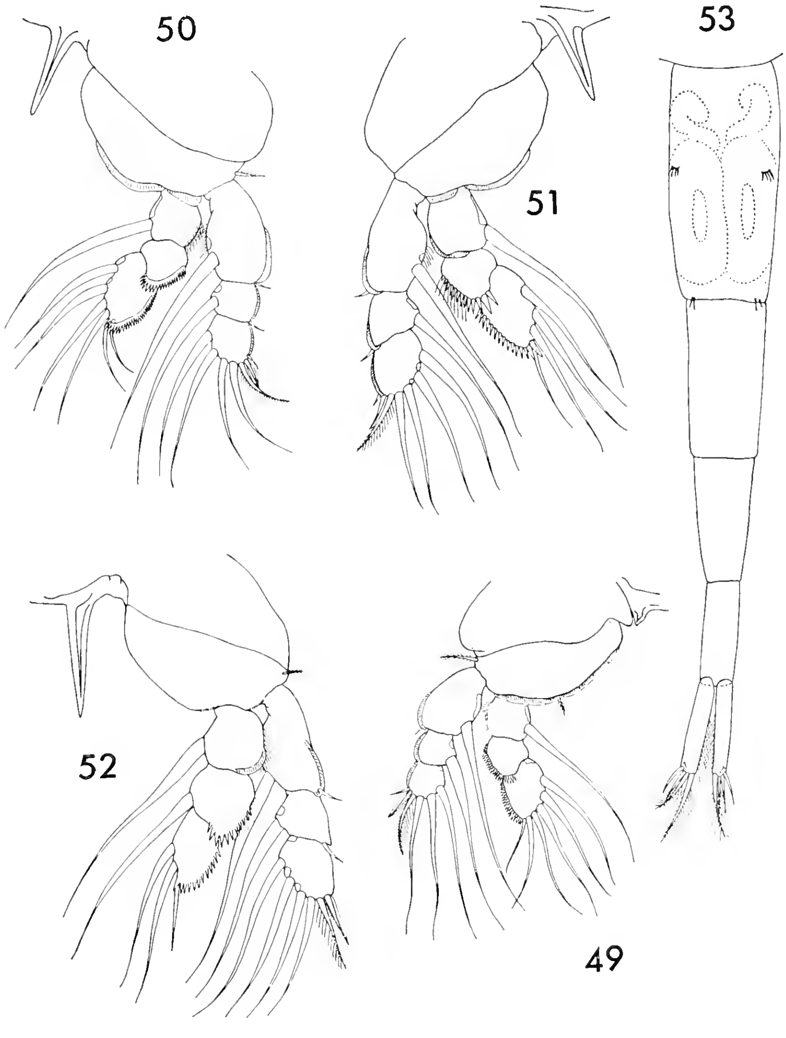
FIGURES 41–48.—*Eudactylina pollex*, new species, female: 41, fourth leg; 42, fifth leg. *Kroyeria gemursa*, new species, female: 43, distal end of abdomen and caudal rami; 44, first antenna; 45, second antenna; 46, labrum; 47, second maxilla; 48, maxilliped.

Kroyeria spatulata Pearse, 1948

Collections: From 5 specimens of *Carcharinus maculipinnis*, 2 specimens of *Carcharinus sorrah*, and 2 specimens of *Rhizoprionodon acutus* all from Nosy Bé.

Habitat: Gill filaments.

This copepod has been reported previously from off the southeast coast of the United States. The previously reported hosts plus the new records here indicate that this species may be restricted to sharks generally found only in shallow coastal waters.



FIGURES 49–53.—*Kroyeria gemursa*, new species, female: 49, first leg; 50, second leg; 51, third leg; 52, fourth leg. Male: 53, genital segment, abdomen and caudal rami.

***Kroyeria gemursa*, new species**

FIGURES 5, 43–53

Collections: 4 females and 4 males from 1 specimen of *Sphyrna mokarran* at station 409. Holotype, female, USNM 113294. Allotype, male, USNM 113295. Paratypes (2 females, 3 males) USNM 113296. One female specimen dissected for study.

Female.—Body form as in figure 5. Total length 9.7 mm. Greatest width 1.5 mm. Cephalon as wide as long (1.3 mm), widest near posterior border. Thoracic segments bearing legs 1–4 free. Segment bearing leg 1 with well-developed aciculum, 1.3 mm in length, bifid at tip. Thoracic segments 6 and 7 fused to form genital segment. Genital segment long, comprising slightly more than one-half body length. Abdomen 2-segmented. Terminal segment with posterior sclerotized ring at point of attachment of caudal rami (see fig. 43). Caudal rami (fig. 43) 3 times as long as wide (264μ by 94μ). Each ramus fringed along inner margin, bearing 4 terminal and 2 subterminal setae. Outer 2 terminal setae stout, plumose on inner margins only.

Oral area as in other members of genus. First antenna (fig. 44) 7-segmented, each segment with short, naked setae as in the figure. Second antenna (fig. 45) chelate. Movable process with short spine on inner margin, tips of immovable and movable processes pointed. Mouth tube short. Labrum with lateral spinose lobes. Mandible in form of stylet. First maxilla biramose. Second maxilla (fig. 47) with short, blunt claw at tip. Maxilliped (fig. 48) with long recurved claw. Maxilliped most prominent appendage of cephalon.

Legs 1–4 biramose; each ramus 3-segmented. Spine and setal formula as follows:

	leg 1 exo.	end.	*leg 2* exo.	end.	*eg 3* exo.	end.	*leg 4* exo.	end.
seg. 1	I:1	0:1	I:1	0:1	I:1	0:1	I:1	0:1
seg. 2	0:1	0:0	I:1	0:0	I:1	0:0	I:1	0:1
seg. 3	II:4	6	II:5	6	II:4	4	II:4	3

Leg 1 (fig. 49) exopod with fringe on outer margin of all 3 segments. Outer margin of last 2 endopod segments with row of many short spines. Legs 2 (fig. 50) and 3 (fig. 51) rami with outer margins armed as leg 1. Leg 4 (fig. 52) exopod with fringe on first segment only. Endopod outer margin as in preceding legs. Each corner of intercoxal plate of legs 2–4 with well-developed, posteriorly directed spine. Corners of intercoxal plate of leg 1 with knobs. Leg 5 represented by 4 setae located on margin near middle of genital segment. Setae arranged in 2 groups of 2 setae each. Leg 6 a single seta at posterior corner of genital segment.

Egg strings uniseriate.

Male.—Body form and appendages like those of female. Total length 4.4 mm. Greatest width 1.0 mm. Male differs from female in form of genital segment, abdomen, and caudal rami (fig. 53). Abdomen 3-segmented, end of abdomen not sclerotized as in female. Caudal rami nearly 6 times as long as wide (352μ by 61μ).

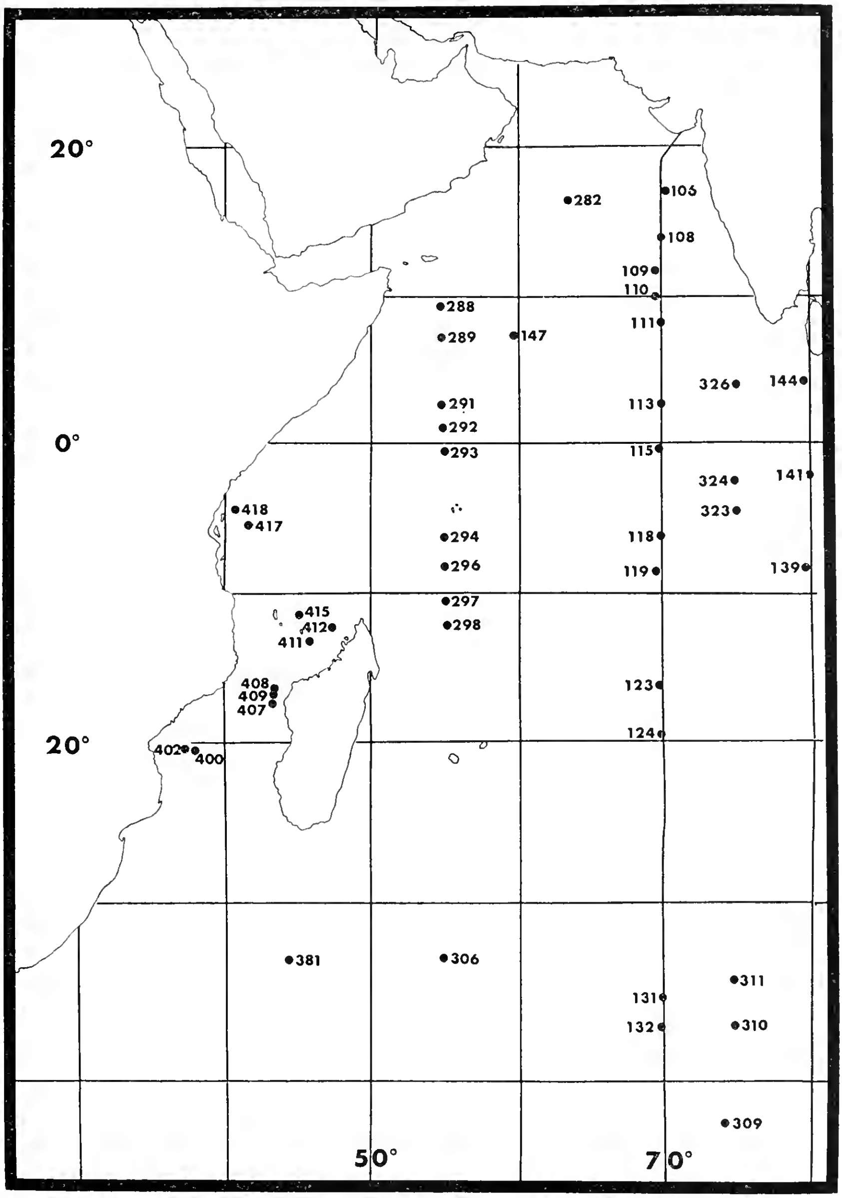


FIGURE 54.—Map of Indian Ocean showing various stations of the R/V *Anton Bruun* cited in this paper.

Legs 1–4 armed as in female except spines on outer edges of endopod segments fewer in male. Leg 5 as in female. Leg 6 consisting of 2 setae on posterior corner of genital segment.

Spermatophores easily visible within genital segment.

REMARKS.—*Kroyeria gemursa* can be separated from all known members of the genus by the sclerotized area at the end of the abdomen. It can be further distinguished from all species except *K. dispar* by the lateral swellings on the labrum. It can be separated from *K. dispar* by the presence of the prominent spines on the intercoxal plates of legs 2–4.

Habitat: Gill filaments.

The name *gemursa,* from Latin, meaning "swelling between toes," refers to sclerotization on abdomen.

Bariaka alopiae Cressey

Collection: From 1 specimen of *Alopias superciliosus* at Nosy Bé and station 119.

Habitat: Gill filaments.

Copepods Parasitic on Sharks Examined

Lamnidae

Isurus oxyrinchus
- *Pandarus smithii*
- *Echthrogaleus denticulatus*
- *Dinemoura latifolia*
- *Nemesis lamna*
- *Anthosoma crassum*

Isurus glaucus
- *Dinemoura latifolia*

Isurus species
- *Anthosoma crassum*
- *Nemesis lamna*

Lamna species
- *Echthrogaleus coleoptratus*

Carcharodon carcharias
- *Pandarus cranchii*
- *Nesippus orientalis*
- *Nemesis lamna*

Alopidae

Alopias vulpinus
- *Pandarus cranchii*
- *Pandarus smithii*
- *Gangliopus pyriformis*
- *Echthrogaleus denticulatus*
- *Dinemoura* sp.
- *Nemesis aggregatus*

Alopias superciliosus
- *Dinemoura* species
- *Pagina tunica*
- *Bariaka alopiae*

Triakidae

Mustelus species
- *Perissopus dentatus*

Carcharinidae

Carcharinus longimanus
- *Pandarus cranchii*
- *Nesippus crypturus*
- *Alebion gracilis*
- *Kroyeria gracilis*

Carcharinus floridanus
- *Pandarus cranchii*
- *Pandarus smithii*
- *Nesippus crypturus*

Prionace glauca
- *Pandarus satyrus*
- *Phyllothereus cornutus*
- *Gangliopus pyriformis*
- *Echthrogaleus coleoptratus*

Galeocerdo cuvier
- *Nesippus orientalis*
- *Nesippus crypturus*
- *Nesippus* sp.
- *Alebion gracilis*
- *Kroyeria dispar*
- *Eudactylina pusilla*

Carcharinus obscurus
- *Perissopus dentatus*
- *Alebion gracilis*

Carcharinus obesus?
Pseudopandarus longus
Carcharinus leucas
Pandarus carcharini
Perissopus dentatus
Nesippus orientalis
Nesippus crypturus
Alebion gracilis
Paralebion elongatus
Nemesis robusta
Kroyeria gracilis
Carcharinus maculipinnis
Pandarus carcharini
Nesippus orientalis
Nesippus crypturus
Nemesis versicolor
Eudactylina aspera
Kroyeria spatulata
Carcharinus limbatus
Alebion alatus
Carcharinus albimarginatus
Alebion gracilis
Carcharinus spallanzani
Pandarus niger
Carcharinus tjutjot
Pseudopandarus longus
Perissopus dentatus
Carcharinus sorrah
Kroyeria spatulata
Scoliodon palasorrah
Pseudopandarus gracilis
Nesippus orientalis
Rhizoprionodon acutus
Pseudopandarus longus
Nesippus orientalis
Eudactylina aspera
Kroyeria spatulata
Rhizoprionodon species
Pseudopandarus longus
Scoliodon species
Pseudopandarus gracilis
Carcharinus species
Pandarus niger
Alebion gracilis

Sphyrnidae

Sphyrna mokarran
Nesippus orientalis
Nesippus crypturus
Alebion elegans
Nemesis robusta
Eudactylina pollex
Kroyeria gemursa
Sphyrna lewini
Nesippus orientalis
Nesippus crypturus
Nemesis robusta
Eudactylina aspera
Sphyrna zygaena
Nesippus orientalis

Literature Cited

Abildgaard, P. C.
1794. Beskrivelse over tvende nye Monoculi Linn., Caligi Mull. (*Caligus crassus* et *oblongus*). Skr. Nat. Hist. Selskabet-Kjobenhavn, vol. 3., no. 2, pp. 46–54.

Beneden, P. J., van
1851. Recherches sur quelques Crustacès inférieurs. Ann. Sci. Nat., vol. 14, no. 3, pp. 71–131.

Bere, R.
1930. The parasitic copepods of the fish of the Passamaquoddy Region. Contr. Canadian Biol. Fish., vol. 5, no. 13, pp. 1–10.
1936. Parasitic copepods from the Gulf of Mexico fish. American Midl. Nat., vol. 17, no. 3, pp. 577–625.

Capart, A.
1953. Quelques copépodes parasites de poissons marins de la région de Dakar. Bull. Inst. Francaise Afrique Noire, vol. 15, no. 2, pp. 647–671.

CRESSEY, R. F.
1963. A new genus of copepods (Caligoida, Pandaridae) from a thresher shark in Madagascar. Cah. O.R.S.T.O.M. Oceanogr., ser. Nosy Bé, vol. 2, no. 6, pp. 285–297.
1966. *Bariaka alopiae* n. gen. n. p. (Copepoda, Caligoida), a parasite on the Gills of the Thresher Shark in Madagascar. Bull. Mar. Sci., vol. 16, no. 2, pp. 324–329.
1967. A revision of the family Pandaridae. Proc. U.S. Nat. Mus., vol. 121, no. 3570, pp. 1–133.

DANA, J. D.
1852. Crustacea, pt. 2. Vol. 13 *in* United States exploring expedition . . . 1838–1842 . . ., pp. 691–1618.

GERSTAECKER, A.
1854. Beschreibung zweier neuer Siphonostomen-Gattungen. Arch. Naturg., vol. 20, no. 1, pp. 185–195.

GNANAMUTHU, C. P.
1951. New copepod parasites of sharks. Ann. Mag. Nat. Hist., vol. 4, ser, 12, pp. 1236–1256.

GUÉRIN-MENEVILLE, F. E.
1837. Crustacés. Vol. 26 *in* Iconographie du regne animal.

HELLER, C.
1868. Crustaceen. No. 8 *in* vol. 2 *of* Zoologischer Teil *in* Reise der Oesterreichischen Fregatte *Novara* . . ., 280 pp., 25 pls.

HO, J. S.
1963. On five species of Formosan parasitic copepods belonging to the suborder Caligoida. Crustaceana, vol. 5, pt. 2, pp. 81–98.

KIRTESINGHE, P.
1950. Parasitic copepods of fish from Ceylon, 3. Parasitology, vol. 40, nos. 1 and 2, pp. 77–86.

LEACH, W. E.
1819. Entomostraca. *In* vol. 14 *of* Dictionaire des sciences naturelles, pp. 524–545.

MILNE-EDWARDS, H.
1840. Histoire naturelle des crustacés comprenant l'anatomie, la physiologie et la classification de ces animaux, 638 pp.

PEARSE, A. S.
1948. A second report on parasitic copepods collected at Beaufort, N.C. Journ. Elisha Mitchell Sci. Soc., vol. 64, no. 1, pp. 127–131.
1951. Parasitic Crustacea from Bimini, Bahamas. Proc. U.S. Nat. Mus., vol. 101, no. 3280, pp. 341–372.

RATHBUN, R.
1886. Descriptions of parasitic copepoda belonging to the genera *Pandarus* and *Chondracanthus*. Proc. U.S. Nat. Mus., vol. 9, pp. 310–324.

RISSO, A.
1826. Histoire naturelle des principales de l'Europe Méridionale et particulièrement ce celles des environs de Nice et des Alpes Maratimes, vol. 5, 135 pp.

SCOTT, A.
1929. The copepod parasites of Irish Sea fishes. Rep. Lancashire Sea Fish Lab. 1929, pp. 81–118.

SCOTT, T.
1901. Notes on some parasites of fishes. 19th Ann. Rep. Fish. Bd. Scotland, pt. 3, pp. 120–153.

SHIINO, S. M.
1957. Copepods parasitic on Japanese fishes, 15: Eudactylinidae and Dichelesthiidae. Rep. Fac. Fish. Pref. Univ. Mie, vol. 2, no. 3, pp. 392–410.

SMITH, S.
1874. Invertebrate animals of Vineyard Sound and adjacent waters. Rep. Comm. Fish Fisheries 1871–1872, 478 pp., 38 pls. [Reference not seen.]

STEENSTRUP, J. J. S., and LÜTKEN, C. F.
1861. Bidrag til Kundskab om det aabne Havs Snyltekrebs og Lernaeer samt om nogle andre nye eller hidtil kun ufuldstaen digt kjendte parasitiske Copepoder, vol. 5, pp. 341–432.

VAISSIERE, R.
1959. Parasites de poissons de mer ouest-africains recoltes par J. Cadenat, 2: Copepodes. Bull. Inst. Françaiş Afrique Noire, vol. 21, ser. A, no. 2, pp. 534–553.

WILSON, C. B.
1905. New species of parasitic copepods from the Massachusetts Coast. Proc. Biol. Soc. Washington, vol. 18, pp. 127–132.
1911. North American parasitic copepods: Descriptions of new genera and species. Proc. U.S. Nat. Mus., vol. 39, pp. 625–634.
1913. Crustacean parasites of West Indian fishes and land crabs, with descriptions of the new genera and species. Proc. U.S. Nat. Mus., vol. 44, pp. 189–277.
1922. North American parasitic copepods belonging to the family Dichelesthiidae. Proc. U.S. Nat. Mus., vol. 60, pp. 1–100.
1932. The copepods of the Woods Hole Region, Massachusetts. U.S. Nat. Mus. Bull. 158, 635 pp.
1935. New parasitic copepods. Smithsonian Misc. Coll., vol. 91, no. 19, pp. 1–9.

YAMAGUTI, S.
1963. Parasitic Copepoda and Branchiura of fishes, 1104 pp.

Proceedings of
the United States
National Museum

SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 121 | 1967 | Number 3573

NEW CYCLOPOID COPEPODS ASSOCIATED WITH THE ALCYONARIAN CORAL TUBIPORA MUSICA (LINNAEUS) IN MADAGASCAR

By Arthur G. Humes and Ju-Shey Ho [1]

At Nosy Bé, in the northwestern part of Madagascar, several species of copepods (Humes and Frost, 1964) are known to be associated with members of the alcyonarian order Alcyonacea, but until now none have been reported living with members of the order Stolonifera.

While participating in the work of the U.S. Program in Biology of the International Indian Ocean Expedition at Nosy Bé in 1963–64, the first author collected 4 species of cyclopoid copepods from washings of *Tubipora musica* (Linnaeus), the common organ-pipe coral. These species are described below.

All figures have been drawn with the aid of a camera lucida.

The study of the material has been aided by a grant (GB–1809) from the National Science Foundation. We wish to thank Dr. Michel Pichon for verification of the identity of the coral and to acknowledge the many courtesies received from the staff of the Centre d'Océanographie et des Pêches at Nosy Bé.

[1] Both authors: Department of Biology, Boston University, Boston, Mass.

Family Lichomolgidae Kossmann, 1877

Genus *Lichomolgus* Thorell, 1860

Lichomolgus organicus, new species

FIGURES 1–30

TYPE MATERIAL.—207 ♀♀, 98 ♂♂, and 15 copepodids from a colony of *Tubipora musica* (Linnaeus), in 1 m, Pte. Ambarionaomby, Nosy Komba, near Nosy Bé, Madagascar, collected June 8, 1964: holotype ♀ (USNM 113387), allotype (USNM 113388), and 144 paratypes (USNM 113389) (100 ♀♀ and 44 ♂♂) deposited in the United States National Museum, 80 paratypes (50 ♀♀ and 30 ♂♂) in the Museum of Comparative Zoology, Harvard University, and the remaining paratypes in the collection of A. G. Humes.

OTHER SPECIMENS.—All from *Tubipora musica* collected in 1964: 8 ♀♀ and 8 ♂♂, in 1 m, Pte. à la Fièvre, Nosy Bé, Jan. 5; 1 ♀, in 15 cm, Tany Kely, a small island south of Nosy Bé, Mar. 29; 4 ♀♀ and 8 ♂♂, in 1 m, Pte. Ambarionaomby, Mar. 31; 15 ♀♀ and 1 ♂, in 1 m, Pte. à la Fièvre, Apr. 15; and 14 ♀♀, in 2 m, Pte. Ambarionaomby, Sept. 27.

FEMALE.—Body (fig. 1) with moderately broad prosome. Body length (not including setae on caudal rami) 0.99 mm (0.92–1.05 mm) and greatest width (in middle of cephalosome) 0.49 mm (0.44–0.53 mm), based on 10 specimens. Ratio of length to width of prosome 1.5:1. Segment of first leg separated dorsally and laterally from head by a transverse furrow; lateral areas of this segment not expanded. Lateral areas of segments bearing legs 2 and 3 expanded and rounded posteriorly; those of segment of leg 4 smaller and somewhat truncated.

Segment of leg 5 (fig. 2) wider than long, 61μ x 133μ, with fifth legs borne laterally. Ventrally between this segment and the genital segment no apparent intersegmental sclerite. Genital segment (fig. 2) about as long as wide, 140μ x 142μ, in dorsal view expanded laterally in its midregion, posterior to which the segment is constricted so that its width at the posterior end is only 80μ. Areas of attachment of egg sacs located dorsolaterally on posterior part of expansions. Each area (fig. 3) with 2 naked setae, 12 and 13μ in length; posterior to the setae a small rounded sclerotized protuberance. Three postgenital segments, each without ornamentation except for a few surficial hairs (sensilla), 37μ x 67μ, 26μ x 55μ, and 28μ x 51μ, respectively, from anterior to posterior.

Caudal ramus (fig. 4) only a little elongated, 36μ x 24μ in greatest dimensions, or 1.5 times longer than wide. Length along inner edge to innermost distal seta 23μ, along outer edge to base of lateral seta 23μ, and to base of outermost distal seta 33μ. Of the usual 6 setae, outer lateral seta naked and 66μ long; remaining 5 feathered: pedicellate dorsal seta 47μ, innermost distal seta 115μ, outermost distal seta 91μ, and the 2 long median terminal setae, both "pegged," 169μ (outer) and 200μ (inner), and inserted between dorsal (unornamented) and ventral (with marginal row of spinules) flaps. In addition, a minute hyaline setule dorsally near insertion of outermost distal seta. Two hairs on dorsal surface of ramus.

Dorsal surface of prosome and dorsal and ventral surfaces of urosome with a few minute hairs. Ratio of length of prosome to that of urosome about 2.1:1.

All ovigerous females observed with broken egg sacs (one shown in fig. 5).

Rostral area (fig. 6) moderately well formed. At level of bases of second antennae a small longitudinal sclerotized ridge between rostrum and anterior part of labrum.

First antenna (fig. 7) 7-segmented, with third segment showing ventrally a proximal sclerotized area suggesting an intercalary segment. Lengths of the segments, measured along their posterior nonsetiferous margins: 28μ (56μ along anterior margin), 95μ, 25μ, 50μ, 50μ, 37μ, and 22μ, respectively. Formula for armature: 4, 13, 6, 3, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete. All setae naked.

Second antenna (fig. 8) 4-segmented, with last segment moderately elongated, 65μ along its outer edge, 39μ along its inner edge, and 27μ wide. Each of first 2 segments with a small inner seta, third segment with 3 setae (1 of them jointed), and last segment with 7 elements: 5 setae and 2 unequal recurved claws 45μ and 34μ long (measured along greatest axis). All setae naked.

Labrum (fig. 9) with 2 relatively short posteroventral lobes, free border of each lobe showing 2 small hyaline lamellae.

Mandible (fig. 10) with its basal region bearing on its posterior surface a small sclerotized area and separated by a constriction from its distal region, whose inner margin bears a prominent sclerotized pointed toothlike process followed by a striated fringe, whose outer margin has a row of slender spinules and which terminates in a long flagellum with lateral spinules. Paragnath (see fig. 9) a small lobe bearing inner hairs. First maxilla (fig. 11) a single segment bearing 2 terminal setae. Second maxilla (fig. 12) 2-segmented, first segment unarmed, second segment produced distally and bearing row of 4–5 teeth (compare figs. 12 and 13) and slender naked terminal process. (If 4 such teeth, distalmost often slightly bifurcated; if 5, teeth all entire.) On postero-inner surface of second segment 2 setae, one finely pectinate along one margin, other bearing long bluntly tipped setules along one side. A minute setule on proximal outer edge of this segment. Maxilliped (fig. 14) 3-segmented. Two naked setae on second segment. Third segment (fig. 15) bearing a naked seta, a setiform element with bifurcated tip, and a terminal process about 22μ long and clawlike, with a small hyaline lobe on each side of distal point.

Postoral area (fig. 16) only slightly produced ventrally; an incomplete line of sclerotization between bases of maxillipeds.

Legs 1–4 (figs. 17–20) with trimerous rami except for 2-segmented endopod of leg 4. Armature of legs as follows (Roman numerals=spines, Arabic numerals=setae):

P 1	protopod	0:1	1:0	exp	I:0	I:1	III,I,4
				end	0:1	0:1	I,5
P 2	protopod	0:1	1:0	exp	I:0	I:1	III,I,5
				end	0:1	0:2	I,II,3
P 3	protopod	0:1	1:0	exp	I:0	I:1	III,I,5
				end	0:1	0:2	I,II,2
P 4	protopod	0:1	1:0	exp	I:0	I:1	II,I,5
				end	0:1	II	

Inner seta on coxa of legs 1–3 long and plumose, but in leg 4 short (17μ) and naked. In first 3 pairs of legs inner margin of basis with short row of hairs, but such hairs absent in leg 4. In all 4 legs setae on inner side of last segment of exopod with lateral hairs shorter proximally than distally. Spine on last segment of endopod of leg 1 24μ in length. Endopod of leg 4 shorter than exopod. First segment $33\mu \times 25\mu$ with inner distal plumose seta 41μ long. Second segment 61μ long (including 2 terminal spinous processes) and 23μ wide in basal half and 19μ wide in distal half, the 2 halves demarcated by very slight indentation. Along outer margin of both segments rows of minute spinules. Terminally second segment with a row of minute spinules near insertion of 2 unequal spines, both with spinulose fringes, outer spine 21μ, inner 39μ long, ratio about 1:1.86.

Leg 5 (fig. 21) with free segment elongated and slightly arcuate in outline, $66\mu \times 23\mu$, with short stout spines along outer edge and extending around to distal ventral surface; bearing terminally 2 naked setae 35μ and 37μ in length. Seta on body near free segment slightly feathered with group of spines near its insertion.

Leg 6 probably represented by 2 setae near areas of attachment of each egg sac (see fig. 3).

Color in life in transmitted light rather translucid, eye red.

MALE.—Body (fig. 22) resembling in general form that of female. Length (excluding ramal setae) 0.89 mm (0.85–0.92 mm) and greatest width 0.32 mm (0.30–0.34 mm), based on 10 specimens. Ratio of length of prosome to that of urosome 1.6:1.

Segment of leg 5 (fig. 23) 29μ x 67μ. Genital segment longer than wide, 164μ x 122μ in greatest dimensions, and in dorsal view rather bottle shaped, its lateral borders gently rounded. No intersegmental sclerite ventrally between these 2 segments. Four postgenital segments 18μ x 45μ, 19μ x 43μ, 15μ x 40μ, and 17μ x 43μ, respectively, from anterior to posterior.

Caudal ramus (fig. 24) resembling that of female, but slightly less elongated, its greatest dimensions 31μ x 21μ, or 1.48 times longer than wide.

Surfaces of prosome and urosome with minute hairs as in female. Ratio of length of prosome to that of urosome 1.56:1.

Rostral area like that in female.

First antenna resembling that of female, but an aesthete added on segments 2 and 4 (at exact points indicated by arrows in fig. 7), so that formula is 4, 13+1 aesthete, 6, 3+1 aesthete, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete. Second antenna (fig. 25) more slender than in female, and last segment elongated, 68μ along outer edge, 52μ along inner edge, and 15μ wide. First segment with inner crescentic row of small spinules. Second segment with numerous small spinules along inner surface, arranged in 2 groups proximal and distal to seta. Last segment with row of very small spinules along inner surface. Armature like that of female, but 2 claws more nearly equal in length (34μ and 35μ), though posterior claw more slender than other.

Labrum, mandible, paragnath, first maxilla, and second maxilla like those in female. Maxilliped (fig. 26) 4-segmented (assuming that proximal part of claw represents fourth segment). First segment unornamented. Second segment bearing on medial surface 2 setae and 2 rows of long spinules. Small third segment unarmed. Slender slightly recurved terminal claw 178μ in length (measured along axis), with narrow terminal lamella, smooth lamellar fringe along its concave surface, and 2 setae near its base, one on posterior surface 44μ long and finely barbed, other on anterior surface 17μ long, naked, and hyaline. Suggestion of division about midway along claw.

Postoral area resembling that of female.

Legs 1–4 resembling those in female and with same spine and setal formula, except for endopod of leg 1 (fig. 27), which has arrangement of 0:1; 0:1; I,I,4. On last segment of this endopod 2 spines, outermost of setae in female being here replaced by a spine; outer spine 29μ long, inner spine 43μ long and recurved distally, and both spines with strong lateral spinules. In alcoholized specimens last segment of endopod flexed outwardly. Terminal spines on endopod of leg 4 in one male 19μ (outer) and 51μ (inner), in another 16μ and 37μ, with an average of 17.5μ and 44μ, ratio of 1:2.5.

Leg 5 (fig. 28) with free segment elongated and slender, 36μ x 9μ, with nearly parallel sides in dorsal view, and with 2 terminal setae unequal, outer 31μ and inner 19μ long. Few minute spinules on outer distal surface of segment. No spinules near insertion of seta on body near free segment.

Leg 6 (fig. 29) a posterolateral flap on ventral surface of genital segment bearing 2 naked setae 23μ and 25μ long.

Spermatophore (fig. 30) inside body of male about 148μ x 68μ plus neck of 14μ.

Color in life resembling that of female.

Etymology.—The specific name *organicus,* from Latin, relating to musical instruments, refers to the association of this species with the organ-pipe coral *Tubipora musica.*

Comparison with related species.—Among those species in the large genus *Lichomolgus,* wherein the mandible has been described, there are 3 that, like *L. organicus,* show a prominent toothlike process on the proximal inner margin of this appendage. From these, *L. organicus* may be readily distinguished. In *L. actinophorus* Humes and Frost (1964) there is a single claw on the last segment of the second antenna, the free segment of leg 5 in the female is somewhat irregular and has a ratio of 2.1:1, the caudal ramus of the female has a ratio of 3.5:1, and there is a setiferous sphere on the second segment of the second maxilla. In *L. decorus* Humes and Frost (1964) there is one claw and one clawlike spine on the last segment of the second antenna, the last segment of the exopod of leg 4 has the formula III,I,5, and the free segment of leg 5 in the female is 2.2:1 with a basal expansion. In *L. protulae* Stock (1959) the shape of the body is transformed, there are 3 strong claws and 2 setiform claws on the last segment of the second antenna, the caudal ramus of the female has a ratio of about 8.3:1, the free segment of leg 5 in the female is about 2.1:1, and the toothlike process on the mandible is directed distally rather than proximally as in *L. organicus.* In addition, the females of *L. actinophorus* and *L. protulae* are distinctly larger.

There are 8 species of *Lichomolgus* in which the form of the mandible is unknown. These may be separated from *L. organicus,* however, on the basis of other characters (in each case using the female, except in the last mentioned species where the female is unknown). In *L. dentipes* Thompson and A. Scott (1903) the formula for the last segment of the exopod of leg 4 is III,I,5 and the free segment of leg 5 has a prominent toothlike inner process. In *L. elegans* Thompson and A. Scott (1903) there is 1 claw on the second antenna and the body is larger (1.5 mm) and more slender. In *L. gigas* Thompson and A. Scott (1903) there is one claw on the second antenna and the body is larger (2 mm). In *L. longipes* (Sewell, 1949) leg 5 is very long (about

8:1) and the body is larger (1.63 mm) and more slender. In *L. rigidus* Ummerkutty (1962) the formula for the last segment of the exopod of leg 4 is III,I,5 and the body is larger (1.25 mm). In *L. rotundus* Sewell (1949) the free segment of leg 5 is short, swollen, and somewhat produced on the outer margin, with a ratio of about 2:1. In *L. tenuicornis* Brady (1910) the caudal ramus is about 7:1, the free segment of leg 5 has a small basal expansion, and the body is larger (1.7 mm). In *L. vagans* Gurney (1927) (based on the male), the body is larger (1.07 mm) and the last segment of the second antenna (Gurney, 1927, p. 466, fig. C) has a ratio of length of the outer margin to width of about 5.6:1, thus being slightly more slender than in *L. organicus*, where the ratio is about 4.5:1.

Since we still do not know the taxonomic importance of the variation in many characters observed in *Lichomolgus* (such as the terminal armature of the second antenna, the armature of the exopod of leg 4, the exact form of the mandible and leg 5, etc.), we find it impossible in *Lichomolgus* to say with which species *L. organicus* is most closely related. Such a conjecture would seem to be premature in view of the apparent very incomplete knowledge of the species in this genus.

***Lichomolgus conjunctus*, new species**

FIGURES 31–36

TYPE MATERIAL.—163 ♀♀ and 25 ♂♂ from a colony of *Tubipora musica* (Linnaeus), in 1 m, Pte. Ambarionaomby, Nosy Komba, near Nosy Bé, Madagascar, collected June 8, 1964: holotype ♀ (USNM 113391), allotype (USNM 113392), and 89 paratypes (USNM 113393) (79 ♀♀ and 10 ♂♂) deposited in the United States National Museum, 45 paratypes (40 ♀♀ and 5 ♂♂) in the Museum of Comparative Zoology, Harvard University, and the remaining paratypes in the collection of A. G. Humes.

OTHER SPECIMENS.—All from *Tubipora musica* collected in 1964: 121 ♀♀ and 53 ♂♂, in 1 m, Pte. à la Fièvre, Nosy Bé, Jan. 5; 9 ♀♀, in 15 cm, Tany Kely, a small island south of Nosy Bé, Mar. 29; 8 ♀♀, in 1 m, Pte. Ambarionaomby, Nosy Komba, Mar. 31; 14 ♀♀ and 3 ♂♂, in 1 m, Pte. à la Fièvre, Apr. 15; and 43 ♀♀, in 2 m, Pte. Ambarionaomby, Sept. 27.

In the description that follows, morphological features not specifically mentioned may be assumed to be essentially like those in *L. organicus*.

FEMALE.—Body (fig. 31) with prosome more pointed anteriorly than in *L. organicus*. Length of body (without ramal setae) 0.80 mm (0.72–0.87 mm) and greatest width 0.38 mm (0.34–0.40 mm), based on 10 specimens. Ratio of length to width of prosome 1.53:1.

Segment of leg 5 (fig. 32) 46μ x 107μ. Genital segment slightly wider than long, 110μ x 115μ, in dorsal view expanded laterally just behind its midregion, posterior to which segment is constricted, with width at posterior end of segment 60μ. Each area of attachment of egg sacs, located dorsolaterally on expanded part of segment, bearing 2 naked setae and rounded protuberance (more prominent than in previous species). Three postgenital segments 25μ x 53μ, 21μ x 48μ, and 23μ x 46μ, respectively, from anterior to posterior.

Caudal ramus (fig. 33) only slightly longer than wide, $28 \times 23\mu$ in greatest dimensions, ratio of length to width 1.22 : 1. Length along inner edge to innermost distal seta 19μ, along outer edge to base of lateral seta 19μ and to base of outermost distal seta 25μ. Pedicellate dorsal seta apparently naked. Relative lengths of 6 setae approximately those of *L. organicus.*

Ratio of length of prosome to that of urosome 2.6 : 1.

Egg sacs on all ovigerous females broken.

Rostral area (fig. 34) slightly more elongated posteriorly than in *L. organicus.* Segments of first antenna 23μ (44μ), 97μ, 21μ, 46μ, 45μ, 31μ, and 20μ in length (measured as before) and arrangement of naked setae and aesthetes as in previous species. Second antenna resembling that of *L. organicus*, but last segment slightly more slender (63μ along its outer edge, 39μ along its inner edge, and 21μ wide). Larger claw 37μ long, and more slender claw 32μ in length.

Labrum, mandible, paragnath, and first maxilla like those in *L. organicus.* Second maxilla closely resembling that species also, but pectinate seta on second segment slightly longer, reaching nearly to end of first tooth; in females studied 4–5 entire teeth, or 4 teeth with distalmost slightly bifurcated. Maxilliped resembling that of *L. organicus*, but subterminal setiform element apparently not as distinctly bifurcated at its tip.

Postoral area similar to that in previous species.

Legs 1–4 with same segmentation and spine and setal formula as in *L. organicus.* Spine on last segment of endopod of leg 1 27μ long. Endopod of leg 4 (fig. 35) with the following dimensions: first segment 33μ x 25μ with inner seta 40μ long, second segment 60μ x 21μ (greatest width) and 18μ (least width) with 2 terminal spines 25μ (outer) and 54μ (inner) in length, the ratio about 2.16:1.

Leg 5 similar to that of *L. organicus*, dimensions of free segment about 63μ x 24μ.

Leg 6 (represented by 2 setae near attachment of egg sacs) like that in previous species.

Color in life resembling that of *L. organicus.*

MALE.—Body (fig. 36) with prosome more pointed than in previous species. Body length (excluding setae on caudal rami) 0.71 mm (0.65–0.76 mm) and greatest width 0.27 mm (0.23–0.30 mm), based on 10 specimens. Ratio of length of prosome to its width 1.5:1.

Segment of leg 5 25μ x 66μ. Genital segment 151μ x 117μ. Four postgenital segments 14μ x 45μ, 16μ x 42μ, 13μ x 40μ, and 17μ x 42μ, respectively, from anterior to posterior. Caudal ramus 25μ x 21μ, or 1.19:1.

Ratio of length of prosome to that of urosome 1.57:1.

TABLE 1.—*Comparison of certain features of* Lichomolgus organicus *and* L. conjunctus

Characters	*L. organicus*	*L. conjunctus*
Female		
body size	0.99 x 0.49 mm	0.80 x 0.38 mm
anterior border of prosome	rounded	more pointed
ratio of prosome to urosome	2.1:1	2.6:1
caudal ramus	36μ x 24μ (1.5:1)	28μ x 23μ (1.22:1)
genital segment	lateral indentations near middle (fig. 2)	lateral indentations further back (fig. 32)
second antenna	last segment 27μ wide, claws 45μ and 34μ	last segment 21μ wide, claws 37μ and 32μ
spine on last segment of endopod of leg 1	24μ	27μ
spines on last segment of endopod of leg 4	21μ and 39μ (1:1.85)	25μ and 54μ (1:2.16)
Male		
body size	0.89 x 0.32 mm	0.71 x 0.27 mm
anterior border of prosome	rounded	more pointed
caudal ramus	31μ x 21μ (1.48:1)	25μ x 21μ (1.19:1)
spines on last segment of endopod of leg 4	17.5μ and 44μ (1:2.5)	18μ and 50μ (1:2.8)
free segment of leg 5	36μ x 9μ (4:1)	28μ x 8μ (3.5:1)

Rostral area like that of female. First antenna resembling that of *L. organicus*, with same formula for setae and aesthetes. Second antenna also resembling that species; last segment 73μ along outer edge, 54μ along inner edge, and 14μ wide. Two claws (34μ and 35μ) similar to those in *L. organicus*.

Labrum, mandible, paragnath, first maxilla, and second maxilla like those in female; in males observed 4 teeth on distal end of second maxilla, last tooth slightly bifurcated or entire. Maxilliped and postoral area much like those in *L. organicus*.

Legs 1–4 resembling those of female with same spine and setal formula, except for sexual dimorphism in leg 1 (as in *L. organicus*). Two spines on last segment of endopod of leg 1 like those in previous species, outer 27μ and inner 40μ long. Two terminal spines on endopod of leg 4 18μ (outer) and 50μ (inner), ratio of 1:2.8.

Leg 5 resembling that of *L. organicus*, but free segment relatively slightly shorter, 28μ x 8μ.

Leg 6 similar to that in previous species, but 2 naked setae slightly longer (28μ).

Spermatophores, seen only inside body of male, resembling those of *L. organicus*.

Color in life like that of female.

Etymology.—The specific name *conjunctus*, from Latin, meaning "closely related or bordering on," refers to the close similarity between this and the preceding species.

Comparison with related species.—*L. conjunctus* closely resembles *L. organicus* in general appearance, but a careful study shows certain constant and characteristic differences. These are summarized in table 1.

Association of the two lichomolgids with the alcyonarian.—Both *L. organicus* and *L. conjunctus* were recovered after washing unbroken colonies of *Tubipora musica* in sea water to which about 5 per cent ethyl alcohol had been added. The exact habitat of the copepods is unknown, but there seems to be little doubt of their association with the alcyonarian in view of the large numbers of individuals recovered.

Family Clausidiidae Embleton, 1901

Genus *Hippomolgus* Sars, 1917

Hippomolgus latipes, new species

Figures 37–58

Type material.—8 ♀♀ from a colony of *Tubipora musica* (Linnaeus), in 1 m, Pte. Ambarionaomby, Nosy Komba, near Nosy Bé, Madagascar, collected Mar. 31, 1964: holotypic ♀ (USNM 113395) and 4 paratypic ♀♀, (USNM 113396) deposited in the United States National Museum; remaining 3 ♀♀ (dissected) in the collection of A. G. Humes.

Other material.—Also from *Tubipora musica*: 1 ♀, in 1 m, Pte. Ambarionaomby, Nosy Komba, June 8, 1964.

Female.—Body (fig. 37) with a rather harpacticoid appearance. Length (excluding setae on caudal rami) 1.13 mm (0.97–1.19 mm) and greatest width 0.32 mm (0.27–0.37 mm), based on 8 specimens. Ratio of length to width of prosome 1.65:1. Segment bearing leg 1 completely fused with head. Lateral areas of segments of legs 1–3 not produced; those of segment of leg 4 slightly angular posteriorly.

Segment of leg 5 (fig. 38) broad, 94μ x 242μ, with fifth legs borne posterolaterally. Between this segment and genital segment on ventral side a weak intersegmental sclerite. Genital segment (fig. 38) wider than long, 130μ x 198μ. In ventral view its lateral border (fig. 39) with a small notch near middle of segment and a more pronounced indentation posteriorly. Areas of attachment of egg sacs situated dorsolaterally in midregion of segment. Each area (fig. 40) bearing outwardly a rather hyaline flange and inwardly a slender seta 11μ long, a spiniform seta 8μ long, and 2 small spinous processes. On ventral surface of posterior half of genital segment a transverse row of prominent spinules. Three postgenital segments 78μ x 135μ, 60μ x 118μ, and 91μ x 91μ, respectively, from anterior to posterior. Anal segment (fig. 41) bearing anteriorly 4 transverse rows of spinules, 2 rows ventrolateral and 2 ventral; along its posterior border near insertion of each caudal ramus a row of small spinules, this row continued on dorsal side.

Caudal ramus (fig. 42) 104μ x 34μ, or 3 times longer than wide. Minute basal outer spinule 3μ long. Outer lateral seta 22μ long and naked. Outermost terminal seta 41μ long, naked, and composed of 2 parts: a sclerotized proximal half and a more slender distal portion. Innermost terminal seta 57μ long and haired along inner side. Two long terminal setae 209μ (outer) and 462μ (inner), both basally "pegged" and bearing lateral spinules. Pedicellate dorsal seta 39μ long and naked. Dorsal surface of ramus with small hairs and refractile points as indicated in figure.

Dorsal surface of prosome and dorsal and ventral surfaces of urosome with scattered refractile points and hairs. Prosome slightly longer than urosome, ratio 1.1:1.

In single ovigerous female collected egg sac (fig. 43) 319μ x 107μ, extending a little beyond ends of caudal rami, with each egg about 40μ in diameter.

Rostral area (fig. 44) small and well sclerotized. Posterior to it, between bases of second antennae, a small circular sclerotization.

First antenna (fig. 45) 6-segmented and relatively short and robust, its length about 143μ. Lengths of segments measured along their posterior nonsetiferous margins: 15μ (39μ along anterior margin), 19μ, 28μ, 18μ, 13μ, and 24μ, respectively. First segment with 5 setae, proximal one lightly haired, distal one spiniform, with a row of scalelike spinules along one edge. On second segment 2 similar spiniform setae. All remaining setae naked. Each of last 3 segments with long prominent aesthete. Formula for armature: 5, 14, 9, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete. Only ornamentation on first antenna consisting of crescentic row of spinules on first segment.

Second antenna (fig. 46) 4-segmented, last segment 32μ x 19μ in greatest dimensions. Each of first 2 segments with a seta, third segment with a spine and 2 slender setae on its inner distal expansion, and last segment bearing 7 elements (a spine and 6 setae). Ornamentation indicated in figure, inner margins of third and fourth segments having rows of scalelike spinules.

Labrum (figs. 47, 48) ornamented with spinules as indicated in figures.

Mandible (fig. 49) bearing 3 terminal elements: a clawlike ventral (outer) spine with 1–2 spinous processes on its concave edge, a spine with lateral spinous projections on its basal half, and a slender barbed seta. No paragnath. First maxilla (fig. 50) bilobed, with 8 setae disposed in groups of 3, 4, and 1. Second maxilla (fig. 51) 2-segmented; first segment unarmed, second with outer haired seta and 2 inner barbed spinulose setae and terminating in a short clawlike process with at either side a setiform barbed process (these 2 processes perhaps setae but their articulation not evident). Maxilliped (fig. 52) 4-segmented, first segment with inner barbed seta, second with 2 naked setae, third unarmed, and fourth (fig. 53) subterminally with small naked seta and terminally with minute spiniform process and fringe of spiniform ornamentations resembling a small fan.

Area behind mouth and between mouthparts (fig. 47) showing anteriorly a transversely elongated median lobe (lingua) with a few very minute lateral spinules, followed immediately by a transverse row of hairs in 2 groups. Posterior to this a row of prominent spinules, with at either end a cluster of hairs. Bases of maxillipeds joined by sclerotized lines. Postoral area between maxillipeds and leg 1 broadly protuberant, especially noticeable in lateral view.

Legs 1–4 (figs. 54–57) with 3-segmented rami. Armature of legs as follows (Roman numerals=spines, Arabic numerals=setae):

P 1	protopod	0:1	1:I	exp	I:0	I:1	III,I,4
				end	0:1	0:1	I,3
P 2	protopod	0:1	1:0	exp	I:0	I:1	III,I,5
				end	0:1	0:2	II,I,3
P 3	protopod	0:1	1:0	exp	I:0	I:1	III,I,5
				end	0:1	0:2	II,II,2
P 4	protopod	0:1	1:0	exp	I:0	I:1	II,I,5
				end	0:1	0:2	II,II,1

Free edges of all 4 intercoxal plates with rows of long slender setules. Inner margin of basis of leg 1 (fig. 54) bearing spinulose spine 25μ long, with near its insertion an outer row of spinules and an inner spiniform process with slightly bifurcated tip. In legs 2–4 this margin more or less rounded and carrying only a row of hairlike setules. Terminal segment of endopod of leg 1 with 1 spine and 3 setae. Spinous processes at each side of insertion of spine either entire or bifurcated at tip. Ornamentation of legs indicated in figures.

Leg 5 (fig. 58) having an expanded free segment 83μ x 53μ in greatest dimensions. Four elements borne on this segment consisting (from dorsal to ventral) of a finely barbed spine 39μ long, a naked seta 66μ long, a strong spinulose spine 44μ long, and a short weakly barbed spine 23μ in length. Along dorsal edge of segment a row of spinules. Seta borne on body dorsal to insertion of segment 40μ long and naked. (In dorsal or ventral view of undissected animal, segment of leg 5 appearing much less expanded than actually.)

Leg 6 probably represented by seta and spine near attachment of each egg sac (see fig. 40).

Color in life unknown.

Male.—Unknown.

Etymology.—The specific name *latipes*, from Latin, meaning "having broad feet," refers to the wide free segment of leg 5 in this species.

Comparison with related species.—Only a single species of the genus *Hippomolgus*, *H. furcifer* Sars (1917), has been known until now. This species was described on the basis of 3 females found free in 60 fathoms, muddy bottom, on the coast of Norway. Males of *Hippomolgus* are unknown, although Nicholls (1944, p. 46) has expressed the view that the male of *Hersiliodes dubia* Thompson and A. Scott (1903) is in reality a *Hippomolgus*. This opinion was followed by Krishnaswamy (1953), who reported males of *Hippomolgus dubia* from the plankton of Madras. It seems improbable to us, however, that *Hersiliodes dubia* is a *Hippomolgus*. The mandible, described by Thompson and Scott as having "2 horizontal plumose projections and 2 plumose setae," is very different. Bocquet and Stock (1957) think it probable that a new genus should be created for *Hersiliodes dubia*.

Like *Hippomolgus furcifer*, *H. latipes* has a body form that is less cyclopoid and more harpacticoid, has a relatively short 6-segmented first antenna with a prominent aesthete on each of the last 3 segments, lacks paragnaths, and has a generally similar structure of the second antennae, mouthparts, and legs 1–5.

There are, however, important differences between these 2 species (based of necessity on the female only). In *H. latipes* the first segment of the first antenna does not bear a spine such as described in *H. furcifer*. The mandible bears 3 terminal elements (2 spines and

1 seta) instead of 4, as in Sars' figure (pl. 82, m). The maxilliped is 4-segmented, the last segment ornamented with a small fanlike fringe, instead of being 3-segmented as in Sars' figure (pl. 82, mp[2]). The armature of the last segment of the endopod of leg 1 is I,3 instead of I,II,3 as in Sars' species. The free segment of leg 5 is expanded instead of being narrow as in *H. furcifer.* The caudal ramus is only 3 times longer than wide instead of about 13:1 as in the Norwegian species. The length of the female is 1.13 mm, instead of 1.40 mm as in *H. furcifer.*

Hippomolgus cognatus, new species

FIGURES 59–69

TYPE MATERIAL.—Holotype ♀ (USNM 113397) from a colony of *Tubipora musica* (Linnaeus), in 1 m, Pte. Ambarionaomby, Nosy Komba, near Nosy Bé, Madagascar, collected Mar. 31, 1964, deposited in the United States National Museum.

OTHER MATERIAL.—2 ♀♀ from *Tubipora musica*, in 1 m, Pte. à la Fièvre, Nosy Bé, Jan. 5, 1964, 1 ♀ (USNM 113398) in the United States National Museum, the other (dissected) in the private collection of A. G. Humes.

FEMALE.—Body (fig. 59) resembling that of *H. latipes.* Length (not including setae on caudal rami) 0.90 mm (0.82–0.95 mm) and greatest width 0.29 mm (0.28–0.31 mm), based on 3 specimens. Ratio of length to width of prosome 1.56:1.

Segment of leg 5 broad, 78μ x 188μ. Genital segment (fig. 60) only slightly wider than long, 120μ in length, 132μ wide in its anterior half, and 110μ wide in its posterior half, where sides in dorsal view are nearly parallel. Areas of attachment of egg sacs located dorsolaterally on midregion of segment. Each area (fig. 61) with a slender naked seta 22μ long, a spine 8μ long, and 2 spinous processes. Three postgenital segments 66μ x 101μ, 60μ x 91μ, and 80μ x 82μ, respectively, from anterior to posterior.

Caudal ramus (fig. 62) 64μ x 31μ in greatest dimensions, or 3 times longer than wide. Outer lateral seta 25μ, outermost terminal seta 39μ, innermost terminal seta 88μ, 2 long terminal setae 220μ (outer) and 450μ (inner), dorsal seta 33μ long.

Ratio of prosome to urosome 1.17:1.

In single ovigerous female collected egg sac (fig. 63) 352μ x 138μ, reaching nearly to ends of caudal rami, with each egg about 47μ in diameter.

Rostral area (fig. 64) bearing 2 rows of minute denticles.

First and second antennae like those in *H. latipes.* Labrum (figs. 65, 66) ornamented as indicated in figures. Mandible (fig. 67) bearing 3 terminal elements as in *H. latipes*, but these with different ornamentation, i.e., with spinous processes on both sides of 2 spines and with seta naked. Paragnath absent. First and second maxillae and maxilliped like those in *H. latipes*.

Area behind mouth and between mouthparts with median lobe (lingua) weakly developed. Postoral area between maxillipeds and leg 1 (fig. 65) less protuberant than in *H. latipes*.

Legs 1–4 with same spine and setal formula as in *H. latipes*, except for endopod of leg 1 being 0:1; 0:1; I,4. Leg 1 (fig. 68) with inner spine on basis 22μ long and adjacent spiniform process asymmetrically bifurcated; terminal segment of endopod with 4 setae and with 3 small and rather obtuse processes between spine and first seta. Legs 2–4 resembling those of *H. latipes*.

Leg 5 (fig. 69) with relatively slender free segment, 61μ along inner and ventral margin, 51μ along outer and dorsal margin, and 22μ wide. Armature from dorsal to ventral consisting of spine 21μ, seta 50μ, spine 25μ, and spine 40μ in length, all ornamented as in figure.

Leg 6 probably represented by spine and seta near attachment of each egg sac (see fig. 61).

In other respects similar to *H. latipes*.

Color in life unknown.

Male.—Unknown.

Etymology.—The specific name *cognatus*, from Latin, meaning "related or closely allied," refers to apparent close relationship between this species and *H. latipes*.

Comparison with related species.—*H. cognatus* differs from *H. furcifer* Sars (1917) in lacking a spine such as described on the first segment of the first antenna in the Norwegian species, in having 3 terminal elements instead of 4 on the mandible, in having a 4-segmented maxilliped with a terminal fanlike fringe, in having the last segment of the endopod of leg 1 armed as I,4 instead of I,II,3 as in Sars' species, and in having a relatively much shorter caudal ramus, 3:1 instead of 13:1 as in *H. furcifer*. The length of the female is 0.90 mm instead of 1.40 mm as in the species described by Sars.

H. cognatus apparently is closely related to *H. latipes* but differs from it chiefly in the form of the genital segment, the presence of denticles on the rostral area, the form and ornamentation of the labrum, the ornamentation of the 3 elements on the mandible, the armature of the last segment of the endopod of leg 1, and the form of the free segment of leg 5.

Association of the two clausidiids with the alcyonarian.—Whether *Hippomolgus latipes* and *H. cognatus* live in a close association with *Tubipora musica* or occur only sporadically in the coral colony is difficult to determine on the basis of the relatively few specimens collected. (No *Hippomolgus* were found in 4 other colonies of *Tubipora musica.*)

Literature Cited

Bocquet, C., and Stock, J. H.

1957. Copépodes parasites d'invertébrés des côtes de France, 1: Sur deux genres de la famille des Clausidiidae, commensaux de mollusques: *Hersiliodes* Canu et *Conchyliurus* nov. gen. Proc. Koninkl. Nederlandsche Akad. Wetensch. Amsterdam, ser. C, vol. 60, no. 2, pp. 212–222.

Brady, G. S.

1910. Die marinen Copepoden der Deutschen Südpolar-Expedition 1901–1903, 1: Über die Copepoden der Stämme Harpacticoida, Cyclopoida, Notodelphyoida und Caligoida. No. 5 *of* vol. 11 (Zool. vol. 3) *in* Deutsche Südpolar-Expedition 1901–1903, pp. 497–593.

Gurney, R.

1927. Zoological results of the Cambridge expedition to the Suez Canal, 1924, XXXIII: Report on the Crustacea: Copepoda (Littoral and semiparasitic). Trans. Zool. Soc. London, vol. 22, no. 4, pp. 451–577.

Humes, A. G., and Frost, B. W.

1964. New lichomolgid copepods (Cyclopoida) associated with alcyonarians and madreporarians in Madagascar. Cah. O.R.S.T.O.M. Océanogr., Sér. Nosy-Bé, vol. 2, no. 6, pp. 131–212.

Krishnaswamy, S.

1953. Pelagic Copepoda of the Madras coast. Journ. Madras Univ., vol. 23 B, no. 1, pp. 61–75.

Nicholls, A. G.

1944. Littoral Copepoda from South Australia, II: Calanoida, Cyclopoida, Notodelphyoida, Monstrilloida and Caligoida. Rec. South Australian Mus., vol. 8, no. 1, pp. 1–62.

Sars, G. O.

1917. Clausidiidae, Lichomolgidae (part). Pts. 11 and 12 *of* vol. 6 (Copepoda, Cyclopoida) *in* An account of the Crustacea of Norway with short descriptions and figures of all the species, pp. 141–172.

Sewell, R. B. S.

1949. The littoral and semi-parasitic Cyclopoida, the Monstrilloida and Notodelphyoida. No. 2 *of* vol. 9 *in* John Murray Expedition 1933–34 Scientific Reports, pp. 17–199.

Stock, J. H.

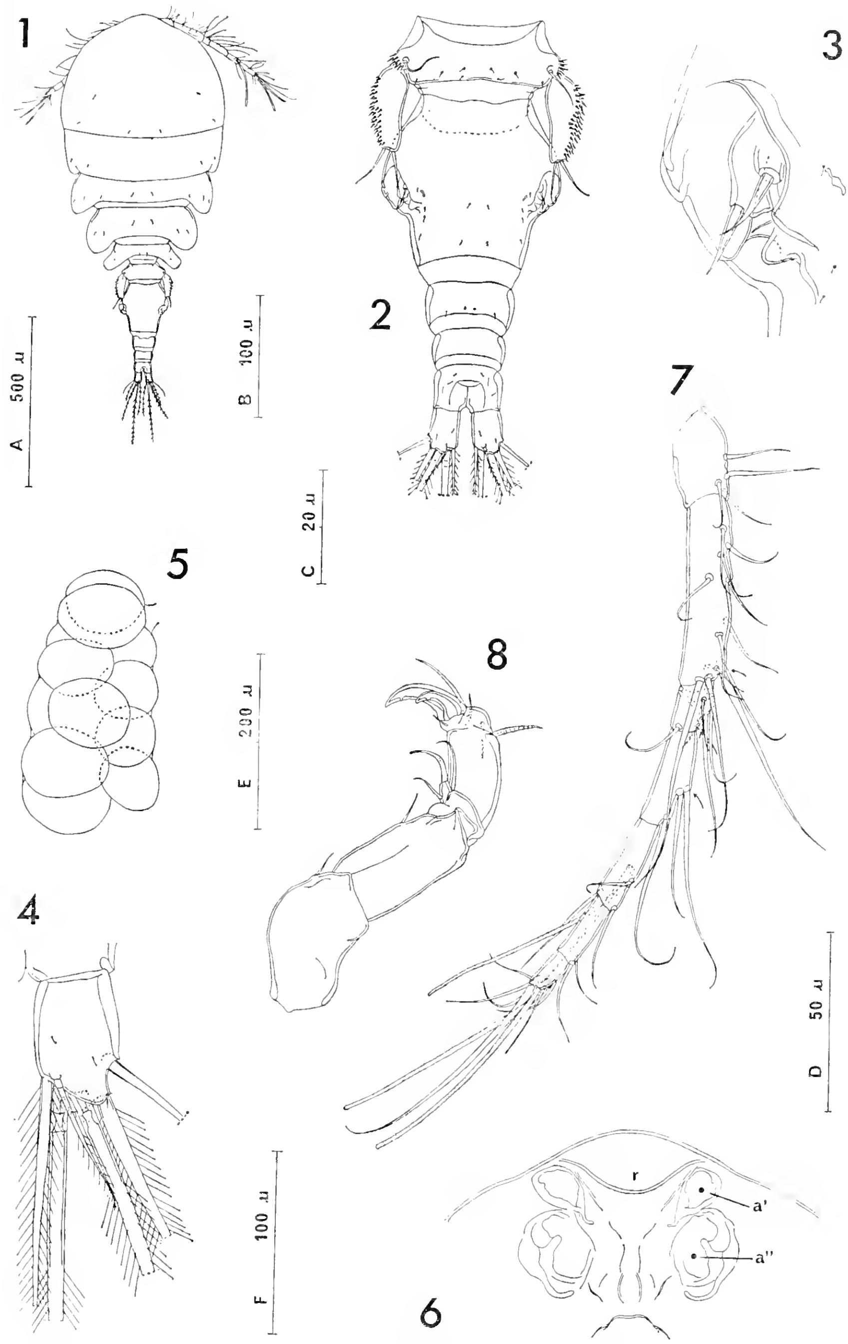
1959. Copepoda associated with Neapolitan invertebrates. Pubbl. Staz. Zool. Napoli, vol. 31, no. 1, pp. 59–75.

Thompson, I. C., and Scott, A.

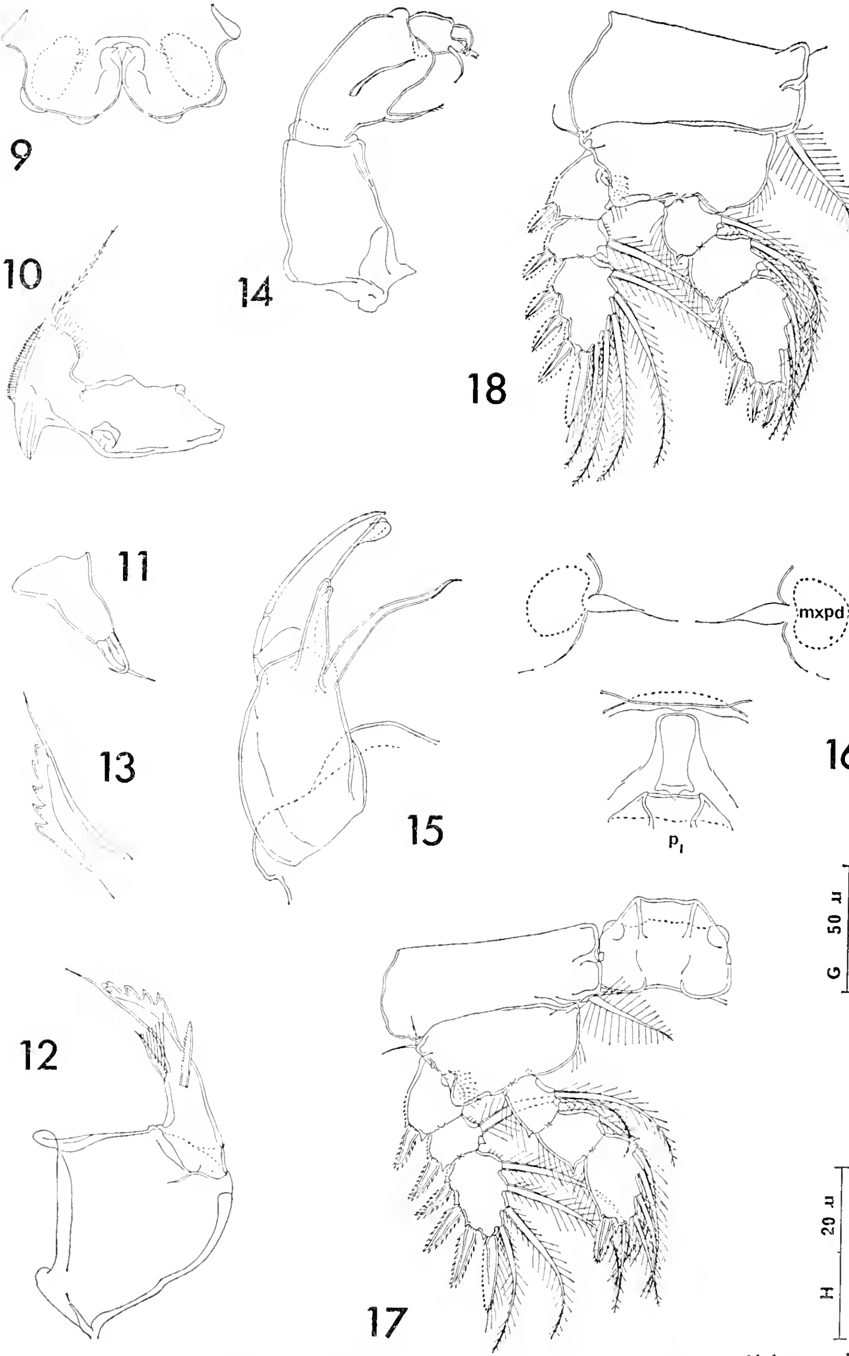
1903. Report on the Copepoda collected by Professor Herdman, at Ceylon, in 1902. Rep. Gov. Ceylon Pearl Oyster Fish. Gulf of Manaar, suppl. rep., no. 7, pp. 227–307.

Ummerkutty, A. N. P.

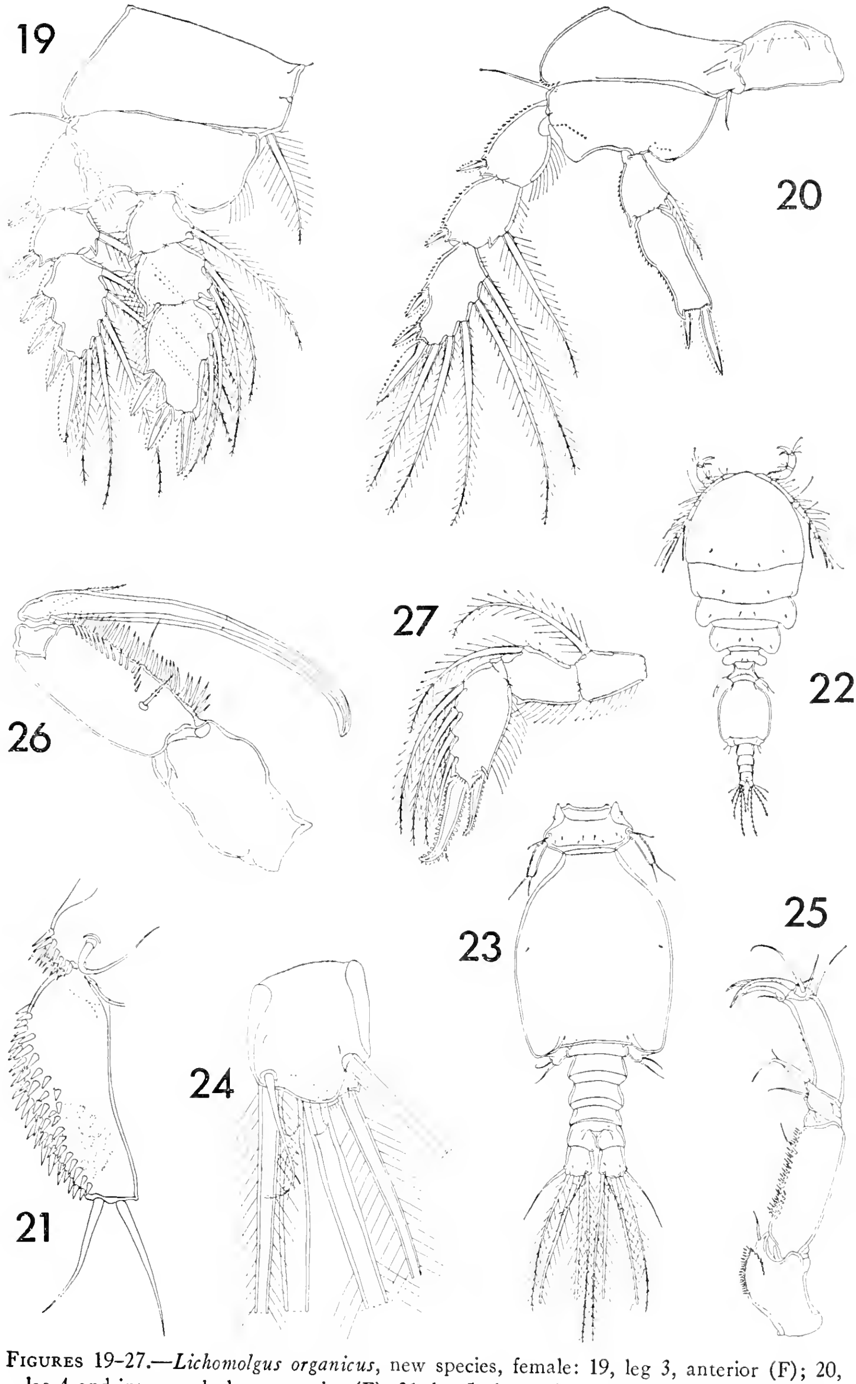
1962. Studies on Indian copepods, 5: On eleven new species of marine cyclopoid copepods from the south-east coast of India. Journ. Mar. Biol. Assoc. India, 1961, vol. 3, nos. 1 and 2, pp. 19–69.



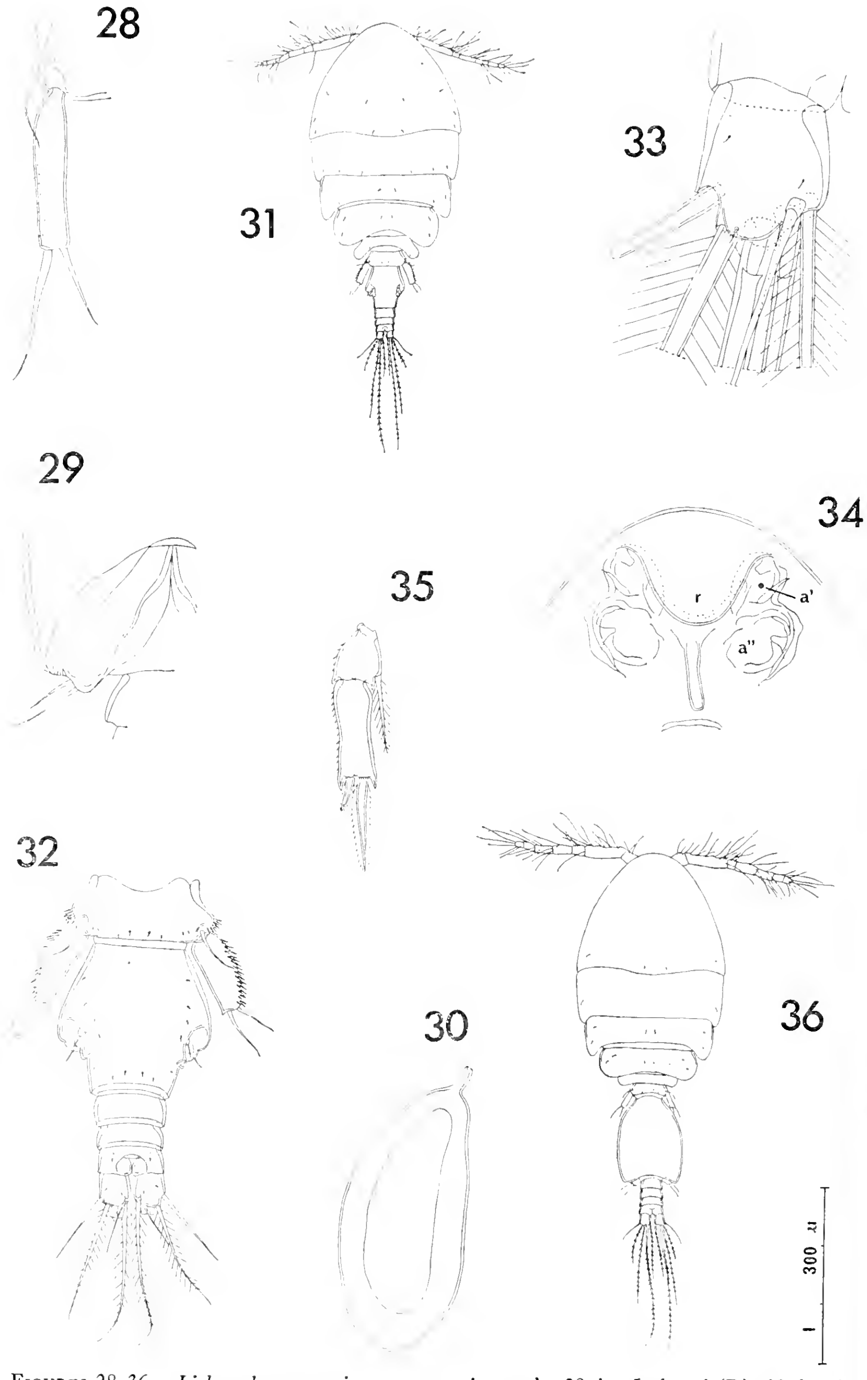
FIGURES 1–8.—*Lichomolgus organicus*, new species, female: 1, dorsal (A); 2, urosome, dorsal (B); 3, area of attachment of egg sac, dorsal (C); 4, caudal ramus, dorsal (D); 5, egg sac, dorsal (E); 6, rostral area, ventral (B); 7, first antenna, with two arrows indicating positions of aesthetes added in male, dorsal (F); 8, second antenna, posterior (F). (Capital letters=scale at which drawn; a′=first antenna, a″=second antenna, r=rostral area.)



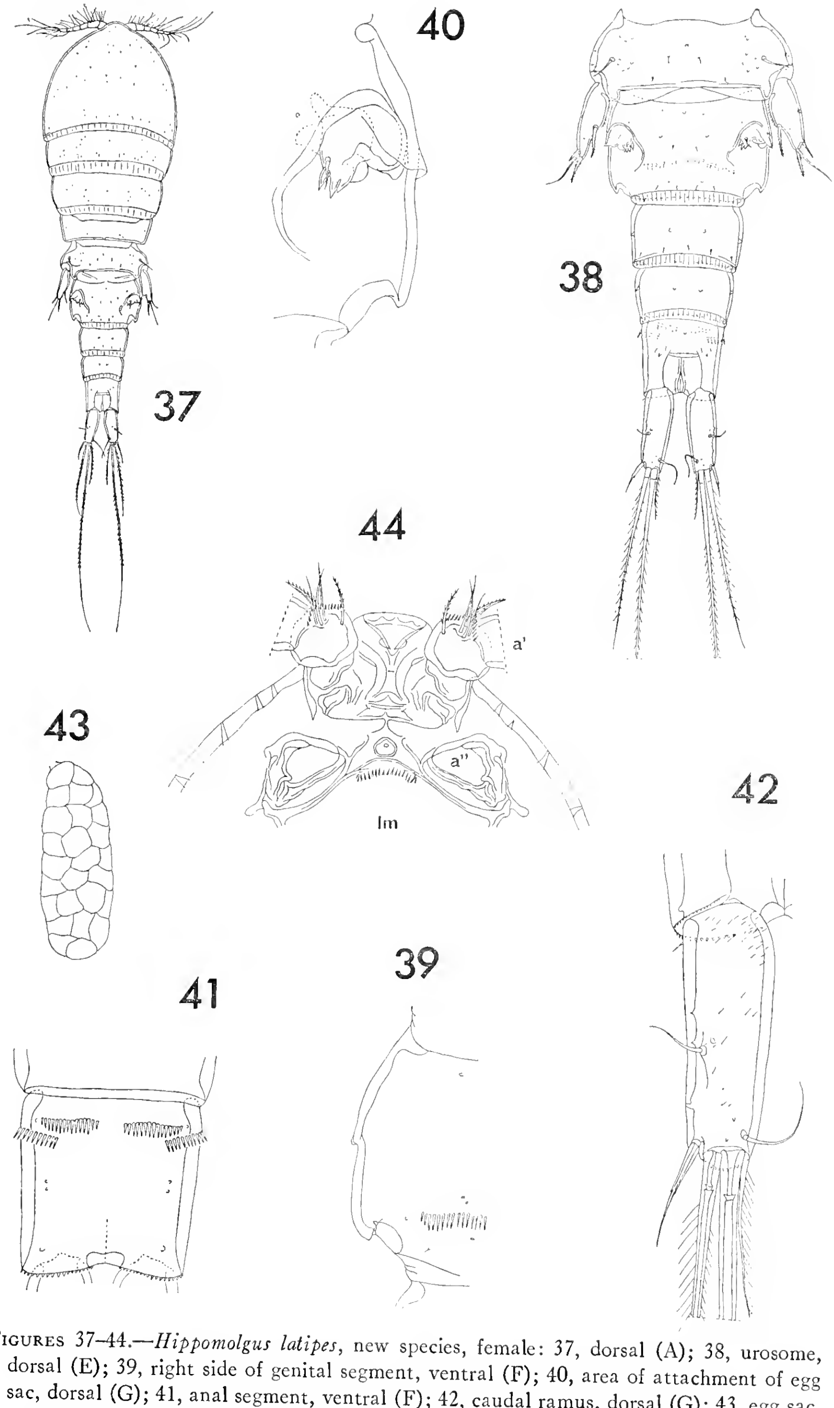
FIGURES 9–18.—*Lichomolgus organicus*, new species, female: 9, posterior part of labrum, with paragnaths indicated by dashed lines, ventral (G); 10, mandible, posterior (G); 11, first maxilla, posterior (G); 12, second maxilla, postero-inner (G); 13, tip of second maxilla, postero-inner (D); 14, maxilliped, posterior (G); 15, terminal segment of maxilliped, antero-inner (H); 16, postoral area between maxillipeds and leg 1, ventral (F); 17, leg 1 and intercoxal plate, anterior (F); 18, leg 2, anterior (F). (Capital letters=scale at which drawn; mxpd=maxilliped, P_1=leg 1.)



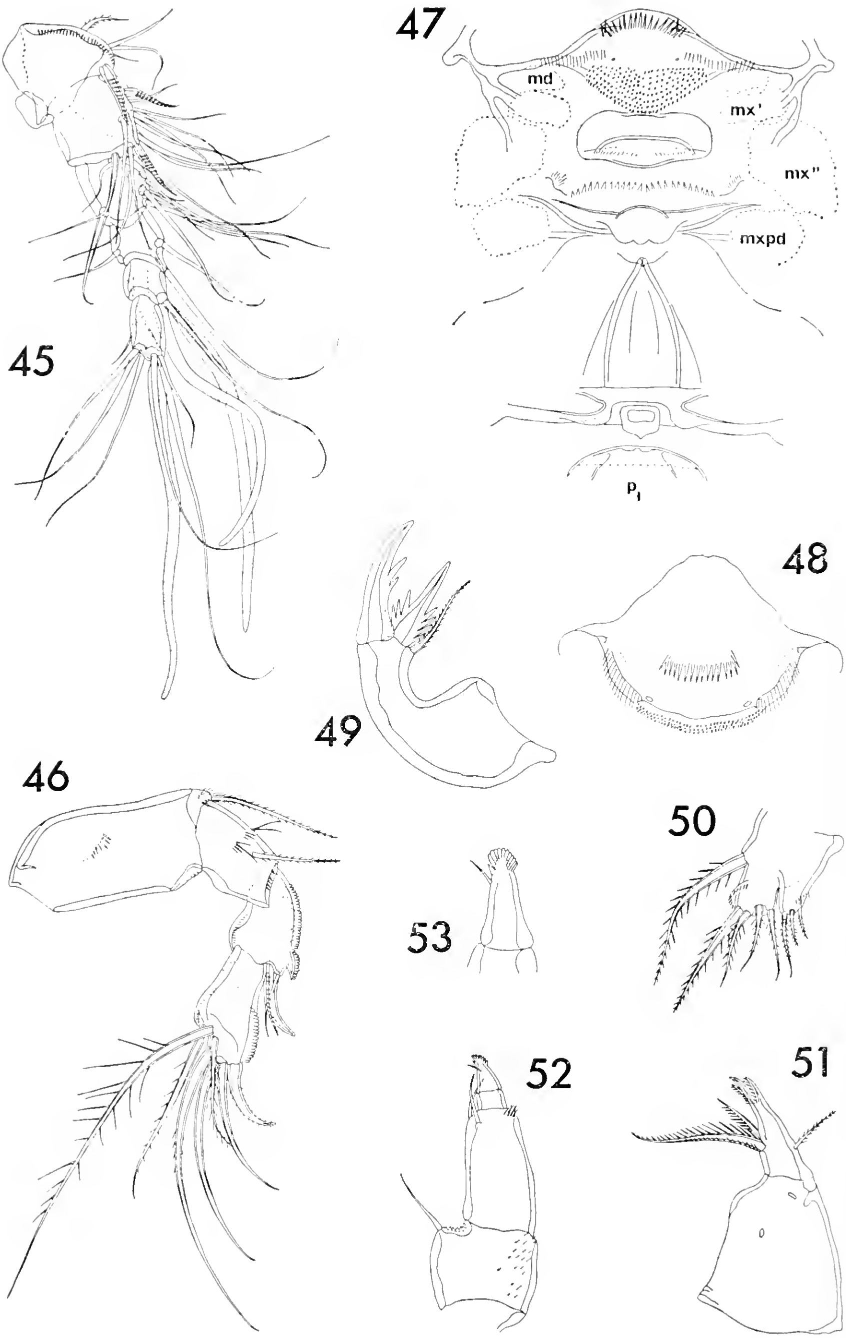
Figures 19–27.—*Lichomolgus organicus*, new species, female: 19, leg 3, anterior (F); 20, leg 4 and intercoxal plate, anterior (F); 21, leg 5, dorsal (D). Male: 22, dorsal (A); 23, urosome, dorsal (B); 24, caudal ramus, dorsal (C); 25, second antenna, anterior (F); 26, maxilliped, anterior (F); 27, endopod of leg 1, anterior (G). (Capital letters=scale at which drawn.)



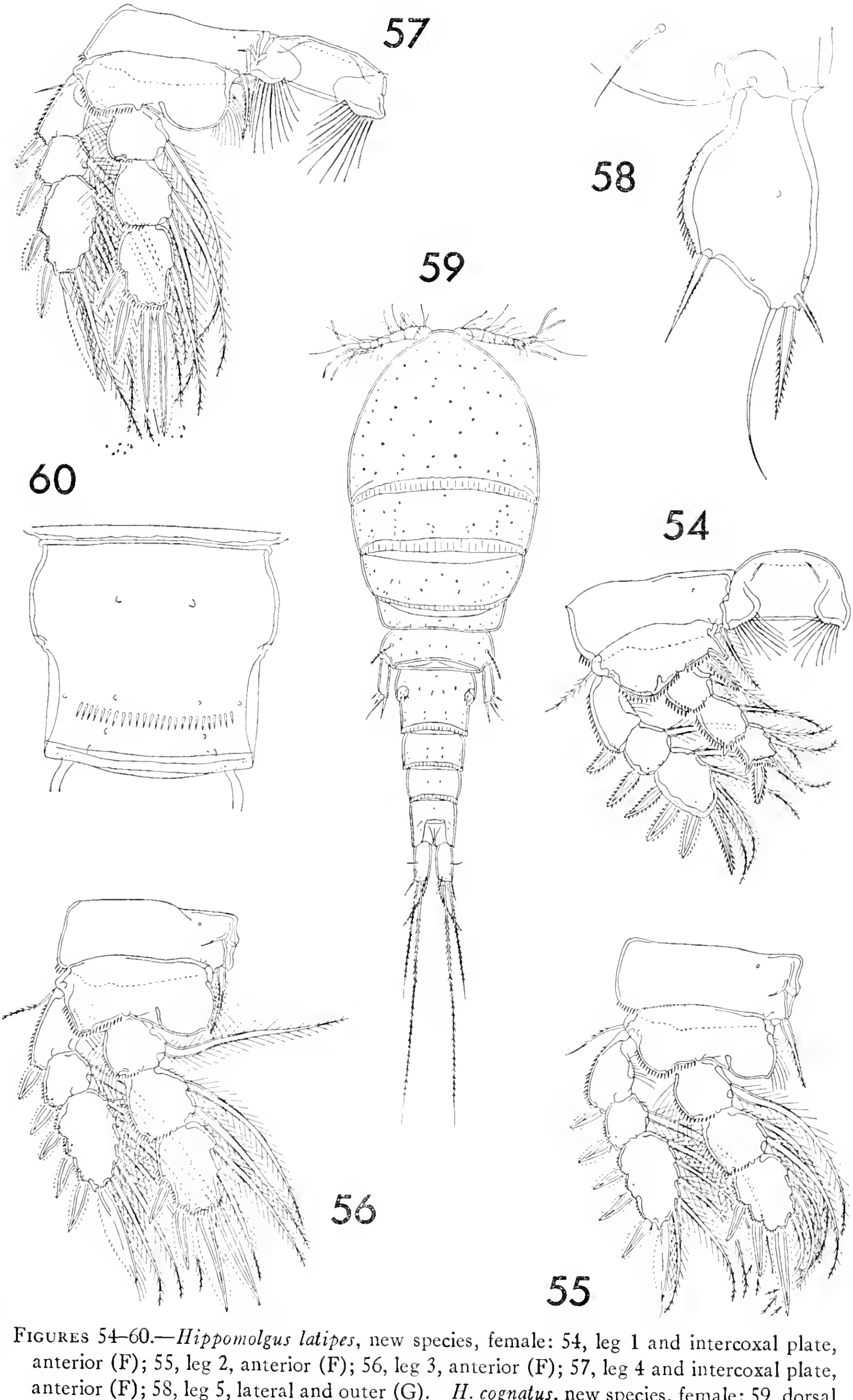
FIGURES 28–36.—*Lichomolgus organicus*, new species, male: 28, leg 5, dorsal (D); 29, leg 6, ventral (G); 30, spermatophore, inside male, ventral (F). *Lichomolgus conjunctus*, new species, female: 31, dorsal (A); 32, urosome, dorsal (B); 33, caudal ramus, dorsal (C); 34, rostral area, ventral (B); 35, endopod of leg 4, anterior (F). Male: 36, dorsal (I). (Capital letters=scale at which drawn; a′=first antenna, a″=second antenna, r=rostral area.)



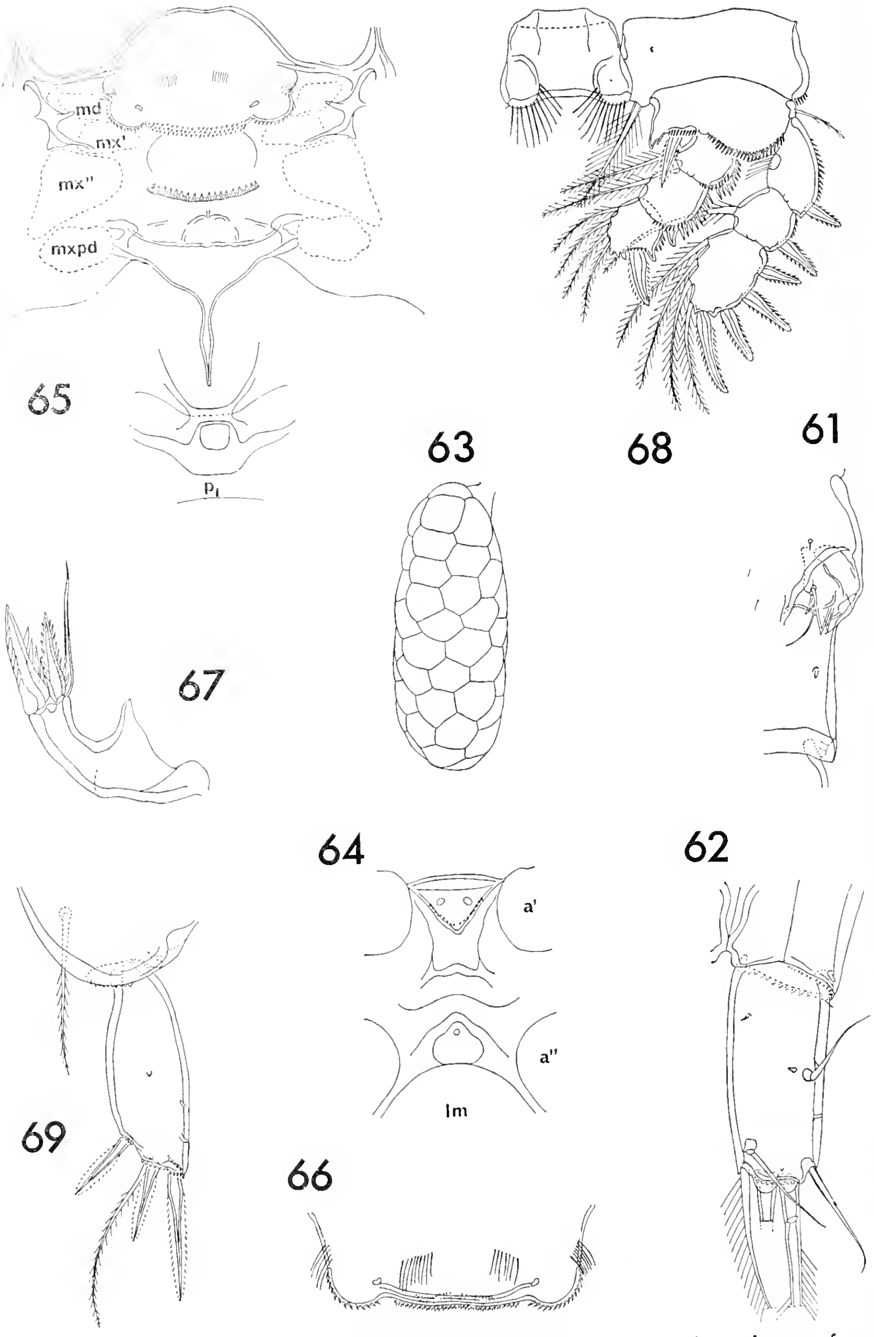
FIGURES 37–44.—*Hippomolgus latipes*, new species, female: 37, dorsal (A); 38, urosome, dorsal (E); 39, right side of genital segment, ventral (F); 40, area of attachment of egg sac, dorsal (G); 41, anal segment, ventral (F); 42, caudal ramus, dorsal (G); 43, egg sac, lateral (I); 44, rostral area, ventral (F). (Capital letters=scale at which drawn; a′=first antenna, a″=second antenna, lm=labrum.)



FIGURES 45–53.—*Hippomolgus latipes*, new species, female: 45, first antenna, dorsal (G); 46, second antenna, posterior (D); 47, oral and postoral areas, with labrum erected, ventral (G); 48, labrum, ventral (G); 49, mandible, posterior (C); 50, first maxilla, anterior (D); 51, second maxilla, anterior (D); 52, maxilliped, anterior (D); 53, last segment of maxilliped, ventral (H). (Capital letters=scale at which drawn; md=mandible, mx'=first maxilla, mx"=second maxilla, mxpd=maxilliped, p_1=leg 1.)



FIGURES 54–60.—*Hippomolgus latipes*, new species, female: 54, leg 1 and intercoxal plate, anterior (F); 55, leg 2, anterior (F); 56, leg 3, anterior (F); 57, leg 4 and intercoxal plate, anterior (F); 58, leg 5, lateral and outer (G). *H. cognatus*, new species, female: 59, dorsal (I); 60, genital segment, ventral (F). (Capital letters=scale at which drawn.)



FIGURES 61–69.—*Hippomolgus cognatus*, new species, female: 61, area of attachment of egg sac, dorsal (G); 62, caudal ramus, dorsal (D); 63, egg sac, lateral (E); 64, rostral area, ventral (G); 65, oral and postoral areas, ventral (G); 66, free edge of labrum, ventral (D); 67, mandible, posterior (C); 68, leg 1, anterior (G); 69, leg 5, ventrolateral (D). (Capital letters=scale at which drawn; md=mandible, mx′=first maxilla, mx″=second maxilla, mxpd=maxilliped; P_1=leg 1, a′=first antenna, a″=second antenna, lm=labrum.)

U.S. GOVERNMENT PRINTING OFFICE: 1967

Proceedings of the United States National Museum

SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 121 | 1967 | Number 3574

COPEPOD CRUSTACEANS PARASITIC ON TELEOST FISHES OF THE HAWAIIAN ISLANDS[1]

By ALAN G. LEWIS[2]

Introduction

This is the third and last of a series of papers covering the copepod parasites of Hawaiian fishes. The first (Lewis, 1964a) deals with the caligoid copepod parasites of Hawaiian acanthurid fishes, the second (Lewis, 1966) covers the copepod crustaceans parasitic on elasmobranch fishes, and the present paper deals with copepod crustaceans parasitic on teleost fishes. An additional paper (Lewis, 1964b), dealing with the caligoid genus *Dentigryps*, includes descriptions of two species found on Hawaiian fishes.

Other than the papers mentioned above, the references to copepods taken from Hawaiian teleosts are those of Nordmann (1864), describing *Norion expansus* and *Peniculus calamus* from unknown hosts, and Edmondson (1946), who figures a species of *Lernaeenicus* from dolphins. Bonnet (1948) lists some Hawaiian copepods taken primarily from pelagic fishes, and Shiino (1963) describes *Midias lobodes*, *Caligus coryphaenae*, and *Brachiella thynni* from fishes examined in the Honolulu Fish Market. In addition to these, Randall

[1] This study was supported by grants (G-24956 and GB-2464) from the National Science Foundation.

[2] Associate Professor of Oceanography, Institute of Oceanography, University of British Columbia, Vancouver, Canada.

(1958) lists, by family, the copepods taken from the stomachs of some parasite-picking fishes of the genus *Labroides* and (1961) the parasitic copepods taken from the Manini (*Acanthurus triostegus sandvicensis*).

The study here reported has benefited from collections made by the Honolulu division of the U.S. Fish and Wildlife Service and from the assistance given to the author by the Division of Marine Invertebrates of the Smithsonian Institution, especially by Drs. Bowman, Manning, and Cressey, whose assistance with the synonymies is deeply appreciated. The author is also grateful to the officers and crew of the U.S. Coast Guard vessel *Buttonwood* and to Lester Zukeran and Samuel Kaolulo for the collection of both host and copepod material.

Methods.—The external surface, gill cavities, buccal cavity, and nasal cavities of the teleost hosts were examined for parasitic copepods. Copepods collected were killed in either 95 percent ethyl alcohol or 10 percent formalin and later transferred to 95 percent ethyl alcohol. Specimens to be drawn or dissected were placed in 85 percent lactic acid to clear and soften them, stained with Chlorazol Black E dissolved in 85 percent lactic acid, and then placed in benzyl alcohol for final clearing and for dissection and drawing.

Drawings of the entire animal were made from specimens placed in benzyl alcohol and covered with a cover slip, supported so that the shape of the organism was not distorted. Both a camera lucida and a Bausch and Lomb Tri-Simplex Micro-Projector were used in making the drawings. The appendages and processes were drawn in situ or were removed and mounted in either Hoyer's mounting medium or a 1:1 mixture of Turtox's CMC–10 and CMC–S. Measurements were made with an ocular micrometer on specimens softened in lactic acid and held loosely in place by a cover slip supported by spacers.

In the following figures the ♀ and ♂ signs are used separately under each drawing to indicate a difference between the appendage or body part of the female and that of the male. The symbols are used together (♀ ♂) to indicate the similarity of the appendage or body part in both sexes. In the latter case the sex of the specimen from which the drawing is made is indicated by a line under the appropriate symbol. If only one sex is represented in the collection, the symbols are not used.

Terminology.—The term "cephalothorax" is used to indicate a condition in which one or more of the thoracic segments are fused with the cephalon. The maxilliped-bearing segment is considered as the first thoracic segment. The term "pedigerous segment" is used to indicate a leg-bearing thoracic segment, while the terms "free thoracic segments" or "free pedigerous segments" are used to designate those thoracic segments that are not fused with the cephalon. The term "genital segment" is used, although with some question, to designate the fused sixth and seventh thoracic segments (=fifth and sixth pedigerous segments) in the Caligidea (Caligoidea of Yamaguti, 1963). In the lernaeocerids, pennellids, and lernaeopodoids, the terms "cephalothorax" and "trunk" are used. The term "cephalothorax" has the same meaning as that given above, while the term "trunk" designates the region immediately posterior to the cephalothorax. The term "ovigerous" is used to indicate a female with egg strings, the term "nonovigerous" to indicate a female without egg strings even though the genital segment (or trunk) may contain eggs.

With three exceptions, the terminology applied to the appendages and processes is the same as that in Lewis (1964a). Thus, the term "antennules" refers to the first antennae and the term "antennae" refers to the second. The term "mandibles" refers to the pair of appendages immediately adjacent to the mouth and normally projecting into a "mouth cone" if it is present. The term "maxillipeds" refers to the modified pair of appendages on the first thoracic segment, while the "sternal furca" is a bifurcate, posteroventrally directed projection between and slightly posterior to the maxilliped bases of trebiids, euryphorids, and caligids. The term "thoracic legs" designates the pair of semifoliaceous or foliaceous appendages arising from some of the thoracic segments posterior to the first or maxilliped-bearing segment, while the "caudal rami" are the pair of appendages at the posterior end of the body.

The three exceptions to the original terminology have arisen from a recently completed study made by the author on the nature of the maxillae in the Caligidea (ms in preparation). It appears that the setule- or seta-bearing node lateral to the mouth cone of this group of caligoids is the maxillule, but it seems that the spine or plate immediately behind this structure in the trebiids, eirgids, euryphorids, and caligids is an accessory formation and not part of the maxillule. The name "maxillule" is now given to the setule-bearing node (maxillary palp of Yamaguti, 1963), while the term "postoral process" refers only to the spine or plate immediately behind the maxillule. The term "maxillae" applies to the second pair of maxillae with its associated pair of openings to the maxillary glands. The term "postantennal process" is used to designate the process-bearing nodules and the spinelike projection, if present, situated lateral and slightly posterior to the base of the antenna.

To facilitate the use of the thoracic leg tables, a hypothetical thoracic leg is shown in figure 1, giving the various thoracic leg armature elements used in the tables. Further, an analysis of the hypothetical thoracic leg is given in table 1.

In the section entitled "Material" for each of the species, the abbreviation USFWS means U.S. Fish and Wildlife Service, HMS means the USFWS vessel *Hugh M. Smith*, CHG the USFWS vessel

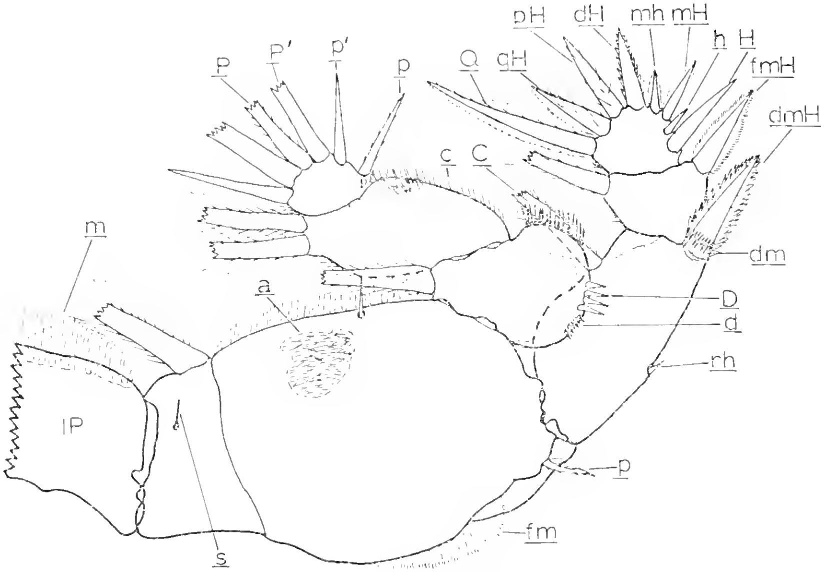


FIGURE 1.—Hypothetical thoracic leg showing various armament components:

a: adhesion surface
C: heavy fringing plumosities
c: light fringing plumosities
D: large denticulations
d: small denticulations
dH: large denticulated spine
dm: denticulated membrane
dmH: large spine with denticulated membrane
fm: frilled membrane
fmH: large spine with frilled membrane
H: large spine
h: small spine
IP: interpodal plate
m: membrane
P: plumose seta
p: plumose setule
P′: naked seta
p′: naked setule
pH: large plumose spine
Q: seta plumose on one side and membranous on other
qH: large spine plumose on one side and membranous on other
rh: spinule
s: solitary hairlike process

TABLE 1.—*Armature of hypothetical thoracic leg shown in figure 1*

Leg	Surface	Interpodal Plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
	Outer	m		fm,p	rh,dm, dmH	fmH	H,h,mH, mh,dH	d,D, C	c	d,p,p′,P′, P
	Inner		s,P	m,a,s	c,P	c,P	c,Q,qH,pH	P	c,2P	c,p′,P′

Charles H. Gilbert, JRM the USFWS vessel *J.R. Manning*, and LL means a USFWS longline cruise on board a chartered vessel.

The names of the Hawaiian fishes that served as hosts are taken from the "Handbook of Hawaiian Fishes" by Gosline and Brock (1960). The names of previously reported hosts are as they appear in the references giving these hosts.

A list of the Hawaiian fishes examined is given following the descriptions. Included in this list are the species of copepods found on each of the hosts.

Order Cyclopoida

Family Bomolochidae

Pseudotaeniacanthus Yamaguti and Yamasu, 1959

Diagnosis.—Body cyclopoid, cephalon fused with first 2 thoracic segments, slightly broader than rest of prosome; second to fifth pedigerous segments gradually narrowed posteriorly, projecting laterally over respective protopodites; fifth pedigerous segment not appreciably expanded laterally. Abdomen 4-segmented. Antennule 5- or 6-segmented; antenna uniramous, with 4 clawlike terminal spines. Postantennal processes present, fused, Y-shaped, with rows of spinules giving brushlike appearance, with or without large, posterior hooks at apex of Y. Maxillule setiferous; maxillae as in other bomolochids or reduced; maxilliped clawlike in male, reduced in female. Thoracic legs 1–4 biramous, rami 3-segmented; endopodite of first leg longer than exopodite, with few marginal setae; fifth and sixth legs uniramous.

Pseudotaeniacanthus puhi, new species

Figures 2, 3

Material.—One adult female (holotype, USNM 112862), 1 adult male (allotype, USNM 112863), 12 adult females, and 8 adult males (paratypes, USNM 112864) from the gill cavity of a "Brown Moray" from the Honolulu Aquarium. One adult female and 1 adult male (paratypes, USNM 112865) from the gill cavity of a "Green Moray" from the Honolulu Aquarium.

Measurements.—(In mm) 14 females and 10 males:

	female		male	
	mean	range	mean	range
Greatest length, excluding caudal setae	1. 15	0. 92–1. 27	1. 05	0. 92–1. 18
Length of prosome	0. 78	0. 68–0. 88	0. 66	0. 54–0. 74
Width of prosome	0. 39	0. 35–0. 42	0. 37	0. 32–0. 42
Length of cephalothorax	0. 30	0. 27–0. 32	0. 32	0. 28–0. 37
Length of genital segment	0. 10	0. 09–0. 12	0. 11	0. 08–0. 14
Width of genital segment	0. 14	0. 13–0. 15	0. 14	0. 13–0. 16
Length of egg sac (3 sacs)	0. 16, 0. 18, 0. 48			

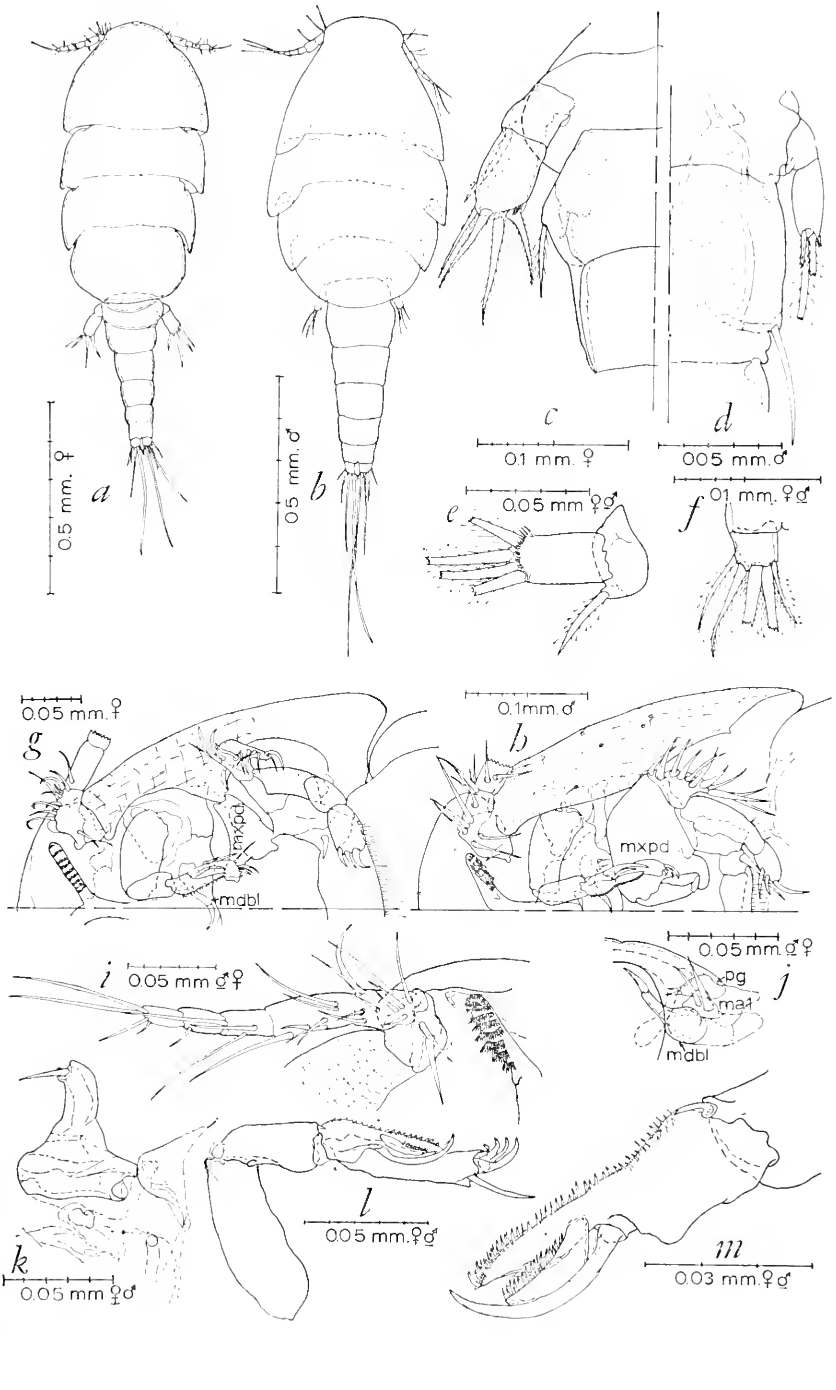
Description.—Female cephalothorax (fig. 2*a*) bell shaped, consisting of cephalon, maxilliped-bearing, and first pedigerous segments. Second pedigerous segment distinct from and slightly narrower than cephalothorax; third pedigerous segment distinct from and slightly narrower than second; fourth pedigerous segment distinct from and slightly narrower than third, broadly rounded posteriorly. Fifth pedigerous segment approximately half the width of fourth, anterior end overhung by posterior end of fourth pedigerous segment. Genital segment (fig. 2*c*) distinct from fifth pedigerous segment, lateral margins convex; oviducal opening surrounded by series of small sclerites. Remaining urosome segments 4 in number, each tapered slightly, narrower and shorter than preceding segment. Caudal ramus (fig. 2*f*) subrectangular, short, with 2 long and 3 short terminal setae.

Male prosome (fig. 2*b*) more ovoid than that of female, general makeup otherwise similar. Urosome tapered, genital segment (fig. 2*d*) similar in shape to remaining 4 urosome segments although larger.

Female and male antennule (fig. 2*i*) 5- or 6-segmented, proximal segment expanded on proximal posterior surface. Female and male antenna (figs. 2*l*, *m*) uniramous, 3-segmented, situated posterior and slightly lateral to antennule base; first segment approximately one and one-half times the length of second, both segments without armature. Third segment elongate, length slightly less than that of first segment, proximal portion with folded, flaplike extension with denticulations, naked seta and large, spinelike projection distally (fig. 2*m*) Distal end of third segment with 1 naked seta and 4 clawlike spines.

Female and male mandible (fig. 2*j*) rodlike, 2-parted. First part tapered slightly from proximal to distal end, second part tapered to pointed distal end, curved inward slightly distally. Female and male with Y-shaped postantennal process on anterior ventral surface (fig. 2*i*), arms of Y with 9–10 transverse rows of spinules giving brushlike appearance. Female and male maxillule (fig. 2*j*) situated immediately posterior to mandible base, consisting of pair of setae attached to platelike area of heavy sclerotization contiguous with posterior edge of platelike area of heavy sclerotization forming attachment surface for mandible. Maxilla (fig. 2*k*) represented by large,

Figure 2.—*Pseudotaeniacanthus puhi*, new species, dorsal view: *a*, female; *b*, male. Fifth pedigerous segment, fifth leg, genital segment, sixth leg, and first abdominal segment: *c*, female; *d*, male, same, also includes anterior end of fiıst abdominal segment. Right fifth leg: *e*, posterior view. Ventral view: *f*, caudal ramus; *g*, female cephalothorax (mdbl= mandible, mxpd=maxilliped); *h*, male cephalothorax (mxpd=maxilliped); *i*, right antennule and heavily sclerotized postantennal process; *j*, right mandible (mdbl), maxillule (ma-1), and paragnath (pg); *k*, maxilla; *l*, antenna; *m*, projection on proximal portion of third segment of antenna.


a
0.5 mm. ♀
b
0.5 mm. ♂
c
0.1 mm. ♀
d
0.05 mm.♂
e
0.05 mm ♀♂
f
0.1 mm. ♀♂
g
0.05 mm.♀
mxpd
mdbl
h
0.1mm.♂
mxpd
i
0.05 mm ♂♀
j
0.05 mm.♂♀
pg
ma1
mdbl
k
0.05 mm ♀♂
l
0.05 mm.♀♂
m
0.03 mm.♀♂

heavily sclerotized, knoblike projection posterior and lateral to oral region. Knob with broad base, tapered to narrow distal region with

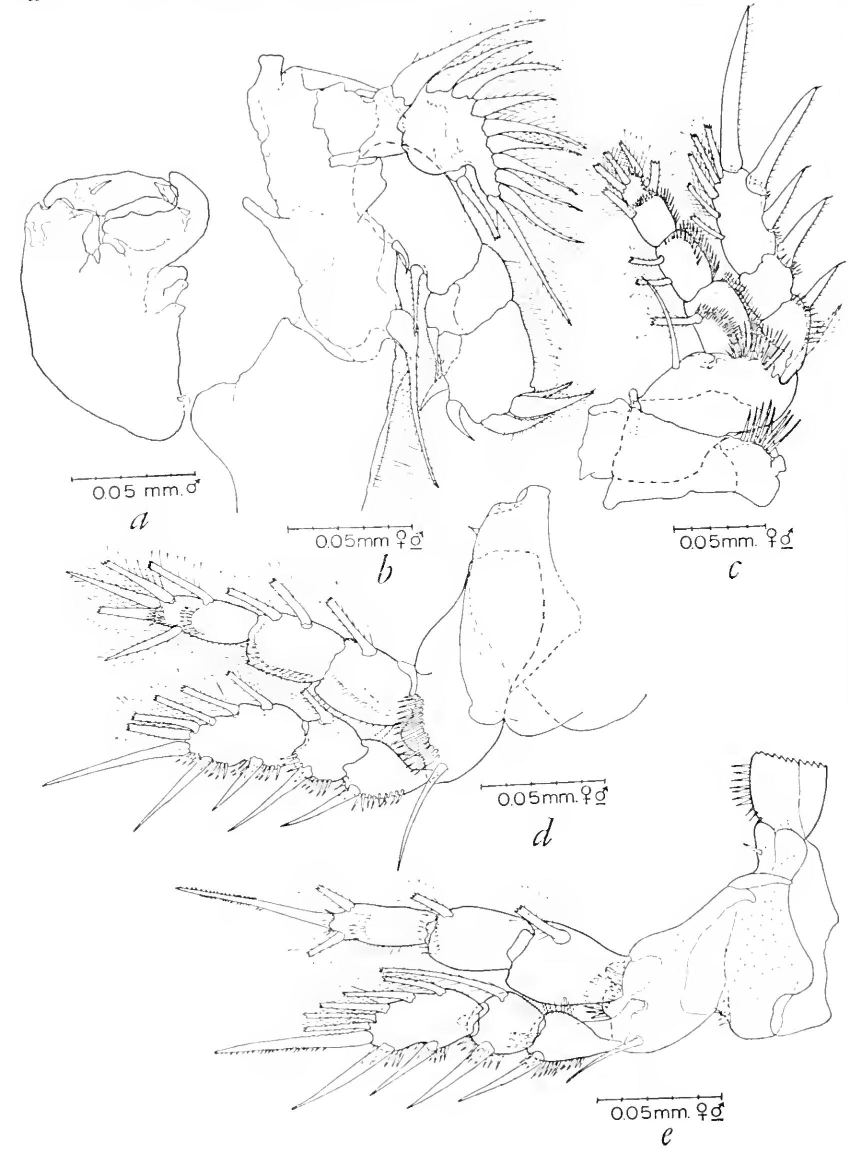


FIGURE 3.—*Pseudotaeniacanthus puhi*, new species: *a*, male maxilliped, ventral view. Thoracic legs: *b*, left first, anterior view; *c*, left, second, posterior view; *d*, right third posterior view; *e*, right fourth, posterior view.

medially facing cuplike indentation, indentation bearing single, seta-like process. Female and male paragnath (fig. 2*j*) minute, situated immediately posterior to maxillule, consisting of single, flabby, subconical projection bearing pair of setules distally.

Female maxilliped (fig. 2*g*) knoblike, broad based, distally concave, without armature. Male maxilliped (fig. 3*a*) 2-segmented, first segment large, strongly developed, narrow proximally, broad distally, with 3 small, lappet-like projections along inner surface and single, large, distally recurved projection from distal inner surface. Second segment fused with clawlike terminal process, bearing single, accessory seta proximally.

For nature of legs and armature, see figures 2*c–e*, 3*b–e*, and table 2.

TABLE 2.—*Armature of thoracic legs 1–4 of the female and male of* Pseudotaeniacanthus puhi, *new species*

Leg	Surface	Interpodal Plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
I	Outer	c	p			P	9P	c	c	c,3P
	Inner		P				P	p	p	2P′
II	Outer	D	D	P D	D, pII*	D, pII*	D,pH*,D,2pH	2D	2D	2D, P, 2D, 2P
	Inner			P′	c	P	5P	P	2P	2P
III	Outer	D	D	P D	D, pH	D, pII	D, pII,D,2pH	C,D	C, D	C, D, P, 2D, 2P
	Inner		rh		c	P	5P	P	2P	2P
IV	Outer	D	D	P D	D, pH	D, pH	D, pII,D, 2pH	2C	C, D	C, 2D, 2pH
	Inner		rh		c	P	5P	P	P	P

*Present on female, male=II.

DISCUSSION.—*Pseudotaeniacanthus puhi* differs from *P. congeri* Yamaguti and Yamasu, 1959, primarily in not having the large "posterior hooks" of the latter species, in the armature of the thoracic legs, and in the smaller thoracic pleura. The species name is derived from "Puhi," the Hawaiian name for moray eels, the host of the species.

Anchistrotos Brian, 1906

DIAGNOSIS.—Body cyclopoid, cephalothorax consisting of cephalon and first 2 thoracic segments. Cephalothorax the broadest part of prosome, 3 free prosomal segments tapering posteriorly. Small frontal region present, with rostrum. Abdomen 3- or 4-segmented; caudal rami short. Antennule 6- or 7-segmented, proximal segments not fused; antenna 3-segmented, distal segment with pectinate margin, bearing terminal claws and setae. Mandible 2-segmented, second segment with terminal blade and subterminal palp. Postantennal process well developed, clawlike. Maxillule nodular or conical, typically with 5 associated setae or setules; maxilla tipped with pectinate blade, with 1–2 subterminal setalike or palplike processes. Maxilliped with or without claw. Thoracic legs 1–4 biramous, first with 2- or 3-segmented rami; second to fourth with 3-segmented rami. Fifth legs uniramous, 2-segmented; sixth legs setiform or lacking.

REMARKS.—*Anchistrotos* is quite similar to *Taeniacanthus;* the only consistent difference appears to be that the length of the caudal rami of *Anchistrotos* is shorter than that of *Taeniacanthus.* The variation in this characteristic, however, is such that no distinct relationship can be stated. Yamaguti (1963) uses the presence of a "rostral projection at center of frontal margin" as a key characteristic to separate *Anchistrotos* from the remaining taeniacanthins, but this projection is not present in *A. occidentalis* Wilson, 1924, and is not apparent from the figures of several other species of the genus. Additionally, the frontal region of members of *Anchistrotos* and *Taeniacanthus* is similar. Wilson (1911a, p. 387) states that "the three basal joints [of the antennule are] thoroughly fused . . ." in the diagnosis of the genus *Taeniacanthus.* If this characteristic had been used in later descriptions (e.g., *Taeniacanthus sebastichthydis* Yamaguti, 1939a), it would have provided a better means of separating the two genera.

The following species is included in the genus *Anchistrotos* because it does have a slight rostral projection, the caudal rami are "short," the proximal 3 segments of the antennule are not fused, and, in general, the other characteristics most closely approximate those of the species previously described for the genus.

Anchistrotos moa, new species

FIGURES 4, 5

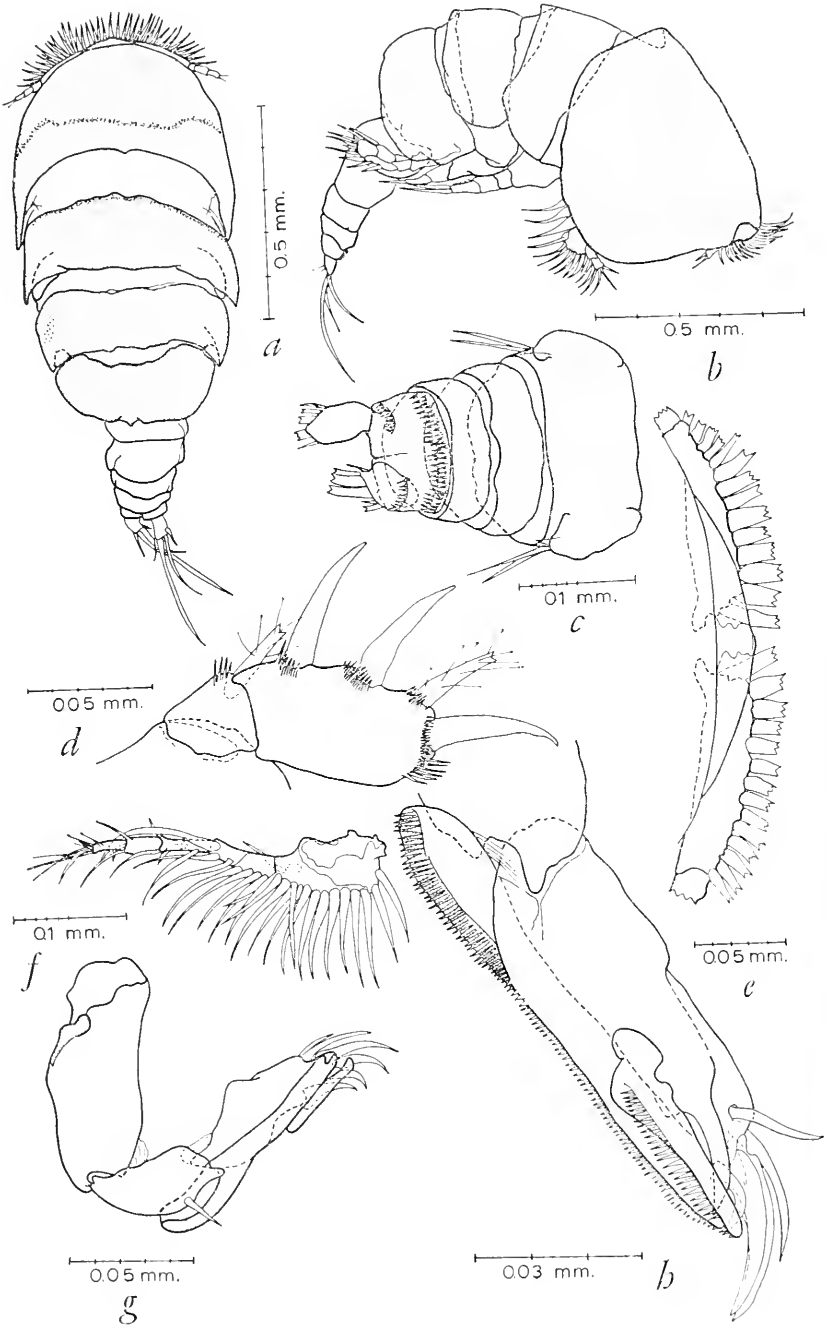
MATERIAL.—Two adult, nonovigerous females (holotype, USNM 112866; paratype, USNM 112868) from a specimen of *Ostracion lentiginosus* captured at Rabbit Island, adjacent to Oahu, Hawaii. Two adult nonovigerous females (paratypes, USNM 112867) collected from a second specimen of *O. lentiginosus* captured at Rabbit Island. All 4 specimens were given to the author without information concerning their location on the host.

MEASUREMENT.—(In mm) 4 females:

	mean	*range*
Greatest length, excluding caudal setae	0. 76	0. 70–0. 85
Length of prosome	0. 57	0. 52–0. 62
Width of prosome	0. 40	0. 34–0. 43
Length of cephalothorax	0. 33	0. 30–0. 36
Length of genital segment	0. 07	0. 06–0. 07
Width of genital segment	0. 13	0. 12–0. 14
Length of egg sac (1 sac)		0. 55

Description of female.—Body (figs. 4*a*, *b*) of general taeniacanthiform nature. Cephalothorax consisting of cephalon, maxilliped-bearing, and first pedigerous segments; second through fourth pedigerous segments distinct. Frontal region (fig. 4*e*) narrow, unarmed except for small, slightly projecting rostrum. Cephalothorax projecting ventrally well below ventral surface, extending posteriorly over lateral anterior surface of second pedigerous segment, with irregular, heavily sclerotized band across dorsal surface of posterior region. Second, third, and fourth pedigerous segments decreasing in width, with ventrally and posteriorly projecting extensions as on cephalothorax except not as well developed. Fourth pedigerous segment rounded posteriorly, extending over dorsal surface of fifth pedigerous or first urosomal segment. Genital segment (fig. 4*c*) indistinctly swollen, slightly larger than fifth pedigerous segment; sixth legs present as pair of very lightly plumose setae and spinule-like projection immediately posterior to oviducal openings. Abdomen 3-segmented, segments diminishing in length and width, from dorsal viewpoint. Ventral surface of third abdominal segment with 2 rows of minute spinules anteriorly, separated by pair of larger spinules medially, and incomplete row of spinules in region of attachment of caudal rami (fig. 4*c*). Caudal rami short, slightly longer than wide, with 2 long, lightly plumose median setae, 2 short outer setae, and 1 inner setule on distal surface.

Antennule (fig. 4*f*) 7-segmented although segmentation not completely distinct, first and second segments and third and fourth segments appearing partially fused. First segment with 5 lightly plumose setae along anterior surface; second with 11 on anterior, 3 on dorsal surface; third segment with 4 or 5 plumose setae anteriorly; fourth with 3; fifth with 4; sixth with 3 naked setules; seventh with one naked setule from distal posterior surface, 3 small, naked setules from posterior distal surface, 3 long, naked setules and one aesthete(?) from anterior distal surface. Antenna (figs. 4*g*, *h*) uniramous, 3-segmented; first segment tapered slightly toward distal end, with slight knob on outer distal corner. Second segment slightly more than half the length of first, with small spine on distal inner surface; third segment 1½ times the length of second, with large, elongate projection on inner surface, extending from distal end of segment proximally, past proximal end to form cup-shaped projection overlapping distal half of second segment. Additional irregularly awl-shaped projection present on distal ventral surface, projecting past distal end of segment. Both projections with complete marginal denticulations. Additional armature of third segment consisting of 3 naked setules and 4 clawlike spines distally.


0.5 mm.
a
0.5 mm.
b
0.1 mm.
c
0.05 mm.
d
0.05 mm.
e
0.1 mm.
f
0.05 mm.
g
0.03 mm.
h

Mandible (fig. 5*a*) 2-segmented, first segment slightly longer than second, second bearing 2 short, flattened, pectinate processes distally, ventralmost longest. Postantennal process (fig. 5*b*) well developed, consisting of spinelike falciform projection slightly posterior to antennule base and directed posteroventrally; base heavily sclerotized and enlarged, tip sharply pointed. Maxillule (fig. 5*a*) nodular, situated immediately posterior to mandible base, bearing 2 long, very lightly plumose setae, 1 shorter naked seta and 2 minute setules. Maxilla (figs. 5*a*, *c*) with one distinct segment although indication of second segment fused with cephalothorax; armature of distinct segment consisting of 2 spikelike projections, one subterminal and very lightly plumose, second terminal, finely denticulated along inner margin. Paragnath (fig. 5*a*) lobate, curved inward sharply, with slightly fuzzy distal end.

Maxilliped (fig. 5*d*) 2-segmented although indication of third segment suggested by heavily sclerotized, platelike process intimately associated with cephalothorax but forming articulation surface for maxilliped. First segment elongate, with 1 or 2 naked setae arising from slight depression of median posterior surface. Second segment with long, indistinctly separable falciform process, distal end of segment with nodular swelling bearing 1 or 2 naked, setule-like accessory processes.

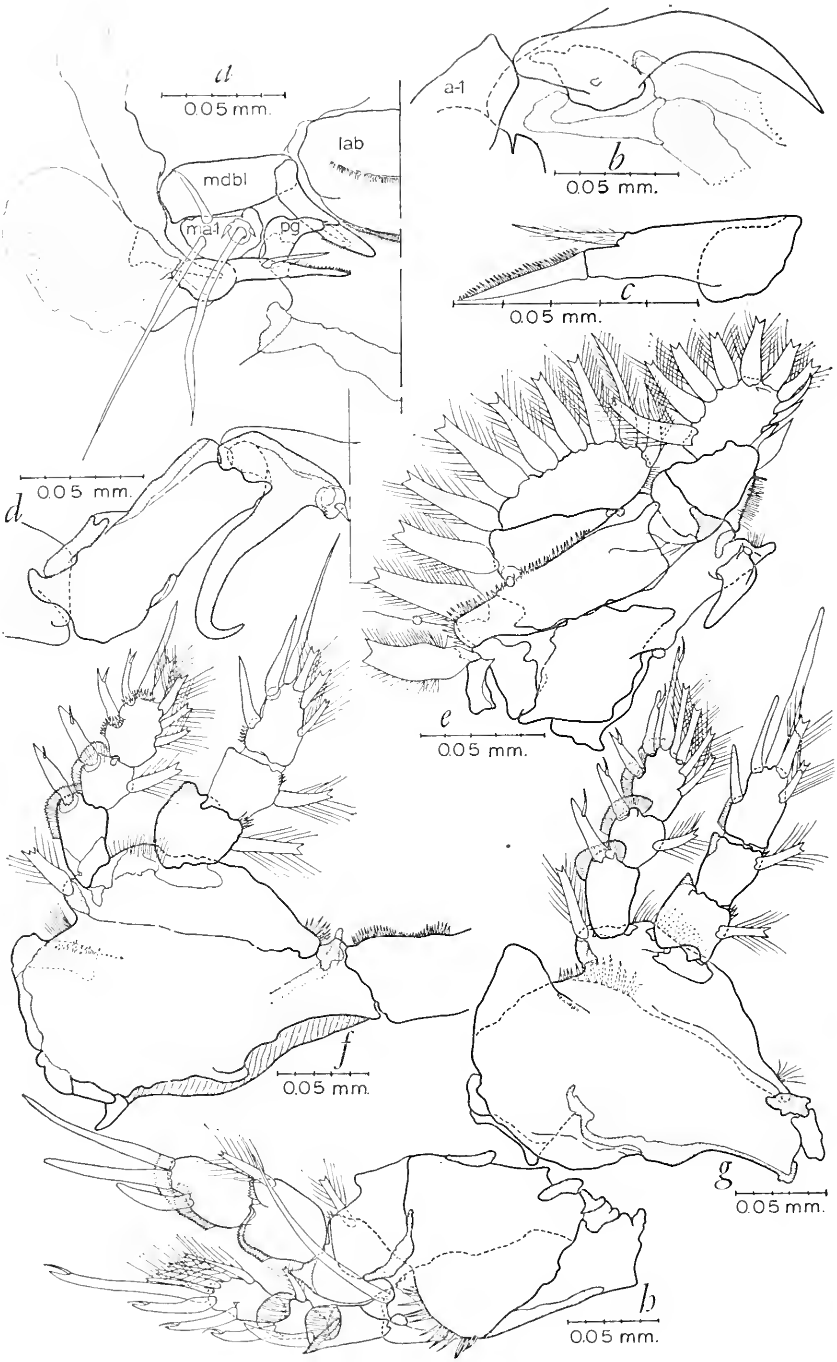
For nature of legs and armature see figures 4*c*, *d*, 5*e–h*, and table 3.

TABLE 3.—*Armature of thoracic legs I–V of the female of* Anchistrotos moa, *new species*

Leg	Surface	Interpodal Plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
I	Outer	C	c,P		2H	2H,P			c	
	Inner		2P,d			6P		P	7P	
II	Outer	C	c,P		dm,H	dm,H	2dm,3H			dm,3H
	Inner		C			P	4P	P,C	P,C	3P
III	Outer	C	C,P		dm,H	dm,H	2dm,3H			dm,3H
	Inner		c,c			P	4P	P,C	P,C	2P
IV	Outer	C	C,P		dm,H	dm,H	3H		dm	2dm,3H
	Inner					P	4P	P,C	P,C	
V	Outer		C,P*		dm,2H, dm, P, dm, H,C*					

*Designation under protopodite and exopodite for convenience; association of segment uncertain.

FIGURE 4.—*Anchistrotos moa*, new species, female: *a*, dorsal view; *b*, lateral view; *c*, genital segment, sixth legs, abdomen, and caudal rami, ventral view; *d*, fifth leg, ventral view; *e*, rostrum, frontal region and proximal segment of antennules, dorsal view; *f*, right antennule, dorsal view (setal plumosities not figured); *g*, antenna, ventral view; *h*, third segment of antenna, dorsal view.


a
0.05 mm.
lab
mdbl
ma-1
pg
a-1
c
b
0.05 mm.
c
0.05 mm.
0.05 mm.
d
e
0.05 mm.
f
0.05 mm.
g
0.05 mm.
h
0.05 mm.

DISCUSSION.—*Anchistrotis moa* is most closely related to *A. ostracionis* (Richiardi, 1870). The overhanging tergal regions of the cephalothorax and prosomal pedigerous segments of *A. moa*, the absence of the small basal projection found on the postantennal process of *A. ostracionis*, and the nature of the spination on the ventral surface of the third abdominal segment are the most readily distinguished characteristics which separate the two species. The species name is derived from "Moa," one of the Hawaiian names for *Ostracion lentiginosus*, the host of this copepod.

Order Caligoida

Family Dichelesthiidae

Hatschekia Poche, 1902

DIAGNOSIS OF FEMALE.—Cephalothorax consisting of cephalon and first thoracic segment; distinct although incompletely separated from second thoracic segment. At least second and third thoracic segments pedigerous, segments either distinct or fused. Fourth and fifth thoracic segments fused with genital segment. Abdomen, if distinct, short, 1-segmented; frequently fused with genital segment; caudal rami minute. Antennule 3- to 7-segmented, antenna 2- or 3-segmented, terminal segment with claw. Mandible rodlike, denticulated distally. One pair of maxillae apparently lacking; maxillules or maxillae (probably maxillules) 2-parted or biramous (depending on degree of reduction), each part (if rudimentary) or ramus (if well developed) typically with 2 setae or spines. Maxilliped slender, terminal process typically bifurcate. First 2 thoracic leg pairs biramous, rami 1- or 2-segmented; third and fourth thoracic leg pairs rudimentary or absent; fifth pair absent.

DIAGNOSIS OF MALE.—Cephalothorax distinct from second thoracic segment, postcephalothoracic segments incompletely or completely fused. Abdomen, if distinct from genital segment, 1-segmented; caudal rami larger than in female, armed with spines or stiff setae. Appendages similar to those of female.

Hatschekia breviramus, new species

FIGURES 6, 7

MATERIAL.—Thirteen adult females from the external surface of *Mulloidichthys auriflamma* Forskål collected at Kauai, Hawaii. One

FIGURE 5.—*Anchistrotos moa*, new species, female, ventral view: *a*, oral region, right side showing labrum (lab), mandible (mdbl), maxillule (ma-1), maxilla, and paragnath (pg); *b*, antennule base (a-1) and postantennal process; *c*, projecting portion of maxilla; *d*, maxilliped. Thoracic legs, anterior view: *e*, right first; *f*, left second; *g*, left third; *h*, right fourth.

of these females has been designated as the holotype (USNM 112870), the others as paratypes (USNM 112869).

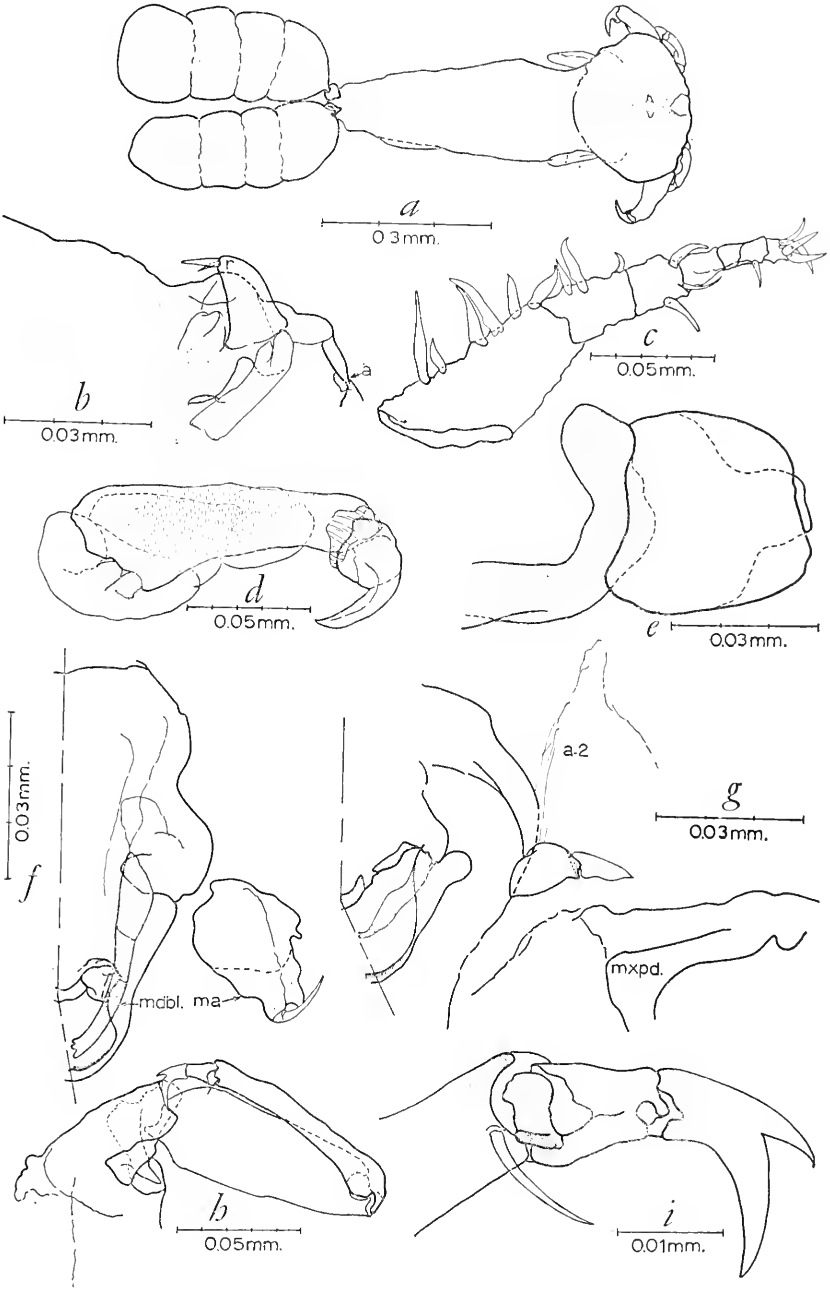
MEASUREMENTS.—(In mm) 10 females:

	mean	*range*
Greatest length of body	0. 67	0. 61–0. 73
Length of cephalothorax	0. 18	0. 16–0. 20
Width of cephalothorax	0. 29	0. 24–0. 33
Length of trunk	0. 56	0. 49–0. 62
Width of trunk	0. 23	0. 20–0. 25
Length of egg strings (5 strings)	0. 44	0. 36–0. 52

DESCRIPTION OF FEMALE.—Body (fig. 6*a*) divisible into two regions. Cephalothorax, including cephalon and maxilliped-bearing thoracic segment, forming first region, pedigerous segments and genital segment forming second. Cephalothorax of general ovoid shape, margins slightly irregular. Anterior dorsal region of cephalothorax heavily sclerotized, with cross-shaped region of sclerotization extending posteriorly on median dorsal surface to middle of cephalothorax although fine line of heavy sclerotization extending posteriorly to posterior-median dorsal surface. Second region composed of fused pedigerous and genital segments, constricted anteriorly into necklike connection with cephalothorax, constriction composed anteriorly of 2 dorsally fused pedigerous segments. Posterior two-thirds of second region tapered in some specimens to posterior end although shape variable, depending at least partially on number of eggs in genital segment. Posterior lateral and posterior ventral surfaces of second region irregular, knobby, knobs forming margin of oviducal openings and more apparent in ovigerous females. Posterior end rounded, projecting past oviducal openings in some specimens, bearing knoblike caudal rami on lateral ventral surface. Caudal rami (fig. 6*b*) small, each tipped by 2 small setules.

Antennule (fig. 6*c*) 6-segmented, strongly compressed. First segment with 6 irregular naked setae from ventral margin; second segment with 3 setae; third with 1 from ventral margin, 1 from distal, and third from dorsal surface; fourth segment naked; fifth with one seta from dorsal surface; sixth with 7 setules distally. Antenna (fig. 6*d*) 2- or 3-segmented, basalmost portion squat and irregular, segment-like but questionable, with several knoblike articulation surfaces received by proximal end of penultimate segment. Penultimate

FIGURE 6.—*Hatschekia breviramus*, new species, female: *a*, dorsal view; *b*, posterior region, left side showing caudal ramus (r) and anal indentation (a); *c*, right antennule, anterior view; *d*, left antenna, ventral view; *e*, membrane-like flap at base of antenna, ventral view; *f*, oral region, left side showing mouth cone, mandible (mdbl), and maxillule (ma); *g*, oral region showing mouth cone, mandible, maxilla?, antenna base (a-2), and maxilliped base (mxpd); *h*, maxilliped, ventral view; *i*, distal end of maxilliped, ventral view.


a
0 3mm.
b
0.03mm.
a
c
0.05mm.
d
0.05mm.
e
0.03mm.
f
0.03mm.
mdbl.
ma
a-2
g
0.03mm.
mxpd.
h
0.05mm.
i
0.01mm.

segment elongate, broader proximally than distally, posterior and medial surfaces rugose. Distalmost segment short, subspherical, fused with clawlike terminal process, with very fine, hairlike accessory process (not shown in figure). Distinct flaplike projection present on heavily sclerotized cephalothoracic depression associated with antenna base (figs. 6*d*, *e*). Mandible (fig. 6*f*) appearing 3-parted although divisions indistinct; appendage rodlike, curved inward distally, distal surface composed of 3 small denticulations. Maxillule? platelike, projecting posteriorly and slightly ventrally from just lateral and posterior to mouth cone base, irregularly pointed distally, with single setule from distal surface.

Maxilliped (figs. 6*h*, *i*) 3- or 4-segmented, basalmost portion appearing as segment-like projection of cephalothorax. Projection concave distally, forming articulation surface for first distinct segment; segment slightly wider proximally than distally although proximal end tapered sharply to narrow proximal surface. Penultimate segment slender, proximal end with knob-shaped articulation surfaces, distal end with hairlike process. Distalmost segment short, heavily sclerotized, with bifurcate terminal process. Terminal process with both tines sharply pointed, innermost slightly less than twice the length of outermost.

First thoracic legs with 2-segmented exopodite, 1-segmented endopodite; second thoracic legs with 2-segmented exopodite and endopodite. Interpodal plates heavily sclerotized. For nature and armature of legs see figures 7*a*, *b*, and table 4.

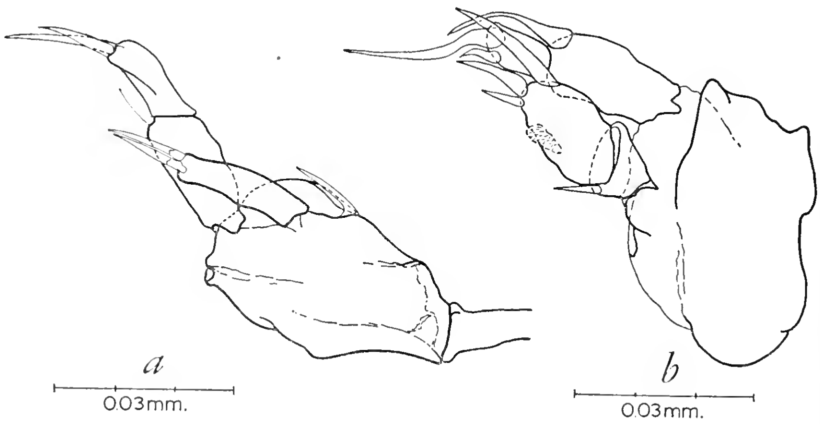


FIGURE 7.—*Hatschekia breviramus*, new species, female, thoracic legs: *a*, first; *b*, second.

DISCUSSION.—*Hatschekia breviramus* has characteristics which can be compared most closely to 5 other members of the genus:

1. *H. diodontis* Yamaguti, 1953: Similar in general body shape,

TABLE 4.—*Armature of thoracic legs I and II of the female of* Hatschekia breviramus, *new species*

Leg	Surface	Interpodal Plate	Protopodite	Exopodite		Endopodite	
				1	2	1	2
I	Outer			p′	p′	p′	
	Inner		p′		p′	p′	
II	Outer			P′	P′		P′
	Inner				p′	p′	2p′

distinct principally in nature of armature of antennule and thoracic legs.

2. *H. ostracii* Yamaguti, 1953: Similar in body shape and in the presence of the processes at the base of the antennae. *H. breviramus* differs from this species in having 6, not 7, segments in the antennule, the processes at the base of the antennae are not as large, the caudal rami are tipped by 2 setules, while there are 5 in *H. ostracii.* The endopodite of the first thoracic leg is 2-segmented in *H. ostracii* and 1-segmented in *H. breviramus; H. ostracii* also has a rudimentary third thoracic leg which is not present in *H. breviramus.*

3. *H. cadenati* Nunes-Ruivo, 1954: The thoracic leg armature is similar although the caudal rami of *H. cadenati,* in addition to other body parts, differ, having 5 setae and setules instead of 2 as in *H. breviramus.*

4. *H. bodiani* Nunes-Ruivo, 1954a: This species, like *H. ostracii* Yamaguti, 1953, has the projections at the base of the antennae that are present in *H. breviramus.* The maxilliped armature is also similar but the 2 species differ, most distinguishably in the armature of the caudal rami and thoracic legs.

5. *H. cluthae* (Scott, T., 1902): Similar in reduced armature of first thoracic leg, differs firstly in having 2-segmented endopodite on the first thoracic leg, secondly in having a more distinct abdomen, different armament on maxilliped, and general body shape.

The species name "*breviramus*" is derived from the Latin words "brevis" (short) and "ramus" (branch) and refers to the short caudal ramus.

Family Lernaeoceridae

Peniculus Nordmann, 1832

DIAGNOSIS.—See Lewis, 1964a.

Peniculus calamus? Nordmann

Peniculus calamus Nordmann, 1864, p. 5, no figures.
Peniculus calamus?—Lewis, 1964a, p. 233, fig. 24. [For bibliography, see Lewis 1964a.]

Hosts and distribution.—8 host records:

location	*hosts*	*reference*
Hawaiian Islands	Unknown	Nordmann, 1864
	Acanthurus dussumieri	Lewis, 1964a
	A. mata	
	A. olivaceus	
	A. triostegus sandvicensis	
	Ctenochaetus strigosus	
	Naso hexacanthus	
	N. unicornis	

Material.—One ovigerous female collected by D. Watson from the dorsal fin of *Pervagor spilosoma* (Lay and Bennett) from the Honolulu Aquarium.

Measurements.—Length from anterior end of head to posterior end of abdomen, excluding projecting second antennae, 2.89mm. Length of head 0.41mm; greatest width 0.28mm. Length of neck 0.22mm; greatest width 0.13mm. Greatest length of combined fourth pedigerous segment, genital segment, and abdomen 2.15mm. Length of egg strings 2.81 and 2.96mm.

Description.—See Lewis, 1964a.

Family Pennellidae

Pennella Oken, 1816

Diagnosis.—Female: Body heavily sclerotized, separable into cephalothorax, neck, and trunk (including abdomen). Cephalothorax suborbicular, consisting of cephalon and at least first thoracic segment; oral region at or near anterior end, surrounded by one or more types of papillae. Two to three heavily sclerotized horns present on posterior region of cephalothorax, at junction of cephalothorax and neck, or on anterior end of neck; horns of variable length and shape, usually projecting laterally or posterolaterally. Neck slender, cylindrical, distinct from cephalothorax due to size difference, usually continuous with trunk. Trunk elongate, cylindrical or slightly flattened dorsoventrally, with ventral indentation at genital openings and frequently with annulations along entire length. Abdomen forming posterior part of trunk, behind ventral indentation at genital openings, tapered posteriorly; posterior surface bilobed due to anal indentation, bearing minute caudal rami. Numerous branched or simple filiform processes arising from lateral or ventral and ventral lateral surface of abdomen, giving plumose appearance to posterior part of body. Egg strings long, frequently more than twice the length of body. Antennule 2- to 5-segmented, situated on dorsal surface of cephalothorax, behind antennae. Antennae chelate, 2- or 3-segmented (movable portion of claw designated as segment with terminal process). Mandibles of unknown nature; maxillules, maxillae, and maxillipeds present in late stages of development but absent in adult. Four pairs of thoracic legs present although poorly developed; first 2 pairs in close proximity on anterior ventral surface of trunk, third and fourth pairs removed variable distance behind second pair. First 2 pairs biramous, third pair typically uniramous, fourth pair probably always uniramous.

REMARKS.—The third and fourth thoracic legs are described as uniramous in the genus *Pennella* (Wilson, 1917; Leigh-Sharpe, 1928; Yamaguti, 1963). The third leg of one of the species here described is biramous. The difference may be interspecific in nature although the rami of any of the thoracic legs of the adult female are brittle and easily broken.

Pennella histiophori? Thomson, 1889

FIGURES 8, 9

Pennella histiophori Thomson, 1889, p. 368, pl. 38, fig. 2.—Bassett-Smith, 1899, p. 483.—Wilson, 1917, p. 113 (key).—Yamaguti, 1963, p. 208.
Pennella zeylanica? Kirtisinghe, 1932, p. 137, figs. 1–5.
Pennella instructa? Kirtisinghe, 1964, p. 110, fig. 153.

HOSTS AND DISTRIBUTION.—2 host records:

location	*hosts*	*reference*
New Zealand	*Histiophorus herschelli*	Thomson, 1889
Ceylon	*H. gladius*	Kirtisinghe, 1932, 1964

MATERIAL.—One complete, ovigerous female, 1 nonovigerous female without cephalothoracic papillae, and 1 incomplete female (trunk and part of neck missing), in addition to part of larval exuvium, collected by D. W. Strasburg from external surface of *Makaira audax* (Philippi) at 9°34′S, 136°45′W (USNM 112871).

REMARKS.—Although the host was collected far from the Hawaiian Islands, the wide distribution of the host and its common occurrence around Hawaii suggested the inclusion of the copepod in this treatise.

MEASUREMENTS.—(In mm) 2 females:

Total length (1 specimen)	172
Length of cephalothorax, excluding papillae	7, 7
Width of cephalothorax	8, 8
Length of neck	79, 51
Width of neck	3, 2
Length of trunk	86, 89
Width of trunk	6, 5
Approximate length of abdominal plumosities	25, 28
Length of attachment horns	(17, 10), (12, 12)
Length of egg string (1 string)	178

DESCRIPTION.—Female: Cephalothorax (figs. 8*a*, *b*) presumably consisting of cephalon and first thoracic segment although maxillipeds

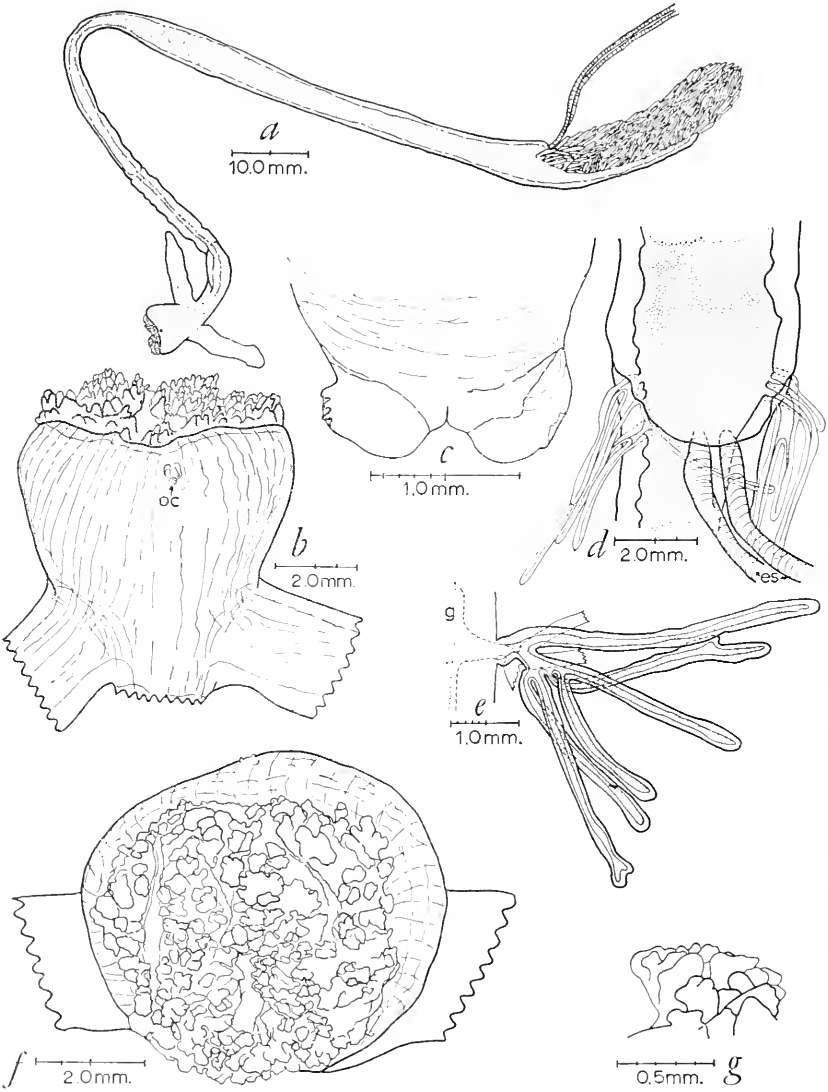


FIGURE 8.—*Pennella histiophori*? Thomson, 1889, female: *a*, dorsal view; *b*, cephalothorax, dorsal view (oc=ocular region); *c*, posterior end of abdomen, dorsal view showing caudal rami and anal indentation; *d*, genital region, ventral view showing egg strings (es); *e*, part of one filamentous posterior process showing connection with gut (g); *f*, cephalothorax, anterior view showing oral region; *g*, lateral view of some papillae in oral region.

not visible. Cephalothorax with 2 large, heavily sclerotized, dactyliform attachment processes on posterior lateral surface, processes projecting laterally and slightly posteriorly. Anterior end of cephalothorax with 4 adjacent rows of soft, irregular papillae (figs. 8*f*, *g*) running dorsoventrally, oral opening a distinct depression situated in middle of anterior end of cephalothorax, between inner 2 rows of papillae. Cephalothorax indistinctly separable from neck by indistinct, incomplete line of division extending between posterior ends of bases of attachment processes. Neck indistinctly separable into two parts by slight constriction of neck and alimentary tract; posterior end of neck separable from anterior end of trunk only by difference in width. Anterior part of neck with distinct constriction in figured specimen (fig. 8*a*) but constriction believed due to twisting of specimen. Trunk elongate, width varying little throughout length. Oviducal openings situated on indentation in posterior third of trunk (fig. 8*d*), at beginning of abdominal portion of trunk. Abdominal region tapered distally, bearing numerous ramified processes from lateral, ventral lateral, and ventral surfaces, with extension of alimentary tract running to blind termination at distal ends of processes (fig. 8*e*). Caudal rami knoblike, on distal lateral surfaces of abdomen, flanking V-shaped indentation at anal opening (fig. 8*c*), without setae; indication of armature present as 3 small irregularities of heavily sclerotized ramal surface.

Antennules and antennae situated on median dorsal surface, just posterior to frontal process region. Antennae anterior to antennules, articulating on heavily sclerotized ridge, ridge expanded medially, forming convex projection bearing small, indistinct remains of copepodite rostrum and small, heavily pigmented ocular region posterior to rostrum (fig. 9*a*). Antennule (fig. 9*b*) 3-segmented although articulating in doughnut-shaped structure distinct from cephalothoracic cuticle. First segment with 7 very lightly plumose setae on anterior surface, second segment more elongate than first, with approximately 11 very lightly plumose setae on anterior and anterior dorsal surface in addition to 1 elongate, aesthete-like structure on distal anterior surface. Third segment slightly narrower than second, with one aesthete-like structure from distal posterior surface, 7 naked processes from distal surface (1 of 7 aesthete-like). Antennae (fig. 9*c*) 3-segmented, first 2 segments broad, distalmost segment with clawlike terminal process. Inner proximal corner of first segment forming knoblike articulation surface, inner lateral margin of segment longer than outer margin; distal surface irregularly cup shaped, inner portion receiving inner proximal surface of second segment. Second segment with cup-shaped projection in inner distal surface, projection receiving distal end of terminal process of third segment when segment flexed, with large, irregular, heavily sclerotized projection of outer portion that forms articulation surface for third segment. Third segment small, proximal end irregular, heavily sclerotized; division between terminal process and segment indistinct; setalike accessory process present, distal to division between segment and terminal process.

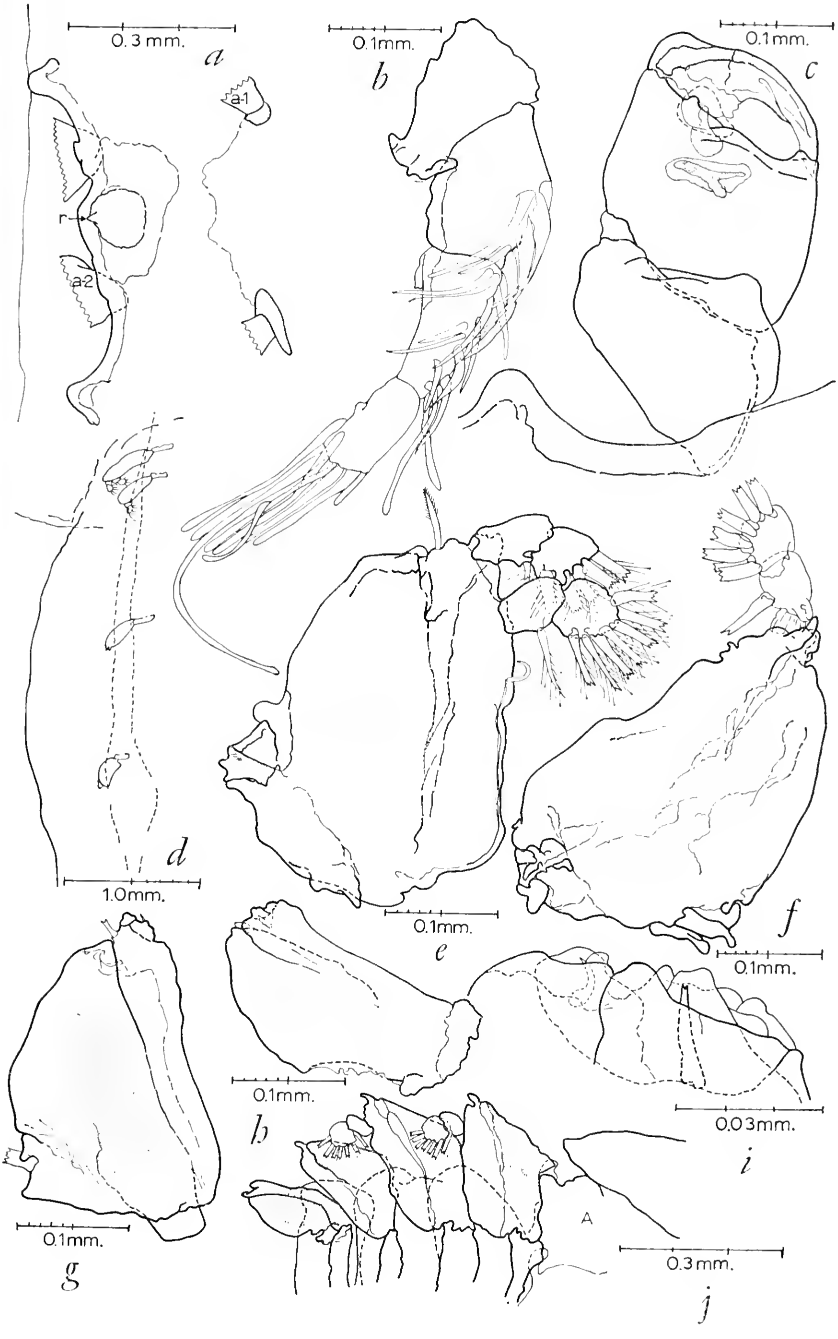
First 2 thoracic leg pairs in close proximity at anterior end of neck, third placed well behind second, and fourth behind third; ratio of proximity equals 1 (first to second leg): 5.5 (second to third): 5.5 (third to fourth) (fig. 9*d*). Protopodite of legs 1-segmented although appearing 2-parted, attached to well-developed interpodal plate. First thoracic leg biramous, rami 2-segmented, second leg appearing uniramous, both in adult female (fig. 9*f*) and larval exuvium (fig. 9*j*), although outline of leg and presence of exopodite on adult leg and endopodite on larval exuvium suggest loss of endopodite in adult specimen. Third and fourth thoracic legs without distinct indication of rami. Protopodite of all legs with dark brown to black pigment spot in alcohol-preserved specimens. For nature and armature of thoracic legs, see figures 9*e–j* and table 5.

TABLE 5.—*Armature of thoracic legs I–IV of the female of* Pennella histiophori? *Thomson, 1889*

Leg	Surface	Interpodal Plate	Protopodite	Exopodite		Endopodite	
				1	2	1	2
I	Outer Inner		p p′	 p	2P 3P	 P	3P 4P
II	Outer Inner			 P	3P 3P		
III	Outer Inner		p′				
IV	Outer Inner		 p′				

DISCUSSION.—The identification of the Hawaiian material as *Pennella histiophori*? Thomson, 1889, as well as the inclusion of the two names used by Kirtisinghe in the synonymy, is done with some question. The intraspecific variation present within the members of the genus, the wide distribution of many of the hosts of the genus, and the relative absence of definitive descriptions leave the

FIGURE 9.—*Pennella histiophori*? Thomson, 1889, female: *a*, ocular region, dorsal view showing rostrum (r), antennule base (a-1), and antenna base (a-2); *b*, antennule, dorsal view; *c*, antenna, dorsal view; *d*, pedigerous region of neck, ventral view. Right thoracic legs: *e*, first, posterior view; *f*, second (endopodite missing), anterior view; *g*, third (ramus or rami missing), posterior view; *h*, fourth (ramus missing), posterior view; *i*, distal end of protopodite of fourth, posterior view. Pedigerous region of larval exuvium: *j*, ventral view (A=anterior).


0.3 mm.
a
a-1
r
a-2
0.1mm.
b
0.1mm.
c
d
1.0mm.
0.1mm.
e
f
0.1mm.
0.1mm.
g
0.1mm.
h
0.03mm.
i
A
0.3mm.
j

taxonomy of the genus in confusion. Of all of the species, *P. instructa* Wilson is by far the most easily recognized, and the characteristic ramshorn-shaped attachment structures show little variation in the specimens present in the U.S. National Museum. Yamaguti's identification of Japanese pennellids from *Xiphias gladius* as *P. instructa* (1939b) may warrant some question although there is more evidence for his identification, from his figure (pl. 33, fig. 193) and from the host, than there is for the inclusion of other material in the species.

The original description of *P. histiophori* Thomson, 1889, indicates some differences between the type material and that here described. *P. histiophori* is figured as having a larger rounded protuberance on the ventral surface, between the bases of the attachment structures, the 4 pairs of thoracic legs appear to be more closely grouped, and the pedigerous area of the neck appears more swollen and distinct from the rest of the neck. The size of the minute ventral protuberance between the bases of the attachment structures is variable in the 3 specimens examined for this description, and there is variation in the size, shape, and position of numerous small irregularities on the cephalothorax. The grouping of the thoracic legs may be distinctive although Thomson's original figure is not clear enough to offer grounds for separation. The difference in the size of the pedigerous region of the neck and the distinction of this region from the rest of the neck may, based on an examination of the variation in some of the other members of the genus, be due to intraspecific variation.

Pennella species

Material.—One complete and 1 incomplete (abdomen missing) nonovigerous female (USNM 112872) from the external surface of *Remoropsis brachypterus* (Solander) collected by the USFWS from the stomach of a yellow-fin tuna, *Neothunnus macropterus* (Schlegel), captured off Hawaii.

Measurements.—(In mm) females:

Greatest length of body (N=1)	35.85
Length of cephalothorax (N=2)	4.00, 3.75
Width of cephalothorax (N=2)	2.85, 3.00
Length of neck (N=2)	10.88, 12.75
Width of neck (N=2)	1.65, 1.35
Length of trunk (N=1)	21.00
Width of trunk (N=1)	1.50
Approximate length of abdominal plumosities (N=1)	7.13
Length of attachment structures (N=2)	(2.25, 2.25), (3.15, 4.05)

Description.—Cephalothorax (figs. 10*a*, *b*) presumably consisting of cephalon and first thoracic segment although maxillipeds not discernible. Pair of long, dactyliform attachment processes present immediately posterior to cephalothorax. Cephalothorax with 2 types

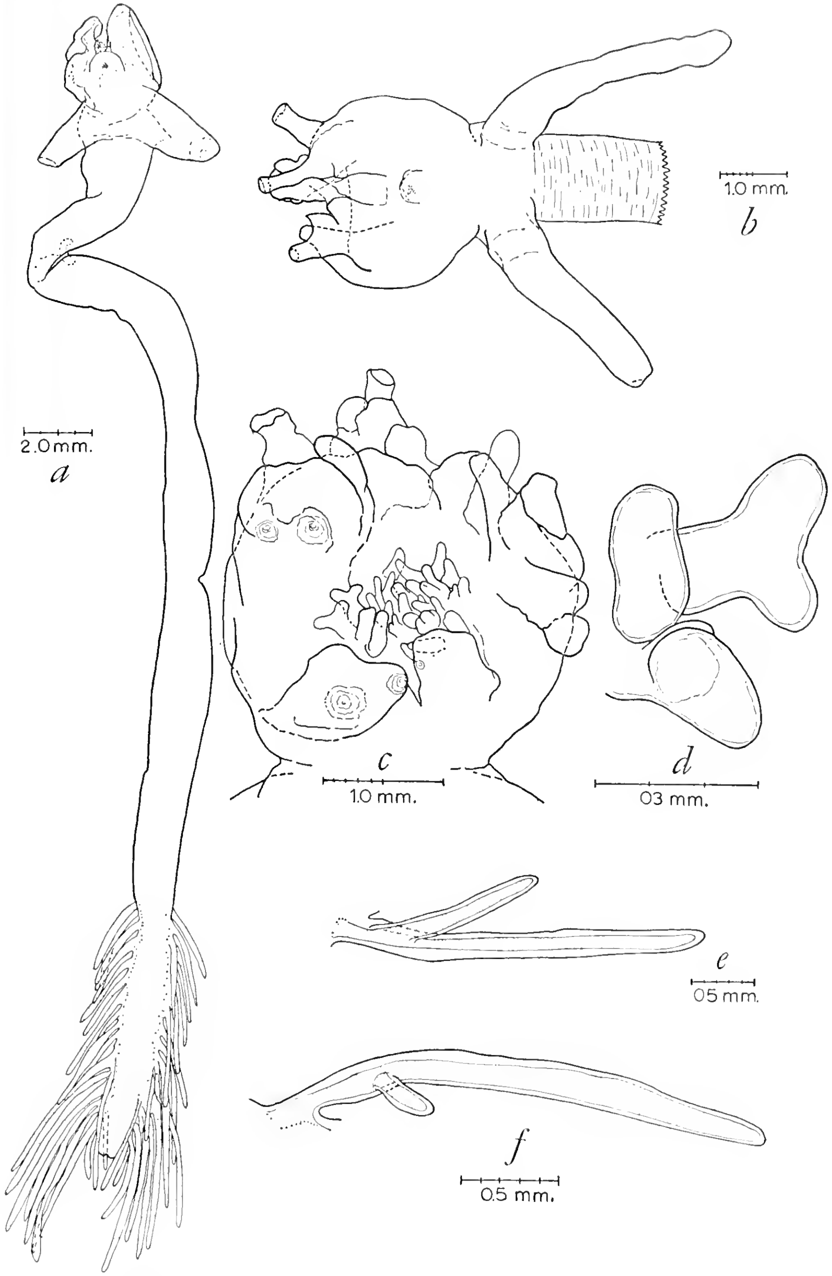


FIGURE 10.—*Pennella* species, female: *a*, dorsal view (specimen 1); *b*, anterior trunk region and cephalothorax, dorsal view (spec. 2); *c*, cephalothorax, ventral view showing large peripheral and smaller oral papillae (spec. 2); *d*, three oral papillae (spec. 2); *e*, *f*, abdominal processes.

of soft protuberances (figs. 10*c*, *d*): first large, irregularly shaped, clustered on anterior end but extending posterolaterally to mouth region, pair also present on posteroventral surface, somewhat isolated from other large protuberances; second type also irregular, smaller, clustered around oral orifice. Neck indistinctly separable from cephalothorax, width varying little throughout length, separated from trunk by slight constriction. Trunk width varying little throughout length, with narrow, V-shaped, heavily sclerotized indentation just posterior to minute, lappet-shaped spermatophores adjacent to oviducal openings (fig. 11*b*). Abdominal portion of trunk tapered distally, with numerous rodlike uniramous or biramous processes from lateral surface (figs. 10*e*, *f*), each with extension of alimentary tract running to blind termination at distal end. Distal end of abdomen bilobed, anal opening at median indentation, each lobe with minute caudal ramus. Caudal rami (fig. 11*a*) consisting of 5 naked setules, 3 on irregular knob, 2 on abdominal surface adjacent to knob.

Dorsal surface of cephalothorax with narrow, U-shaped region of heavy sclerotization anteriorly, apex of U directed anteriorly, with irregular suborbicular projections; ends of U with minute, spikelike projections. Antennal articulation surfaces present on region, just lateral to apex. Antennules not present although indication of articulation surface present lateral and slightly posterior to antennal base. Antennae (fig. 11*d*) 3-segmented, segments 1 and 2 broad, segment 3 and associated terminal process forming clawlike structure. Outer proximal surface of first segment extending as knoblike articulation surface, inner lateral surface approximately three-fourths the length of outer, with knoblike heavily sclerotized region distally. Second segment slightly more than half the length of first, inner distal and lateral surfaces forming spikelike projection, outer distal surface irregular, forming articulation surface for third segment. Third segment short, continuous with terminal process; small, lappet-shaped accessory process present on proximal surface of fused segment and terminal process.

First 2 thoracic leg pairs in close proximity at anterior end of trunk, third somewhat distant from second and fourth from third. Ratio of proximity of thoracic leg pairs equals 1 (first to second leg): 2 (second to third): 1.5 (third to fourth). Protopodites of all 4 legs 1-segmented although appearing 2-parted, all attached to distinct interpodal plate. Thoracic legs I–III biramous (exopodite of leg II lost in one specimen), rami 2-segmented; fourth thoracic leg probably uniramous, ramus 2-segmented. Protopodite of all 4 legs with dark brown to black pigment spot. Nature and armature of thoracic legs given in figures 11*e*–*h* and table 6. Some errors are believed incorporated into both the figures and the table because of the method

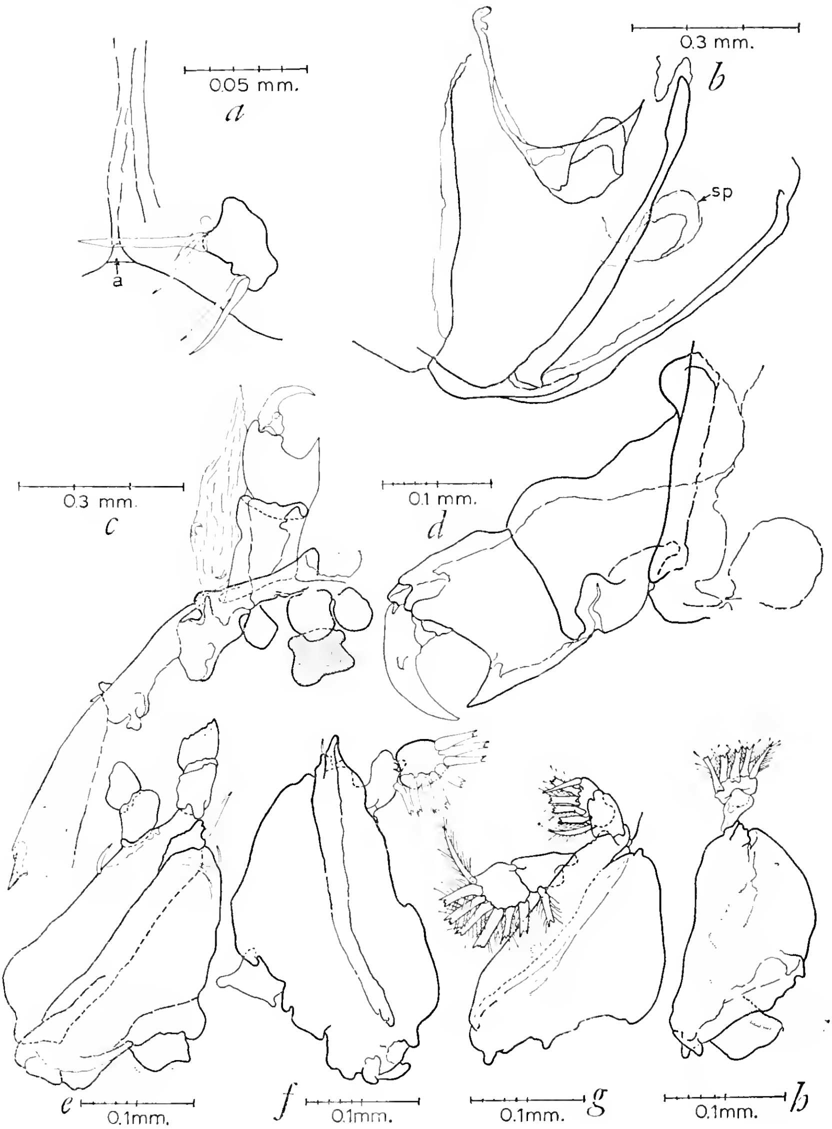


FIGURE 11.—*Pennella* species, female: *a*, caudal ramus, dorsal view (a = anus); *b*, ventral portion of genital region, lateral view (sp = spermatophore); *c*, ocular region of cephalon, dorsal view showing antenna, heavily sclerotized spine, and ridge; *d*, right antenna, dorsal view. Thoracic legs, anterior view: *e*, right first; *f*, left second (exopodite missing); *g*, right third; *h*, right fourth.

of collection of the specimens and the brittle nature of the thoracic legs of adult females of the genus.

TABLE 6.—*Armature of thoracic legs I–IV of the female of* Pennella *species*

Leg	Surface	Interpodal Plate	Protopodite	Exopodite		Endopodite	
				1	2	1	2
I	Outer Inner		s, p′ p′	?	5P?	?	6P?
II	Outer Inner		s	?	6P?	P	7P
III	Outer Inner		s		5P, p	P	6P, p
IV	Outer Inner				4P, p		

DISCUSSION.—Although much of the body and many of the appendages and processes of the 2 specimens were apparently undamaged by the ingestion and partial digestion of the host, there is some evidence of damage (e.g., thoracic legs). For this reason it is felt that specimens in better condition are essential before a name is given to this species. The specimens, however, have characteristics similar to several species of the genus:

1. *Pennella selaris* Kirtisinghe, 1964: Similar in cephalothorax, orientation of abdominal plumosities. Differs from *Pennella* species in possessing shorter and unbranched abdominal plumosities and in the arrangement of the thoracic legs.

2. *P. biloba* Kirtisinghe, 1932: Cephalothorax and general body shape similar. Abdominal processes unbranched in *P. biloba*, branched in *P.* sp.

3. *P. diodontis* Oken, 1816: Arrangement of cephalothoracic papillae and abdominal processes similar. Abdominal processes unbranched in *P. diodontis*.

4. *P. exocoeti* (Holten, 1802): Arrangement and branching of abdominal processes similar. Cephalothorax not bilobed in *P. exocoeti*, nature and arrangement of cephalothoracic papillae appear different.

5. *P. remorae* Murray, 1856: Abdominal processes in 2 rows, as in *P.* sp. Cephalothorax of *P. remorae* not lobed, with 3 horns (characteristic variable), anterior end cuplike (not depressed in *P.* sp.), neck more distinct, abdominal processes more ramified.

Family Anthosomatidae

Norion Nordmann, 1864

DIAGNOSIS.—See Lewis, 1964a.

Norion expansus Nordmann

Norion expansus Nordmann, 1864, p. 489, pl. 6.—Lewis, 1964a, p. 226, figs. 22–23. [For bibliography, see Lewis, 1964a.]

HOSTS AND DISTRIBUTION.—3 host records:

location	*hosts*	*reference*
Hawaiian Islands	unknown	Nordmann, 1864
	Naso lituratus	
	N. hexacanthus	Lewis, 1964a

DESCRIPTION.—See Lewis, 1964a.

Family Pandaridae

Nesippus Heller, 1865

DIAGNOSIS.—See Lewis, 1964a.

Nesippus costatus? Wilson

Nesippus costatus Wilson, 1924, p. 213, pl. 20.
Nesippus costatus?—Lewis, 1964a, p. 211, figs. 19–21.

HOSTS AND DISTRIBUTION.—7+ host records:

location	*hosts*	*reference*
Galapagos Islands	"A nine-foot shark"	Wilson, 1924
Hawaiian Islands	Cysts on:	Lewis, 1964a
	Acanthurus triostegus sandvicensis	
	A. nigroris	
	A. xanthopterus	
	Ctenochaetus strigosus	
	Diodon holocanthus	
	Scarus species	
	labrids	
	pomacentrids	
	zanclids	

MATERIAL.—One immature male (early encysted stage of Lewis, 1964a) in cyst on dorsal fin of *Seriola dumerilli* (Risso) from Honolulu Aquarium. Cysts with exuviae (no animal) or partially resorbed cysts found on specimens of *Aulostomus chinensis* (Linnaeus), *Chaetodon miliaris* Quoy and Gaimard, and *Myripristis pralinius* Cuvier and Valenciennes.

MEASUREMENTS.—Length of body, excluding caudal setae, 1.96mm. Length of cephalothorax, including frontal region, 1.39mm; width 1.55mm. Length of genital segment 0.34mm; width 0.47mm. Length of caudal rami 0.22mm.

DESCRIPTION.—See Lewis, 1964a.

Family Euryphoridae

Euryphorus Milne-Edwards, 1840

DIAGNOSIS.—Cephalothorax suborbicular, consisting of cephalon and first 4 thoracic segments, frontal region well defined. Free fourth pedigerous segment with alae (larger in female than in male). Female genital segment large, suborbicular, with pair of posterior lobes; male genital segment longer than wide, of variable shape but lateral margins generally parallel, without posterior lobes. Abdomen 2- or 3-segmented, female first segment elongate, with pair of large, lamellate processes extending posteriorly past caudal rami, remaining segment or segments without lamellate processes; male first segment shorter than in female, lamellate processes thicker and smaller, extending posteriorly only to region of second abdominal segment, remaining segment or segments as in female. Caudal rami similar to those of other euryphorids. Antennule 2-segmented; antenna 3-segmented, prehensile, male with enlarged secondary spines. Mandible rod shaped, denticulated distally; maxillule nodular, tipped by 3 setae; maxillae 2-segmented. Postantennal process consisting of 2 nodules with hairlike processes; postoral process spinelike. Maxilliped 2-segmented, prehensile, with 2 subtriangular protuberances on first segment. Sternal furca with divergent tines in female, almost parallel tines in male; furca-like processes present posterior to interpodal plate of first and second thoracic legs. Thoracic legs I–IV biramous, ramal segment count 2–2, 3–3, 3–3, 3–2, fifth legs setiform.

Euryphorus nordmanni Milne-Edwards

Figures 12–15

Euryphorus nordmanni Milne-Edwards, 1840, p. 462, pl. 39, fig. 1.—Kner, 1859, p. 268, figs. 1–3.—Bassett-Smith, 1899, p. 461.—Kirtisinghe, 1937, p. 445, figs 74–87.—Yamaguti, 1963, p. 98.

Euryphorus nympha Steenstrup and Lütken, 1861, p. 365, pl. 6, fig. 12.—Heller, 1868, p. 198.—Bassett-Smith, 1899, p. 461.—Wilson, 1913, p. 225.—Shiino, 1954b, p. 284, figs. 5–6; 1959a, p. 350; 1959b, p. 20, fig. 9.—Ho, 1963, p. 83, figs. 1–3.—Yamaguti, 1963, p. 99.—Kirtisinghe, 1964, p. 88, fig. 104.

Euryphorus coryphaenae Krøyer, 1863, p. 161, pl. 10, fig. 4a–h.—Wilson, 1913, p. 225.—Yamaguti, 1936b, p. 1, pl. 1, figs. 1–17.—Bonnet, 1948, p. 7.—Causey, 1953a, pp. 7, 9; 1953b, p. 11; 1955, p. 6.

Remarks.—See discussion section, following description, for discussion of synonymy.

Hosts and distribution.—10 host records:

locality	*host*	*reference*
"Des mers d'Asie"	Unknown	Milne-Edwards, 1840
Western Pacific	*Coryphaena hippurus*	Yamaguti, 1936b
	Neothynnus macropterus	Shiino, 1954b
Hawaii	*Coryphaena hippurus*	Bonnet, 1948
Indian Ocean	"Seefischen"	Kner, 1859
	Coryphaena hippurus	
	C. h. equisetis	Kirtisinghe, 1937

ocality	host	reference
Tropical, subtropical Atlantic	*Lampugus punctulatus*	Steenstrup and Lütken, 1861
	Coryphaena hippurus	Krøyer, 1863
Gulf of Mexico	*Coryphaena hippurus*	Causey, 1953a

MATERIAL.—Two females and 2 males (USNM 112873) from the gill cavity of *Coryphaena hippurus* Linnaeus taken by trolling 120 miles south of Oahu, Hawaii (USFWS). Two females and 2 males (USNM 112874) from the gill cavity of *C. hippurus* Linnaeus taken by trolling at 15°N, 115°W (USFWS). One female and one male (USNM 112875) from the gill cavity and buccal cavity of *C. hippurus* Linnaeus taken by trolling, 130 miles south of Niihau, Hawaii (USFWS).

MEASUREMENTS.—(In mm) 5 females and 5 males:

	female		male	
	mean	range	mean	range
Length of body, excluding caudal setae	9. 65	7. 80–10. 50	5. 84	5. 33–6. 45
Length of cephalothorax, including frontal region	2. 77	2. 63– 2. 96	2. 46	2. 37–2. 52
Width of cephalothorax	2. 75	2. 63– 2. 81	2. 35	2. 26–2. 52
Length of genital segment, excluding genital flap	1. 98	1. 52– 2. 22	1. 27	1. 15–1. 44
Width of genital segment	2. 55	1. 85– 2. 85	1. 13	1. 04–1. 18
Length of abdomen	4. 31	2. 70– 5. 10	1. 50	1. 43–1. 58
Length of alae	0. 78	0. 74– 0. 83	0. 55	0. 45–0. 61
Length of genital flap	0. 67	0. 61– 0. 72		
Length of abdominal projection	4. 85	2. 70– 6. 08	1. 10	0. 98–1. 28
Length of caudal rami	0. 46	0. 43– 0. 49	0. 34	0. 31–0. 36
Length of egg string (1 string)		9. 23		

DESCRIPTION.—Female cephalothorax (fig. 12*a*) ovoid, consisting of cephalon, maxilliped-bearing, and first 3 pedigerous segments. Frontal region broad, approximately one-tenth the length of cephalothorax, distinctly separable from rest of cephalothorax; anterior edge with fine membrane. Lateral cephalothoracic margins flatly convex except for sharp median indentation, margin bearing narrow membranous flange. Posterior lateral cephalothoracic regions sharply rounded, extending posteriorly slightly past median cephalothoracic region. Posterior sinuses distinct (fig. 12*c*), U-shaped, with narrow but distinct flange extending medially from outer margin and bearing fine membrane. Dorsal cephalothoracic grooves forming irregular H, posterior longitudinal grooves of H formed by junction of posterior lateral cephalothoracic region and median cephalothoracic region; crossbar irregular, in posterior third of body; anterior longitudinal grooves extending anteriorly to just lateral to 3-parted ocular region. Ocular region consisting of 2 ovoid contiguous pigmented bodies, each with lens, and smaller pigmented area between posterior

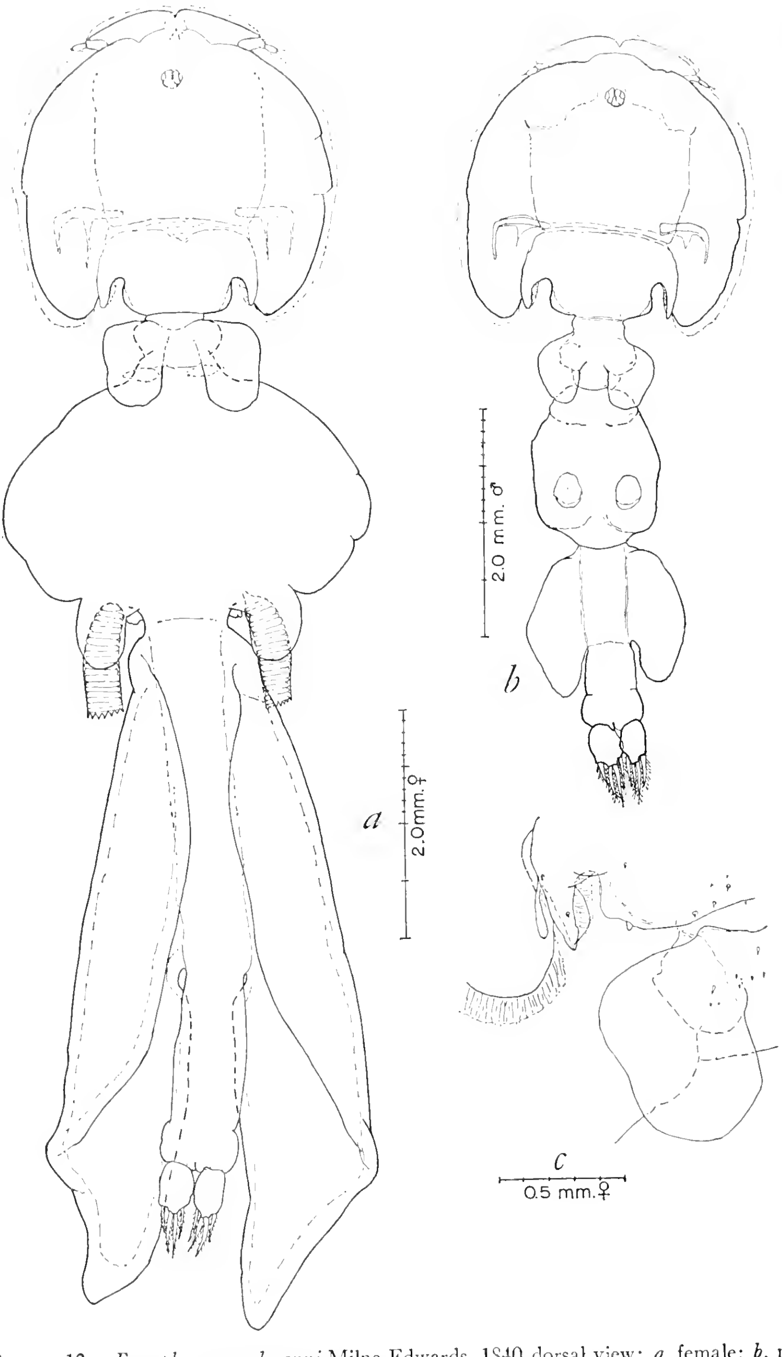


FIGURE 12.—*Euryphorus nordmanni* Milne-Edwards, 1840, dorsal view: *a*, female; *b*, male; *c*, female posterior cephalothoracic sinus and free fourth pedigerous segment, including ala.

regions of ovoid bodies. Posterior median cephalothoracic region with several spinules dorsally.

Female free fourth pedigerous segment distinct from cephalothorax and genital segment, greatest length, excluding alae, slightly less than one-fifth the length of cephalothorax. Segment broadest medially, with short, necklike region anteriorly. Alae small, subrectangular although shape variable, arising from broad medial portion of segment, extending posteriorly over part of anterior dorsal surface of genital segment. Alae not connected as indicated by Shiino (1954b). Median dorsal surface of segment with several spinules.

Female genital segment (fig. 13*a*) broad, lateral margins irregular, lateral surface projecting laterally past ventrally swollen medial region. Anterior end of segment narrow, bearing pair of heavily sclerotized, leglike plates (fig. 13*e*) ventrally, each with fimbriated edge. Plates connected by ridge of heavy sclerotization similar to interpodal plates of fourth thoracic legs. Homologies of structure unknown, no comparable structure on male or on members of genus *Elytrophora,* which appears closely related to *Euryphorus.* Posterior surface of genital segment irregular, with pair of knobby projections ventrally, in region of oviducal openings and with pair of small, lappet-shaped projections dorsally, overlapping egg strings. Female fifth legs (fig. 13*c*) situated ventral and lateral to base of lappet-shaped projections, consisting of 2 nodules, first bearing single plumose setule, second bearing 3 plumose setules.

Female abdomen (fig. 12*a*) elongate, distinctly separable from genital segment ventrally, indistinctly separable dorsally. Segmentation of adult female obscured although suggestion of 3 segments. First segment approximately 65 percent of total length, slender, bearing pair of large, curled, or uncurled flaps projecting posteriorly past caudal rami. Division between first and second segments suggested only by end of base of flaps although division complete in male. Second segment elongate, forming 25 percent of abdomen length. Division between second and third "segments" indicated by cuticular constriction, third "segment" short, approximately 9 percent of abdomen length, median posterior surface projecting slightly in biconvex anal region. Caudal rami (fig. 13*f*) ovate, margins irregular, distal inner surface plumose; distal surface with 2 large plumose setae from tubercular projection, 2 additional large setae, one on either side of projection, and 2 plumose setules.

Male cephalothorax (fig. 12*b*) similar to that of female although indentation of lateral margin less distinct and posterior median region with fewer dorsal spinules. Free fourth pedigerous segment similar, alae smaller, of general ovoid shape. Genital segment (fig.

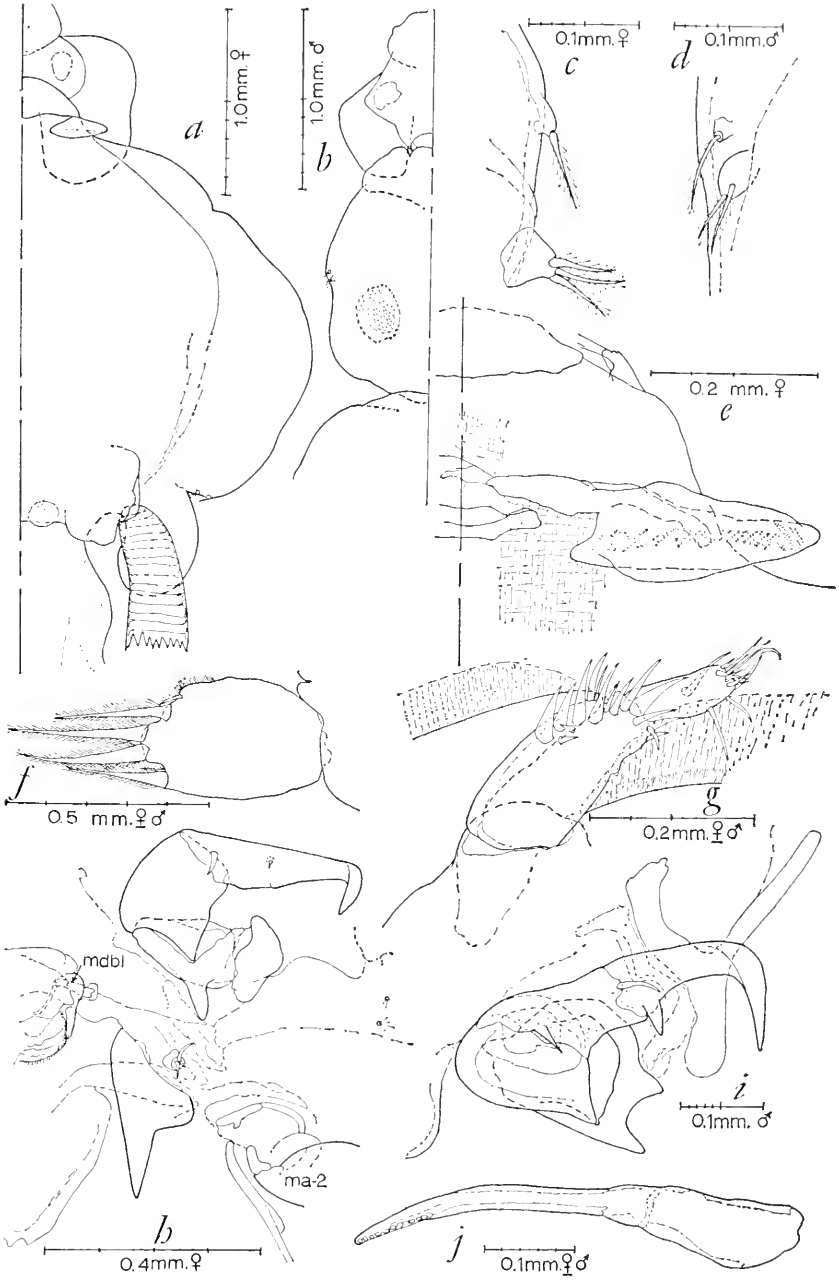
13*b*) distinct from fourth pedigerous segment, shape irregularly ovoid. Segment appearing 2-parted dorsally, with indication of break ventrally; anterior fourth of segment (in region of ventrally projecting plates in female) with distinct line of division on lateral dorsal surface. Fifth legs (fig.13*d*) situated on lateral ventral surface in middle of segment, consisting of 2 nodules, anteriormost with single plumose setule, posteriormost with 3 plumose setules. Abdomen distinct from genital segment, elongate, segmentation more distinct than in female. First segment approximately 53 percent of abdomen length, with pair of large flaps (smaller than those of female although thicker) extending posteriorly to end of second segment. Second segment approximately 27 percent of abdomen length, cylindrical; third "segment" approximately 20 percent of abdomen length, similar in shape to that of female. Caudal rami as in female.

Female antennule (fig. 13*g*) 2-segmented, attached to lateral-anterior ventral surface of cephalothorax and posterior-lateral ventral surface of frontal region. First segment slightly more than twice the length of second, with approximately 15 naked or lightly plumose setules. Second segment cylindrical, with single naked setule from median dorsal surface, second from median posterior surface, approximately 11 from distal region. Male antennule similar to that of female although sclerotization of first segment irregular, giving pseudosegmented appearance (Shiino's "2 false joints," 1954b, p. 288). Female antenna (fig. 13*h*) 3-segmented, attached posterior and medial to antennule base. First segment short, irregular, with posteriorly projecting spike from posterior surface. Second segment strongly developed, without any major irregularities. Third segment and terminal process clawlike, segment separable from terminal process only by indistinct break in sclerotization, with setalike accessory process from proximal posterior surface, second from distal posterior surface. Male antenna (fig. 13*i*) similar to that of female except spikelike projection of first segment smaller, third segment distinctly separable from terminal process, terminal process with spikelike projection from proximal posterior surface.

Female and male mandible (figs. 13*h*, *j*) 3-parted, rodlike. First part broad proximally, tapered distally; second part short, slightly less than half the length of first, tapered. Third part elongate, slightly

---

FIGURE 13.—*Euryphorus nordmanni* Milne-Edwards, 1840; ventral view: *a*, female free fourth pedigerous segment, genital segment (with projecting plates at anterior end), and anterior end of abdomen; b, male, same; *c*, female fifth leg; *d*, male fifth leg; *e*, anterior end of female genital segment showing projecting plates; *f*, caudal ramus; *g*, left antennule; *h*, female oral region, left side showing antenna, postantennal process, mouth cone, mandible (mdbl), maxillule, postoral process, maxilla base (ma–2), and postoral V-shaped ridge; *i*, male left antenna; *j*, mandible.


a
1.0mm.♀
b
1.0mm.♂
0.1mm.♀
c
0.1mm.♂
d
0.2 mm.♀
e
f
0.5 mm.♀♂
g
0.2mm.♀♂
mdbl
ma-2
h
0.4mm.♀
i
0.1mm.♂
j
0.1mm.♀♂

less than twice the length of first, distal region curved inward slightly, with 12 denticulations on inner surface. Female and male postantennal process (fig. 13*h*) evidenced only by pair of nodules lateral to antenna base, each with several hairlike processes. Female and male postoral process (fig. 13*h*) spikelike, with broad base, tapered to sharp distal end, outer margin sharply indented medially. Female and male maxillule (fig. 13*h*) nodular, with 3 setule-like processes distally. V-shaped heavily sclerotized ridge present posterior to

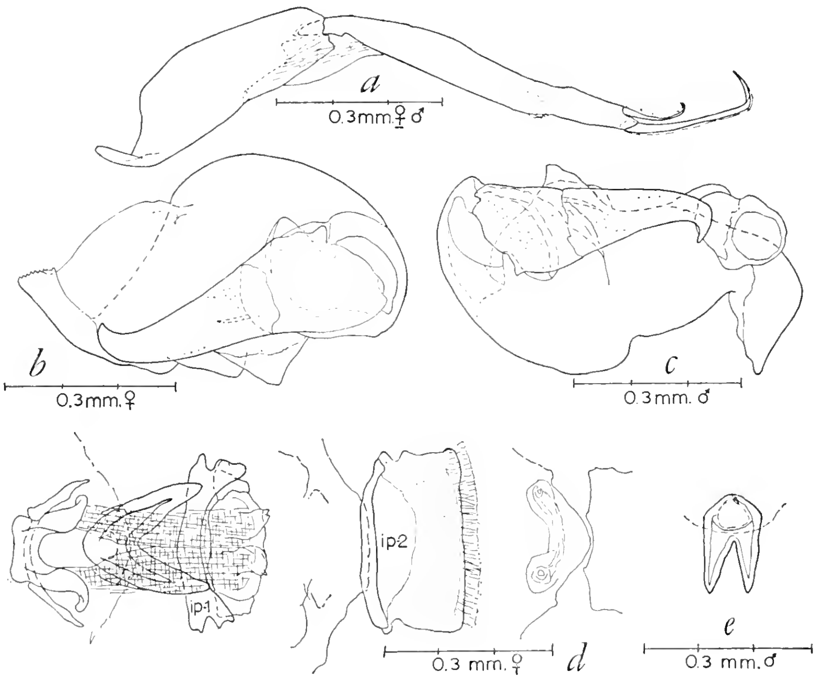


FIGURE 14.—*Euryphorus nordmanni* Milne-Edwards, 1840, ventral view: *a*, left maxilla; *b*, female left maxilliped; *c*, male, same; *d*, female sternal furca, interpodal plates of first and second thoracic legs (ip-1, 2), and furcal modification of platelike projections behind interpodal plates; *e*, male sternal furca.

mouth cone (fig. 13*h*), in same region as adhesion pads of pandarids, some euryphorids and some caligids. Female and male maxilla (fig. 14*a*) 2-segmented, situated lateral and slightly posterior to postoral process, arising from padlike projection. First segment approximately three-fourths the length of second; second segment elongate, broadest medially, with membrane extending along median posterior surface. Distal end of second segment with 2 setalike processes, innermost slightly less than twice the length of outermost, with fine membrane along inner margin; outermost process with frilled membrane along outer margin.

Female maxilliped (fig. 14*b*) 2-segmented, situated posterior and medial to maxilla base, on ovoid, padlike projection. First segment strongly developed, irregular, narrow proximally, broad medially, with 2 subtriangular projections from inner surface. Second segment and terminal process clawlike, segment short, distinct from terminal process, with setule-like accessory process from distal inner surface. Male maxilliped (fig. 14*c*) similar to that of female except with additional, knoblike projection on proximal inner surface of first segment. Female sternal furca (fig.14*d*) V-shaped, tines bluntly pointed. Male sternal furca (fig. 14*e*) with V-shaped sinus but lateral margins almost parallel, tines not diverging as in female.

For nature of thoracic legs and armature, see figure 15 and table 7. Flabby, bifurcate projection present just posterior to interpodal plate of first thoracic leg, similar though less distinct projection present posterior to second thoracic legs.

TABLE 7.—*Armature of thoracic legs I–IV of the female and male of* Euryphorus nordmanni *Milne-Edwards, 1840*

Leg	Surface	Interpodal Plate	Protopodite 1	Protopodite 2	Exopodite 1	Exopodite 2	Exopodite 3	Endopodite 1	Endopodite 2	Endopodite 3
I	Outer		p		h	d,dH,2dH, P			C,P	
	Inner		p		c	3P			2P	
II	Outer	m		m,p	m,d,fmH	fmH	2fmH,Q,2P	c	c	3P
	Inner		s,P	m,s	c,P	c,P	3P	P	c,2P	3P
III*	Outer	m	m,P		d,H	d,h	3h,2P	c	c	3P
	Inner		2s,r†,P,m,3s		c,P	c,P	3P	P	c,2P	P
IV*	Outer		p		d,fmH	d,fmH	d,fmH,d, 2fmH	c	c,2P	
	Inner		fm			P	4P	P	c,2P	

*Numerous hairlike projections (s) in middle of segment, not included in table.
†Roughened area (in this case by denticulations).

DISCUSSION.—The synonymyzing of *Euryphorus coryphaenae* Krøyer with *E. nympha* Steenstrup and Lütken was first done by Bassett-Smith (1899) although no reasons were given. Wilson (1913) suggested that the two were synonymous but it was not until Shiino (1954b) that Bassett-Smith's belief was reiterated. Shiino did not have Krøyer's original description of *E. coryphaenae* so did not give an analysis of the two species.

In a comparison of *E. nympha* and *E. coryphaenae*, the major differences appear, from the publications, to be in the sternal furca (that of *E. nympha* having more widely spaced tines) and in the armature and its position on the first thoracic leg (*E. coryphaenae* figured as having

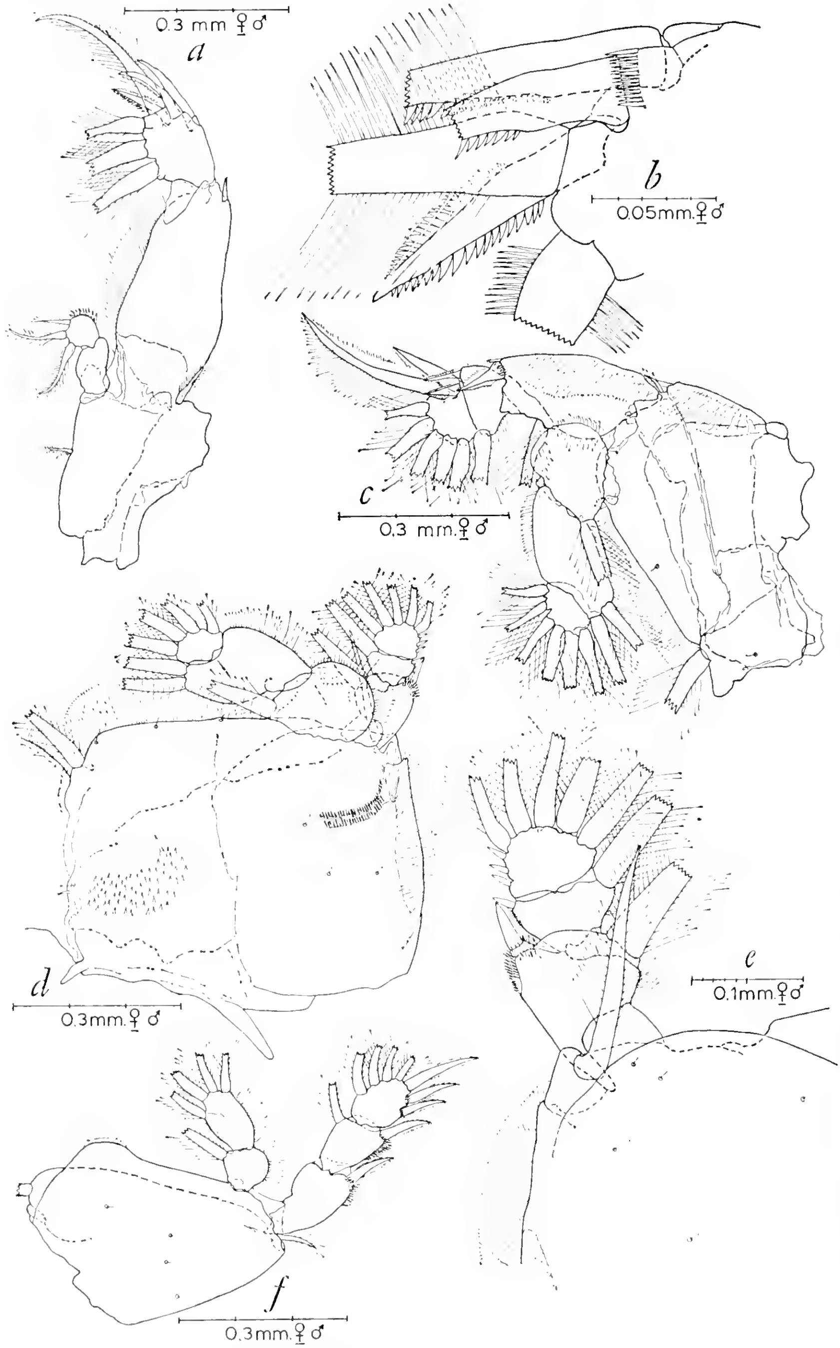


FIGURE 15.—*Euryphorus nordmanni* Milne-Edwards, 1840, right thoracic legs, anterior view: *a*, first; *b*, distal end of second segment of exopodite of first; *c*, second; *d*, third; *e*, exopodite of third (posterior view); *f*, fourth.

the terminal elements more broadly spaced on the exopodite and having 3 short, spinelike projections in addition to the 3 setae figured for both species). The variation present in the angle of the furcal tines, the rather confusing picture given by the terminal elements on the second segment of the exopodite of the first thoracic leg (fig. 15*b*), the similarity of the general body shape and particularly the first abdominal segment (which is considered, by this author, to be of taxonomic significance in this genus and in the genus *Elytrophora*), in addition to the similarity of other body parts described and figured in the original descriptions suggest that the two species are conspecific.

The reasons given by Steenstrup and Lütken (1861) for separating *Euryphorus nympha* from *E. nordmanni* Milne-Edwards are:

1. *E. nordmanni* has a better developed pair of antennules than *E. nympha*.

2. The specimens in the Paris museum (*E. nordmanni*) were from the "Asiatic" ocean while *E. nympha* was described from material collected in the subtropical Atlantic.

Kner (1859) described *E. nordmanni* from fish captured off Zanzibar. Steenstrup and Lütken, however, did not feel that Kner had sufficient material or sufficient experience (based at least partially on his misinterpretation of the first thoracic legs) to identify his specimens properly and felt that his material was *E. nympha*.

Specimens identified as either *E. nympha* or *E. coryphaenae* have been reported from most of the tropical and subtropical regions of the world (Japan, Indian Ocean, Atlantic, West Indies, Gulf of Mexico). The distribution of *E. nympha* (recognizing *E. coryphaenae* as a synonym of this species) appears to parallel that of the principal host, *Coryphaena hippurus* Linnaeus. The host that Milne-Edward's and Kner's specimens came from is unknown and *E. nordmanni* has been reported only once, from *Coryphaenae hippurus*, since Kner's publication (Kirtisinghe, 1937). Even this report was later believed erroneous, Kirtisinghe (1964 and personal communication) feeling that his specimens should have been identified as *E. nympha*.

The validity of *E. nympha* appears to be dependent upon the absence of the host name in the original description of *E. nordmanni*, the different locality from which *E. nordmanni* was collected, and the belief that *E. nordmanni* has a better developed pair of antennules. There even appears to have been some question, by Steenstrup and Lütken (1861), as to whether their species, *E. nympha*, was distinct. The following is a translation of the second footnote on page 366 of their 1861 publication:

> There is, unfortunately, an almost complete lack of precedent as to whether or not we can refuse to equate an animal type to one already described in the literature just because one is from the Atlantic and one from the Indian Ocean.

Are the larger pelagic fish forms actually the same for these two oceans, or does each have their own characteristic species? So little is at present known about this that one assumption appears to be valid as the other. We are inclined to prefer the latter, and do therefore not wish to accept that the same species of parasitic crustaceans occur in both oceans as long as a possible comparison is lacking.

The wide distribution and the similar and unique morphology of the *E. nordmanni-E. nympha-E. coryphaenae* complex indicates, to this author, that these 3 species are synonymous.

Elytrophora Gerstäecker, 1853

Diagnosis.—Cephalothorax consisting of cephalon and first 4 thoracic segments, frontal region distinct; lateral margins with slight indentation medially. Free fourth pedigerous segment with alae extending posteriorly over anterior region of genital segment; female alae with sharp indentation medially, male alae with or without slight indentation. Female genital segment variable in size and shape, longer in egg-producing females than in immature females, with pair of posteriorly projecting, lobe-shaped plates, plates straight or angled inward slightly. Male genital segment without plates. Abdomen 2-segmented, first segment of female with small, posteriorly projecting lateral lobes, lobes of variable size and shape; first segment of male without lobes. Second segment of abdomen with small, bilobed anal projection. Antennule 2-segmented; antenna 3-segmented, with clawlike terminal process (male with small secondary spine at base of terminal process). Mandible rodlike, with 12 denticulations on inwardly curved distal region. Maxillule nodular, bearing setules; maxilla 2-segmented; postoral process spinelike, distal region more slender in mature specimens than in immature. Maxilliped 2-segmented, with clawlike terminal process. Thoracic legs I–IV biramous although endopodite of first and fourth legs reduced; ramal count 2–2, 3–3, 3–3, 3–2. Fifth legs present, setiform.

Remarks.—The similarity of *Euryphorus* and *Elytrophora* is remarkable. This similarity is principally in the general shape of the cephalothorax, the female alae, genital plates, abdominal processes (although they are much larger in *Euryphorus*), and number of segments in the rami of the first 4 pairs of thoracic legs (identical in members of both genera).

Elytrophora brachyptera Gerstäecker

Figures 16–21

Elytrophora brachyptera Gerstäecker, 1853, p. 60, pl. 3, fig. 12.—Nordmann, 1864, p. 468.—Heller, 1866, p. 753.—Van Beneden, 1870a, p. 57.—Richiardi, 1880, p. 3.—Stossich, 1880, p. 257.—Valle, 1880, p. 60.—Carus, 1885, p. 360.—

Bassett-Smith, 1896a, p. 158; 1896b, p. 12, pl. 4, fig. 3.—Brian, 1899a, p. 4.—Bassett-Smith, 1899, p. 462.—Brian, 1906, p. 51, pl. 1, figs. 2–3; 1908, p. 3; 1912, p. 10.—Scott and Scott, 1913, p. 83, pl. 19, fig. 10; pl. 23, figs. 1–2; pl. 31, figs. 1–6.—Yamaguti, 1936b, p. 3.—Bonnet, 1948, p. 7.—Delamare-Deboutteville and Nunes-Ruivo, 1953, p. 202, fig. 1.—Shiino, 1954b, p. 279, figs. 3–4.—Heegaard, 1955, p. 46, figs. 9–11.—Shiino, 1957a, p. 364.—Yamaguti, 1963, p. 102, pl. 123, fig. 1.

Dinematura Thynni Krøyer, 1863, p. 157.—Wilson, 1907a, p. 376 (as *thynni*). [Nomen nudum, label name attributed to Kollar.]

Arnaeus thynni Krøyer, 1863, p. 157, pl. 8, fig. 5a–g.

Material.—15+ host records:

locality	*hosts*	*reference*
Mediterranean	Unknown	Gerstäecker, 1853
	Thynnus vulgaris	Heller, 1866
	Thynnus thynnus	Brian, 1899a
	"Germon"	Brian, 1908
	"Thon rouge"	Delamare-Deboutteville and Nunes-Ruivo, 1953
Northeastern Atlantic	*Thynnus vulgaris*	Van Beneden, 1870a
	Thynnus thynnus	Bassett-Smith, 1896a
	Orcynus thynnus	Scott and Scott, 1913
Subtropical Atlantic	Plankton?	Heegaard, 1955
Pacific	*Thynnus thynnus*	
	T. alalunga	Yamaguti, 1936a
Western Pacific	*Thynnus orientalis*	
	Parathynnus sibi	Shiino, 1954a
	Neothunnus albacora	
	Parathunnus obesus	Shiino, 1957a
Hawaii	*Thynnus* species	Bonnet, 1948

Material.—Two adult females and 4 adult males (USNM 112876) from the gill cavity of *Parathunnus sibi* Schlegel from the Honolulu Fish Market (USFWS collections). Two adult females and 1 adult male (USNM 112877) from the gill cavity of *Neothunnus macropterus* (Schlegel) captured by longline near Christmas Island (Line Islands) (JRM cruise 27, longline station 2). Four adult females (USNM 112878) from inside operculum of an unknown host (probably *N. macropterus* (Schlegel)) captured by longline north of Christmas Island (Line Islands) (LL cruise 6). Additional specimens, retained by the author, include 2 adult females and 2 adult males from inside operculum of unknown host captured by longline north of Christmas Island (Line Islands) (USFWS); 1 adult female and 1 adult male from the external surface of *N. macropterus* (Schlegel) captured by longline at 0°29′N, 157°49′W (USFWS); 3 adult males from inside operculum of unknown host captured by longline north of Christmas Island (Line Islands) (USFWS); 2 adult females from inside operculum of unknown host captured by longline north of Christmas Island (Line Islands) (USFWS).

Measurements.—(In mm) 10 females and 10 males:

	female		male	
	mean	*range*	*mean*	*range*
Total length, excluding caudal setae	8. 37	6. 23– 9. 68	6. 33	5. 10–7. 80
Length of cephalothorax, including frontal region	4. 43	2. 85– 4. 88	3. 45	3. 23–4. 05
Width of cephalothorax	4. 51	3. 48– 4. 95	3. 10	2. 48–3. 60
Length of genital segment, excluding genital flap	1. 93	1. 13– 2. 37	1. 45	1. 18–1. 70
Width of genital segment	1. 70	0. 72– 1. 95	1. 27	0. 58–1. 43
Length of abdomen	1. 27	0. 99– 1. 52	1. 04	0. 70–1. 44
Length of alae (N=9 in female)	1. 21	1. 00– 1. 33	0. 73	0. 56–0. 85
Length of genital flap	0. 87	0. 70– 1. 15		
Length of caudal rami	0. 57	0. 49– 0. 63	0. 53	0. 44–0. 63
Length of egg strings (4 strings)	9. 13	7. 50–10. 50		

Remarks.—Two sets of descriptions are given below, the first for the mature adult, the second for the immature adult. The author feels that the changes that occur in the adult life history stage, as indicated in the measurements, may have caused some confusion in the taxonomy of the genus. The bases for this belief are given in the discussion section, following the description of the species.

Description.—(Mature adult): Female cephalothorax (fig. 16*a*) ovoid, consisting of cephalon and first 4 thoracic segments. Frontal region distinct, length approximately one-twelfth that of entire cephalothorax, with median cleft and narrow membrane along anterior margin. Lateral cephalothoracic margins with indentation medially, distinct in some specimens, indistinct in others; margin with fine membrane. Posterior lateral cephalothoracic region broadly rounded, extending past median posterior region, with socket-like depression (not figured); posterior sinus (fig. 16*c*) distinct, U-shaped, with fine membrane along outer margin. Median-posterior region with pair of small lobes laterally. Major dorsal cephalothoracic grooves forming irregular H, anterior legs extending past indistinct ocular region (ocular region not figured). Dorsal cephalothoracic surface without plumosities but with minute, spikelike irregularities laterally and small denticulations posteriorly.

Free fourth pedigerous segment, excluding alae, approximately one-fifth width of cephalothorax, widest medially, at origin of fourth thoracic legs. Alae sharply indented on median lateral margin, extending posteriorly over anterior end of genital segment. Division between fourth pedigerous and genital segments distinct, demarcated ventrally by ridgelike transverse projection.

Female genital segment (fig. 16*d*) of variable shape, narrow anteriorly in some specimens, broad in others, posterior dorsal surface with pair of lateral lappets, lappets distinct from segment. Dorsal surface of segment lightly rugose, extending laterally slightly past ventral region. Fifth legs (fig. 16*f*) arising from posterior lateral surface of dorsal overlap, consisting of 2 nodules, anteriormost with single setule, posterior with 3 setules.

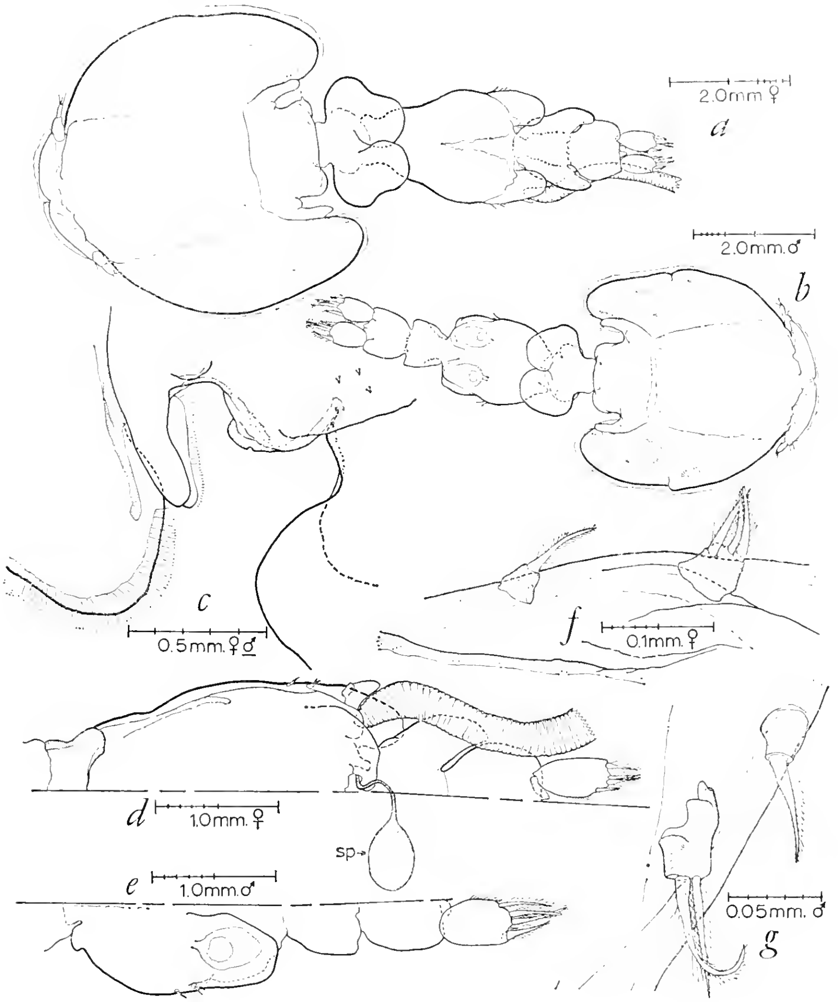


FIGURE 16.—*Elytrophora brachyptera* Gerstäecker, 1853, matuie adult, dorsal view: *a*, female; *b*, male; *c*, posterior cephalothoracic sinus. Ventral view: *d*, female genital segment showing spermatophore (sp), abdomen, and caudal ramus; *e*, male genital segment, abdomen and caudal ramus; *f*, female left fifth leg; *g*, male left fifth leg.

Abdomen 2-segmented, distinct from genital segment ventrally, indistinctly separable dorsally. First segment, excluding lateral projections, slightly shorter than second, with pair of distinct, flap-like projections extending laterally and posteriorly, to middle of second segment. Second segment convex laterally, flat posteriorly except for slight, bilobed anal projection. Caudal rami broad, with 4 plumose setae and 2 lightly plumose setules distally, with row of fine denticulations around base of outermost seta.

Male cephalothorax (fig. 16*b*) similar to that of female although lateral indentations more distinct. Alae on free fourth pedigerous segment tapered laterally, without sharp constriction present in female. Genital segment (fig. 16*e*) with flatly convex lateral margins anteriorly, almost straight lateral margins posteriorly. Fifth legs (fig. 16*g*) similar to those of female except posteriormost nodule with 2 lightly plumose setules instead of 3. Abdomen 2-segmented, first segment narrow anteriorly, angled to widest point medially, lateral margins straight posteriorly. Second segment and caudal rami similar to that in female.

Female and male antennule (fig. 17*a*) 2-segmented, attached to anterior-lateral ventral surface of cephalothorax and adjacent portion of frontal region. First segment slightly less than twice the length of second, tapered distally, bearing 23 naked or lightly plumose setae and setules on distal half of anterior ventral surface and distal ventral surface. Second segment club shaped, with 14 naked setules distally. Female antenna (fig. 17*b*) 3-segmented, situated posterior and medial to antennule base. First segment short, irregular, with well-developed, posteriorly projecting spine from lateral posterior surface. Second segment broader proximally than distally, with minute setule on distal inner surface (not figured); third segment fused with clawlike terminal process, bearing flabby, setalike accessory process proximally, more elongate, setalike accessory process from median third, at break in sclerotization suggesting point of fusion of segment and terminal process. Male antenna (fig. 17*c*) similar to that of female although projection on first segment shorter, with secondary claw on terminal process of third segment.

Female and male mandible (fig. 17*b*) rodlike, jointed in proximal medial region, proximal portion tapered to joint, distal part flattened distally, with indistinct break at beginning of flattened part; flattened region curved inward, with 12 denticulations along inner margin Female and male postantennal process (fig. 17*b*) consisting of 2 nodules, each bearing several hairlike projections. Female and male postoral process (fig. 17*b*) broadly based, distally slender, spinelike, curving laterally distally. Maxillule (fig. 17*b*) situated lateral to mouth cone base, immediately anterior to postoral process, consisting of node bearing naked seta and 2 naked setules. Maxilla (fig. 17*d*) 2-segmented, situated lateral and slightly posterior to postoral process. First segment slightly less than four-fifths the length of second, excluding terminal processes. Second segment elongate, broadest medially,

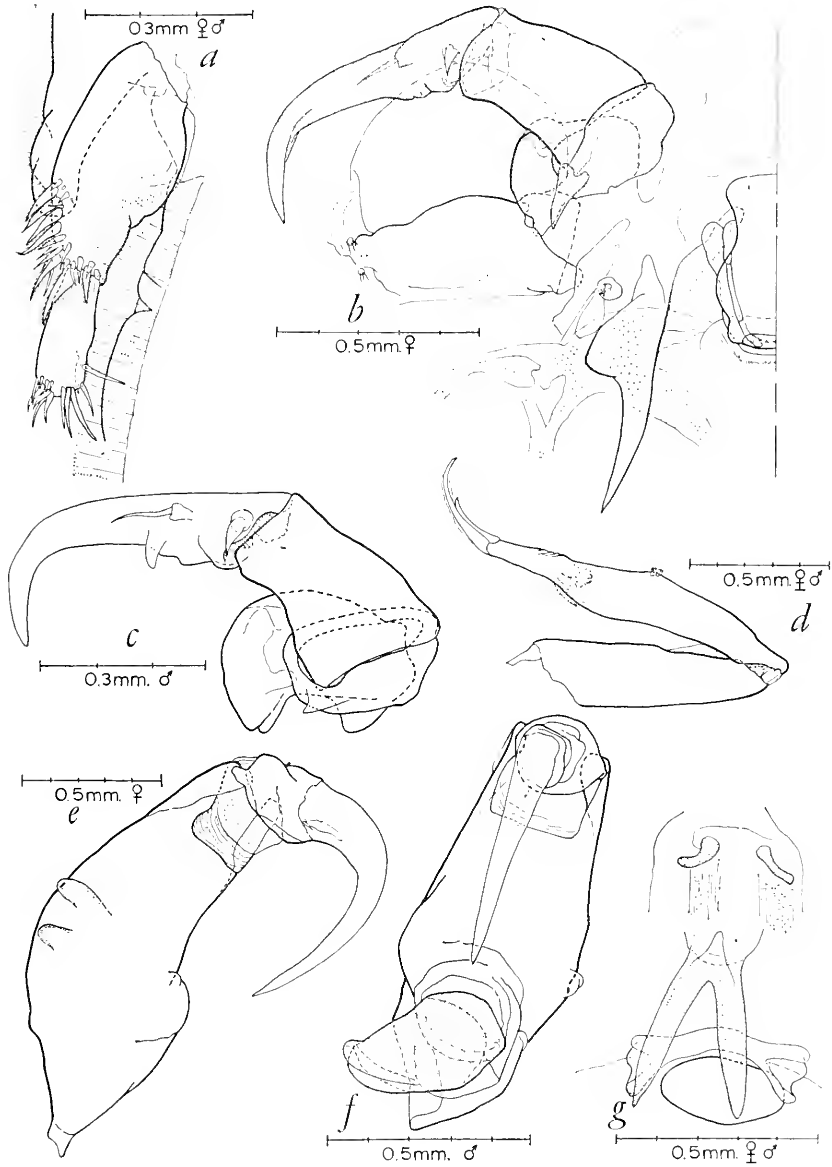


FIGURE 17.—*Elytrophora brachyptera* Gerstäecker, 1853, mature adult, ventral view: *a*, right antennule; *b*, female oral region, right side showing antenna, postantennal process, mouth cone, mandible, maxillule, and postoral process; *c*, male right antenna; *d*, left maxilla; *e*, female maxilliped; *f*, male maxilliped; *g*, sternal furca.

with small, fan-shaped projection from outer margin at widest point and 2 larger, frilled membranes more distally, 1 on inner surface, second on outer. Second segment also with small roughened area on distal outer surface, similar to that of adhesion surface; distal end bearing 2 setalike terminal processes, innermost slightly less than twice the length of outer, with fine membrane along outer and inner margin, outermost with finely frilled membrane along outer margin.

Female maxilliped (fig. 17*e*) 2-segmented, situated posterior and slightly medial to maxilla base. First segment strongly developed, narrow proximally and distally, broad medially, with pair of small, shelflike projections on medial posterior surface. Second segment short, distinct from clawlike terminal process, with setule-like accessory process on inner surface, at junction of segment and terminal process. Male maxilliped (fig. 17*f*) differing from that of female by presence of large, lobate projection from proximal inner surface of first segment, projection containing heavily sclerotized, clawlike process; ridges on first segment not as distinct as in female.

Female and male sternal furca (fig. 17*g*) V-shaped, tines slender, extending posteriorly over interpodal plate of first thoracic legs.

For nature of legs and armature, see figures 18*a–f* and table 8. Small, platelike projection present immediately behind interpodal plate of first thoracic legs, with minute nodules in immature adults, similar to those of *Euryphorus nordmanni* Milne-Edwards.

DESCRIPTION.—Immature adult. Female cephalothorax (fig. 19*a*) ovoid, consisting of cephalon and first 4 thoracic segments. Frontal region approximately one-twelfth the total length of cephalothorax, with median cleft and narrow membrane on anterior margin. Lateral cephalothoracic margins convex, with membrane; with distinct indentation medially, indentation formed by folding of dorsal cuticle, extending inward to median cephalothoracic region. Posterior lateral cephalothoracic region broadly rounded, terminating at junction with median cephalothoracic region, forming outer surface of posterior sinus (fig. 19*c*). Sinus irregularly U-shaped, outer margin with fine, irregular membrane. Posterior median cephalothoracic region not extending to end of posterior lateral cephalothoracic region, margin lobed laterally, flat medially, distinct from anterior end of free fourth pedigerous segment. Major dorsal cephalothoracic grooves forming irregular H, anterior legs of H extending to just posterior to ocular region, turning inward sharply. Ocular elements distinct. Dorsal cephalothoracic surface with numerous, elongate plumosities arranged in 2 groups, one extending anteriorly, from just posterior to crossbar of dorsal cephalothoracic grooves, to anterior region of longitudinal grooves; second group, containing fewer plumosities, located on posterior lateral cephalothoracic region.

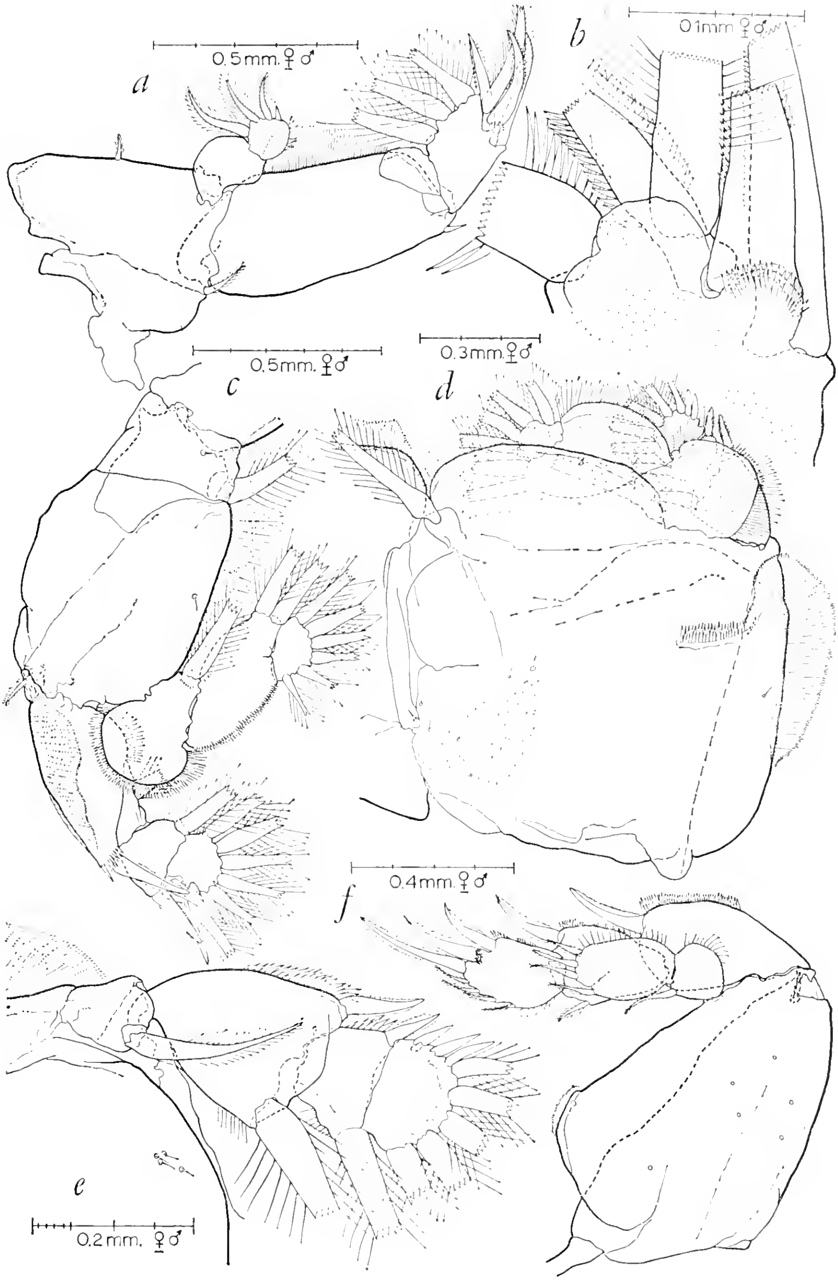


FIGURE 18.—*Elytrophora brachyptera* Gerstäecker, 1853, mature adult, right thoracic legs, anterior view: *a*, first; *b*, second segment of exopodite of first; *c*, second; *d*, third; *e*, exopodite of third (posterior view); *f*, fourth.

Female free fourth pedigerous segment, excluding alae, slightly more than one-fifth the width of cephalothorax, widest medially, at attachment of fourth thoracic legs. Alae widest anteriorly, constricted medially, broadly rounded posteriorly, covering anterior third of genital segment.

Female genital segment (fig. 19*d*) broadly rounded anteriorly, lateral margins flatly convex, lateral-posterior dorsal surface extending posteriorly as pair of lobate projections, projections not distinct from genital segment. Dorsal surface of genital segment platelike, extending laterally past somewhat irregular posterior ventral surface. Fifth legs (fig. 19*f*) arising from ventral lateral surface of platelike projection of dorsal surface of genital segment, consisting of pair of nodules, anteriormost with single setule, posterior with 3 setules. Ovoid, adhesion-like surface present just posterior to fifth legs.

Female abdomen 2-segmented, distinct from genital segment. First segment slightly shorter than second, broader anteriorly than posteriorly, with slight posterior lateral projections; second segment with convex lateral margins and slight, bilobed, anal projection. Caudal rami broad, with 4 plumose setae and 2 naked or very lightly plumose setules from distal surface, with row of fine denticulations around base of outermost seta.

Male cephalothorax (fig. 19*b*) similar to that of female although somewhat narrower, without dorsal plumosities or distinct projections indicating previous presence. Free fourth pedigerous segment more drawn out medially than in female, alae not as large, without medial constriction present in female. Genital segment (fig. 19*e*) basically ovoid, without platelike dorsal part and posterior extensions of female; fifth leg (fig. 19*g*) similar to that of female, genital segment without adhesion-like surface present in female. Abdomen 2-segmented, first segment slightly shorter than second, overlapping second dorsally; second segment tapered anteriorly, with flatly convex lateral margins and bilobed anal projection. Caudal rami as in female although more plumose along inner margin.

Female and male antennule (fig. 20*a*) 2-segmented, most of anterior surface of first segment overlapped by ventrally curved lateral surface of frontal region. First segment slightly more than twice the length of second, broad proximally, tapered irregularly to narrow distal end, with small, knoblike projection from posterior distal surface, with 15 naked or lightly plumose setules from anterior ventral and distal ventral surfaces in female, male with 19 naked or lightly plumose setules. Second segment subrectangular, with 1 naked setule from median dorsal surface, second from distal posterior surface, and 8 or 9 naked setules from distal surface. Female antenna (fig. 20*b*) 3-segmented, situated medial and posterior to antennule base. First

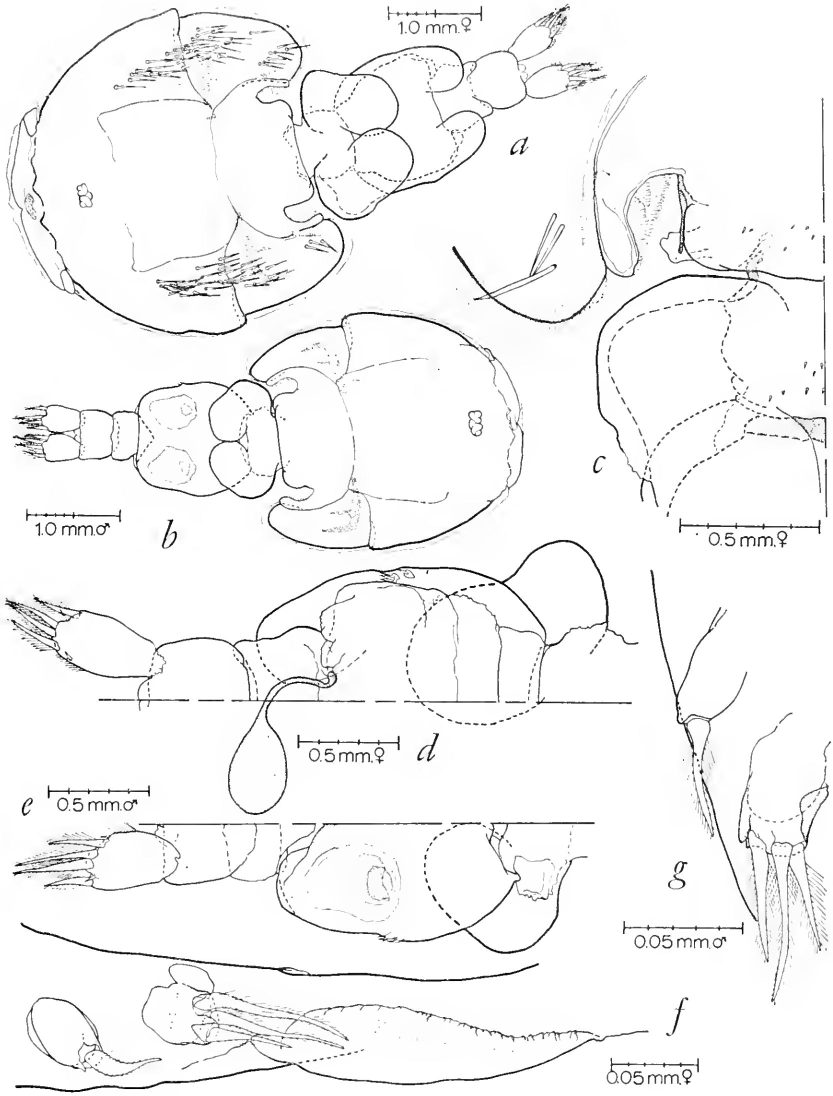


FIGURE 19.—*Elytrophora brachyptera* Gerstäecker, 1853, immature adult, dorsal view: *a*, female; *b*, male; *c*, lateral posterior cephalothoracic region and free fourth pedigerous segment. Ventral view: *d*, female free fourth pedigerous segment, genital segment (showing attached spermatophore), abdomen, and caudal ramus; *e*, male free fourth pedigerous segment, genital segment, abdomen, and caudal ramus; *f*, right fifth leg and genital fold of female; *g*, male right fifth leg.

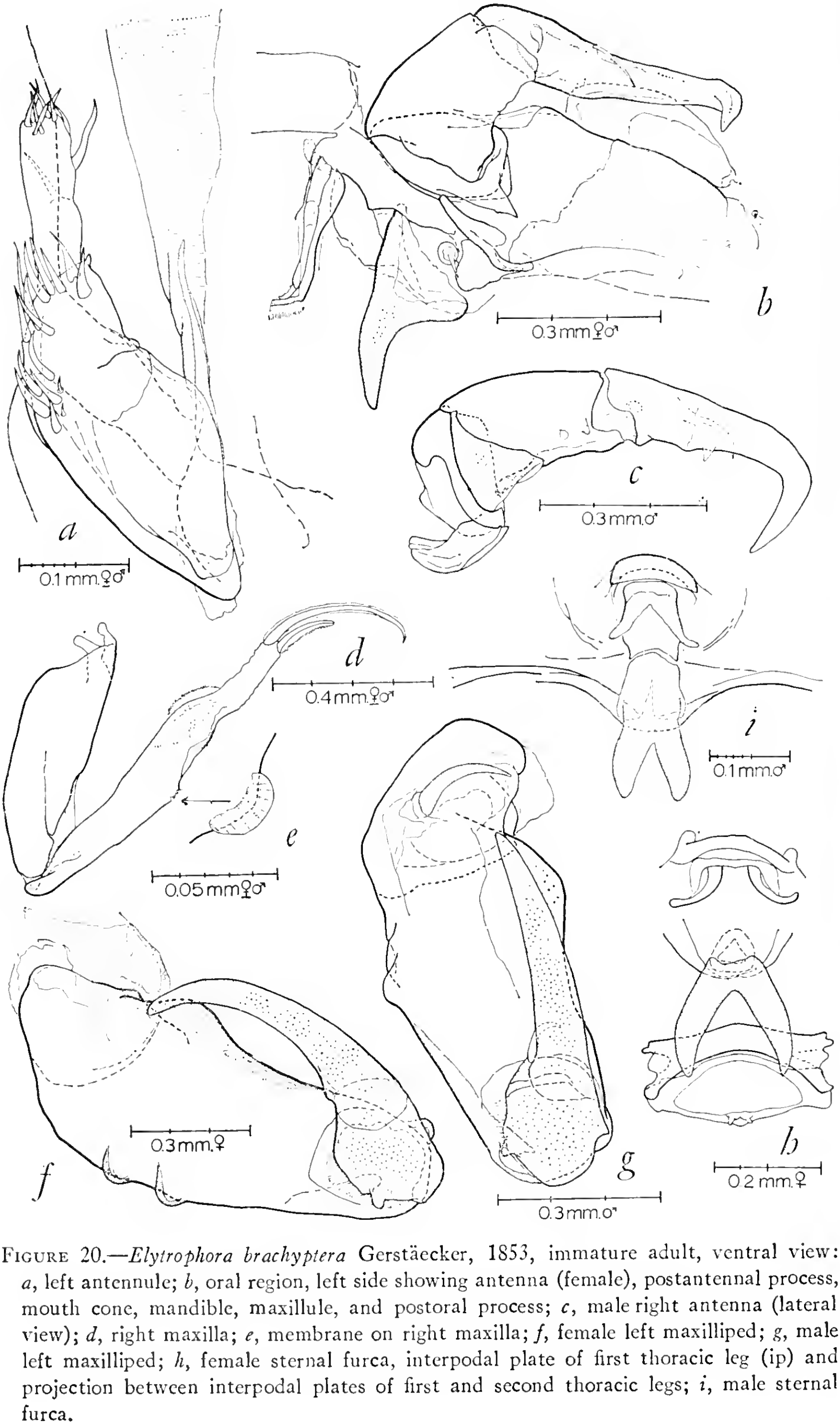


FIGURE 20.—*Elytrophora brachyptera* Gerstäecker, 1853, immature adult, ventral view: *a*, left antennule; *b*, oral region, left side showing antenna (female), postantennal process, mouth cone, mandible, maxillule, and postoral process; *c*, male right antenna (lateral view); *d*, right maxilla; *e*, membrane on right maxilla; *f*, female left maxilliped; *g*, male left maxilliped; *h*, female sternal furca, interpodal plate of first thoracic leg (ip) and projection between interpodal plates of first and second thoracic legs; *i*, male sternal furca.

segment short, irregular, with triangular projection from lateral posterior surface; second segment approximately 4 times the length of first, broader proximally than distally. Third segment fused with clawlike terminal process, with flabby, setalike accessory process from proximal surface and elongate, setalike accessory process from medial third, at break in sclerotization suggesting distal end of segment and proximal end of terminal process. First segment of male antenna (fig. 20*c*) similar to that of female although triangular projection smaller; second segment with pair of minute, lappet-like projections medially and small adhesion surface (not figured) on slight swelling of distal posterior surface. Third segment separable from clawlike terminal process, bearing same accessory processes as in female; terminal process strongly curved distally, with small, pointed secondary projection proximally.

Female and male mandible (fig. 20*b*) 2-parted, first part short, tapered distally, with indistinct break at beginning of taper. Second part elongate, flattened distally, with indistinct break just proximal to flattened part, distal inner surface with 12 denticulations. Female and male postantennal process (fig. 20*b*) consisting of pair of nodules, each with several hairlike processes, just lateral to padlike swelling situated lateral to antenna base. Female and male postoral process (fig. 20*b*) spinelike, with broad base and laterally curved tip, not as elongate as in mature adult specimens. Female and male maxillule (fig. 20*b*) nodular, bearing 2 setules and 1 seta. Female and male maxilla (fig. 20*d*) 2-segmented, situated lateral to postoral process. First segment slightly less than four-fifths the length of second, excluding terminal process; second elongate, with small, fan-shaped projection (fig. 20*e*) from outer surface medially, 2 additional membranes present distally; terminal processes setalike, innermost more than twice the length of outer, with membranous band and fine plumosities along margin.

Female maxilliped (fig. 20*f*) 2-segmented, situated posterior and slightly medial to maxilla base. First segment strongly developed, with pair of small, shelflike projections from posterior medial surface; second segment small, distinct from long, clawlike terminal process, bearing setalike accessory process from inner distal surface. Male maxilliped (fig. 20*g*) similar to that of female although shelflike projections of first segment smaller and proximal end of segment more complex, with heavily sclerotized, clawlike projection from proximal inner surface.

Female sternal furca (fig. 20*h*) V-shaped, overlapping interpodal plate of first thoracic legs. Male sternal furca (fig. 20*i*) similar to that of female although tines not as regular and not appearing as heavily sclerotized.

Thoracic legs I–IV differing from those of adult specimens in nature of segment divisions and minor armature elements (e.g., division between first and second segments of protopodite of second thoracic leg indistinct in female; plumosities on ramal segments not as extensive). For nature of legs and armature see figures 21*a-f* and table 8. Small, platelike projection present just posterior to interpodal plate of first thoracic legs, projection bearing pair of minute nodules from median distal surface.

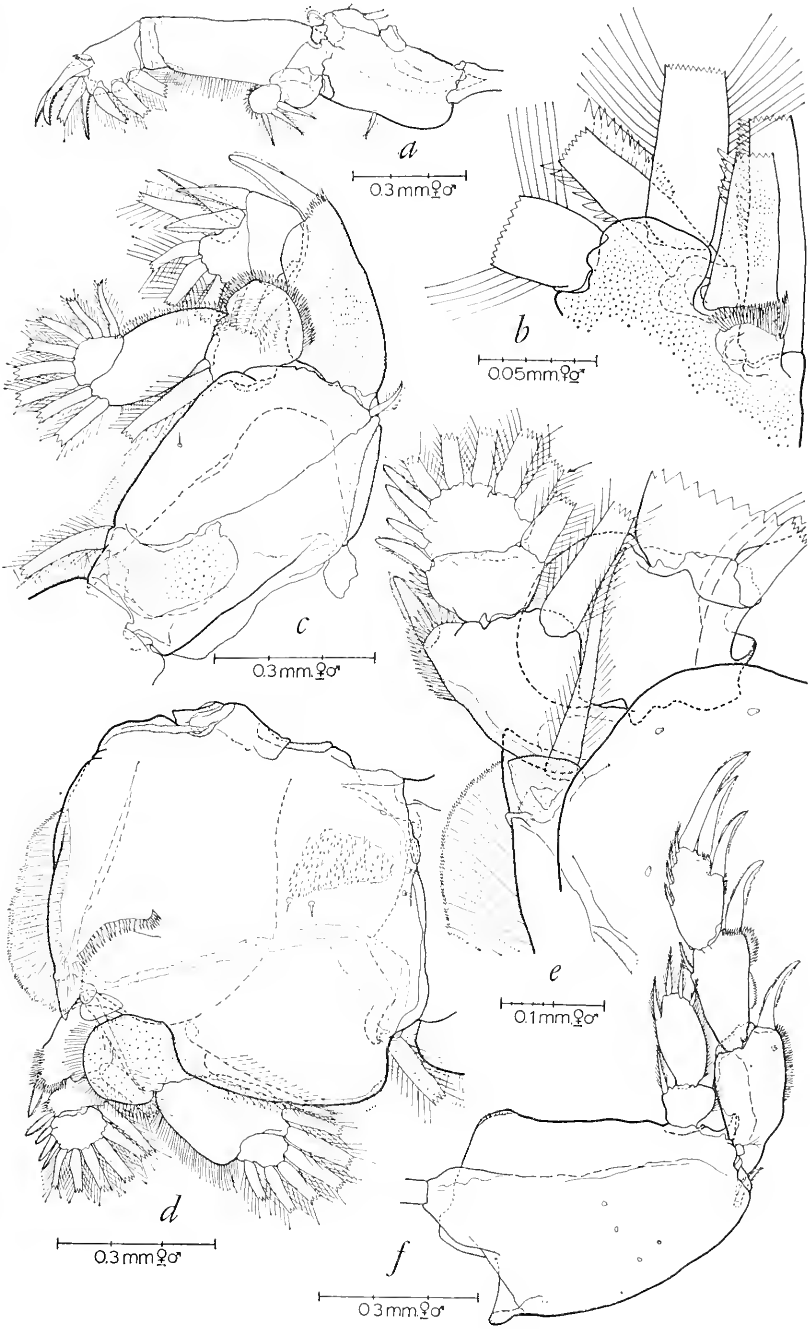
TABLE 8.—*Armature of thoracic legs I–IV of the female and male of* Elytrophora brachyptera *Gerstäecker, 1853*

Leg	Surface	Interpodal Plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
I	Outer		s,p		rh§	dm,3dmII			C	
	Inner		p		c	4P			3p	
II	Outer	m		m,p	m,d,dmII	dmII	2dmII,Q	C	C	2P
	Inner		s,P	m,s	c,P	c,P	c§,5P	P	c,2P	4P
III*	Outer	m	fm,dm,P		dm,dmII	dm,fmII	3fmII,2P	c	c	2P
	Inner		d†,2d,5s, P,m,4s		c,P	c,P	c§,3P	P	c,2P	2P
IV*	Outer		s§,p		dm,fmII	fm,dm,fmII	fm,dm, fmII,fm, 2fmII	c	c,3p‡	
	Inner		fm,s§			c§,4p‡		p‡	p‡	

*Numerous, hairlike processes on protopodite not tabulated.
†Denticulations very small.
‡Larger in male than in female.
§Not present in immature adults.

DISCUSSION.—The measurements, descriptions, and figures of the 2 adult stages of *Elytrophora brachyptera* indicate that a morphological change takes place in the transition from the immature to the mature condition. This, however, is not the first time that this has been indicated. Heegaard (1955) points out some of the differences between his immature "Atlantide" material and figures of the adult *E. brachyptera*. Among these he indicates (p. 46) that the sternal furca in the adult "is delicate with two long pointed branches with a V-shaped incision between them. In the young 'Atlantide' specimens the furca is not fully grown and therefore more plump in the peduncle, shorter in the branches which are more blunt at their points and together shaping a U instead of the V in the adult." This age variation, which is present to a lesser degree in the immature adult specimens used for this description,

FIGURE 21.—*Elytrophora brachyptera* Gerstäecker, 1853, immature adult, right thoracic legs, anterior view: *a*, first; *b*, second segment of exopodite of first; *c*, second; *d*, third; *e*, exopodite of third (posterior view); *f*, fourth.


a
0.3 mm ♀♂
b
0.05 mm ♀♂
c
0.3 mm ♀♂
d
0.3 mm ♀♂
e
0.1 mm ♀♂
f
0.3 mm ♀♂

can also be found in many other characteristics. The presence of plumosities on the dorsal surface of the cephalothorax in immature adult (with spermatophore) female specimens is suggested only by small, spikelike irregularities in ovigerous female specimens. The dimensions of the female genital segment become larger as egg production begins; the angle changes at the point where the genital flap projects, and the flap becomes distinct from the segment in the mature adult female. The projections on the first abdominal segment of the female greatly enlarge in the transition from the immature to mature adult condition. The claw-containing process on the proximal inner surface of the male maxilliped is poorly sclerotized: the claw projects in the immature state while it is heavily sclerotized and is covered by the cuticle in the mature adult. The described differences in the armature of the thoracic legs are more difficult to reconcile although specimens collected from the same species of host in the same geographic area (Line Island specimens) exhibit this variation. Most of the change, however, occurs in the genital segment, the abdomen, and the amount of sclerotization. These variations are evident not only in the material used for this description but also in specimens identified as *E. brachyptera* by C. B. Wilson (USNM 78931). It is suggested, therefore, that some of the characteristics previously used in the taxonomy of the species in the genus should be reexamined on the basis of the maturity of the specimens.

Gloiopotes Steenstrup and Lütken, 1861

Diagnosis.—Cephalothorax ovoid, consisting of cephalon and first 4 thoracic segments, with spines or hairlike processes, or both, on dorsal surface. Free fourth pedigerous segment with alae. Female genital segment with pair of lobate projections posteriorly. Fifth legs large, heavily sclerotized, projecting past genital segment proper, either rodlike or lobate; sixth legs, if present, strongly reduced. Abdomen elongate, 2-segmented, caudal rami rodlike. Antennule 2-segmented; antenna 3-segmented, with clawlike terminal process, male terminal process modified. Mandible rodlike, distal surface slightly flattened, with 12–13 denticulations along inner surface. Maxillule nodular, with several setalike processes; maxilla 2-segmented. Postantennal process consisting of plate bearing 1 or more spinelike projections and 2 nodules, each with several hairlike processes; postoral process spinelike, bifurcate, or simple. Maxilliped 2-segmented, prehensile. Thoracic legs I–III biramous although endopodite of first leg reduced; fourth thoracic leg uniramous. Ramal count of first 4 thoracic legs 2–2, 3–3, 3–2, 3; second segment of exopodite of first leg tipped by 1 simple and 2 bifid spines, bifid spines with spinelike accessory process.

Gloiopotes huttoni (Thomson)

FIGURES 22–24

Lepeophtheirus huttoni Thomson, 1889, p. 354, pl. 28, fig. 10a–c; pl. 29, fig. 1a–m.
Gloiopotes huttoni (Thomson) Bassett-Smith, 1899, p. 458.—Hewitt, 1964a, p. 86, figs. 1–16.—Yamaguti, 1963, p. 104.
Gloiopotes costatus Wilson, 1919, p. 313, pl. 21; 1937, p. 429.—Yamaguti, 1963, p. 103.
Caligus longicaudatus Marukawa, 1925, p. 1243, fig. 2396; 1947, p. 927, fig. 2654.
Gloiopotes watsoni Kirtisinghe, 1934, p. 167, figs. 1–17.—Yamaguti, 1963, p. 104, pl. 126, fig. 1.
Gloiopotes species Yamaguti, 1936b, p. 4, pl. 2, fig. 20; pl. 3, figs. 21–35.
Gloiopotes zeugopteri Rao, 1951, p. 248, figs. 1–15.
Gloiopotes longicaudatus (Marukawa) Shiino, 1954b, p. 273, figs. 1–2; 1957a, p. 364; 1958, p. 105; 1959a, p. 348.—Heegaard, 1962, p. 174, figs. 151–153.—Ho, 1963, p. 87, figs. 6–10.—Shiino, 1963a, p. 343.—Yamaguti, 1963, p. 104, pl. 125, fig. 1.—Kirtisinghe, 1964, p. 87, figs. 102–103.

HOSTS AND DISTRIBUTION.—24 host records:

location	*hosts*	*reference*
New Zealand	*Histiophorus herschelli*	Thomson, 1889
	Makaira mitsukurii	Hewitt, 1964a
Australia	*Marlina zelandica*	
	Istiompax australis	Heegaard, 1962
Indian Ocean	*Histiophorus brevirostris*	Bassett-Smith, 1899
	H. gladius	Kirtisinghe, 1934
	Xiphias zeugopteri	Rao, 1951
	Makaira indica	Kirtisinghe, 1964
	M. mazara	
	Tetrapturus mitsukurii	
	T. marlina	Shiino, 1958, 1959a
Eastern Pacific	"Swordfish"	Wilson, 1919
	Istiophorus greyi "Marlin"	Wilson, 1937
	"Black Marlin"	
	Makaira audax	
	Makaira species	
	Xiphias gladius	Shiino, 1963a
South Pacific	"Marlin"	Wilson, 1929?
Western Pacific	*Tetrapturus mitsukurii*	Yamaguti, 1936b
	Parathynnus sibi	
	M. mazara	Shiino, 1954b
	Istiophorus orientalis	
	Xiphias gladius	Ho, 1963

MATERIAL.—Two females and 2 males (USNM 112879) collected by D. W. Strasburg (USFWS) from external surface of *Makaira ampla* (Poey) captured by rod and reel off Kona, Hawaii. Thirteen females and 1 male (USNM 112880) collected by E. C. Jones (USFWS) from external surface of *Makaira audax* (Philippi) captured off Waianae, Hawaii. Two females and 2 males (retained by author) from external surface of *Makaira audax* (Philippi) captured off Waianae, Hawaii.

Two females and 2 males (retained by author) from either *Makaira ampla*? (Poey) or *Istiompax marlina* (Jordan and Hill) examined at Honolulu Fish Market (USFWS). Two females and 1 male (retained by author) from external surface of *Makaira ampla*? (Poey) captured in Hawaiian region (USFWS).

Measurements.—(In mm) 18 females and 6 males:

	female		*male*	
	mean	*range*	*mean*	*range*
Total length, excluding caudal setae	12. 02	10. 20–12. 90	10. 25	9. 53–10. 95
Length of cephalothorax, including frontal region	5. 81	5. 03– 6. 08	4. 63	4. 35– 4. 88
Width of cephalothorax	5. 06	4. 35– 5. 63	4. 00	3. 60– 4. 28
Length of genital segment, excluding fifth legs	3. 21	2. 40– 3. 60	2. 16	1. 95– 2. 25
Width of genital segment	3. 03	2. 70– 3. 30	1. 94	1. 88– 2. 03
Length of abdomen	2. 29	1. 67– 2. 55	1. 83	1. 52– 2. 04
Length of alae (male N=5)	1. 76	1. 33– 2. 11	1. 08	0. 93– 1. 15
Length of fifth leg, measured along outer margin (male N=5)	1. 61	1. 41– 1. 78	1. 56	1. 30– 1. 63
Length of caudal rami	1. 06	0. 89– 1. 30	1. 23	1. 04– 1. 37
Length of egg strings (12 strings)	3. 34	2. 40– 4. 65		

Description.—Female cephalothorax (fig. 22*a*) ovoid, consisting of cephalon and first 4 thoracic segments. Frontal region distinct, with small, median, knoblike projection and frilled membrane on anterior margin; heavily sclerotized articulation surfaces (articulation with cephalothorax proper) present on posterior surface. Lateral cephalothoracic margins flatly convex although slightly irregular, with narrow frilled membrane and row of plumosities, membrane extending around posterior end of broadly curved posterior lateral cephalothoracic region, terminating adjacent to origin of posterior sinus. Posterior sinus (fig. 22*c*) irregularly U-shaped, open end constricted, lateral margin formed by heavily sclerotized extension of median cephalothoracic region, small, lappet-shaped dorsal projection present at anterior end of sinus in addition to small membrane along lateral margin of sinus and second, posteriorly projecting membrane, from dorsal lateral surface. Median cephalothoracic region extending to or slightly past posterior end of lateral cephalothoracic regions, margin irregular. Dorsal surface of cephalothorax with numerous hairlike projections laterally, giving fuzzy appearance; 3 rows of long, slender, bifid plumosities present on lateral regions, lateral to ocular region. Dorsal surface also with numerous spinules, primarily on median cephalothoracic region, extending around ocular region and on posterior end of median cephalothoracic region. Dorsal cephalothoracic grooves distinct, major grooves forming irregular H. Eyes distinct, in anterior third of cephalothorax.

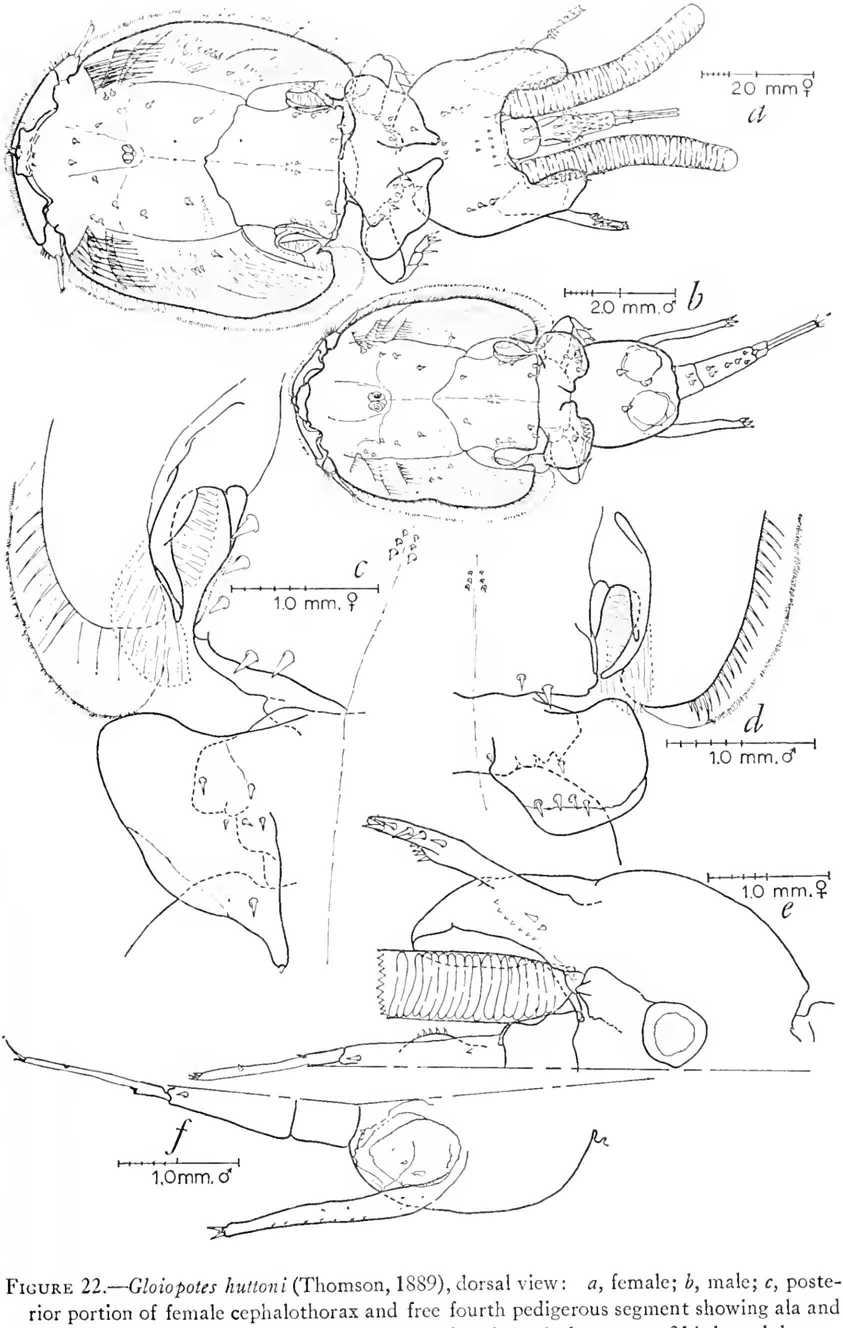


FIGURE 22.—*Gloiopotes huttoni* (Thomson, 1889), dorsal view: *a*, female; *b*, male; *c*, posterior portion of female cephalothorax and free fourth pedigerous segment showing ala and armature; *d*, male, same. Ventral view: *e*, female genital segment, fifth leg, abdomen, and caudal ramus; *f*, male genital segment, fifth leg abdomen, and caudal ramus.

Female free fourth pedigerous segment less than half the width of cephalothorax, tapered sharply anteriorly and posteriorly from widest point, at fourth leg attachment. Alae broad anteriorly, tapered (in figured specimen) to narrow, sharply rounded posterior end tipped with single spinule; alae rounded posteriorly in some specimens, subrectangular in others. Alae extending posteriorly, over anterior region of genital segment, bearing several spinules dorsally; medial lateral surface semimembranous.

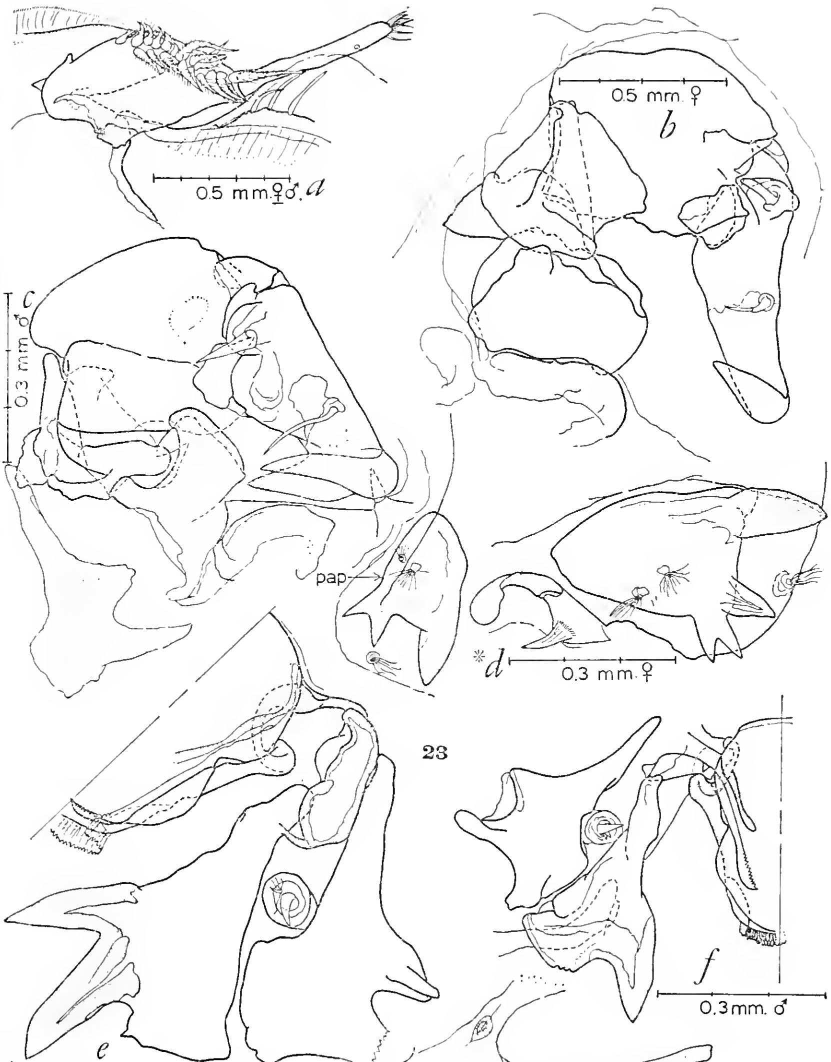
Female genital segment (fig. 22*e*) indistinctly separable from fourth pedigerous segment, broad medially, with large, lobate projection from each lateral posterior surface, lateral surface of segment roughened adjacent to lobes. Genital segment bearing strong, heavily sclerotized fifth legs projecting from ventral lateral posterior surface, at base of lobate projections; legs extending posteriorly and laterally to end of abdomen, with row of spinules on distal ventral surface and on indentation in distal medial region.

Female abdomen 2-segmented, distinctly separable from genital segment. First segment subrectangular, approximately half the length of elongate second segment; second segment with club-shaped swelling on dorsal surface. Both segments with numerous spinules. Caudal rami elongate, appearing 2-parted although "division" an indentation in lateral surface (rami not 2-segmented as indicated by Heegaard, 1962, p. 174). Distal lateral surface of rami with single spine, distal ventral surface with 1 and distal surface with at least 3 spines; several spinules present on remaining ramal surface (not figured).

Cephalothorax of male (fig. 22*b*) similar to that of female although number and arrangement of spinules on dorsal surface different. Alae of free fourth pedigerous segment (fig. 22*d*) primarily lateral expansions, without narrow, posterior extension present in female; with semimembranous trailing edge. Genital segment (fig. 22*f*) distinct from fourth pedigerous segment, ovoid in outline, without lobate posterior projections. Heavily sclerotized fifth legs projecting from posterior ventral surface, without distal medial indentation present in female, with small spinules and bearing 3 spinules from distal surface. Abdomen of both sexes similar in general outline although male without club-shaped dorsal swelling of second segment. Caudal rami similar to those of female although inner terminal process longer.

Female and male antennule (fig. 23*a*) 2-segmented, first segment

FIGURE 23.—*Gloiopotes huttoni* (Thomson, 1889), ventral view: *a*, left antennule; *b*, female left antenna; *c*, male left antenna and postantennal process (pap); *d*, female left postantennal process (*=see text); *e*, female oral region, left side showing mouth cone, mandible, maxillule, and postoral process; *f*, male, same, right side; *g*, right maxilla (pop=postoral process; a=adhesion pad, not present in male); *h*, left maxilliped.


0.5 mm.♀♂. a
0.5 mm. ♀
b
c
0.3 mm ♂
pap
*d
0.3 mm. ♀
23
f
0.3mm. ♂
e
0.3 mm. ♀
pop
a
g
0.5mm. ♀♂
h
0.5 mm. ♀ ♂

approximately 1¼ times the length of second, tapered from broad proximal to narrow distal end, bearing approximately 22 lightly plumose setae from anterior ventral and distal ventral surfaces. Second segment elongate, rod shaped, with naked setule from distal posterior surface, approximately 7 from distal surface. Female antenna (fig. 23*b*) 3-segmented, situated posterior and medial to antennule base. First segment subtriangular, small, with roughened, triangular projection from proximal posterior surface. Second segment almost twice the size of first, with small, lappet-like anterior distal projection. Third segment indistinctly separable from clawlike terminal process, with small, knoblike projection proximally, projection bearing setule-like accessory process; second setule-like accessory process present at junction of segment and terminal process. Male antenna (fig. 23*c*) 3-segmented, first 2 segments similar to those of female, third with larger accessory processes and bifurcate terminal process.

Female and male mandible (fig. 23*e*) indistinctly 3-parted, rodlike; third part flattened, distal inner surface with 12 denticulations. Small, bilobed cuticular flap present in female adjacent to mandible base. Postantennal process of figured female (fig. 23*d*) situated lateral and slightly posterior to base of antenna, consisting of platelike region of heavy sclerotization bearing large spine on lateral posterior surface, smaller spine on inner posterior surface, and bifurcate spinous projection on posterior inner surface. Platelike region also bearing 2 nodules on medial surface, each with several hairlike projections; additional nodule present just posterior to process, with several hairlike processes. Other female specimens with condition similar to that of male or with various combinations of spines (see discussion). Small, spinelike projection present adjacent to anterior inner surface of postantennal process, arising from edge of depression associated with base of antenna. Male postantennal process (fig. 23*c*) similar to that of figured female although lacking smaller of 2 single spinelike projections. Female postoral process (fig. 23*e*) bifurcate, each ramus spinelike; additional, minute, sharply pointed projection present just lateral to bifurcation. Male postoral process (fig. 23*f*) spinelike, not bifurcate as in female. Possible remnant of postoral adhesion pad present in female as minute, oblong protrusion just posterior to postoral process and medial to maxilla base. Female maxillule (fig. 23*e*) nodular, bearing single setule and cluster of hairlike processes. Male maxillule (fig. 23*f*) nodular, with 2 or 3 setules. Female and male maxilla (fig. 23*g*) 2-segmented, first segment approximately three-fourths the length of second, slender, width varying little throughout length. Second segment narrow proximally and distally, swollen medially, with indistinct membrane on medial inner surface;

distal surface bearing 2 saber-shaped processes, inner longer than outer, both with fine membranes along margins.

Female maxilliped (fig. 23*h*) 2-segmented, situated posterior and slightly medial to maxilla base. First segment strongly developed, lobate proximally, widest medially, tapered to slightly narrower distal end, without distinct irregularities. Second segment short, distinct from clawlike terminal process, with single, setule-like accessory process on inner surface, at junction of segment and terminal process. Male maxilliped similar in outline to that of female; first segment with 2 minute, lappet-like projections on inner surface, second segment with second setule-like accessory process proximally.

Sternal furca of female and male (fig. 24*a*) situated between and slightly posterior to maxilliped bases. Process basically bifurcate, arising from oval platelike area of heavy sclerotization, with spine-like projection on either side, just proximal to apex of bifurcation. Tines of bifurcation angled outward, bifurcate distally, each ramus of distal bifurcation bluntly rounded. Cuticular flap present on either side of sternal furca, with pointed projection laterally in both female and male, with rounded projection medially in female.

For nature of armature and legs, see figures 24*b*–*g* and table 9.

TABLE 9.—*Armature of thoracic legs I–IV of the female and male of* Gloiopotes huttoni (*Thomson, 1889*)

Leg	Surface	Inter-podal Plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
I	Outer		sss,p		h			d*	2p	
	Inner		p		c	3P,p,3dH			p′	
II	Outer	m		m,p′	m,fmH†	dH	dH,H,Q,P	C	c	c,4P
	Inner		s,P	m,s	c,P	c,P	4P	P	c,2P	2P
III	Outer	m	s,m,p		H	H	3H,2P	C	c,2P	
	Inner		2ss,P, m, 2s,C§		P	c,P	c,3P	c,2P	2P	
IV	Outer‡		h,p ‖		rh,3h, D,H	D,H	D,3H,D			

*Denticulations in clump in female, in row in male.
† Spine denticulated in male, not in female.
‡ Numerous spinules on protopodite and first segment of exopodite not tabulated. Spinule arrangement slightly different in two sexes.
§ Elements between rami.
‖ Elements in middle of segment, not on edge.

DISCUSSION.—*Gloiopotes huttoni* (Thomson, 1889) exhibits a wide variation in many characteristics. This variation may be a natural variation or the result of breakage and regrowth of some of the heavily sclerotized parts. The most striking example of this, in the Hawaiian specimens, is the variation in the spines associated with the postantennal process. In the figured female specimen (fig. 23*d*),

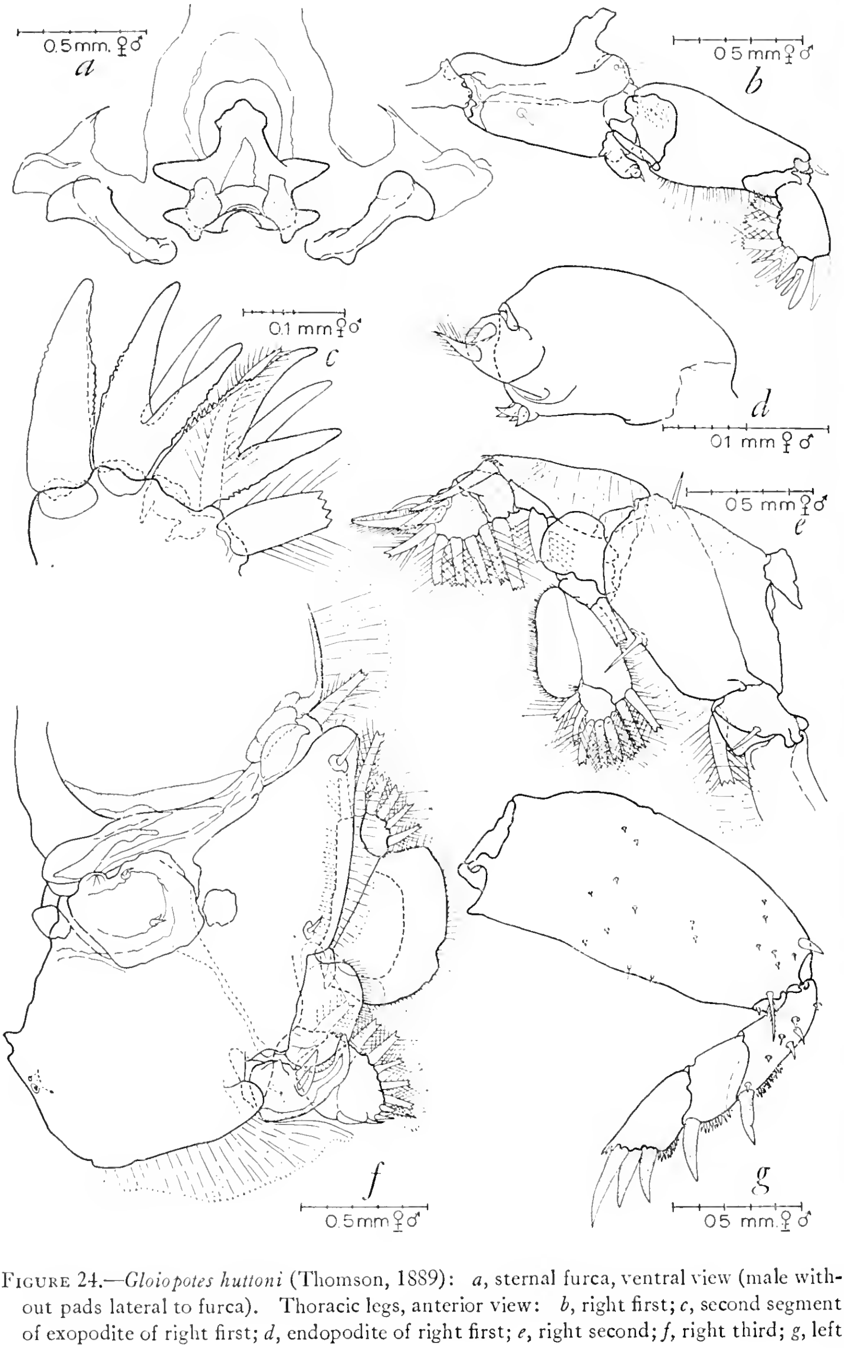


FIGURE 24.—*Gloiopotes huttoni* (Thomson, 1889): *a*, sternal furca, ventral view (male without pads lateral to furca). Thoracic legs, anterior view: *b*, right first; *c*, second segment of exopodite of right first; *d*, endopodite of right first; *e*, right second; *f*, right third; *g*, left fourth.

the process has a single, posteriorly directed spine, an inwardly directed bifid spine, and a single spine arising between the preceding two. In a second female, from the same host specimen, the left postantennal process is similar to that figured by Shiino (1954b, fig. 1*e*) and by Hewitt (1964a, fig. 13), having only the posteriorly directed spine and the bifid inwardly directed spine. In the same female specimen, the postantennal process on the right side has a posteriorly directed spine and a bifid inwardly directed spine, but the tip of the anteriormost tine of the latter is bifid, giving an appearance similar to that shown in figure 23*d* although the bifurcation is not as well developed. Many of the characteristics used to separate the species within the genus *Gloiopotes* have been shown to be variable (Hewitt, 1964a). Hewitt, however (p. 93), states that "the shape of the plates [alae] on the fourth thoracic [fourth pedigerous] segment does not appear to vary but they may be inclined at various angles . . .". The figured female specimen (figs. 22*a*, *c*) exhibits alae with a posterior projection while the alae of some of the other Hawaiian specimens do not have this projection and are rounded posteriorly or are almost flat. It is felt that the use of alae shape as the primary means of distinguishing between species is open to question, as is the use of the inclination of these plates and the amount and position of plumosities on the dorsal surface of the cephalothorax (Hewitt, 1964a). Hewitt also discusses the variation in the number of spines present in the material that he had available for study. This variation is exhibited by the Hawaiian specimens and, from an examination of material in the U.S. National Museum, appears to be characteristic of members of the genus. This author feels that spines may be of value, but only if a complete series is either absent or present (see discussion of *G. ornatus* below). One of the problems in using this characteristic, however, is that many of the spinules or even small spines are not figured or described in the literature (see discussion of *G. auriculatus* below.)

An examination of the type material of *G. costatus* Wilson, 1919 (USNM 49772, 49773, not 51040 and 51041 as Wilson indicates [p. 313]), and other material identified as this species, indicated that the variation that prompted Wilson to erect this species is also found in the Hawaiian specimens of *G. huttoni* (the variation in the number and position of spinules and the shape and inclination of the alae). One of the differences used by Shiino (1954b, p. 278) to separate *G. longicaudatus* (Marukawa) from *G. costatus* Wilson is the tripartite spine figured by Wilson on the first segment of the exopodite of the third leg of *G. costatus*. The female and male cotype specimens used by Wilson for his original description comprised a copulating pair, and the original specimens were in copulo until the present author separated them. An examination of this material suggests that the original figures were made while the pair was in copulo as, among other characteristics, the spine on the first segment of the third leg exopodite is bipartite. An examination of the specimens identified as *G. longicaudatus* by Ho (1963) and deposited in the U.S. National Museum (USNM 111247, 111248) shows the same variation present in the Hawaiian specimens of *G. huttoni* and the variation described by Hewitt (1964a) for the New Zealand specimens of this species.

Based upon these examinations and upon Hewitt's discussion, it is suggested that *G. huttoni* is the species of *Gloiopotes* that is found on billfishes in the Pacific. *G. ornatus* Wilson, 1905b, found on billfishes in the Atlantic, appears to be the counterpart of *G. huttoni* (e.g., Shiino, 1959a). The primary difference between these two species is the presence of a row of spines on the lateral surface of the genital segment of *G. ornatus* (absent in *G. huttoni*).

Barnard (1957) describes a species of *Gloiopotes*, *G. auriculatus*, from a Striped Marlin at Mossel Bay, South Africa. He indicates that it is close to *G. ornatus* Wilson and figures the postcephalothoracic region of both the female and the male. The figure of the female, however, does not show the series of spines on the lateral surface of the genital segment, the diagnostic characteristic for *G. ornatus*. Mossel Bay is at the southern tip of Africa and *G. auriculatus* is bordered on the Indian Ocean side by *G. huttoni* and on the Atlantic side by *G. ornatus*. The association of *G. auriculatus* with the other two species cannot be determined from the literature but offers an intriguing zoogeographical problem.

Gloiopotes hygomianus Steenstrup and Lütken

Figures 25–27

Gloiopotes hygomianus Steenstrup and Lütken, 1861, p. 363, pl. 5, fig. 9.—Bassett-Smith, 1899, p. 458.—Stebbing, 1900, p. 670, pl. 74, fig. A.—Shiino, 1960b, p. 533, figs. 4–6.—Yamaguti, 1963, p. 103, pl. 124, fig. 3.
Gloiopotes species Bonnet, 1948, p. 7.

Distribution and hosts.—4 hosts:

locality	*hosts*	*reference*
Atlantic	Unknown	Steenstrup and Lütken, 1861
Pacific	"Albacore"	Stebbing, 1900
	Acanthocybium solandri	Shiino, 1960b
Hawaii	*Acanthocybium solandri*	Bonnet, 1948

Material.—One female and 1 male (USNM 112881) collected by E. C. Jones (USFWS) from *Acanthocybium solandri* (Cuvier) captured in the Hawaiian area. One female and 1 male (USNM 112882) from the caudal fin of *A. solandri* (Cuvier) captured near the Line Islands

(USFWS). Two females and 1 male (USNM 112883) from *A. solandri* (Cuvier) captured near Washington Island (Line Islands) (USFWS. Two females and 1 male (retained by author) from external surface of *A. solandri* (Cuvier) captured near Fanning Island (Line Islands) (USFWS).

MEASUREMENTS.—(In mm) 6 females and 4 males:

	female		*male*	
	mean	*range*	*mean*	*range*
Total length, excluding caudal setae	14.33	13.65–15.15	9.92	9.38–10.35
Length of cephalothorax, including frontal region	6.85	6.68– 7.13	4.82	4.50– 5.25
Width of cephalothorax	5.44	5.25– 5.78	3.32	3.08– 3.53
Length of genital segment, including posterior projections but not fifth legs	5.37	4.73– 6.15	1.86	1.73– 2.03
Width of genital segment	2.99	2.63– 3.30	1.63	1.58– 1.65
Length of abdomen	3.15	2.89– 3.37	1.69	1.52– 1.78
Length of alae	3.68	3.44– 4.00	1.56	1.52– 1.59
Length of fifth leg, measured along outer margin	1.51	1.41– 1.67	1.43	1.30– 1.52
Length of caudal rami	1.47	1.26– 1.59	1.57	1.41– 1.78
Length of egg strings (4 strings)	12.32	10.95–13.88		

DESCRIPTION.—Female cephalothorax (fig. 25*a*) ovoid, consisting of cephalon and first 4 thoracic segments. Frontal region distinct, with pair of narrow membranes along median anterior edge. Lateral cephalothoracic margins flatly convex, with narrow membrane and row of fine, hairlike plumosities, membrane extending around posterior lateral cephalothoracic regions to beginning of posterior sinus. Posterior sinus ovoid, lateral surface heavily sclerotized, bearing small, posteriorly projecting membrane from posterior half and fine membrane along all of margin, membrane projecting across most of sinus. Anterior end of sinus sharply rounded, with small, lappet-like, posterodorsally projecting membrane; inner surface irregular. Median cephalothoracic region slightly irregular, extending almost to end of lateral cephalothoracic regions. Dorsal surface of posterior lateral cephalothoracic region with row of fine, hairlike plumosities along posterior lateral surface. Dorsal cephalothoracic grooves distinct, forming irregular H although cross groove V-shaped, with apex directed anteriorly; anterior longitudinal grooves of H turning inward sharply just anterior to ocular region. Ocular region small, consisting of 2 darkly pigmented cup-shaped regions contiguous on median longitudinal axis of body, each with spherical lens.

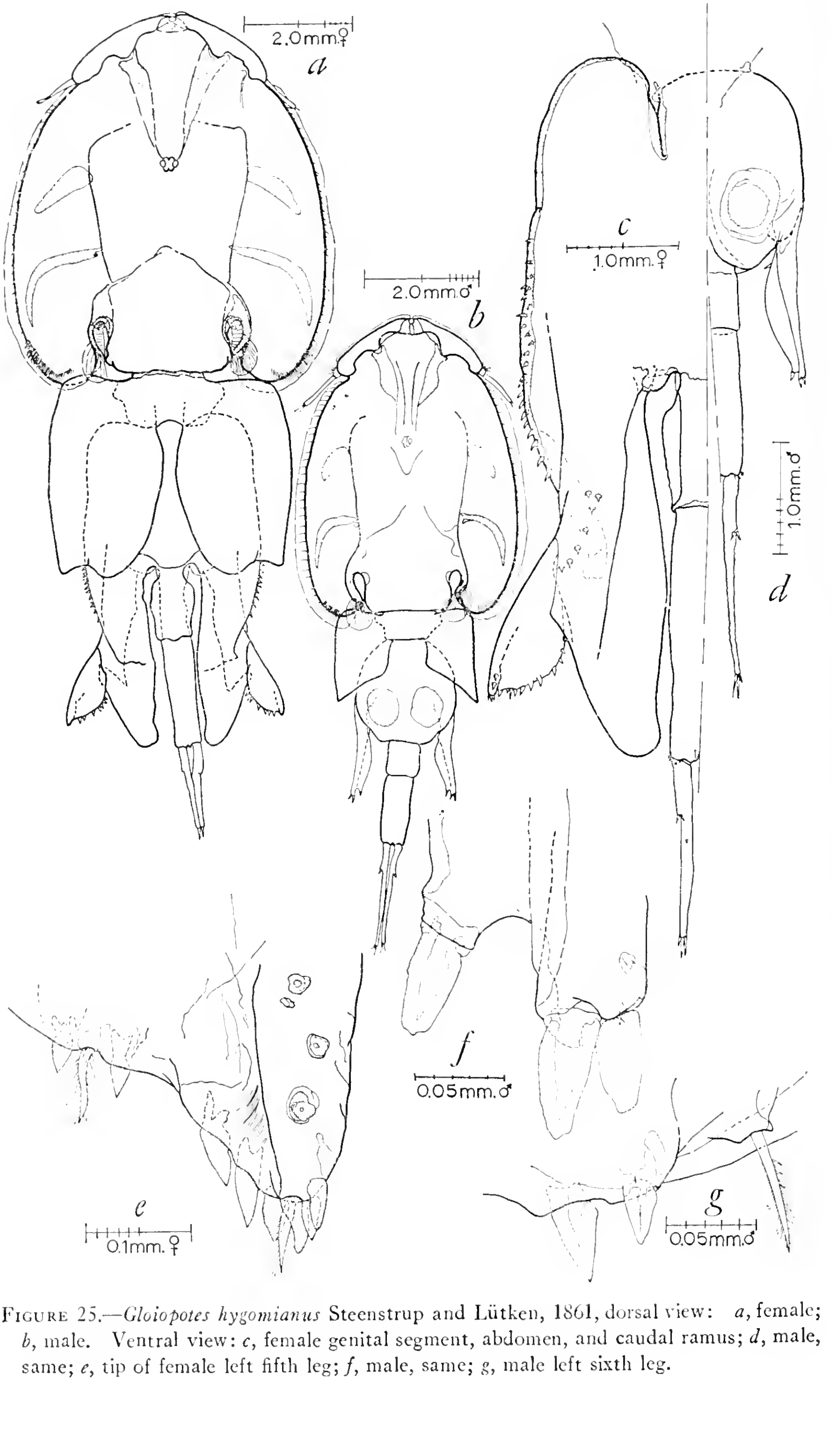


FIGURE 25.—*Gloiopotes hygomianus* Steenstrup and Lütken, 1861, dorsal view: *a*, female; *b*, male. Ventral view: *c*, female genital segment, abdomen, and caudal ramus; *d*, male, same; *e*, tip of female left fifth leg; *f*, male, same; *g*, male left sixth leg.

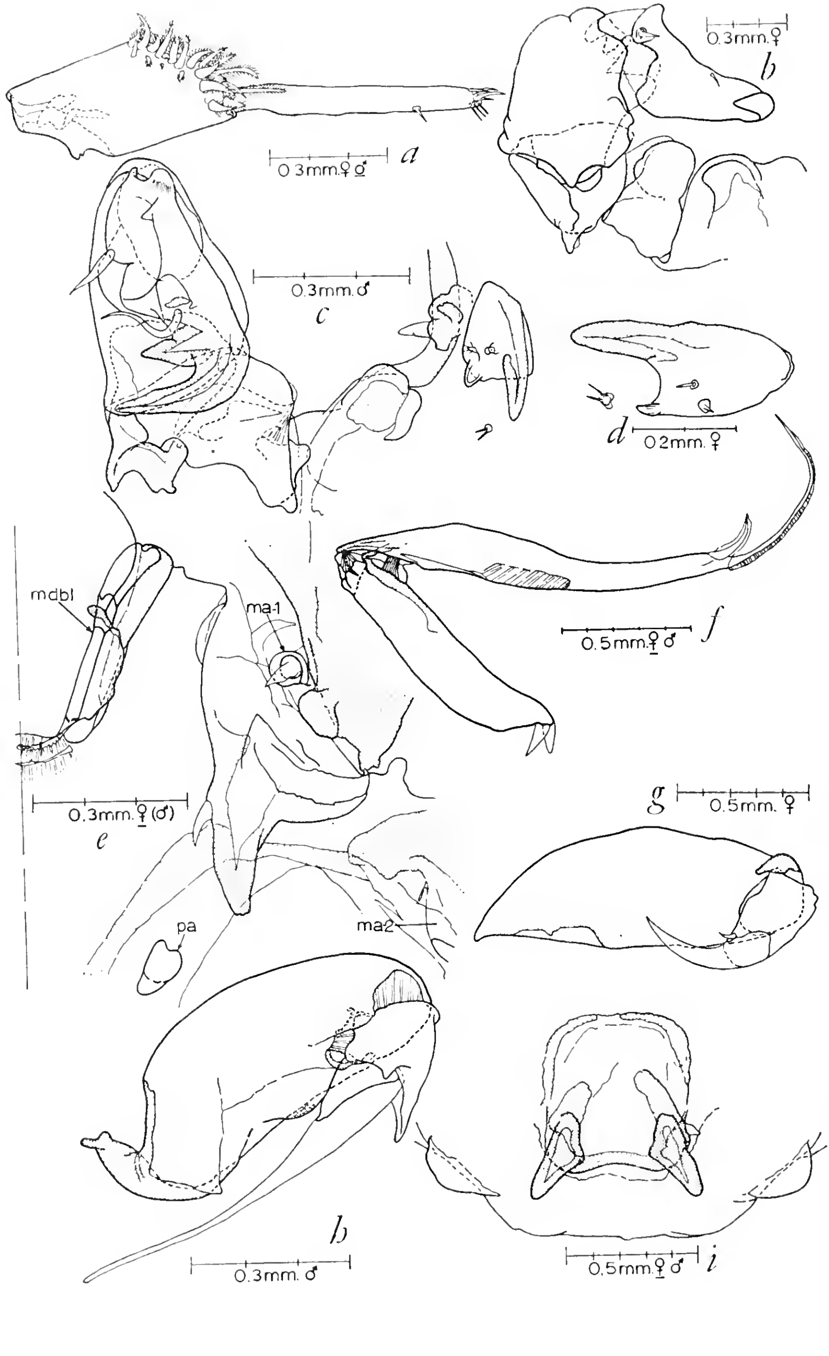
Female free fourth pedigerous segment, excluding ala, slightly more than one-third the width of cephalothorax, indistinctly separable from genital segment. Ala broad, extending laterally past lateral edge of genital segment, with 2 large, subrectangular posterior projections overlapping most of genital segment proper. Apex of sinus between lobes of ala flatly concave, posterior edge of lobes sharply angled laterally, with small, lobate projections medially.

Female genital segment (fig. 25*c*) convex anteriorly, at junction with fourth pedigerous segment, lateral surface smoothly irregular, with row of spinules along posterior two-thirds of segment. Posterior end of segment drawn out into pair of elongate lobes extending posteriorly to end of abdomen, lobes with several rows of spinules and minute spicules (latter not figured). Median lateral surface of lobes also bearing laminate fifth leg projecting laterally and posteriorly. Distal surface of fifth leg (fig. 25*e*) bearing row of spinules and 2 plumose setules.

Female abdomen 2-segmented, incompletely separated from genital segment dorsally and ventrally. First segment slightly more than half the length of second, with distinct dorsal swelling; second segment elongate, tapered slightly toward distal end, with pair of minute spinules on each side in anterior half of segment. Fine frilled membrane present on ventral-lateral posterior surface, at junction with caudal rami. Caudal rami elongate, rodlike, with small lateral indentation in proximal half, indentation bearing 2 plumose setules; distal end with 3 or 4 setules, longer 2 plumose.

Male cephalothorax (fig. 25*b*) generally similar to that of female although more elongate. Apex of posterior sinus without lappet-like membrane although remaining membranes present; cross groove of major dorsal grooves with indistinct apex. Ala of free fourth pedigerous segment with angular posterior edge but without lobes present in female. Male genital segment (fig. 25*d*) more orbicular than that of female, without lappet-like projection but with spikelike fifth leg extending to middle of second abdominal segment, inner dorsal surface of leg projecting medially as narrow, heavily sclerotized flap. Distal end of fifth leg (fig. 25*f*) with 3 spinules, proximal inner surface with minute, plumose setule. Sixth leg (fig. 25*g*) evident as pair of spinules and single minute, plumose setule adjacent to junction of abdomen and genital segment. Abdomen 2-segmented, distinct from genital segment dorsally, indistinctly separable ventrally. Second segment approximately 2½ times the length of first, first without swelling present in female. Caudal rami similar to those of female.

Female and male antennule (fig. 26*a*) 2-segmented, attached to lateral-anterior ventral surface of cephalothorax and adjacent sur-


0.3mm.♀ ♂
a
0.3mm.♀
b
0.3mm.♂
c
0.2mm.♀
d
mdbl
ma-1
ma-2
pa
0.3mm.♀(♂)
e
0.5mm.♀ ♂
f
g
0.5mm.♀
h
0.3mm.♂
0.5mm.♀ ♂
i

face of frontal region. First segment slightly shorter than second, broad proximally, narrow distally, distal half of anterior ventral and anterior surfaces with approximately 24 lightly plumose setae and setules. Second segment elongate, rodlike, with single, naked seta from posterior surface in distal third of segment and 8 naked setae from distal surface. Female antenna (fig. 26*b*) 3-segmented, situated medial and posterior to antennule base. Antennal base in close proximity to several flaplike projections of ventral cephalothoracic cuticle. First segment small, subtriangular in ventral view, with spike-shaped projection from posteriormost surface; second segment irregular, outer surface shorter than inner, proximal and distal surfaces irregular. Third segment separable from clawlike terminal process by break in heavy sclerotization, with small, setule-like accessory process proximally, on knoblike projection of segment, and second small, setule-like accessory process at region of break in sclerotization. Male antenna (fig. 26*c*) with irregular first segment, inner proximal surface with heavily sclerotized bifurcation; second segment similar to that of female. Third segment fused with double-clawed terminal process, bearing setule-like accessory process proximally and second, long, setule-like process just proximal to proximalmost claw and arising from slight indentation behind minute, flaplike cuticular projection.

Female and male mandible (fig. 26*e*) 4-parted; first part broad proximally, tapered distally, with flexible joint between first and second parts. Second part short, tapered slightly; third part elongate, approximately equal to combined lengths of first 2 parts. Fourth part short, flattened distally, inner edge of flattened portion with 13 denticulations. Female and male postantennal processes (figs. 26*c*, *d*) consisting of heavily sclerotized plate lateral and slightly posterior to antennal base, with large, spike-shaped projection from lateral surface and small, spike-shaped projection from inner posterior surface; 3 minute nodules present, 2 on plate, third posterior to plate, each with at least 2 hairlike processes. Male with small, flabby, conical projection just medial to inner surface of postantennal process, on ridge of heavy sclerotization extending from lateral anterior margin of cephalothorax to antennal base (fig. 26*c*). Female and male postoral process (fig. 26*e*) large, spinelike, female with small spine arising from inner proximal surface, process absent on male. Female and male maxillule (fig. 26*e*) nodular, with setule distally. Female with pair

FIGURE 26.—*Gloiopotes hygomianus* Steenstrup and Lütken, 1861, ventral view: *a*, left antennule; *b*, female left antenna; *c*, male left antenna and postantennal process; *d*, female right postantennal process; *e*, oral region, left side showing mouth cone, mandible (mdbl), maxillule (ma-1), postoral process, maxilla base (ma-2), and postoral adhesion process (pa); *f*, left maxilla; *g*, female right maxilliped; *h*, male left maxilliped; *i*, sternal furca.

of small, knob-shaped projections posterior to mouth cone base, similar in position to postoral adhesion pads. Female and male maxilla (fig. 26*f*) 2-segmented, situated lateral and posterior to post-oral process. First segment approximately two-thirds the length of second, proximal end with pair of subconical articulation projections, segment tapered slightly to distal region. Second segment elongate, broadest medially, with fine membranous flange on inner medial surface, with 2 saber-shaped processes from distal surface, inner more than twice the length of outer, with fine membrane along inner margin, outer with membranes along both margins.

Female maxilliped (fig. 26*g*) 2-segmented, situated posterior and medial to maxilla base. First segment strongly developed; second segment short, distinct from clawlike terminal process, bearing single, setule-like accessory process from inner surface, at junction of segment and terminal process. Male maxilliped (fig. 26*h*) 2-segmented, proximal end of first segment recurved, terminating in socket-shaped articulation surface; segment with slightly roughened adhesion surface on medial inner surface. Second segment appearing bifurcate distally, one ramus of bifurcation formed by scoop-shaped terminal process; segment bearing long, flexible process just proximal to apex of bifurcation. Flexible process longer than first segment, possibly representing elongate accessory process, based on position of origin as well as absence of small, setule-like accessory process present on female.

Female and male sternal furca (fig. 26*i*) situated between and posterior to maxilliped bases, consisting of plate bearing 2 widely separated, bluntly pointed tines and 2 accessory spines, at base of tines. Pair of lappet-like projections present just posterior and lateral to furca.

For nature of armature and legs, see figure 27 and table 10.

TABLE 10.—*Armature of thoracic legs I–IV of the female and male of* Gloiopotes hygomianus *Steenstrup and Lütken, 1861*

Leg	Surface	Inter-podal Plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
I	Outer		ss,p		h			c	c,2P	
	Inner		p		c	3P,p,3dH			p	
II	Outer	m		m,p′	2m,dH	dH	dH,mH, Q,P	c	c	c,4P
	Inner		s,P	m,s	c,P	c,P	4P	P	c,2P	2P
III	Outer	m	m,p		3s,H	h	3h,2P	c	3P	
	Inner		2s,P,m,2s, c*		P	P	3P	c,2P	P	
IV	Outer‡		p†		d,D,dH	D,dH	D,3fm,3dH			

*Elements between rami.
†Element in middle of segment.
‡Spinules along inner surface not tabulated.

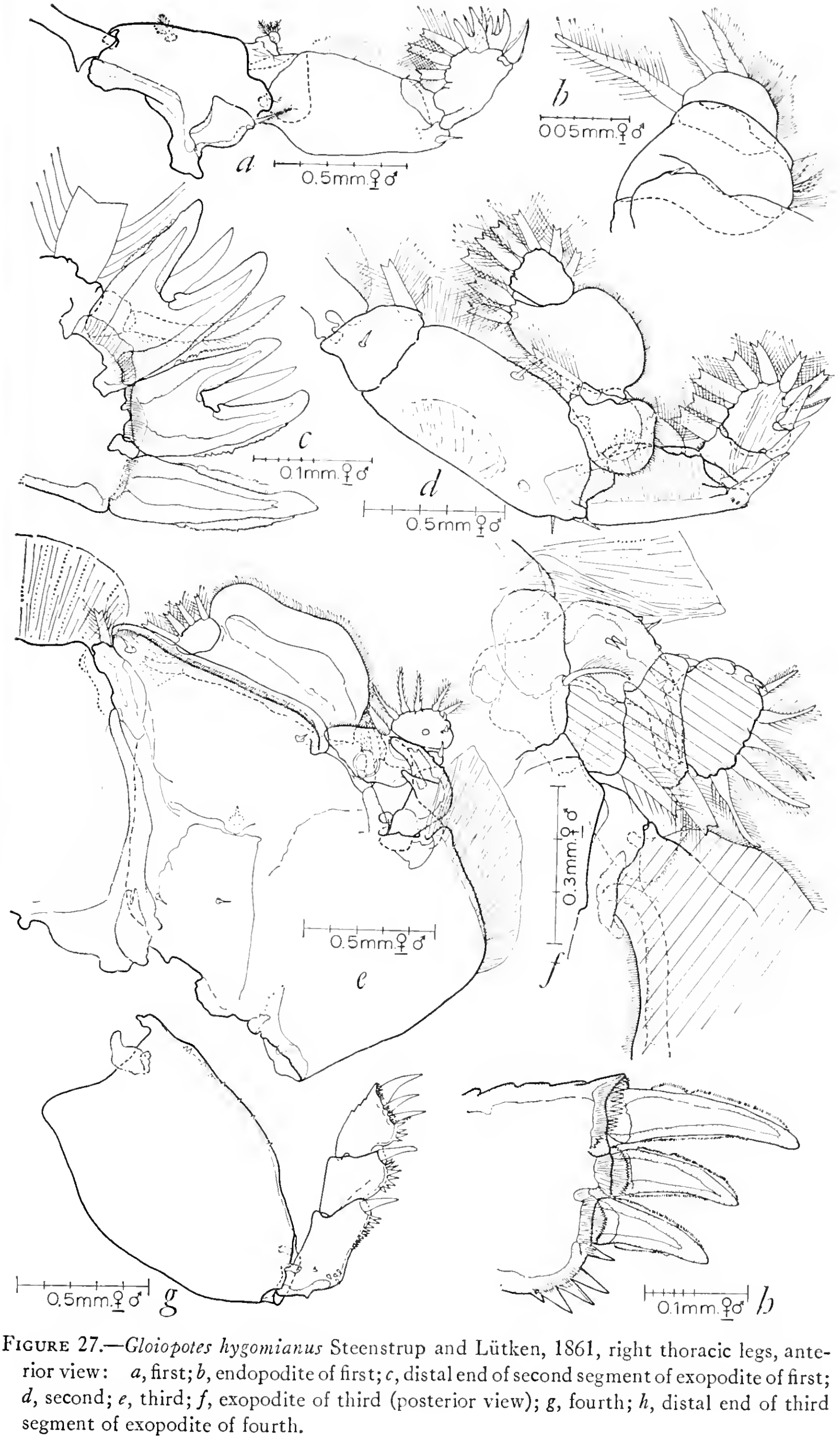


FIGURE 27.—*Gloiopotes hygomianus* Steenstrup and Lütken, 1861, right thoracic legs, anterior view: *a*, first; *b*, endopodite of first; *c*, distal end of second segment of exopodite of first; *d*, second; *e*, third; *f*, exopodite of third (posterior view); *g*, fourth; *h*, distal end of third segment of exopodite of fourth.

Family Caligidae

Dentigryps Wilson, 1913

DIAGNOSIS.—See Lewis, 1964b.

Dentigryps ulua Lewis

Dentigryps ulua Lewis, 1964b, p. 351, figures 2–4; 12a, e, i; 13a.

HOSTS AND DISTRIBUTION.—1 host record:

location	*hosts*	*reference*
Hawaiian Islands	*Caranx melampygus*?	Lewis, 1964b

MATERIAL.—Two females and 1 male (retained by author) from external surface of *Caranx melampygus*? Cuvier and Valenciennes captured in a fishtrap between Diamond Head and Koko Head, Oahu, Hawaii, by Samuel Kaolulo.

MEASUREMENTS.—(In mm) 2 females and 1 male:

	female	*male*
Total length, excluding fifth legs and caudal setae	6. 60, 6. 83	5. 18
Length of cephalothorax, including frontal region	4. 43, 4. 43	3. 45
Width of cephalothorax	3. 40, 3. 66	2. 92
Length of genital segment, including lobes but excluding fifth legs	1. 67, 1. 67	0. 93
Width of genital segment	1. 70, 1. 70	1. 04
Length of abdomen	0. 61, 0. 76	0. 49
Length of caudal rami	0. 31, 0. 29	0. 29
Length of fifth legs, measured along outer margin	1. 19, 1. 28	0. 99
Length of fifth leg terminal process	0. 05	0. 06
Length of sixth leg, measured along outer margin		0. 15
Length of sixth leg terminal process		0. 14

DESCRIPTION.—See Lewis, 1964b.

Dentigryps bifurcatus Lewis

Dentigryps bifurcatus Lewis, 1964a, p. 203, figs. 17a–c, e–k, m–q; 18a–c, e–f; 1964b, p. 356, figs. 5; 12b, f, j; 13b.

DISTRIBUTION AND HOSTS.—5 host records:

locality	*hosts*	*reference*
Hawaiian Islands	*Acanthurus olivaceus*	
	A. triostegus	
	sandvicensis	Lewis, 1964a
	Naso hexacanthus	
	Fistularia petimba	Lewis, 1964b

MATERIAL.—Three males (retained by author) from external surface of *Bodianus bilunulatus* (Lacépède) from the Honolulu Aquarium. One male (retained by author) from external surface of *Chaetodon fremblii* Bennett captured in a fishtrap by Samuel Kaolulo between Diamond Head and Koko Head, Oahu, Hawaii.

Two immature males (retained by author) from external surface of *Aulostomus chinensis* (Linnaeus) captured in a fishtrap by Samuel Kaolulo between Diamond Head and Koko Head, Oahu, Hawaii.

MEASUREMENTS.—(In mm) 4 males:

Total length, excluding fifth legs and caudal setae	2.15, 2.26, 2.22, 2.29
Length of cephalothorax, including frontal region (N=2)	1.64, 1.62
Width of cephalothorax	1.58, 1.55, 1.48, 1.53
Length of genital segment, excluding fifth legs	0.36, 0.36, 0.36, 0.35
Width of genital segment	0.46, 0.41, 0.41, 0.38
Length of abdomen	0.12, 0.11, 0.11, 0.12
Length of fifth leg, measured along outer margin (N=3)	0.17, 0.19, 0.18
Length of fifth leg terminal process (N=2)	0.04, 0.04
Length of sixth leg, measured along outer margin (N=3)	0.07, 0.09, 0.07
Length of sixth leg terminal process (N=3)	0.09, 0.08, 0.07
Length of caudal rami	0.13, 0.14, 0.13, 0.14

DESCRIPTION.—See Lewis, 1964a.

Anuretes Heller, 1865

DIAGNOSIS.—See Lewis, 1964a.

Anuretes serratus Shiino

Anuretes serratus Shiino, 1954a, p. 260, figs. 1–2.—Lewis, 1964a, p. 188, figs. 13–14.

DISTRIBUTION AND HOSTS.—2 host records:

locality	*hosts*	*reference*
Japan	*Xesurus scalprum*	Shiino, 1954a
Hawaiian Islands	*Naso hexacanthus*	Lewis, 1964a

DESCRIPTION.—See Lewis, 1964a.

Anuretes menehune Lewis

Anuretes menehune Lewis, 1964a, p. 195, figs. 15, 16.

DISTRIBUTION AND HOSTS.—2 host records:

locality	*hosts*	*reference*
Hawaiian Islands	*Naso hexacanthus*	
	N. unicornis	Lewis, 1964a

DESCRIPTION.—See Lewis, 1964a.

Lepeophtheirus Nordmann, 1832

DIAGNOSIS.—Cephalothorax consisting of cephalon and first 4 thoracic segments; frontal region distinct, without lunules. Free fourth pedigerous segment without alae. Genital segment without projecting plates; fifth legs present on female and male, setiform or projecting slightly, without ornamentation; sixth legs present on male, setiform. Abdomen 1–2 segmented. Antennule 2-segmented, antenna 3-segmented, with clawlike terminal process and frequently, in male, with adhesion or additional spinelike process. Mandible rodlike, distal region flattened, with 12 denticulations on distal inner surface. Postantennal process consisting of 3 nodules, each with several hairlike processes, and clawlike projection; postoral process spinelike, often with smaller, spinelike secondary projection on inner surface in male. Maxillule nodular, with setule-like processes; maxilla 2-segmented, with 2 saber-like terminal processes. Sternal furca present. Thoracic legs I–III biramous although endopodite of first legs rudimentary; fourth legs uniramous, typically with 4 segments.

Lepeophtheirus crassus (Wilson and Bere)

Figures 28–30

Gloiopotes crassus Wilson and Bere, *in* Bere, 1936, p. 590, pl. 5, figs. 109–111; pl. 6, figs. 125–155.

Lepeophtheirus crassus (Wilson and Bere) Shiino, 1960c, p. 546, figs. 3–4.—Yamaguti, 1963, p. 72.—Shiino, 1963a, p. 337, fig. 2.

Distribution and hosts.—4 host records:

locality	*hosts*	*reference*
Western Atlantic	*Rhombochirus osteochir*	Wilson and Bere, 1936
Eastern Pacific	"Remora"	
	Remilegia australis	Shiino, 1963a
Indian Ocean	*Echeneis albescens*	Shiino, 1960c

Material.—Five females (USNM 112884) from external surface of *Rhombochirus osteochir* (Cuvier) taken from *Tetrapturus angustirostris* Tanaka captured by longline at 21°04.5′N, 173°47.5′E (USFWS). Two females and 1 male (USNM 112885) from external surface of *Rhombochirus osteochir* (Cuvier) taken at 20°50.5′N, 167°34.5′E.

Remarks.—Although these specimens were taken well west of the Hawaiian Islands, the hosts are found in the Hawaiian area. Based upon this and the wide reported distribution of the copepod, the author feels that the copepod is a member of the Hawaiian parasitic copepod fauna.

Measurements.—(In mm) 7 females and 1 male:

	female		*male*
	mean	*range*	
Total length, excluding caudal setae	6. 36	5. 63–7. 05	4. 80
Length of cephalothorax, including frontal region	3. 73	3. 53–4. 20	3. 00
Width of cephalothorax	3. 07	2. 70–3. 38	2. 48
Length of genital segment, excluding fifth legs	1. 69	0. 98–2. 06	0. 82
Width of genital segment	1. 91	1. 50–2. 18	0. 75
Length of abdomen	0. 81	0. 53–0. 98	0. 53
Length of fifth leg, excluding setae	0. 79	0. 72–0. 86	0. 40
Length of fifth leg subterminal seta (female N=6)	0. 08	0. 07–0. 11	0. 04
Length of egg strings (4 strings)	2. 83	2. 63–3. 15	

Description.—Female cephalothorax (fig. 28*a*) ovoid, consisting of cephalon and first 4 thoracic segments. Frontal region narrow,

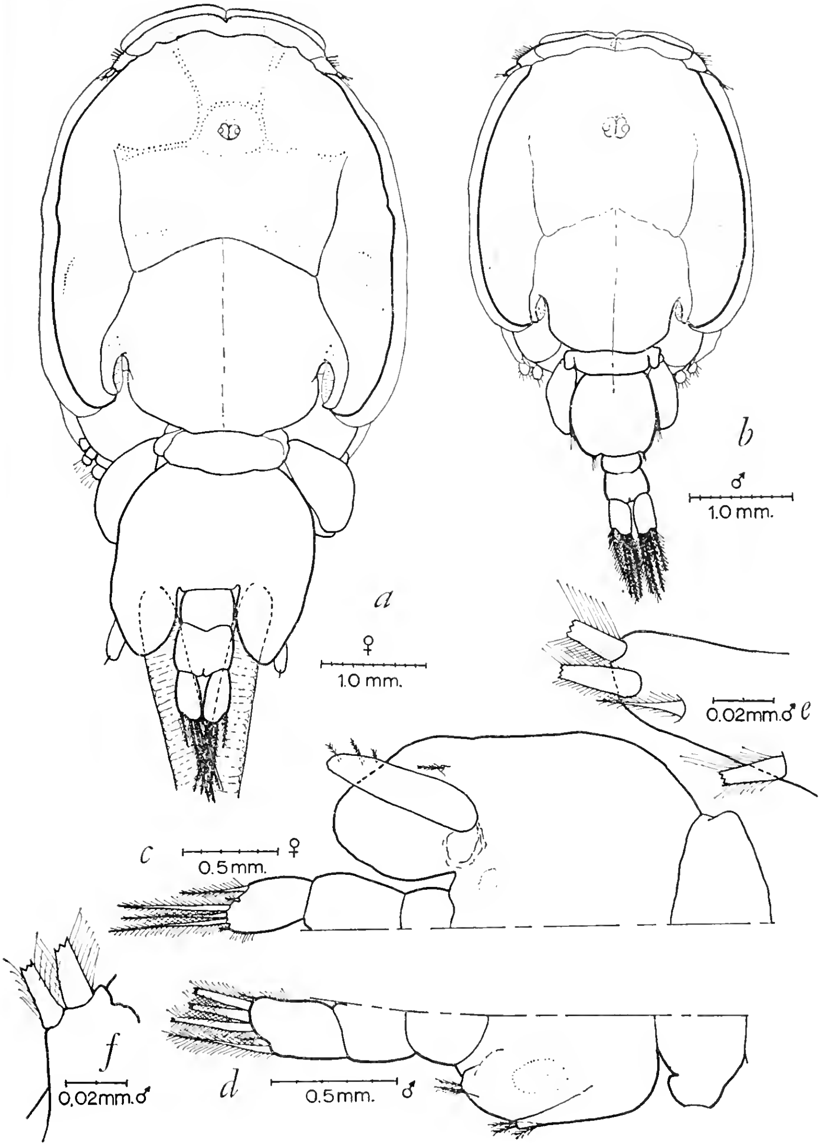


Figure 28.—*Lepeophtheirus crassus* (Wilson and Bere, 1936), dorsal view: *a*, female; *b*, male. Ventral view: *c*, female genital segment, fifth leg, abdomen, and caudal ramus; *d*, male, same; *e*, male tip of fifth leg; *f*, male sixth leg.

anterior edge with median indentation and narrow, membranous flange. Lateral margins of cephalothorax flatly convex except for slight medial swelling, posterior lateral corners smoothly rounded, lateral surface terminating just lateral to beginning of posterior cephalothoracic sinuses, at origin of longitudinal legs of cephalothoracic grooves. Posterior sinuses distinct, U-shaped, lateral margin heavily sclerotized, bearing filmy membrane that projects into sinus. Posterior margin of median cephalothoracic region with slight concavity medially, lateral margins convex. Major cephalothoracic grooves forming irregular H, posterior longitudinal legs forming line of division between median and lateral cephalothoracic regions. Cross groove of flattened V-shape, apex pointing anteriorly. Anterior longitudinal grooves extending anteriorly and slightly laterally to indistinct termination lateral and slightly posterior to ocular region. Ocular region distinct, consisting of 2 heavily pigmented cup-shaped regions, contiguous on median longitudinal axis of body, each with spherical lens. Small, heavily pigmented area present between posterior ends of cup-shaped regions and small, heavily sclerotized V-shaped region present at anterior end of eyes, apex of V extending into depression formed by inner anterior margins of cup-shaped pigmented region.

Female free fourth pedigerous segment short, width more than twice the length. Dorsal surface heavily sclerotized, medial posterior margin of segment distinct dorsally, flatly convex.

Lateral margins of genital segment (fig. 28*c*) flatly convex, posterior lateral surfaces forming lobate projections extending posteriorly almost to end of second segment of abdomen. Fifth legs originating on posterior ventral surface, just lateral to oviducal opening, at base of lobate projections. Fifth legs dactyliform although slightly irregular, not heavily sclerotized, extending posteriorly past posterior end of lobate projection, bearing 3 plumose setules on dorsal surface in distal third of leg; additional plumose setule present on ventral surface of genital segment, just lateral to leg base.

Abdomen 2-segmented, distinct from genital segment. First segment approximately four-fifths the length of second, lateral margins flatly convex, posterior margin convex ventrally, V-shaped dorsally, overlapping anterior end of second segment. Lateral margins of second segment flatly convex, posterior margin slightly irregular, tapered to bilobed anal region. Caudal rami laminate, length slightly less than twice the width. Both lateral margins flatly convex, inner lateral surface plumose distally. Outer distal margin indented, bearing single plumose seta; inner two-thirds of distal surface rounded, bearing 4 plumose setae; knoblike projection present on inner distal surface, bearing minute, spikelike terminal process.

Cephalothorax of male (fig. 28*b*) generally similar to that of female. Anterior margin of frontal region flatter than in female; V-shaped region of heavy sclerotization at anterior end of ocular region also flatter. Free fourth pedigerous segment as in female. Genital segment (fig. 28*d*) slightly longer than wide, lateral margins flatly convex, posterior surface of segment overlapping dorsal surface of first abdominal segment slightly. Fifth legs dactyliform, originating on anterior-medial ventral surface, extending posteriorly and slightly laterally to posterior medial region of genital segment. Fifth legs with 2 plumose terminal setules, one plumose subterminal setule, and one plumose setule from outer dorsal surface approximately two-thirds the distance from proximal to distal end of leg (fig. 28*e*). Sixth legs (fig. 28*f*) small, somewhat irregular, projecting slightly from posterior-lateral ventral surface of segment and tipped by 2 plumose setules. Abdomen 2-segmented, similar to that of female except dorsal posterior projection of first segment not as distinct. Caudal rami somewhat more rectangular in shape than those of female, otherwise similar.

Female and male antennule (fig. 29*a*) 2-segmented; first segment more than twice the length of second, proximal margin broad, irregular, with several small concavities and projections, one concave depression in posterior margin forming articulation surface for small, knoblike projection of platelike area on anterior ventral surface of cephalothorax. Anterior lateral margin of first segment convex, posterior lateral margin almost straight except distally where posterior lateral surface forms base of small, shelflike extension of distal surface; distal surface narrow, irregular. Anterior and distal ventral surfaces with at least 14 plumose setae. Second segment club shaped, ovoid in cross section, narrow proximally and distally, widest medially. Distal medial region of posterior surface with one naked seta, distal surface with 11 naked setae and one spikelike process, on anterior distal corner. Female antenna (fig. 29*b*) 3-segmented, located posterior and slightly medial to antennule base. First segment irregular, proximal end narrow, distal medial region broad, bearing posteriorly projecting lobe; second segment strongly developed, slightly shorter than first segment, greatest width slightly more than four-fifths the length, distal corner projecting slightly as heavily sclerotized, rounded process (not figured). Third segment and clawlike terminal process continuous, proximal posterior surface with small, poorly developed, laminate lobe. Setalike accessory process present on middle of combined segment and terminal process, presumably at junction of segment and terminal process. Male antenna (fig. 29*c*) 3-segmented; first segment flattened, median third forming adhesion surface. Second segment well developed, longer than first segment, most of proximal inner surface forming adhesion surface, inner distal surface with 2 heavily sclerotized swellings serving as articulation surfaces for 2 swellings on inner proximal surface of

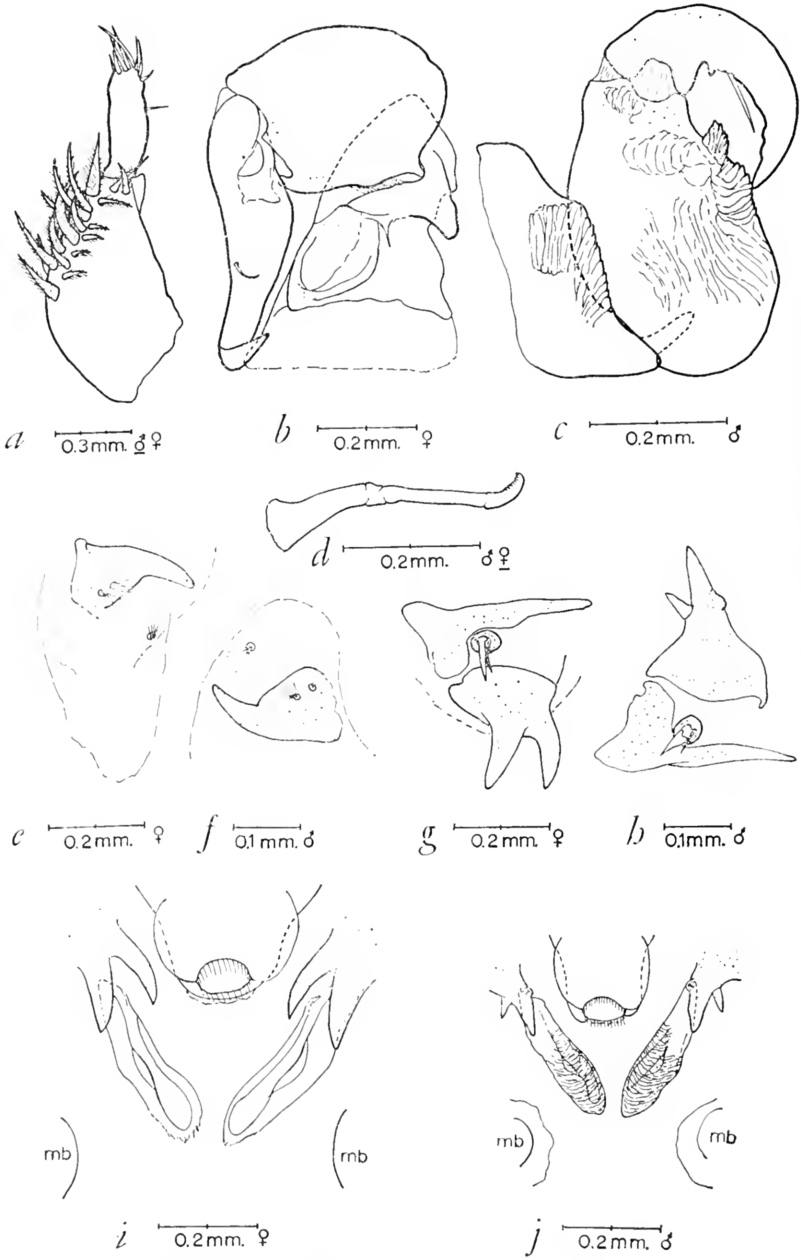
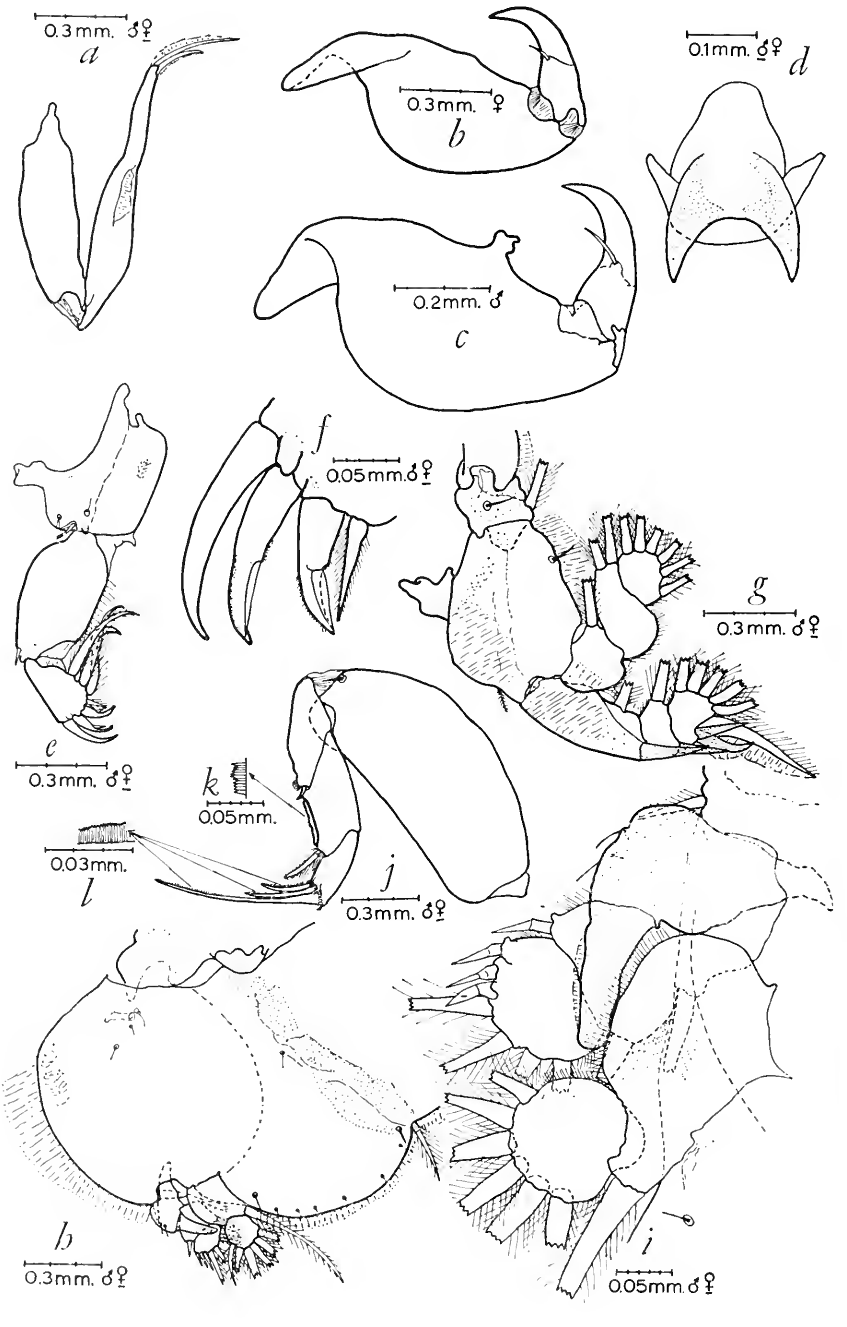


FIGURE 29.—*Lepeophtheirus crassus* (Wilson and Bere, 1936), ventral view: *a*, left antennule; *b*, female right antenna; *c*, male, same; *d*, right mandible; *e*, female left postantennal process; *f*, male, same; *g*, female right maxillule and postoral process; *h*, male, same; *i*, female postoral adhesion pads, postoral processes, posterior end of mouth cone and maxilliped bases (mb); *j*, male, same.

third segment; posteriormost swelling on second segment with small, slightly projecting adhesion surface. Third segment and terminal process continuous, claw shaped, inner surface irregular, appearing roughened or minutely denticulated distally; single, long, needle-like accessory process present on inner surface just distal to small swelling on proximal medial region of segment.

Female and male mandible (fig. 29*d*) 4-parted, fourth part short, curved inward smoothly, bluntly rounded distally, inner margin with 12 denticulations although proximal 2 denticulations indistinct in some specimens. Female postantennal process (figs. 29*e, f*) consisting of platelike region of heavy sclerotization bearing spikelike projection and 3 nodules, each nodule with several hairlike processes; spikelike projection broad proximally, tapering sharply in proximal half, gradually in distal half, curving medially sharply in male, slightly in female, sharply rounded, or pointed, distally. Female postoral process (fig. 29*g*) bifurcate, both tines pointed; male postoral process (fig. 29*h*) spinelike, with small spine projecting from middle of outer surface and small, heavily sclerotized swelling on middle of inner surface. Female and male maxillule (figs. 29*g, h*) nodular, with 3 setules distally. Female and male maxilla (fig. 30*a*) 2-segmented, situated just lateral and posterior to postoral process. First segment approximately three-fourths the length of second, slender, lateral margins almost parallel; second segment elongate, widest medially, medial region with fine membrane and, in male, small, spinelike projection just distal to membrane. Distal end of second segment with 2 saber-shaped, flexible processes, innermost approximately 1½ times the length of outermost, inner bearing fine membrane on inner surface, outer with denticulated, membrane-like process along outer margin. Male with pair of ovoid adhesion surfaces (fig. 29*f*) extending posteriorly and medially from just posterior to postoral processes to just anterior to maxilliped bases, surfaces distinctly rugose. Female also with surfaces but not rugose (fig. 29*i*).

Female maxilliped (fig. 30*b*) 2-segmented, situated posterior and slightly medial to maxilla base. First segment strongly developed, proximal end lobate, extending into cephalothorax as articulation and muscle attachment surface. Second segment and terminal process continuous, length of segment and process slightly greater than half that of first segment, terminal process clawlike, sharply pointed; single small, setalike accessory process present on inner surface at irregular division between segment and terminal process. Male maxilliped (fig. 30*c*) similar to that of female although small, irregular protrusion present on medial inner surface of first segment, protrusion receiving distal end of second segment terminal process when


0.3mm. ♂♀
a
0.3mm. ♀
b
0.1mm. ♂♀
d
0.2mm. ♂
c
f
0.05mm. ♂♀
g
0.3mm. ♂♀
e
0.3mm. ♂♀
k
0.05mm.
0.03mm.
l
j
0.3mm. ♂♀
h
0.3mm. ♂♀
i
0.05mm. ♂♀

segment flexed. Terminal process of second segment not as sharply curved as in female, accessory process slightly longer.

Female and male sternal furca (fig. 30*d*) situated about halfway between maxilliped bases and interpodal plate of first thoracic leg. Process consisting of ovoid, heavily sclerotized plate with 2 winglike anterolaterally projecting structures in addition to U-shaped furca. Tines of furca either pointed or sharply rounded, outer margins flatly convex.

For nature of legs and armature, see figure 30 and table 11.

TABLE 11.—*Armature of thoracic legs I–IV of the female and male of* Lepeophtheirus crassus (*Wilson and Bere, 1936*)

Leg	Surface	Interpodal Plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
I	Outer		ss,p		rh	3H,P				
	Inner		p		c	3P				
II	Outer	m		m,p	m,fmH	fmH	H,qH,Q,2P	c	c	c,3P
	Inner		s,P	m,s	c,P	c,P	c,3P	P	c,2P	c,3P
III	Outer	m	m,P		3s	c,p′	c,3p′,P	c	c,2p	
	Inner		P,s,m,11s*		p,mH	c,P	c,3P	P	c,4P	
IV	Outer		s		dm,h	dm,fmH	3dm,3fmH			

*On both anterior and posterior surfaces of protopodite.

Lepeophtheirus dissimulatus Wilson

Lepeophtheirus dissimulatus Wilson, 1905b, p. 631, pl. 22.—Lewis, 1963, p. 195, figs. 1–20; 1964a, p. 178, figs. 11–12. [For synonymy, see Lewis, 1964a.]

REPORTED DISTRIBUTION AND HOSTS.—24 host records:

locality	*hosts*	*reference*
Bermuda	*Epinephalus morio*	Wilson, 1905b
	E. striatus	
	Mycteroperca apua	Linton, 1907
	Thynnus pelamys	Heegaard, 1943b
Dry Tortugas	*Lactophrys triqueter*	Wilson, 1935b
Galapagos Islands	*Epinephelus labriformis*	Wilson, 1905b
	Mycteroperca species	Heegaard, 1943b
Eastern Pacific	*Bodianus diplotaenis*	
	Epinephelus labrifrons	Shiino, 1959d
	Merluccius productus	
	Paralichthys californicus	
	Hypsopsetta guttulata	
	Sphyraena argentea	

FIGURE 30.—*Lepeophtheirus crassus* (Wilson and Bere, 1936), lateral view: *a*, maxilla; *b*, female maxilliped; *c*, male maxilliped; *d*, sternal furca (ventral view). Right thoracic legs, anterior view: *e*, first; *f*, second segment of exopodite of first; *g*, second; *h*, third; *i*, exopodite and endopodite of third; *j*, fourth; *k*, frilled membrane on second segment of exopodite of fourth; *l*, frilled membrane on terminal spines of third segment of exopodite of fourth.

locality	*hosts*	*reference*
	Paralabrax nebulifer	
	Sphaeroides annulatus	
	Galeichthys guatemalensis	Causey, 1960
	Gadus macrocephalus	Lewis, 1964a
Hawaii	*Acanthurus olivaceus*	
	A. dussumieri	
	A. triostegus sandivcensis	
	Zebrasoma flavescens	
	Naso hexacanthus	
	Chaetodon quadrimaculatus	Lewis, 1964a
Mauritania	*Labrus* species sensu lato	Brian, 1924

MATERIAL.—Four females and 4 males (retained by author) from gill cavity of *Parupeneus pleurostigma* (Bennett) captured in fishtrap by Samuel Kaolulo between Diamond Head and Koko Head, Oahu, Hawaii. One female and 1 male (retained by author) from external surface of *P. pleurostigma* (Bennett) captured by trap by Samuel Kaolulo between Diamond Head and Koko Head, Oahu, Hawaii.

MEASUREMENTS.—(In mm) 4 females and 5 males:

	female		*male*	
	mean	*range*	*mean*	*range*
Total length, excluding caudal setae	2. 66	2. 53–2. 75	2. 17	2. 03–2. 25
Length of cephalothorax, including frontal region	1. 78	1. 75–1. 83	1. 60	1. 52–1. 75
Width of cephalothorax	1. 68	1. 65–1. 70	1. 43	1. 40–1. 45
Length of genital segment	0. 60	0. 53–0. 68	0. 36	0. 34–0. 38
Width of genital segment	0. 86	0. 78–0. 95	0. 35	0. 35 (all)
Length of abdomen	0. 13	0. 12–0. 14	0. 11	0. 10–0. 12
Length of caudal rami	0. 08	0. 07–0. 09	0. 10	0. 08–0. 11
Length of egg strings (2 strings)	1. 00, 1. 48			

DESCRIPTION.—See Lewis, 1964a.

Lepeophtheirus? fallolunulus, new species

FIGURES 31–33

MATERIAL.—One female (holotype, USNM 112886) from the gill cavity of *Naso unicornis* (Forskål) speared off Lehua Rock, Niihau, Hawaii. One immature adult male (allotype, USNM 112887) from buccal cavity of *Naso unicornis* (Forskål) speared near "the blowhole," Oahu, Hawaii.

MEASUREMENTS.—(In mm) 1 female and 1 male:

	female	*male*
Total length, excluding caudal setae	3. 05	2. 25
Length of cephalothorax, including frontal region	1. 43	1. 30
Width of cephalothorax	1. 30	1. 23
Length of genital segment	1. 08	0. 54
Width of genital segment	0. 85	0. 45
Length of abdomen	0. 15	0. 14
Length of caudal rami	0. 07	0. 08
Length of egg strings	1. 20	

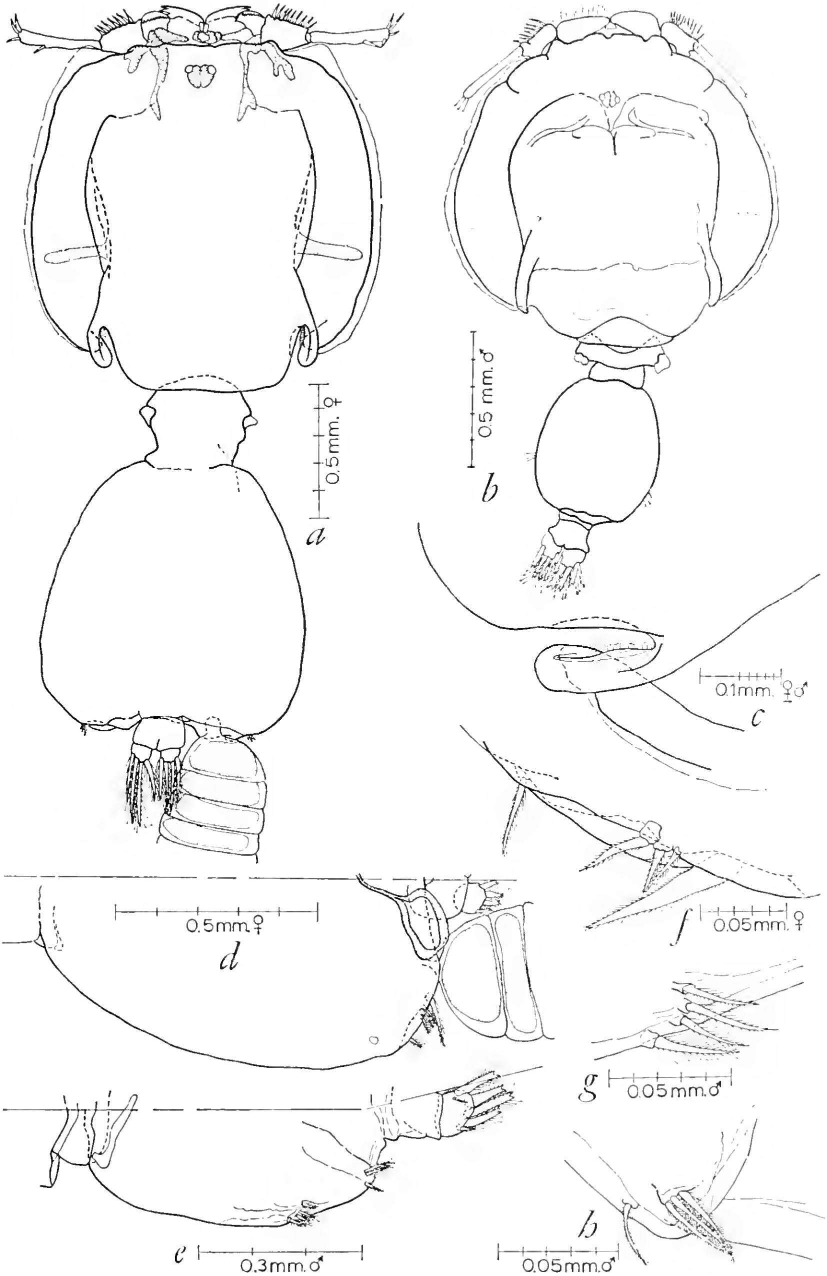
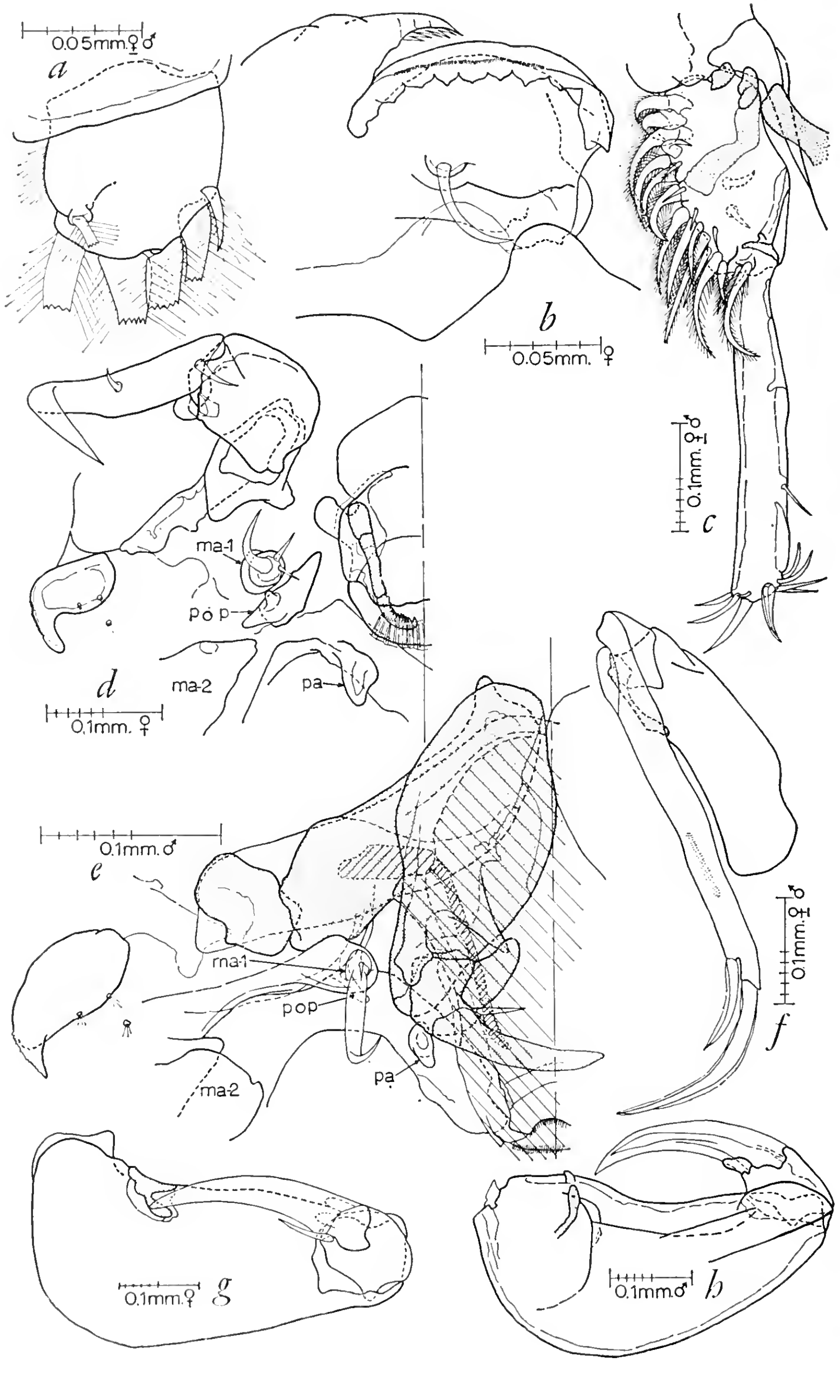


FIGURE 31.—*Lepeophtheirus? fallolunulus*, new species, dorsal view: *a*, female; *b*, immature adult male; *c*, posterior cephalothoracic sinus. Ventral view: *d*, female genital segment, abdomen, and caudal ramus; *e*, male, same; *f*, female right fifth leg; *g*, male, same; *h* male right sixth leg.


0.05mm.♀♂
a
b
0.05mm. ♀
0.1mm.♀♂
c
ma-1
pop
d
ma-2
pa
0.1mm. ♀
0.1mm.♂
e
ma-1
pop
pa
ma-2
0.1mm.♀♂
f
0.1mm.♀
g
0.1mm.♂
h

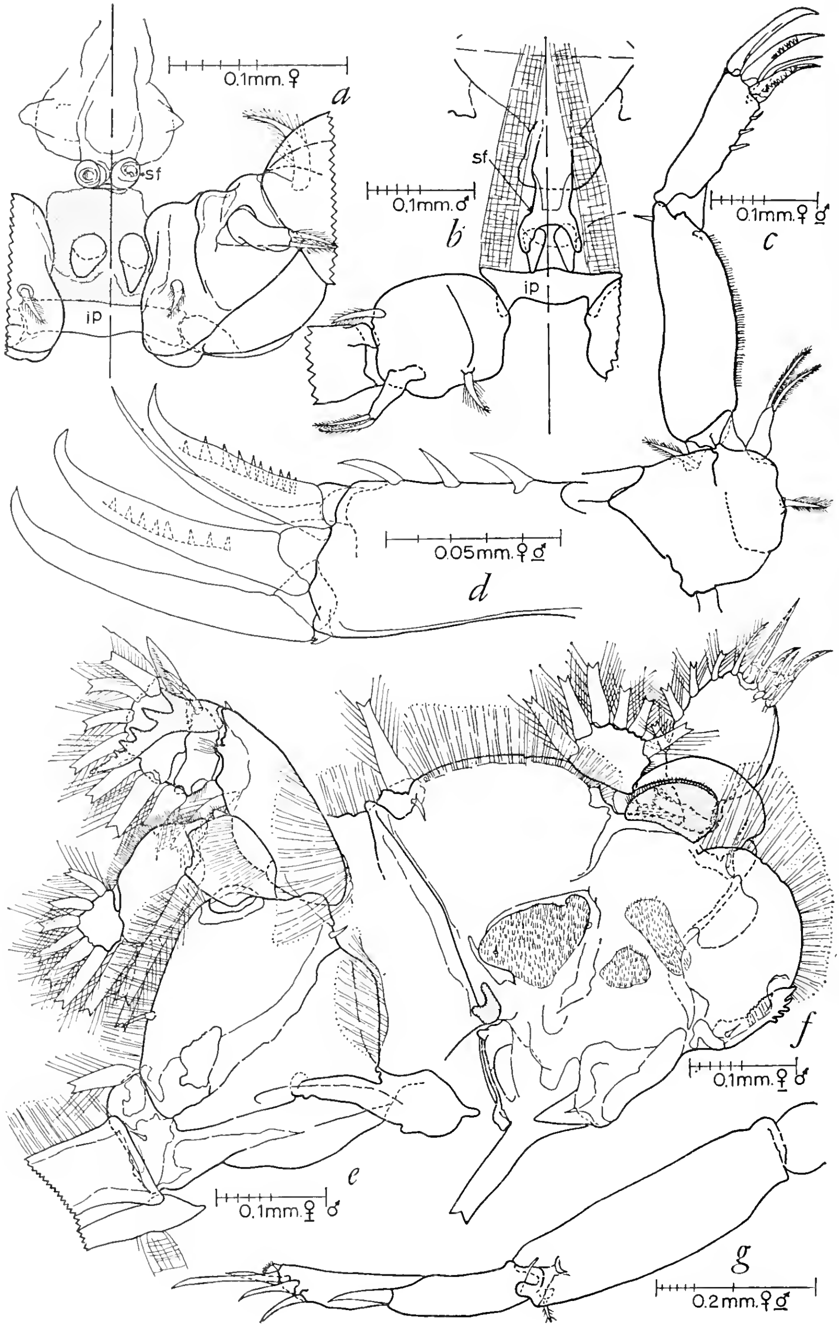
Description.—Female cephalothorax (fig. 31*a*) oblong, consisting of cephalon and first 4 thoracic segments. Frontal region with dorsally facing lunule-like modification laterally, with deep incision medially and fine membrane along anterior ventral surface median to modification. Lunular modifications (fig. 32*b*) with denticulated, dorsally facing anterior margin, bearing single setule posteriorly. Division between frontal region and cephalothorax distinct; 2 large, subtriangular projections present, extending anteriorly to posterior region of lunular modifications from origin on lateral anterior surface of cephalothorax. Posterior two-thirds of median cephalothoracic region raised dorsally, above lateral cephalothoracic regions. Lateral surface of cephalothorax forming distinct flange ventrally, bearing fine membrane along entire length. Posterior sinus (fig. 31*c*) distinct, slender, with heavily sclerotized lateral surface, bearing fine membrane along outer surface. Posterior end of median cephalothoracic region extending well past posterior end of lateral regions, covering anterior end of free fourth pedigerous segment. Major dorsal cephalothoracic grooves running longitudinally, cross groove absent. Free fourth pedigerous segment slender, without dorsal plates.

Female genital segment (fig. 31*d*) ovoid, indistinctly separable from free fourth pedigerous segment. Posterior end of segment irregular, irregularities primarily in region of oviducal openings. Fifth leg (fig. 31*f*) consisting of 5 plumose setules on lateral ventral surface just lateral to oviducal opening.

Female abdomen 1-segmented, distinct from genital segment. Caudal rami subrectangular, irregular distally, inner surface plumose; distal region with 4 plumose setae and 2 plumose setules.

Male cephalothorax (fig. 31*b*) differing from female in shape (circular), in absence of lunular modification of frontal region, in absence of deep median incision of frontal region, in membrane projecting from anterior edge of frontal region instead of from anterior ventral surface. Also differing in concave nature of posterior median cephalothoracic region, with large, lappet-shaped projection extending over anterior half of free fourth pedigerous segment and forming attachment surface of segment. Median cephalothoracic region with fine cuticular extension dorsally, extension covering concave posterior margin of region and most of lappet-shaped projection. Free fourth pedigerous

Figure 32.—*Lepeophtheirus? fallolunulus*, new species, ventral view: *a*, left caudal ramus; *b*, female frontal region, right side showing lunule-like structure (dorsal view); *c*, right antennule; *d*, female oral region, right side showing antenna, postantennal process, mouth cone, mandible, maxillule (ma-1), postoral process (pop), postoral adhesion process (pa), and maxilla base (ma-2); *e*, male oral region, right side showing antenna (stippled), postantennal process, mouth cone (hatched), mandible (hatched), maxillule (ma-1), postoral process (pop), postoral adhesion process (pa) and maxilla base (ma-2); *f*, right maxilla; *g*, female left maxilliped; *h*, male right maxilliped.


0.1mm. ♀
a
sf
ip
sf
0.1mm. ♂
b
ip
0.1mm. ♀ ♂
c
0.05mm. ♀ ♂
d
f
0.1mm. ♀ ♂
e
0.1mm. ♀ ♂
g
0.2mm. ♀ ♂

segment without plates. Segment-like projection present between fourth pedigerous and genital segments, separable from fourth pedigerous segment (at least superficially) both dorsally and ventrally, distinct from genital segment; projection without processes. Genital segment (fig. 31*e*) barrel shaped, fifth and sixth legs (figs. 31*g, h*) evident as series of plumose setules. Abdomen 1-segmented although with annulations anteriorly. Caudal rami as in female.

Female and male antennule (fig. 32*c*) 2-segmented, attached to ventral surface of subtriangular projection from lateral anterior surface of cephalothorax. Anterior and distal ventral surface of first segment with 20 plumose setae and setules, median dorsal surface with 2. Distal-medial posterior surface of elongate second segment with single naked setule, distal surface with 10. Female antenna (fig. 32*d*) 3-segmented, situated posterior to subtriangular projection associated with antennule and frontal region. First segment short, irregular, attached to laterally extending, heavily sclerotized ridge. Third segment fused with clawlike terminal process, bearing 2 setule-like accessory processes. Male antenna (fig. 32*e*) 3-segmented, first segment originating on heavily sclerotized ridge, extending medially and ventrally so that second segments of both antennae in close proximity to each other. Second segment club shaped, with 1 large and 1 small, spinelike projection on inner ventral surface. Third segment short, distinct from long, saber-shaped terminal process, shorter, spinelike subterminal process and setule-like accessory process.

Female and male mandible (figs. 32*d, e*) 4-parted, rodlike, distal part curving inward, inner surface with 12 denticulations. Female and male postantennal process (figs. 32*d, e*) consisting of sharply curved, spinelike process, with outer margin denticulated distally, in addition to 3 nodules, 2 on base of spinelike process, third posterior to process, each with several hairlike processes. Female postoral process (fig. 32*d*) formed of heavily sclerotized plate bearing small bifurcate projection, tines rounded distally. Male postoral process (fig. 32*e*) small, lappet-like projection of heavily sclerotized ridge. Female maxillule (fig. 32*d*) nodular, with 3 setules distally; male maxillule (fig. 32*e*) nodular, with 1 long and 1 short setule distally. Male oral region well anterior and congested, mouth cone located between projecting first segments of antennae; postoral process, antenna base, mouth cone, maxillule, and maxilla in close proximity.

FIGURE 33.—*Lepeophtheirus? fallolunulus*, new species, ventral view: *a*, female sternal furca (sf), tinelike projections, and base of first thoracic legs (ip=interpodal plate); *b*, male sternal furca (sf), tinelike projections, and first thoracic legs (ip=interpodal plate). Right thoracic legs: first, posterior view; *d*, second segment of exopodite of first, posterior view; *e*, second, anterior view; *f*, third, anterior view; *g*, fourth, posterior view.

Small, heavily sclerotized, knoblike postoral adhesion process present in both female and male (figs. 32*d, e*), arising from Y-shaped region of heavy sclerotization, just posterior to postoral process. Female and male maxilla (fig. 32*f*) 2-segmented, second segment with fine membrane along medial posterior surface and 2 saber-shaped terminal processes, innermost approximately twice the length of outermost.

Female and male maxilliped (figs. 32*g, h*) 2-segmented, situated medial and posterior to maxilla base. First segment strongly developed, with indentation on proximal inner surface, identation with pair of small, heavily sclerotized projections, adjacent surfaces of projections forming groove receiving distal end of second segment terminal process when second segment flexed. Second segment separable from clawlike terminal process, bearing setalike and lappet-shaped accessory processes.

Sternal furca (figs. 33*a, b*) situated well posterior to maxilliped bases. Bifurcate portion of female furca at end of necklike process, bifurcate portion of male furca also on process although process much shorter. Pair of spinelike projections present, posterior to furcal base, just anterior to interpodal plate of first thoracic legs.

For nature of legs and armature, see figures 33*c–g* and table 12. First thoracic leg with 3 spinules on inner surface of second segment of exopodite instead of 3 plumose setae normally found.

TABLE 12.—*Armature of thoracic legs I–IV of the female and male of* Lepeophtheirus? fallolunulus, *new species*

Leg	Surface	Inter-podal Plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
I	Outer		p		rh	H,2dH,P′		p′		
	Inner		p		C	3rh		p′		
II	Outer	m		m,p	m,H‡	h	h,mh,Q,2P	C	c	c,3P
	Inner		s,P	m,p′	c,P	c,P	3P	P	c,2P	3P
III	Outer	m	D†,s,a*,m,p		H	P,p,2P		c	c,3P	
	Inner		r§,2s,P,m		P	4P,p			3P	
IV	Outer		p‖		s,H	3mH,H				

*Five-lobed adhesion pad.
†Single large denticulation.
‡Ramified spine; female with 6 rami (excluding tip), male with 7.
§Three roughened areas.
‖Several hairlike processes not tabulated.

DISCUSSION.—The species is tentatively placed in the genus *Lepeophtheirus* because the general characteristics most closely approximate those of *Lepeophtheirus* (e.g., fourth pedigerous segment free, not completely covered dorsally by median projection of cephalothorax; abdomen distinct, not fused with genital segment; first 3 thoracic legs biramous although endopodite of first leg reduced, fourth thoracic leg uniramous). These characteristics plus the lunule-like structure are also found in *Caligus*. The lunule-like structure, however, is not identical with that of *Caligus* and other lunule-bearing genera (see below).

The species differs from the majority of the species in *Lepeophtheirus* for the following reasons:

1. Part of the frontal region is modified to form a lunule-like process.

2. The fourth thoracic legs are 3-segmented, not 4-segmented, although *Lepeophtheirus* does include some species with 3-segmented fourth thoracic legs (e.g., *L. watanabei* Shiino, 1954d).

3. There are 4 terminal spines on the fourth thoracic legs instead of 3.

4. The endopodite of the first thoracic legs is larger than in most members of the genus. Many authors state that the first and fourth thoracic legs are uniramous in *Lepeophtheirus* (e.g., Wilson, 1905b, Yamaguti, 1963). The endopodite of the first leg of members of this genus is reduced or rudimentary but it is present (e.g., *L. dissimulatus* Wilson, 1905b; *L. gonistii* Yamaguti, 1936a) and the leg is biramous.

5. The postoral process is reduced, especially in the male.

The lunule-like structure of *L. fallolunulus* is formed of the upturned lateral anterior surface of the frontal region. Further, the structure is partially separated from the rest of the frontal area and has a strongly denticulated membrane instead of the frilled membrane found on the rest of the region. In *Caligus* and other lunule-bearing caligoids, the lunule is formed of part of the membrane found on the leading edge of the frontal region. In these, however, the membrane is either formed around a sinus in the frontal region or it itself forms a sinus. This structure can be simple (e.g., *C. enormis* Wilson, 1913) or the membrane can be well developed and the sinus remain open (e.g., *C. zei* Norman and Scott, 1906), or the membrane can be well developed, the sinus closed, and the lunule of a distinct cup shape (e.g., *C. coryphaenae* Steenstrup and Lütken, 1861). In all cases, however, the lunule is associated with some type of sinus and is directed ventrally. In *L. fallolunulus* there is no sinus, the structure is directed dorsally and not ventrally, and it is found only on the female.

In several characteristics, the species is similar to some members of the genus *Anuretes* and the genus *Pseudoanuretes*. *Anuretes parvulus* Wilson, 1913, resembles this species in the general shape of the fourth pedigerous segment and genital segment, antennule, and maxilliped, but it differs in the less distinct abdomen, the absence of the lunule-like structure, the reduction of the female postantennal process, the reduction of the sternal furca, and in the nature of most of the appendages. The 3 small, spinelike projections present on the inner surface of the second segment of the exopodite of the first thoracic leg in *L. fallolunulus* are also found in *Pseudoanuretes chaetodontis* Yamaguti, 1936a, while the ramified spine on the first segment of the exopodite of the second thoracic leg is similar to the condition of this spine in *Anuretes serratus* Shiino, 1954a.

The name "fallolunulus" is derived from the Latin terms "fallo" (deceive) and "lunula" (small moon) and refers to the nature of the lunule-like structure on the female.

Midias Wilson, 1911b

Diagnosis.—Cephalothorax ovoid, consisting of cephalon and first 4 thoracic segments. Frontal region distinct, with lunules. Free fourth pedigerous segment wider than long, tergal region heavily sclerotized (as is most of the dorsal body surface), with flaplike lateral extensions, segment without alae or separate plates in either sex. Genital segment with short, heavily sclerotized, spinelike fifth leg projections on posterior lateral surface. Abdomen of female 2-segmented, of male 1- or 2-segmented, basal segment of female with lateral lobes. Antennule 2-segmented; antenna 3-segmented, with clawlike terminal process, male with adhesion surfaces on first and second segments. Mandible rodlike, distal region curved inward, slightly flattened, with 12 denticulations along distal inner surface. Postantennal process consisting of spinelike projection and 3 nodules, each bearing several hairlike processes; postoral process spinelike, either bifid or simple, male with adhesion surface on distal region of process. Maxillule nodular, with setules; maxilla 2-segmented, tipped by 2 saber-shaped processes. Maxilliped 2-segmented, with clawlike terminal process; sternal furca well developed. Thoracic legs I–III biramous although endopodite of first leg reduced, fourth thoracic leg uniramous.

Remarks.—Two species have been described in this genus and are compared in the discussion section following the description of *M. lobodes*.

Wilson (1911b, p. 628) placed *M. lobodes* in the subfamily Euryphorinae (now recognized as a distinct family) because, "among general characters," of the large size, "the possession of rudimentary dorsal plates on the fourth" pedigerous segment, "a strongly inflated genital segment . . . an abdomen with lateral lobes on the basal joint and posterior lobes on the terminal joint," the possession of a 2-segmented endopodite on the first thoracic leg, and the presence of 3 segments in each of the rami of the third thoracic legs. Yamaguti (1963) accepts this placement and includes the genus in the Euryphoridae and in his subfamily Tuxophorinae, which includes both *Midias* and *Tuxophorus*, the latter of which has distinct alae on the fourth pedigerous segment.

The division between the Caligidae and the Euryphoridae is tenuous, both families sharing common characteristics. *Dentigryps*, a caligid genus, for example, possesses euryphorid-like fifth legs; *Pupulina*, a caligid, has euryphorid-like extensions of the genital segment. Additionally, one of the characteristics of the euryphorids is the presence of a biramous condition in the first 4 pairs of thoracic legs, yet *Gloiopotes*, a distinct euryphorid, has a distinctly uniramous fourth leg. The euryphorids are considered to be a transition group, between the caligids and the pandarids, and as such there are characteristics of the family that associate them with either or both the caligids and the pandarids.

Midias, *Dentigryps*, and a few other genera exhibit some characteristics which approach those of the Euryphoridae (see Lewis, 1964b, for a discussion of the association of *Dentigryps* with the Euryphoridae). *Midias* is characterized by having certain parts of the body heavily sclerotized. This condition is particularly noticeable on the tergal region and on some of the projections on the body and the appendages. The "dorsal plates," used as a euryphorid characteristic by Wilson, are not distinct plates but rather are thickenings of the tergum which are heavily sclerotized and do not project as do the plates of the alae-bearing groups. These thickenings are also found in other caligids (e.g., *Caligus productus* Dana, 1853). Of the other characteristics used by Wilson, the inflated genital segment is not unique (e.g., *Synestius*, a caligid), the lateral lobes of the first segment of the abdomen are also found in *Dartevellia*, and the posterior lobes on the abdomen are present in *Dentigryps curtus* Wilson, 1913, both of the last two being caligids. Further, the posterior lobes are not described for *Midias carangis* Rangnekar, 1956. The possession of a 2-segmented endopodite on the first thoracic leg is a qualifying characteristic although the endopodite is strongly reduced and no larger than that found in many caligids.

Midias is here placed in the Caligidae because of the absence of distinctly euryphorid characteristics, the presence of a uniramous, 4-segmented fourth thoracic leg, the presence of well-developed lunules, the presence of a spinelike projection as part of the postantennal process, and the presence of a reduced endopodite on the first thoracic leg. The author also accepts the fact that most of these characteristics are as open to criticism as are those Wilson used to include the genus in the Euryphoridae.

Midias lobodes Wilson

FIGURES 34–36

Midias lobodes Wilson, 1911b, p. 626, pl. 65; 1913, p. 225.—Causey, 1953b, p. 11.—Shiino, 1958, p. 98, figs. 1–3; 1963a, p. 343.—Yamaguti, 1963, p. 107, pl. 127, fig. 1.

DISTRIBUTION AND HOSTS.—4 host records:

locality	*hosts*	*references*
Gulf of Mexico	*Sphyraena barracuda*	Wilson, 1911b
Western Atlantic	*S. barracuda*	Wilson, 1913
Hawaii	*S. barracuda*	Shiino, 1963a
Indian Ocean	*Sphyraena* species	Shiino, 1958

MATERIAL.—One female and 1 male (USNM 112888) from the external surface of *Sphyraena barracuda* (Walbaum) captured 80 miles south of Oahu, Hawaii (USFWS). Two females and 2 males (retained by author) from the external surface of *S. barracuda* (Walbaum) captured in the Hawaiian region (USFWS).

MEASUREMENTS.—(In mm) 1 female and 3 males:

	female	*male*
Total length, excluding caudal setae	12.00	7.13, 6.90, 6.30
Length of cephalothorax, including frontal region	4.73	3.68, 3.68, 3.38
Width of cephalothorax	4.35	3.38, 3.38, 3.08
Length of genital segment, excluding fifth legs	3.29	1.55, 1.44, 1.33
Width of genital segment	3.33	1.81, 1.92, 1.85
Length of abdomen	3.29	1.70, 1.78, 1.67
Width of first segment of abdomen	3.11	
Length of fifth leg	0.27	0.48, 0.54, 0.56
Length of caudal rami	0.35	0.29, 0.31, 0.28

DESCRIPTION.—Female cephalothorax (fig. 34*a*) subovoid, consisting of cephalon and first 4 thoracic segments. Frontal region approximately one-fifteenth the length of cephalothorax, with pair of ovoid lunules and bearing fine membrane along anterior edge. Lateral cephalothoracic margin smoothly irregular, with fine membrane extending laterally and second membrane extending medially, from ventral edge. Posterior lateral surface of cephalothorax with small, pocket-like depression; posterior sinus (fig. 34*c*) narrow, outer and inner margins converging at opening, outer surface with fine membrane extending into sinus and second membrane extending laterally over division between lateral and median cephalothoracic regions. Median cephalothoracic region not extending past posterior end of lateral cephalothoracic regions, posterior margin irregular. Major dorsal cephalothoracic grooves forming irregular H; ocular region distinct in anterior third of body. Dorsal surface with scattered nodules, each bearing 1 or 2 hairlike processes.

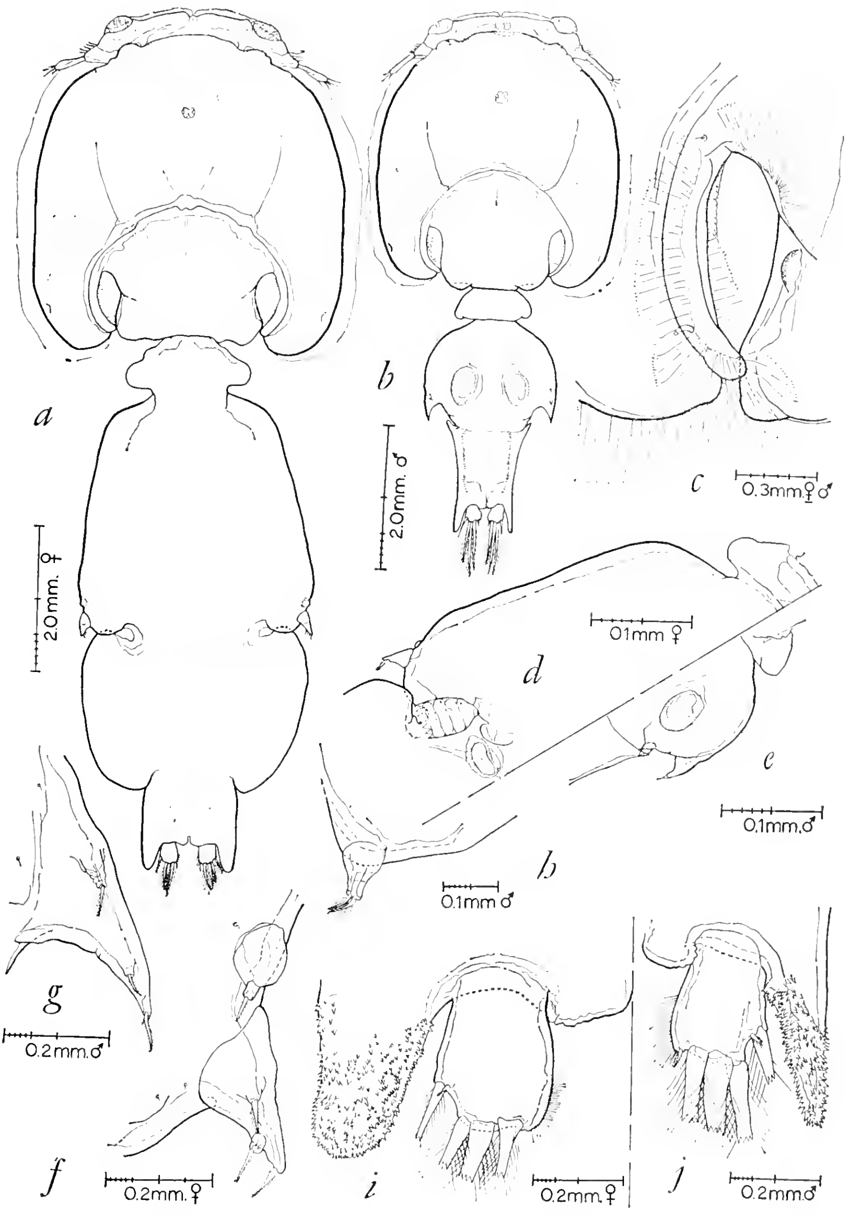


FIGURE 34.—*Midias lobodes* Wilson, 1911, dorsal view: *a*, female; *b*, male; *c*, posterior cephalothoracic sinus. Ventral view: *d*, female genital segment; *e*, male genital segment. Dorsal view: *f*, female right fifth leg; *g*, male, same. Ventral view: *h*, male right sixth leg; *i*, female caudal ramus and abdominal projection; *j*, male, same.

Female free fourth pedigerous segment distinct from cephalothorax, also from genital segment on ventral but not on dorsal surface. Segment short, expanded medially into small, flaplike projections over place of attachment of fourth thoracic legs. Genital segment (fig. 34*d*) broader posteriorly, tapered regularly from slightly narrower anterior end, lateral posterior surface slightly lobate. Fifth legs (fig. 34*f*) situated on posterolateral surface, consisting of minute, knoblike swelling, bearing single plumose setule, additional spikelike projection present immediately posterior to swelling, bearing 3 plumose setules, 2 on dorsal surface, third on distal inner surface.

Female abdomen indistinctly 2-segmented, incompletely separable from genital segment. First segment butterfly shaped; second segment subrectangular except for lobate outer distal surfaces, lobes denticulated. Caudal rami slightly narrower proximally than distally, distal half of inner margin plumose, distal surface with 3 plumose setae medially and 1 laterally in addition to 2 plumose setules, 1 adjacent to both outer and inner setae.

Male cephalothorax (fig. 34*b*) similar to that of female. Free fourth pedigerous segment with smaller lateral projections situated more posteriorly, but still over position of leg attachment. Genital segment (fig. 34*e*) distinct from both free fourth pedigerous segment and abdomen, lateral surfaces broadly convex, fifth legs (fig. 34*f*) spikelike, projecting from posterior lateral surfaces, spike bearing plumose setule from nodule on proximal dorsal surface, plumose setule from distal dorsal surface, and plumose setule from distal surface. Sixth legs (fig. 34*h*) present medial to fifth, consisting of node bearing 2 plumose setules distally. (The condition of the fifth and sixth legs of the male approaches that of the male of *Dentigryps*.) Abdomen appearing as 1 segment although indistinct evidence of second segment visible in posterior half. Abdomen broader anteriorly than posteriorly, lateral margins flatly concave, dorsal surface strongly concave. Outer distal surfaces lobate, lobes denticulated. Caudal rami as in female.

Female and male antennule (fig. 35*b*) 2-segmented, attached to ventral-lateral anterior surface of cephalothorax, just posterior to division between frontal region and remaining cephalothorax. First segment approximately 1⅓ times the length of second, distal half of anterior and anterior ventral surface bearing approximately 26 lightly plumose setae and setules. Second segment elongate, slightly longer in male than in female, with single naked setule from posterior medial surface, 11 from distal surface. Female antenna (fig. 35*c*) 3-segmented, situated slightly medial and posterior to antennule base. First segment short, knoblike, with small, heavily sclerotized subconical projection from posterior surface. Second segment short, subrectangular;

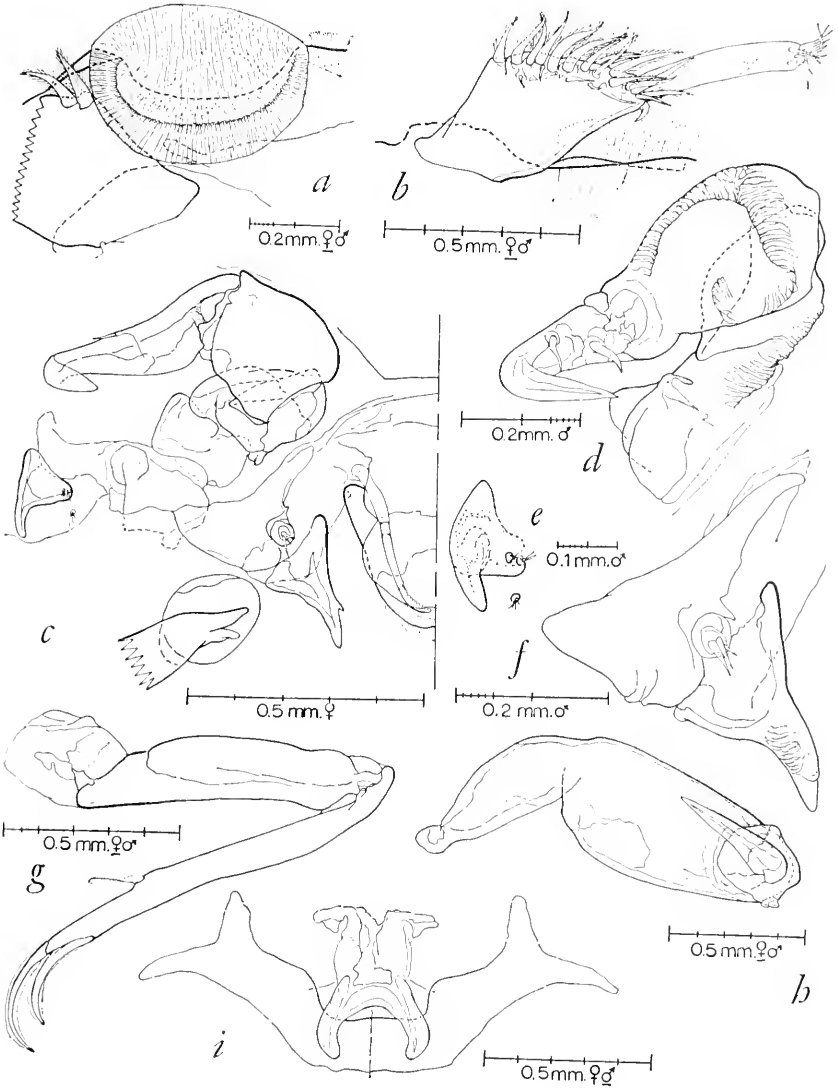


FIGURE 35.—*Midias lobodes* Wilson, 1911, ventral view: *a*, right side of frontal region showing lunule; *b*, left antennule; *c*, female oral region, right side showing antenna, postantennal process, mouth cone, mandible, maxillule, postoral process, and maxilla base; *d*, male right antenna; *e*, male right postantennal process; *f*, male right postoral process and maxillule; *g*, left maxilla; *h*, right maxilliped; *i*, sternal furca.

third segment fused with clawlike terminal process, bearing 2 setule-like accessory processes, 1 at indication of division between segment and terminal process, second from proximal inner surface. Male antenna (fig. 35*d*) basically similar to that of female although segments and processes relatively longer and first 2 segments bearing adhesion surfaces.

Female and male mandible (fig. 35*c*) 4-parted, distalmost part curved inward, with 12 denticulations on inner surface. Female post-antennal process (fig. 35*c*) consisting of short, spikelike projection, just lateral to antennal base, and 3 nodules, each with several hairlike processes; 2 nodules situated on base of spikelike projection, third just posterior to base. Male postantennal process (fig. 35*e*) similar to that of female although projection slightly thicker distally. Female postoral process (fig. 35*c*) spike shaped, with small spine projecting from distal half of inner surface. Male postoral process (fig. 35*f*) similar to that of female except with lappet-shaped accessory projection and adhesion surface. Female and male maxillule (fig. 35*c*) nodular, bearing 3 setules distally. Female and male maxilla (fig. 35*g*) 2-segmented, situated lateral and slightly posterior to postoral process. First segment approximately three-fourths the length of second, both elongate. Second segment with large, oval, membranous projection from distal half of inner surface, with 2 saber-shaped terminal processes. Innermost terminal process approximately 1½ times the length of outermost, both with very lightly frilled membranes along both inner and outer margins.

Female maxilliped (fig. 35*h*) 2-segmented, situated posterior and slightly medial to maxilla base. First segment strongly developed, with elongate proximal projection serving as articulation and muscle attachment surface. Second segment short, incompletely fused with clawlike terminal process, bearing small, setule-like accessory process from inner surface, at junction of segment and terminal process. Male maxilliped similar to that of female except first segment with transverse ridge on distal half of inner surface. Female and male sternal furca (fig. 35*i*) situated between and posterior to maxilliped bases, associated with heavily sclerotized transverse band on cephalothorax. Tines curving medially slightly toward distal ends, sinus U-shaped, lateral surface of tines thinner than medial and inner surfaces.

For nature of legs and armature, see figures 36*a–h* and table 13.

FIGURE 36.—*Midias lobodes* Wilson, 1911, right thoracic legs, anterior view: *a*, first; *b*, distal end of second segment of exopodite of first; *c*, second; *d*, third; *e*, exopodite of third (posterior view); *f*, first segment of exopodite of female third; *g*, male fourth; *h*, protopodite of female fourth.

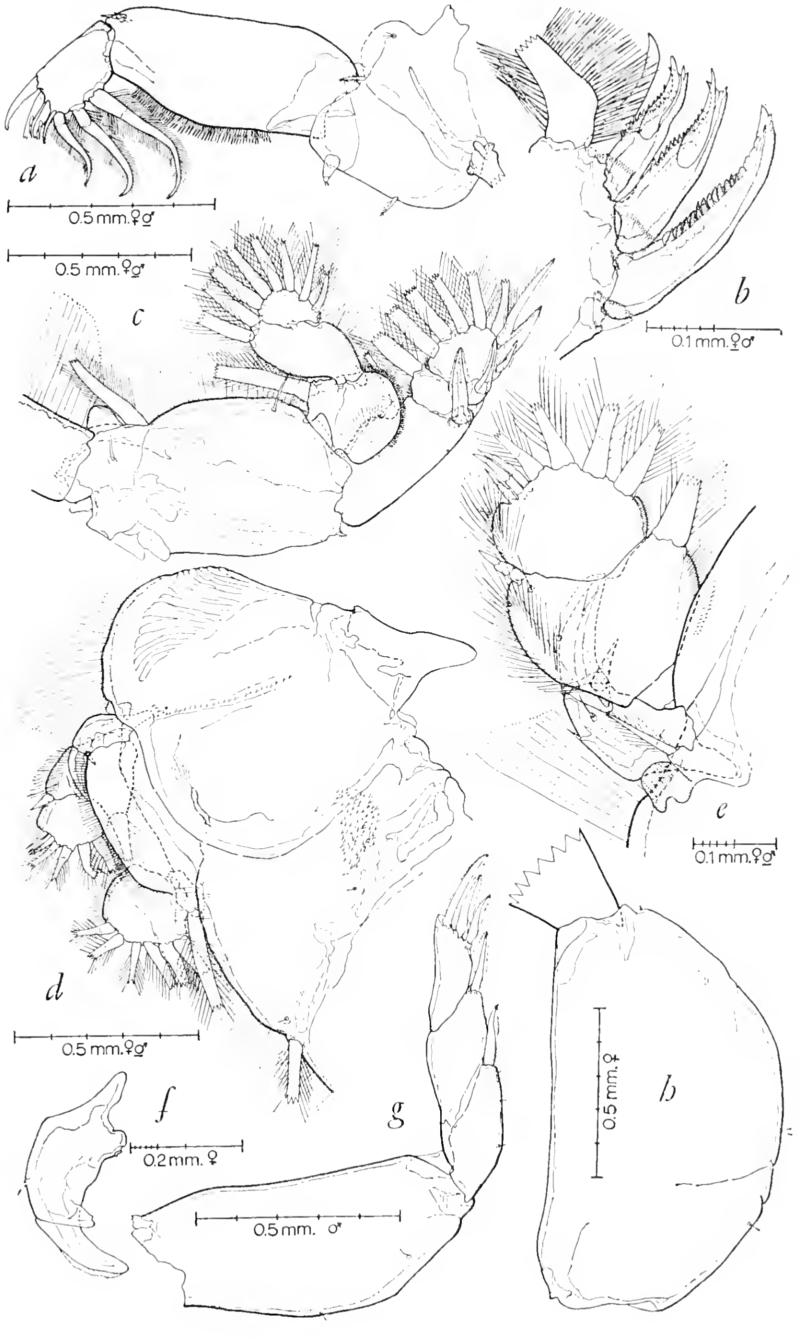

a
0.5 mm. ♀♂
0.5 mm. ♀♂
b
0.1 mm. ♀♂
c
d
0.5 mm. ♀♂
e
0.1 mm. ♀♂
f
0.2 mm. ♀
g
0.5 mm. ♂
h
0.5 mm. ♀

TABLE 13.—*Armature of thoracic legs I–IV of the female and male of* Midias lobodes *Wilson, 1911b*

Leg	Surface	Interpodal Plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
I	Outer		ss,p		fm,rh	3fm,3dH, H			ss	
	Inner		p		C	3P				
II	Outer	m		m,p	m,fm, dmH	dmH	2dmH,Q, P	c,C	c	c,3P
	Inner		s,P	m,s	c,P	e,P	c,4P	P	e,2P	c,3P
III	Outer	m	a,d,m,p		s,fmH	3s,e,p′	c,3p′,P	c	c,2P	
	Inner		d,3s,P,s, m,s			c,P	c,3P	P	c,4P	
IV	Outer		s,ss,s*(p†)		2s,fm,fmH	fm,fmH	3fm,3fmH			

*Female only.
†Male only.

DISCUSSION.—Several parts of Wilson's original description (1911b) need to be mentioned and characteristics that he did not describe should be discussed. These are characteristics noted not only on the Hawaiian material but also on the original type material. Wilson does not figure or describe an accessory process on the third segment of the antenna but a setule-like process is present in the female and 2 are present in the male (figs. 36*c*, *d*). The postantennal process is composed of 3 nodules, each bearing several hairlike processes, as well as a spinule-like projection. There is a great deal of variation in the spinelike projection forming the postoral process; basically, it is bifid in the female and simple in the male, but some of the female specimens in the collections of the U.S. National Museum have a simple process, while in others the process is bifid on one side and simple on the other (see discussion of *Gloiopotes huttoni* for similar case). Wilson indicates that the endopodite of the third thoracic leg is 3-segmented although in all of the specimens examined, including the type material, the endopodite is 2-segmented. There is a cuticular break in the second segment in all of the specimens (fig. 36*d*) but this break is incomplete and there is no indication of a 3-segmented condition, either in the cuticle or by the associated musculature.

Wilson deposited a series of cotypes (USNM 39613) in the type collection. One of these (a female, USNM 39613) has been selected as the lectotype, a second (male, USNM 112846) as the allolectotype, while the rest (USNM 112847) have been designated paralectotypes.

Rangnekar (1956) described the only other species in the genus, *M. carangis*. The feature which best distinguishes the two species is the presence of posterior lobes on the second segment of the abdomen of *M. lobodes* and their stated absence in *M. carangis*. A second characteristic is the described "sickle-shaped claw" on the first segment of the exopodite of the third thoracic leg in *M. carangis;* this claw is bifid in *M. lobodes.*

Caligus Müller, 1785

Diagnosis.—Cephalothorax consisting of cephalon and first 4 thoracic segments; frontal region distinct, with lunules. Free fourth pedigerous segment without alae, sometimes with small, lappet-like lateral projections of tergum extending over proximal surface of fourth thoracic leg. Genital segment of variable shape, infrequently with extensions of posterior lateral surface, without elongate, heavily sclerotized fifth leg projections. Abdomen 1–4 segmented, of variable length but not longer than combined lengths of cephalothorax, free fourth pedigerous segment and genital segment. Antennule 2-segmented; antenna 3-segmented, with clawlike terminal process, variously modified in male. Mandible rodlike, distal end curved inward, slightly flattened, distal inner surface with 12 denticulations. Postantennal process consisting of 3 nodules, each with several hairlike processes, usually with spinelike projection. Postoral process spinelike, simple or with small accessory spine. Maxillule nodular, with hairlike or setular projections; maxilla 2-segmented, terminated by 2 saber-shaped projections. Maxilliped 2-segmented, with clawlike terminal process and setule-like accessory process. Sternal furca present. Thoracic legs I–III biramous although endopodite of first reduced; fourth thoracic legs uniramous.

Caligus coryphaenae Steenstrup and Lütken

Figures 37–39

?*Caligus scutatus* Milne-Edwards, 1840, p. 453.

Caligus coryphaenae Steenstrup and Lütken, 1861, p. 360, pl. 4, fig. 7.—Richiardi, 1880, p. 148.—Valle, 1880, p. 58.—Carus, 1885, p. 358.—Bassett-Smith, 1899, p. 451.—Brian, 1899a, p. 4.—Wilson, 1905b, p. 556, 559 (key).—Brian, 1908, p. 2; 1912, p. 7.—Wilson, 1923, p. 5; 1937, p. 424.—Heegaard, 1949, p. 241, figs. 6–10.—Pearse, 1952a, p. 15.—Capart 1959, p. 81, fig. 14a–d.—Shiino, 1959b, p. 2, figs. 1–2; 1959d, p. 294, fig. 12.—Kurian, 1961, p. 68, figs. 16-24.—Nunes-Ruivo, 1962a, p. 70.—Pillai, 1962b, p. 513, figs. 1, 2.—Shiino, 1963a, p. 336, fig. 1.—Yamaguti, 1963, p. 51, pl. 59, fig. 3.

Caligus bengoensis Scott, 1894, p. 130, pl. 14, fig. 19.

Caligus aliuncus Wilson, 1905b, p. 576, pl. 9; 1935b, p. 330.—Bonnet, 1948, p. 7.—Causey, 1953b, p. 8.

Caligus elongatus Heegaard, 1943b, p. 11, figs. 21–31.

Caligus tesserifer Shiino, 1952, p. 89, fig. 5.

Not *Caligus coryphaenae.*—Brian, 1935, p. 51, figs. 19, 20.—Yamaguti, 1936a, p. 5, pl. 4, figs. 40–54.—Barnard, 1955, p. 246, figs. 8a–d.

DISTRIBUTION AND HOSTS.— 19 + host records:

locality	*hosts*	*reference*
Subtropical Atlantic	*Coryphaena*	Steenstrup and
	"Bonito"	Lütken, 1861
	C. hippurus	Brian, 1908
	Plankton	Scott, 1894
	Parathunus obesus	Nunes-Ruivo, 1962a
Gulf of Mexico	*Euthynnus alleteratus*	Wilson, 1935b
	Coryphaena hippurus	Pearse, 1952a
Eastern Pacific	*Sarda* species	Wilson, 1937
	Coryphaena hippurus	Heegaard, 1949
	Euthynnus lineatus	
	Katsuwonus pelamis	Shiino, 1959
Hawaii	*Euthynnus alleteratus*	Bonnet, 1948
	Coryphaena hippurus	Shiino, 1959d
Western Pacific	*Katsuwonus pelamis*	
	Coryphaena hippurus	Shiino, 1959b
Indian Ocean	Unknown	?Milne-Edwards, 1840
	Squalus acanthias	Wilson, 1923
	Neothunnus albacora	Shiino, 1959b
Mediterranean	*Coryphaena hippurus*	Richiardi, 1880

MATERIAL.—One female and 1 male (USNM 112889) from the external surface of *Katsuwonus pelamis* (Linnaeus) collected near Fanning Island (USFWS, LL cruise 9). One female (USNM 112890) from the external surface of *K. pelamis* (Linnaeus) collected at 20°35′N, 157°-45′W (USFWS, CHG cruise 30, station 30). One female and one male (USNM 112891) from the external surface of *K. pelamis* (Linnaeus) collected in the Hawaiian Island region (USFWS, HMS cruise 34). One female and 1 male (USNM 112892) from the external surface of *K. pelamis* (Linnaeus) collected at 20°4.5′N, 160°37.5′W (USFWS, HMS cruise 39, station 17). One immature male (USNM 112893) from the plankton, 0°00′N, 157°42′W (USFWS, HMS cruise 2, station 52). One female and one male (USNM 112894) from the external surface of *K. pelamis* (Linnaeus) collected 120 miles north of Oahu, Hawaii (USFWS). One female and 2 males (USNM 112895) from the external surface of *Euthynnus yaito* (Jordan and Evermann) collected at French Frigate Shoals (USFWS, HMS cruise 39, station 32). One male (USNM 112896) from the external surface of *Coryphaena hippurus* Linnaeus from unknown locality (in collections of U.S. Fish and Wildlife Service, Honolulu). Two females (USNM 112897) from the external surface of *Euthynnus yaito* (J. and E.) taken near Moku Manu Island, near Oahu, Hawaii (USFWS). One female and 1 male (USNM 112898) from the external surface of *Katsuwonus pelamis* (Linnaeus) collected at 2°S, 132°W (USFWS, JRM cruise 34, station 5). One male (USNM 112899) from the external surface of *Euthynnus yaito* (J. and E.) collected in unknown locality (USFWS, CHG cruise 52). Five females and 2 males (retained by author) from the external surface of *K. pelamis* (Linnaeus) captured by Robert Stevenson near Oahu, Hawaii.

MEASUREMENTS.—(In mm) 13 females and 10 males:

	female		male	
	mean	*range*	*mean*	*range*
Total length, excluding caudal setae	6.61	5.85–7.28	5.52	4.73–6.00
Length of cephalothorax, including frontal region	3.28	3.03–3.63	3.52	3.11–3.74
Width of cephalothorax	2.71	2.44–3.00	2.78	2.52–3.03
Length of genital segment	1.77	1.30–2.11	0.99	0.81–1.11
Width of genital segment	1.58	1.33–1.81	1.25	1.11–1.33
Length of abdomen	1.53	1.06–1.80	0.82	0.68–0.94
Length of caudal rami	0.25	0.23–0.30	0.27	0.23–0.30
Length of egg strings (4 strings)	6.15	2.40–8.78		

DESCRIPTION.—Female cephalothorax (fig. 37*a*) consisting of cephalon and first 4 thoracic segments, with several hairlike processes scattered over dorsal surface. Frontal region approximately one-fifteenth the length of cephalothorax, with narrow membrane along anterior margin; lunules large, projecting posteriorly, on ventral surface, past division between frontal region and remaining cephalothorax. Lateral cephalothoracic margins slightly irregular, with fine membrane, also with distinct socket-shaped depression posteriorly. Posterior sinus (fig. 37*c*) distinct, U-shaped, with finely serrated membrane along outer margin. Posterior median cephalothoracic region projecting slightly past lateral cephalothoracic regions, posterior margin flatly convex. Major dorsal cephalothoracic grooves forming irregular H, with posterior and anterior longitudinal grooves flaring outward, anterior extending to just posterior to ocular region. Ocular region distinct, pigment cups, containing lens element, contiguous on median longitudinal axis of body.

Female fourth pedigerous segment free, width approximately three times the length, dorsal surface raised slightly, appearing platelike. Genital segment (fig. 37*d*) distinct from fourth pedigerous segment, anterior end narrower than posterior, lateral margins wavy. Posterior lateral regions of genital segment lobate, projecting posteriorly slightly, bearing fifth legs on outer surface. Fifth leg (fig. 37*f*) consisting of 2 adjacent nodes, first bearing single plumose seta, second bearing 3 plumose setules. Median posterior surface of genital segment indistinctly and incompletely separable from abdomen. Abdomen considered 4-segmented by most workers although only 2 distinct divisions (3 segments) present, third division suggested by constriction. Anterior part of abdomen with constriction and may represent 2 segments although constriction superficial and developing eggs extend from genital segment through full length of first part of abdomen. Anterior part also with small, bean-shaped

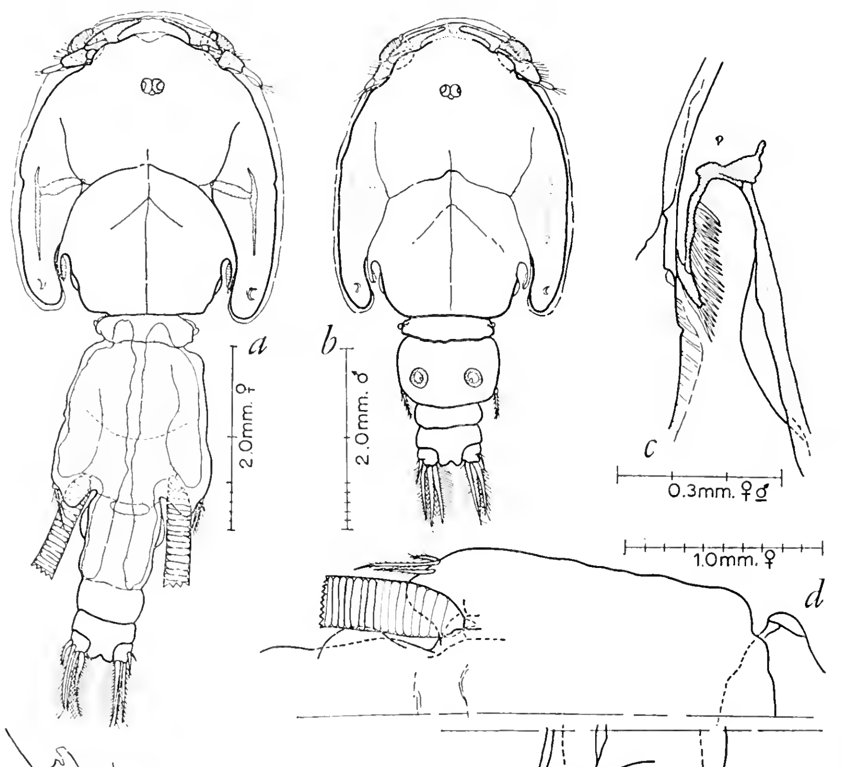


FIGURE 37.—*Caligus coryphaenae* Steenstrup and Lütken, 1861, dorsal view: *a*, female; *b*, male; *c*, posterior cephalothoracic sinus. Ventral view: *d*, female free fourth pedigerous segment, genital segment, and anterior end of abdomen; *e*, male, same; *f*, female fifth leg; *g*, male fifth (V) and sixth (VI) legs. Dorsal view: *h*, left caudal ramus; *i*, frontal region, right side showing lunule and antennule base.

process on anterior dorsal surface. Posteriormost segment with deep indentation in posterior half of lateral surface, indentations forming articulation and attachment surfaces for caudal rami. Caudal rami (fig. 37*h*) short, not extending past posterior end of last abdominal segment, bearing 3 large, plumose setae from medial posterior surface, 2 additional plumose setae from outer posterior surface; sixth plumose seta present on inner posterior surface.

Male cephalothorax and free fourth pedigerous segment (fig. 37*b*) similar to female. Genital segment (fig. 37*g*) suborbicular, lateral posterior surface indented, indentations bearing fifth legs. Fifth leg (fig. 37*g*) similar to that of female; sixth leg (fig. 37*g*) arising medial and slightly posterior to fifth, from broad, lappet-like pad, leg consisting of single plumose seta and 2 plumose setules. Abdomen distinct from genital segment, 2-segmented, first segment broader anteriorly than posteriorly, second segment similar to posteriormost segment of female. Caudal rami as in female.

Female and male antennule (fig. 38*a*) 2-segmented, attached to lateral-anterior ventral surface of cephalothorax, immediately posterior to division between frontal region and remaining cephalothorax. First segment more than twice the length of second, with approximately 17 plumose setae and setules in addition to 2 knobs along distal half of anterior ventral surface; second segment club shaped, with 1 plumose and 9 naked setae and setules in distal region. Female antenna (fig. 38*b*) 3-segmented, situated posterior and slightly medial to antennule base. First segment short, irregularly cup shaped, heavily sclerotized; second segment longer than first, length approximately 1⅕ times the width. Third segment fused with clawlike terminal process, bearing knoblike accessory process at indistinct break in sclerotization, in proximal third; second knoblike accessory processs at proximal end of segment. Male antenna (fig. 38*c*) 3-segmented, first 2 segments basically similar to those of female, third segment terminal process distinct from segment, with second claw at proximal end of process.

Female and male mandible (fig. 38*b*) 4-parted, fourth part flattened, with 12 denticulations along inner margin. Female and male postantennal process (fig. 38*b*) consisting of 3 nodules, each with several fine, hairlike processes. Female and male postoral process (fig. 38*b*) consisting of subtriangular, spinelike projection, bluntly pointed or rounded distally. Female and male maxillule (fig. 38*b*) nodular, bearing 3 setae, situated in depression of platelike area of heavy sclerotization between posterior margin of first segment of antenna and subtriangular postoral process. Ovoid area of heavy sclerotization present, extending posteriorly and medially between bases of maxillae, with ridgelike projection along axis. Female and male maxilla (fig. 38

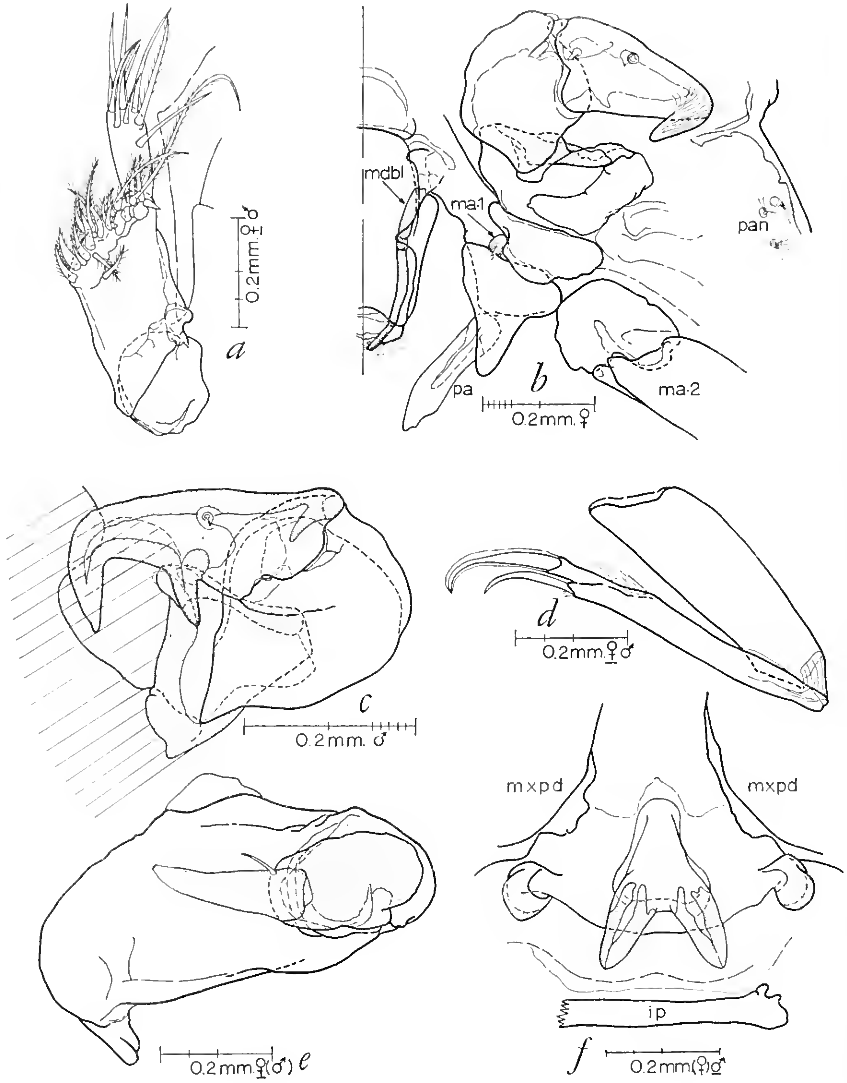


FIGURE 38.—*Caligus coryphaenae* Steenstrup and Lütken, 1861, ventral view: *a*, left antennule; *b*, female oral region, left side showing antenna, postantennal process (pan), mouth cone, mandible (mdbl), maxillule (ma-1), postoral process, postoral adhesion pad (pa), and maxilla base (ma-2); *c*, male right antenna; *d*, left maxilla; *e*, right maxilliped; *f*, sternal furca, maxilliped bases (mxpd), and interpodal plate of first thoracic leg (ip).

d) 2-segmented, situated just lateral and posterior to postoral process. First segment slightly shorter than second, excluding terminal processes, although wider; second segment elongate, tapered proximally and distally, bearing membrane from middle of inner margin and 2 saber-shaped terminal processes, each with membrane along margins.

Female maxilliped (fig. 38*e*) 2-segmented, situated posterior and medial to maxilla base. First segment approximately 2½ times the length of second, strongly developed, width slightly less than half the length. Second segment distinct from clawlike terminal process, bearing single, setule-like accessory process from posterior-inner distal surface. Male maxilliped similar to that of female although first segment with small, ledge-shaped projection on proximal inner surface. Female and male sternal furca (fig. 38*f*) situated between posterior ends of maxilliped bases. Furcal tines diverging widely, heavily sclerotized. Pair of lappet-shaped projections present, lateral to base of furca.

For nature of legs and armament, see figure 39 and table 14.

TABLE 14.—*Armature of thoracic legs I–IV of the female and male of* Caligus coryphaenae *Steenstrup and Lütken, 1861*

Leg	Surface	Inter-podal Plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
I	Outer		ss,s,p		rh	3dmH,p′				
	Inner		p		c	3P				
II	Outer	m		m,p	m,m,mH	mH	2H,Q	C	C	C,3P
	Inner		p′,P	m,p	c,P	c,P	c,5P	P	c,2P	c,3P
III	Outer	m	d,m,p		mH	p′*,c,p′	c,3p′,p	c	c,2P	
	Inner		d,P,s,m,s			c,P	3P	P	4P	
IV	Outer		p		fm,dH†	fm,dH†	fm,dH,fm, dH,fm,dH†			

*Element in middle of segment.
†Female has denticulated membrane, not separate denticulations as in male.

DISCUSSION.—Steenstrup and Lütken (1861, p. 362) state that "Our *C. coryphaenae* also seems closely related to *C. scutatus* M. Edw. (hist. d. Crust. t. III P. 453 no. 7), but as this is from the Indian Ocean it does not seem probable to us that this is the same species." The present distribution and hosts of *Caligus coryphaenae* suggest that Steenstrup and Lütken erred in using the different location as a

FIGURE 39.—*Caligus coryphaenae* Steenstrup and Lütken, 1861, right thoracic legs, anterior view: *a*, first; *b*, distal region of second segment of exopodite of first; *c*, second; *d*, third; *e*, exopodite of third (posterior view); *f*, fourth.

primary reason for separating the two species. Milne-Edwards (1840), however, does not provide a figure of *C. scutatus* and does not list the host from which the female specimen(s?) (male unknown) was collected. Further, *C. scutatus* is not given in a list of Milne-Edwards' species contained in the Paris Museum where most of his specimens were deposited (list sent to Dr. R. Parker, Fisheries Research Board of Canada, Nanaimo, British Columbia). Because of the lack of a definitive description and specimens of *C. scutatus*, it is felt best to use the name only as a questionable entry in the synonymy of C. *coryphaenae*.

The deletion of Brian, 1935, and Barnard, 1955, from the synonymy is based on Pillai's 1962b discussion of the synonymy of *C. coryphaenae*. Shiino, 1959b, also lists *Caranx pelagica*, *Seriola dorsalis*, *Rachycentron canadus*, and *Caranx hippos* as reported hosts.

Caligus quadratus Shiino

Figures 40–42

Caligus productus.—Rathbun, 1884, p. 487.—Wilson, 1905b, p. 597, pl. 14, figs. 162–170.

Caligus coryphaenae.—Yamaguti, 1936a, p. 5, pl. 4, figs. 162–170.

Caligus quadratus Shiino, 1954c, p. 26, fig. 1; 1959b, p. 8, figs. 3–5; 1960a, p. 472.—Yamaguti, 1963, p. 59, pl. 75, fig. 4.

Distribution and hosts.—8 host records:

locality	*host*	*reference*
Japan	*Neothynnus macropterus*	
	Histiophorus orientalis	
	Coryphaena hippurus	
	Neothunnus albacora	
	Rhinobatus schlegelii	Shiino, 1954c, 1959b, 1960a
"Pacific"	*Coryphaena hippurus*	Yamaguti, 1936a
Atlantic	*Coryphaena hippurus*	Wilson, 1905b
Western North Atlantic	*Coryphaena* species	Rathbun, 1884

Material.—Five females and 2 males (USNM 112900) from the gill cavity of *Coryphaena hippurus* Linnaeus captured at 15°N, 155°30′W (USFWS, HMS cruise 36, stations 26–27). Two females (1 immature) (USNM 112901) from the gill cavity of *C. hippurus* Linnaeus captured 120 miles south of Oahu, Hawaii (USFWS). Two females (1 immature) (USNM 112902) from the gill cavity of *C. hippurus* Linnaeus captured 130 miles south of Niihau, Hawaii (USFWS, HMS cruise 39). Three females and 1 male (retained by author) from the buccal cavity, external surface and gill cavity of *C. hippurus* Linnaeus captured near Oahu, Hawaii.

MEASUREMENTS.—(In mm) 11 females and 3 males:

	female		male
	mean	range	
Total length, excluding caudal setae	5. 02	3. 90–6. 15	3. 50, 3. 25, 2. 85
Length of cephalothorax, including frontal region	1. 79	1. 28–2. 08	1. 93, 1. 95, 1. 53
Width of cephalothorax	1. 65	1. 30–1. 88	1. 65, 1. 58, 1. 33
Length of genital segment	1. 55	1. 33–1. 80	0. 73, 0. 60, 0. 55
Width of genital segment	1. 24	1. 08–1. 43	0. 58, 0. 55, 0. 43
Length of abdomen	1. 64	1. 20–2. 18	0. 73, 0. 60, 0. 53
Length of caudal rami	0. 15	0. 10–0. 18	0. 18, 0. 19, 0. 13
Length of egg strings (4 strings)	2. 33	1. 25–3. 05	

DESCRIPTION.—Female cephalothorax (fig. 40*a*) ovoid, consisting of cephalon and first 4 thoracic segments. Frontal region slightly more than one-tenth the length of cephalothorax, with membrane along most of anterior margin. Lunules extending posteriorly, on ventral surface, past junction of frontal region and rest of cephalothorax. Lateral margin of cephalothorax slightly irregular, with numerous small indentations, bearing narrow membrane extending laterally and second, frilled membrane extending medially, on ventral surface. Posterior lateral cephalothoracic surface with small, pocket-like depression on dorsal surface. Posterior sinus (fig. 40*c*) irregularly V-shaped, with fine membrane along outer surface. Posterior margin of median cephalothoracic area irregularly convex, area extending posteriorly slightly past lateral areas, with 3 pairs of minute, hairlike processes on median-posterior dorsal surface. Major dorsal cephalothoracic grooves forming irregular H; dorsal surface with scattered minute, hairlike processes, in addition to those on posterior median surface. Ocular region distinct, in anterior third of cephalothorax, pigmented cups contiguous on median longitudinal axis of body.

Female free fourth pedigerous segment broadest medially, angled toward anterior and posterior ends. Segment distinct from cephalothorax, distinctly separable from genital segment ventrally, indistinctly separable dorsally. Genital segment (fig. 40*d*) variable in shape, subovoid to rectangular, anterior lateral and lateral posterior surfaces frequently slightly lobate. Fifth leg (fig. 40*f*) situated on lateral ventral surface in posterior fourth of segment, consisting of 2 nodules, outermost with single lightly plumose setule, innermost with 2 lightly plumose setules.

Abdomen elongate, consisting of 1 or more segments, distinct from genital segment. Anterior end of abdomen narrower ventrally than dorsally. Lateral surfaces irregular, with several distinct constrictions in some specimens, constrictions absent in others. Abdomen narrower posteriorly than anteriorly, posterior region (ap-

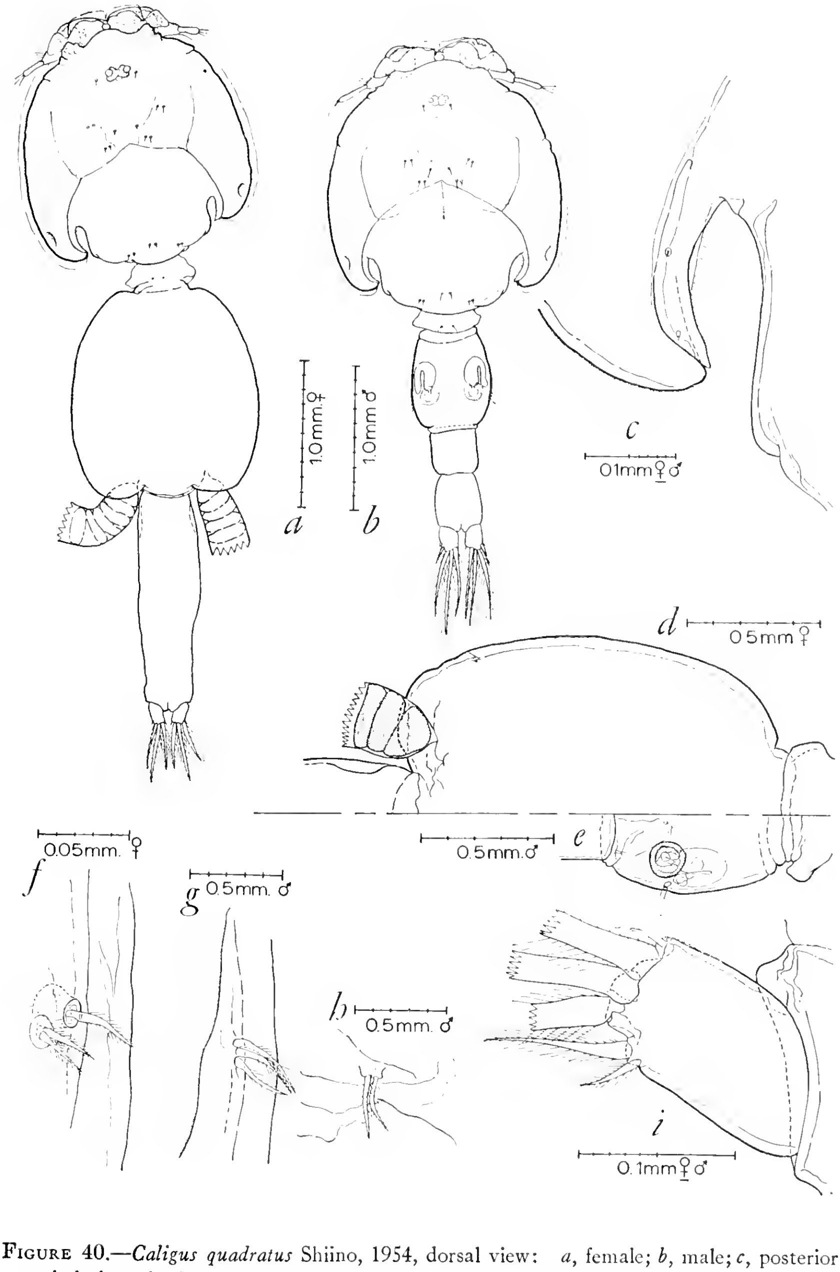


FIGURE 40.—*Caligus quadratus* Shiino, 1954, dorsal view: *a*, female; *b*, male; *c*, posterior cephalothoracic sinus. Ventral view: *d*, female genital segment; *e*, male, same; *f*, female fifth leg; *g*, male, same; *h*, male sixth leg; *i*, caudal ramus.

proximately one-seventh the total length) with almost parallel sides, region with indistinct evidence of division from rest of abdomen. Posterior end of abdomen with concave lateral surfaces, irregularly U-shaped median region, at anal opening. Caudal rami (fig. 40*i*) subrectangular, inner margin plumose distally, distal surface with 3 plumose setae medially, fourth plumose seta laterally; 2 plumose setules also present, one on either side of setae.

Cephalothorax of male (fig. 40*b*) similar to that of female. Free fourth pedigerous segment of similar shape although division between segment and genital segment distinct, segment bearing ridgelike area of heavy sclerotization posteriorly, extending from posterior end of fourth leg attachment surface. Genital segment (fig. 40*e*) barrel shaped, constricted slightly anteriorly. Fifth legs (fig. 40*g*) situated in posterior half of ventral lateral surface, consisting of 3 lightly plumose setules. Sixth legs (fig. 40*h*) situated on posterior-lateral ventral surface, consisting of pair of lightly plumose setules arising from nodule. Abdomen 2-segmented, distinct from genital segment. Second segment slightly less than 1¼ times the length of first, first subrectangular; second segment narrower anteriorly than posteriorly, lateral margins flatly convex, posterior surface as in female. Caudal rami as in female.

Female antennules (fig. 41*b*) 2-segmented, attached to lobate projection of lateral anterior-ventral surface of cephalothorax. First segment slightly less than 1½ times the length of second, broad proximally, tapered to narrow distal surface; distal half of anterior and anterior ventral surface bearing approximately 26 lightly plumose setules and setae. Second segment rod shaped, distal region with approximately 12 naked setules. Male antennule similar to that of female except second segment (fig. 41*c*) longer. Female antenna (fig. 41*d*) 3-segmented, situated posterior and slightly medial to antennule base. First segment stubby, irregular, base subtriangular, bearing small, heavily sclerotized, subconical projection from outer posterior surface. Second segment well developed, broader proximally than distally. Third segment indistinctly separable from clawlike terminal process, bearing setule-like accessory process from distal lateral surface and small, lappet-like process from proximal posterior surface. Male antenna (fig. 41*e*) 3-segmented, first segment short, subovate, concave distally. Second segment club shaped, narrow end distalmost, with small adhesion surface on proximal anterior surface and second, ridge-shaped adhesion surface on distal half of inner surface. Third segment short, indistinctly separable from trifid terminal process, bearing setule-like accessory process from anterior distal surface. Tines of trifid terminal process short, situated at distal end of process.

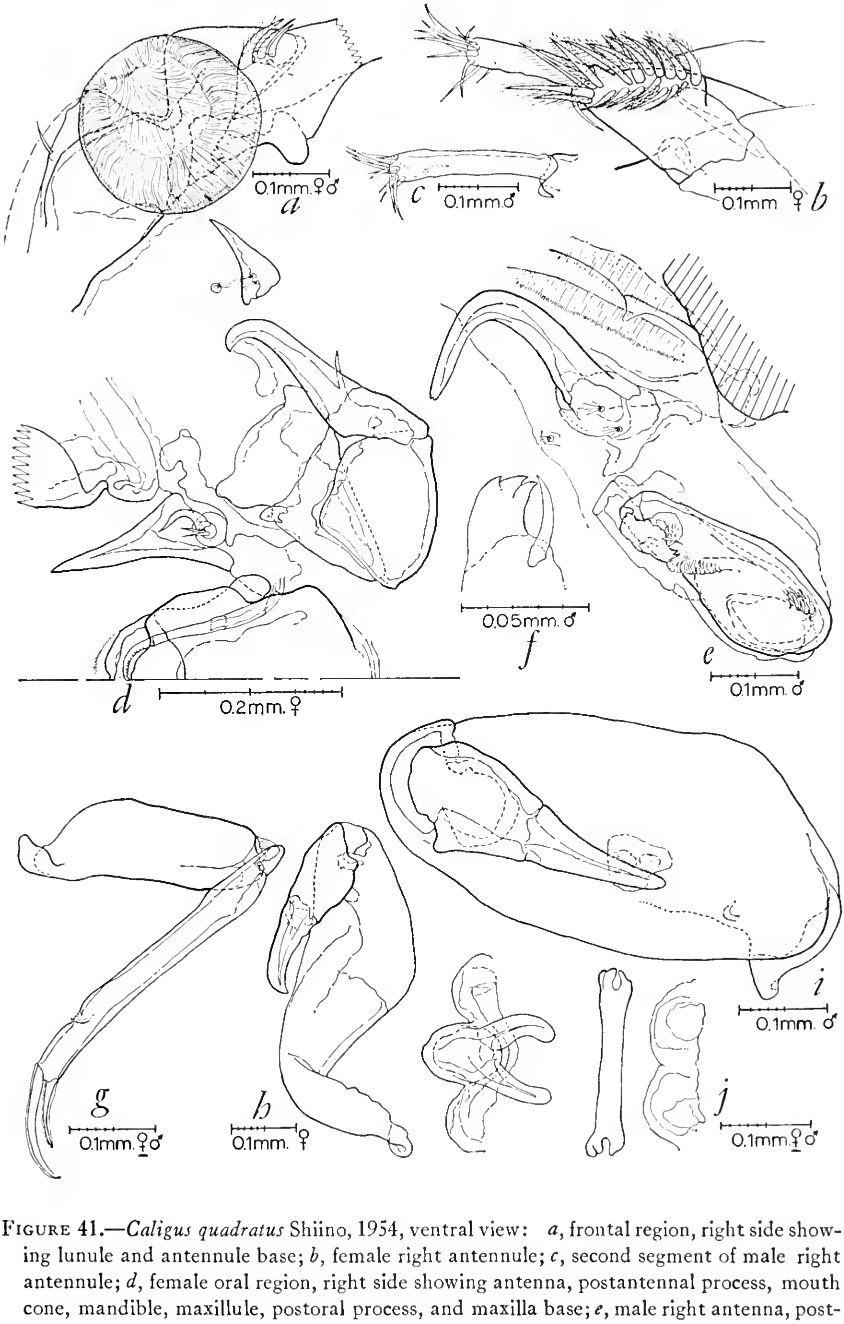


FIGURE 41.—*Caligus quadratus* Shiino, 1954, ventral view: *a*, frontal region, right side showing lunule and antennule base; *b*, female right antennule; *c*, second segment of male right antennule; *d*, female oral region, right side showing antenna, postantennal process, mouth cone, mandible, maxillule, postoral process, and maxilla base; *e*, male right antenna, postantennal process and base of antennule; *f*, claw and accessory process of male left antenna; *g*, left maxilla; *h*, female left maxilliped; *i*, male, same; *j*, sternal furca.

Female and male mandible (fig. 41*d*) 4-parted, distalmost part curved medially, with 12 denticulations along inner surface. Female postantennal process (fig. 41*d*) situated lateral to antennal base, consisting of short, spinelike projection bearing pair of nodules on proximal surface, third nodule present slightly posterior to base of projection, all 3 nodules with several hairlike processes. Male postantennal process (fig. 41*e*) also consisting of spinelike projection and 3 nodules although projection much longer and strongly curved. Female and male postoral process (fig. 41*d*) spinelike, elongate. Female and male maxillule (fig. 41*d*) nodular, with 3 setules distally. Female and male maxilla (fig. 41*g*) 2-segmented, situated lateral and slightly posterior to postoral process. First segment more than four-fifths the length of second; second segment elogate, with small, horseshoe-shaped membrane from distal medial surface and 2 saber-shaped terminal processes. Innermost terminal process slightly less than 1½ times the length of outermost, bearing fine, filmy membrane along inner margin; outermost with very finely frilled membrane along both outer and inner margins.

Female maxilliped (fig. 41*h*) 2-segmented, situated posterior and slightly medial to maxilla base. First segment well developed, with long, strongly curved proximal articulation and muscle attachment projection. Second segment distinct from clawlike terminal process, bearing setule-like accessory process on distal inner surface. Male maxilliped (fig. 41*i*) more strongly developed, proximal projection of first segment shorter, inner medial surface of segment with small nodes proximally, larger node distally (node spinelike on 1 maxilliped of 1 of the 3 specimens); second segment and processes as in female. Female and male sternal furca (fig. 41*j*) situated between and slightly posterior to maxilliped bases. Furca with slightly curved or straight tines, arising from butterfly-shaped area of heavy sclerotization. Second butterfly-shaped area present between interpodal plates of first and second thoracic legs.

For nature of legs and armature, see figure 42 and table 15.

Discussion.—The Hawaiian specimens here described as *C. quadratus* Shiino differ from Shiino's 1954c and 1959b description as follows:

1. The terminal process of the male antenna differs from that shown by Shiino although he does not include a lateral view of this structure in his figures. The terminal process of the Hawaiian specimens more closely resembles that of *C. kuroshio* Shiino, 1959c, although the characteristic denticulation of the outer margin of the second segment of the endopodite of the second thoracic leg of *C. quadratus* and the Hawaiian specimens is not indicated. The

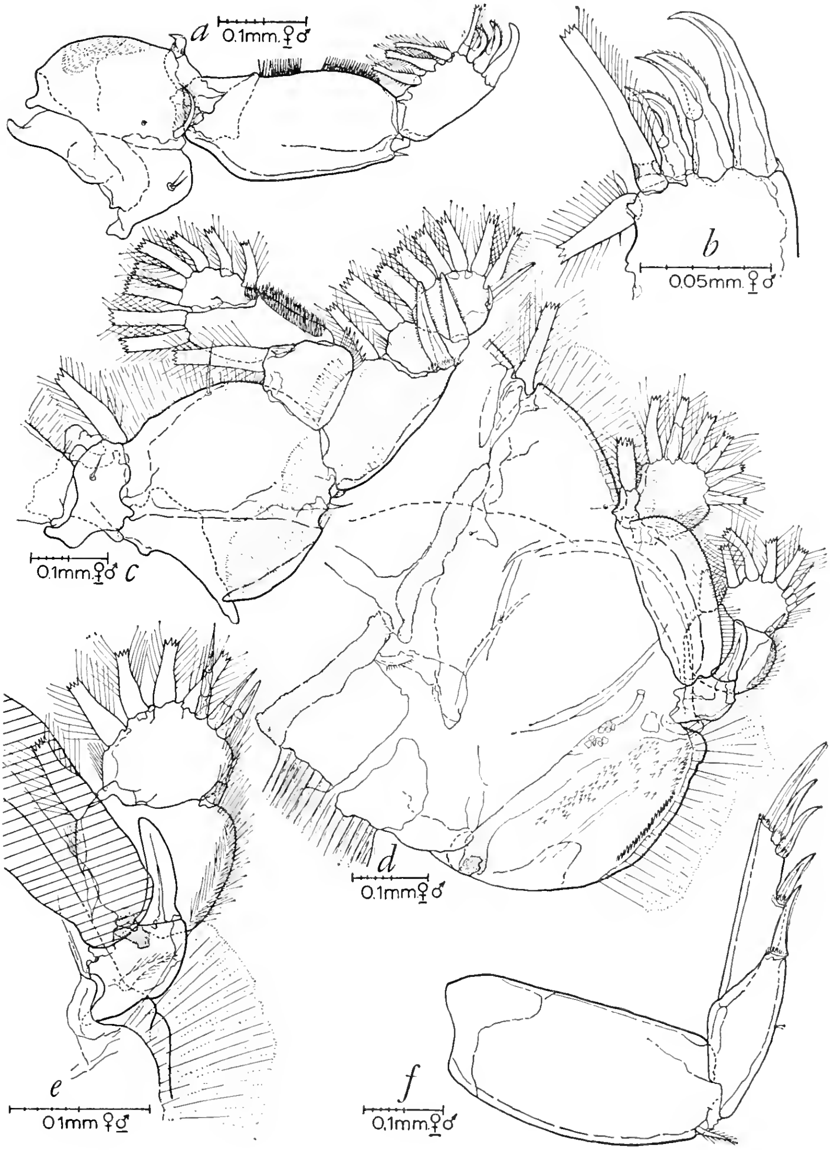


FIGURE 42.—*Caligus quadratus* Shiino, 1954, right thoracic legs, anterior view: *a*, first; *b*, distal end of second segment of exopodite of first; *c*, second; *d*, third; *e*, exopodite of third; *f*, fourth.

Table 15.—*Armature of thoracic legs I–IV of the female and male of* Caligus quadratus *Shiino, 1954c*

Leg	Surface	Interpodal Plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
I	Outer		ss,p		rh	H,2dH,P				
	Inner		d,p		c,c	3P				
II	Outer	m		m,p	m,fm,fmH	fmH	h,mH,Q	D	D	D,3P
	Inner		s,P	m,s	c,P	c,P	c,5P	P	c,2P	c,3P
III	Outer	m	d,m,p		H	c,p′	c,3p′,P	c	c,2P	
	Inner		2s,P,s,m,s			c,P	c,3P	P	c,4P	
IV	Outer		s,p		s,fm,fmH	4fm,4mH				

Hawaiian specimens also differ from *C. kuroshio* in the nature of other appendages and the body.

2. Shiino does not figure or describe a break in the plumosities on the inner margin of the first segment of the exopodite of the first thoracic leg in *C. quadratus*. This break, although slight, is distinct in the Hawaiian specimens.

Caligus quadratus and the following 2 species of *Caligus* are difficult to separate. A discussion of the characteristics most readily usable is given following the description of the third species.

Caligus productus Dana

Figures 43–45

Caligus productus Dana, 1853, p. 1354, pl. 94, fig. 4.—Steenstrup and Lütken, 1861, p. 357, pl. 3, fig. 6.—Krøyer, 1863, p. 138. pl. 3, fig. 4a–i.—Brian, 1898, p. 10.—Bassett-Smith, 1899, p. 452.—Brian, 1906, p. 42.—Fowler, 1912, p. 481.—Wilson, 1913, p. 208.—Brian, 1935, P. 53.—Pearse, 1952a, p. 15.—Causey, 1953a, p. 6; 1953b, p. 10; 1955, p. 5.—Shiino, 1959b, p. 14, figs. 6–8.—Causey, 1960, p. 329.—Shiino, 1960a, p. 471.—Hewitt 1963, p. 65.—Shiino, 1963a, p. 335.—Yamuguti, 1963, p. 58, pl. 73, fig. 3.—Kirtisinghe, 1964, p. 53, figs. 25–26.

Caligus monacanthi Krøyer, 1863, p. 59, pl. 3, fig. 2a-e.—Wilson 1905b, p. 607; 1937, p. 424, figs. 6–19.

Caligus lobatus Wilson, 1935a, p. 1, pl. 1, figs. 1–10.

Caligus katuwo Yamaguti, 1936a, p. 6, pl. 4, fig. 55; pl. 5, figs. 56–68.—Shiino, 1954f, 1 fig.—Nunes-Ruivo, 1956, p. 11, pl. 1, fig. b; pl. 2, fig. b.

Distribution and hosts.—37+host records:

locality	*hosts*	*references*
Subtropical Atlantic	*Thymnus pelamys* [sic]	Dana, 1853
	Thynnus	Steenstrup and Lütken, 1861
	Coryphaena	
	Monacanthus species	Kröyer, 1863
	Bonito	Fowler, 1912
	Naucrates ductor	Wilson, 1935a
	Neothunnus albacora	Nunes-Ruivo, 1956

locality	*hosts*	*references*
Gulf of Mexico	*Scomberomorus cavalla*	
	Sarda sarda	
	Elops saurus	
	Coryphaena hippurus	Pearse, 1952a
	Scomberomorus maculatus	Causey, 1953b
	Pogonias cromis	Causey, 1955
Eastern Pacific	Bonito	Wilson, 1937
	Auxis thazard	
	Coryphaena hippurus	
	Neothunnus albacora	Shiino, 1959b
	Seriola dorsalis	
	Paralabrax clathratus	
	P. maculatofasciatus	
	Verrunculus polylepos	
	Mackerel	
	Katsuwonus vagans	
	Sphyraena argentea	
	Scomberomorrus sierra	
	Coryphaena species	
	Seabass	
	Calamus brachysomus	
	Lutianus species	
	Centropomus species	Causey, 1960
Japan	*Katsuwonus pelamis*	
	Coryphaena hippurus	Shiino, 1959b
"Pacific"	*Euthynnus pelamys*	Yamaguti, 1936a
Indian Ocean	*Coryphaena hippurus*	
	Katsuwonnus pelamis	
	Euthynnus affinis	Kirtisinghe, 1964
Mediterranean	*Chrysophrys aurata*	Brian, 1898

MATERIAL.—Twenty-one females and 15 males (USNM 112904) from the extenal surface of *Katsuwonus pelamis* (Linnaeus) captured near Oahu, Hawaii by Robert Stevenson. One male (USNM 112905) from the external surface of *Neothunnus macropterus* (Schlegel) captured by D. W. Strasburg off Kona, Hawaii. One immature female (USNM 112906) from the buccal cavity of *Auxis thazard* (Lacépède) collected south of Nawiliwili, Kauai, Hawaii (USFWS, HMS cruise 39, station 37). One female and 1 male (USNM 112907) from the gill cavity of *Euthynnus yaito* (Jordan and Evermann) from an unknown locality (USFWS). One male (USNM 112908) from the external surface of *Katsuwonus pelamis* (Linnaeus) collected in the Hawaiian region (USFWS, HMS cruise 34). One immature female and 1 male (USNM 112909) from the external surface of 2 specimens of *K. pelamis* (Linnaeus) captured at 20°41.5′N, 160°37.5′W (USFWS, HMS cruise 39, station 17). One female and 1 male (USNM 112910) from the gill cavity of *K. pelamis* (Linnaeus) captured at an unknown locality (USFWS). Three females (retained by author) from the gill cavity of 3 specimens of *K. pelamis* (Linnaeus) captured southeast of Kauai, Hawaii (USFWS, HMS cruise 39). Three females and 1 male (retained by author) from the gill cavity of *K. pelamis* (Linnaeus) captured at 20°41.5′N, 160°37.5′W (USFWS, HMS cruise 39, station 17). Four females and 2 males (retained by author) from the gill cavity of *K. pelamis* (Linnaeus) captured 120 miles north of Oahu, Hawaii (USFWS). One female and 1 male (retained by auther) from the external surface and gill cavity of *K. pelamis* (Linnaeus) captured at 2°S, 132°W (USFWS, JRM cruise 34, station 5).

Measurements.—(In mm) 32 females and 22 males:

	female		*male*	
	mean	*range*	*mean*	*range*
Total length, excluding caudal setae	4. 80	4. 10–5. 45	4. 58	4. 05–5. 15
Length of cephalothorax including frontal region	2. 16	1. 83–2. 33	2. 39	2. 10–2. 78
Width of cephalothorax	1. 92	1. 50–2. 10	2. 04	1. 88–2. 28
Length of genital segment	1. 58	1. 05–1. 93	1. 07	0. 90–1. 20
Width of genital segment	1. 09	0. 80–1. 28	0. 75	0. 65–0. 83
Length of abdomen	1. 14	0. 96–1. 39	0. 87	0. 47–1. 00
Length of caudal rami	0. 24	0. 19–0. 27	0. 26	0. 22–0. 29
Length of egg strings (17 strings)	2. 86	1. 50–4. 15		

Description.—Female cephalothorax (fig. 43*a*) ovoid, consisting of cephalon and first 4 thoracic segments. Frontal region approximately one-twelfth the length of cephalothorax, with membranous margin along anterior edge; lunules extending the length of frontal region. Lateral cephalothoracic margin slightly irregular, with membrane extending laterally and second projecting medially, on ventral surface; small but distinct concavity present in posterior lateral surface. Posterior sinus (fig. 43*c*) narrower at opening than medially, with fine membrane along outer margin. Medial posterior margin of median cephalothoracic region smoothly convex, projecting posteriorly slightly past rounded lateral margins of median region and slightly past posterior end of lateral cephalothoracic regions. Dorsal cephalothoracic surface with numerous small, hairlike processes; major dorsal grooves forming irregular H. Ocular region distinct, in anterior third of cephalothorax; pigmented cups contiguous on median longitudinal axis of body.

Female free fourth pedigerous segment distinct from cephalothorax, indistinctly separable from genital segment dorsally, distinctly separable laterally and ventrally. Segment broad medially, in region of fourth leg attachment, narrower anteriorly and posteriorly. Genital segment (fig. 43*d*) with anterior end narrow, anterior lateral margins convex; posterior lateral surfaces forming pair of posteriorly projecting lobes. Fifth legs (fig. 43*f*) not visible dorsally, situated on lateral ventral surface, at base of lobes; consisting of pair of knobs, outermost with single plumose setule, innermost with 2 plumose set-

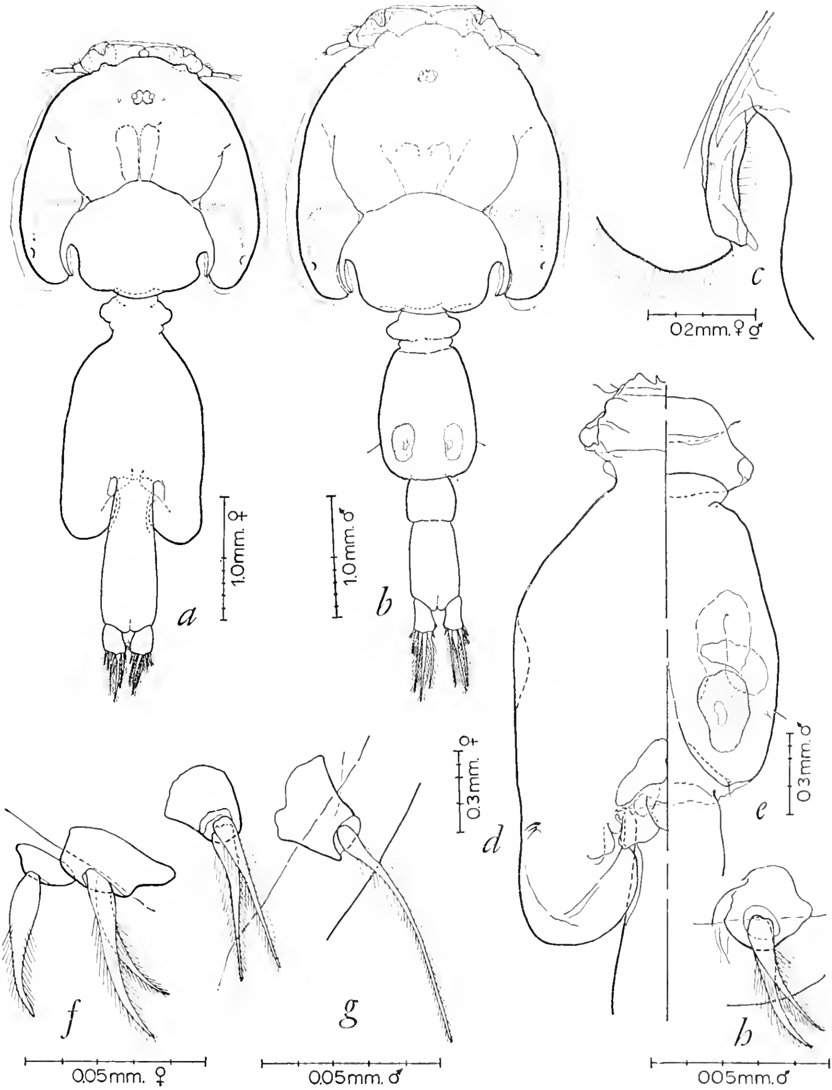


FIGURE 43.—*Caligus productus* Dana, 1853, dorsal view: *a*, female; *b*, male; *c*, posterior cephalothoracic sinus. Ventral view: *d*, female genital segment; *e*, male, same. Legs: *f*, female fifth; *g*, male fifth; *h*, male sixth.

ules. Abdomen 1-segmented, elongate, indistinctly separable from genital segment; with small concavity in anterior-ventral lateral surface, concavity giving 2-segmented appearance but no complete division indicated, either by cuticle or musculature. Posterior half of abdomen broader than anterior, posterior margin angled laterally, with anal concavity medially. Caudal rami (fig. 45*h*) width approximately nine-tenths the length, narrower proximally than distally, distal half of inner margin plumose. Distal surface bearing 3 large plumose setae medially, smaller plumose seta laterally and 2 plumose setules, 1 on either side of setae.

Male cephalothorax (fig. 43*b*) similar to that of female although slightly larger. Free fourth pedigerous segment with small, plate-like lateral extensions of tergal region, attached anteriorly to place of fourth leg attachment. Genital segment (fig. 43*e*) distinct from fourth pedigerous segment, barrel shaped, posterior surface slightly irregular, ventral surface with padlike swelling posteriorly. Fifth leg (fig. 43*g*) situated on lateral ventral surface in posterior half of segment, similar to that of female; sixth leg (fig. 43*h*) situated on posterior ventral surface, consisting of nodule bearing 2 plumose setules. Abdomen 2-segmented, distinct from genital segment dorsally, indistinctly separable ventrally. First segment approximately five-ninths the length of second, subrectangular; second segment slightly narrower anteriorly than posteriorly, posterior end similar to that of female. Caudal rami as in female.

Female and male antennule (fig. 44*b*) 2-segmented, attached to lateral-anterior ventral cephalothoracic surface. First segment approximately 1½ times the length of second, broad proximally, distal half of anterior surface angled to narrow distal surface, bearing approximately 25 plumose setae and setules. Second segment rod shaped, rounded distally, distal surface bearing approximately 12 naked setae and setules. Female antenna (fig. 44*c*) 3-segmented, situated medial and posterior to antennule base. First segment short, squat, almost completely fused with cephalothorax, with spikelike posterior projection. Second segment broad proximally, narrower distally; third segment fused with clawlike terminal process, bearing setule-like accessory process proximally. Male antenna (fig. 44*d*) 3-segmented; first segment of each antenna in close proximity, structurally similar to female first segment although spinelike projection smaller. Second segment elongate, with adhesion surface extending as band in median third of segment, segment also bearing spike-shaped projection from distal third of inner surface, projection with adhesion surface. Third segment indistinctly separable from clawlike terminal process, with setule-like accessory process proximally.

Female and male mandible (fig. 44*c*) 4-parted, distal part curved

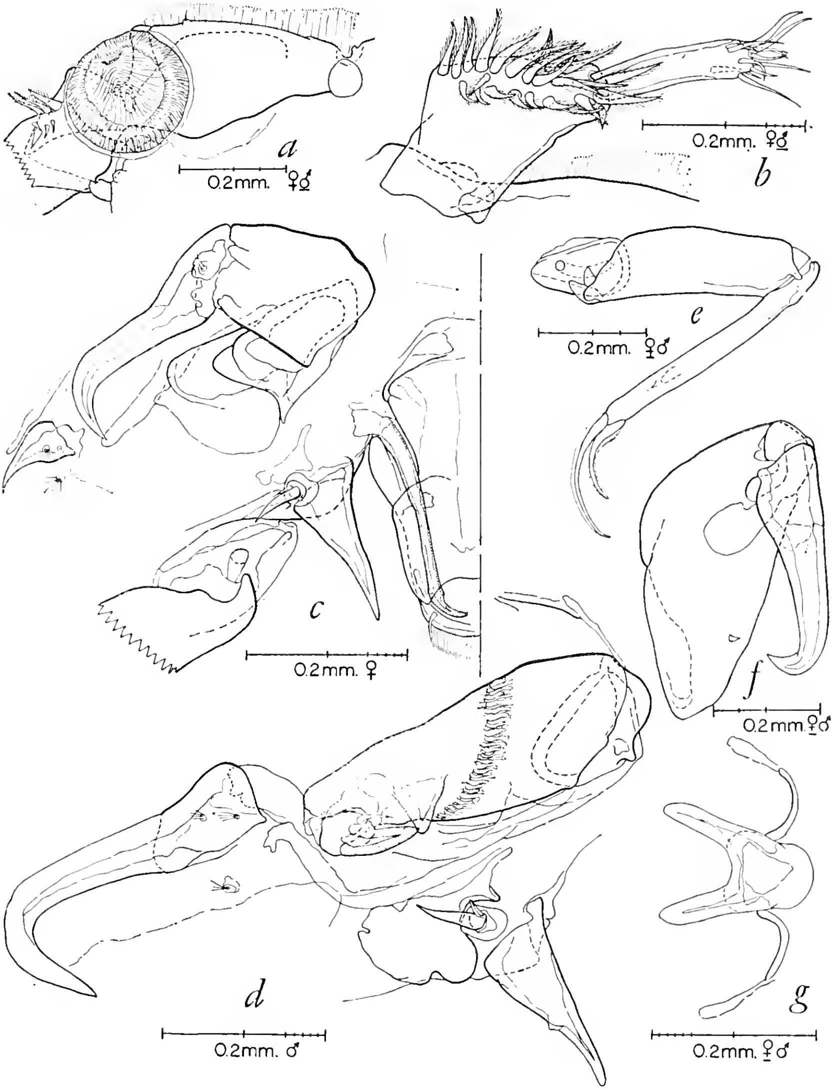


FIGURE 44.—*Caligus productus* Dana, 1853, ventral view: *a*, frontal region, right side showing lunule; *b*, left antennule; *c*, female oral region, right side showing antenna, postantennal process, mouth cone, mandible, maxillule, postoral process, and maxilla base; *d*, male, same as *c* except mouth cone, mandible, and maxilla base not shown; *e*, left maxilla; *f*, right maxilliped; *g*, sternal furca.

inward, inner surface with 12 denticulations. Female postantennal process (fig. 44*c*) short, clawlike, with 2 nodules on proximal surface and additional nodule just posterior to clawlike projection, all 3 nodules with several hairlike processes. Postantennal process of male (fig. 44*d*) much longer than that of female, recurved; nodules and hairlike processes as in female. Female postoral process (fig. 44*c*) long, spinelike; male (fig. 44*d*) as in female except for small, knoblike projection on outer medial surface. Female and male maxillule (figs. 44*c*, *d*) nodular, with 3 setules. Female and male maxilla (fig. 44*e*) 2-segmented, situated lateral and slightly posterior to postoral process. First segment slightly shorter than second, second rodlike, with fine membrane on posterior surface of distal half of segment and 2 saber-like terminal processes. Innermost terminal process approximately 1½ times the length of outermost, with fine membrane along inner margin; outermost process with finely frilled membrane along both margins.

Female and male maxilliped (fig. 44*f*) 2-segmented, situated posterior and medial to maxilla base. First segment strongly developed, narrow proximally and distally, broad medially, with small, spinelike projection from proximal half of inner surface. Second segment short, distinct from clawlike terminal process, with small, setule-like accessory process from distal inner surface. Female and male sternal furca (fig. 44*g*) situated on median longitudinal axis posterior to maxilliped bases. Tines diverging, rounded distally.

Second segment of exopodite of first leg without large plumose setae along inner margin but with 3 minute projections in position normally occupied by setae. For nature of legs and armature, see figures 45*a–g* and table 16.

TABLE 16.—*Armature of thoracic legs I–IV of the female and male of* Caligus productus *Dana, 1852*

Leg	Surface	Interpodal Plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
I	Outer		2s*,p		rh	H,2dH,dP′				
	Inner		d,p		C,C	3s				
II	Outer	m		m,p	m,mH	mH	mH,2Q	C	D	3P
	Inner		2s,P	m,s	c,P	c,P	c,5P	P	c,2P	c,3P
III	Outer	m	d,m,p		s,H	c,p′	c,3p′,P	c	c,2P	
	Inner		d,3s,P,s,m,s			c,P	c,3P	P	c,4P	
IV	Outer		4s,p		4s,dmH†	2dmH,2H				

* More than one hairlike process.
† Very fine denticulations on membrane.

DISCUSSION.—The synonymy does not show several references included by Shiino (1959b) (Rathbun, 1884; Wilson, 1935a), and

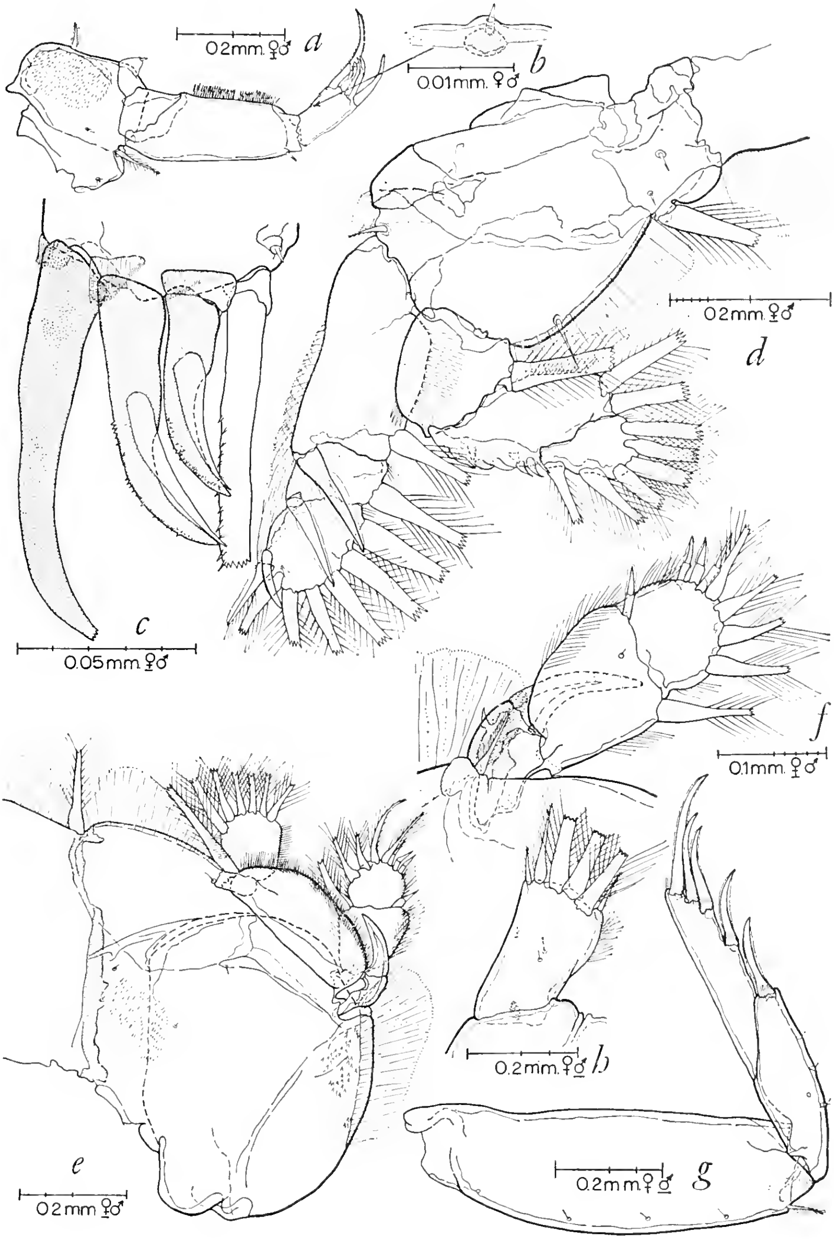


FIGURE 45.—*Caligus productus* Dana, 1853, right thoracic legs: *a*, first, anterior view; *b*, proximalmost setule on inner margin of second segment of exopodite of first; *c*, distal region of second segment of exopodite of first, anterior view; *d*, second, anterior view; *e*, third, anterior view; *f*, exopodite of third, posterior view; *g*, fourth, anterior view; *h*, caudal ramus, ventral view.

Wilson's 1937 reference ("*C. monacanthi*") is changed. In an examination of the material identified by Rathbun as *Caligus productus* (USNM 6109) for his 1884 publication, all of the specimens were found to belong to *C. quadratus* Shiino. The female specimen that Wilson (1935a) identified as *C. productus* (USNM 69776) is not *C. productus* and does not belong to either of the 2 closely related species here described. The material that Wilson (1937) described as *C. monacanthi* from Panama Bay (USNM 69867, 69868) is all *C. productus.* Shiino (1959b) indicates that the males identified as *C. monacanthi* by Wilson are *C. quadratus* and the females *C. productus.* This indication is presumably based on Wilson's statement (1937, p. 426) that "the terminal segment of the first legs [of the male] carries the usual 3 plumose setae on its posterior margin." This indicates that the males are not *C. productus* inasmuch as the absence of the 3 setae is characteristic of this species. From an examination of Wilson's material, however, it was found that the males as well as the females do not possess any plumose setae on the posterior margin of the second (terminal) segment of the exopodite of the first thoracic leg. Additionally, all of these specimens have other characteristics that associate them with *C. productus.* An examination of the type material for *C. lobatus* Wilson, 1935a (USNM 64059, 64060) supports Shiino's conclusion that this species is also a synonym of *C. productus.*

The species described as *Caligus dentatus* Heegaard, 1962, shows some of the characteristics found in *C. productus*, particularly the absence of plumose setae on the second segment of the exopodite of the first thoracic leg. Whether this species is synonymous with *C. productus* or is distinct remains questionable, and further, undamaged material should be adequately described, figured, and compared with associated species before the relationship can be realized.

For a comparison of *C. productus* with closely related species found in Hawaiian waters, see the discussion section following the description of the following species.

Caligus bonito Wilson

FIGURES 46–48

Caligus bonito Wilson, 1905b, p. 589, pl. 13, figs. 150–153, text figs. 5, 12–15, 29, 30, 35, 37, 38, 40–45.—Rathbun, 1905, p. 89.—Brian, 1924, p. 13.—Wilson, 1932, p. 407, fig. 255.—Brian, 1935, p. 188, fig. 14.—Yamaguti, 1936a, p. 8, pl. 5, figs. 69–71; pl. 6, figs. 72–85.—Bere, 1936, p. 582.—Causey, 1953a, p. 4; 1953b, p. 8.—Nunes-Ruivo, 1956, p. 6, pl. 2, fig. a.—Causey, 1960, p. 328.—Shiino, 1960b, p. 527, fig. 1; 1963a, p. 336.—Yamaguti, 1963, p. 50, pl. 56, fig. 3.

?*Caligus kuroshio* Shiino, 1959c, p. 51, figs. 1–2.—Pillai, 1963, p. 80, fig. 9.—Yamaguti, 1963, p. 55, pl. 71, fig. 3.

Distribution and hosts.—20 host records:

locality	*hosts*	*references*
Western North Atlantic	Bonito	Wilson, 1905b
	Gymnosarda pelamis	Rathbun, 1905
Subtropical Atlantic	*Cybium*	Brian, 1924
	Katsuwonus pelamis	Nunes-Ruivo, 1956
Gulf of Mexico	*Pomatomas saltatrix*	
	Scomberomorus maculatus	
	Lutianus griseus	
	Mugil cephalus	
	Oligoplites saurus	
	Scomberomorus cavalla	Bere, 1936
	Gymnosarda alleterato	Causey, 1953a
	Sarda sarda	Causey, 1953b
Eastern Pacific	*Sarda chilensis*	
	?*Lutjanus* species	Causey, 1960
	Katsuwonus pelamis	Shiino, 1963a
Japan	*Euthynnus pelamis*	Yamaguti, 1936a
	Katsuwonus pelamis	
	Thunnus thynnus	Shiino, 1959c
Indian Ocean	*Euthynnus affinis*	Pillai, 1963
Mediterranean	*Pelamys sarda*	Brian, 1935

Material.—Three females (USNM 112911) from the gill cavity of several specimens of *Katsuwonus pelamis* (Linnaeus.) captured 100 miles north of Oahu, Hawaii (USFWS).

Measurements.—(In mm) 3 females:

Total length, excluding caudal setae	6.20, 6.50, 6.45
Length of cephalothorax, including frontal region	2.70, 3.05, 3.10
Width of cephalothorax	2.50, 2.85, 2.85
Length of genital segment	2.00, 2.05, 2.00
Width of genital segment	1.50, 1.35, 1.60
Length of abdomen	1.25, 1.35, 1.25
Length of caudal rami	0.19, 0.20, 0.22
Length of egg strings (all 3 nonovigerous)	

Description of female.—Cephalothorax (fig. 46*a*) ovoid, consisting of cephalon and first 4 thoracic segments. Frontal region approximately one-tenth the total length of cephalothorax, with fine membrane along anterior margin. Lunules distinct, slightly longer than greatest length of frontal region. Lateral cephalothoracic margin slightly irregular, with narrow membrane projecting laterally and second projecting medially. Posterior lateral surface with small indentation. Posterior sinus (fig. 46*b*) U-shaped, with fine membrane along outer margin. Posterior medial surface extending posteriorly slightly past lateral cephalothoracic regions, with narrow, median projection covering junction of cephalothorax and free fourth pedigerous segment. Major dorsal cephalothoracic grooves forming irregular H, transverse groove of H distinct, irregular. Ocular elements distinct, contiguous on median longitudinal axis of body, in anterior third of cephalothorax.

Free fourth pedigerous segment wedge shaped, distinctly separable from genital segment ventrally, appearing fused dorsally. Genital segment (fig. 46*c*) constricted anteriorly, with pair of lobate projections posteriorly, distinct from abdomen. Fifth legs (fig. 46*d*)

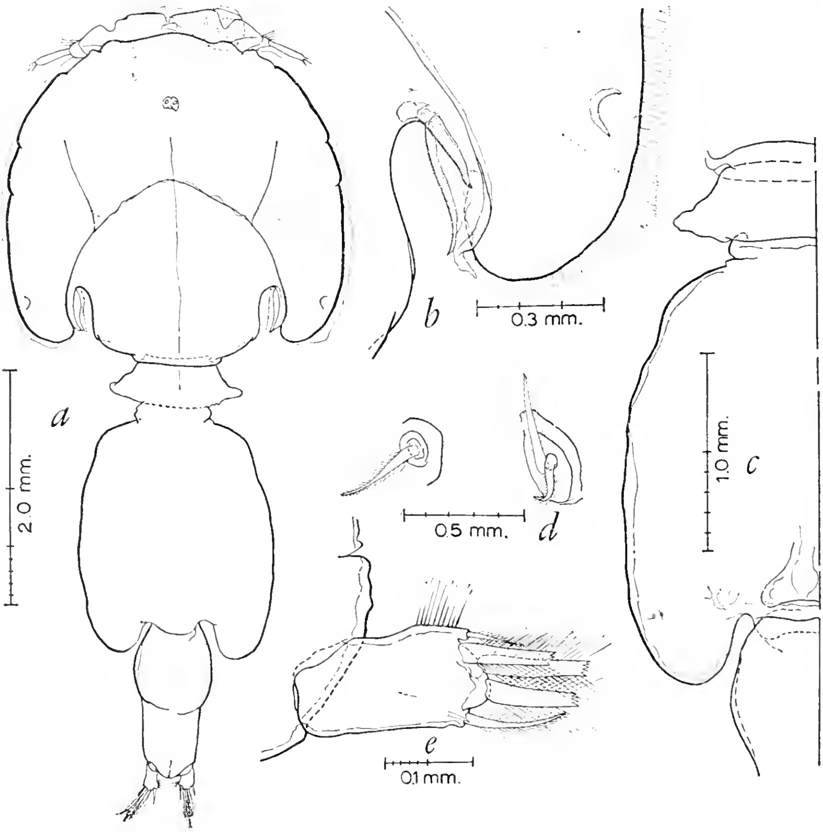


FIGURE 46.—*Caligus bonito* Wilson, 1905, female: *a*, dorsal view; *b*, posterior cephalothoracic sinus, dorsal view. Ventral view: *c*, free fourth pedigerous segment, genital segment, and anterior region of abdomen; *d*, right fifth leg; *e*, caudal ramus.

minute, situated on ventral posterior lateral surface, consisting of single, lightly plumose setule laterally, pair of lightly plumose setules just medial to lateral setule.

Abdomen 1-segmented, anterior half appearing swollen, degree of swelling varying in 3 Hawaiian specimens. Posterior half of abdomen rounded on dorsal posterior surface, with pair of concavities on ventral surface forming place of attachment of caudal rami, anal indentation slight. Caudal rami (fig. 46*e*) narrower proximally than distally, distal half of inner surface slightly swollen, swelling terminating posteriorly in slight knob bearing plumose setule. Distal inner margin plumose, distal surface with 3 plumose setae originating ventral

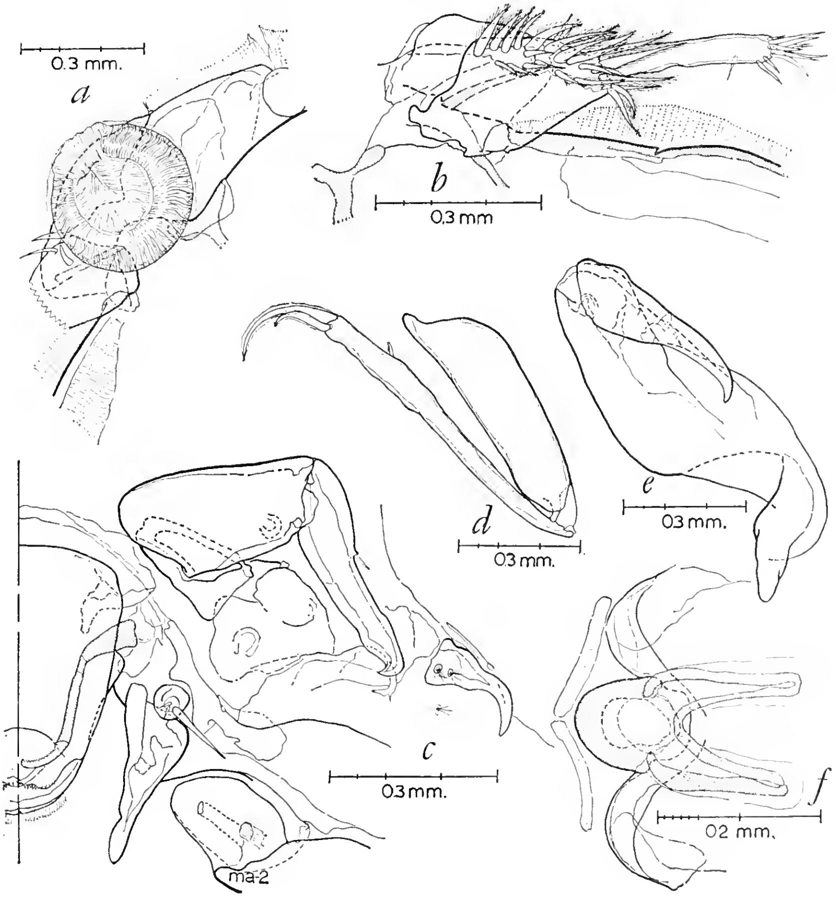


FIGURE 47.—*Caligus bonito* Wilson, 1905, female, ventral view: *a*, right side of frontal region showing lunule and antennule base; *b*, left antennule; *c*, oral region, left side showing antenna, postantennal process, mouth cone, mandible, maxillule, postoral process, and maxilla base (ma-2); *d*, left maxilla; *e*, left maxilliped; *f*, sternal furca.

to small median lobe, plumose setule present lateral to setae and 2 minute setules present, 1 on each side of ramus.

Antennule (fig. 47*b*) 2-segmented, attached to lateral-anterior ventral surface of cephalothorax and lateral-posterior ventral surface of frontal region. First segment slightly longer than second, proximal half broad, distal tapered to narrow distal end, anterior ventral surface with approximately 23 plumose setae and setules, anterior dorsal surface with pair of plumose setules. Second segment rodlike, with approximately 12 naked setules distally. Antenna (fig. 47*c*) 3-segmented, situated posterior and medial to antennule base. First segment short, squat; second segment broad proximally, tapered to lightly narrower distal end, with small, horseshoe-like projection on lateral anterior surface in distal half of segment. Third segment and clawlike terminal process fused, single setule-like accessory process present.

Mandible (fig. 47*c*) 4-parted, rodlike, distalmost part curved medially, with 12 denticulations on inner surface. Labrum with minute denticulations on distal surface. Postantennal process (fig. 47*c*) situated lateral to antenna base, consisting of clawlike process and 3 nodules, each with several hairlike processes. Postoral process (fig. 47*c*) long, spinelike, distal end flattened slightly, appearing spade shaped. Maxillule (fig. 47*c*) nodular, with 3 setules. Maxilla (fig. 47*d*) 2-segmented, situated lateral and slightly posterior to postoral process. First segment approximately four-fifths the length of second; second elongate, slightly swollen medially, with fine membrane on medial swelling and 2 saber-shaped terminal processes. Innermost terminal process approximately twice length of outer, with fine membrane along both margins; outer terminal process with frilled membrane along outer margin.

Maxilliped (fig. 47*e*) 2-segmented, situated posterior and medial to maxilla base. First segment strongly developed, proximal half tapered to narrow proximal end, curved strongly; distal half tapered to irregular distal end. Second segment short, separable from clawlike terminal process, bearing single setule-like accessory process from distal inner surface. Sternal furca (fig. 47*f*) situated on median longitudinal axis of body approximately halfway between maxilliped bases and first thoracic legs. Tines chisel shaped, diverging slightly; furca attached to small, platelike projection.

For nature of legs and armature, see figure 48 and table 17.

Discussion.—The Hawaiian material differs from the original description of *Caligus bonito* Wilson, 1905b, in one major respect, the longer abdomen of *C. bonito*. In an examination of the type material of *C. bonito* (USNM 6035, 41975) considerable variation was noted in both the length and width of the abdomen. This variation appears to be due to the maturity of the specimens. The length of the region posterior to the swollen anterior portion of the abdomen of the Hawaiian specimens approximates the length of the region behind the slight constriction (joint between segments) of the abdomen of *C. bonito*. Based upon this, upon the absence of egg strings in the Hawaiian material (although formative strings are present in the

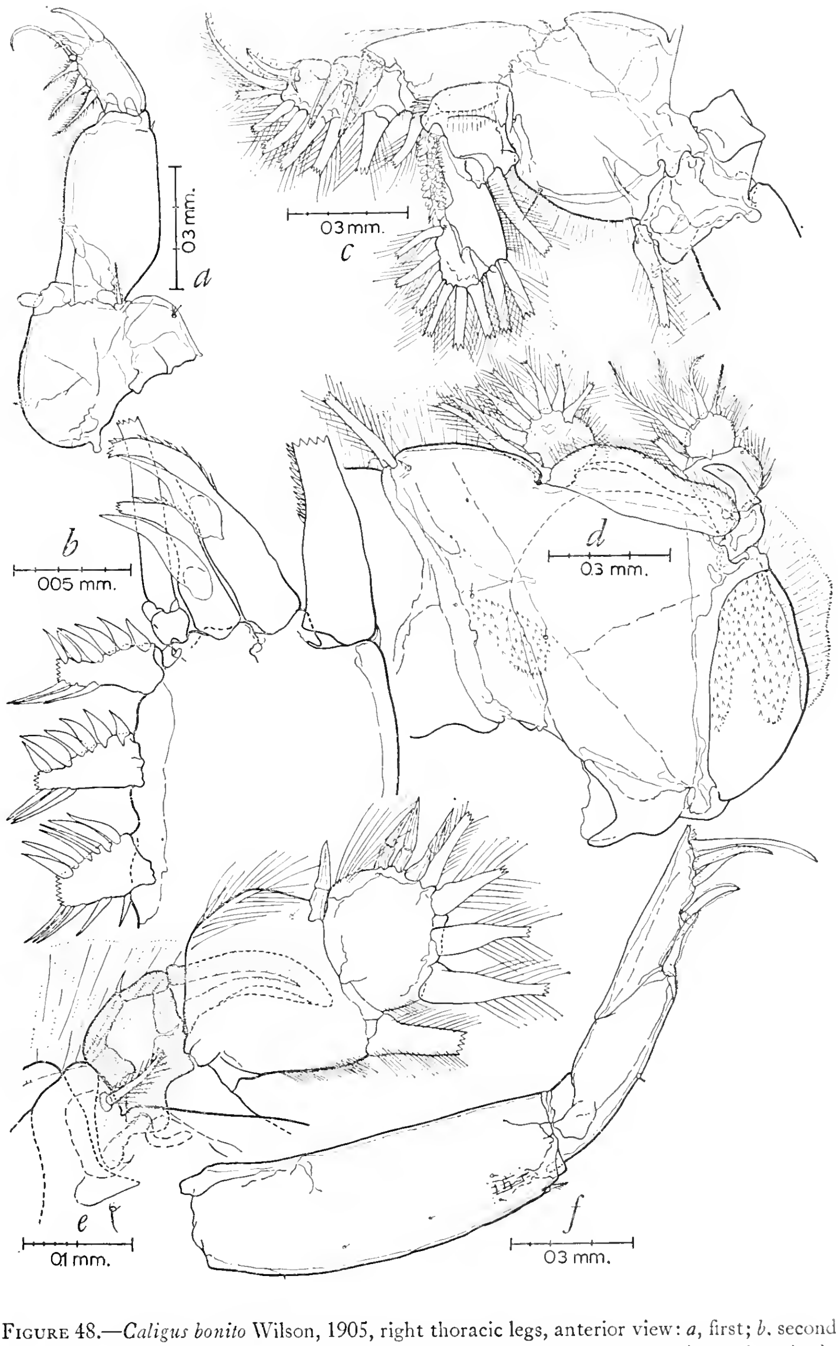


FIGURE 48.—*Caligus bonito* Wilson, 1905, right thoracic legs, anterior view: *a*, first; *b*, second segment of exopodite of first; *c*, second; *d*, third; *e*, exopodite of third (posterior view); *f*, fourth.

TABLE 17.—*Armature of thoracic legs I–IV of the female of* Caligus bonito *Wilson, 1905b*

Leg	Surface	Inter-podal Plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
I	Outer		s,p		rh	3dH,P′				
	Inner		p		c	3P				
II	Outer	m		m,p	m,fm,mH	mH	fmH,mH, Q,P	C	D	D,4P
	Inner		s,P	m,s	c,P	c,P	4P	P	c,2P	c,2P
III	Outer		d,m,p		s,H	c,s,p′	c,3p′,P	c	c	
	Inner	m	d,2s,P,s, m,s			c,P	c,3P	P	c,6P	
IV	Outer		5s,p		s,fm,mH	fm,mH,3fm, 3H				

genital segment), upon the change that occurs in the length of the abdomen in other species (e.g., *Caligus coryphaenae*), and upon Wilson's statement (1905b, p. 589) that "the joints [are] about equal in immature females" (the 2-segmented condition is not evident in the Hawaiian specimens), the present author feels that the difference in the length of the abdomen between the Hawaiian material and Wilson's original description of *C. bonito* is due to the immature condition of the Hawaiian specimens.

The differences between the Hawaiian specimens and *Caligus kuroshio* Shiino, 1959c, are primarily differences in the small armature elements of the appendages. The caudal rami of the Hawaiian specimens possess a small, nodular projection on the inner distal surface that bears a plumose setule while Shiino's figure does not show the nodule. Shiino indicates (table I) that there is a large, plumose seta on the second segment of the protopodite of the second thoracic leg which is not present in the Hawaiian specimens; however, he does not figure this armature element and its presence would make *C. kuroshio* unique. Shiino describes a 2-segmented condition for the exopodite of the third thoracic leg while the present author describes a 3-segmented condition for the Hawaiian specimens of *C. bonito*. Shiino's "first segment" is what the present author calls segments 1 and 2. The large, inwardly curved spine is at the distal end of the first segment (fig. 48*e*) while the plumose seta and naked setule (1h in Shiino's table I) are on the second segment. Shiino also uses the smaller size of his specimens to differentiate *C. kuroshio* from *C. bonito*. The size of Wilson's holotype female is 8.3 mm, the largest specimen in Shiino's 1959c description is 6.92 mm (range 5.39–6.92), Yamaguti (1936a, *C. bonito*) lists 4.5–5.6 mm, Brian (1935, *C. bonito*) lists 8mm, Brian (1924, *C. bonito*) lists 4,5,7 and 8 mm females, and a male at 5 mm, Shiino (1960b, *C. bonito*) gives the largest female at 6.7 mm, while the Hawaiian female specimens range from 6.2–6.5 mm.

REMARKS.—*Caligus quadratus, C. productus,* and *C. bonito* are difficult to separate not only because of the similarity in their morphology but also because they are found on the same species of hosts and not too infrequently they may be on the same host specimen. Although this leads to some speculation on the relationships of the three, there is some evidence to support the belief that they are distinct species. This evidence, or part of it, can be used to separate the species without going through a complete morphological analysis. Assuming that the general body shape and number of segments in the thoracic legs agrees with the figures (i.e., that the specimens belong to this species complex), *Caligus productus* can be separated by the absence of the 3 plumose setae normally present on the inner margin of the second segment of the exopodite of the first thoracic leg. Both *Caligus quadratus* and *C. bonito* possess these 3 setae, but *C. bonito* possesses a series of distinct denticulations on the outer margin of the first and second segments of the endopodite of the second thoracic leg. *Caligus quadratus,* on the other hand, possesses a patch of stiff plumosities in the same region. The difference between stiff plumosities and denticulations is not great but it is a distinct difference and sufficiently diagnostic to be used as a key characteristic.

Caligus asymmetricus, Kabata 1965b

FIGURES 49–51

Caligus thynni Pillai, 1963, p. 89, fig. 14.
Caligus asymmetricus Kabata, 1965b, p. 110, figs. 1B, D, E.
Caligus asymmetricus Pillai.—Kabata, 1965b, pp. 109, 110.

DISTRIBUTION AND HOST.—Trivandrum, South India, *Euthynnus affinis* (*in* Pillai, 1963); Queensland, Australia, *Euthynnus alleteratus* (*in* Kabata, 1956b).

REMARKS.—Dana (1853, p. 1353) described the caligid *Caligus thymni* "from the external surface of a Bonito (*Thymnus pelamys*) . . . ." Presumably the species was named after the host although the spelling of the generic part of the host name (*Thymnus*) has, to my knowledge, never been used in the taxonomy of the tunas, the name being *Thynnus.* The name *Caligus thymni* again appears (p. 219) in a handwritten "Catalogue of Crustacea of the U.S. Expl. Exped. during 1838–'42 . . . collected and described by James D. Dana. Geologist and Zoologist Exp.," dated 1856 by Dana and located in the U.S. National Museum. Yamaguti (1963, p. 61) uses "*C. thymni* [misprint for *thynni*] Dana, 1853 . . ." in his account. It is highly probable that *thymni* was not a misprint but a lapsus by Dana, based on his erroneous spelling, *Thymnus,* of the host

Thynnus. In either case, *Caligus thymnus* is an incorrect original spelling and must be emended to *Caligus thynni* Dana. *Caligus thynni* Pillai (1963), a distinct species from *Euthynnus affinis*, thereby becomes a junior homonym.

After the publication of *Caligus thynni* Pillai, the author of the name became aware of the problem of homonymy and submitted a manuscript ("Copepods parasitic on Indian marine fishes—a review") containing the replacement name *Caligus asymmetricus*. During this period, however, specimens of the species had also been found on a fish captured near Green Island, Queensland, Australia, and had been submitted to Z. Kabata for identification. After corresponding with Pillai and learning of the replacement name that was then in press, Kabata submitted a manuscript containing the replacement name as well as a description of the species. It is unfortunate that the manuscript containing Pillai's replacement name was not published prior to the publication of Kabata's manuscript. Since, however, Kabata (1965b) was the first to publish the replacement name, he, therefore, becomes the author of that name.

The present author deeply appreciates the helpful correspondence with Dr. Pillai and the discussion with Dr. Kabata concerning some of the above details.

MATERIAL.—One adult female and 3 males (USNM 112912) from the external surface of *Euthynnus yaito* (Jordan and Evermann) captured off Moku Manu Island, near Oahu, Hawaii. One adult female (USNM 112913) from the gill cavity of *Euthynnus yaito* (Jordan and Evermann) captured at French Frigate Shoals (USFWS, HMS cruise 39, station 32).

MEASUREMENTS.—(In mm) 2 females and 3 males:

	female	*male*
Total length, excluding caudal setae	3. 00, 3. 35	3. 15, 2. 80, 2. 55
Length of cephalothorax, including frontal region	1. 95, 2. 05	2. 03, 1. 88, 1. 68
Width of cephalothorax	1. 58, 1. 65	1. 55, 1. 53, 1. 30
Length of genital segment	0. 80, 0. 90	0. 60, 0. 55, 0. 50
Width of genital segment	0. 70, 0. 83	0. 53, 0. 55, 0. 48
Length of abdomen	0. 31, 0. 34	0. 41, 0. 37, 0. 33
Length of caudal rami	0. 11, 0. 11	0. 13, 0. 11, 0. 10
Length of egg strings (neither female ovigerous)		

DESCRIPTION.—Female cephalothorax (fig. 49*a*) ovoid, consisting of cephalon and first 4 thoracic segments. Frontal region approximately one-thirteenth the greatest length of cephalothorax, with fine membrane along anterior margin and pair of lunules overlapping division between frontal region and remaining cephalothorax ventrally. Lateral margin of cephalothorax slightly irregular, with fine membrane projecting laterally and second membrane projecting medially on ventral surface. Posterior lateral surface with small but

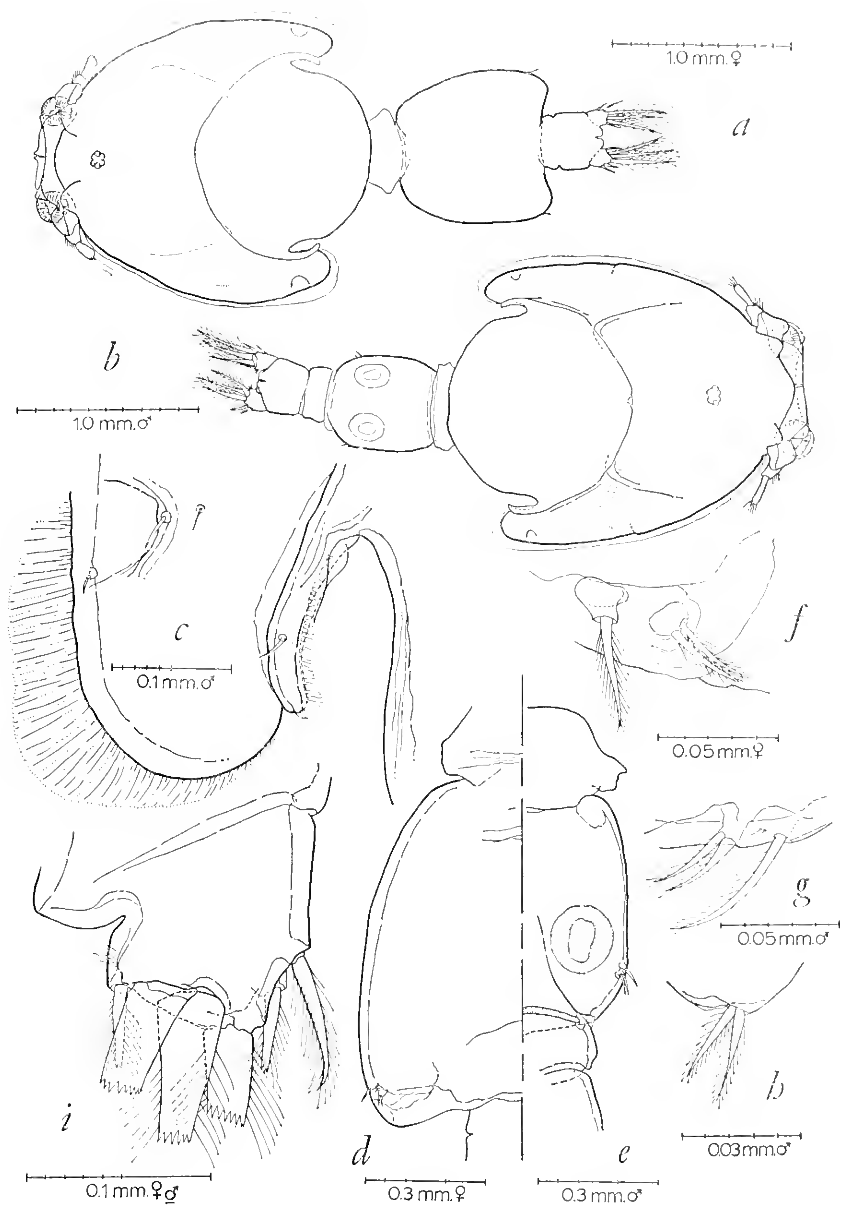


FIGURE 49.—*Caligus asymmetricus* Kabata, 1965b, dorsal view: *a*, female; *b*, male; *c*, posterior cephalothoracic sinus. Ventral view: *d*, female genital segment; *e*, male, same; *f*, female right fifth leg; *g*, male left fifth leg; *h*, male left sixth leg; *i*, caudal ramus.

distinct concavity. Posterior sinus (fig. 49*c*) narrow, bearing fine membrane along outer surface. Posterior median cephalothoracic region broadly convex, projecting posteriorly well past posterior lateral cephalothoracic region, overlapping anterior end of free fourth pedigerous segment. Major dorsal cephalothoracic grooves forming irregular H; dorsal surface with several spinules. Ocular region distinct, pigmented cups contiguous on median longitudinal axis in anterior third of cephalothorax.

Female free fourth pedigerous segment wedge shaped, irregular posteriorly, indistinctly separable from genital segment. Genital segment (fig. 49*d*) narrower anteriorly than posteriorly, lateral margins flatly convex, posterior flatly concave. Fifth legs (fig. 49*f*) situated on ventral-posterior lateral surface, consisting of pair of knobs, anteriormost with single plumose setule, posterior with 2 plumose setules.

Female abdomen indistinctly separable from genital segment, consisting of 1 or 2 segments. Indication of 2-segmented condition given by constriction anteriorly although indication superficial. Posterior two-thirds of abdomen subrectangular, posterior end tapered at junction with caudal rami, indented at anal opening. Caudal rami (fig. 49*i*) short, division between abdomen and rami incomplete. Lateral margins of rami essentially parallel, distal surface irregular, with 3 large plumose setae medially, 2 plumose setules on outer surface and 1 on inner surface; inner lateral margin of rami lightly plumose distally.

Male cephalothorax (fig. 49*b*) and free fourth pedigerous segment as in female although fourth pedigerous segment of figured male retracted under median posterior region of cephalothorax more than in female. Genital segment (fig. 49*e*) barrel shaped, distinct from both fourth pedigerous segment and abdomen. Fifth legs (fig. 49*g*) situated on posterior half of lateral surface, consisting of 3 plumose setules grouped as in female but without knobs. Sixth legs (fig. 49*h*) on slight ventral swelling posterior and medial to fifth legs, consisting of 2 plumose setules. Abdomen distinctly 2-segmented, first segment short, slightly more than half the length of second, second as in posterior two-thirds of female abdomen. Caudal rami as in female.

Female and male antennule (fig. 50*b*) 2-segmented, attached to lateral-anterior ventral surface of cephalothorax and lateral-posterior ventral surface of frontal region. First segment approximately 1½ times the length of second, broad medially, narrower proximally and distally, distal two-thirds of anterior and anterior ventral surface bearing approximately 26 lightly plumose setae and setules, including 1 long, anteriorly projecting seta. Second segment club shaped, bearing approximately 12 naked setae and setules distally, including 5 long setae (length slightly shorter than length of segment). Female antenna (fig. 50*c*) 3-segmented, situated posterior and medial to anten-

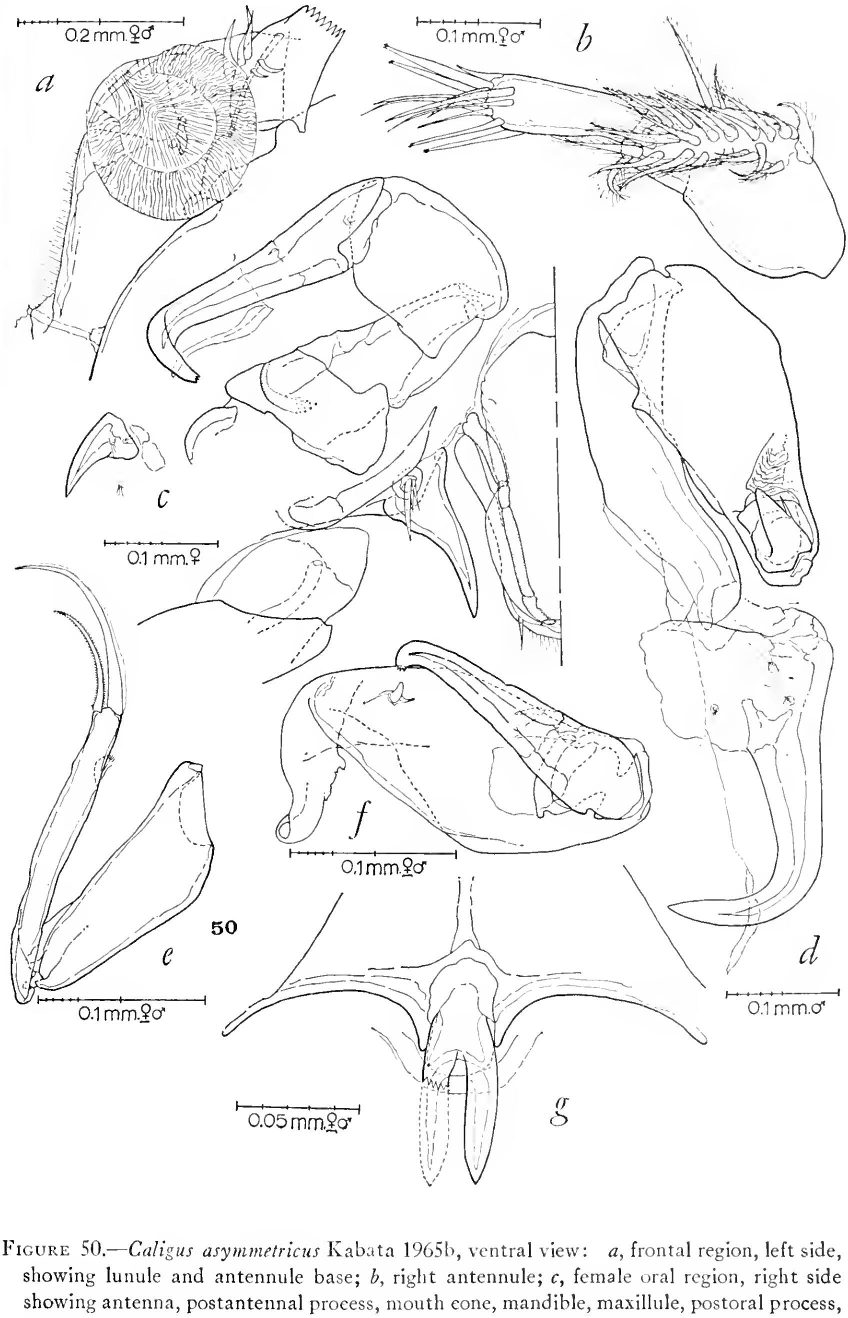


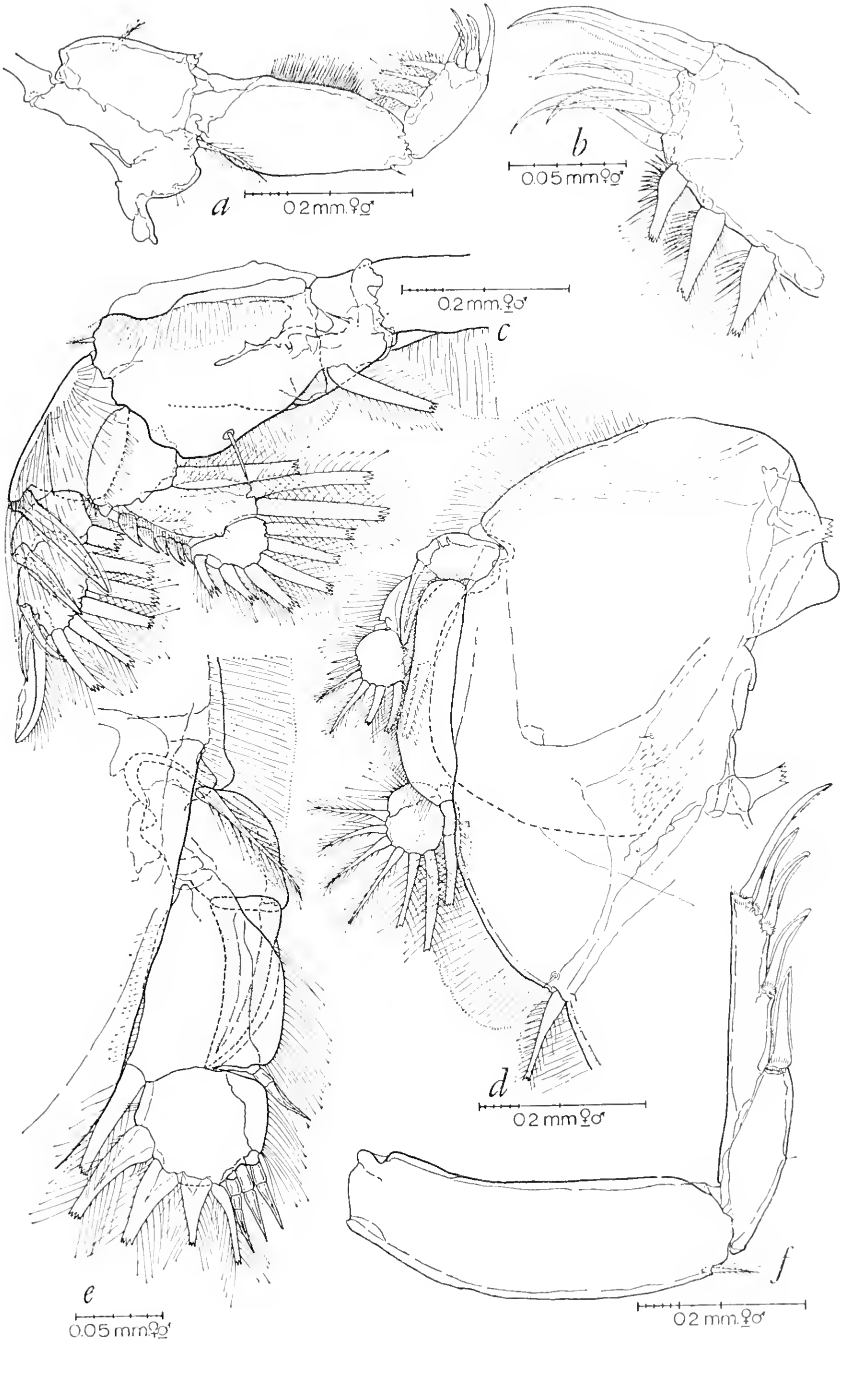
FIGURE 50.—*Caligus asymmetricus* Kabata 1965b, ventral view: *a*, frontal region, left side, showing lunule and antennule base; *b*, right antennule; *c*, female oral region, right side showing antenna, postantennal process, mouth cone, mandible, maxillule, postoral process, and maxilla base; *d*, male left antenna and postantennal process; *e*, left maxilla; *f*, right maxilliped, *g*, sternal furca.

nule base. First segment short, squat, heavily sclerotized, with very slight indication of posterior projection at base; second segment slightly more than two-thirds as wide as long, narrower distally than proximally. Third segment fused with clawlike terminal process, bearing small, lappet-like projection on proximal posterior surface and small spinule-like accessory process at distinct break in sclerotization in proximal half of fused segment and terminal process. Male antenna (fig. 50*d*) 3-segmented, first segment elongate, heavily sclerotized, irregular; second segment shorter than first, broad proximally, tapered to narrower distal end, with ridged, lappet-like adhesion pad on distal inner surface, just proximal to third segment articulation surface and apparently receiving terminal process of third segment when segment flexed. Third segment fused with short, clawlike terminal process, bearing setule-like accessory process on anterior surface.

Female and male mandible (fig. 50*c*) 4-parted, distalmost part flattened, curved inward, with 12 denticulations along inner surface. Female postantennal process (fig. 50*c*) situated lateral to antenna, consisting of short, clawlike projection and 3 nodules, 2 on base of claw, third posterior to claw, each with several hairlike processes. Male postantennal process (fig. 50*d*) immediately lateral to antennal base, clawlike process much longer than in female and strongly curved distally, nodes as in female. Female and male postoral process (fig. 50*c*) long, spinelike, curved outward distally. Female and male maxillule (fig. 50*c*) nodular, with 3 setules. Female and male maxilla (fig. 50*e*) 2-segmented, situated lateral and slightly posterior to postoral process. First segment slightly shorter than second, more strongly developed; second segment elongate, tapered proximally, with fine membrane along inner medial surface and 2 saber-shaped terminal processes. Innermost terminal process slighty less then 1½ times the length of outermost, with fine membrane along inner margin; outermost process with finely frilled membrane along both margins.

Female and male maxilliped (fig. 50*f*) 2-segmented, situated posterior and medial to maxilla base. First segment strongly developed, broad medially, tapering proximally and distally, proximal end strongly curved, heavily sclerotized; small, subconical projection present on inner medial surface. Second segment distinct from clawlike terminal process, with setule-like accessory process on distal inner surface. Female and male sternal furca (fig. 50*g*) situated on median longitudinal axis of body, posterior to maxilliped bases. Base of furca

FIGURE 51.—*Caligus asymmetricus* Kabata, 1965b, right thoracic legs, anterior view: *a*, first; *b*, second segment of exopodite of first; *c*, second; *d*, third; *e*, exopodite of third (posterior view); *f*, fourth.


a
0.2 mm. ♀♂
b
0.05 mm ♀♂
0.2 mm. ♀♂
c
d
0.2 mm ♀♂
f
0.2 mm. ♀♂
e
0.05 mm ♀♂

between 2 concave, lappet-like projections; tines sharply pointed, essentially parallel (right tine broken on figured female specimen, tines more irregular on second female specimen).

For nature of legs and armature, see figures 51*a–f* and table 18.

TABLE 18.—*Armature of thoracic legs I–IV of the female and male of* Caligus asymmetricus *Kabata, 1965b*

Leg	Surface	Inter-podal Plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
I	Outer		ss,p		rh	3fmH,P′				
	Inner		p		c,c	3P				
II	Outer	m		m,p	m,mH	mH	2mH,Q	C	D,c	c,3P
	Inner		s,P	m,s	c,P	c,P	5P	P	c,2P	3P
III	Outer	m	d,m,P		mH	c,p′	c,3p′,P	c	c,2P	
	Inner		d,2s,P,s, m,s			c,P	c,3P	P	4P	
IV	Outer		p		s,fm,mH	fm,mH, fm,mH, fm,H				

DISCUSSION.—The Hawaiian specimens differ from the original description of *Caligus asymmetricus* Kabata in several respects. The genital segment is more swollen, a characteristic that may be due to maturity. The tines of the sternal furca of the figured specimen are not quite as angular as those figured by Pillai (1963), although the tines on the other female are similar to Pillai's figure. The terminal processes of the exopodite of the first thoracic leg are structurally similar to those figured by Pillai but they are at the end of the segment, not subterminal as Pillai figures them. The denticulations on the outer margin of the second segment of the endopodite of the figured second thoracic legs differ in number (6 instead of 9) but not in character. There is, however, some variation in the number of denticulations in the Hawaiian material, even in the same specimen, the number ranging from 5–14 denticulations. Pillai (1963) based his description on 1 female specimen (nonovigerous?) from a specimen of *Euthynnus affinis* along with several specimens of *C. kuroshio* (=?*C. bonito* Wilson, 1905*b*), while the Hawaiian material came from a specimen of *Euthynnus yaito*.

Caligus pelamydis Krøyer

FIGURES 52, 53

Caligus pelamydis Krøyer, 1863, p. 124, pl. 4, fig. 4a–g.—Richiardi, 1880, p. 148.—Valle, 1882, p. 245.—Carus, 1885, p. 357.—Bassett-Smith, 1899, p. 452.—Brian, 1899b, p. 198.—Wilson, 1905b, p. 594, pl. 13, figs. 154–161; pl. 14, fig. 161a.—Brian, 1906, p. 43.—Brady, 1910, p. 589, fig. 69.—Stebbing, 1910,

p. 558.—Guiart, 1913, p. 7.—Scott and Scott, 1913, p. 57, pl. 7, figs. 2,3; pl. 9, figs. 1–5; pl. 71, fig. 14.—Scott, 1929, p. 89.—Wilson, 1932, p. 406, fig. 254.—Heegaard, 1943b, p. 5.—Causey, 1953a, p. 5; 1953b, p. 10; 1955, p. 4.—Nunes-Ruivo, 1956, p. 5, pl. 1, fig. a.—Barnard, 1955, p. 245.—Causey, 1960, p. 329.—Hewitt, 1963, p. 78, fig. 6.

Caligus scomberi Bassett-Smith, 1896b, p. 11, pl. 3, fig. 2; 1899, p. 450.

Caligus scombri Scott T., 1901, p. 148, pl. 5, fig. 9–10.—Scott A., 1906, p. 196, pl. 6.—Guiart, 1913, p. 6.

Distribution and hosts.—12 host records:

locality	*hosts*	*references*
North Atlantic	*Pelamys sarda*	Krøyer, 1863
	Scomber scombrus	Scott and Scott, 1913
East coast of North Atlantic	Unknown	Wilson, 1905b
South Atlantic	Unknown	Brady, 1910
		Stebbing, 1910
	Sarda sarda	Nunes-Ruivo, 1956
Gulf of Mexico	*Pogonias cromis*	
	Scomberomorus cavalla	Causey, 1953a
	Sarda sarda	Causey, 1953b
New Zealand	*Thyrsites atun*	Hewitt, 1963
Mediterranean	*Scomber scomber*	
	Pelamys sarda	Richiardi, 1880
	Unknown	Guiart, 1913

Material.—One female (USNM 112914) from the gill cavity of *Euthynnus yaito* (Jordan and Evermann) captured at French Frigate Shoals (USFWS, HMS cruise 39, station 32).

Measurements.—(In mm) 1 female:

Total length, excluding caudal setae	4. 05
Length of cephalothorax, including frontal region	1. 38
Width of cephalothorax	1. 20
Length of genital segment	1. 18
Width of genital segment	1. 10
Length of abdomen	1. 45
Length of caudal rami	0. 17
Length of egg strings (female nonovigerous)	

Description of female.—Cephalothorax (fig. 52*a*) ovoid, consisting of cephalon and first 4 thoracic segments. Frontal region narrow, middle of anterior surface distinctly indented, margin with fine membrane. Lunules (fig. 52*f*) large but filmy, extending posteriorly, on ventral surface, past junction of frontal region and remaining cephalothorax. Lateral margin of cephalothorax slightly irregular, bearing fine membrane extending laterally and second extending medially on ventral surface. Posterior lateral cephalothoracic surface with small concavity. Posterior sinus (fig. 52*b*) narrow, constricted at opening, with fine membrane along outer surface. Posterior median cephalothoracic surface extending past lateral surface, posterior end overlapping junction of cephalothorax and free fourth pedigerous segment, margin flatly convex. Major dorsal cephalothoracic grooves forming irregular H, posterior longitudinal legs and crosssbar continuous, heavily sclerotized. Ocular region distinct.

Free fourth pedigerous segment short, distinct from cephalothorax, incompletely separable from genital segment; segment sharply angled posteriorly and anteriorly, from region of fourth leg attachment. Genital segment (fig. 52*c*) broad for most of length, anterior end concavely angled inward, posterior end with pair of broad lappets dorsolaterally, lappets extending posteriorly past junction of genital segment and abdomen. Fifth legs (fig. 52*d*) consisting of single, plumose setule arising from ventral lateral surface at anterior end of lappets. Spermatophores visible on single Hawaiian specimen, attached immediately ventral to junction of genital segment and lateral surface of abdomen.

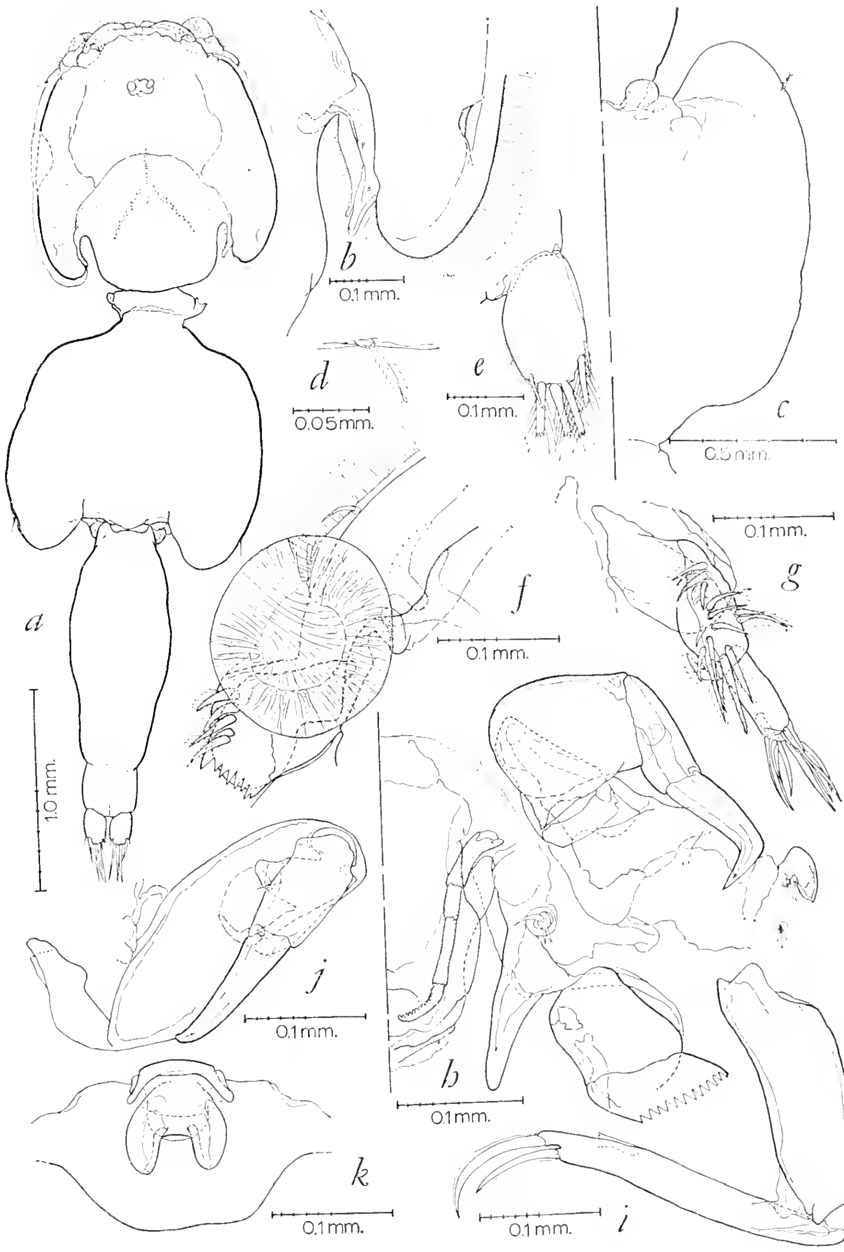
Abdomen indistinctly 2-segmented, junction with genital segment distinct. First segment approximately five times the length of second, broadest in anterior medial portion, irregularly curved to anterior and posterior ends; second segment with flatly convex lateral margins, anal indentation slight. Caudal rami (fig. 52*e*) approximately 1½ times as long as wide, distal half of inner surface plumose; three plumose setae present on distal surface, single plumose seta on outer distal surface and 1 plumose setule on either side of setae.

Antennule (fig. 52*g*) 2-segmented, attached to lateral-anterior ventral surface of cephalothorax. First segment slightly less than twice the length of second, broader proximally than distally; ventrally curved distal half of anterior surface with approximately 18 plumose setules. Second segment rodlike, distal end with approximately 12 naked setules. Antenna (fig. 52*h*) 3-segmented, attached medial and posterior to antennule base. First segment squat, irregular, heavily sclerotized; second segment tapered slightly from broad proximal to slightly narrower distal end, proximal outer surface with small, subtriangular projection. Third segment and clawlike terminal process indistinctly separable, segment elongate, with small, lappet-like projection from posterior medial surface.

Mandible (fig. 52*h*) 4-parted, rodlike, distalmost part curved inward, with 12 denticulations on inner surface. Postantennal process

---

FIGURE 52.—*Caligus pelamydis* Krøyer, 1863, female: *a*, dorsal view (broken line=nick in specimen). Ventral view: *b*, posterior cephalothoracic sinus; *c*, genital segment (anterior end directed downward); *d*, fifth leg; *e*, caudal ramus; *f*, right side of frontal region showing lunule and antennule base; *g*, right antennule; *h*, oral region, left side showing antenna, postantennal process, mouth cone, mandible, maxillule, postoral process, and maxilla base; *i*, left maxilla; *j*, left maxilliped; *k*, sternal furca.


a
1.0 mm.
b
0.1 mm.
c
0.5 mm.
d
0.05 mm.
e
0.1 mm.
f
0.1 mm.
g
0.1 mm.
h
0.1 mm.
i
0.1 mm.
j
0.1 mm.
k
0.1 mm.

(fig. 52*h*) situated lateral and slightly posterior to antenna base, consisting of short, heavily sclerotized, dagger-shaped projection and 3 nodules, 2 at base of projection, third slightly posterior, each with several hairlike processes. Postoral process (fig. 52*h*) large, heavily sclerotized, spinelike. Maxillule (fig. 52*h*) nodular, situated adjacent to inner proximal surface of postoral process, with 3 setules distally. Maxilla (fig. 32*i*) 2-segmented, situated slightly lateral and posterior to postoral process. First segment approximately four-fifths the length of second, second elongate, with narrow, frilled membrane on medial inner surface, with 2 saber-shaped terminal processes. Innermost terminal process approximately 1½ times the length of outermost, both with fine membranes along inner and outer margins.

Maxilliped (fig. 52*j*) 2-segmented, situated medial and posterior to maxilla base. First segment strongly developed, with narrow, heavily sclerotized, strongly curved proximal articulation and muscle attachment surface. Second segment indistinctly separable from clawlike terminal process, with single, small, setule-like accessory process from distal inner surface. Sternal furca (fig. 52*k*) situated between and slightly posterior to maxilliped bases, tines broad, parallel, terminating in rounded surface. Furca associated with platelike area of heavy sclerotization extending posteriorly almost to interpodal plate of first thoracic legs and extending laterally past line running along longitudinal axis of body, through region of attachment of maxilliped bases.

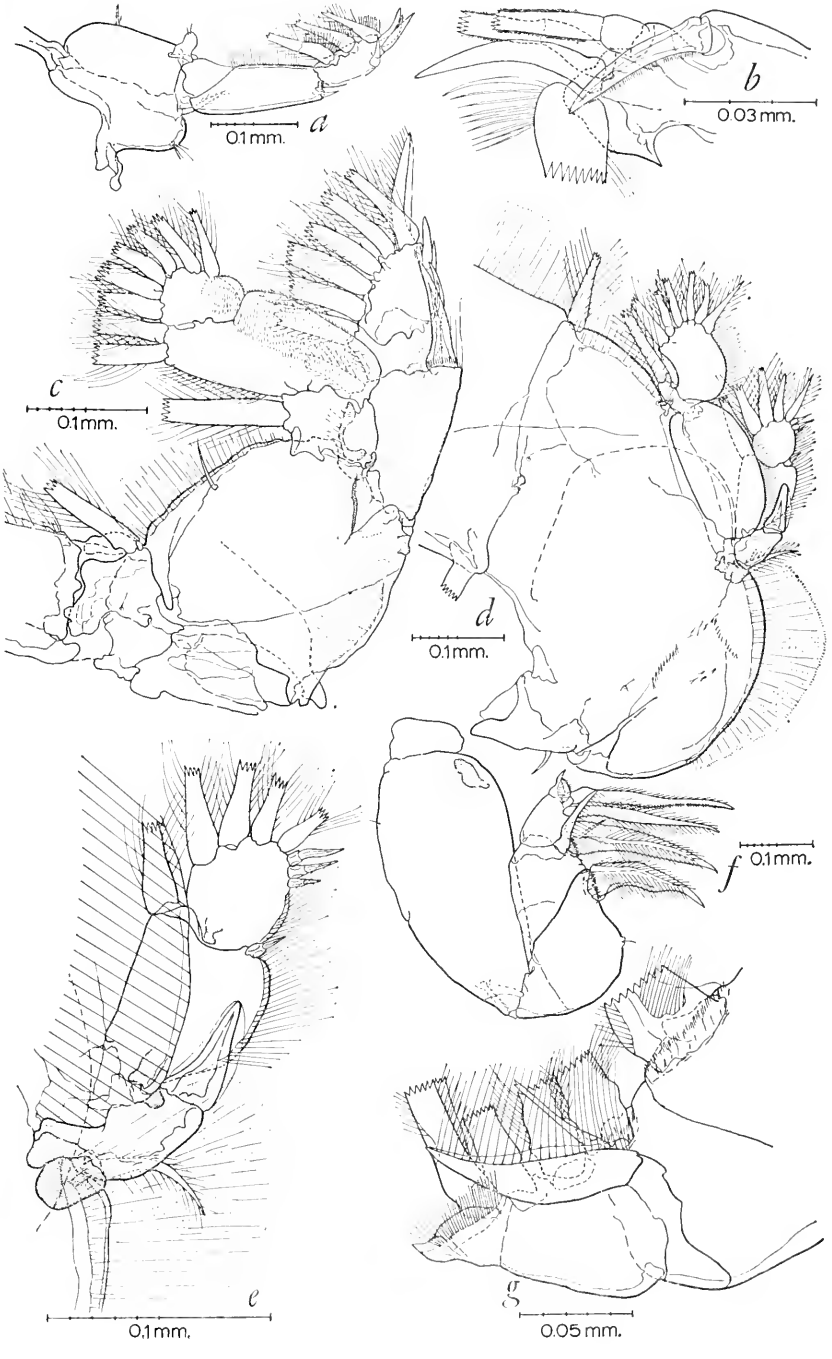
Fourth thoracic leg uniramous, poorly developed, similar, in segment constitution, to that of caligids in last chalimus stages. For nature of legs and armature, see figure 53 and table 19.

TABLE 19.—*Armature of thoracic legs I–IV of the female of* Caligus pelamydis *Krøyer, 1863*

Leg	Surface	Inter-podal Plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
I	Outer		sss,p		h	4H		s		
	Inner		p		c	3P		s		
II	Outer	m		m	m,fm,H	H	H,mH,Q		C	C,3P
	Inner		s,P	m,s	c,P	c,P	5P	P	c,2P	3P
III	Outer	m	m,d,p		H	c,p′	c,3p′,P	c	c,2P	
	Inner		2s,P,s,m,s			P	3P	P	4P	
IV*	Outer		2s,p		s,fm,pH	fm,2pH,p′, 3pH,fm				

*Segmentation of this leg in doubt: protopodite and first segment of exopodite recognizable, others questionable.

FIGURE 53.—*Caligus pelamydis* Krøyer, 1863, female, right thoracic legs, anterior view: *a*, first; *b*, distal end of second segment of exopodite of first; *c*, second; *d*, third; *e*, exopodite of third; *f*, fourth; *g*, exopodite of fourth.


a
0.1 mm.
b
0.03 mm.
c
0.1 mm.
d
0.1 mm.
e
0.1 mm.
f
0.1 mm.
g
0.05 mm.

DISCUSSION.—Wilson (1905b) suggests that *Caligus pelamydis* Krøyer, and *C. scomberi* Bassett-Smith are synonymous but they were not synonymyzed until 1913 (Scott and Scott). Guiart (1913), however, feels that there is some evidence for maintaining both species. In comparing the two, he states: "Cette espèce [*C. pelamydis*] est beaucoup plus volumineuse que la précédente [*C. scombri*, T. Scott's (1901) modification of Bassett-Smith's *C. scomberi*], le segment génital beancoup (sic) plus long et l'abdomen nettement forme de deux segments. Beaucoup d'autres caractères s'opposent du reste à la fusion de cette espèce avec la précédente, comme le voulait Wilson (8, p. 596)." Scott and Scott (1913, p. 59), however, state: "We think there can be no reasonable doubt that the form obtained by Krøyer on *Pelamys sarda*, and described by him in the work referred to under the name of *Caligus pelamydis*, is identical with that from the mackerel [*C. scombri*]; the general structure of the animal, the shape of the sternal fork and of the genital segment, and the structure and armature of the fourth pair of thoracic legs, are similar in both forms." A comparison of specimens of these species in the U.S. National Museum suggests, to the present author, that the two are synonymous.

Caligus pelamydis is most readily distinguished by the nature of the fourth thoracic leg. The shape of the female genital segment is variable. In some of the specimens in the U.S. National Museum (USNM 74284 and 74358) the lobate condition of the posterior end of the genital segment is present, as shown in figures 52*a*,*c*, while in others the lobes are reduced or absent.

The fourth thoracic leg is complex, the armature elements are poorly defined, and, in most cases, lightly sclerotized. The figure given by Wilson (1905b, pl. 13: fig. 161) does not show the frilled membranes adjacent to the bases of at least the first 2 spines and does not show the fine accessory projection at base of the second spine that was evident in a stained mount of the leg made from a specimen in the USNM collection.

Caligus kanagurta Pillai, 1961, exhibits a very close similarity to *C. pelamydis*. The fourth thoracic leg, however, is figured as having three small, plumose spines on the distal segment which are not present in *C. pelamydis*.

Caligus longipedis Bassett-Simth

FIGURES 54–56

Caligus longipedis Bassett-Smith, 1898b, p. 359, pl. 10, figs. 2–3.—Yamaguti, 1963, p. 56.

Caligus longipes Bassett-Smith, 1899, p. 452.—Wilson, 1905b, p. 556 (in key).

Caligus amplifurcus Pearse, 1952b, p. 199, figs. 29–35.—Shiino, 1959d, p. 280, figs. 7–8.—Yamaguti, 1963, p. 49.
Caligus amplifurcatus Pearse, 1952b, p. 200 (figure title) (lapsus).
Caligus lucidus Heegaard, 1962, p. 158, figs. 54–61.

DISTRIBUTION AND HOSTS.—4 host records:

locality	*hosts*	*references*
Gulf of Aden	*Caranx melamphigus*	Bassett-Smith, 1898b
Australia	*Cantherhines ayraud*	Heegaard, 1962
Eastern Pacific	*Caranx lugubrius*	Shiino, 1959
Gulf of Mexico	*Caranx crysos*	Pearse, 1952b

MATERIAL.—Twenty-six females and 3 males (USNM 112915) from the external surface of *Caranx melampygus* Cuvier and Valenciennes, captured in fishtrap by Samuel Kaolulo between Diamond Head and Koko Head, Oahu, Hawaii. One female (USNM 112916) from the external surface of *C. melampygus* Cuvier and Valenciennes, captured in fishtrap by Samuel Kaolulo between Diamond Head and Koko Head, Oahu, Hawaii. Four females (one damaged) and 1 male (retained by author) from the external surface of *C. melampygus* Cuvier and Valenciennes, captured in fishtrap by Samuel Kaolulo between Diamond Head and Koko Head, Oahu, Hawaii.

MEASUREMENTS.—(In mm) 28 females and 4 males:

	female		*male*	
	mean	*range*	*mean*	*range*
Total length, excluding caudal setae	5. 06	4. 58–5. 48	5. 24	5. 03–5. 48
Length of cephalothorax, including frontal region	3. 16	2. 89–3. 33	3. 47	3. 07–3. 74
Width of cephalothorax	2. 94	2. 63–3. 11	3. 32	3. 15–3. 52
Length of genital segment	1. 12	0. 94–1. 35	0. 78	0. 76–0. 83
Width of genital segment	1. 29	1. 00–1. 52	0. 83	0. 81–0. 89
Length of abdomen	0. 56	0. 49–0. 67	0. 60	0. 56–0. 63
Length of caudal rami	0. 29	0. 27–0. 33	0. 39	0. 38–0. 41
Length of egg strings (10 strings)	3. 24	2. 22–3. 96		

DESCRIPTION.—Female cephalothorax (fig. 54*b*) ovoid, consisting of cephalon and first 4 thoracic segments. Greatest length of frontal region approximately one-tenth that of entire cephalothorax, with fine membrane along anterior margin, bearing pair of ovoid lunules (fig. 55*a*) extending posteriorly, on ventral surface, to junction of frontal region and rest of cephalothorax. Lateral margin of cephalothorax slightly irregular, with narrow membrane extending laterally and second membrane extending medially, on ventral surface. Posterior-lateral dorsal surface of cephalothorax with small, posteriorly facing depression. Posterior sinus (fig. 54*c*) irregularly U-shaped, with thickened membrane-like projection along outer margin. Posterior median cephalothoracic surface projecting well past lateral surfaces, posterior end of surface with short, lappet-like projections laterally. Major dorsal cephalothoracic grooves incomplete, partially replaced by heavily sclerotized bands forming irregular H. Ocular region distinct, in anterior third of body.

Female free fourth pedigerous segment distinct from cephalothorax, incompletely separable from genital segment dorsally and ventrally,

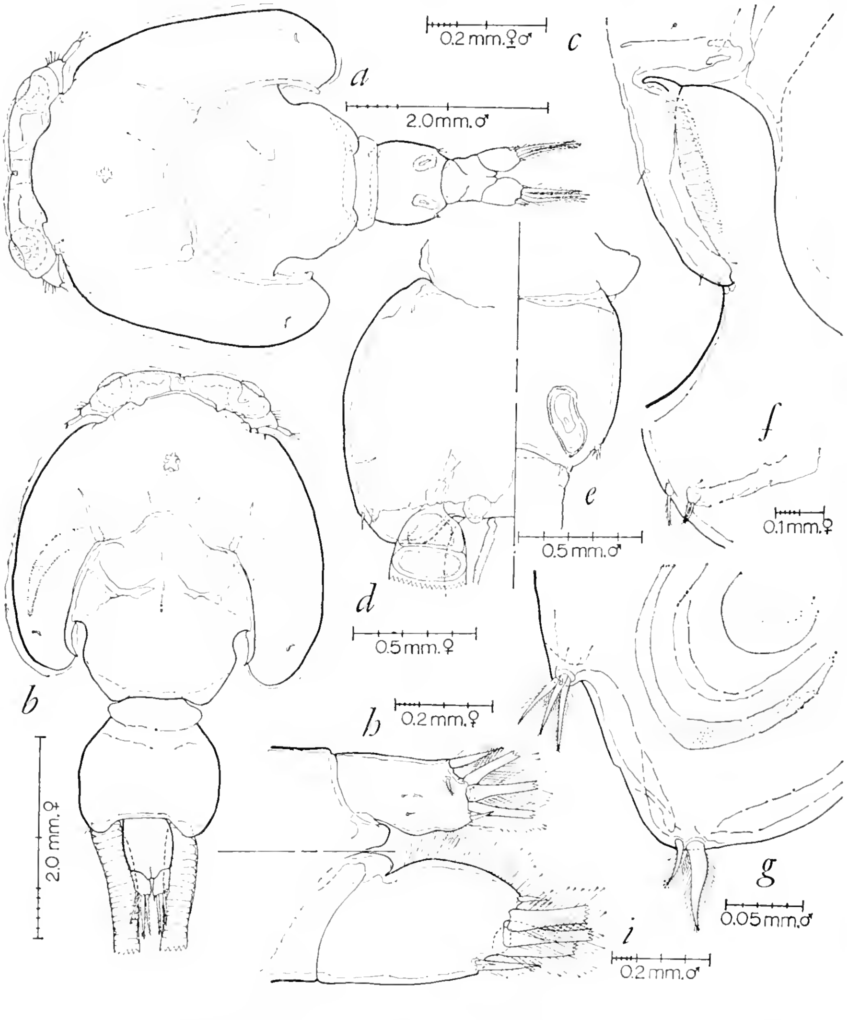


FIGURE 54.—*Caligus longipedis* Bassett-Smith, 1898, dorsal view: *a*, male; *b*, female; *c*; posterior cephalothoracic sinus. Ventral view: *d*, female genital segment; *e*, male, same, *f*, female fifth leg; *g*, male fifth and sixth legs; *h*, female caudal ramus; *i*, male, same.

overlapped anteriorly by lappet-like projections of posterior median cephalothoracic surface. Segment widest medially, angled toward anterior end, convexly curved posteriorly. Genital segment (fig. 54*d*) obcordate. Fifth legs (fig. 54*f*) situated on posterior lateral surface, consisting of 2 nodules, anteriormost with single plumose setule, posterior with 2 plumose setules. Abdomen 1-segmented, broadest anteriorly, constricted at anterior end, tapered to biconcave posterior end. Caudal rami (fig. 54*h*) subrectangular, with slight concavity on medial inner surface, inner surface plumose. Distal end of rami with 3 long, plumose setae medially, additional seta on outer distal surface, plumose setule on inner surface and second on ventral surface just proximal and medial to outermost seta.

Male cephalothorax (fig. 54*a*) similar to that of female, free fourth pedigerous segment slightly shorter, distinct from both cephalothorax and genital segment, with flat or slightly concave dorsal posterior margin instead of convex margin of female. Genital segment (fig. 54*e*) of general barrel shape, lateral surface indented posteriorly, at origin of fifth legs. Fifth legs (fig. 54*g*) consisting of nodule bearing 3 plumose setules; sixth legs (fig. 54*g*) situated on posterior-lateral ventral surface, consisting of 2 closely associated plumose setules. Abdomen 1-segmented although incomplete V-shaped band of heavy sclerotization in anterior portion giving 2-segmented appearance. Posterior region of abdomen widest, posterior surface biconcave, with distinct anal depression. Caudal rami (fig. 54*i*) larger than those of female, inner surface convex, plumose in distal half, remaining armature as in female.

Female and male antennule (fig. 55*b*) 2-segmented, attached to knoblike extension of ventral-lateral anterior surface of cephalothorax, not appearing to be attached to frontal region. First segment slightly more than twice the length of second (male second segment slightly longer), anterior margin bent almost at right angle medially, anterior and anterior ventral surface of distal half of segment bearing approximately 21 lightly plumose setae and setules. Second segment club shaped, distal end with approximately 12 naked setules. Female antenna (fig. 55*c*) 3-segmented, situated medial and posterior to antennule base. First segment short, squat, irregular, with spike-like projection from posterior distal surface. Second segment strongly developed, broad proximally, tapered to narrower distal end. Third segment fused with clawlike terminal process, bearing setule-like accessory process from proximal inner surface, second from anterior surface. Male antenna (fig. 55*d*) 3-segmented, first segment irregular, second irregularly club shaped, with indistinct adhesion surface on medial inner surface, with distinct swelling just distal to adhesion surface, swelling bearing well-defined adhesion surface. Third segment abrupt, terminal process fan shaped, with setule-like accessory process on distal inner surface.

Female and male mandible (fig. 55*c*) 4-parted, distalmost part curved inward, bearing 12 denticulations along inner surface. Female postantennal process (fig. 55*c*) situated lateral to antenna base, consisting of elongate, spine-shaped projection and 3 nodules, 2 on base of projection, third slightly posterior to base, each with several hairlike projections. Male postantennal process similar to that of female except spine-shaped projection longer. Female and male postoral process (fig. 55*c*) spine shaped, proximal end broad, medial region narrow, distal region expanded, flattened. Female and male maxillule (fig. 55*c*) consisting of pseudosegmented node bearing 3 setules distally. Female and male maxilla (figs. 55*e, f*) 2-segmented, situated slightly lateral and posterior to postoral process. Second segment approximately 1¼ times the length of first, both segments elongate, second thinner than first, distal end of outer surface knoblike, distal half of outer surface finely denticulated. Second segment bearing membranous conical process distally and 2 saber-shaped terminal processes, innermost slightly less than twice the length of outermost, with fine membrane along both margins; outermost terminal process with finely frilled membrane along both margins.

Female maxilliped (fig. 55*g*) 2-segmented, small in comparison with that of other members of the genus, situated medial and posterior to maxilla base. First segment well developed although of general elongate nature, tapered proximally to narrow proximal end. Second segment slender, approximately four-tenths the length of first, distinct from short, clawlike terminal process, bearing setule-like accessory process from distal inner surface (not figured) and small, hairlike process from nodule on distal posterior surface. Male maxilliped (fig. 55*h*) slightly larger than that of female, first segment more strongly developed, with 2 ridge-shaped projections on inner surface, distalmost with small secondary ridge bearing adhesion surface. Second segment and processes as in female. Female and male sternal furca (fig. 55*i*) situated between and posterior to maxilliped bases. Furcal base elongate, tines angled outward slightly, with broad surface, bluntly rounded distally.

Inner 2 terminal spines of second segment of exopodite of first thoracic leg bifid, both parts of equal length. For armature and nature of thoracic legs, see figure 56 and table 20.

Discussion.—One of the distinguishing characteristics of *C. longipedis* is the nature of the second segment of the maxilla, with its broad distal end, denticulated margin, and membranous, spine-shaped subterminal process. Additionally, the broad tines of the sternal furca and the long processes on the exopodite of the fourth thoracic leg are diagnostic characteristics. Although Bassett-Smith's original description (1898b) and figures leave much to be desired, these characteristics, as well as the body shape, are evident. An examination of the type material of *C. amplifurcus* Pearse (USNM 93710)

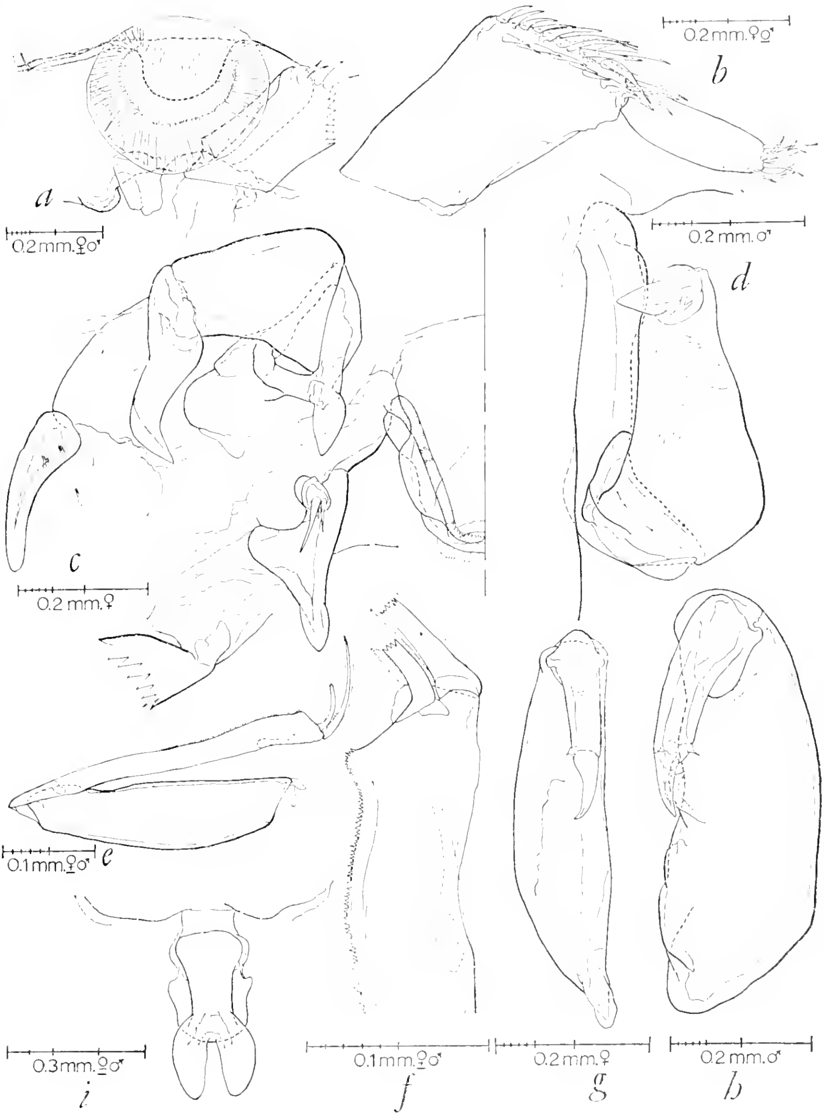


FIGURE 55.—*Caligus longipedis* Bassett-Smith, 1898, ventral view: *a*, frontal region, left side showing lunule and antennule base; *b*, left antennule; *c*, female oral region, right side showing antenna, postantennal process, mouth cone, mandible, maxillule, postoral process, and maxilla base; *d*, male right antenna; *e*, left maxilla; *f*, distal half of second segment of left maxilla; *g*, female right maxilliped; *h*, male, same; *i*, sternal furca.

TABLE 20.—*Armature of thoracic legs I–IV of the female and male of* Caligus longipedis *Bassett-Smith, 1898b*

Leg	Surface	Inter-podal Plate	Protopodite 1	Protopodite 2	Exopodite 1	Exopodite 2	Exopodite 3	Endopodite 1	Endopodite 2	Endopodite 3
I	Outer		s,p		rh	3H,P′				
	Inner		p		c,c	3P				
II	Outer	m		m,p*	m,fm,mH	mH	mh,mH,Q	c	c	c,2P
	Inner		s,P	m,s	c,P	c,P	5P	P	c,2P	4P
III	Outer	m	2s,m,p		m,s,H	c,2s,p′	c,3p′	c	c	
	Inner		2s,P,s,m,s			P	4P	P	6P	
IV	Outer		ss,s,P		dm,H	3dm,2H, mH				

*Plumosities not visible but minute fragments of dirt clustered around setule suggest fine plumosities are present.

showed the presence of these features as well as other characteristics of *C. longipedis*. In Pearse's original description (1952b), however, the figures do not indicate the relationship. The shape of the genital segment in the figure of the female, the presence of 2 segments in the abdomen of the figure of the male, and the "appendage on basal segment of second leg" (Pearse, 1952b, fig. 31) all suggest a species distinct from *C. longipedis*. Pearse, however, apparently made his description and figures from permanent whole mounts. The absence of spacers between the slide and the coverslip has distorted the shape of the body and, in one specimen at least, changed the shape of the appendages. The so-called appendage on the basal segment of the second leg could not be definitely found although, presumably in the original mounting of the specimens, the proximal end of one of the sclerites on the surface of the second segment of the female second thoracic leg has torn free. This sclerite projects anteriorly and medially, giving an appearance similar to that shown in Pearse's figure 31 and the appearance that it arises from the first segment of the protopodite.

Although the author has not examined specimens of *Caligus lucidus* Heegaard, 1962, the suggested nature of the maxilla (Heegaard's "first maxilliped," no figure number given but identified as MxP_1 in figure series 54–61), the nature of the armature on the fourth thoracic leg (fig. 58; although the segmentation is not shown), and the shape of the body of the female all indicate that the species is synonymous with *C. longipedis*.

The description by Shiino, 1959d, of *C. amplifurcus* Pearse differs in few details from that given here. The one important difference is that Shiino indicates the presence of 2 segments in the exopodite of the third thoracic leg while the present author indicates that this ramus is 3-segmented. As in *C. quadratus*, however, Shiino

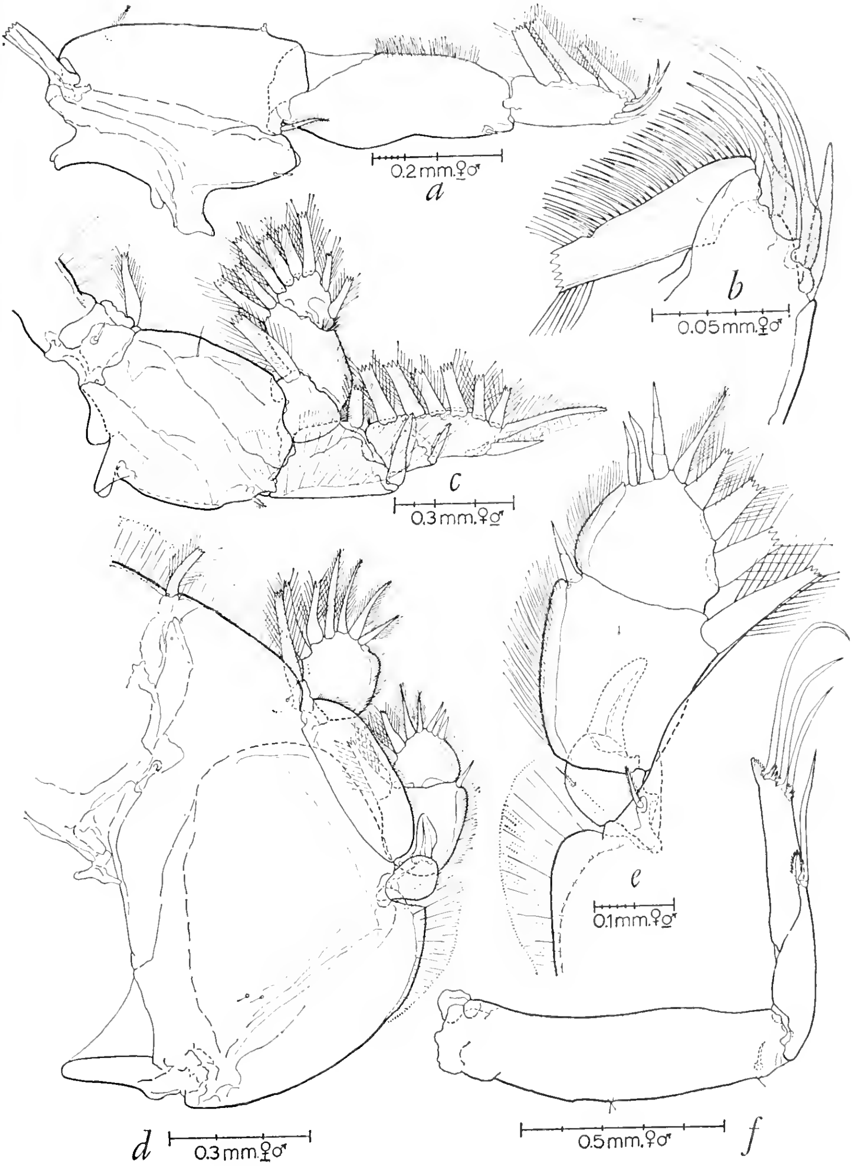


FIGURE 56.—*Caligus longipedis* Bassett-Smith, 1898, right thoracic legs, anterior view: *a*, first; *b*, distal region of second segment of exopodite of first; *c*, second; *d*, third; *e*, exopodite of third (posterior view); *f*, fourth.

indicates that the first segment includes not only the segment bearing the hook-shaped spine but also the succeeding segment and it is here suggested (fig. 56*e*) that these are 2 distinct segments.

The distribution of *C. longipedis* is intriguing. Originally described from near Aden, it has since been described from Australia, the Revillagigedos, the Gulf of Mexico, and now Hawaii. Peculiarly enough, there has, to the author's knowledge, never been a specimen described from either India or Ceylon. Many of the collections of parasitic copepods made from the latter, however, were from market fish, and in a good many cases these collections were from the gill cavities and buccal cavity of the hosts. The only reports giving parasite location of *C. longipedis* indicate that it is found on the external surface of the host. In collections from Hawaiian fishes it was noted that specimens of this species move rapidly and have a tendency to crawl off the surface of the host when it starts to dry.

C. rugosus Shiino, 1959d, exhibits characteristics which closely ally it with *C. longipedis* (maxilla, thoracic legs). The exact relationship, however, can not be presently determined.

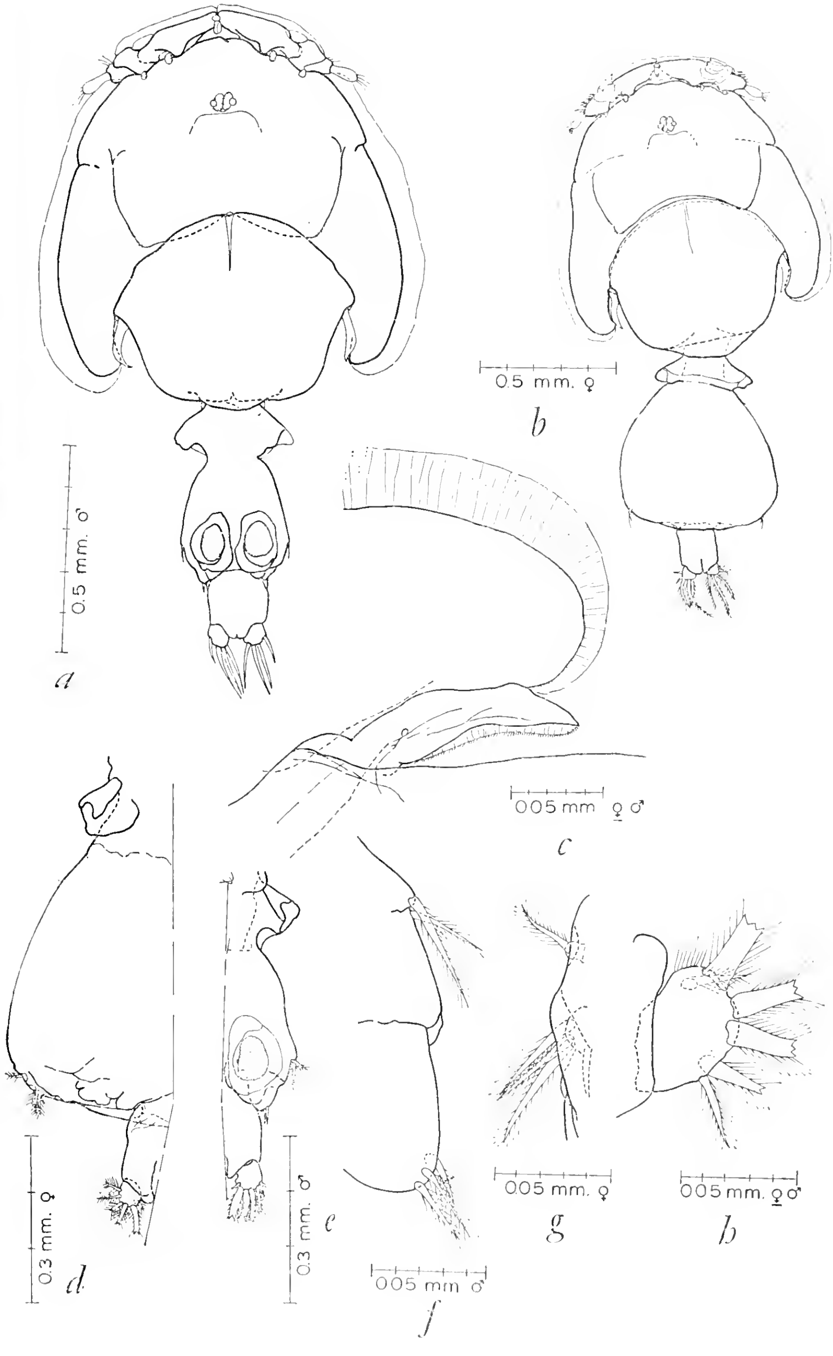
Caligus kapuhili, new species

FIGURES 57–59

MATERIAL.—One female (holotype, USNM 112918) from the gill cavity of *Chaetodon miliaris* Quoy and Gaimard, captured in a fishtrap by Lester Zukeran in Kaneohe Bay, Oahu, Hawaii. One male (allotype, USNM 112919) from the holotype host specimen. One female and 1 male (paratypes, USNM 112920) from the gill cavity of *C. miliaris* Q. and G., captured in a fishtrap by Lester Zukeran in Kaneohe Bay, Oahu, Hawaii. Two females and 1 male (paratypes, USNM 112921) from the gill cavity of an unknown chaetodontid captured in the Oahu area, Hawaii. One female (paratype, USNM 112922) from the gill cavity of *Chaetodon fremblii* Bennett, speared by Carolyn Lewis off Rabbit Island, Oahu, Hawaii. One female (paratype, USNM 112923) from the gill cavity of *C. miliaris* Q. and G. from the Honolulu Aquarium. One female (paratype, USNM 112924) from the gill cavity of *C. miliaris* Q. and G., captured in a fishtrap by Lester Zukeran in Kaneohe Bay, Oahu, Hawaii. One female (paratype, USNM 112925) from the gill cavity of *C. miliaris* Q. and G., captured in a fishtrap by Lester Zukeran in Kanohe Bay, Oahu, Hawaii. Five females and 2 males (one immature) (paratypes,

---

FIGURE 57.—*Caligus kapuhili*, new species, dorsal view: *a*, male; *b*, female; *c*, posterior cephalothoracic sinus. Ventral view: *d*, female free fourth pedigerous segment, genital segment, abdomen, and caudal ramus; *e*, male, same; *f*, male fifth and sixth legs; *g*, female fifth leg; *h*, caudal ramus


0.5 mm. ♂
a
0.5 mm. ♀
b
0.05 mm ♀♂
c
0.3 mm. ♀
d
0.3 mm. ♂
e
0.05 mm ♂
f
0.05 mm. ♀
g
0.05 mm. ♀♂
h

USNM 112926) from the gill cavity of several specimens of *C. fremblii* Bennett, captured in fishtraps by Samuel Kaolulo between Diamond Head and Koko Head, Oahu, Hawaii. One female and 1 male (male damaged) (paratypes, retained by author) from the gill cavity of *C. fremblii* Bennett, speared by Carolyn Lewis off Rabbit Island, Oahu, Hawaii. Two females (1 damaged) (paratypes, retained by author) from the gill cavity of *C. miliaris* Q. and G., captured in a fishtrap by Lester Zukeran in Kaneohe Bay, Oahu, Hawaii. Four females and 2 males (1 male damaged) (paratypes, retained by author) from the gill cavity of 4 specimens of *C. miliaris* Q. and G., captured in fishtraps by Lester Zukeran in Kaneohe Bay, Oahu, Hawaii.

Measurements.—(In mm) 17 females and 5 males:

	female		*male*	
	mean	*range*	*mean*	*range*
Total length, excluding caudal setae	1. 94	1. 67–2. 37	1. 52	1. 44–1. 59
Length of cephalothorax, including frontal region	1. 03	0. 92–1. 10	0. 90	0. 86–0. 92
Width of cephalothorax	0. 91	0. 79–1. 01	0. 78	0. 76–0. 85
Length of genital segment	0. 57	0. 45–0. 72	0. 32	0. 32–0. 34
Width of genital segment	0. 63	0. 50–0. 74	0. 26	0. 25–0. 27
Length of abdomen	0. 19	0. 13–0. 23	0. 14	0. 14–0. 15
Length of caudal rami	0. 06	0. 05–0. 07	0. 05	(all)
Length of egg strings (3 strings) 0. 74, 0. 56, 0. 72				

Description.—Female cephalothorax (fig. 57*b*) ovoid, consisting of cephalon and first 4 thoracic segments. Frontal region distinct, approximately one-twelfth the total length of cephalothorax, with fine membrane along anterior margin. Lunules (fig. 58*a*) large though finely membranous, extending posteriorly, on ventral surface, almost to junction of frontal region and remaining cephalothorax. Lateral margins of cephalothorax smooth, slightly irregular, with slight indentation in anterior third, with fine membrane extending laterally. Posterior sinus (fig. 57*c*) narrow, irregularly V-shaped, with finely frilled membrane on outer margin. Posterior median cephalothoracic region projecting well past posterior lateral regions, with broad, lappet-like projection extending from posterior surface over anterior end of free fourth pedigerous segment. Major dorsal cephalothoracic grooves forming irregular H, posterior legs and crossbar of H continuous. Ocular region distinct, in anterior third of cephalothorax.

Female free fourth pedigerous segment distinctly separable from cephalothorax, indistinctly separable from genital segment; segment angled sharply toward anterior end from region of fourth leg attachment, in posterior part of segment. Genital segment (fig. 57*d*) subtriangular, distended by eggs in figured female, posterior surface overlapping anterior end of abdomen dorsally. Fifth legs (fig. 57*g*)

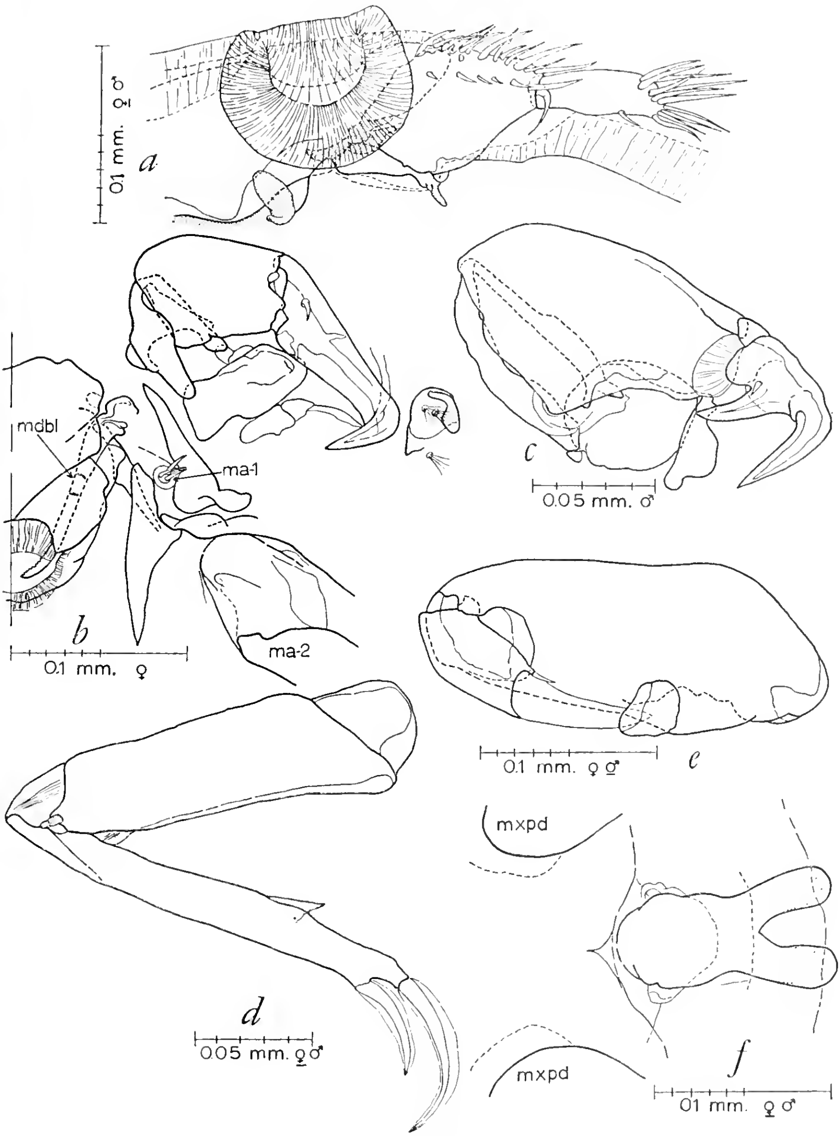


FIGURE 58.—*Caligus kapuhili*, new species, ventral view: *a*, left antennule and frontal region showing lunule; *b*, female oral region, left side showing antenna, postantennal process, mouth cone, mandible (mdbl), maxillule (ma-1), postoral process, and maxilla base (ma-2); *c*, male left antenna; *d*, right maxilla; *e*, left maxilliped; *f*, sternal furca and maxilliped bases (mxpd).

situated on posterior lateral surface of genital segment, consisting of 2 nodules, each in slight depression; anteriormost nodule with single plumose setule, posterior with 3 plumose setules.

Abdomen 1-segmented, distinct from genital segment, anterior half slightly swollen, posterior half straight, anal identation in medial posterior surface formed by pair of small, lappet-like projections. Caudal rami (fig. 57*h*) short, rounded distal half of inner margin plumose, distal surface with 4 plumose setae and 2 plumose setules, 1 on either side of setae.

Male cephalothorax (fig. 57*a*) similar to that of female. Free fourth pedigerous segment distinct from cephalothorax, fused with genital segment, shape as in female. Genital segment (fig. 57*e*) narrow anteriorly, broader posteriorly, with slight indentation at fifth leg and with small, lobate projections from posterior ventral surface. Fifth legs (fig. 57*f*) consisting of 2 plumose setules; sixth legs (fig.57*f*) arising from 1 of lobate projections on posterior ventral surface of genital segment, consisting of 3 plumose setules. Abdomen and caudal rami similar to those of female although anterior end of abdomen not swollen as in female.

Female and male antennule (fig. 58*a*) 2-segmented, attached to lateral-anterior ventral surface of cephalothorax and adjacent frontal region. First segment approximately 1½ times the length of second, narrow proximally and distally, broad medially, distal half of anterior and anterior ventral surface with approximately 21 lightly plumose setules. Second segment rodlike, with 12 naked setules distally. Female antenna (fig. 58*b*) 3-segmented, situated posterior and medial to antennule base. First segment socket-like, irregular; second segment broader proximally than distally. Third segment fused with clawlike terminal process, bearing setule-like accessory process proximally. Male antenna (fig. 58*c*) with similar first segment, second segment larger; third segment indistinctly separable from double-clawed terminal process, with setule-like accessory process at base of proximalmost claw, at junction of segment and terminal process.

Female and male mandible (fig. 58*b*) 4-parted, distalmost part flattened, with 12 denticulations along inner surface. Female and male postantennal process (fig. 58*b*) consisting of small, lappet-like projection and 3 nodules, 2 at base of projection, third slightly posterior to base, each with several hairlike processes. Female and male postoral process (fig. 58*b*) elongate, spinelike. Female and male maxillule (fig. 58*b*) nodular, with 3 setules distally. Female and male maxilla (fig. 58*d*) 2-segmented, situated lateral to postoral process. Both segments elongate, second more slender, slightly longer than first, with membranous projection from middle of inner surface and 2 saber-shaped terminal

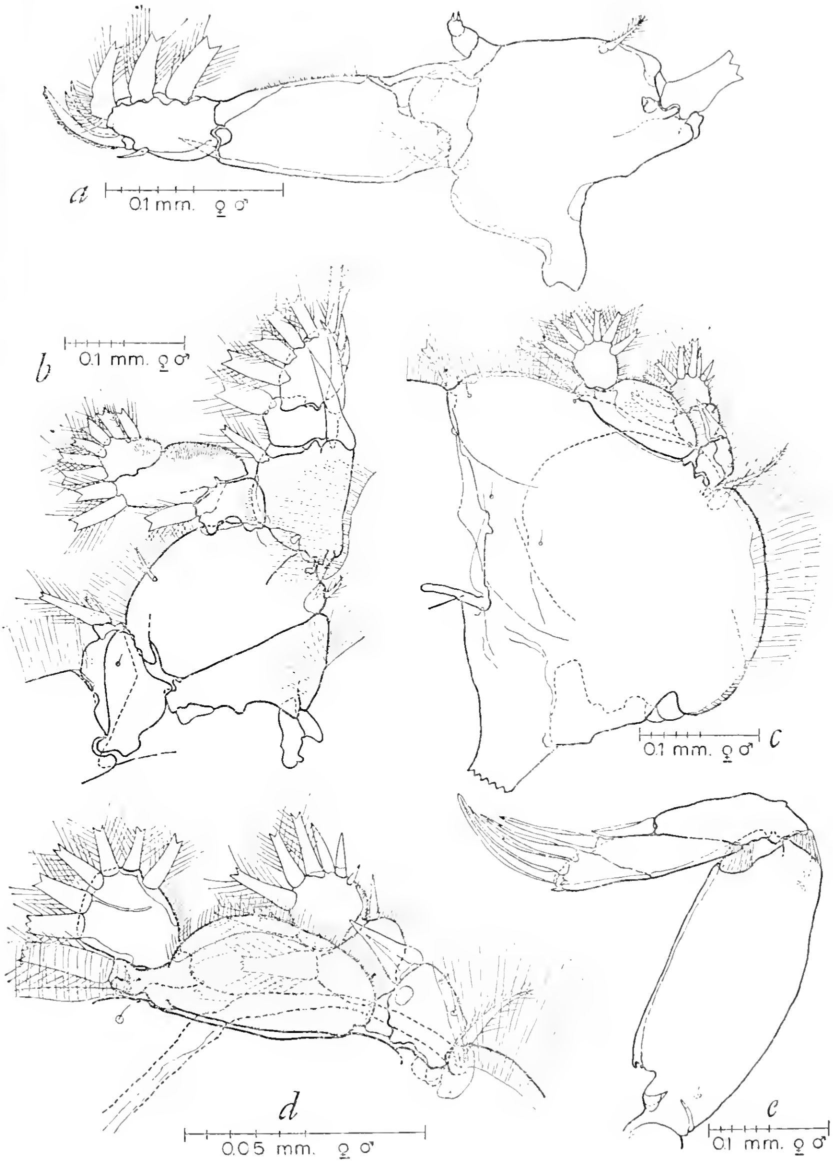


FIGURE 59.—*Caligus kapuhili*, new species, right thoracic legs. Posterior view: *a*, first. Anterior view: *b*, second; *c*, third; *d*, exopodite and endopodite of third; *e*, fourth.

processes. Innermost terminal process approximately 1½ times the length of outermost, both with fine membranes along margins.

Female and male maxilliped (fig. 58*e*) 2-segmented, situated posterior and slightly medial to base of maxilla. First segment strongly developed, with distally concave ledge on inner surface that receives tip of terminal process of second segment when segment flexed. Second segment distinct from clawlike terminal process, with single, setulelike accessory process on distal inner surface. Female and male sternal furca (fig. 58*f*) situated approximately halfway between maxilliped bases and interpodal plate of first thoracic legs, on small, heavily sclerotized platelike region projecting laterally as 2 small lobate processes, adjacent to base of furca. Furcal tines diverging, sinus irregularly V-shaped, tines broad, flat.

Spine at distal end of first segment of exopodite of third thoracic leg straight, not curved. For nature and armature of legs, see figure 59 and table 21.

TABLE 21.—*Armature of thoracic legs I–IV of the female and male of* Caligus kapuhili, *new species*

Leg	Surface	Interpodal Plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
I	Outer		p		h	h,mH,2H			rh?	
	Inner		p		c	3P			rh?	
II	Outer	m		m,p	m,H	H	2h,Q		C	C, 3P
	Inner		P,s	m,s	c,P	c,P	5P	P	c,2P	3P
III	Outer	m	a,m,P		2ss,H	c,p′	c,3p′	c	c,3P	
	Inner		3s,P,m,s			P	4P	P	c,3P	
IV*	Outer		3s,p		mH	mh	3mH,m			

*Division between second and third segments of exopodite indistinct, incomplete.

DISCUSSION.—*Caligus kapuhili* exhibits several characteristics closely approximating those of *C. laticaudus* Shiino, 1960a. The similarity of the lunule, the female and male antenna (male *C. laticaudus* decribed by Pillai, 1961), the maxilliped with its cup-shaped projection on the first segment, and the similarity of the first 3 thoracic legs suggest that these 2 species are closely related. The differences between the species are in the body shape, the size relationship of the body parts, and the characteristics of the appendages other than those mentioned above. Shiino's female and only specimen of *C. laticaudus* is reportedly 3.51 mm in length. Pillai reports a length of 2.6 mm for his female specimens (no length given for the male), the average length of the Hawaiian female specimens is 1.94mm, and the range is from 1.67–2.37mm. The abdomen is distinctly 2-segmented in *C. laticaudus* and 1-segmented in *C. kapuhili,* while its length (female only) is 0.71mm in *C. laticaudus* and an average of 0.19 mm (range 0.13-0.23 mm) in *C. kapuhili.* The relationship of the length of the abdomen to the length of the body (average total length divided by average length of abdomen) is 4.94 in *C. laticaudus* and 10.2 in *C. kapuhili.* The spinelike projection of the postantennal process in *C. laticaudus* is elongate and distally pointed, while in *C. kapuhili* it is short and distally rounded. The fourth thoracic leg of *C. laticaudus* has a frilled membrane at the base of each spine; with the exception of the innermost terminal spine, these membranes are absent in *C. kapuhili.*

The species name is derived from "Kapuhili," the Hawaiian name for several of the chaetodontids or butterfly fishes, the host of the species.

Caligus kala Lewis

FIGURES 60, 61

Caligus kala Lewis, 1964a, p. 142, figs. 2–3

DISTRIBUTION AND HOSTS.—Hawaiian Islands, *Naso hexacanthus.*

MATERIAL.—One female and 1 male (USNM 112927) from the buccal cavity of *Dascyllus albisella* Gill, captured by spear by Robert Stevenson, Oahu, Hawaii. One male (USNM 112928) from the buccal cavity of *D. albisella* Gill from the Honolulu Aquarium. One immature male (USNM 112929) from the gill cavity of *Saurida gracilis* (Quoy and Gaimard), captured in a fishtrap by Samuel Kaolulo between Diamond Head and Koko Head, Oahu, Hawaii. Two males (USNM 112930) from the gill cavity of *D. albisella* Gill, captured by rotenone off Waikiki, Oahu by William Gosline. One female (USNM 112931) from the gill cavity of *D. albisella* Gill, from the Honolulu Aquarium. One immature male (USNM 112932) from the buccal cavity of *D. albisella* Gill, from the Honolulu Aquarium. One female and 1 male (retained by author) from the buccal cavity of *Pomacentrus jenkinsi* (Jordan and Evermann), speared by N. Ferris in Hanauma Bay, Oahu, Hawaii. One damaged female (retained by author) from the gill cavity of *D. albisella* Gill, from the Honolulu Aquarium.

MEASUREMENTS.—(In mm) 5 females and 7 males:

	female		*male*	
	mean	*range*	*mean*	*range*
Total length, excluding caudal setae	4. 20	3. 95–4. 40	2. 79	2. 20–3. 20
Length of cephalothorax, including frontal region	2. 27	2. 10–2. 43	1. 87	1. 70–2. 05
Width of cephalothorax	1. 85	1. 75–2. 00	1. 50	1. 30–1. 63
Length of genital segment	1. 27	1. 18–1. 38	0. 53	0. 50–0. 60
Width of genital segment	1. 18	1. 00–1. 45	0. 63	0. 58–0. 78
Length of abdomen	0. 68	0. 61–0. 77	0. 31	0. 25–0. 37
Length of caudal rami	0. 14	0. 13–0. 15	0. 12	0. 10–0. 14
Length of egg strings (2 strings)	1. 30, 1. 48			

Description.—Female and male cephalothorax (figs. 60*a,b*) elliptical, consisting of cephalon and first 4 thoracic segments. Frontal region less than one-ninth the length of cephalothorax, with fine membrane along anterior margin. Lunules large, extending posteriorly, on ventral surface, slightly past division between frontal region and rest of cephalothorax. Posterior margin of median cephalothoracic region trilobed, not convex as originally described, median lobe projecting over anterior end of free fourth pedigerous segment. For description of rest of cephalothorax and fourth pedigerous segment, see original description.

Female genital segment (fig. 60*d*) of general obcordate shape although anterior end broadly rounded. Posterior lobes projecting to middle of abdomen, tipped by fifth legs. Fifth legs (fig. 60*f*) consisting of 2 knobs, outermost with single plumose setule, inner with 2 plumose setules. Female abdomen indistinctly 2-segmented, broad, lateral margins irregularly convex. First "segment" shorter than second, second with flatly angled distal end, with deep anal depression. Caudal rami of female and male (fig. 60*h*) as origionally described except for additional small setule present on outer distal ventral surface and hairlike process from middorsal surface.

Male genital segment (fig. 60*e*) of varible shape, variation appearing due to longitudinal contraction of free body segments. Distinct separation of fourth pedigerous and genital segments in holotype specimen, separation not visible in presently figured specimen but present in specimens exhibiting contracted condition. "Posterior margin" of original description (p. 144) thus formed by cuticular fold. Sixth leg (fig. 60*g*) present as small, naked setule and small plumose setule, both situated immediately ventral to junction of abdomen and genital segment.

In the description of the appendages and processes given below, those of the heretofore undescribed female are given only if they differ from the male. Additional descriptions are given if there appeared to be some error in the original description (Lewis, 1964a).

Female and male antennule (fig. 61*a*) as originally described except attachment to both frontal region and anterior-lateral ventral surface of cephalothorax, not just to frontal region. Female antenna (fig. 61*b*) 3-segmented, situated posterior and medial to antennule base. First segment short, squat, with posteriorly directed lobate projection; second segment broader proximally than distally, well developed. Third segment indistinctly separable from clawlike terminal process, with setule-like accessory process from proximal inner surface, second from inner distal surface. Male antenna (fig. 61*a*) as originally described except only one accessory process, on anterior inner surface. Female postantennal process (fig. 61*b*) situated lateral to antenna base,

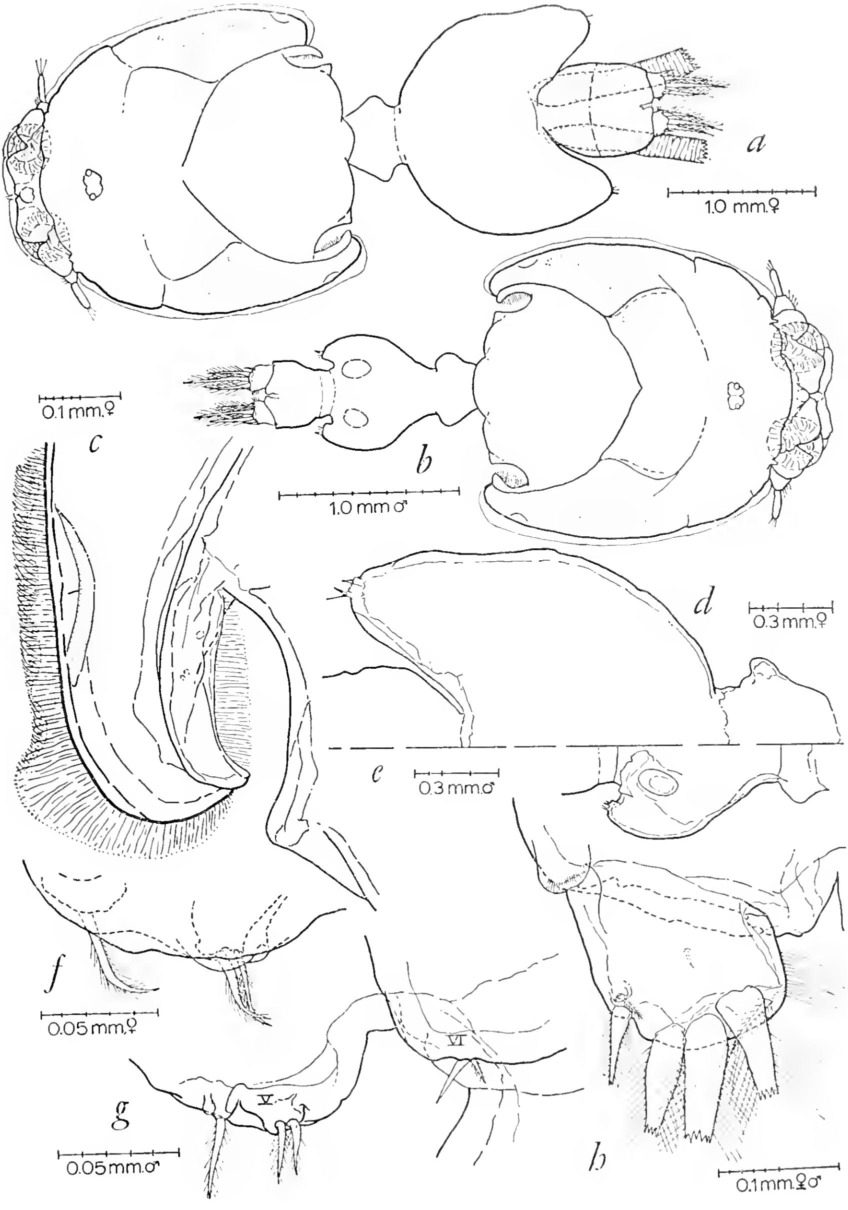


FIGURE 60.—*Caligus kala* Lewis, 1964, dorsal view: *a*, female; *b*, male; *c*, posterior cephalothoracic sinus. Ventral view: *d*, female genital segment; *e*, male, same; *f*, female right fifth leg; *g*, male right fifth (V) and sixth (VI) legs; *h*, caudal ramus.

consisting of short, slightly curved, spinelike process, with 2 nodes proximally, third node present slightly posterior to spinelike process, all 3 nodes with several hairlike processes. Male postantennal

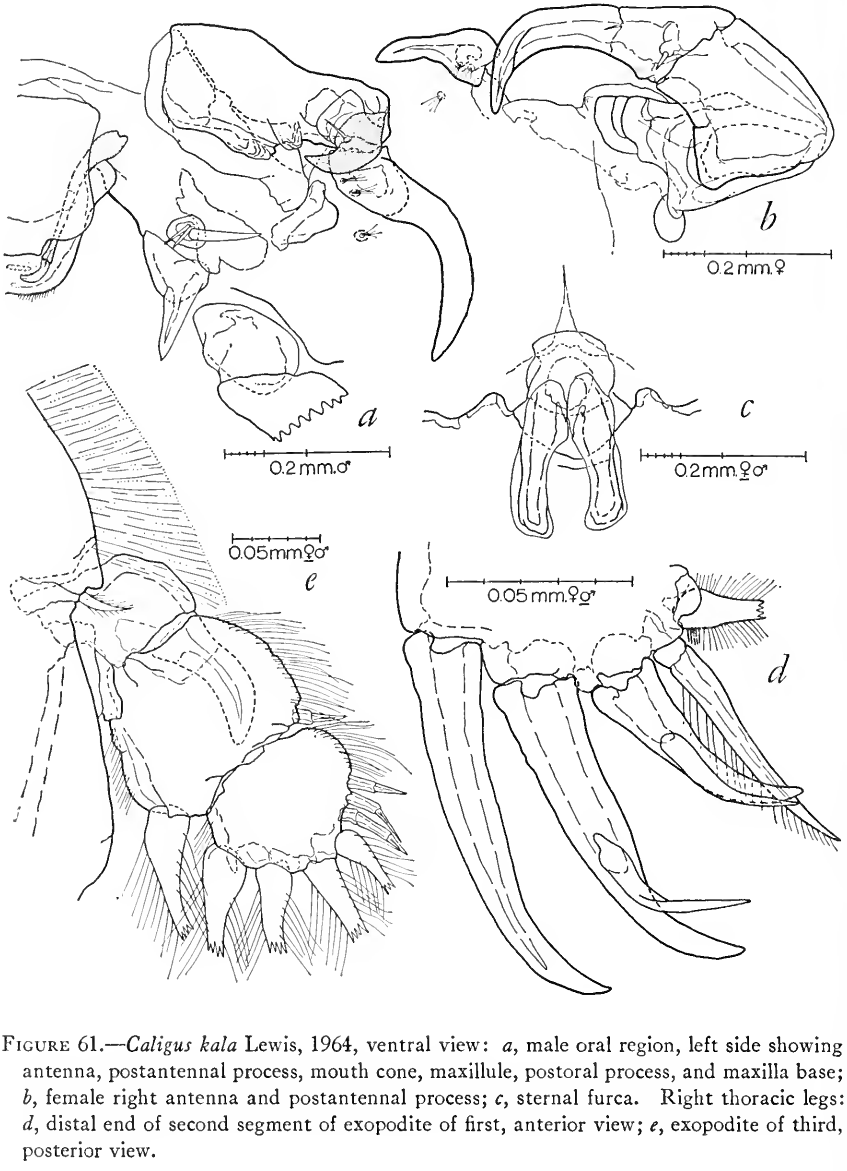


FIGURE 61.—*Caligus kala* Lewis, 1964, ventral view: *a*, male oral region, left side showing antenna, postantennal process, mouth cone, maxillule, postoral process, and maxilla base; *b*, female right antenna and postantennal process; *c*, sternal furca. Right thoracic legs: *d*, distal end of second segment of exopodite of first, anterior view; *e*, exopodite of third, posterior view.

process (fig. 61*a*) similar although spinelike process much longer than in female. Female and male maxillule (fig. 61*a*;=part of postoral process in original description) nodular, with 1 large and 2 small, setules. Female and male maxilla as originally described except lobate process on middle of second segment a folded membrane. Female maxilliped similar to that of male except with single tuberculate projection from middle of inner margin of first segment, not with 2 as in male.

Female and male sternal furca (fig. 61*c*) attached to ventral surface of cephalothorax between pair of small, lobate, anteriorly directed projections. Additional pair of somewhat larger lobate projections present between interpodal plates of first and second thoracic legs. First thoracic leg with distinct break in plumosities along inner surface of first segment of exopodite; both inner spines on distal surface of second segment of exopodite with flexible accessory processes, not just middle spine as originally indicated. Exopodite of third thoracic legs 3-segmented, not 2 as originally noted, protopodite with plumose setule at base of exopodite. Endopodite of third legs includes lobate projection previously indicated as arising between rami. For nature of armature and thoracic legs, see figures 61*d*, *e* and table 22 in present publication, figures 3*a*-*f* in Lewis, 1964a.

TABLE 22.—*Armature of thoracic legs I–IV of the female and male of* Caligus kala *Lewis, 1964a*

Leg	Surface	Interpodal plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
I	Outer		sss,P		rh	3H,P				
	Inner		d,p		c,c	3P				
II	Outer	m		m,p	m,m,mH	mH	h,H,Q,P	c,C	D	3P
	Inner		s,P	m,s	c,P	c,P	c,4P	P	P	c,3P
III	Outer	m	d,m,p		H	c,p′	c,3p′,P	c	c,3P	
	Inner		d,2s,P,s, m,s			c,P	c,3P	P	c,3P	
IV	Outer		2s,p		s,m,mH	4m,4mH				

Caligus ligatus Lewis

FIGURES 62–64

Caligus ligatus Lewis, 1964a, p. 164, figs. 8–9.

DISTRIBUTION AND HOSTS.—Hawaiian Islands, *Acanthurus dussumieri*, *Naso hexacanthus*.

MATERIAL.—Five females and 2 males (USNM 112933) from the gill cavity and buccal cavity of *Dascyllus albisella* Gill, from the Honolulu Aquarium. One male (retained by author) from the buccal cavity of *Aulostomus chinensis* (Linnaeus), captured in fishtrap by Samuel Kaolulo between Diamond Head and Koko Head, Oahu, Hawaii. One male (retained by author) from the gill cavity of

Holocentrus xantherythrus Jordan and Evermann, from the Honolulu Aquarium. One immature female and 5 males (retained by author) found in bait well after loading *Pranesus insularum* (Jordan and Evermann) at French Frigate Shoals (USFWS, JRM 31).

MEASUREMENTS.—(In mm) 5 females and 3 males:

	female		*male*
	mean	*range*	
Total length, excluding caudal setae	3. 29	3. 20–3. 35	2. 25, 2. 55, 2. 65
Length of cephalothorax, including frontal region	1. 62	1. 55–1. 68	1. 40, 1. 58, 1. 60
Width of cephalothorax	1. 49	1. 43–1. 53	1. 18, 1. 30, 1. 33
Length of genital segment	0. 95	0. 93–0. 98	0. 43, 0. 50, 0. 53
Width of genital segment	0. 93	0. 88–1. 03	0. 38, 0. 40, 0. 43
Length of abdomen	0. 59	0. 58–0. 61	0. 29, 0. 43, 0. 34
Length of caudal rami	0. 13	(all)	0. 12, 0. 15, 0. 14
Length of egg strings (2 strings)	1. 55, 0. 73		

DESCRIPTION.—Female cephalothorax (fig. 62*a*) ovoid, consisting of cephalon and first 4 thoracic segments. Frontal region approximately 15 percent of total length of cephalothorax, with broad membrane along anterior margin and pair of lunules (fig. 63*a*) extending posteriorly, on ventral surface, slightly past junction of frontal region and rest of cephalothorax. Lateral margin of cephalothorax slightly irregular, with fine membrane extending laterally and second membrane extending medially, on ventral surface; posterior lateral surface with small but distinct concavity. Posterior sinus (fig. 62*c*) irregularly U-shaped, with fine membrane along outer surface. Posterior median cephalothoracic region flatly convex, extending posteriorly well past lateral cephalothoracic regions, connected to free fourth pedigerous segment by flaccid arthrodial membrane. Major dorsal cephalothoracic grooves forming irregular H although anterior longitudinal grooves of H extending posteriorly and medially, past cross groove (more pronounced in female than in male). Ocular region distinct, in anterior third of cephalothorax.

Female free fourth pedigerous segment narrow anteriorly, lateral margins angled outward sharply to region of fourth leg attachment. Segment indistinctly separable from genital segment. Genital segment (fig. 62*d*) apple shaped, broader posteriorly, with fifth legs from ventral-posterior lateral surface. Fifth legs (fig. 62*f*) consisting of 2 knobs, anteriormost with 1 plumose setule, posteriormost with 2.

Female abdomen indistinctly separable from genital segment, consisting of 1 or 2 segments. Indication of segment division indistinctly present in middle of abdomen. Abdomen subrectangular, width approximately half the length, tapered slightly toward posterior end. Posterior end angled sharply at attachment of caudal rami, anal region bilobed. Caudal rami (fig. 62*h*) subrectangular, with small indentation on medial outer surface, indentation bearing single plumose seta. Three plumose setae present on distal surface; single plumose setule on inner distal surface, second on outer surface, just medial to indenta-

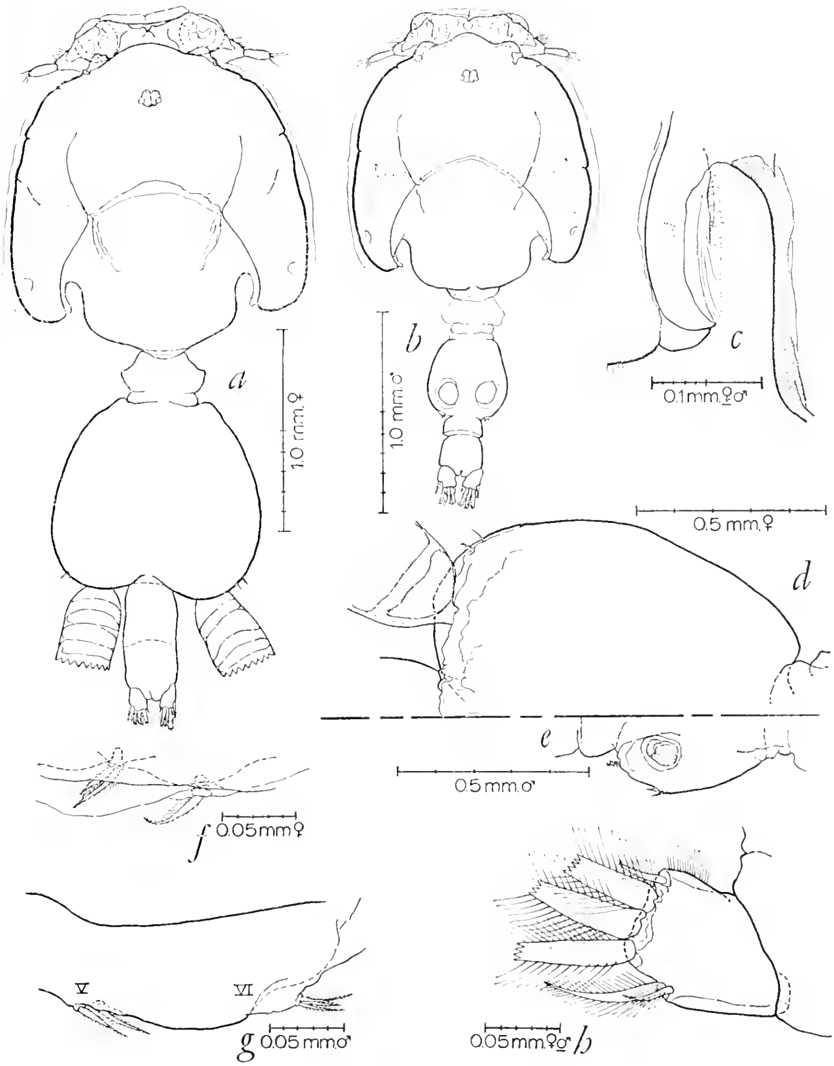


FIGURE 62.—*Caligus ligatus* Lewis, 1964, dorsal view: *a*, female; *b*, male; *c*, posterior cephalothoracic simus. Ventral view: *d*, female genital segment; *e*, male, same; *f*, female left fifth leg; *g*, male right fifth (V) and sixth (VI) legs; *h*, caudal ramus.

tion; distal half of inner surface plumose.

Male cephalothoax (fig. 62*b*) similar to that of female, free fourth pedigerous segment also similar except for irregular posterior lateral margins. Genital segment (fig. 62*e*) subovoid, fifth legs (fig. 62*g*) arising from ventral lateral surface, consisting of 2 knobs, each with single, plumose setule; sixth legs (fig. 62*g*) arising from slight swelling on lateral-posterior ventral surface, consisting of minute nodule bearing 3 plumose setules. Abdomen distinctly 2-segmented, first segment approximately one-third the total length, constricted sharply posteriorly; second segment slightly wider posteriorly than anteriorly. Caudal rami as in female.

Female and male antennule (fig. 63*b*) 2-segmented, attached to anterior ventral surface of cephalothorax, not attached to adjacent frontal region. First segment slightly less than 1½ times the length of second, narrow proximally and distally, broad medially; distal half of anterior and anterior ventral surface with approximately 23 plumose setae and setules. Second segment club shaped, with single naked setule from distal half of posterior surface, approximately 11 naked setules from distal surface. Female antenna (fig. 63*c*) 3-segmented, situated posterior and medial to antennule base. First segment dactyliform, ventrally facing surface irregular; second segment broader proximally than distally. Third segment short, incompletely fused to clawlike terminal process, with single setule-like accessory process from posterior medial surface. Male antenna (fig. 63*d*) 3-segmented, first segment elongate, irregular; second segment broader proximally than distally, with adhesion surface on proximal half of anterior surface and small, shelflike adhesion surface projecting from distal half. Third segment short, incompletely fused with short, bifurcate terminal process, tines of bifurcation sharply pointed. Single, setule-like accessory process present on distal anterior surface of segment.

Female and male mandible (fig. 63*c*) 4-parted, distalmost part curved medially, with 12 denticulations. Postantennal process of female (fig. 63*c*) situated lateral and slightly posterior to antenna base, consisting of short, clawlike projection with 3 associated nodules, 2 on base of projection, third just posterior to base, each with several hairlike processes. Male postantennal process (fig. 63*d*) consisting of long, strongly curved, clawlike projection with 2 nodules proximally, each with several hairlike processes, third nodule not visible. Female and male postoral process (fig. 63*c*) with broad base, tapered abruptly to slender, slightly curved spinelike projection. Female and male maxillule (fig. 63*c*) nodular, with 2 small and 1 large setule. Female and male maxilla (fig. 63*e*) 2-segmented, situated lateral and slightly posterior to postoral process. First segment slightly more than four-fifths the length of second, narrower proximally and distally than medially. Second segment elongate, with small, lobate membrane on distal half of posterior surface and 2 saber-shaped terminal

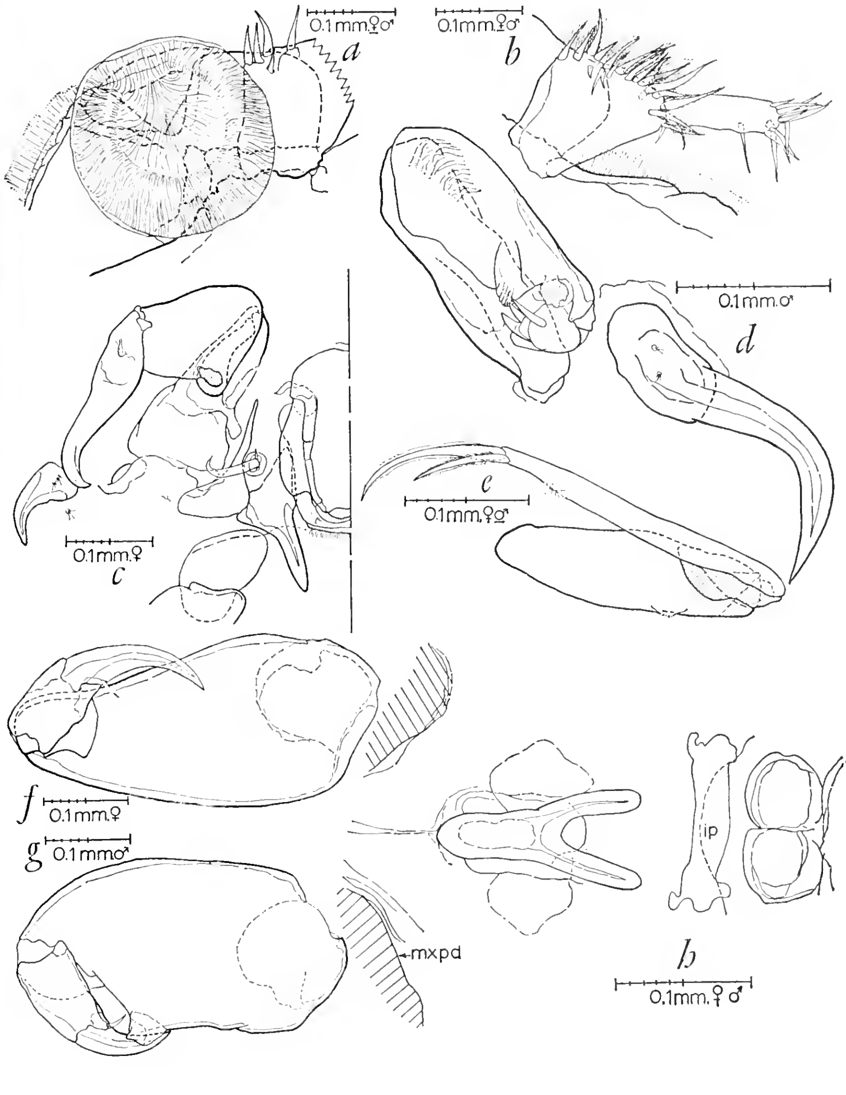


FIGURE 63.—*Caligus ligatus* Lewis, 1964, ventral view: *a*, frontal region, left side showing lunule and antennule base; *b*, left antennule; *c*, female oral region, right side showing antenna, postantennal process, mouth cone, mandible, maxillule, postoral process, and maxilla base; *d*, male left antenna and postantennal process; *e*, left maxilla; *f*, female right maxilliped; *g*, male left maxilliped; *h*, maxilliped bases (mxpd), sternal furca, interpodal plate of first thoracic leg (ip), and processes between interpodal plates of first and second thoracic legs.

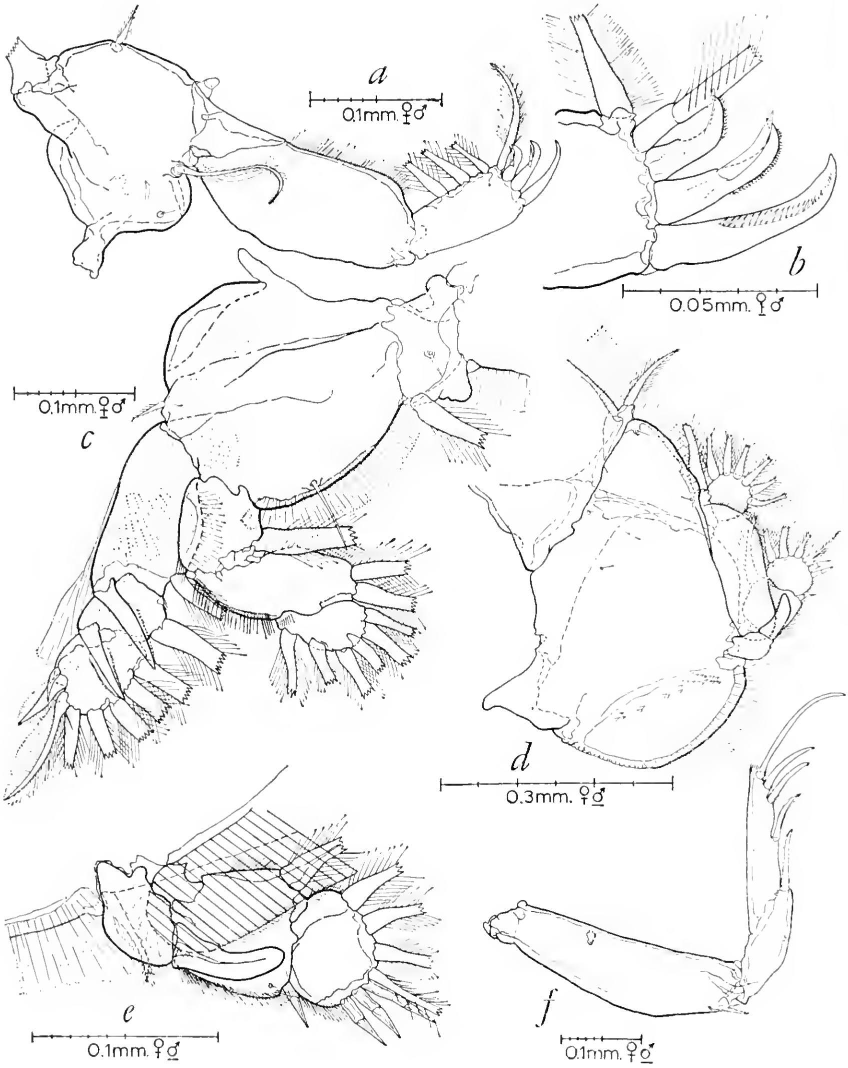


FIGURE 64.—*Caligus ligatus* Lewis, 1964, right thoracic legs, anterior view: *a*, first; *b*, distal region of second segment of exopodite of first; *c*, second; *d*, third; *e*, exopodite of third; *f*, fourth.

processes. Outermost terminal process approximately 1½ times the length of innermost, with fine membrane along both margins; innermost with finely serrated membrane along both margins.

Male maxilliped (fig. 63*g*) 2-segmented, situated posterior and medial to maxilla base. First segment large, strongly developed, with knoblike projection on distal half of inner surface, distal surface of knob grooved, appearing to receive distal part of terminal process of second segment when segment flexed. Second segment short, tapered from proximal end to indistinct junction with clawlike terminal process, single, setule-like accessory process present on distal inner surface of segment. First segment of female maxilliped (fig. 63*f*) not as well developed as that of male, without projection of distal inner surface. Second segment and terminal process as in male. Sternal furca situated on median longitudinal axis of body, posterior to maxilliped bases, base of furca long, lobate, tines diverging in curved manner from point of bifurcation, terminating in rounded tips.

For nature of legs and armature, see figure 64 and table 23.

REMARKS.—The presence of mature females and the variation exhibited in the males in the present collection indicated that a redescription of the species was in order.

TABLE 23.—*Armature of thoracic legs I–IV of the female and male of* Caligus ligatus *Lewis, 1964a*

Leg	Surface	Inter-podal Plate	Protopodite		Exopodite			Endopodite		
			1	2	1	2	3	1	2	3
I	Outer		ss,p		rh	3H,P				
	Inner		p		c	3P				
II	Outer	m		m,p	m,fm,mH	dmH	h,mH,Q,P	c	C*	c,3P
	Inner		s,P	m,s	c,P	c,P	4P	P	c,2P	3P
III	Outer	m	m,d,p		s,H	c,s,p′	c,3p′	c	c,3P	
	Inner		s,P,s,m,s			c,P	c,4P	P	c,3P	
IV	Outer		p		s,fm,mH	mH,fm,mH, fm,H,fm,H				

* Condition on male, female=D.

Caligus flexispina Lewis

Caligus flexispina Lewis, 1964a, p. 149, figs. 4–5.

DISTRIBUTION AND HOSTS.—Hawaiian Islands, *Acanthurus triostegus sandvicensis*.

MATERIAL.—One female (retained by author) from the external surface of *Aulostomus chinensis* (Linnaeus), captured in a fishtrap by Samuel Kaolulo between Diamond Head, and Koko Head, Oahu, Hawaii. One male (retained by author) from the external surface of an unknown labrid captured in the Hawaiian region.

MEASUREMENTS.—(In mm) 1 female and 1 male:

	female	*male*
Total length, excluding caudal setae	2. 37	2. 29
Length of cephalothorax, including frontal region	1. 53	1. 67
Width of cephalothorax	1. 21	1. 26
Length of genital segment	0. 59	0. 38
Width of genital segment	0. 68	0. 38
Length of abdomen	0. 20	0. 20
Length of caudal rami		0. 20
Length of egg strings (female nonovigerous)		

DESCRIPTION.—See Lewis, 1964a.

Caligus randalli Lewis

Caligus randalli Lewis, 1964a, p. 156, figs. 6a, b, d–f, h–l, n–q; fig. 7.

DISTRIBUTION AND HOSTS.—Hawaiian Islands, *Acanthurus triostegus sandvicensis.*

DESCRIPTION.—See Lewis, 1964a.

Caligus kalumai Lewis

Caligus kalumai Lewis, 1964a, p. 171, fig. 10.

DISTRIBUTION AND HOSTS.—Hawaiian Islands, *Acanthurus guttatus.*

DESCRIPTION.—See Lewis, 1964a.

Order Lernaeopodoida

Family Lernaeopodidae

Charopinopsis Yamaguti, 1963

DIAGNOSIS.—Female: Cephalothorax, including posteriorly removed maxilla-bearing segment, in line with rest of body, anterior portion of tergum heavily sclerotized. Trunk broader than cephalothorax, flattened dorsoventrally, without indication of segmentation, with subconical or conical projection at each posterolateral corner; with pair of long, dactyliform posterior processes medially, ventral to oviducal openings. Abdomen and caudal rami not visible. Antennule 3-segmented, subconical; antenna biramous, not chelate, exopodite broadly rounded, without externally projecting armature, endopodite 2-3 segmented (status of distalmost "segment" questionable). Maxillule with small palp, palp tipped by setule (spine?), distal surface of maxillule with 3 setules (spines?). Maxillae posterior to maxillipeds, joined at bulla, distal region convoluted, giving knoblike appearance. Maxillipeds 2-segmented, prehensile, second segment with short, clawlike terminal process.

Male: See Yamaguti, 1963, p. 251.

Charopinopsis quaternia (Wilson)

FIGURE 65

Charopinus quaternius Wilson, 1935b, p. 343, pl. 4, figs. 42–49.—Causey, 1953a, p. 11, fig. 15.
Brachiella coryphaenae Pearse, 1952a, p. 35, figs. 129–135.—Pillai, 1962a, p. 85, fig. 18.—Yamaguti, 1963, p. 248, pl. 270, fig. 7.
Charopinopsis quaternia (Wilson) Yamaguti, 1963, p. 251, pl. 271, fig. 3.

DISTRIBUTION AND HOSTS.—4 host records:

locality	*hosts*	*references*
Gulf of Mexico	*Peristedion gracilis*	
	Coryphacna hippurus	Wilson, 1935b
	Scomberomorus cavalla	Causey, 1953a
Indian Ocean	*Coryphaena hippurus*	Pillai, 1962

MATERIAL.—Nine females (USNM 112934) from the gill filaments of *Coryphaena hippurus* Linnaeus, captured 120 miles south of Oahu, Hawaii (USFWS, HMS cruise 34).

MEASUREMENTS.—(In mm) 9 females:

	mean	*range*
Total length, excluding posterior processes	6. 75	6. 23–7. 35
Length of cephalothorax	1. 54	1. 37–1. 70
Width of anterior region of cephalothorax	0. 78	0. 74–0. 85
Width of posterior region of cephalothorax (at level of maxillae)	0. 54	0. 47–0. 63
Length of "neck" between maxillae and trunk	0. 95	0. 81–1. 11
Length of trunk, excluding posterior processes	4. 38	4. 13–4. 65
Width of trunk	1. 75	1. 30–2. 00
Length of lateral-dorsal posterior processes	0. 66	0. 44–0. 85
Length of median-ventral posterior processes	2. 91	2. 48–3. 55
Length of egg strings (8 strings)	7. 54	6–53–8. 18

DESCRIPTION OF FEMALE.—Cephalothorax (fig. 65*a*) elongate, anterior part bearing small, terminally concave projection from median anterior surface, in addition to cephalic appendages (except maxillae) and maxillipeds. Posterior part of cephalothorax necklike, slightly narrower than anterior part. Trunk elongate, broader than cephalothorax, constricted at junction with cephalothorax, without indication of segmentation. Posterior end of trunk with 2 pairs of processes (fig. 65*b*), 1 short, dactyliform pair that may be curved on outer posterior surfaces; 1 long, filamentous pair on ventral posterior surface, adjacent to oviducal openings. Median posterior ventral surface of trunk with small, padlike projection appearing to contain droplets of viscous material, projection not appearing to be associated with reproductive elements. Median posterior surface essentially concave although heavily sclerotized, forming place of attachment for ovoid spermatophores that project slightly and give biconcave outline to surface.

Antennule (fig. 65*c*) 3-segmented, attached to concave frontal projection, immediately anterior and slightly lateral to labrum. Appendage flaccid, first segment broad proximally, approximately half as wide distally, with flexible, subconical projection on inner surface. Second segment short, approximately two-thirds the length of third segment; third segment rounded distally, distal surface with 2 setules. Antennae (fig. 65*d*) large, biramous, attached lateral and slightly posterior to antennule. Protopodite subrectangular, with irregular areas of heavy sclerotization. Exopodite separable from distal surface of protopodite by breaks in sclerotization, with 2 minute, knoblike projections on inner part of rounded distal surface; entire ramus, including projections, covered by filmy cuticle. Endopodite distinctly separable from distal inner surface of protopodite, apparently 3-segmented although status of terminal "segment" questionable. First and second segments subcylindrical, first slightly less than twice the length of second. Third "segment" approximately two-thirds the length of second, concave distally, with minute, setule-like projection arising from concavity.

Mandible (fig. 65*d*) rodlike, distal end flattened, inner edge rounded, without apparent denticulations. Maxillule (fig. 65*e*) situated adjacent to posterior lateral edge of mouth cone base, consisting of stalk with palp on distal half of inner surface, palp tipped by spinelike projection. Distal end of maxillule rounded, with single short, setalike process on outer edge, 2 long, setalike processes on medial and inner edge. Maxillae (fig. 65*a*) subcylindrical, flabby, distal region (fig. 65*f*) tapered to bulbous swelling formed by convolution of distal end of each maxilla; swellings enclosing tip of capstan-shaped bulla.

Maxilliped (fig. 65*g*) 2-segmented, situated posterior and medial to maxillule base, arising from small, apron-shaped projection of ventral surface of cephalothorax. First segment well developed, approximately twice the length of second, medial inner surface with knob-shaped swelling bearing small, conical projection. Second segment with wavy outline, distal third of inner surface denticulated, inner distal surface bearing setalike process. Terminal process of second segment originating on outer distal surface of segment, claw-like except for spike-shaped accessory projection on medial inner surface.

Discussion.—The Hawaiian specimens differ from Wilson's type-material (USNM 64009–64011) and Pearse's holotype and paratype slides (USNM 92663, 92688) in size, the Gulf of Mexico specimens being approximately four-fifths the length of the Hawaiian specimens (excluding posterior processes). There is also some minor variation in the size and shape of the various body regions and posterior proc-

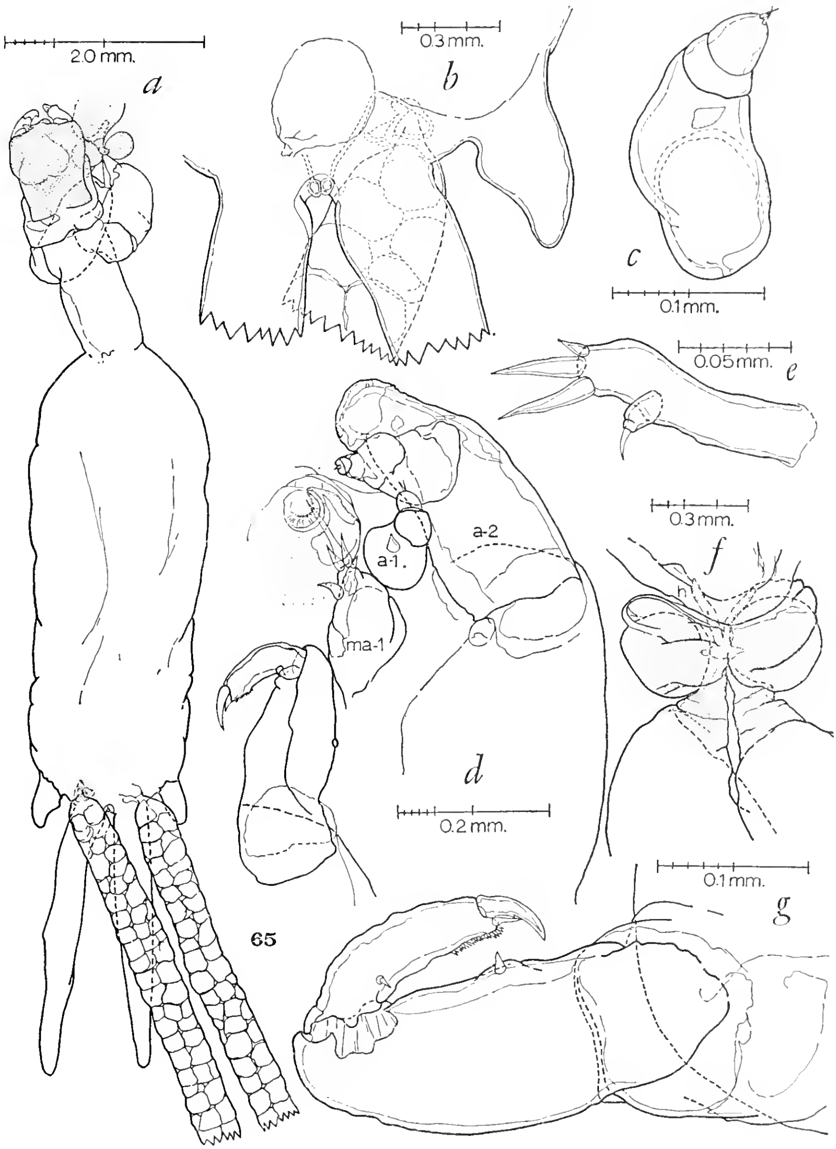


Figure 65.—*Charopinopsis quaternia* (Wilson, 1935), female: *a*, dorsal view (eggs drawn in free hand). Ventral view: *b*, posterior end of trunk showing posterior processes, region of genital openings, and part of one egg string; *c*, right antennule; *d*, anterior end of cephalothorax, left side showing antennule (a-1), antenna (a-2), mouth cone, mandible, maxillule (ma-1), and maxilliped; *e*, left maxillule; *f*, distal end of maxilla showing attachment with host tissue (h); *g*, right maxilliped.

esses, both in the 3 collections as a whole and individually, but the author attributes this to natural variation. Pillai (1962a, p. 86) points out that the posterior processes on the trunk of his specimens "are more narrowing towards the tip" than those described by Pearse (1952a). Pearse, however, made permanent mounts of his specimens and flattening of the specimens and their component parts has taken place, as evidenced by his figures.

Brachiella Cuvier, 1829

Diagnosis.—Female: Cephalothorax elongate, frequently at angle to trunk, anterior region of tergum heavily sclerotized. Trunk swollen, flattened dorsoventrally, with 1 or 2 pairs of posterior processes and single genital process (1 or more of these may be reduced or lacking); without recogmizable abdomen or caudal rami. Antennule 2–4 segmented, subconical; antennae biramous, exopodite with or without armature, endopodite reduced. Maxillule with palp; maxillae removed well behind maxillipeds, distally united, with bulla. Maxillipeds close to oral region, 2-segmented, second segment with clawlike terminal process.

Male: Body divisible into prosome (=cephalothorax) and urosome, separated by constriction or internal indication of constriction. Urosome longer than prosome, usually narrower, caudal rami small. Antennule 3–4 segmented, antennae biramous, exopodite 1-segmented, lobate, endopodite 2-segmented. Maxillule similar to that of female; maxilla 2-segmented, tipped with clawlike terminal process. Maxilliped 2-segmented, second segment with clawlike terminal process.

Brachiella thynni Cuvier

Figures 66, 67

B. thynni Cuvier, 1829, p. 257, pl. 15, fig. 5.—Guérin-Méneville, 1829–1844, pl. 9, fig. 6a–c.—Nordmann, 1832, p. 90.—Milne-Edwards, 1840, p. 512.—Steenstrup and Lütken, 1861, p. 420, pl. 15, fig. 36.—Van Beneden, 1851, p. 128; 1861, p. 153.—Heller, 1866, p. 756.—Van Beneden, 1870a, p. 37; 1870b, p. 244.—Vogt, 1877, pl. 3, fig. 9.—Richiardi, 1880, p. 7.—Stossich, 1880, p. 268.—Valle, 1880, p. 77.—Carus, 1885, p. 375. Bassett-Smith, 1896a, p. 162.—Brian, 1899a, p. 6.—Bassett-Smith, 1899, p. 502.—Brian, 1901, p. 1, fig. 1.—Graeffe, 1902, p. 16.—Thompson and Scott, 1903, p. 294.—Stenta, 1904, p. 345.—Miculicich, 1905a, p. 600; 1905b, p. 733.—Rathbun, 1905, p. 102.—Brian, 1905, p. 8; 1906, p. 105, pl. 9, fig. 1.—Scott and Scott, 1913, p. 204, pl. 64, figs. 4–6.—Wilson, 1915, p. 703, pl. 25, fig. C; pl. 53, figs. 209–215.—Leigh-Sharpe, 1926, p. 386.—Kirtisinghe, 1935, p. 342, figs. 40–42.—Bere, 1936, p. 613.—Bonnet, 1948, p. 7.—Causey, 1953b, p. 15.—Delamare-Deboutteville and Nunes-Ruivo, 1953, p. 217.—Shiino, 1956b, p. 283, figs. 8–9; 1958, p. 112; 1960b, p. 539.—Pillai, 1962a, p. 81, figs. 15, 16.—Shiino, 1963a, p. 346.—Yamaguti, 1963, p. 247, fig.1.—Kirtisinghe, 1964, p. 119, figs. 171, 172.

Thynnicola ziegleri Miculicich, 1904, p. 48, figs. 1–3.

DISTRIBUTION AND HOSTS.—28 host records:

locality	*hosts*	*references*
Unknown	*Scomber thynnus*	Nordmann, 1832
	"tuna"	Milne-Edwards, 1840
North Atlantic	*Thynnus thynnus*	Bassett-Smith, 1896a
	T. vulgaris	Rathbun, 1905
	"tuna"	Wilson, 1915
	Orcynnus thynnus	Scott and Scott, 1913
Equatorial Atlantic	"Albacore"	
	Sciaena aquila	
	"Baracottaer"	Steenstrup and Lütken, 1861
Baltic	*Thynnus vulgaris*	Van Beneden, 1870a
Gulf of Mexico	*Pomatomus saltatrix*	Bere, 1936
	Scomberomorus cavalla	Causey, 1953b
Hawaii	*Thynnus* species	Bonnet, 1948
	Thunnus albacares	
	Parathunnus sibi	
	Thunnus obesus	Shiino, 1963a
Japan	*Acanthocybium solandri*	Shiino, 1956b
Indian Ocean	*Chirocentrus dorab*	Thompson and Scott, 1903
	Thunnus (Germo) macropterus	Kirtisinghe, 1935
	Parathunnus obesus	
	Neothunnus albacora	Shiino, 1958
	Acanthocybium solandri	Shiino, 1960b
	Indocybium lineolatum	Pillai, 1962*a*
	Neothynnus macropterus	Kirtisinghe, 1964
Mediterranean	*Thynnus vulgaris*	Carus, 1885
	Thynnus thynnus	Brian, 1899a
	"tuna"	Brian, 1901
	Thunnus thynnus	Delamare-Deboutteville and Nunes-Ruivo, 1953

MATERIAL.—Three females and 2 males (USNM 112935) from the external surface of *Acanthocybium solandri* (Cuvier) caught in the Hawaiian region (USFWS, HMS cruise 38).

MEASUREMENTS.—(In mm) 3 females and 1 male:

	female
Total length, excluding posterior processes	9.30, 14.55, 16.13
Length of cephalothorax, including "neck"	5.85, 11.25, 10.50
Width of anterior region of cephalothorax	0.93, 1.07, 0.96
Width of posterior region of cephalothorax (at maxillae)	1.30, 1.26, 1.30
Length of trunk	3.45, 3.30, 5.63
Width of trunk	2.29, 3.48, 3.77
Length of dorsal posterior processes	5.93, 9.15, 9.15
Length of ventral posterior processes	3.90, 8.18, 9.15
Length of egg strings	6.23, 13.05, 15.90

	male
Total length	1. 85
Length of prosome	0. 76
Width of prosome	0. 53
Length of urosome	0. 91
Width of urosome	0. 53
Width at constriction between prosome and ursome	0. 24
Length of caudal rami	0. 12

Description of female.—Body (fig. 66*a*) consisting of 2 parts, anteriormost (cephalothorax) elongate, vermiform, posteriormost (trunk) flattened dorsoventrally, swollen laterally. Cephalothorax, except for maxilla-bearing segment, with heavily sclerotized tergum; maxillae arising from posterior end of cephalothorax, well posterior to maxillipeds. Swollen trunk slightly narrower anteriorly than posteriorly, lateral margins irregular. Dorsal surface of trunk flatly convex, with slight irregularities, distinctly separable from vermiform cephalothorax, without distinct evidence of segmentation. Ventral surface of trunk (fig. 66*b*) with 3 pairs of bosses, with distinct though incomplete line of division posterior to each pair, giving 4-segmented appearance. Lateral posterior surfaces projecting past slightly biconvex median portion as lobate extensions; median posterior surface bearing 4 elongate, lanceolate projections, 2 dorsally, 2 ventrally, each member of dorsal pair with knob-shaped proximal swelling. Trunk with small, knoblike projection between and ventral to base of processes. Egg strings projecting from posterior surface, between dorsal and ventral posterior processes.

Antennule (fig. 66*c*) 3-segmented, club shaped, arising from anterior ventral surface of cephalothorax, just lateral and anterior to mouth cone. First segment swollen, flabby, slightly less than twice the combined lengths of remaining 2 segments. Second segment cylindrical; third segment approximately 1½ times the length of second, rounded distally, with single, minute spinule from medial anterior surface and 2 hairlike processes distally. Antennae (fig. 66*e*) biramous, situated posterior and lateral to antennule base, extending anteriorly around anterior end of cephalothorax. Division between antenna base and cephalothorax indistinct, incomplete. Protopodite and exopodite separable only by breaks in sclerotization, forming dactyliform projection. Endopodite rudimentary, knoblike, with 3 spinules distally.

Mandible (fig. 66*f*) rodlike, wavy, flattened distally, distal inner surface with 6 denticulations (including distal end). Maxillule (fig. 66*g*) situated adjacent to lateral posterior surface of mouth cone, consisting of stalk (with indistinct evidence of segmentation) bearing node from medial posterior surface, node tipped by spinule; stalk flattened distally, distal surface with 3 nodes, each tipped by spinule.

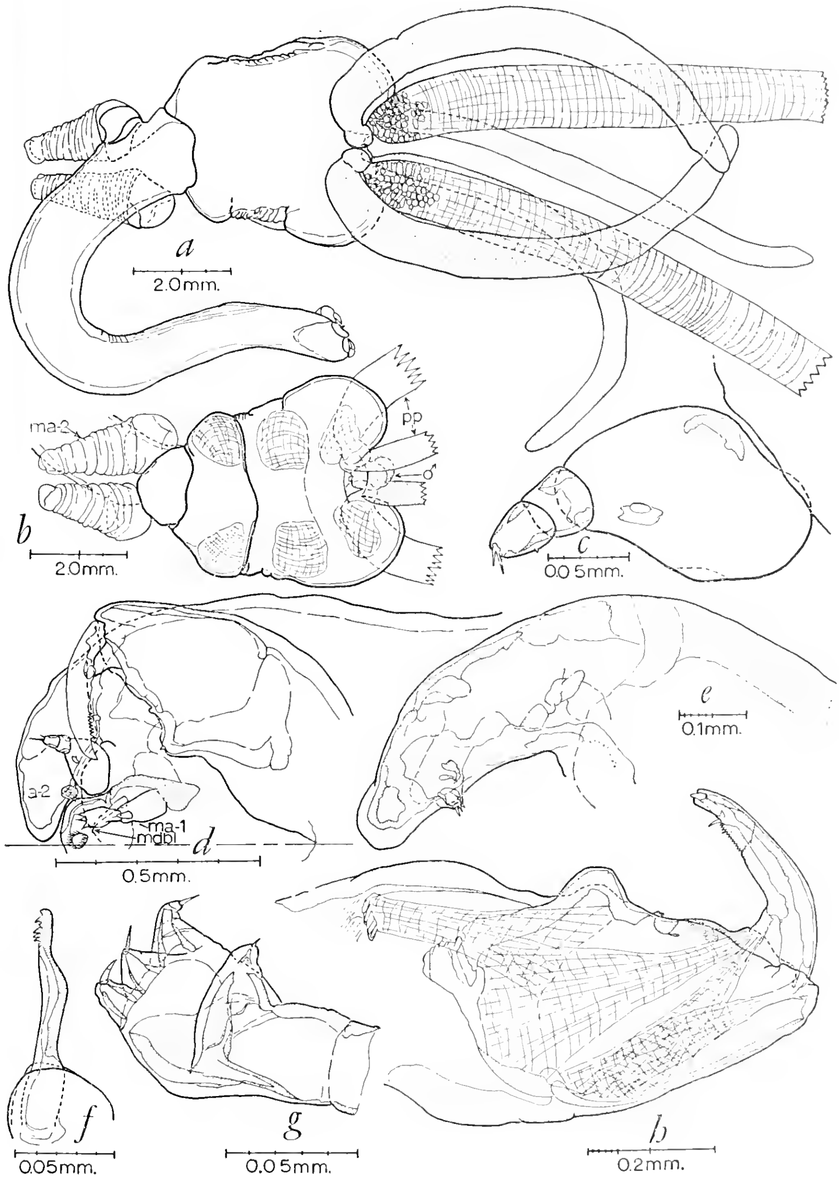


Figure 66.—*Brachiella thynni* Cuvier, 1829, female: *a*, dorsal view. Ventral view: *b*, posterior end of neck and trunk showing maxillae (m-2), bosses on trunk (crosshatched areas), posterior processes (pp), and attached male; *c*, left antennule; *d*, anterior end of cephalothorax, left side showing antennule, antenna (a-2), mouth cone, mandible (mdbl), maxillule (ma-1), and maxilliped; *e*, left antenna; *f*, left mandible; *g*, right maxillule (posterior view); *h*, left maxilliped, showing musculature.

Shiino (1956b) describes an accessory lamella associated with the maxillule (Shiino's "maxilla") which was not found on the dissected appendage although a cuticular flap is present on the mouth cone anterior to the maxillule. Maxilla (fig. 66*b*) subconical, with numerous superficial annulations, distal end concave on inner half and enveloping cylindrical bulla (not figured).

Maxilliped (fig. 66*h*) situated posterior and slightly lateral to mouth cone, segmentation indistinct and incomplete although musculature suggests 3-segmented condition. Appendage divisible into heavy basal part and clawlike distal part; basal part with knob-shaped projection from medial inner surface, with minute, doughnut-shaped projection just distal to knob with series of minute denticulations on distal inner surface. Clawlike distal part bluntly pointed distally, with setule-like accessory process on distal inner surface, with row of minute denticulations extending from medial inner surface to base of accessory process.

Description of male.—Cephalothorax or prosome (figs. 67*a*,*b*) ovoid in both lateral and dorsal view, consisting of cephalon and maxilliped-bearing segment. Division between prosome and urosome distinct, complete. Urosome broadest anteriorly, tapered to narrow posterior end; posterior end with large, lappet-like anal laminae, also bearing pair of subconical caudal rami, rami without armature elements.

Antennule (fig. 67*c*) 3-segmented, situated on lateral-anterior dorsal surface. First segment broad proximally, proximal width more than twice medial width, approximately 4 times distal width; length approximately twice combined lengths of second and third segments. First segment with spinule on distal half of anterior dorsal surface. Second segment approximately two-thirds the length of third, with spinule on distal half of anterior dorsal surface. Third segment with indentation on medial anterior surface, indentation bearing single spinule; rounded distal end with 4 setules. Antennae (fig. 67*d*) biramous, situated on anterior ventral surface of cephalothorax, below antennule base and lateral to mouth cone. Protopodite 1-segmented, originating from angular projection of ventral surface of cephalothorax. Exopodite lamellate, with spine on medial posterior surface, second spine on distal-outer posterior surface (spines not noted by Shiino, 1956b). Endopodite 2-segmented, first segment approximately twice the length of second, second with sharp indentation on distal inner surface, bearing clawlike terminal spine and small spinule from indentation.

Mouth cone projecting anteriorly from anterior ventral surface of cephalothorax, labrum and labium indistinctly separable. Labrum flat, with membranous lateral surface; labium rounded, with heavily sclerotized band distally, band bearing fine membrane projecting medially and membrane-like projection directed distally, latter topped

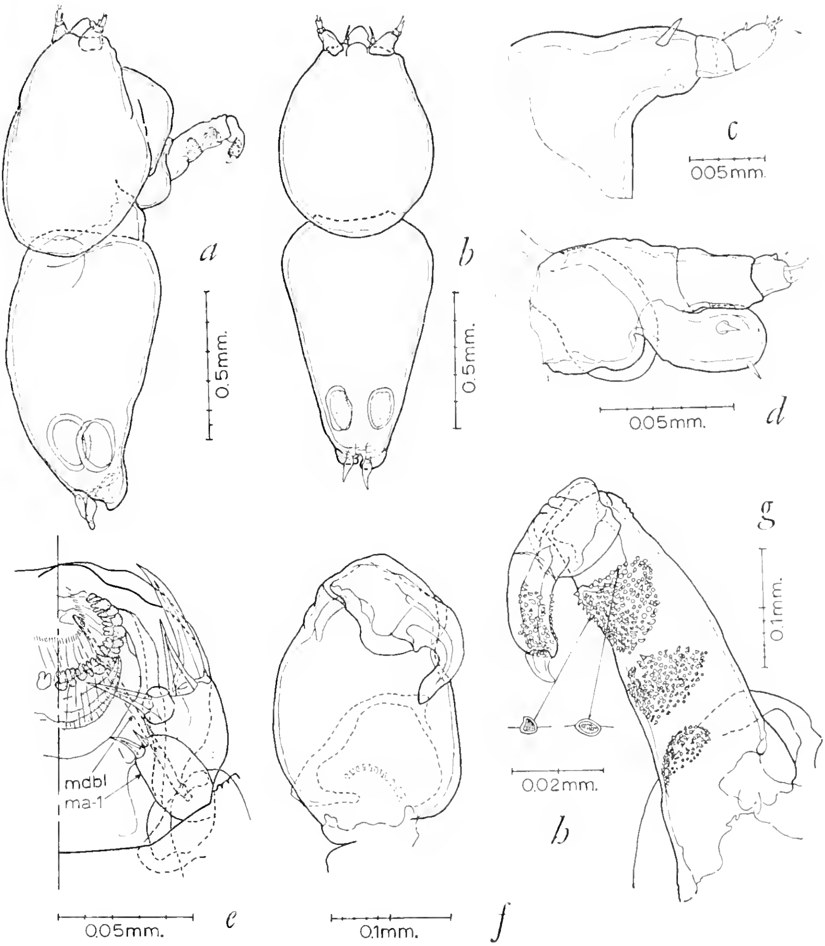


Figure 67.—*Brachiella thynni* Cuvier, 1829, male: *a*, lateral view; *b*, dorsal view. Ventral view: *c*, left antennule; *d*, left antenna; *e*, oral region, left side showing mouth cone, mandible (mdbl), and maxillule (ma-1); *f*, right maxilla; *g*, right maxilliped; *h*, projections on right maxilliped.

by row of small, bifid pads, pads topped by finely frilled membrane. Mandible (fig. 67*e*) rodlike, originating from padlike swelling adjacent to mouth cone. Maxillule basically similar to that of female except node on medial surface bearing 2 spinules instead of 1, distal 3 nodes not as prominent as in female. Maxillae and maxillipeds situated on irregular, apron-like projection, posterior half of projection separated from anterior half by distinct ridge. Maxillae (fig. 67*f*) well developed, 2-segmented, situated on anterior half of projection. Both maxillae connected at inner proximal end by posteriorly bifurcate band of heavy sclerotization. First segment well developed, with heavily sclerotized ring at proximal end, duct from maxillary gland visible inside proximal inner surface of appendage. Second segment fused to clawlike terminal process.

Maxilliped (fig. 67*g*) 2-segmented, situated on posterior half of apron-like projection. First segment of maxilliped elongate, with 3 adhesion surfaces on inner surface. Adhesion surfaces formed by numerous minute, padlike or hook-shaped projections (fig. 67*h*). Proximal adhesion surface associated with heavily sclerotized ridge and pad, medial surface associated with swelling, swelling with spinule; distal adhesion surface associated with swelling on distal inner surface. Second segment elongate, with adhesion process on distal half of posterior surface; terminal process short, clawlike, distinct from segment.

Discussion.—The Hawaiian specimens differ from the description given by Shiino (1956b) primarily in the characteristics of the male: the shorter cephalothorax and longer trunk, the presence of 3 instead of 2 tuberculated bulges (adhesion pads) on the first segment of the maxilliped, and the presence of 2 spinules on the exopodite of the antenna. Whether or not these differences warrant specific consideration remains questionable. The similarity of the female and the males, with the exceptions here noted, and the broad distribution of the parasite and the pelagic hosts that it characteristically parasitizes suggest, to the present author, that these differences are due to intraspecific variation.

***Brachiella regia*, new species**

Figures 68, 69

Material.—Two females and 2 males from the gill arches of *Lampris regius* (Bonnet) captured in the Oahu region and examined by Walter Fujii, at the Honolulu Aquarium. One of the females (USNM 112936) has been designated as the holotype, 1 of the males (USNM 113033) as the allotype, and the remaining male and female (USNM 113034) have been designated as paratypes.

Measurements.—(In mm) 1 female and 1 male:

	female
Total length, excluding lateral posterior processes but including median projection	9.08
Length of cephalothorax, anterior to maxillae	4.70
Width of anterior region of cephalothorax	0.86
Length from maxillae to trunk	0.78
Width of posterior region of cephalothorax (at maxilla)	0.99
Length of trunk	3.07
Width of trunk	1.60
Length of median posterior process	1.11
Length of dorsal posterior processes	0.52
Length of ventral posterior processes	0.58
Length of egg string	2.48
	male
Total length, excluding posterior processes	3.44
Length of prosome	1.08
Width of prosome	0.90
Length of urosome	2.25
Width of urosome	0.81
Width at constriction between prosome and urosome	0.77

Description of female.—Body (fig. 68*a*) 2-parted, anterior part consisting of cephalothorax, posterior of trunk. Cephalothorax elongate, at sharp angle to longitudinal axis of trunk, consisting of cephalon and maxilliped-bearing segment; anterior third with heavily sclerotized tergum. Trunk, excluding posterior processes, approximately three-fourths the length of cephalothorax, separable from cephalothorax by distinct groove on lateral and ventral surfaces, groove not as distinct dorsally. Trunk flattened dorsoventrally, basically rectangular from dorsal viewpoint although with numerous small irregularities. Posterior end (fig. 68*c*) with 2 pairs of short, knoblike processes laterally, with rounded projection on ventral median surface.

Antennules, antennae, maxillules, maxillae, and maxillipeds covered with thick layer of cuticular material, material overlying thin, darker inner layer. Segment division of mentioned appendages not extending through outer layer although usually discernible and distinct in inner layer.

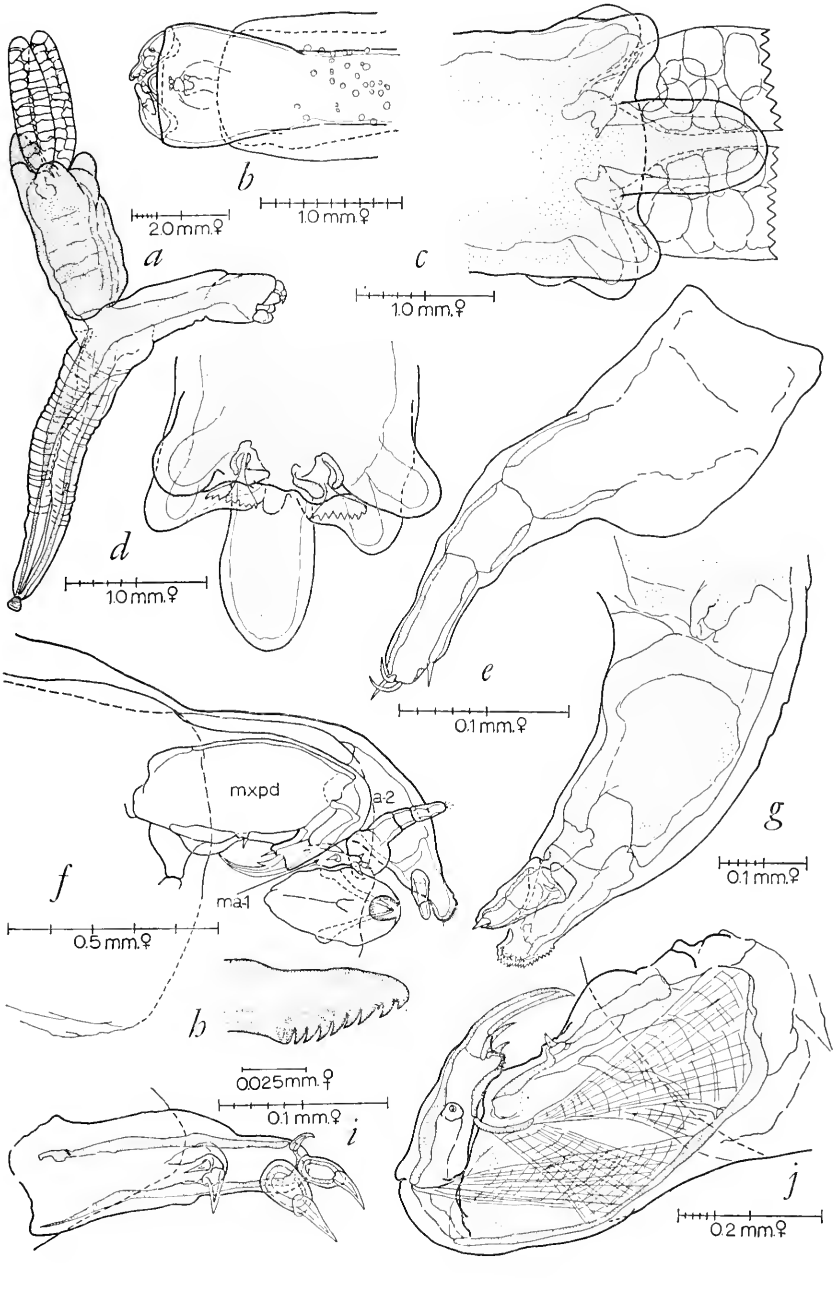
Antennule (fig. 68*e*) 3-segmented, situated on ventral anterior surface of cephalothorax. First segment large, irregular, approximately 1¼ times the combined lengths of second and third segments. Second segment slightly more than half the length of third; third segment elongate, rounded distally, distal end with 4 naked setules. Antenna (fig. 68*g*) biramous, originating from lateral anterior surface of cephalothorax. Protopodite 1-segmented, inner, darker portion of cuticle forming 3 knob-shaped proximal processes articulating with indentations on knob-shaped processes of cephalothorax. Distal end of protopodite irregular, indistinct along inner surface, at origin of endopodite. Exopodite appearing 1-segmented, approximately three-fourths the length of protopodite. Distal end of exopodite curved inward slightly, outer margin broadly convex, surface finely denticulated, inner margin broadly concave. Endopodite small, 2-segmented, first segment slightly longer than second, second with spinule on distal end.

Mandible (fig. 68*h*) appearing 3-parted, proximal part broad proximally, tapered abruptly, remaining parts tapered gradually to bluntly rounded distal end. Inner surface of distal part with 8–10 primary denticulations and 2 secondary denticulations, 1 between the first and second primary denticulations, the other between the second and third. Maxillule (fig. 68*i*) situated just posterior to mandible base, consisting of stalk bearing palp on median posterior surface, palp with 2 spinules distally; distal surface of maxillule with 2 nodules and spinule, both nodules with spinule distally. Maxillae (fig. 68*a*) elongate, approximately 1¼ times the length of cephalothorax, situated at posterior end of cephalothorax, well behind maxillipeds. Maxillae separate to distal end, attached to small, top-shaped bulla.

Maxilliped (fig. 68*j*) 2-segmented, extending anteriorly from pad-like ledge slightly posterior to mouth cone. First segment strongly developed, with smoothly irregular outline, bearing small, spinule-like projection from medial inner surface. Second segment elongate, with nodule on medial ventral surface, nodule bearing minute, subconical projection. Distal end of second segment irregular, with step-like indentation on inner surface, bearing 2 small, spinelike accessory processes from inner surface and single, large, clawlike terminal process.

Description of male.—Body (figs. 69*a*, *b*) tapered at both ends, lateral margins parallel throughout most of length although constric-

FIGURE 68.—*Brachiella regia*, new species, female: *a*, lateral view; *b*, anterior portion of cephalothorax, dorsal view showing irregular cuticular splotches; *c*, posterior region of trunk showing posterior processes and portion of egg strings, ventral view; *d*, same, from dorsal viewpoint with all except base of egg strings removed; *e*, left antennule, ventral view; *f*, oral region, right side showing antennule, antenna (a-2), mouth cone, mandible, maxillule (ma-1), and maxilliped (mxpd), ventral view; *g*, right antenna, ventral view; *h*, denticulated portion of mandible, lateral view [drawn by Z. Kabata]; *i*, right maxillule, ventral view; *j*, right maxilliped, ventral view.


a
2.0 mm.♀
b
1.0 mm.♀
c
1.0 mm.♀
d
1.0 mm.♀
e
0.1 mm.♀
mxpd
a-2
ma-1
f
0.5 mm.♀
g
0.1 mm.♀
h
0.025mm.♀
0.1 mm.♀
i
j
0.2 mm.♀

tion present immediately posterior to maxillipeds in 1 specimen (not shown in figures). Posterior region with pair of unarmed subterminal dorsal flaps (caudal rami?) and pair of slightly projecting, knoblike terminal processes. Anterior third of body heavily sclerotized dorsally; mouth cone projecting anteriorly and ventrally, slightly past anterior end of cephalothorax.

Antennule (fig. 69*c*) 3-segmented, situated lateral and slightly posterior to anterior edge of mouth cone base. First segment more than 1½ times the combined lengths of second and third segments,

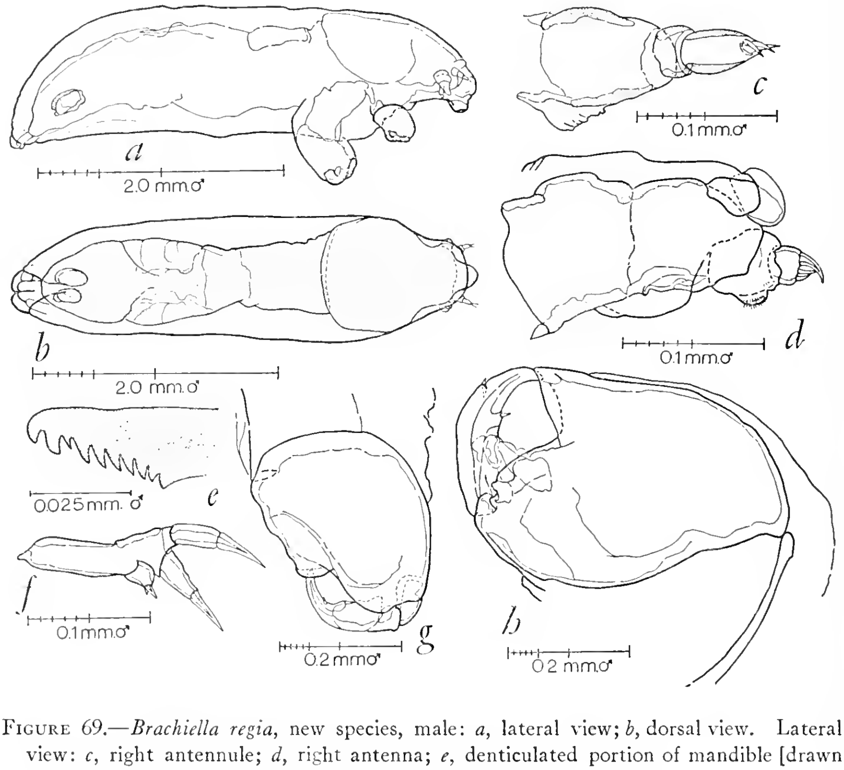


FIGURE 69.—*Brachiella regia*, new species, male: *a*, lateral view; *b*, dorsal view. Lateral view: *c*, right antennule; *d*, right antenna; *e*, denticulated portion of mandible [drawn by Z. Kabata]; *f*, right maxillule; *g*, right maxilla; *h*, right maxilliped.

broad proximally, tapered slightly to distal end. Second segment short, collar shaped; third segment dactyliform, approximately twice the length of second, distal end rounded, tipped by 3 naked setules. Antenna (fig. 69*d*) biramous, situated slightly posterior and lateral to antennule base. Protopodite 2-segmented, segments of approximately equal size, both irregular in outline. Exopodite 1-segmented, small, less than one-third the length of protopodite, broadly rounded distally, without armature. Endopodite 2-segmented, slightly more than one-third the length of protopodite. First segment approximately twice the length of second, with small, finely denticulated knob on inner surface. Distal surface of second segment flattened, with 2 small spinules on inner half and single, larger spinule on outer half.

Mandible (fig. 69*e*) appearing 3-parted, rodlike; distalmost part flattened, inner surface with 9 denticulations, the third slightly smaller and considered a secondary denticulation by Kabata (from correspondence). Maxillule (fig. 69*f*) adjacent to posterior lateral portion of mouth cone base, consisting of stalk bearing single palp on median posterior surface, palp with 2 terminal spinules; 2 elongate, spinule-tipped dactyliform processes present on distal end of maxillule. Maxilla (fig. 69*g*) prehensile, 2-segmented, situated well posterior to mouth cone base. First segment strongly developed, proximal and outer margins flatly convex, inner surface indented medially, indentation with pocket-like depression receiving terminal process of second segment when segment flexed. Second segment short, heavily sclerotized, fused with clawlike terminal process, and bearing minute, spinelike accessory process on inner surface.

Maxilliped (fig. 69*h*) 2-segmented, originating from irregular projection immediately posterior to maxillae. First segment strongly developed, narrow proximally, flared to broad distal half; inner surface indented distally, indentation with small concavity receiving terminal process of second segment when segment flexed. Second segment small, heavily sclerotized, fused with clawlike terminal process, bearing small, spinelike accessory process from inner surface and minute, spinule-like process from outer surface.

Discussion.—The species is placed in the genus *Brachiella* because the female cephalothorax is elongate and cylindrical, is flexed backward, and is "covered" by a heavily sclerotized tergum. Additionally, the trunk of the female is swollen and flattened dorsoventrally, there are 4 pairs of posterior processes, an unpaired genital process is present, and there is no visible abdomen or caudal rami. The characteristics of the male cast some doubt on the inclusion of the species in *Brachiella*. The prosome and urosome of the figured specimen are in an essentially straight line although the urosome of the second male specimen is at an angle to the prosome. The author is deeply indebted to Dr. Z. Kabata for a rather exhaustive examination of the paratype material and a comparison of the male with the male of *Andropoda lampri* (Scott, 1901). Based upon the comparison of the males of *B. regia* and *A. lampri* and upon the similarity of the female of *B. regia* with other members of the genus *Brachiella*, the species is presently placed within this genus.

The female of *Brachiella regia* shows some affinities with species such as *B. concava* Wilson, 1913, and *B. gracilis* Wilson, 1908, in the nature of the cephalothorax and maxillae. Additionally, the short posterior processes of the female are comparable with those of *B. pteroplateae* Yamaguti and Yamasu, 1959, *B. bera* Yamaguti, 1939c, and *B. mitrata* Wilson, 1915. The combination of the long reflexed cephalothorax, the long maxillae, the short posterior processes, and the large genital process is, however, unique.

The male shows some affinities with the male of *B. thynni* Cuvier, 1829, in the general nature of the body. The appendages of the cephalothorax, however, are strongly reminiscent of those of *Andropoda lampri* (Scott, 1901), although the mandible has one denticulation that Kabata (correspondence) terms a secondary tooth, while the denticulations in *A. lampri* are homogeneous. There is some variation in the denticulation of the mandible of both the female and the male, the female possessing 8–10 primary denticulations, the male "secondary tooth" being slightly larger in the unfigured male than in the figured male. Further, the posterior end of the male of *B. regia* does not protrude as in *Andropoda lampri*, and the posterior processes are not as distinct and do not project past the thick, heavily sclerotized cuticle.

The species name is derived from the name of the host, *Lampris regius*.

Family Naobranchiidae

Naobranchia Hesse, 1863

Diagnosis.—Female: Cephalothorax elongate, vermiform; trunk swollen, anterior end including maxilla-bearing segment. Abdomen and caudal rami usually distinct although sometimes covered by egg masses. Eggs enclosed in membranous extension of cuticle, enveloping posterior and at least part of lateral surface of trunk. Antennule 2–5 segmented; antenna biramous. Mandible rodlike. Maxillule bipartite, with or without palp; maxilla foliaceous, usually with muscle bands extending length of appendage, forming organ of attachment that envelops gill filaments of host. Maxilliped 2-segmented, second segment fused with clawlike terminal process. Oval adhesion pads or cup-shaped structures may be present adjacent to maxillipeds.

Male: See Yamaguti, 1963, p. 303.

Naobranchia species

Figure 70

Material.—One female (USNM 112937) from gill cavity of spotted moray eel from Honolulu Aquarium.

MEASUREMENTS.—(In mm) 1 female:

	female
Total length, including egg masses	3. 75
Length of cephalothorax, to maxillae	2. 30
Length of cephalothorax, to maxillipeds	0. 36
Width of anterior region of cephalothorax	0. 37
Width of posterior region of cephalothorax, just anterior to maxillae	0. 94
Length from anterior to posterior end of maxillae	0. 94
Width of base of maxillae	0. 80
Length of trunk	2. 00
Width of trunk	2. 33

DESCRIPTION OF FEMALE.—Body (figs. 70*a*, *b*) separable into 2 parts, vermiform cephalothorax and broad, posteriorly rounded trunk. Anterior end of cephalothorax slightly expanded, from dorsal viewpoint; tapered to narrow, rounded end, in lateral view, ventral surface bearing antennules, antennae, mandibles, maxillules, and maxillipeds. Margin of anterior end of cephalothorax with heavily sclerotized band broken by several minute swellings associated with minute channels through band, similar to nodules bearing hairlike processes on caligoids. Remaining part of cephalothorax irregular (irregularities may be due to preservation), with several superficial, incomplete annuli. Trunk expanded, rounded from dorsal and ventral viewpoints, overlapping dorsal posterior end of cephalothorax; lateral and posterior surfaces covered by egg cases, cases projecting dorsally at flat angle giving semi V-shaped appearance in transverse section. No abdomen visible although possibly covered by egg cases; caudal rami not distinct although 2 minute, knoblike projections present between egg cases at posterior end of trunk, projections not visible unless egg cases separated. Outer covering of egg cases appearing thick, with moderately sclerotized band on lateral region.

Because of the small size of the appendages, with the exception of the second maxillae and maxillipeds, the presence of only a single specimen in the collection and the resultant hesitancy to dissect the appendages, the following description should be used with some caution.

Antennule (fig. 70*d*) situated on lateral-median ventral surface of cephalothorax, behind anterior end of body and slightly lateral to mouth cone. Appendage 3-segmented, first segment longer than combined lengths of remaining 2 segments; third segment bearing 4 minute, subconical projections. Antenna (fig. 70*e*) situated between antennule and base of labrum, appearing uniramous; 2-segmented, tipped by clawlike projection. Mouth cone distinct though small, with distinct space between labrum and labium. Labrum appearing pointed distally, with heavily sclerotized band medially; labium with U-shaped opening distally. Mandible (fig. 70*e*) rodlike, flattened distally, with approximately 6 falciform denticulations along distal inner margin. Maxillule (fig. 70*e*) nodular, situated adjacent to posterior lateral surface of labium base, with 2 setule-like projections distally. Maxillae (fig. 70*f*) fused, foliaceous, situated at posterior

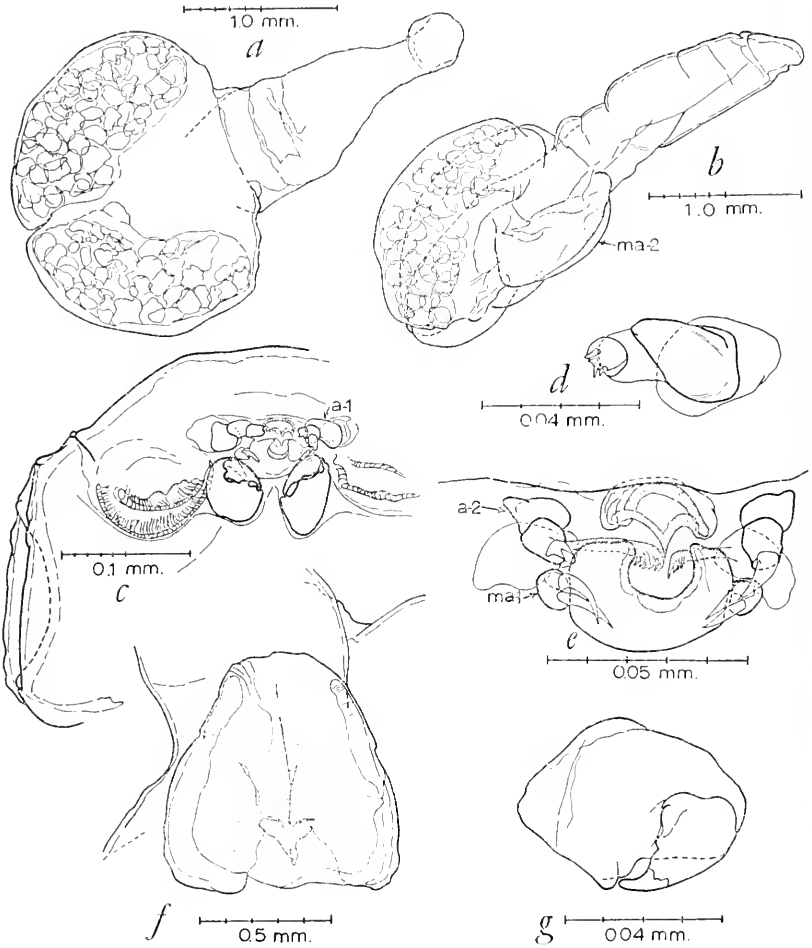


FIGURE 70.—*Naobranchia* species, female: *a*, dorsal view; *b*, lateral view (ma-2=maxillae). Ventral view: *c*, anterior end of cephalothorax showing antennules (a-1) (antennae hidden under antennules and not visible), mouth cone, maxillules, maxillipeds, and cup-shaped structure lateral to mouth cone; *d*, left antennule; *e*, oral region showing antenna (a-2), mouth cone, mandibles, and maxillule (ma-1); *f*, maxilla; *g*, right maxilliped.

end of vermiform cephalothorax and included in anterior portion of trunk. Fused maxillae forming obcordate ventral projection, fusion appearing to be at distal ends of maxillae, not with body; maxillae without distinct muscle bands.

Maxilliped (fig. 70*g*) 2-segmented, situated in small concavity slightly posterior and lateral to labium base. First segment with shelflike indentation on distal half of inner surface, shelf with pair of nodules forming depression receiving distal end of second segment terminal process when segment flexed. Second segment small, subconical, tipped by indistinctly separable, claw-shaped terminal process.

Semicircular cuplike cuticular (?) formation present lateral to maxilliped base, extending anteriorly to region of antennule base. Posterior surface of formation with pair of membranous, flangelike projections bearing fine indistinct grooves.

Discussion.—The single specimen has several distinctive features. The presence of the semicircular cuplike formation (adhesion pads?) is found in *N. aulopi* Yamaguti (1939c), although in this species they are oriented in a longitudinal direction while in the Hawaiian specimen they are oriented laterally. The apparent lack of muscle bands in the maxillae and the fusion of these 2 appendages to each other and not the body surface may be diagnostic although it may instead suggest an immature condition as Pearse (1952a, fig. 126) indicates for *N. spinosa* Pearse. The possible immature condition of the specimen may also explain the distinctive cuplike structures. Yamaguti (1939c) figures a distinct cuplike structure for a 3.2 mm specimen of *N. aulopi* while Shiino (1958) states "striated pads just behind 2nd maxillipeds [= maxillipeds] rather low and inconspicuous" in a 5.07 mm specimen of *N. aulopi*. Both of these authors figure the adult female with eggs so that if this is a characteristic of immature specimens, the pad is still present at the time ovulation commences. In adult female specimens of *N. variabilis* Brian, deposited by R. Bere in the U.S. National Museum (79146), there is no distinct process of this type although there is a slight concavity in the same region and curved, heavily sclerotized rodlike structures are visible in the cuticle.

The Hawaiian specimen appears to most closely resemble *N. variabilis* Brian. The similarity is not only in the general shape of the body in the 3-segmented antennule although Pillai (1962a) describes a 5-segmented appendage for this species. The antenna of the Hawaiian specimen is here described as uniramous although with some question. The maxillules and maxillipeds also are similar to those described for *N. variabilis* by Bere (1936) and Pillai (1962a).

Host-Parasite List

The list given below provides the scientific and common name of the host, when available, and the parasitic copepods taken from it in Hawaiian waters. The list includes the copepods described in the present paper and in Lewis, 1964a,b, 1966. With few exceptions, the hosts are arranged in the same sequence used by Gosline and Brock (1960) in their "Handbook of Hawaiian Fishes."

host	*copepod parasites*
Carcharodon carcharias (white shark)	*Anthosoma crassum*
	Dinematura latifolia
Prionace glauca (great blue shark)	*Pandarus satyrus*
	Phyllothyreus cornutus
Galeocerdo cuvier (tiger shark)	*Nesippus crypturus*
	Alebion echinatus
Pterolamiops longimanus (whitetip shark)	*Pandarus cranchii*
Carcharhinus melanopterus? (blacktip shark)	*Pandarus smithii*
Sphyrna lewini (hammerhead shark)	*Kroyeria praelongacicula*
	Pandarus cranchii
	Alebion echinatus
	Paeon vaissierei
Hexanchus griseus?	*Demoleus heptapus*
Unidentified sharks	*Alebion gracilis*
	Dinematura latifolia
	Pandarus cranchii
	Pandarus smithii
?*Aetobatus narinari* (eagle ray)	*Trebius caudatus*
Saurida gracilis (lizard fish)	*Caligus kala*
Muraenidae (moray eels)	*Pseudotaeniacanthus puhi*
	Naobranchia species
Fistularia petimba (cornet fish)	*Dentigryps bifurcatus*
Aulostomus chinensis (trumpet fish)	*Nesippus costatus*?
	Dentigryps bifurcatus
	Caligus ligatus
	Caligus flexispina
Holocentrus xantherythrus	*Caligus ligatus*
Myripristis pralinius	*Nesippus costatus*?
Lampris regius	*Brachiella regia*
Sphyraena barracuda	*Midias lobodes*
Pranesus insularum?	*Caligus ligatus*
Seriola dumerilii (yellowtail)	*Nesippus costatus*?
Caranx melampygus?	*Dentigryps ulua*
	Caligus longipedis
Coryphaena hippurus (dolphin)	*Euryphorus nordmanni*
	Caligus coryphaenae
	Caligus quadratus
	Charopinopsis quaternia

host	*copepod parasites*
Mulloidichthys auriflamma	*Hatschekia breviramus*
Parupeneus pleurostigma	*Lepeophtheirus dissimulatus*
Chaetodon fremblii	*Dentigryps bifurcatus*
	Caligus kapuhili
Chaetodon quadrimaculatus	*Lepeophtheirus dissimulatus*
Chaetodon miliaris	*Nesippus costatus?*
	Caligus kapuhili
Dascyllus albisella	*Caligus kala*
	Caligus ligatus
Pomacentrus jenkinsi	*Caligus kala*
Bodianus bilunulatus	*Dentigryps bifurcatus*
Unidentified labrid	*Caligus flexispina*
Scarus species	*Nesippus costatus?*
Zanclus canescens	*Nesippus costatus?*
Acanthurus guttatus	*Caligus kalumai*
Acanthurus nigroris	*Nesippus costatus?*
Acanthurus olivaceus	*Dentigryps bifurcatus*
	Lepeophtheirus dissimulatus
	Peniculus calamus?
Acanthurus dussumieri	*Caligus ligatus*
	Lepeophtheirus dissimulatus
	Peniculus calamus?
Acanthurus xanthopterus	*Nesippus costatus?*
Acanthurus mata	*Peniculus calamus?*
Acanthurus triostegus sandvicensis	*Nesippus costatus?*
	Dentigryps bifurcatus
	Lepeophtheirus dissimulatus
	Caligus flexispina
	Caligus randalli
	Peniculus calamus?
Ctenochaetus strigosus	*Nesippus costatus?*
	Peniculus calamus?
Zebrasoma flavescens	*Lepeophtheirus dissimulatus*
Naso lituratus	*Norion expansus*
Naso hexacanthus	*Norion expansus*
	Dentigryps bifurcatus
	Anuretes serratus
	Anuretes menehune
	Lepeophtheirus dissimulatus
	Caligus kala
	Caligus ligatus
	Peniculus calamus?
Naso unicornis	*Anuretes menehune*
	Lepeophtheirus? fallolunulus
	Peniculus calamus?
Acanthocybium solandri (wahoo, ono)	*Gloiopotes hygomianus*
	Brachiella thynni
Auxis thazard (frigate mackerel)	*Caligus productus*
Katsuwonus pelamis (skipjack)	*Caligus coryphaenae*
	Caligus productus
	Caligus bonito

host	*copepod parasites*
Euthynnus yaito (little tuna)	*Caligus coryphaenae*
	Caligus asymmetricus
	Caligus productus
	Caligus pelamydis
Neothunnus macropterus (yellowfin tuna)	*Elytrophora brachyptera*
	Caligus productus
Parathunnus sibi	*Elytrophora brachyptera*
	Brachiella thynni
Thunnus albacares (*in* Shiino, 1963a)	*Brachiella thynni*
Thunnus obesus (*in* Shiino, 1963a)	*Brachiella thynni*
Istiompax marlina? (black marlin)	*Gloiopotes huttoni*
Makaira ampla? (Pacific blue marlin)	*Gloiopotes huttoni*
Makaira audax (striped marlin)	*Pennella histiophori*?
	Gloiopotes huttoni
Remoropsis brachypterus	*Pennella* species
Rhombochirus osteochir	*Lepeophtheirus crassus*
Pervagor spilosoma	*Peniculus calamus*?
Ostracion lentiginosus	*Anchistrotos moa*
Diodon holocanthus	*Nesippus costatus*?
Plankton	*Caligus coryphaenae* (immature male)

Literature Cited

(*Reference not seen by author.)

Baird, W.

1847. On a new species of *Pennella.* Ann. Mag. Nat. Hist., vol. 19, p. 280, 1 fig.

Barnard, K. H.

1955. South African parasitic Copepoda. Ann. South African Mus., vol. 41, no. 4, pp. 223–312, figs. 1–33.

1957. Additions to the fauna-list of South African Crustacea. Ann. Mag. Nat. Hist., ser. 12, vol. 10, pp. 1–12, figs. 1–8.

Bassett-Smith, P. W.

1896a. A list of the parasitic Copepoda of fish obtained at Plymouth. Journ. Mar. Biol. Assoc. United Kingdom, vol. 4, no. 2, pp. 155–163.

1896b. Notes on the parasitic Copepoda of fish obtained at Plymouth, with descriptions of new species. Ann. Mag. Nat. Hist., ser. 6, vol. 18, pp. 8–16, pls. 3–6.

1898a. Further new parasitic copepods found on fish in the Indo-Tropical region. Ann. Mag. Nat. Hist., ser. 7, vol. 2, pp. 77–98, pls. 3–6.

1898b. Some new or rare parasitic copepods found on fish in the Indo-Tropical Region. Ann. Mag. Nat. Hist., ser. 7, vol. 2, pp. 357–372, pls. 10–12.

1899. A systematic description of parasitic Copepoda found on fishes, with an enumeration of the known species. Proc. Zool. Soc. London, pp. 437–507.

Bere, Ruby

1936. Parasitic copepods from Gulf of Mexico fish. American Midl. Nat., vol. 17, no. 3, pp. 577–625, pls. 1–12.

Bonnet, D.

1948. Some parasitic copepods from Hawaiian fishes. Proc. Hawaiian Acad. Sci., no. 23, p. 7.

Brady, G. S.

*1910. Die marinen Copepoden, 1: Ueber die Copepoden der Stämme Harpacticoida, Cyclopoida, Notodelphyoida und Caligoida. No. 8 (vol. 5) *in* Zoology (vol. 11) *in* Drygalski, Deutsche Südpolar-Expedition 1901–1903, pp. 497–593.

Brian, Alessandro

1898. Catologo di copepodi parassiti dei pesci della Liguria. Atti Soc. Ligustica Sci. Nat. Geogr., vol. 9, pp. 5–31, pls. 1–4.

1899a. Di alcuni crostacei parassiti dei pesci dell'Isola d'Elba. Atti Soc. Ligustica Sci. Nat. Geogr., vol. 10, pp. 3–10, figs. 1–5.

1899b. Crostacei parassiti dei pesci dell'Isola d'Elbe, 2: Contribuzione. Atti Soc. Ligustica Sci. Nat. Geogr., vol. 10, pp. 197–207.

1901. Caso di anomalia verificatosi su di una *Brachiella* del Tonno. Bull. Mus. Zool. Anat. Comp. Univ. Genova, 3 pp., 1 fig.

1903. Sulla *Lophoura edwardsii* Kolliker e sopra alcuni altri copepodi del Golfo di Genova. Atti Soc. Ligustica Sci. Nat. Geogr., vol. 14, pp. 3–11.

226-321—67——13

BRIAN, ALESSANDRO

1905. Sui copepodi raccolti nei golfo di Napoli da Oronzio G. ed Achille Costa. Ann. Mus. Zool. Regia Univ. Napoli, n.s., vol. 1, no. 24, pp. 1-11, pls. 3–4.

1906. Copepodi parassiti dei pesci d'Italia, 191 pp., 21 pls.

1908. Note préliminaire sur les copépodes parasites des poissons provenant des campagnes scientifiques de S.A.S. le Prince Albert I[er] de Monaco ou déposés dans les collections du musée oceanographique. Bull. Inst. Oceanogr. Monaco, no. 110, pp. 1–19, figs.1–7.

*1912. Copépodes parasites des poissons et des échinidés provenant des Campagnes Scientifiques de S.A.S. le Prince Albert I[er] de Monaco (1886–1910). Vol. 38 *in* Albert Honoré Charles, Resultats de Campagnes Scientifiques accomplies sur son Yacht . . . , 58 pp.

1913. Di una nuova specie de *Hatschekia* Poche (*Clavella* Oken) copepode parassita del *Crenilabrus pavo.* (*H. subpinguis* n. sp.). Estr. Monit. Zool. Italiano, vol. 24, no. 3, pp. 60–65, pl. 3.

1924. Parasitologia Mauritanica: Matériaux pour la faune parasitologique en Mauritanie. Bull. Com. Etud. Hist. Sci. Afiique Occ. Franc., vol. 1, no. 1, pp. 1–66, figs. 1–67.

1935. I *Caligus* parassiti dei pesci del Mediterraneo (Copepodi). Estr. Ann. Mus. Civ. Stor. Nat. Genova, vol. 57, no. 7, pp. 152–211, figs. 1–20.

CAPART, ANDRÉ

1953. Quelques copépodes parasites de poissons marins de la région de Dakar. Bull. Inst. Français d'Afrique Noire, vol. 15, no. 2, pp. 646–671, figs. 1–10.

1959. Copépodes parasites. In Expédition Océanographique Belge dans les Eaux Côtières Africaines de l'Atlantique Sud (1948–1949): Résultats scientifiques, vol. 3, no. 5 pp. 56–126, figs. 1–37.

CARUS, J. V.

1885. Coelenterata, Echinodermata, Vermes, Arthropoda. Vol. 1 of Prodromus faunae Mediterraneae sive descriptio animalium Maris Mediterranei incolarum . . . , XI + 525 pp.

CAUSEY, DAVID

1953a. Parasitic Copepoda from Grand Isle, Louisiana. Occ. Pap. Mar. Lab. Louisiana State Univ., no. 7, 18 pp., 3 pls.

1953b. Parasitic Copepoda of Texas coastal fishes. Publ. Inst. Mar. Sci. Univ. Texas, vol. 3, no. 1, pp. 7–16, figs. 1–15.

1955. Parasitic Copepoda from Gulf of Mexico fish. Occ. Pap. Mar. Lab. Louisiana State Univ., no. 9, 19 pp., 3 pls.

1960. Parasitic Copepoda from Mexican coastal fishes. Bull. Mar. Sci. Gulf and Caribbean, vol. 10, no. 3, pp. 323–337, figs. 1–2.

CLAUS, C.

1864. Beiträge zur Kenntniss der Schmarotzerkrebse. Zeitschr. Wiss. Zool., vol. 14, pp. 365–383, pls. 33–36.

CUVIER, G. L.

*1829. Le Règne Animal, vol. 3, pp. 255–258; vol. 4, pp. 189–202.

DANA J. D.

1853; 1855. Crustacea. Pt. 2 *of* vol. 13 *in* United States Exploring Expedition during the years 1838, 1839, 1840, 1841, 1842 under the command of Charles Wilkes, U.S.N., 1618 pp. (1853); atlas, 27 pp., 96 pls. (1855).

DELAMARE-DEBOUTTEVILLE, CLAUDE, and NUNES-RUIVO, L. P.
1951. Étude de *Pennella remorae* Murray et remarques sur la biologie et la systématiques des *Pennella* Öken. Rev. Fac. Ciénc. Lisboa, ser. 2ª, vol. 1, no. 2, pp. 341–352, figs. 1–9.
1953. Copépodes parasites des poissons méditerranéens. Vie et Milieu, vol. 4, no. 2, pp. 201–218, figs. 1–9.
1954. Parasites des poissons de mer ouest-africains récoltés par M. J. Cadenat. Bull. Inst. Français d'Afrique Noire, ser. A, vol. 16, no. 1, pp. 139–166, figs. 1–16.

EDMONDSON, C. H.
1946. Reef and shore fauna of Hawaii. Bernice P. Bishop Mus. Spec. Publ. 22, Honolulu, iii + 381 pp., 223 figs.

FAGE, L.
1931. Remarques sur le parasitisme des copépodes du genre *Pennella*. Bull. Soc. Zool. France, vol. 56, no. 1, pp. 190–193.

FOWLER, H. W.
1912. Crustacea of New Jersey. Ann. Rep. New Jersey State Mus., 1911, 651 pp., 150 pls.

GERSTAECKER, A.
1853. Ueber eine neue und eine weniger gekannte Siphonostomen gattung. Arch. Naturg., vol. 19, no. 1, pp. 58–70, pls. 1–3.

GOSLINE, W. A., and BROCK, V. E.
1960. Handbook of Hawaiian fishes, ix + 372 pp., 277 figs.

GRAEFFE, E.
*1902. Übersicht der Fauna des Golfes von Triest nebst Notizen über Vorkommen, Lebensweise, Erscheinungsung Laichzeit der einzelnen Arten, 5: Crustacea. Arb. Zool. Inst. Wien, vol. 13, pp. 3–17.

GUÉRIN-MÉNEVILLE, F. E.
*1829–1844. Crustacés. Vol. 2 *of* Iconographie du règne animal.

GUIART, J.
1913. Crustacés commensaux et parasites de la baie de Concarneau. Bull. Inst. Océanogr. Monaco, no. 264, pp. 1–11, figs. 1–2.

HEEGAARD, P.
1940. Some new parasitic copepods (Chondracanthidae and Lernaeopodidae) from western Australia. Vidensk. Medd. Dansk. Naturh. Foren., vol. 104, pp. 87–101, figs. 1–28.
1943a. Some new caligids from the Gilbert Islands. Ark. Zool., vol. 34A, no. 16, pp. 1–12, figs. 1–3.
1943b. Parasitic copepods mainly from tropical and Antarctic seas. Ark. Zool., vol. 34A, no. 18, pp. 1–37, figs. 1–94.
1945. Some parasitic copepods from fishes in the Uppsala University collections. Ark. Zool., vol. 35A, no. 18, pp. 1–27, figs. 1–54.
1949. Notes on parasitic copepods. Vidensk. Medd. Dansk. Naturh. Foren., vol. 111, pp. 235–245, figs. 1–10.
1955. Parasitic copepods from tropical west Africa. Atlantide Rep. 3, pp. 41–56, figs. 1–20.
1962. Parasitic Copepoda from Australian waters. Rec. Australian Mus., vol. 25, no. 9, pp. 149–233, figs. 1–250.

HELLER, C.
1865. Crustaceen. No. 8 *in* vol. 2 of Zoologischer Theil *in* Reise der Oesterreichischen Fregatte *Novara* . . in den Jahren 1857, 1858, und 1859 . . . , 280 pp., 25 pls.

HELLER, C.

1866. Carcinologische Beiträge zur Fauna des adriatischen Meeres. Verh. Kais.-Königl. Zool.-Bot. Ges. Wien, pp. 723–760.

HESSE, C. E.

*1863. Recherches sur quelques Crustacés rares ou nouveaux des côtes de France, 3^{me} Mem.: *Naobranchia cygniformis.* Ann. Sci. Nat., ser. 4, vol. 20, pp. 101–132, 1 pl.

1878. Description des crustacés rares ou nouveaux des côtes de France. Ann. Sci. Nat., vol. 8, no. 14, pp. 1–34, pls. 19–21.

HEWITT, G. C.

1963. Some New Zealand parasitic Copepoda of the family Caligidae. Trans. Roy. Soc. New Zealand, Zool. vol. 4, no. 3, pp. 61–115, figs. 1–14.

1964a. A redescription of *Gloiopotes huttoni* (Thomson, 1889), with a key to the species of the genus. Trans. Roy. Soc. New Zealand, Zool., vol. 5, no. 8, pp. 85–96, figs. 1–16.

1964b. A new species of *Caligus* (Copepoda) on a species of *Tripterygion* from New Zealand. Trans. Roy. Soc. New Zealand, Zool., vol. 5, no. 10, pp. 123–130, figs. 1–2.

HO, JU-SHEY

1963. On five species of Formosan parasitic copepods belonging to the suborder Caligoida. Crustaceana, vol. 5, no. 2, pp. 81–98, figs. 1–22.

HOLTEN, H. S.

1802. *Lernaea merluccii* og *exocoeti* to nye Arter. Skr. Naturh. Selsk. Kjöbenhavn, vol. 2, pp. 135–137.

HUMES, A. G., and ROSENFIELD, D. C.

1960. *Anchistrotos occidentalis* C.B. Wilson, 1924 (Crustacea, Copepoda), a parasite of the orange filefish. Crustaceana, vol. 1, no. 3, pp. 179–187, figs. 1–26.

HUTTON F.W.

*1904. Index Faunae Novae Zealandiae, viii + 372 pp.

KABATA, Z.

1965a. *Andropoda,* a new genus of Lernaeopodidae (Copepoda) from the gills of *Lampris luna* (Gmelin). Crustaceana, vol. 8, no. 2, pp. 213–221, figs. 1–2.

1965b. Copepoda parasitic on Australian fishes, IV: Genus *Caligus* (Caligidae). Ann. Mag. Nat. Hist., ser. 13, vol. 8, pp. 109–126, figs. 1–6.

KIRTISINGHE, P.

1932. *Pennella zeylanica* n.sp., a parasitic copepod of *Histiophorus gladius* Day. Parasitology, vol. 24, pp. 137–139, figs. 1–5.

1934. *Gloiopotes watsoni* n.sp. and *Lernaeenicus seeri* n.sp., parasitic copepods of fish from Ceylon. Parasitology, vol. 26, no. 2, pp. 167–175, figs. 1–21.

1935. Parasitic copepods of fish from Ceylon. Parasitology, vol. 27, no. 3, pp. 332–344, figs. 1–46.

1937. Parasitic copepods of fish from Ceylon, 2. Parasitology, vol. 29, no. 4, pp. 435–452, figs. 1–107.

1964. A review of the parasitic copepods of fish recorded from Ceylon with descriptions of additional forms. Bull. Fish. Res. Sta. Ceylon, vol. 17, no. 1, pp. 45–132, figs. 1–191.

KNER, R.

1859. Über mänchen und weibchen von *Euryphorus nordmanni* M. Edw. Sitzungsb. Akad. Wiss. Wien (Math.-Naturwiss.), vol. 34, pp. 268–274, figs. 1–3.

KRØYER, H.

1835. Om Snyltekrebsene, isaer med Hensyn til den Danske Fauna: Om Lernaeerne i Almindelighed. *In* Naturhistorisk Tidsskrift, vol. 1, no. 2, pp. 172–189, pl. 2.

1838. Om Snyltekrebsene, isaer med Hensyn til den Danske Fauna. *In* Naturhistorisk Tidsskrift, vol. 2, pp. 8–52, pl. 1; pp. 131–137, pl. 3.

1863. Bidrag til Kundskab om Snyltekrebsene. *In* Naturhistorisk Tidsskrift, pp. 75–320, pls. 1–18.

KURIAN, C. V.

1955. Parasitic copepods of Travancore-Cochin. Bull. Cent. Res. Inst. Univ. Travancore, ser. C, vol. 4, no. 1, pp. 103–116, figs. 1–38.

1961. Parasitic copepods of fishes from Kerala. Bull. Cent. Res. Inst. Univ. Kerala, ser. C. (Nat. Sci.), vol. 8, no. 3, pp. 63–77, figs. 1–37.

LEIGH-SHARPE, W. H.

1926. A list of parasitic Copepoda found at Plymouth. Parasitology, vol. 28, no. 4, pp. 384–386, fig. 1.

1928. The genus *Pennella* (Copepoda) as represented by the collection in the British Museum. Parasitology, vol. 20, no. 1, pp. 79–89, figs. 1–7.

1930. Resultats scientifiques du voyage aux Indes Orientales Néerlandaises de LL. AA. RR. le Prince et la Princesse Léopold de Belgique, vol. 3, no. 2, pp. 1–9, pls. 1–5.

1931. *Pennella germonia* n. sp., a parasitic copepod of *Germo alatunga* [sic]. Parasitology, vol. 23, no. 1, pp. 109–111, 1 fig.

1933. A list of British fishes with their characteristic parasitic Copepoda. Parasitology, vol. 25, no. 1, pp. 109–112.

1934. The Copepoda of the *Siboga* Expedition, 2: Commensal and parasitic Copepoda. No. 123 (vol. 29b) *in* Weber, *Siboga* Expeditie . . ., viii + 44, 39 figs.

1935. *Anchistrotos laqueus* n. sp., a parasitic copepod of *Serranus cabrilla*. Parasitology, vol. 27, no. 2, pp. 266–269, figs. 1–3.

1936. New parasitic Copepoda from Naples. Parasitology, vol. 28, no. 1, pp. 63–71, figs. 1–9.

LEWIS, A. G.

1963. Life history of the caligid copepod *Lepeophtheirus dissimulatus* Wilson, 1905 (Crustacea: Caligoida). Pacific Sci., vol. 17, no. 2, pp. 195–242, figs. 1–20.

1964a. Caligoid copepods (Crustacea) of the Hawaiian Islands: parasitic on fishes of the family Acanthuridae. Proc. U.S. Nat. Mus., vol. 115, no. 3482, pp. 137–244, figs. 1–24.

1964b. The caligid copepod genus *Dentigryps* (Crustacea: Caligoida). Proc. U.S. Nat. Mus., vol. 115, no. 3487, pp. 347–380, figs. 1–13.

1966. Copepod crustaceans parasitic on elasmobranch fishes of the Hawaiian Islands. Proc. U.S. Nat. Mus., vol. 118, no. 3524, pp. 57–154, figs. 1–40.

LINTON, E.

1907. Notes on parasites of Bermuda fishes. Proc. U.S. Nat. Mus., vol. 33, no. 1560, pp. 85–126, pls. 1–2.

MARUKAWA, H.
*1925. *In* Illustrated encyclopaedia of the fauna of Japan, 1243 pp., 2396 figs.
*1947. *In* Illustrated encyclopaedia of the fauna of Japan, exclusive of Insecta, rev. ed., 927 pp., 2654 figs.

MICULICICH, V. M.
1904. Ein neuer Lernaeopodide. Zool. Anz., vol. 28, no. 2, pp. 47–52, figs. 1–2.
1905a. Zur Kenntnis der Gattung *Brachiella* Cuv. und der Organisation der Lernaeopodiden. Zool. Anz., vol. 28, no. 18, pp. 599–620, figs. 1–7.
1905b. Weitere Mitteilungen zur Kenntnis der Gattung *Brachiella* Cuv. Nach trag zu dem Aufsatz in Nr. 18 des Zoologischen Anzeigers. Zool. Anz., vol. 28, nos. 21, 22, pp. 733–736.

MILNE-EDWARDS, M. H.
1840. Histoire naturelle des Crustacés, vol. 3, 638 pp.; plates, 32 pp. + 42 pls.

MÜLLER, O. F.
1785. Entomostraca, seu Insecta testacea, quae in aquis Daniae et Norvegiae reperit, descripsit et iconibus illustravit, iv + 134 pp., 21 col. pls.

MURRAY, A.
1856. Description of a new species of *Echeneis* (*E. tropicus*); and of a new lernaean of the genus *Pennella* (*P. remorae*), infesting the *Echeneis* remora; with some remarks on the economy of the remora, Edinburgh New Philos. Journ., n.s. vol. 4, pp. 287–301, 5 figs.

NORDMANN, A. V.
1832. Mikrographische Beiträge zur Naturgeschichte der wirbellosen Thiere, 2 vols. [in one] , 150 pp., 10 pls.
1864. Neue Beiträge zur Kenntniss Parasitischer Copepoden. Bul. Soc Imp. Nat. Moscou, vol. 37, no. 4, pp. 461–519, pls. 5–8.

NORMAN, A., AND SCOTT, T.
1906. The Crustacea of Devon and Cornwall, xv + 232 pp., 24 pls.

NUNES-RUIVO, L.
1953. Copépodes parasites de poissons: Résultats des Campagnes du "Prof. Lacaze-Duthiers" en Mediterranée, Algérie, 1952. Vie et Milieu, suppl. 3, 24 pp., 11 figs.
1954. Parasites de poissons de mer ouest-africains récoltés par M. J. Cadenat III: Copépodes (2e note): Genres *Prohatshekia* [sic] n. gen. et *Hatschekia* Poche. Bull. Inst. Français d'Afrique Noire, ser. A, vol. 16, no. 2, pp. 479–505, figs. 1–14.
1956. Copépodes parasitas de peixes dos Mares de Angola. Anais Junta Invest. Ultramar, vol. 9, pt. 2, pp. 3–39, figs. 1–7.
1957. Lernaeopodidae (Copepoda) parasites des Trigles. Rev. Portuguesa Zool. Biol. Ger., vol. 1, pp. 89–107, figs. 1–5.
1962a. Copépodes parasites de poissons des côtes d'Angola. Mem. Junta Invest. Ultramar, vol. 33, pp. 67–86, figs. 1–8.
1962b. Copépodes parasitas de peixes das costas de Angola (Liste Faunistique). Notas Mimeogr. Centro Biol. Pisc. Lisboa, no. 33, 28 pp.

NUNES-RUIVO, L., and FOURMANOIR, P.
1956. Copépodes parasites de poissons de Madagascar. Mém. Inst. Sci. Madagascar, ser. A, vol. 10, pp. 69–80, figs. 1–8.

OKEN, L.

1816. Fleischthiere. Pt. 2 *of* Zoologie (vol. 3) *in* Okens Lehrbuch der Naturgeschichte, xvi + 1270.

OTTO, A. W.

1821. Conspectus animalium quorundam maritimorum nondum editorum pars prior, 20 pp.,

1828. Beschreibung einiger neuen, in den Jahren 1818 und 1819 im Mitteländischen Meere gefundener Crustaceen. Nov. Act. Acad. Caes.-Leop.-Carol., vol. 14, pt. 1, pp. 331-354, pls. 21-23.

PAIVA, CARVALHO T. DE P.

1956. *Caligus oligoplitisi* sp. n. copepodo parasito del "Zapatero" *Oligoplitis saliens* (Block). Neotropica, vol. 2, no. 7.

PEARSE, A. S.

1948. A second report on parasitic copepods collected at Beaufort, N.C. Journ. Elisha Mitchell Sci. Soc., vol. 64, no. 1, pp. 127–131, figs. 1–18.

1952a. Parasitic Crustacea from the Texas coast. Publ. Inst. Mar. Sci., vol. 2, no. 2, pp. 5–42, figs. 1–157.

1952b. Parasitic crustaceans from Alligator Harbor, Florida. Quart. Journ. Florida Acad. Sci., vol. 15, no. 4, pp. 187–243, figs. 1–143.

1954. Parasitic Crustacea from Bimini, Bahamas. Proc. U.S. Nat. Mus., vol. 101, no. 3280, pp. 341–372, figs. 67–77.

PILLAI, N. K.

1961. Copepods parasitic on south Indian fishes, 1: Caligidae. Bull. Cent. Res. Inst. Univ. Kerala Trivandrum, vol. 8, pp. 87–130, figs. 1–23.

1962a. Copepods parasitic on south Indian fishes families Lernaeopodidae and Naobranchidae. Journ. Mar. Biol. Assoc. India, vol. 4, no. 1, pp. 58–94, figs. 1–22.

1962b. Observations on the synonymy of *Caligus coryphaenae* Stp. & Ltk. Ann. Mag. Nat. Hist., ser. 13, vol. 5, no. 57, pp. 513–522, figs. 1–4.

1963. Copepods parasitic on south Indian fishes—family Caligidae. Journ. Mar. Biol. Assoc. India, vol. 5, no. 1, pp. 68–96, figs. 1–15.

POCHE, F.

1902. Bemerkungen zu der arbeites Herrn Bassett-Smith, "A systematic description of parasitic Copepoda found on fishes, with an enumeration of the known species." Zool. Anz. vol. 26, pp. 8–20.

POISSON, R., and RAZET, P.

1953. A propos des pennelles (crustacés copépodes) parasites des germons, *Pennella germania fagei* nov. subsp. Ann. Sci. Nat. Zool., ser. 11, vol. 15, nos. 3, 4, pp. 397–403, figs. 1–4.

QUIDOR, A.

1906. Sur les copépodes recueillis par la mission Jean Charcot dans les mers Antarctiques. Bull. Mus. Hist. Nat., vol. 1, pp. 1–6, figs. 1–48.

1910. Note préliminaire sur *Pennella balaenopterae* (Koren et Danielssen). Bull. Mus. Hist. Nat., vol. 16, no. 2, pp. 97–98.

1912. Copépodes parasites. In Deuxième Expédition Antarctique Française (1908–1910), pp. 197–215, pls. 1–4.

RANDALL, J. E.

1958. A review of the labrid fish genus *Labroides*, with descriptions of two new species and notes on ecology. Pacific Sci., vol. 12, no. 4, pp. 327–347, 1 pl., figs. 1–6.

1961. The biology of the convict surgeonfish. Pacific Sci., vol. 15, no. 2, pp. 215–272, figs. 1–25.

RANGNEKAR, M. P.

1956. Parasitic copepods from the marine fishes of Bombay. Journ. Univ. Bombay, vol. 24, no. 5, pp. 42–65, 7 figs.

RAO, T. S. S.

1951. On a new caligid parasite, *Gloiopotes zeugopteri* sp. nov., from *Xiphias zeugopteri*, Lawson's Bay, Waltair. Proc. Indian Acad. Sci., vol. 34B, pp. 248–255, figs. 1–15.

RATHBUN, M. J.

1905. Fauna of New England, 5: List of the Crustacea. Occ. Pap. Boston Soc. Nat. Hist., vol. 7, pp. 117+11.

RATHBUN, RICHARD

1884. Annotated list of the described species of parasitic Copepoda (Siphonostoma) from American waters contained in the United States National Museum. Proc. U.S. Nat. Mus., vol. 7, no. 31, pp. 483–492

REDKAR, M. V.; RANGNEKAR, P. G.; and MURTI, N. N.

1949. Four new species of parasitic copepods from the marine fishes of Bombay. Journ. Univ. Bombay, vol. 18, no. 3, pp. 36–50, figs. 1–44.

1950. Two new species of *Hatschekia* parasitic on Bombay fishes. Journ. Univ. Bombay, vol. 19, no. 3, pp. 35–42, figs. 1–14.

RICHIARDI, S.

1870. Intorno ad una nuova specie del genere *Bomolochus* (*B. ostracionis*). Arch. Zool. Anat. Fisiol., ser. 2, vol. 2, pp. 47–59, 1 pl.

1880. Catalogo sistematico dei crostacei che vivono sul corpo degli animali aquatici in Italia, pp. 147–152.

ROUNDS, H. D.

1960. *Anchistrotos hematus* n. sp., a parasitic copepod from *Serranus scriba*. Trans. American Micros, Soc., vol. 79, no. 4, pp. 485–488, pls. 1–2.

SCOTT, A.

1906. Faunistic notes. Proc. Trans. Biol. Soc. Liverpool, vol. 20, pp. 191–201, pls. 2–7.

1929. The copepod parasites of Irish Sea fishes. *In* Report of the 1928 Lancashire Sea-Fisheries Laboratory, University of Liverpool, pp. 81–118, pls. 1–3.

SCOTT, T.

1894. Report on Entomostraca from the Gulf of Guinea. Trans. Linn. Soc. London, vol. 6, no. 1, pp. 1–161, pls. 1–15.

1901. Notes on some parasites of fishes. Nineteenth Ann. Rep. Fish. Bd. Scotland, pt. 4, pp. 120–152, pls. 7, 8.

1902. Notes on some parasites of fishes. Twentieth Ann. Rep. Fish. Bd. Scotland, pt. 3, pp. 288–303, pls. 12,13.

1909. Some notes on fish parasites. Twenty-sixth Ann. Rep. Fish. Bd. Scotland, pt. 3, pp. 73–92, pls. 3–7.

SCOTT, T. and SCOTT, A.

1913. The British parasitic Copepoda, vol. 1, x + 256 pp., 2 pls.; Atlas (vol. 2), xii pp., 72 pls. [Publ. by Ray Society, London.]

SHIINO, S. M.

1952. Copepods parasitic on Japanese fishes, 1: On the species of *Caligus* and *Lepeophtheirus*. Rep. Fac. Fish. Pref. Univ. Mie, vol. 1, no. 2, pp. 79–113, figs. 1–14.

1954a. Copepods parasitic on Japanese fishes, 3: On two new species of the genus *Anuretes*. Rep. Fac. Fish. Pref. Univ. Mie, vol. 1, no. 3, pp. 260–272, figs. 1–5.

1954b. Copepods parasitic on Japanese fishes, 4: The family Euryphoridae. Rep. Fac. Fish. Pref. Univ. Mie, vol. 1, no. 3, pp. 273–290, figs. 1–6.

1954c. Notes on *Caligus quadratus* n. sp., a copepod parasitic on the fish, *Neothynnus macropterus* (T. & S.). Bull. Japanese Soc. Sci. Fish., vol. 20, no. 1, pp. 26–29, 1 fig.

1954d. On the parasitic copepod, *Lepeophtheirus watanabei* n. sp., found on the fish *Myxocephalus raninus* J. & S. Bull. Japanese Soc. Sci. Fish., vol. 20, no. 2, pp. 96–100, 1 fig.

1954e. Note on a new parasitic copepod, *Caligus brevis* n. sp. Bull. Japanese Soc. Sci. Fish., vol. 20, no. 3, pp. 178–183, figs. 1–2.

1954f. On the male form of the copepod, *Caligus katuwo* Yamaguti, parasitic on the Japanese bonito *Euthynnus pelamys* (L.). Zool. Mag., vol. 63, pp. 246–249, 1 fig.

1955a. A. new piscicola copepod belonging to the genus *Caligus* from Matusima Bay. Bull. Biogeogr. Soc. Japan, vols. 16–19, pp. 135–140, figs. 1–3.

1955b. On the male of *Caligus cordiventris* Shiino. Zool. Mag., vol. 64, no. 3, pp. 65–67, 1 fig.

1956a. Copepods parasitic on Japanese fishes, 10: The redescription of three species of *Caligus*. Rep. Fac. Fish. Pref. Univ. Mie, vol. 2, no. 2, pp. 233–241, figs. 1-4.

1956b. Copepods parasitic on Japanese fishes, 12: Family Lernaeopodidae. Rep. Fac. Fish. Pref. Univ. Mie, vol. 2, no. 2, pp. 269–311, figs. 1–20.

1957a. Copepods parasitic on Japanese fishes, 13: Parasitic copepods collected off Kesennuma, Miyagi Prefecture. Rep. Fac. Fish. Pref. Univ. Mie, vol. 2, no. 3, pp. 359–375, figs. 1–6.

1957b. Copepods parasitic on Japanese fishes, 14: Three species from *Spheroides alboplumbeus* (Richardson). Rep. Fac. Fish. Pref. Univ. Mie, vol. 2, no. 3, pp. 376–391, figs. 1–7.

1957c Copepods parasitic on Japanese fishes, 15: Eudactylinidae and Dichelesthiidae. Rep. Fac. Fish. Pref. Univ. Mie, vol. 2, no. 3, pp. 392–410, figs. 1–7.

1957d. Copepods parasitic on Japanese fishes, 16: Bomolochidae and Taeniacanthidae. Rep. Fac. Fish. Pref. Univ. Mie, vol. 2, no. 3, pp. 411–428, figs. 1–6.

1958. Parasitic copepods from fishes collected in the Indian Ocean. Ann. Rep. Pref. Univ. Mie, sec. 2, vol. 2, no. 3, pp. 98–113, figs. 1–6.

1959a. Sammlung der parasitischen Copepoden in der Präfekturuniversität von Mie. Rep. Fac. Fish. Pref. Univ. Mie, vol. 3, no. 2, pp. 334–374, figs. 1–17.

1959b. Revision der auf Goldmakrele, *Coryphaena hippurus* L., schmarotzenden Caligidenarten. Ann. Rep. Pref. Univ. Mie, sec. 2, vol. 3, no. 1, pp. 1–34, figs. 1–9.

1959c. Neuer Artname für japanische Exemplare von *Caligus bonito*. Bull. Biogeogr. Soc. Japan, vol. 20, no. 11, pp. 51–57, figs. 1–2.

SHIINO, S. M.
1959d. Ostpazifische parasitierende Copepoden. Rep. Fac. Fish. Pref. Univ. Mie, vol. 3, no. 2, pp. 267–333, figs. 1–25.
1960a. Copepods parasitic on the fishes collected on the coast of Province Shima, Japan. Rep. Fac. Fish. Pref. Univ. Mie, vol. 3, no. 3, pp. 471–500, figs. 1–10.
1960b. Parasitic copepods of fishes from the eastern Pacific. Rep. Fac. Fish. Pref. Univ. Mie, vol. 3, no. 3, pp. 527–541, figs. 1–6.
1960c. Copepods parasitic on remoras from the Bay of Bengal. Rep. Fac. Fish. Pref. Univ. Mie, vol. 3, no. 3, pp. 542–552, figs. 1–4.
1963a. Parasitic copepods of the eastern Pacific fishes. Rep. Fac. Fish. Pref. Univ. Mie, vol. 4, no. 3, pp. 335–347, figs. 1–4.
1963b. Parasitic copepods of the eastern Pacific fishes, 4: On *Clavellistes shoyoae* gen. et sp. nov. Rep. Fac. Fish. Pref. Univ. Mie, vol. 4, no. 3, pp. 369–375, figs. 1–2.

STEBBING, T. R. R.
1900. On Crustacea brought by Dr. Willey from the south seas. No. 33 *of* pt. 5 *in* Willey, Zoological Results . . ., pp. 605–690, pls. 64–74.
1910. General catalogue of South African Crustacea (Part V of S. A. Crustacea, for the Marine Investigations in South Africa). Ann. South African Mus., vol. 6, pt. 4, pp. 281–593, pls. 15–21.

STEENSTRUP, J. J. S., and LÜTKEN, C. F.
1861. Bidrag til Kundskab om det aabne Havs Snyltekrebs og Lernaeer samt om nogle andre nye eller hidtil kun ufuldstaendigt kjendte parasitiske copepoder. Kongel. Danske Vidensk. Selsk. Skr. Naturh. Math. Afdel., 5 R., vol. 5, pp. 341–432, pls. 1–15.

STENTA, M.
1904. *Thynnicola ziegleri* Miculicich = *Brachiella thynni* Cuv. Zool. Anz., vol. 28, nos. 8–9, p. 345.

STOSSICH, M.
*1880. Prospetto della fauna del mare Adriatico. Boll. Soc. Adriatica Sci. Nat. Trieste, vol. 5, pp. 178–271.

STUARDO, J., and FAGETTI, E.
1961. Copepodos parasitos Chilenos, 1: Una lista de las especies conocidas y descripcion de tres especies nuevas. Rev. Chilena Hist. Nat., vol. 55, pp. 55–82, figs. 1–7.

THOMPSON, I. C., and SCOTT, A.
1903. On the copepoda. Suppl. rep. VII *in* Report to the Government of Ceylon on the pearl oyster fisheries of the Gulf of Manaar, pp. 227–307, pls. 1–20.

THOMSEN, R.
1949. Copépodos parásitos de los peces marinos del Uruguay. Comm. Zool. Mus. Hist. Nat. Montevideo, vol. 3, no. 54, pp. 1–41, pls. 1–14.

THOMSON, G. M.
1889. Parasitic Copepoda of New Zealand, with descriptions of new species. Trans. Proc. New Zealand Inst., vol. 22, pp. 353–376, pls. 25–29.

VALLE, A. DELLA
*1880. Crostacei parassiti dei pesci del mare Adriatico. Boll. Soc. Adriatica Sci. Nat., vol. 6, pp. 55–90.
*1882. Aggiunte ai crostacei parassiti dei perci del mare Adriatico. Boll. Soc. Adriatica Sci. Nat., vol. 7, pp. 245–247.

VAN BENEDEN, P. J.

1851. Recherches sur quelques Crustacés inférieurs. Ann. Sci. Nat., sér. 3 (Zool.), vol. 16, pp. 71–131, pls. 2–6.

1861. Recherches sur les Crustacés du littorale de Belgique. Bull. Acad. Roy. Sci. Belgique, vol. 33, no. 3, 174 pp.

1870a. Les poissons des côtes de Belgique, leurs parasites et leurs commensaux, xx + 100 pp., 8 pls.

1870b. Recherches sur l'embryogénie des Crustacés, 4: Développement des genres *Anchorella, Lerneopoda, Brachiella* et *Hessia.* Bull. Acad. Roy. Sci. Belgique, pp. 225–254, 1 pl.

VOGT, C.

*1877. Recherches cotières faites à Roscoff: crustacés parasites des poissons. Arch. Zool. Expèr. Gen., vol. 6, pp. 385–456.

WIERZEJSKI, A.

1877. Ueber Schmarotzerkrebse von Cephalopoden. Zeitschr. Wiss. Zool., vol. 29, pp. 562–582, pls. 32–34.

WILSON, C. B.

1905a. New species of parasitic copepods from the Massachusetts coast. Proc. Biol. Soc. Washington, vol. 18, pp. 127–132.

1905b. North American parasitic copepods belonging to the family Caligidae, 1: The Caliginae. Proc. U.S. Nat. Mus., vol. 28, no. 1404, pp. 479–672, pls. 5–28, figs. 1–50.

1907a. North American parasitic copepods belonging to the family Caligidae, 2: The Trebinae and Euryphorinae. Proc. U.S. Nat. Mus., vol. 31, no. 1504, pp. 669–720, pls. 15–20

1907b. North American parasitic copepods belonging to the family Caligidae, 3 and 4: A revision of the Pandaranae and the Cecropinae. Proc. U.S. Nat. Mus., vol. 33, no. 1573, pp. 323–490, pls. 17–43.

1908. North American parasitic copepods: A list of those found upon the fishes of the Pacific coast, with descriptions of new genera and species. Proc. U.S. Nat. Mus., vol. 35, no. 1652, pp. 431–481, pls. 66–83.

1910. North American parasitic copepods, 9: The Lernaeopodidae. Proc. U.S. Nat. Mus., vol. 39, no. 1783, pp. 189–226, pls. 29–36.

1911a. North American parasitic copepods belonging to the family Ergasilidae. Proc. U.S. Nat. Mus., vol. 39, no. 1788, pp. 263–400, pls. 41–60, figs. 1–41.

1911b. North American parasitic copepods: Descriptions of new genera and species. Proc. U.S. Nat. Mus., vol. 39, no. 1805, pp. 625–634, pls. 65–68.

1913. Crustacean parasites of West Indian fishes and land crabs, with descriptions of new genera and species. Proc. U.S. Nat. Mus., vol. 44, no. 1950, pp. 189–227, pls. 18–53.

1915. North American parasitic copepods belonging to the Lernaeopodidae, with a revision of the entire family. Proc. U.S. Nat. Mus., vol. 47, no. 2063, pp. 565–729, pls. 25–56, figs. 1–15.

1917. North American parasitic copepods belonging to the Lernaeidae, with a revision of the entire family. Proc. U.S. Nat. Mus., vol. 53, no. 2194, pp. 1–150, pls. 1–21, figs. a–c.

1919. A new species of parasitic copepod, with notes on species already described. Proc. U.S. Nat. Mus., vol. 55, no. 2274, pp. 313–316, pl. 21.

WILSON, C. B.

1921. New species and a new genus of parasitic copepods. Proc. U.S. Nat. Mus., vol. 59, no. 2354, pp. 1–17, pls. 1–7.

1922. North American parasitic copepods belonging to the family Dichelesthiidae. Proc. U.S. Nat. Mus., vol. 60, no. 2400, pp. 1–100, pls. 1–13.

1923. Parasitic copepods in the collection of the Riksmuseum at Stockholm. Ark. Zool., vol. 15, no. 3, pp. 1–15, pls. 1–2.

1924. Parasitic copepods from the Williams Galapagos Expedition. Zoologica, New York Zool. Soc., vol. 5, no. 19, pp. 212–217, pl. 20.

1932. The copepods of the Woods Hole region, Massachusetts. U.S. Nat. Mus. Bull., vol. 158, xix + 635 pp., 41 pls., 316 figs.

1935a. Reports on the collections obtained by the first Johnson-Smithsonian Deep-Sea Expedition to the Puerto Rican Deep. Smithsonian Misc. Coll., vol. 91, no. 19, pp. 1–9, pls. 1–3.

1935b. Parasitic copepods from the Dry Tortugas. Carnegie Inst. Washington, publ. 452, Pap. Tortugas Lab., vol. 29, no. 12, pp. 327–347, pls. 1–6.

1936. Note on a copepod from Cuba. Mem. Soc. Cubana Hist. Nat., vol. 10, no. 1, p. 32.

1937. Some parasitic copepods from Panama Bay. Journ. Washington Acad. Sci., vol. 27, no. 10, pp. 423–431, figs. 1–34.

YAMAGUTI, S.

1936a. Caligoida, I. Pt. 2 *in* Parasitic copepods from fishes of Japan, 22 pp. 12 pls. [Publ. by author.]

1936b. Caligoida, II. Pt. 3 *in* Parasitic copepods from fishes of Japan, 21 pp., 9 pls. [Publ. by author.]

1939a. Cyclopoida, II. Pt. 4 *in* Parasitic copepods from fishes of Japan, pp. 391–415, pls. 1–13. [Vol. Jub. pro Prof. Sadao Yoshida, vol. 2.]

1939b. Caligoida, III. Pt. 5 *in* Parasitic copepods from fishes of Japan, pp. 443–487, pls. 14–33. [Vol. Jub. pro Prof. Sadao Yoshida, vol. 2.]

1939c. Lernaeopoida, I. Pt. 6 *in* Parasitic copepods from fishes of Japan, pp. 529–578, pls. 34–58. [Vol. Jub. pro Prof. Sadao Yoshida, vol. 2.]

1953. Cyclopoida, III, and Caligoida, IV. Pt. 7 *in* Parasitic copepods from fishes of Japan. Publ. Seto Mar. Biol. Lab., vol. 3, no. 2, pp. 221–231, pls. 1–5.

1954. Parasitic copepods from fishes of Celebes and Borneo. Publ. Seto Mar. Biol. Lab., vol. 3, no. 3, pp. 375–398, pls. 1–6.

1963. Parasitic Copepoda and Branchiura of fishes, vii + 1104 pp., 333 pls.

YAMAGUTI, S., and YAMASU, T.

1959. Parasitic copepods from fishes of Japan with descriptions of 26 new species and remarks on two known species. Biol. Journ. Okayama Univ., vol. 5, nos. 3, 4, pp. 89–165, pls. 1–14.

U. S. GOVERNMENT PRINTING OFFICE: 1967

Proceedings of
the United States
National Museum

SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 121 1967 Number 3575

SOME BATHYAL POLYNOIDS FROM CENTRAL AND NORTHEASTERN PACIFIC (POLYCHAETA: POLYNOIDAE)

By Marian H. Pettibone
Associate Curator, Division of Worms

Polychaetes obtained from bathyal and abyssal regions are delicate and, thus, easily mutilated. Among the polynoids, the dorsal scales or elytra are usually missing; the styles of the antennae and the tentacular, dorsal, ventral, and anal cirri are often partly or completely missing; the setae and even the parapodia may be broken off; in addition, the body may be fragmented.

This study of some deepwater polynoids was prompted by the discovery of a single, somewhat mutilated specimen of polynoid collected in 900 fathoms off the mouth of the Columbia River, Oregon. It is herein described as a new species belonging to a new genus, *Bathyadmetella*. As the name indicates, it shows certain affinities to *Admetella* McIntosh.

The generic standing of *Admetella*, based on *Polynoe* (*Admetella*) *longipedata* McIntosh (1885), was first indicated by Darboux (1900). Darboux gave a diagnosis for the genus based on the incomplete description by McIntosh. The description of *A. longipedata* has been supplemented subsequently by other polychaete workers, particularly by Augener (1906), Ehlers (1908), and Ditlevsen (1917). Some specimens of *A. longipedata* in the U.S. National Museum, from the *Albatross* collections, are in relatively good condition, enabling me to supplement further the previous descriptions and to give an emended diagnosis for the genus.

Chamberlin (1919) added 2 new species to *Admetella* McIntosh, *A. dolichopus* and *A. hastigerens*. The type specimens of both species in the U.S. National Museum have been examined and are herein referred to as *A. longipedata*. Hartman (1938) examined the type specimen of *Polynoe*(?) *renotubulata* Moore (1910) in the U.S. National Museum and referred it to *Admetella*. The specimen has been re-examined and is herein designated the type species for the new genus, *Bathymoorea*.

This study was aided in part by a grant from the National Science Foundation (NSF GB-1269).

Family Polynoidae Malmgren

Genus *Admetella* McIntosh, 1885; emended

Type species: *Polynoe* (*Admetella*) *longipedata* McIntosh, 1885, by monotypy. Gender: feminine.

Diagnosis: Polynoids with body large, oval, flattened; segments more than 50 (52–82). Prostomium with 2 long palps and 3 antennae; median antenna with large ceratophore inserted on middle third of prostomium; lateral antennae inserted on anterolateral extensions of prostomium (i.e., lepidonotoid); with paired antennal scales. Tentacular segment (I) achaetous, with 2 pairs tentacular cirri, with bulbous facial tubercle between bases of palps. Buccal segment (II) achaetous, with paired, long, ventral buccal cirri and first pair elytra; with dorsal, low, transverse nuchal fold. Elytra more than 20 pairs, arranged on segments 2, 4, 5, 7, then on alternate segments to 23, and then on every third segment to end of body. Parapodia very long, subbiramous; notopodia small; both rami with elongated digitiform acicular processes. Notosetae form small bundles. Neurosetae numerous, forming fan-shaped bundles. Both noto- and neurosetae long, slender, transparent, fragile, inflated, and flattened distally, with faint spinous rows and tapered tips.

Admetella longipedata (McIntosh)

FIGURES 1, 2

Polynoe (*Admetella*) *longipedata* McIntosh, 1885, p. 124, pl. 14, fig. 5; pl. 20, fig. 6; pl. 12A, fig. 17.

Admetella longipedata Darboux, 1900, p. 103.—Augener, 1906, p. 123.—Ehlers, 1908, p. 40, pl. 2, figs. 10, 11; pl. 3, figs. 1–5.—Horst, 1917, pp. 101, 140.—Ditlevsen, 1917, p. 37.—Fauvel, 1932, p. 27.—Eliason, 1951, p. 133.

Polynoe mirabilis Treadwell, 1906, p. 1149; 1920, p. 590. [Not McIntosh, 1885.]

Admetella hastigerens Chamberlin, 1919, p. 64, pl. 9, figs. 6–8.—Treadwell, 1923, p. 3.
Admetella dolichopus Chamberlin, 1919, p. 67, pl. 10, fig. 1.

Remarks: The following study is based on 12 specimens in the U.S. National Museum, collected from seven *Albatross* stations from the vicinity of Hawaii, Philippine Islands, and Lower California to off Central America. The specimens were identified by Treadwell as *Polynoe mirabilis* McIntosh (Treadwell, 1906, 1920) and *Admetella hastigerens* Chamberlin (Treadwell, 1923) and by Chamberlin (1919) as 2 new species of *Admetella, A. hastigerens,* and *A. dolichopus.* All of the above are herein referred to *Admetella longipedata* (McIntosh). Fauvel (1914, p. 39) questioned the identification by Treadwell (1906, p. 1149) of *Polynoe mirabilis* from off Hawaii. Uschakov (1950, p. 157) also questioned the identifications in both records of Treadwell (1906, 1920). Eliason (1951, p. 133) questionably referred *A. hastigerens* to *A. longipedata.*

Material examined: From seven *Albatross* stations, Sta. 2635 (Apr. 18, 1891), off Mexico, 20°47′ N, 106°15′ W, 2022 fms, dark green mud (USNM 19325, type of *Admetella dolichopus* Chamberlin); Sta. 4022 (June 21, 1902), vicinity of Kauai, Hawaiian Islands, 374–399 fms, coral, sand, foraminifera, rock (USNM 5458, identified by Treadwell as *Polynoe mirabilis,* 2 spec.); Sta. 4621 (Oct. 21, 1904), southwest coast of Central America, 6°36′ N, 81°45′ W, 581 fms, green sand (USNM 19326, type of *Admetella hastigerens* Chamberlin); Sta. 5114 (Jan. 20, 1908), Balayan Bay and Verde Island Passage, Philippine Islands, 13°36′ N, 120°45′ E, 340 fms, fine sand (USNM 17507, identified by Treadwell as *Polynoe mirabilis,* 5 spec.); Sta. 5122 (Feb. 2, 1908), east coast of Mindoro, Philippine Islands, 13°21′ N, 120°30′ E, 220 fms, green mud (USNM 17606, identified by Treadwell as *Polynoe mirabilis,* 1 spec.); Sta. 5677 (Mar. 17, 1911), between Ballenas Bay and Santa Maria Bay, Lower California, 25°23′ N, 113°16′ W, 735 fms, green mud, fine sand (USNM 19149, by Treadwell as *Admetella hastigerens,* 1 spec.); Sta. 5685 (Apr. 22, 1911), south of Abrejos Point, Lower California, 25°42′ N, 113°30′ W, 645 fms, black sand, coral (USNM 19150, identified by Treadwell as *Admetella hastigerens,* 1 spec.).

Description: Length 50 to 100 mm; width, including parapodia (without setae), 16 to 35 mm; segments 64 to 82, last 4 to 6 very small. Body spindle shaped, widest in middle, tapering anteriorly and posteriorly, arched dorsally, flattened ventrally. Parapodia very long, as long as width of body, inflated and flattened transversely (fig. 1*c*). Elytra (usually missing) on large inflated elytrophores, 25 to 31 pairs, arranged on segments 2, 4, 5, 7, then alternate segments to 23, and then on every third segment to end of body. Elytra missing on all specimens examined (according to Treadwell, 1923, elytra are large, delicate, gray to black in color). Dorsal tubercles on cirrigerous segments inflated, thin walled, continuous as inflated ridge to base of

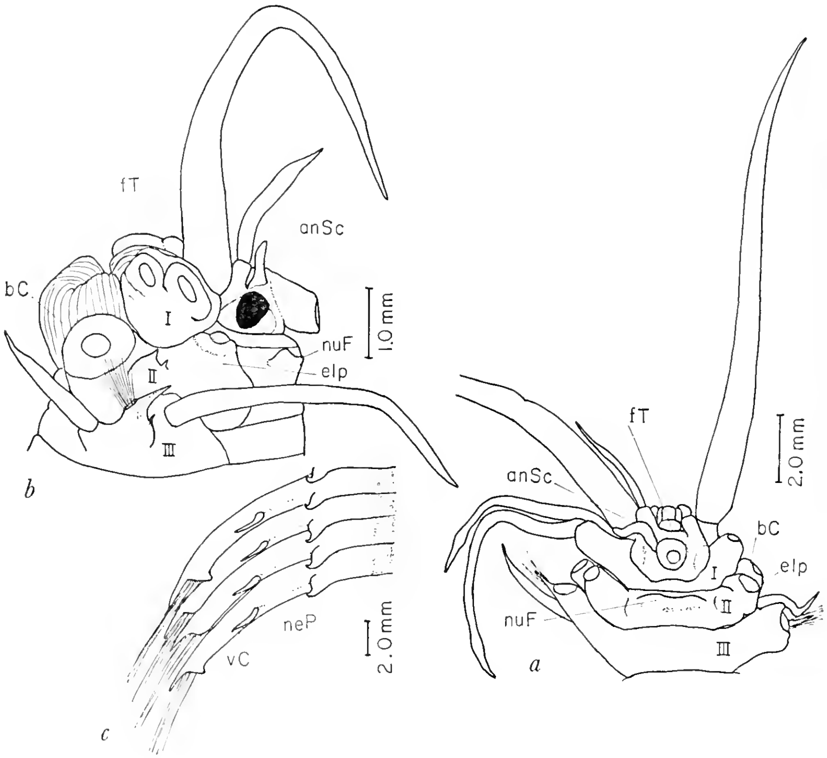


FIGURE 1.—*Admetella longipedata: a*, dorsal view anterior end (USNM 19150) with pharynx partially extended, ocular areas not pigmented, styles of median antenna and right lateral antenna and right antennal scale missing, styles of right tentacular cirri missing (I), elytra and styles of buccal cirri missing (II), styles of dorsal cirri missing (III); *b*, lateral view anterior end (USNM 17606) with pharynx partially extended, ocular area pigmented, style of median antenna missing, tentacular cirri missing (I), style of buccal cirrus and elytron missing (II); *c*, ventral view of several segments on right half in middle part of body. (I–III=segments, anSc=antennal scale, bC=cirrophore buccal cirrus, elp=elytrophore, fT=facial tubercle, neP=nephridial papilla, nuF=nuchal fold, vC=ventral cirrus.)

short cylindrical cirrophores of dorsal cirri; styles of dorsal cirri long, extending beyond the tips of neurosetae, delicate, with tapered tips.

Prostomium (figs. 1*a,b*) bilobed, much wider than long, with pair of very large rounded ocular areas, pigmented or colorless. Ceratophore of median antenna large, occupying middle third of prostomium and projecting dorsally; style usually missing (delicate, slender, extending to about segment 9, according to Treadwell, 1923). Ceratophores of lateral antennae formed by continuations of anterolateral borders of prostomium; styles cylindrical, tapering distally to slender tips, with slight subterminal enlargements. Paired, thin, flattened, subtriangular processes or antennal scales attached between bases of ceratophores of lateral antennae and median antenna; antennal scales broad basally, tapering to blunt tips, tending to curl around basal parts of lateral antennae (antennal scales sometimes broken off but scars of attachment visible). Paired, very long, tapering, smooth palps.

First or tentacular segment (figs. 1*a*,*b*) dorsally forms short ring, projecting lateral to prostomium, achaetous, with 2 pairs tentacular cirri; cirrophores large, inflated; styles long, smooth, delicate, with attenuate tips; a bulbous facial tubercle between bases of palps, continuous with a longitudinal ridge on upper lip. Second or buccal segment with first pair elytrophores; parapodia rudimentary, achaetous; with dorsal, low, slightly bilobed, transverse nuchal fold between elytrophores; forms posterior lip of mouth ventrally; ventral or buccal cirri with large inflated cirrophores, with styles long, similar to tentacular cirri. Third segment with setigerous biramous parapodia not especially elongated. Beginning with segment 4, parapodia elongated. Ventral cirri on segments 3–5 extend beyond tips of neuropodia. On remaining segments, ventral cirri smaller, subulate, in middle of elongated neuropodia (figs. 2*a*,*b*).

Parapodia (figs. 2*a*,*b*) elongated, inflated, thin walled, flattened transversely, subbiramous. Notopodia small lobes on anterodorsal faces of elongated neuropodia, inflated basally with elongated digitiform acicular processes, with small bundles of notosetae (easily broken and may be overlooked). Notosetae somewhat more slender than neurosetae, transparent, flattened distally, tapered to rounded tips, with faint spinous rows (fig. 2*c*). Neuropodia elongated, somewhat flared distally, postsetal lobes subtriangular, presetal lobes extending as long digitiform acicular processes. Acicula of both rami yellowish, tapering distally to fine tips within the acicular processes. Neurosetae numerous, forming fan-shaped bundles. Neurosetae (fig. 2*d*) long, slender, flexible, transparent, iridescent, fragile (may be mostly broken), with long bare basal regions and flattened distal spinous regions consisting of transverse rows of low spines; tips very thin, bare, tapered (when broken, fracture in various ways, as indicated by pl. 12A, fig. 17 in McIntosh, 1885; pl. 3, figs. 1–5 in Ehlers, 1908; pl. 9, figs. 7, 8, in Chamberlin, 1919).

Anus dorsal, surrounded by small parapodia of last 4 to 5 segments. Anal cirri not noted. Nephridial papillae (figs. 1*c*,2*b*) on ventral bases of parapodia, begin on segment 6 and continue posteriorly, inflated basally, tapered distally to short tubes directed between parapodia.

Pharynx partially extended in most preserved specimens, thin walled, with conspicuous dorsal longitudinal ridge on basal part which is continuous with bulbous facial tubercle between bases of palps (figs. 1*a*,*b*). Pharynx reddish to blackish; distally with soft papillae and 2 pairs light-brown interlocking jaws. Color (according to Treadwell, 1920) livid flesh pink, some cirri showing violet color.

Remarks: *Admetella longipedata* is characterized particularly by the paired antennal scales on the prostomium. It may be distin-

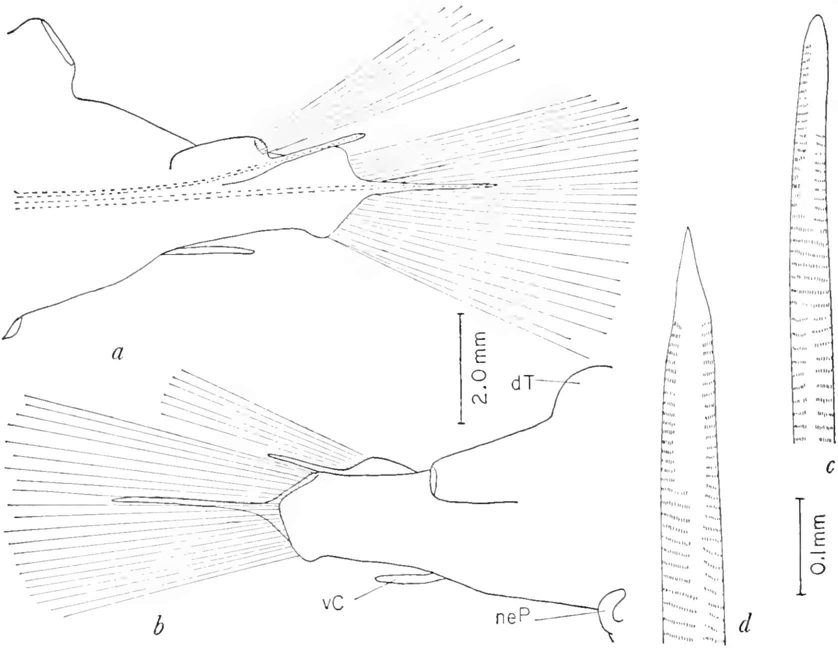


FIGURE 2.—*Admetella longipedata: a*, parapodium of clytragerous segment, anterior view, elytron missing, position of acicula shown in dotted lines; *b*, parapodium of cirrigerous segment, posterior view, lateral part of dorsal tubercle indicated, style of dorsal cirrus missing; *c*, tip of notoseta; *d*, tip of neuroseta. (dT=dorsal tubercle, neP=nephridial papilla, vC=ventral cirrus.)

guished from *Bathyadmetella* and *Bathymoorea* according to the key on page 13.

Distribution: Widely distributed deep-sea form, North and South Atlantic, Indian Ocean, North Central Pacific. In 220 to 2779 fms.

Bathyadmetella, new genus

Type species: *B. commando*, new species. Gender: feminine.

Diagnosis: Polynoids with body large, oval, flattened, segments more than 50 (58). Prostomium with 2 long palps and 3 antennae;

median antenna with ceratophore inserted on anterior part of prostomium; lateral antennae inserted on anterolateral extensions of prostomium (i.e., lepidonotoid); with paired long antennal sheaths dorsal to lateral antennae. Tentacular segment (I) achaetous, with 2 pairs tentacular cirri, with paired long tentacular sheaths between palps and tentacular cirri, with bulbous facial tubercle between bases of palps. Buccal segment (II) with parapodia rudimentary, achaetous, with paired, long, ventral buccal cirri and first pair dorsal elytrophores. With lamellar papillae on ventral lip and ventral bases of parapodia on segments 2 and 3. Elytra or elytrophores more than 20 pairs (23), arranged on segments 2, 4, 5, 7, then on alternate segments to 23, and then on every third segment to end of body. Parapodia very long, subbiramous; notopodia small, with digitiform acicular lobes, achaetous; neuropodia with elongated acicular processes. Neurosetae numerous, forming brushlike bundles, transparent, fragile, inflated and flattened distally, with faint spinous rows and tapered tips.

***Bathyadmetella commando*, new species**

FIGURES 3, 4

Material examined: The species is represented by a single damaged specimen, collected in a trawl haul, southwest of the mouth of the Columbia River, Oregon, 45°45′ N, 125°09′ W, 900 fms, 2.6° C bottom temperature, 34.372°/₀₀ salinity, May 29, 1964, M/V *Commando*, M. S. Alton, collector. The holotype is deposited in the U.S. National Museum (USNM 33419).

Description: Length 55 mm, width of body 6 mm; width including parapodia 24 mm, including setae 34 mm; segments 58, last few small. Body widest in middle, tapering gradually anteriorly and more so posteriorly; flattened dorsoventrally; with extremely long parapodia. Integument thin, delicate. Body reddish brown, darker on parapodia and distal halves of elytrophores, lighter ventrally. Elytra all missing; elytrophores elongated, inflated basally, 23 pairs, arranged on segments 2, 4, 5, 7, then on alternate segments to 23, and then on every third segment to end of body. Dorsal tubercles on cirrigerous segments thin walled, inflated, continuous as low ridges to cirrophores of dorsal cirri; styles of dorsal cirri all missing.

Prostomium (figs. 3*a*,*b*) bilobed, wider than long, with paired very large bulging eyes occupying most of posterior half of prostomium; eyes with semicircular, dark purplish pigmented cups basally. Ceratophore of median antenna short, cylindrical, on anterior border prostomium; style missing. Ceratophores of lateral antennae long cylindrical extensions of anterolateral borders of prostomium; styles long, slender, with slight subterminal enlargements and slender tips. Paired elongate antennal sheaths dorsal to the lateral antennae, wider basally, tapering distally; sheaths may completely enclose lateral antennae. Paired palps very long, tapering, and smooth. Prostomium with triangular pigmented area around base of ceratophore of median antenna, extending posteriorly between the two large eyes.

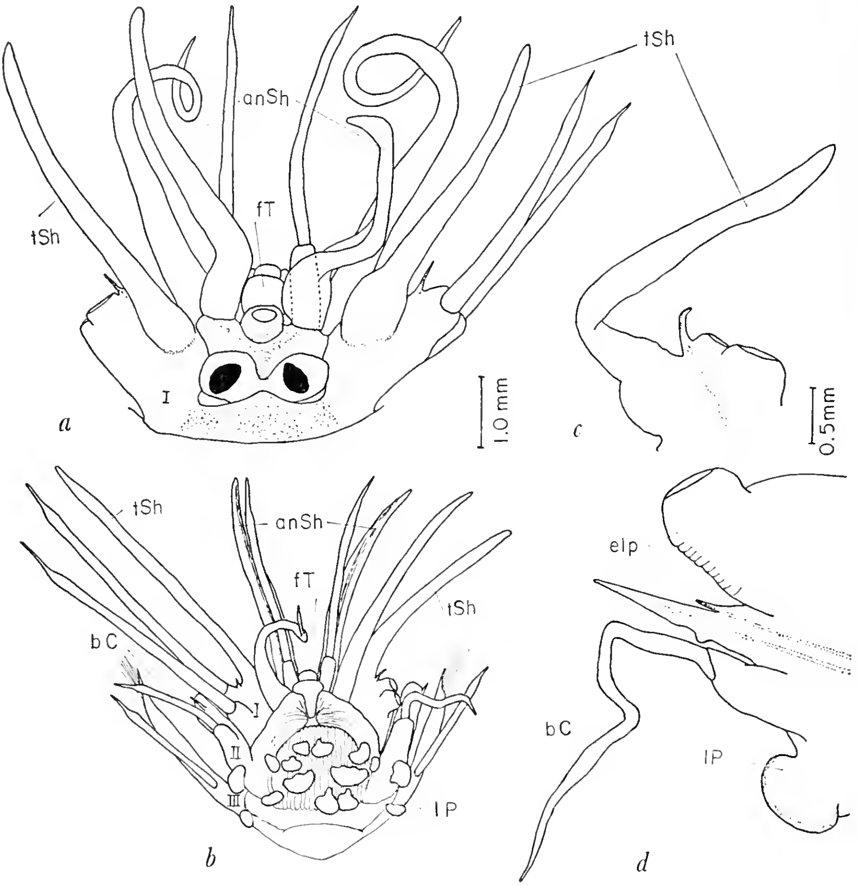


FIGURE 3.—*Bathyadmetella commando*, new species: *a*, dorsal view anterior end, styles of median antenna and left tentacular cirri missing, ceratophores of lateral antennae hidden by antennal sheaths (shown in dotted lines on right); *b*, same, ventral view; *c*, anterior view of achaetous parapodium of tentacular segment (I); styles of tentacular cirri missing; *d*, posterior view of left achaetous parapodium of buccal or first elytragerous segment (II). (anSh=antennal sheath, bC=buccal cirrus, elp=elytrophore, fT=facial tubercle, lP=lamellar papilla, tSh=tentacular sheath.)

First or tentacular segment (figs. 3*a–c*) forms short ring dorsally, projecting laterally to prostomium, achaetous, with 2 pairs long slender tentacular cirri similar to lateral antennae, cirrophores short, cylindrical, with a projecting acicular process. Paired long tentacular sheaths attached basally on tentacular segment, wider basally, tapering distally, as long as tentacular cirri and may partially encircle the palps. A bulbous facial tubercle between bases of palps, continuous with a longitudinal ridge on upper lip. Second or buccal segment (figs. 3*b*, *d*) with first pair elytrophores; parapodia rudimentary, not elongated, with noto- and neuroacicular achaetous lobes; ventral or buccal cirri with inflated cirrophores and long styles; a lamellar papilla on ventral base of parapodium; ventral lip (fig. 3*b*) inflated, longitudinally grooved, with 11 lamellar papillae in three irregular rows. Setigerous parapodia elongated from third segment on. Lamellar papillae at ventral parapodial bases of segments 2 and 3;

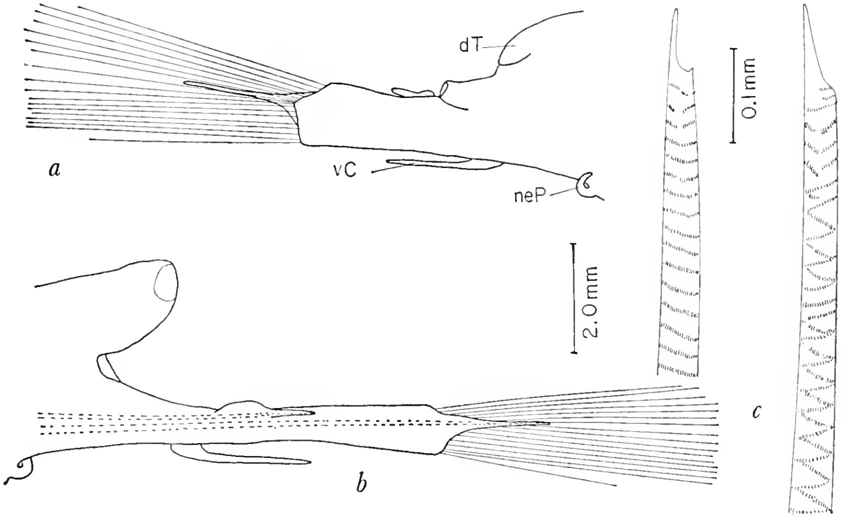


FIGURE 4.—*Bathyadmetella commando*, new species: *a*, cirrigerous parapodium, posterior view, style of dorsal cirrus missing; *b*, elytragerous parapodium, anterior view, elytron missing, position of acicula shown in dotted lines; *c*, tips of neurosetae. (dT=dorsal tubercle, neP=nephridial papilla, vC=ventral cirrus.)

ventral cirri on these 2 segments extra long, extending beyond the distal tips of the neuropodia (fig. 3*b*). Rest of ventral cirri short, subulate, in middle of elongated neuropodia (figs. 4*a*, *b*).

Parapodia (figs. 4*a*,*b*) elongated, subbiramous. Notopodia small lobes on anterodorsal faces of neuropodia, inflated basally, tapering to short digitiform acicular lobes, enclosing the slender tips of the notoacicula; notosetae lacking. Neuropodia flattened transversely, inflated subdistally, postsetal lobes subtriangular, presetal lobes with elongate acicular processes containing the neuroacicula. Neurosetae numerous, forming brushlike transparent bundles. Neurosetae with long, bare, basal regions, distally wider, flattened, with somewhat spirally arranged fine spinous rows, tapered rather abruptly to very thin tips (fig. 4*c*).

Anus dorsal in position, surrounded by last few small segments (damaged somewhat in this area). Anal cirri not observed. Nephridial papillae on ventral bases of parapodia, beginning on segment 4 and continuing posteriorly, small at first, becoming longer (shorter than ventral cirri), cylindrical and directed between the parapodia (fig. 4*a*). Pharynx not extended. The single specimen is ovigerous.

Remarks: *Bathyadmetella commando* is unique among the polynoids in having long antennal and tentacular sheaths and lamellar papillae on the ventral lip and ventral bases of the second and third segments. It is also unusual for its extremely large bulging eyes. It may be distinguished from *Admetella* and *Bathymoorea* according to the key on page 13.

Distribution: Northeastern Pacific (off Oregon). In 900 fms.

***Bathymoorea*, new genus**

Type species: *Polynoe*(?) *renotvbulata* Moore, 1910. Gender: feminine.

Diagnosis: Polynoids with relatively few segments (33). Prostomium with 2 long palps and 3 antennae; median antenna with ceratophore inserted in middle of prostomium; lateral antenna inserted on anterolateral extensions of prostomium (i.e., lepidonotoid). Tentacular segment (I) achaetous, with 2 pairs tentacular cirri, with bulbous facial tubercle between bases of palps. Buccal segment (II) with first pair elytra, setigerous parapodia, and long ventral buccal cirri. Elytra 14 pairs, arranged on segments 2, 4, 5, 7, then on alternate segments to 23, 26, 28, and absent on last 5 small segments. Parapodia elongated, subbiramous, with small notopodia; both rami with elongated, digitiform acicular processes. Notopodia with small tufts of setae. Notosetae delicate, finely spinous. Neuropodia with dense, brushlike bundles of transparent setae. Neurosetae distally expanded and flattened, with faint spinous rows and tapered tips. Nephridial papillae remarkably elongated, some extending to tips of neuropodia.

***Bathymoorea renotubulata* (Moore), new combination**

FIGURE 5

Polynoe(?) *renotubulata* Moore, 1910, p. 368, pl. 31, figs. 59–64.
Admetella renotubulata Hartman, 1938, p. 123.

Material examined: Holotype *Polynoe*(?) *renotubulata* (USNM 16878), *Albatross* Sta. 4397 (Apr. 1, 1904), off Santa Catalina Islands, southern California 33° 43′ N, 117° 42′ W, 2196 to 2228 fms, gray mud.

Description: Length 26 mm, width of body 3.6 mm; width including parapodia 13 mm, including setae 22 mm; segments 33, last few segments very small. Body subfusiform, widest in middle, tapering anteriorly and posteriorly. Elytra (usually missing) on large inflated elytrophores, 14 pairs, arranged on segments 2, 4, 5, 7, then on alternate segments to 23, 26, 28. First elytron (observed by Moore, now missing) suborbicular, of thick, soft, cushiony texture, thickly covered with soft dome-shaped papillae with single coarse filament at summit. Dorsal tubercles on cirrigerous segments inflated; cirrophores of dorsal cirri small; styles missing.

Prostomium (fig. 5*a*) bilobed, wider than long, with large pair, opaque ocular areas. Ceratophore of median antenna in middle of prostomium; style missing. Lateral antennae with short ceratophores formed by anterolateral extensions of prostomium; styles tapered. Palps paired, thick, smooth, tapering.

First or tentacular segment projecting lateral to prostomium, achaetous, with 2 pairs tentacular cirri; styles long, slender, tapered. A bulbous facial tubercle between palps, continuous with longitudinal ridge on upper lip. Second or buccal segment with first pair elytrophores, notopodial acicular lobes, and neuropodial acicular lobes bearing bundles of neurosetae; cirrophores of ventral cirri large, styles missing. Ventral cirri on remaining segments short, subulate (fig. 5*c*).

Parapodia (figs. 5*b*, *c*) elongated, subbiramous, with tapering yellow acicula. Notopodia inflated basally, prolonged into long acicular processes, with small tufts of notosetae. Notosetae delicate, finely spinous (fig. 5*d*). Neuropodia with subconical postsetal lobes; presetal lobes prolonged into delicate acicular processes, with long, dense, brushlike bundles of neurosetae. Neurosetae transparent, distally expanded and flattened, with faint spinous rows, abruptly tapering to entire tips (may be split, appearing bifid, fig. 5*e*).

Anus dorsal, surrounded by small posterior segments. Anal cirri not observed. Nephridial papillae begin on segment 6 and continue posteriorly, becoming remarkably elongated, some extending beyond distal tips of neuropodia (figs. 5*b*, *c*). Pharynx not extended.

Remarks: Moore (1910) questionably placed this species in the genus *Polynoe*. Hartman (1938) referred it to *Admetella*; however, there is no trace of the triangular antennal scales characteristic of *Admetella*. Other differences are indicated in the key on page 13. As the specific name indicates, *B. renotubulata* is remarkable for the length of the nephridial papillae.

Distribution: Off southern California. In 2196 to 2228 fms.

The 3 bathyal genera, *Admetella*, *Bathyadmetella*, and *Bathymoorea*, have a number of characters in common, e.g., prostomia with paired

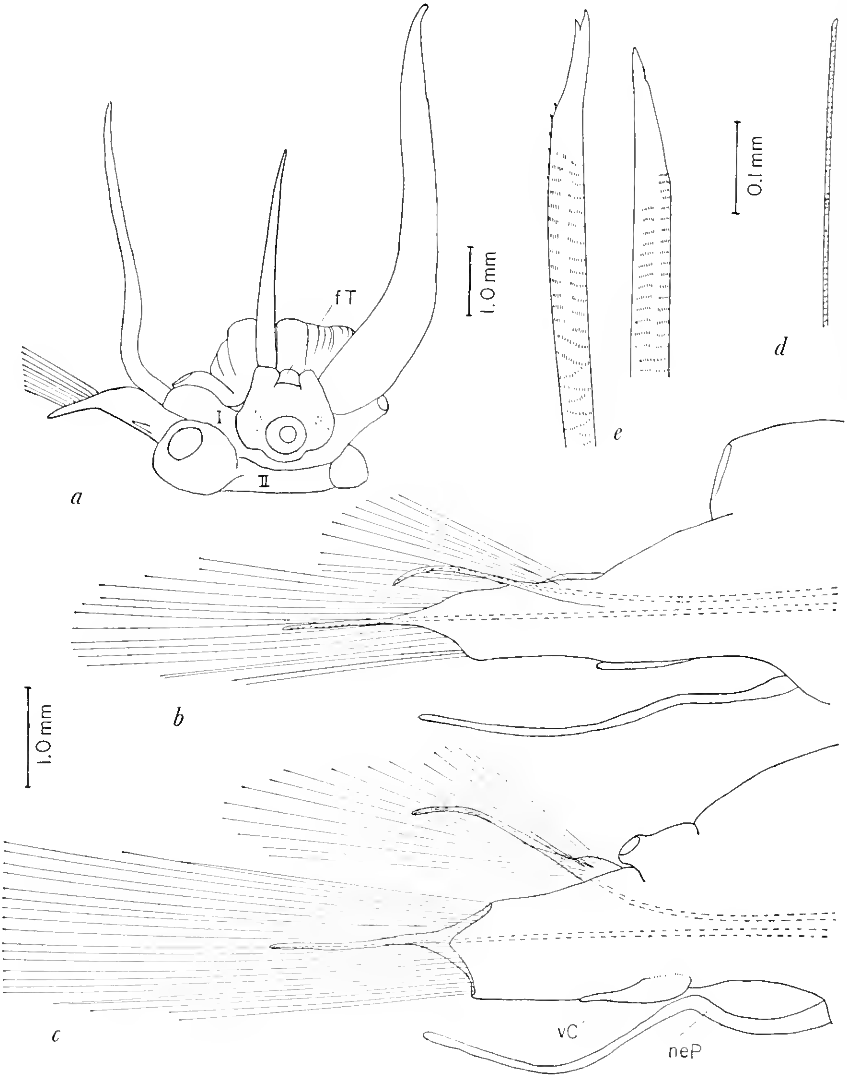


FIGURE 5.—*Bathymoorea renotubulata: a*, dorsal view anterior end, pharynx partially extended, opaque ocular areas stippled, left palp and styles of median and right lateral antennae missing, lower left and right tentacular cirri missing (I), right elytrophore and parapodium missing (II), *b*, elytragerous parapodium, anterior view, elytron missing, position of acicula shown in dotted lines; *c*, cirrigerous parapodium, posterior view, style of dorsal cirrus missing; *d*, tip of notoseta; *e*, tips of neurosetae. (I–II=segments, fT=facial tubercle, neP=nephridial papilla, vC=ventral cirrus.)

large eyes or ocular areas; ceratophores of lateral antennae formed by anterolateral continuations of prostomia (i.e., lepidonotoid); bulbous facial tubercle present and continuous with ridges on upper lips; long ventral cirri (buccal cirri) on segment II; parapodia very long, subbiramous, notopodia scarcely separated basally from the neuropodia, both rami with digitiform acicular processes; neurosetae all of one kind, numerous, long, transparent, flattened distally, distal tips very thin, entire (unless broken). The 3 genera may be distinguished according to the following key.

Key to *Admetella*, *Bathyadmetella*, and *Bathymoorea*

1. Segments 33. Elytra (or elytrophores) 14 pairs, on segments 2, 4, 5, 7, then on alternate segments to 23, 26, 28, and absent from last 5 segments. Prostomium without antennal scales or sheaths. Ceratophore of median antenna in middle of prostomium. Without tentacular sheaths. Without nuchal fold. Buccal segment (II) with setigerous parapodia. Lower lip region bare, without papillae. Notopodia with long acicular processes and small bundles of delicate notosetae. Nephridial papillae extremely long, may extend beyond neuropodial lobes . . . . **Bathymoorea**, new genus
   B. renotubulata (Moore)

   Segments more than 50. Elytra (or elytrophores) more than 20 pairs, on segments 2, 4, 5, 7, then on alternate segments to 23, and then on every third segment continuing to end of body. Prostomium with antennal scales or sheaths. Buccal segment (II) with parapodia rudimentary, achaetous, with or without acicula. Nephridial papillae not especially elongated, shorter than ventral cirri 2

2. Antennal scales short, triangular, attached between ceratophores of median and lateral antennae. Ceratophore of median antenna in middle of prostomium. Without tentacular sheaths. With low transverse nuchal fold on segment II between first pair elytrophores. Lower lip region bare, without papillae. Notopodia with long acicular processes and small bundles notosetae . . . . **Admetella** McIntosh
   A. longipedata (McIntosh)

   Antennal sheaths long, digitiform, attached basally to and enclosing lateral antennae. Ceratophores of median antenna on anterior part of prostomium. With paired long digitiform tentacular sheaths between palps and tentacular cirri. Without nuchal fold. Lower lip region with series of lamellar papillae. Notopodia with short acicular processes, achaetous.
   Bathyadmetella, new genus
   B. commando, new species

Literature Cited

AUGENER, HERMANN

1906. Westindische Polychaeten. Bull. Mus. Comp. Zool. Harvard, vol. 43, pp. 91–196, 8 pls.

CHAMBERLIN, RALPH V.

1919. The Annelida Polychaeta. Mem. Mus. Comp. Zool. Harvard, vol. 48, pp. 1–514, 80 pls.

DARBOUX, J. GASTON

1900. Recherches sur les Aphroditiens. Bull. Sci. France et Belgique, vol. 33, pp. 1–274, 83 figs.

DITLEVSEN, HJALMAR

1917. Annelides I. Pt. 4 *of* vol. 4 *in* The Danish *Ingolf* expedition, 71 pp., 6 pls.

EHLERS, ERNST

1908. Die bodensässigen Anneliden aus den Sammlungen der Deutschen Tiefsee-Expedition. *In* Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition, 1898–1899, vol. 16, pp. 1–168, 23 pls.

ELIASON, ANDERS

1951. Polychaeta. *In* Report of the Swedish Deep-Sea Expedition, 1947–1948, Zool., vol. 2, no. 11, pp. 131–148, 2 pls., 5 figs.

FAUVEL, PIERRE

1914. Annélides Polychètes non pélagiques provenant des campagnes de l'*Hirondelle* et de la *Princesse-Alice* (1885–1910). Res. Camp. Sci. Monaco, vol. 46, pp. 1–432, 31 pls.

1932. Annelida Polychaeta of the Indian Museum, Calcutta. Mem. Indian Mus., vol. 12, pp. 1–262, 40 figs.

HARTMAN, OLGA

1938. The types of the polychaete worms of the families Polynoidae and Polyodontidae in the United States National Museum and the description of a new genus. Proc. U.S. Nat. Mus., vol. 86, pp. 107–134, 41 figs.

HORST, R.

1917. Polychaeta errantia of the *Siboga* Expedition, 2: Aphroditidae and Chrysopetalidae. *In Siboga*-Expedition, vol. 24b, pp. 1–140, 19 pls., 5 figs.

McINTOSH, WILLIAM C.

1885. Annelida Polychaeta. *In Challenger* reports, vol. 12, pt. 3, pp. 1–554, 94 pls.

MOORE, J. PERCY

1910. The polychaetous annelids dredged by the U.S.S. *Albatross* off the coast of southern California in 1904, 2: Polynoidae, Aphroditidae, and Segaleonidae. Proc. Acad. Nat. Sci. Philadelphia, vol. 62, pp. 328–402, pls. 28–33.

TREADWELL, AARON LOUIE

1906. Polychaetous annelids of the Hawaiian Islands collected by the steamer *Albatross* in 1902. Bull. U.S. Fish Comm. Washington, vol. 23, pp. 1145–1181, 81 figs.

1920. Polychaetous annelids collected by the United States Fisheries steamer *Albatross* in the waters adjacent to the Philippine Islands in 1907–1910. Bull. U.S. Nat. Mus., no. 100, pp. 589–602, 8 figs.

1923. Polychaetous annelids from Lower California with descriptions of new species. Amer. Mus. Novitat. New York, no. 74, pp. 1–11, 8 figs.

USCHAKOV, P.

1950. [Polychaeta from the Sea of Okhotsk.] Issled. dalnevost morei SSSR, no. 2, pp. 140–234, 2 pls., 39 figs. [In Russian.]

U.S. GOVERNMENT PRINTING OFFICE: 1967

Proceedings of the United States National Museum

SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 121 1967 Number 3576

NEW SPECIES AND RECORDS OF PACIFIC AMPELISCIDAE (CRUSTACEA: AMPHIPODA)

By J. Laurens Barnard

Associate Curator, Division of Crustacea

Ampeliscidae from the east tropical and warm-temperate Pacific Ocean and from warm-temperate Japan collected by the "*Albatross*," "*Velero III*," and individual collectors are reported upon in this paper. These records and descriptions complete an inventory of all Pacific Ocean materials of this family collected by the two expeditionary vessels, on which previous reports have been made by Holmes (1908), Shoemaker (1925), and J. L. Barnard (1954a, 1960, 1964a). Ampeliscidae are among the most dominantly occurring families of sublittoral and bathyal depths. Of particular interest are three new species of *Byblis* from Japan which demonstrate a remarkable diversity in that genus.

This study was supported by the Richard Rathbun Fund of the Smithsonian Institution and was part of a project organized by Dr. Fenner A. Chace, Jr., to complete the analysis of important expeditionary collections deposited in the U.S. National Museum. The writer is grateful also to the Beaudette Foundation of California for assistance in the completion of the work in 1960.

Station data are presented in the list below. Depths are quoted in fathoms as in the original data, but in the sections on distribution of species they are converted to meters to conform to international practice.

List of Localities

Albatross Station Records

2787, Golfo de Penas, Chile, 46°47′30″S, 75°15′00″W, 61 fms, green mud, Feb. 9, 1888

2798, Pearl Islands, Panama, 08°10′30″N, 78°50′30″W, 18 fms, gray sand, broken shells, Mar. 5, 1888

2799, Bay of Panama, 08°44′00″N, 79°09′00″W, 29.5 fms, green mud, Mar. 6, 1888

2824, Greater Bay of La Paz, Gulf of California, 24°22′30″N, 110°19′30″W, 8 fms, broken shells, Apr. 30, 1888

2831, Magdalena Bay, Baja California, 24°32′00″N, 111°59′00″W, 12 fms, fine gray sand, May 2, 1888

2834, near San Juanico Bay, Baja California, 26°14′00″N, 113°13′00″W, 48 fms, yellow mud, May 3, 1888

2835, near Punta Abreojos, Baja California, 26°42′30″N, 113°34′15″W, 5.5 fms, green mud, May 4, 1888

2837, Cedros Island, Baja California, 28°10′00″N, 115°09′45″W, 23 fms, fine sand, May 5, 1888

2911, Cortes Bank, Calif., 32°27′30″N, 119°05′00″W, 60 fms, rock, sand, Jan. 16, 1889

2922, Cortes Bank, Calif., 32°27′15″N, 119°05′15″W, 47 fms, fine gray sand, Jan. 17, 1889

2969, Santa Barbara Channel, Calif., 34°20′40″N, 119°37′45″W, 26 fms, gray sand, pebbles, stones, Feb. 11, 1889

3138, Monterey Bay, Calif., 36°55′30″N, 122°02′00″W, 19 fms, fine sand, mud, stones, Mar. 15, 1890

3187, near Pt. Sur, Calif., 36°14′00″N, 121°58′40″W, 298 fms, yellow sand, mud, Apr. 3, 1890

3195, near Morro Bay, Calif., 35°14′00″N, 121°07′00″W, 252 fms, green mud, Apr. 5, 1890

3566, San Diego Bay, Calif., 3 fms, fine sand, broken shells, Mar. 19, 1894

3698, Manazuru Zaki, N 8°, W 4.5 m, off Honshu Island, Japan, 153 fms, green mud, vol. a. s., May 5, 1900

3702, Seno Umi, N 13°, W 1.5 m, off Honshu, Japan, 31–41 fms, volcanic mud, sand, rock, May 7, 1900

3708, Ose Zaki, S 55°, W 2.25 m, off Honshu Island, Japan, 60–70 fms, green mud, volcanic sand, May 8, 1900

3716, Ose Zaki, S 36°, W 0.8 m, off Honshu Island, Japan, 65–125 fms, volcanic sand, shells, rock, May 11, 1900

3738, Ent. Port Heda, N 84°, E 1.2 m, off Honshu Island, Japan, 167 fms, stiff blue mud, May 17, 1900

3739, Ose Zaki, S 25°, W 0.25 m, off Honshu Island, Japan, 55–65 fms, volcanic sands, shells, rock, May 17, 1900

3767, Oboro Saki, N 67°, E 2.3 m, off Honshu Island, Japan, 14–18 fms, gray sand, June 5, 1900

3769, Nagane Saki, N 55°, E 5.3 m, off Honshu Island, Japan, 40–42 fms, green mud, sand, June 5, 1900

3771, Doumiki Saki, N 19°, W 4.5 m, off Honshu Island, Japan, 61 fms, green mud, sand, June 5, 1900

3809, Honolulu Light, N 28°, E 2′, Hawaii, 51–125 fms, fine coral sand, black specks, Mar. 27, 1902
4322, Soledad Hill, Point La Jolla, Calif., S 34°, E 3.2 miles, 110–199 fms, green mud, shells, Mar. 7, 1904
5091, Joga Shima Lt., N 15°, W 4.2 miles, 35°04′10″N, 139°38′12″E, Uraga Strait, Japan, entrance to Gulf of Tokoyo, 197 fms, green mud, coarse black sand, pebbles, Oct. 26, 1906

Velero III Station Records

221, off Gorgona Island, Colombia, 03°01′25″N, 78°10′00″W, 20 fms, rock, shell, Feb. 12, 1934
224, off Gorgona Island, Colombia, 02°59′45″N, 78°13′20″W, 10 fms, gravel, shell, Feb. 12, 1934
257, off South Viradores Islands, Port Culebra, Costa Rica, 10°35′00″N, 85°43′15″W, 10 fms, sand, shells, Feb. 25, 1934
268, north of White Friars, Mexico, 17°31′30″N, 101°29′27″W, 25 fms, coarse sand, Mar. 3, 1934
420, off Port Utria, Colombia, 05°58′00″N, 77°21′15″W, 35 fms, mud, sand, Jan. 25, 1935
460, Playa Blanca, Costa Rica, 10°56′00″N, 85°52′50″W, 3–5 fms, sand, shells, Feb. 8, 1935
562, east of San Esteban Island, Gulf of California, 28°41′25″N, 112°32′15″W, 20–70 fms, sand, rock, Mar. 10, 1936

Collected by Dr. Waldo L. Schmitt

1, Salinas, Ecuador, littoral, Sept. 12, 1926
10, just north of Paita, Peru, dredged off coast, Oct. 7, 1926
24, off passage between San Lorenzo and adjacent island, Callao Bay, Peru, dredged with scallop trawl, Nov. 7, 1926

Collected by Dr. E. F. Ricketts, Pacific Biological Laboratories

24–10, Pacific Grove, Calif., channel, rock, 70 fms, Apr. 13 1928
28–5, Pacific Grove, Calif., channel, rock, 80 fms Apr. 18, 1928
125–1, Monterey Bay, Calif., mud, 65 fms, June 22, 1930
125–2, Monterey Bay, Calif., rocks, 80 fms, June 27, 1930

Miscellaneous

Hemphill 5733, San Diego, Calif.
Hilton A–4, Laguna Beach, Calif., Aug. 5, 1918

Ampeliscidae

Ampelisca brevisimulata J. L. Barnard

Ampelisca brevisimulata J. L. Barnard, 1954a, pp. 33–35, pls. 23–24; 1954b, p. 7; 1964a, p. 212.

Material: *Albatross* 2837 (2).

Record: Cedros Island, Baja California, 23 fms.

Distribution: Eastern Pacific Ocean from Monterey Bay, Calif., to Panama, 11–172 m; Caribbean Sea off Colombia and Venezuela, 9–38 m.

Ampelisca compressa Holmes

Ampelisca compressa Holmes, 1905, pp. 480–481, 1 fig.—Kunkel, 1918, p. 66.—J. L. Barnard, 1960, pp. 31–32; 1964b, p. 101, chart 4; 1964a, p. 213.
Ampelisca vera J. L. Barnard, 1954a, pp. 23–26, pls. 14–16; 1954b, p. 3, pl. 1, figs. k–1.

Material: *Albatross* 2834 (3), 2835 (5), 2837 (6).

Records: Near San Juanico Bay, Baja California, 48 fms; near Punta Abreojos, Baja California, 5.5 fms; Cedros Island, Baja California, 23 fms.

Distribution: Western Atlantic Ocean; Caribbean Sea; Pacific Ocean from Panama to Puget Sound, Wash., 1–266 m.

Ampelisca cristata Holmes

Ampelisca cristata Holmes, 1908, pp. 507–508, figs. 16–17.—J. L. Barnard, 1954a, pp. 26–29, pls. 17–18 (includes forma *microdentata*); 1954b, pp. 3–4, pl. 1, figs. a–g (includes forma *microdentata*); 1959, p. 18 (forma *microdentata*); 1964a, p. 213.

Material: *Albatross* 2835 (5), 2911 (3), 2922 (1), 3566 (1). *Velero* 420 (1).

Records: Near Punta Abreojos, Baja California, 5.5 fms; Cortes Bank, California, 47–60 fms; San Diego Bay, Calif., 3 fms; off Port Utria, Colombia, 35 fms.

Distribution: Eastern Pacific Ocean from Tomales Bay, Calif., to La Plata Island, Ecuador, 6–152 m; Caribbean Sea, off Venezuela and Colombia, ca. 9–42 m.

Ampelisca cristoides J. L. Barnard

Ampelisca cristoides J. L. Barnard, 1954a, pp. 29–31, pls. 19–20; 1954b, p. 4, pl. 1, figs. h–j.

Material: *Albatross* 2798 (1). *Velero* 224 (1), 257 (3), 268 (1).

Records: Pearl Islands, Panama, 18 fms; Gorgona Island, Colombia, 10 fms; South Viradores Islands, Costa Rica, 10 fms; N of White Friars, Mexico, 25 fms.

Distribution: Eastern Pacific Ocean from Thurloe Head, Baja California, to Gorgona Island, Colombia, ca. 9–73 m; Caribbean Sea off north coast of Colombia, ca. 24–40 m.

Ampelisca eoa Gurjanova

Ampelisca eoa Gurjanova, 1951, pp. 313–314, fig. 178.—J. L. Barnard, 1960, p. 25.
Ampelisca catalinensis J. L. Barnard, 1954a, pp. 7–9, pls. 1–2.

Material: *Albatross* 3698 (8), 3738 (1).

Records: Honshu Island, Japan 153–167 fms.

Distribution: Bering Sea, 1000 m; Honshu Island, Japan, 280–330 m; offshore basins of southern California, 421–1, 833 m.

Ampelisca eschrichtii Krøyer

FIGURE 1*o*

Ampelisca Eschrichtii Krøyer, 1842, p. 155.—Sars, 1895, pp. 174–176, pl. 61, fig. 1.—Stephensen, 1925, pp. 139–141.

Ampelisca eschrichtii.—Stebbing, 1906, p. 100.—Shoemaker, 1930, pp. 27–28; 1931, pp. 9–10.

Ampelisca eschrichti.—Stephensen, 1933, pp. 23–24, fig. 9 (map); 1935, pp. 121–123.

Ampelisca eschrichti eschrichti.—Gurjanova, 1955, p. 170, fig. 169.

The shape of the head and article 2 of pereopod 5 distinguish this species from *A. macrocephala* Liljeborg. The obliquely truncated ventral margin of pereopod 5 is a contrast to the transversely truncated margin in *A. macrocephala* (see Stephensen, 1935). In *A. eschrichtii* the ventrolateral corneal lens occurs posterior to the anteroventral cephalic corner, and the ventral cephalic margin posterior to the lens is straight or convex, not excavate as in *A. macrocephala.* The ventrolateral lens of *A. macrocephala* forms the corner of the head. The presence or absence of a long distal spine on the outer ramus of uropod 2 is an invalid character in distinguishing the two species, as both species have the spine (contra J. L. Barnard, 1954a, key).

The Pacific specimens at hand seemed so unlike Sars' (1895) drawings of *A. eschrichtii* that the materials were compared with similar large specimens (20–27 mm) from the western Atlantic Ocean in Smithsonian collections. These large individuals differ materially from Sars' drawings in several conspicuous characters: the shortened uropod 1; the deeper recessment of the ventral pair of corneal lenses; and the greater convexity of the ventral cephalic margin posterior to the lenses. Pacific and some western Atlantic materials are comparable in these characters. A specimen from Bedford Basin, Halifax, Nova Scotia (reported in Shoemaker, 1931), has uropod 1 reaching only halfway along the rami of uropod 2; specimens from Hebron, Labrador, 1908, 75 fms, have uropod 1 reaching two-thirds along the rami of uropod 2; and specimens from Ungava Bay (1883, USNM 9413) have uropod 1 extending to the end of the rami of uropod 2 as shown by Sars (1895). The specimens from Ungava Bay are remarkable also for the development of a high dorsal crest on the posterior pereonal and anterior pleonal segments.

Gurjanova (1955) has figures of *A. eschrichtii eschrichtii* and her *A. e. pacifica* with uropod 1 extending about two-thirds along the rami of uropod 2; *A. e. pacifica* has the indented ventral corneal lens and slightly tumid ventral cephalic margin. Specimens at hand have these characters more exaggerated than previously shown. A representative head is given in figure 1*o*. The Pacific specimens are justifiably identified as *A. eschrichtii,* sensu lato, and this extends the range of the species in the Pacific as far south as Monterey Bay, California. That may be the southern limit because in the time since my (1954a) paper I have examined more than 600 samples and tens of thousands of specimens of *Ampelisca* from southern California, 200 miles south of Monterey, and have never found a specimen of *A. eschrichtii* (paper in preparation). Samples extended from depths of 4 to 1500 m.

There can be no confusion of *A. eschrichtii* with the southern Californian *A. indentata* which has a similar head, because the latter has a large lobe on article 4 of pereopod 5, a strongly saddle-shaped dorsal carina on urosomite 4 and virtually no tooth on pleonal epimeron 3, all in contradistinction to *A. eschrichtii.*

Material: *Albatross* 3187 (9), 3195 (29).

Records: Near Pt. Sur and near Morro Bay, Calif., 252–298 fms.

Distribution: Circumpolar in the northern hemisphere, with known southern limits as follows: The deep sea (1375 m) off Atlantic France (SW of Ireland); sublittoral depths of Georges Bank, east of Massachusetts (41°25′N); bathyal depths off Morro Bay, California; and "Japan Sea" (Gurjanova, 1951), ca. 10–800 m.

Ampelisca furcigera Bulycheva

Ampelisca furcigera Bulycheva, 1936, pp. 242–244, figs. 1–3.—Gurjanova, 1938, p. 256, fig. 4; 1951, pp. 314–316, fig. 180.—J. L. Barnard, 1960, pp. 26–27, fig. 6.

Material: *Albatross* 3698 (1), 3739 (1), 5091 (1).

Records: Honshu Island, Japan 65–153 fms; Uraga Strait, Gulf of Tokyo, Japan, 197 fms.

Distribution: Bering and Okhotsk Seas, Japan, 60–361 m; eastern Pacific Ocean in offshore basins of southern California, 212–386 m.

Ampelisca hancocki J. L. Barnard

Ampelisca hancocki J. L. Barnard, 1954a, pp. 37–38, pl. 26; 1964a, p. 213.

Material: Pacific Biological Laboratories 125–1 (1).

Records: Monterey Bay, Calif., 65 fms.

Distribution: Eastern Pacific Ocean from Monterey Bay, Calif., to Costa Rica, 9–157 m.

Ampelisca indentata J. L. Barnard

Ampelisca indentata J. L. Barnard, 1954a, pp. 43–45, pl. 30; 1964a, pp. 213–214.

Material: *Albatross* 2837 (1).

Record: Cedros Island, Baja California, 23 fms.

Distribution: Eastern Pacific Ocean from about Pt. Conception, Calif., into the Gulf of California, 33–98 m.

Ampelisca lobata Holmes

Ampelisca lobata Holmes, 1908, pp. 517–518, fig. 25.—Shoemaker, 1921, p. 99; 1941, p. 187; 1942, p. 7.—J. L. Barnard, 1954a, pp. 11–14, pls. 5–6; 1954b, p. 2; 1964a, p. 214.
Ampelisca articulata Stout, 1913, pp. 639–640.

Material: *Velero* 562 (1). Schmitt 1 (5). Pacific Biological Laboratories 125–2 (4). Hemphill 5733 (6). Hilton A–4 (1).

Records: San Esteban Island, Baja California, 20–70 fms; Salinas, Ecuador, littoral; Monterey Bay, Calif., rocks, 80 fms.; San Diego Bay, Calif.; Laguna Beach, Calif.

Distribution: Eastern Pacific Ocean from Monterey Bay, Calif., to Lobos de Afueras Islands, Peru, and the Galapagos Islands, 0–183 m but rare in depths exceeding 30 m; Caribbean Sea, off Colombia, Aruba, and Barbados Islands, 9–70 m.

Ampelisca mexicana J. L. Barnard

Ampelisca mexicana J. L. Barnard, 1954a, pp. 45–46, pls. 31–32; 1954b, p. 7; 1964a, p. 214.

Material: *Albatross* 2799 (1).

Record: Bay of Panama, 29.5 fms.

Distribution: Eastern Pacific Ocean from Punta Canoas, Baja California, to Independencia Bay, Peru, 9–73 m; Caribbean Sea: Caledonia, Panama, ca. 18 m.

Ampelisca miharaensis Nagata

Ampelisca miharaensis Nagata, 1959, pp. 70–73, figs. 3–5; 1960, p. 168; 1965, pp. 152–153, fig. 4 (subfigs. 2–4).

Material: *Albatross* 3698 (1), 3702 (1), 3708 (2).

Record: Honshu Island, Japan, 41–153 fms.

Distribution: Japan, 2–280 m.

Ampelisca milleri J. L. Barnard

Ampelisca milleri J. L. Barnard, 1954a, pp. 9–11, pls. 3–4.—Jones, 1961, pp. 253–254.—J. L. Barnard, 1964a, p. 215.

Material: Pacific Biological Laboratories 125–1 (1).

Record: Monterey Bay, Calif., 65 fms.

Distribution: Eastern Pacific Ocean from San Francisco Bay, Calif., to Ecuador, and the Galapagos Islands, 0–187 m.

Ampelisca misakiensis Dahl

Ampelisca misakiensis Dahl, 1944, pp. 6–9, figs. 4–6.—Nagata, 1965, p. 152. fig. 5 (subfigs. 3–6).

Material: *Albatross* 3702 (1), 3708 (1).

Record: Honshu Island, Japan, 31–60 fms.

Distribution: Warm-temperate Japan, 30–110 m.

Ampelisca pugetica Stimpson

Ampelisca pugetica Stimpson, 1864, pp. 158–159.—J. L. Barnard, 1954a, pp. 49–51, pls. 35–36 (includes forma *macrodentata*); 1954b, p. 7; 1960, p. 31, fig. 9; 1964a, p. 215.

Ampelisca californica Holmes, 1908, pp. 513–515, fig. 23.

Ampelisca gnathia J. L. Barnard, 1954a, pp. 46–48, pls. 33–34.

Material: *Albatross* 2831 (1), 2837 (5), 4322 (1).

Records: Magdalena Bay, Baja California, 12 fms; Cedros Island, Baja California, 23 fms; La Jolla, Calif., 110–199 fms.

Distribution: Eastern Pacific Ocean from Puget Sound, Wash., to Todos Santos Island, Baja California (*pugetica pugetica*), from Pt. Fermin, Calif., to Peru and the Galapagos Islands (*pugetica macrodentata*), 0–183+ m; Caribbean Sea off Venezuela, Colombia, and Aruba, 24–42 m.

Ampelisca romigi J. L. Barnard

Ampelisca romigi J. L. Barnard, 1954a, pp. 18–20, pls. 10–11; 1954b, p. 3; 1960, p. 34; 1964a, pp. 215–216.

Ampelisca isocornea J. L. Barnard, 1954a, pp. 20–21, pl. 12.

Material: *Albatross* 2824 (1). Pacific Biological Laboratories 24–10 (1), 28–5 (1).

Records: Greater Bay of La Paz, Gulf of California, 8 fms; Pacific Grove, Monterey Bay, Calif., 70–80 fms.

Distribution: Eastern Pacific Ocean from Monterey Bay, Calif., to Santa Elena Bay, Ecuador, 3–504 m, probably inhabiting only very coarse sediments (rubble, gravel) and thus rarely occurring in shallow water of high latitudes because of absence of substrate; Caribbean Sea, north shore of Colombia and Aruba, 24–42 m.

Ampelisca schellenbergi Shoemaker

FIGURES 1*a–m*

Ampelisca schellenbergi Shoemaker, 1933, pp. 3–5, fig. 2; 1942, p. 9.—J. L. Barnard, 1954a, pp. 14–16, pls. 7–8; 1954b, p. 2.

Material: *Albatross* 3809 (86). *Velero* 221 (10), 224 (1), 562 (1). Schmitt 1 (5). Pacific Biological Laboratories 24 (8).

Records: Off Honolulu, Hawaii, 51–125 fms; Gorgona Island, Colombia, 20 fms (2 records); San Esteban Island, Baja California, 20–70 fms; Salinas, Ecuador, littoral; Pacific Grove, Calif., 70 fms, channel.

Notes on Hawaiian material: Antenna 1 variable, in the largest specimen scarcely exceeding article 4 of antenna 2 peduncle, in other smaller females reaching nearly three-fourths along article 5, in most young males reaching halfway or fully along article 5 and occasionally exceeding it slightly; antenna 2 in female approximately three-fourths as long as body, in young males as long as body; young male antennae stouter than in female, with stouter flagellar articles; base of flagellum of antenna 1 slightly more setose, but young males lacking setal

FIGURE 1.—*Ampelisca schellenbergi* Shoemaker, *Albatross* 3809, female, 7.6 mm: *a*, head; *b–f*, pereopods 1–5; *g*, telson; *h–j*, uropods 1–3; *k*, *l*, coxae 1, 2; *m*, continuation of antenna 2 from fig. *a*; *n*, pleonites 2–6, left lateral (5–6 coalesced). *Ampelisca eschrichtii* Krøyer, female, 20.0 mm, *Albatross* 3195: *o*, head.

tufts typical of adult ampeliscas (no fully adult males at hand); dactyl of pereopod 3 with 3 accessory spines but only 1 on pereopod

4; submarginal medial row of setae on posteroventral edge of article 2 on pereopod 5 more densely packed than in American population; notch and distal end of article 5 with slight ochraceous bulbosities appearing almost lenslike; posterior edges of articles 6–7 with row of small pits similar to stridulating ridges; coxae 1–3 each with 1 small posteroventral slit; peduncle of uropods 1 and 2 without ventrolateral setules occurring on continental American specimens.

Remarks: The members of this one population are consistent in the condition of their third uropods as reflected by the accompanying illustration, unlike the variation shown for *A. schellenbergi* by J. L. Barnard (1954a), and none of the young males has any sexual differentiation on uropod 3.

The Hawaiian population of this species has been compared with Caribbean samples used by Shoemaker in his description of the species and with samples from the eastern Pacific Ocean described by J. L. Barnard (1954a). The scabrous condition of pereopods 3–4 noted in the Hawaiian specimens and the ornamental pits of pereopod 5 also occur in the others. Individuals from all 3 areas have a few serrate spines in the distal groups on article 5 of pereopods 3–4.

Distribution: Hawaiian Islands, "93–229" m; eastern Pacific Ocean from Laguna Beach, Calif., to Lorenzo Island, Peru, 0–"128" m, but probably rare in depths esceeding 40 m; western Atlantic Ocean from Florida, Yucatan, and Panama, 0–46 m.

Ampelisca shoemakeri J. L. Barnard

Ampelisca shoemakeri J. L. Barnard, 1954a, pp. 39–40, pls. 27–28; 1964a, p. 216.

Material: *Albatross* 2837 (29). Schmitt 10 (2).

Records: Cedros Island, Baja California, 23 fms; north of Paita, Peru.

Distribution: Eastern Pacific Ocean from Cedros Island, Baja California, to Paita, Peru, 7–76 m.

Byblis albatrossae, new species

Figure 2

Diagnosis of female: Head with distinct rostrum about one-third as long as article 1 of antenna 1, anterior cephalic margin with strong angular protrusion, anteroventral cephalic margin deeply excavate for reception of antenna 2; ventral pair of corneal lenses situated at and forming rounded anteroventral cephalic angle, arranged so as to point obliquely anteroventrally, dorsal pair of lenses enormous, about 1.5 times as large as ventral pair, protruding strongly; antenna 1 nearly as long as peduncle of antenna 2, article 2 more than twice as long as article 1 and more than half as long as article 4 of antenna 2;

FIGURE 2.—*Byblis albatrossae*, new species, female, holotype, 15.0 mm, *Albatross* 3738: *a*, head; *b*, *c*, coxae 1, 2; *d–h*, pereopods 1–5; *i* ,telson; *j*, outline of maxilla 2, minus setae; *k–m*, uropods 1–3, latter enlarged.

article 4 of antenna 2 longer than peduncle of antenna 1 and much longer than article 5 of antenna 2, flagellum 4 times as long as article 5 of peduncle; anterior coxae unserrate ventrally, shallow, pointing very strongly anteroventrad, coxae 3 and 4 progressively more truncated ventrally, coxa 4 with long, flat ventral margin and narrow posterior tooth; pereopods 1–2 scarcely disproportionate in size, dactyls slightly longer or subequal in length to their respective sixth articles, pereopod 2 more strongly setose than pereopod 1; pereopods 3–4 without special modifications, posterior bilobation of article 2 on pereopod 3 especially symmetrical for genus; article 2 of pereopod 5 with typical overall shape but ventral margin evenly rounded, article 6 about 80 percent as long as article 5, article 7 slightly more than half as long as article 6; uropod 1 extending to end of uropod 2 but with disproportionately short peduncle and long rami, distolateral apex of peduncle with long, slender spine, outer ramus longer than inner and lacking spines, inner ramus with basal ridge for locking outer ramus; uropod 2 with hooked distolateral cusp on peduncle, outer ramus with more than twice as many marginal spines as inner ramus; uropod 3 typically forcipiform, apposing margins of rami strongly serrate; telson of medium length, cleft about one-third.

Remarks: Pleonal epimera are similar to those of *Byblis affinis* (in Sars, 1895, pl. 65). Mouthparts are similar to those of *B. gaimardi* (in Sars, 1895, pl. 65), but article 2 of the mandibular palp is expanded proximally in asymmetrical fashion, each inner plate of the maxillipeds has 2 spine-teeth, and the outer plate of maxilla 2 is slightly broader and distally expanded.

Male: Two specimens, 15 and 13 mm long, have article 5 of antenna 2 nearly as long as article 4, and antenna 1 is equal to or exceeds the peduncle of antenna 2 by the length of 2 flagellar articles.

Holotype: USNM 111268, female, 15.0 mm.

Type locality: *Albatross* 3738, entrance to Port Heda, off Honshu Island, Japan, 167 fms, May 17, 1900.

Material: *Albatross* 3698 (3), 3738 (3).

Records: Manazuru Zaki and Port Heda, Honshu Island, Japan, 153–167 fms.

Relationship: In some ways this species resembles *B. veleronis* J. L. Barnard (1954a), but the disproportionate corneal lenses, the angular protrusion on the anterior margin of the head, and the shape of coxa 4 distinguish *B. albatrossae.* The shape of the anterior 4 pairs of coxae and the first antennal length relate this species to one being described by M. Imbach from Viet Nam, but numerous other characters of that species distinguish it: serrate anterior coxae, equal ocular lenses, straight anterior cephalic margin, more deeply cleft telson, and the form of article 2 on pereopod 3.

The distinct rostrum of *B. albatrossae* prompts comparison with *Haploops securiger* K. H. Barnard (1932) which I transfer to *Byblis*. That species also has a distinct but much longer rostrum, and its ventral pair of corneal lenses is situated beneath the head and concealed from lateral view.

Distribution: Honshu Island, Japan, 280–329 m.

Byblis ampelisciformis, new species

FIGURE 3

Diagnosis of male: Rostrum vestigial, anterior cephalic margin lacking protrusion, anteroventral cephalic margin sinuously excavate for reception of antenna 2, strongly oblique; two pairs of corneal lenses of medium and subequal size, ventral pair situated at and forming rounded anteroventral angle, pointing anterolaterally; antenna 2 as long as body, antenna 1 reaching nearly three-fourths along full length of antenna 2, article 2 of peduncle 2.5 times as long as article 1 and nearly as long as article 4 of peduncle on antenna 2; anterior coxae serrate ventrally, coxa 4 of medium width, slightly truncate ventrally, posterior tooth of medium size; pereopods 1–2 scarcely disproportionate in size, dactyls slightly longer than their respective sixth articles; pereopods 3–4 without special modifications; article 2 of pereopod 5 with typical overall shape, article 6 about 67 percent as long as article 5, article 7 about 40 percent as long as article 6; uropods 1 and 2 of normal proportions, distolateral end of uropod 1 peduncle with stout spine, of uropod 2 with hooked cusp, spines of peduncles and rami remarkably short and stout; rami of uropod 3 furciform, short, asetose, medial margin of inner ramus lined with short spines, ventromedial margin of outer ramus bearing several scales, typical serrations absent; telson short, very broad, cleft halfway; urosome slightly miniaturized in comparison to other species of genus.

Remarks: Mouthparts are similar to those of *Byblis gaimardi* (Krøyer) (*in* Sars, 1895, pl. 64), but the outer plate of maxilla 2 is expanded distally very slightly and article 2 of the mandibular palp is asymmetrically expanded. Pleonal epimera are rounded posteriorly and resemble those of *B. crassicornis* Metzger (*in* Sars, 1895, pl. 66). The medial surface of article 2 of pereopod 5 is densely setose.

Female: Similar to male.

Holotype: USNM 111271, male, 12.0 mm.

Type locality: *Albatross* 3708, Ose Zaki, off Honshu Island, Japan, 60–70 fms, May 8, 1900.

Material: *Albatross* 3708 (3), 3716 (1).

Records: Ose Zaki, Honshu Island, Japan, 70–125 fms.

Relationship: This species resembles *B. veleronis* J. L. Barnard, *B. japonicus* Dahl, and *B. erythrops* Sars in the following characteristics: Corneal lenses present, lower pair visible laterally, pereopod 2 similar to pereopod 1, telson cleft a third or more, antenna 1 subequal

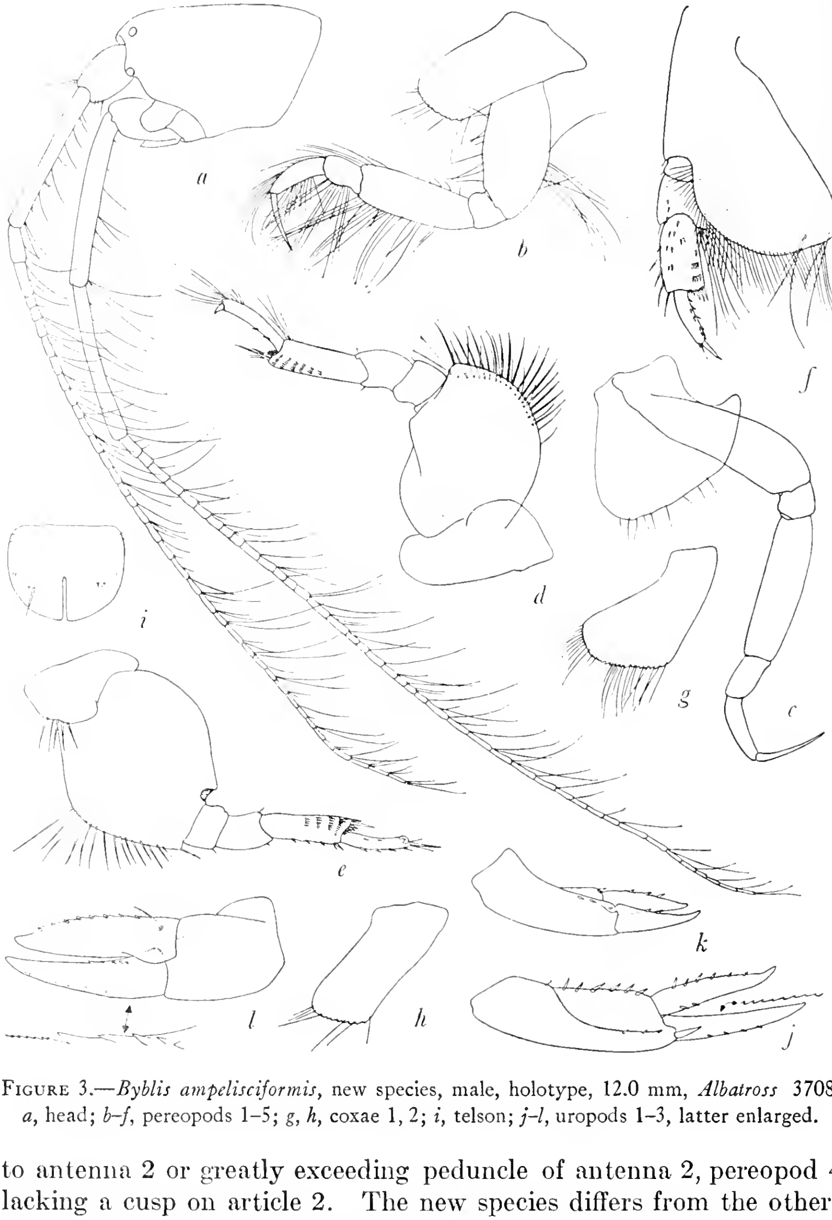


FIGURE 3.—*Byblis ampelisciformis*, new species, male, holotype, 12.0 mm, *Albatross* 3708: *a*, head; *b–f*, pereopods 1–5; *g*, *h*, coxae 1, 2; *i*, telson; *j–l*, uropods 1–3, latter enlarged.

to antenna 2 or greatly exceeding peduncle of antenna 2, pereopod 4 lacking a cusp on article 2. The new species differs from the others in its unusual third uropods with short blunt spines and furciform appearance. Indeed, few other species of *Byblis* are known to have these uropods which are suggestive of the following species of *Ampelisca: lobata* Holmes (females only), *bidentata* Schellenberg, *scabripes* Walker, and *excavata* K. H. Barnard. From the literature, those species appearing to resemble *B. ampelisciformis* in their third uropods are *B. antarctica* Schellenberg (1931) which lacks corneal lenses and has a large distal protrusion on article 5 of pereopod 3, and *B. subantarctica* Schellenberg (1931) which has a very distinctive pereopod 5, no ventral lenses, and which is transferred to *Ampelisca*.

Distribution: Honshu Island, Japan, 128–228 m.

Byblis orientalis, new species

FIGURE 4

Diagnosis of male: Rostrum vestigial, anterior cephalic margin with small protrusion, anteroventral cephalic margin with short, regular excavation for reception of antenna 2; two pairs of corneal lenses of medium and subequal size, ventral pair pointing anterolaterally, situated at and forming rounded anteroventral cephalic angle; antenna 2 as long as body, antenna 1 reaching about three-fourths along article 5 of antenna 2, article 2 of peduncle almost twice as long as article 1 and slightly more than one-third as long as peduncular article 4 of antenna 2; anterior coxae unserrate ventrally, coxa 4 of medium width, not truncate ventrally but posteroventral margin beveled and posterior tooth therefore very slender; pereopods 1–2 scarcely disproportionate in size, dactyls shorter than their respective sixth articles; pereopods 3–4 without special modifications, article 2 of pereopod 5 with typical overall shape, but neither as strongly expanded nor as ventrally extended as in many species of *Byblis*, articles 5 and 6 equal in length, article 7 about half as long as article 6; uropods 1 and 2 of normal proportions, distolateral end of uropod 1 peduncle with stout spine, of uropod 2 with weakly hooked cusp, spines of peduncles and rami of normal size; uropod 3 typically forcipiform, apposing margins of rami weakly serrate; telson of medium length, cleft about one-third.

Remarks: Mouthparts are like those of *B. gaimardi* (Krøyer) (in Sars, 1895, pl. 64) except for the expanded article 2 of the mandibular palp and the stouter spines of the outer plates of the maxillipeds. Article 2 of pereopod 5 is covered medially with setae. Male antennae lack setal tufts on the peduncles. The holotype has the best developed dorsal subcrest on urosomite 1 of any of the specimens. The anterior cephalic protrusion is also best developed on the figured holotype.

Female: Antenna 1 extending along antenna 2 only about 2 flagellar articles beyond article 4.

Holotype: USNM 111274, male, 11.0 mm.

Type locality: *Albatross* 3769, Nagane Saki, off Honshu Island, Japan, 40–42 fms, June 5, 1900.

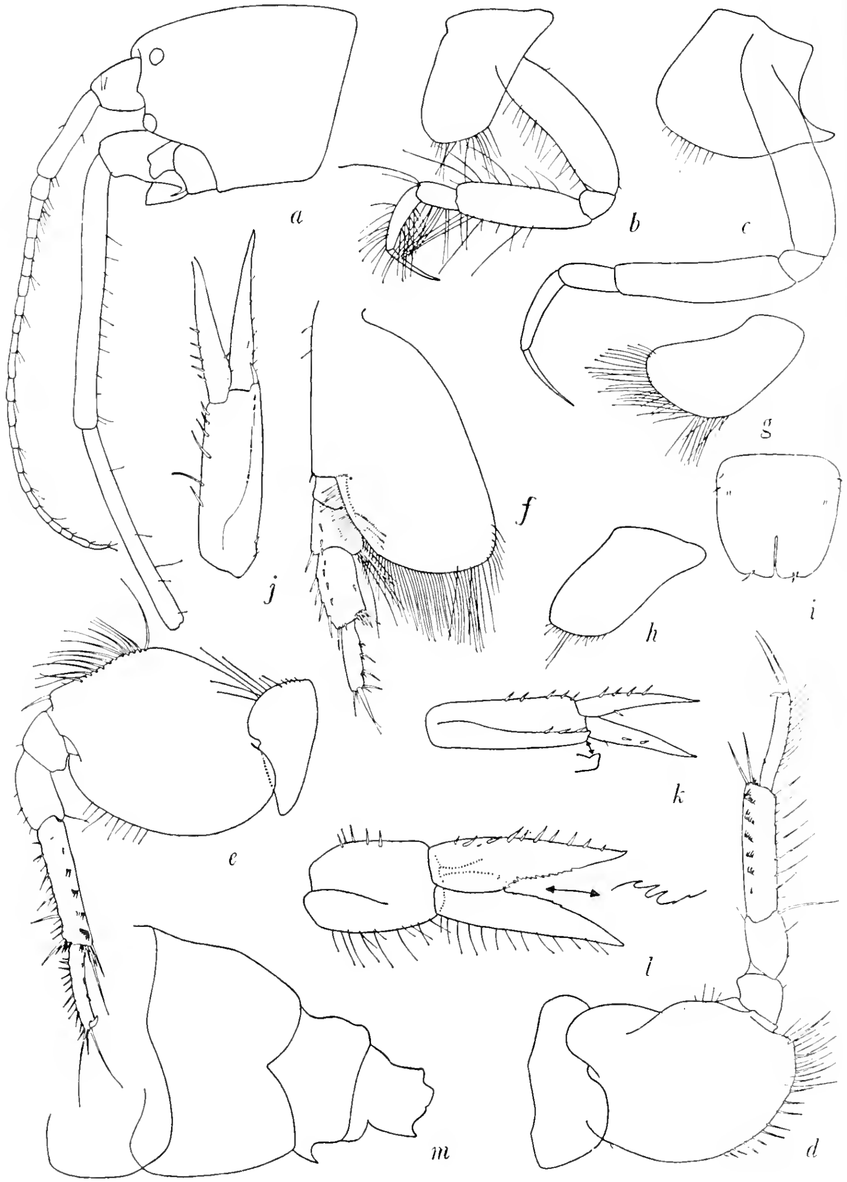


FIGURE 4.—*Byblis orientalis*, new species, male, holotype, 11.0 mm, *Albatross* 3769: *a*, head; *b–f*, pereopods 1–5; *g*, *h*, coxae 1, 2; *i*, telson; j–*l*, uropods 1–3, latter enlarged; *m*, pleonites 2–6, left to right (5–6 coalesced).

Material: *Albatross* 3767 (2), 3769 (9), 3771 (1 specimen, the largest, 16 mm).

Records: Oboro Saki; Nagane Saki; and Doumiki Saki, Honshu Island, Japan, 18–61 fms.

Relationship: Differing from *B. rhinoceros* Pirlot (1936) to which it is closely related in view of antenna 1, head, telson, uropod 3, pereopod 5 articles 3–7, and uropods 1 and 2, by the slightly more quadriform posterodistal corner of article 2 of pereopod 5, and by the considerably shorter first antenna of the female. In many respects this species also resembles *B. crenulata* Pirlot (1936) which is close to if not identical with *B. daleyi* Giles (Pirlot's, 1936, identification of *daleyi* did not account for the extremely long second article of antenna 1), but the head and eyes of *B. crenulata* differ, the lower lens pointing more ventrally, the anterior edge lacking a small protrusion, and the ventral margin of the head apparently not being strongly excavate for the attachment of antenna 2. Article 2 of antenna 1 is subequal to article 1 in contrast to *B. orientalis* and the anterior coxae are serrate ventrally. In addition, article 7 of pereopod 5 is much shorter in *B. crenulata* than it is in *B. orientalis.*

The new species is also related to Pirlot's (1936) identification of *B. daleyi*, but article 2 of antenna 1 is much shorter than in that individual; however, one aberrant specimen of *B. orientalis* in sample 3138 has left and right antennae dissimilar, the left with article 2 more than twice as long as article 1, the right with article 2 scarcely longer than article 1.

This species also resembles a new species to be described by M. Imbach from the South China Sea but differs from it by the sparsity of spines on the "posterior" edge of article 6 on pereopod 3, by the less attenuated and asymmetrical lobe of article 2 on pereopod 5, by the slightly shorter first antennae, the slightly deeper cleft of the telson, the stronger posterior cusp of coxa 4, and the thinness of the setae on the outer ramus of uropod 3. Those two species may be races of a common stem.

Distribution: Honshu Island, Japan, 33–112 m.

Haploops spinosa Shoemaker

Haploops spinosa Shoemaker, 1931, pp. 13–18, figs. 5, 6.
Haploops tubicola.—J. L. Barnard, 1960, p. 35. [Not Liljeborg.]

Barnard overlooked the row of spines on article 3 of pereopod 5 in his misidentification of 1960.

Material: *Albatross* 3698 (1).

Record: Honshu Island, Japan, 153 fms.

Distribution: Western Atlantic Ocean, Bay of Fundy, and Nova Scotia, 22–2300 m; eastern Pacific Ocean, near Pt. Conception, Calif., 117–171 m; Honshu Island, Japan, 250 m.

Literature Cited

BARNARD, J. L.

1954a. Amphipoda of the family Ampeliscidae collected in the eastern Pacific Ocean by the *Velero III* and *Velero IV*. Allan Hancock Pacific Expeditions, vol. 18, pp. 1–137, pls. 1–38.

1954b. Amphipoda of the family Ampeliscidae collected by the *Velero III* in the Caribbean Sea. Allan Hancock Atlantic Expedition, Rept. 7, pp. 1–13, pls. 1–2.

1959. Estuarine Amphipoda. *In* Barnard and Reish, Ecology of Amphipoda and Polychaeta of Newport Bay, California. Allan Hancock Found. Publ. Occ. Pap. 21, pp. 13–69, pls. 1–14.

1960. New bathyal and sublittoral ampeliscid amphipods from California, with an illustrated key to Ampelisca. Pacific Nat., vol. 1, no. 16, pp. 1–36, figs. 1–11.

1964a. Los anfipodos bentonicos marinos de la costa occidental de Baja California. Rev. Soc. Mexicana Hist. Nat., vol. 24, pp. 205–274, figs. 1–11.

1964b. Marine Amphipoda of Bahia de San Quintin, Baja California. Pacific Nat., vol. 4, pp. 55–139, figs. 1–21.

BARNARD, K. H.

1932. Amphipoda. *In* Discovery Reports, vol. 5, pp. 1–326, figs. 1–174, pl. 1.

BULYCHEVA, A.

1936. New species of Amphipoda from the Japan Sea. Ann. Mag. Nat. Hist., ser. 10, vol. 18, pp. 242–256, figs. 1–35.

DAHL, E.

1944. Amphipoda of the family Ampeliscidae from Professor Sixten Bock's expedition to Japan 1914. Arkiv Zool., vol. 35A, pp. 1–18, figs. 1–10.

GURJANOVA, E.

1938. Amphipoda, Gammaroidea of Siaukhu Bay and Sudzukhe Bay (Japan Sea). Reports of the Japan Sea Hydrobiological Expedition of the Zoological Institute of the Academy of Sciences of the USSR in 1934, pt. 1, pp. 241–404, figs. 1–59.

1951. Bokoplavy morei SSSR i sopredel'nyx vod (Amphipoda-Gammaridea). Opred. po Faune SSSR, Izd. Zool. Inst. Akad. Nauk SSSR, vol. 41, pp. 1–1,031, figs. 1–705. [In Russian.]

1955. Novye vidy bokoplavov (Amphipoda, Gammaridea) iz severnoi chasti Tixogo Okeana. Trudy Zool. Inst. Akad. Nauk SSSR, vol. 18, pp. 166–218, figs. 1–23. [In Russian.]

HOLMES, S. J.

1905. The Amphipoda of southern New England. Bull. U.S. Bur. Fisheries, vol. 24, pp. 459–529, pls. 1–13, numerous text figs. [unnumbered].

1908. The Amphipoda collected by the U.S. Bureau of Fisheries Steamer, "Albatross," off the west coast of North America, in 1903 and 1904, with descriptions of a new family and several new genera and species. Proc. U.S. Nat. Mus., vol. 35, pp. 489–543, figs. 1–46.

JONES, M. L.

1961. A quantitative evaluation of the benthic fauna off Point Richmond, California. Univ. California Publ. Zoöl., vol. 67, pp. 219–320, figs. 1–30.

KRØYER, H.

1842. Une nordiske Slaegter og Arter af Amfipodernes Orden, henhørende til Familien *Gammarina* (Foreløbigt Uddrag af et Større Arbejde). Naturh. Tidsskr., vol. 4, pp. 141–166.

KUNKEL, B. W.

1918. The Arthrostraca of Connecticut. Connecticut Geol. Nat. Hist. Surv., vol. 6, bull. 26 (Amphipoda), pp. 15–181, figs. 1–55.

NAGATA, K.

1959. Notes on five species of the amphipod genus Ampelisca from the stomach contents of the triglid fishes. Publ. Seto Mar. Biol. Lab., vol. 7, pp. 67–82, pls. 2–11.

1960. Preliminary notes on benthic gammaridean Amphipoda from the *Zostera* region of Mihara Bay, Seto Inland Sea, Japan. Publ. Seto Mar. Biol. Lab., vol. 8, pp. 163–182, figs. 1–2, pls. 13–17.

1965. Studies on marine gammaridean Amphipoda of the Seto Inland Sea, 1. Publ. Seto Mar. Biol. Lab., vol. 13, pp. 131–170, figs. 1–15.

PIRLOT, J. M.

1936. Les amphipodes de l'expedition du Siboga, Deuxième partie: Les amphipodes gammarides, II. Les amphipodes de la mer profonde, 3: Addendum et partie générale, III: Les amphipodes littoraux, 1: Lysianassidae . . . Gammaridae. Monogr. 33e (vol. 127) *in* Weber, Siboga-Expeditie, pp. 237–328, figs. 102–146.

SARS, G. O.

1895. Amphipoda. *In* An account of the Crustacea of Norway with short descriptions and figures of all the species, vol. 1, pp. i–viii + 1–711, pls. 1–240, suppl. pls. 1–8.

SCHELLENBERG, A.

1931. Gammariden und Caprelliden des Magellangebietes, Südgeorgiens und der Westantarktis. Further Zoological Results of the Swedish Antarctic Expedition 1901–1903, vol. 2, no. 6, pp. 1–290, pl. 1, figs. 1–136.

SHOEMAKER, C. R.

1921. Report on the amphipods collected by the Barbados-Antigua Expedition from the University of Iowa in 1918. Univ. Iowa Studies Nat. Hist., vol. 9, pp. 99–102.

1925. The Amphipoda collected by the United States Fisheries Steamer "Albatross" in 1911, chiefly in the Gulf of California. Bull. American Mus. Nat. Hist., vol. 52, pp. 21–61, figs. 1–26.

1930. The Amphipoda of the Cheticamp Expedition of 1917. Contr. Canadian Biol. Fish., n.s., vol. 5, no. 10, pp. 1–141, figs. 1–54.

1931. The stegocephalid and ampeliscid amphipod crustaceans of Newfoundland, Nova Scotia, and New Brunswick in the United States National Museum. Proc. U.S. Nat. Mus., vol. 79, no. 2888, pp. 1–18, figs. 1–6.

1933. Amphipoda from Florida and the West Indies. American Mus. Nov., no. 598, pp. 1–24, figs. 1–13.

1941. On the names of certain California amphipods. Proc. Biol. Soc. Washington [D.C.], vol. 54, pp. 187–188.

1942. Amphipod crustaceans collected on the Presidential Cruise of 1938. Smithsonian Misc. Coll., vol. 101, no. 11, pp. 1–52, figs. 1–17.

STEBBING, T. R. R.

1906. Amphipoda, 1: Gammaridea. Vol. 21 *in* Das Tierreich, pp. 1–806, figs. 1–127.

STEPHENSEN, K.

1925. Crustacea Malacostraca, VI (Amphipoda, II). *In* Danish Ingolf-Expedition, vol. 3, pp. 101–178, figs. 23–53.

1933. Amphipoda. *In* The Godthaab Expedition, 1928. Medd. om Grønland, vol. 79, no. 7, pp. 1–88, figs. 1–31.

1935. The Amphipoda of N. Norway and Spitsbergen with adjacent waters. Tromsø Mus. Skr., vol. 3, pp. 1–140, figs. 1–19.

STIMPSON, W.

1864. Descriptions of new species of marine Invertebrata from Puget Sound, collected by the naturalists of the North-west Boundary Commission, A. H. Campbell, Esq., Commissioner. Proc. Acad. Nat. Sci. Philadelphia [vol. 16], 1864, pp. 153–165.

STOUT, V. R.

1913. Studies in Laguna Amphipoda. Zool. Jahrb., vol. 34 (Syst.), pp. 633–659, figs. 1–3.

U.S. GOVERNMENT PRINTING OFFICE: 1967

Proceedings of the United States National Museum

SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 121 | 1966 | Number 3577

BREDIN-ARCHBOLD-SMITHSONIAN BIOLOGICAL SURVEY OF DOMINICA

1. The Echinoids of Dominica[1]

By Porter M. Kier

Associate Curator, Division of Invertebrate Paleontology

Although the echinoids have been described from most of the larger islands of the Caribbean, no one has ever reported the echinoids of Dominica. As a member of the Bredin-Archbold-Smithsonian Biological Survey of Dominica, I spent April 1964 studying and collecting echinoids off the island. Underwater diving apparatus was used to make traverses down to 85-foot depths off most of the promotories and in most of the bays. Live individuals were found in 8 of the 10 species collected and their living positions are described. Most of the diving was done in the Caribbean because of the lack of suitable boats on the Atlantic side of the island.

I thank Miss Maureen Downey of the U.S. National Museum for identifying the basket stars and crinoids and Mr. Louis R. Purnell for making the drawings. I wish also to thank William P. Campbell, who assisted in the collecting.

[1] This paper is the first of a series on the faunal studies from the survey that will appear in the "Proceedings of the United States National Museum." A companion series on the flora will appear in the "Contributions of the United States National Museum."

General Description of Coast

The island is of great relief with a high gradient to the shore. Off the promotories the gradient is so steep that in some places there is only a narrow belt less than 100 feet wide with depths of less than 85 feet. The lowest gradients were in some of the sandy bays such as that at Mero, where a depth greater than 85 feet was not encountered within a half mile of the shore. Two main types of environments were apparent on the Caribbean side of the island: the rocky-coral areas and the sand areas.

Rocky-Coral Environment

Off the promontories the bottom is generally rocky with many corals and sponges (fig. 1; pl. 1: fig. 1). Small sandy patches of approximately 100 square feet occur within this rock-coral. Usually this

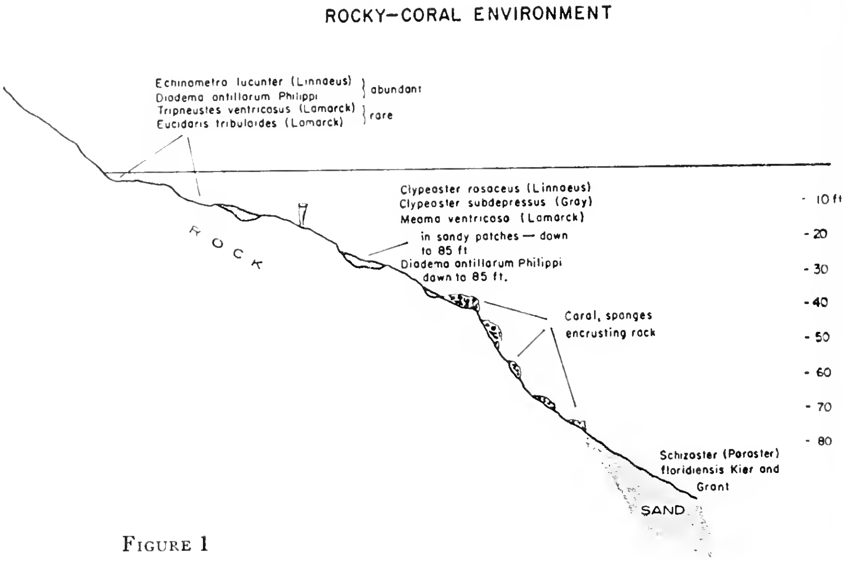


FIGURE 1

rocky-coral area continues down to approximately 75 feet, where the rock ceases, and sand continues downward at a steep grade. Although some of the coral masses are large, most of them are not very thick and barely cover the rocky substrate. The crinoid *Comactinia echinoptera* (Muller) lives commonly in crevices (pl. 1: fig. 1) in the coral from depths of 15–85 feet and probably deeper.

In the shallow water of the rocky-coral areas, from low tide to 10 feet, the most common echinoid is *Diadema antillarum* Philippi (pl. 2: figs. 4, 5) except in areas of strong current, where *Echinometra lucunter* (Linnaeus) is more abundant. I saw a few specimens of *Eucidaris* *tribuloides* (Lamarck) and *Tripneustes ventricosus* (Lamarck) (pl. 2: fig. 4).

Below 10 feet, *Diadema antillarum* was the only echinoid seen in any numbers. The spatangoid *Meoma ventricosa* (Lamarck) lives in the sandy patches together with a few individuals of *Clypeaster subdepressus* (Gray) and *C. rosaceus* (Linnaeus).

Sand Environment

The bottom of the bays are mostly sand or silt except for a narrow band of gravel at the shoreline (fig. 2). Only one echinoid, *Leodia sexiesperforata* (Leske), was found in the shallower parts of these sandy areas. Between 25 and 65 feet holothurians were encountered

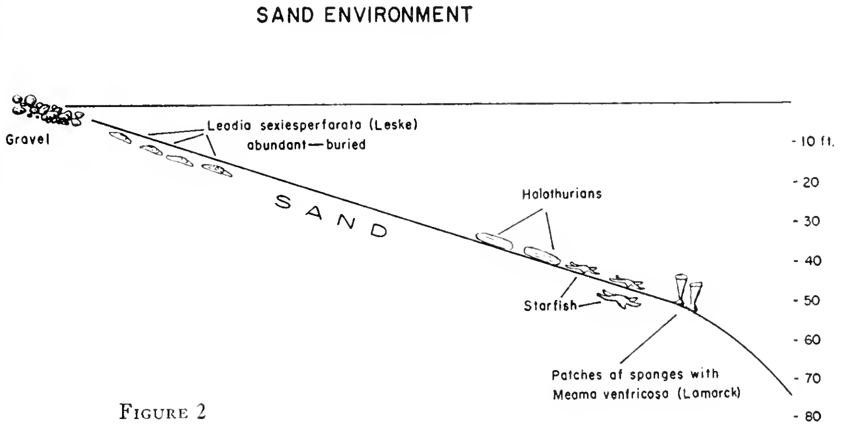


FIGURE 2

frequently and, at one site north of Tarreau Point at 50 feet depth, the starfish *Oreaster reticulatus* (Linneaus) was present in great numbers. In a few of these sandy areas small patches of sponges and a few specimens of *Meoma ventricosa* (Lamarck) were present between the depths of 25 and 50 feet.

Echinoids and Their Localities

species	*locality*
Eucidaris tribuloides (Lamarck)	8
Tripneustes ventricosus (Lamarck)	8, 10, 18
Echinometra lucunter (Linnaeus)	8, 14–16, 18
Echinometra viridis Agassiz	8
Diadema antillarum Philippi	1–3, 5, 6, 8, 10, 13–17
Clypeaster subdepressus (Gray)	2, 6, 10, 13
Clypeaster rosaceus (Linnaeus)	10
Leodia sexiesperforata (Leske)	7, 9, 12
Meoma ventricosa (Lamarck)	2–4, 6, 10, 12
Schizaster (*Paraster*) *floridiensis* Kier and Grant	4

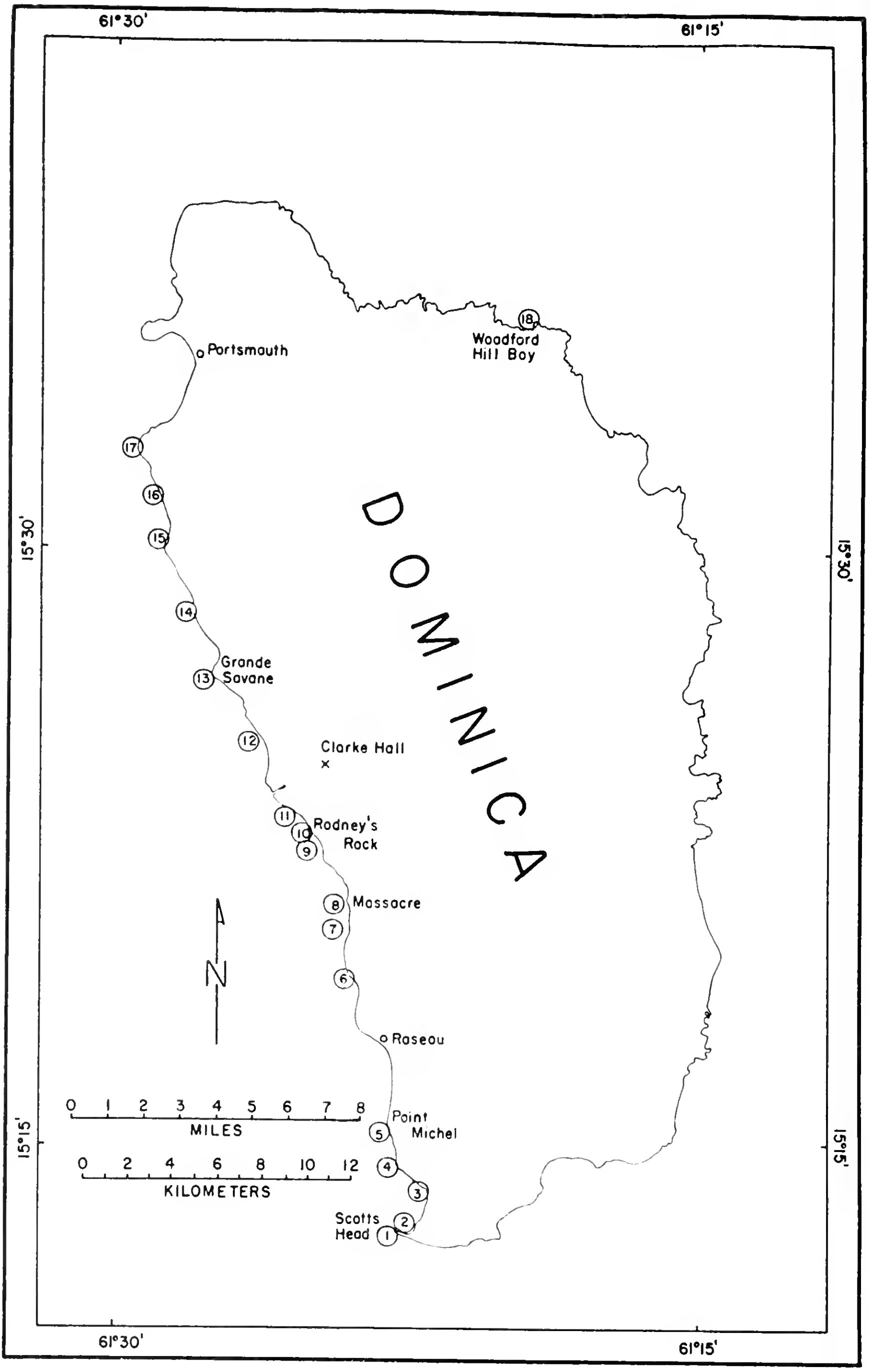

61°30'
61°15'
15°30'
15°15'
DOMINICA
Portsmouth
Woodford Hill Bay
Grande Savane
Clarke Hall
Rodney's Rock
Massacre
Roseau
Point Michel
Scotts Head
N
0 1 2 3 4 5 6 7 8
MILES
0 2 4 6 8 10 12
KILOMETERS
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

FIGURE 3

Locality Data

numerals=location of stations on map (fig. 3)

1 Rocky, few corals, sponges, many *Diadema antillarum* Philippi.

2 Abundant corals, extensive flat area of *Porpites,* large brain corals, dropping rapidly from depth of 25 feet. Abundant crinoids, many *Diadema antillarum* Philippi, *Meoma ventricosa* (Lamarck), few (4 dead tests) *Clypeaster subdepressus* (Gray).

3 Rocky area with few corals, *Diadema antillarum* Philippi in great numbers, one *Meoma ventricosa* (Lamarck) in sandy patch at 50-foot depth. Two basket stars.

4 Rocky area with few corals down to 60 feet, sand at greater depth. At 65 to 85 feet many *Meoma ventricosa* (Lamarck); one *Schizaster* (*Paraster*) *floridiensis* Kier and Grant at 85 feet.

5 Rocky area with few corals, abundant *Diadema antillarum* Philippi.

6 Rocky area with many corals, large sandy patches in shallower region (10′–20′); large sponges, many crinoids and basket stars, abundant *Diadema antillarum* Philippi, *Meoma ventricosa* (Lamarck), one living, many dead tests of *Clypeaster subdepressus* (Gray).

7 Sandy area, no coral, many holothurians, small amount of grass, many conchs, many *Leodia sexiesperforata* (Leske).

8 Rocky area, many corals, sponges, crinoids, on shallow ledge, 1–2 feet deep, many *Echinometra lucunter* (Linnaeus), *Diadema antillarum* Philippi, and few *Tripneustes ventricosus* (Lamarck) in deeper waters, 10–60 feet, *Diadema antillarum* Philippi, *Echinometra viridis* Agassiz, and *Meoma ventricosa* (Lamarck). No rock below 75 feet.

9 Sandy area, no corals, many holothurians, conchs, small amount of grass, *Leodia sexiesperforata* (Leske).

10 Rocky area first 25 feet with few corals, many crinoids, *Diadema antillarum* Philippi, one specimen *Tripneustes ventricosus* (Lamarck) (2 feet), *Meoma ventricosa* (Lamarck) in sandy patches, few dead test of *Clypeaster rosaceus* (Linnaeus), *Clypeaster subdepressus* (Gray) at 25 feet in sandy patch. At depths greater than 25 feet, no rock, sandy bottom, small amount of grass, one *Tripneustes ventricosus* at 30 feet.

11 Sandy area, small amount of grass, many *Oreaster reticulatus* (Linneaus), two basket stars.

12 Sandy area, *Leodia sexiesperforata* (Leske) in great numbers at 5–20 feet; at 25 feet, rocky ledge with corals, sponges, crinoids, and *Meoma ventricosa* (Lamarck), *Diadema antillarum* Philippi, at 60 feet sand again.

13 Rocky area heavy currents, few corals, sea fans, sea whips, *Diadema antillarum* Philippi, many dead tests of *Clypeaster subdepressus* (Gray).

14–16 *Echinometra lucunter* (Linnaeus), *Diadema antillarum* Philippi in shallow water.

17 Rocky area down to 35 feet with corals, sponges, sea whips, *Diadema antillarum* Philippi. Below 35 feet sandy with conches and holothurians.

18 Rocky area, heavy currents, in shallow water many *Echinometra lucunter* (Linnaeus), in 10–15 feet on rock platform abundant *Tripneustes ventricosus* (Lamarck).

225-667—66——2

Discussion of Species

Descriptions, synonyms, and illustrations of the species discussed below can be found in Mortensen (1928–1951), and Kier and Grant (1965).

Eucidaris tribuloides (Lamarck)

Only one specimen of this species was seen on the Caribbean side: in two feet of water in a crevice between a sponge and rock. Living with it were many individuals of *Echinometra lucunter* (Linnaeus) and *Diadema antillarum* Philippi.

Tripneustes ventricosus (Lamarck)

PLATES 1 (FIG. 2), 2 (FIG. 4)

Only three specimens were seen in the Caribbean. Two of them (pl. 2: fig. 4) occurred in just two feet of water on a rock outcrop, one of them up under a rock. The third specimen was in 30 feet of water on sandy, grassy bottom. None of the specimens had any weed or fragments held over its test. Although a thorough search was made for more specimens, none was found.

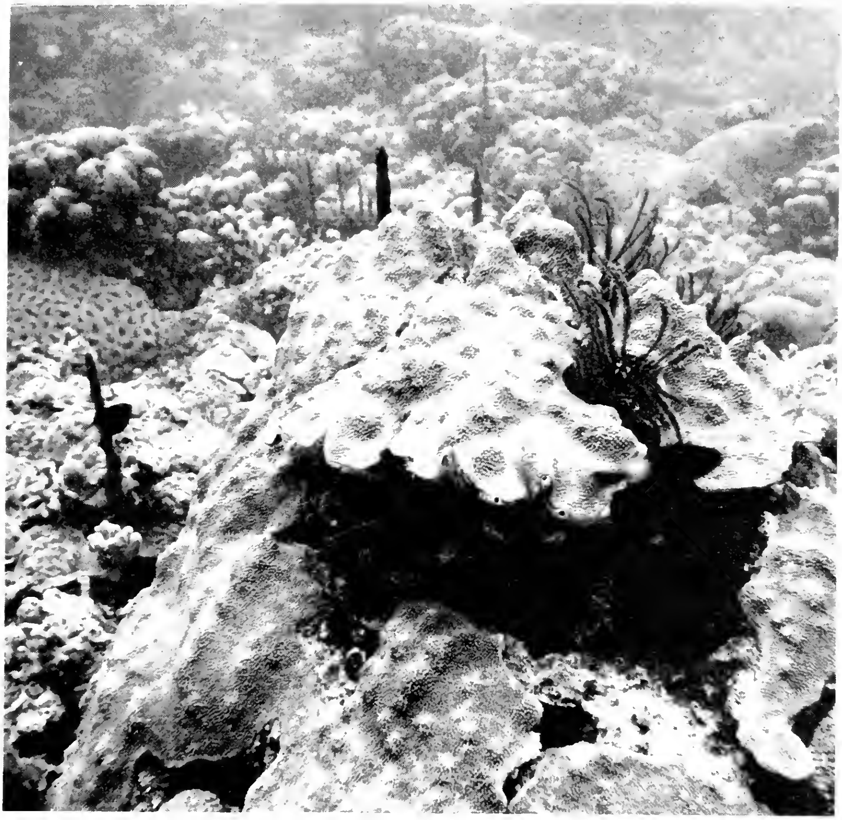
On the Atlantic side this species was abundant at Woodford Hill Bay, where they were found in 10 feet of water (pl. 1: fig. 2). Here a few fragments of weed were held over each test. In some places the echinoids occurred in such abundance that their tests were literally touching each other. Lewis (1958, p. 614) reports that in the Barbados individuals of this species crowd together on the upper surface of rocks during March and April in order to spawn. Presumably, since it was April when I saw this concentration in Dominica, these individuals also were spawning.

Echinometra lucunter (Linnaeus)

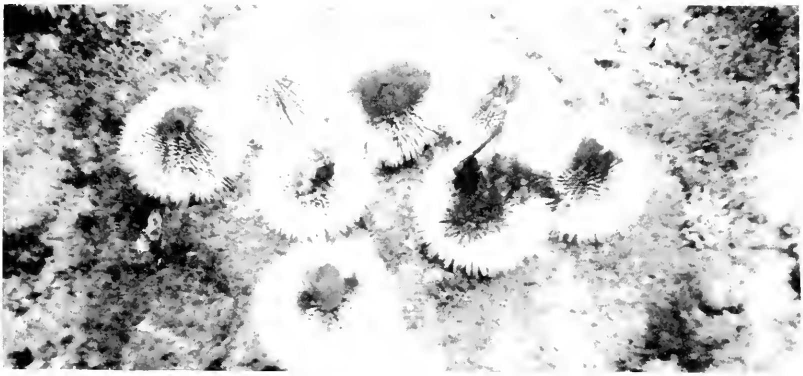
This species was found only at a few sites on the Caribbean side, usually restricted to intertidal zones. It was found only where the normal steep gradient of the sea floor was interrupted by a rock outcrop that formed a platform at intertidal depths. Such sites occur at Massacre, Crabiere Point, and Point Ronde. Here the echinoid occurs in great abundance with approximately two to four specimens in every square foot. Normally, the echinoid lives in a hollow that he presumably has formed in the rock. He is associated with many sea anemones and much algae. Many of the echinoids are exposed at low tide to the air. Deeper than eight feet they are rare, with their greatest concentration at one to two feet below low tide. In

---

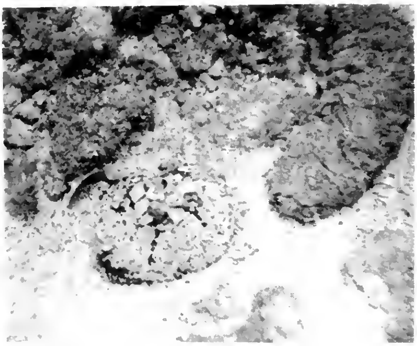
FIGURE 1.—Coral mass in 50-foot depth at locality 8; the crinoid *Comactinia echinoptera* (Muller) can be seen living in crevices in the coral. FIGURE 2.—*Tripneustes ventricosus* (Lamarck) in 10 feet of water in dense aggregations, presumably to spawn.



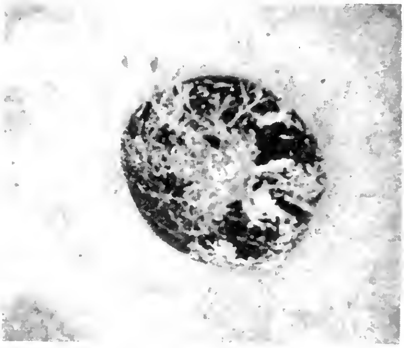
1



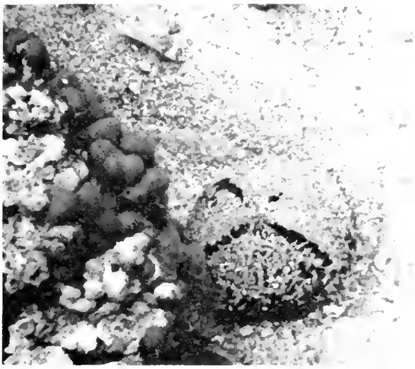
2



1

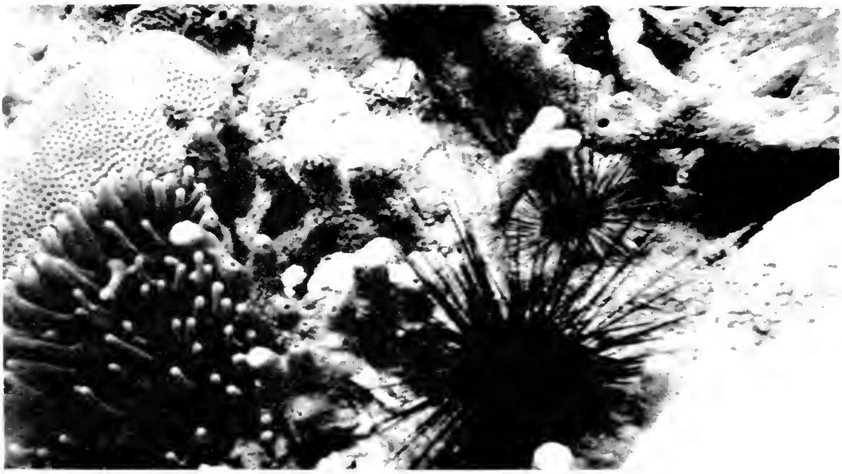


2



3

4



5

every case they were living in areas of high energy with considerable wave motion. Two color types were present, the most common being dark brown but some specimens were much redder. Color difference is distinct, with no transition between the two types. Many individuals of *Diadema antillarum* Philippi and a few of *Eucidaris tribuloides* (Lamarck) and *Tripneustes ventricosus* (Lamarck) live with this species.

Echinometra viridis Agassiz

Only one specimen was seen and this one was found living in a niche in the coral at a depth of 50 feet. A long search was made for more specimens but none was found.

Diadema antillarum Philippi

PLATE 2 (FIGS. 4, 5)

This species is the most abundant of the echinoids living on the Caribbean side of the island. It occurs most commonly on the rocky-coral areas and is usually absent in the sandy bays. It was found in great numbers from low tide level to 65 feet and presumably lives even deeper. Most specimens live in hollows in the coral or rock, but some individuals were seen on the sandy patches within the rocky-coral areas. Although no individuals were ever seen under attack by fish, many disassociated spines were seen, indicating that successful attacks had been made. Both small fish and shrimp were frequently seen living among the spines.

Clypeaster subdepressus (Gray)

Although many dead tests of this species were seen, only one living individual was found. The species lives buried three or four inches in the sandy patches in the rocky-coral areas in association with *Meoma ventricosa* (Lamarck). It was most common in depths of 10 to 25 feet. The living specimen was found in 50 feet of water completely buried. Its location was indicated by the presence of whiter sand (which is usually underneath) on top of the specimen.

FIGURE 1.—*Meoma ventricosa* (Lamarck) with fragments of coral and shell pulled up over the test in 35-foot depth at locality 2; note coarser fragments over madreporite. FIGURE 2.—*Meoma ventricosa* (Lamarck) in 85-foot depth at locality 4; test covered only by bits of algae instead of the usual thick covering of shell fragments and pieces of coral; this is the greatest depth reached during the study and perhaps the echinoid is not covered very much because of the decreased amount of light at this depth. FIGURE 3.—*Meoma ventricosa* (Lamarck) in 35-foot depth at locality 6, showing lack of detrital material over petals and trail made by the echinoid. FIGURE 4.—*Tripneustes ventricosus* (Lamarck) clinging to rock in 2 feet of water at locality 8; *Diadema antillarum* Philippi can be seen to the right. FIGURE 5.—*Diadema antillarum* Philippi in 5 feet of water at locality 13.

Clypeaster rosaceus (Linnaeus)

Three dead tests were found at a depth of 25 feet in one of the sandy patches in the rocky-coral areas in association with *Clypeaster subdepressus* and *Meoma ventricosa* (Lamarck).

Leodia sexiesperforata (Leske)

This species was found living on the sandy areas in the bays in depths from 5 to 20 feet. The animal lives completely buried under 2 to 4 inches of silty sand. The echinoid makes no track in the sand visible on the upper surface of the sea bottom. In most cases the ripple marks on the bottom continue uninterrupted directly over the spot where the echinoid is buried. The only clue to the presence of living specimens is the occurrence of dead tests at the surface. In most places it occurs with no vegetation although in some areas a small amount of eelgrass is present.

Meoma ventricosa (Lamarck)

PLATE 2 (FIGS. 1–3)

Although not abundant, this species was found in sandy patches in every coral-rock environment from depths of 15 to 85 feet. Presumably it occurs at greater depth off Dominica but no dives were made below 85 feet. In other areas in the West Indies it has been dredged from depths down to 600 feet. It is not conspicuous on the bottom because it covers itself with sand and fragments of coral or weed. It would not be correct to say that it buries itself in the sediment, for only approximately one-fifth of its test is below the general level of the surrounding substratum. Rather than pushing itself under the sediment, the animal pulls the sediment over itself with its spines and tubefeet. Generally, larger fragments of coral are concentrated around the apical system (pl. 2: fig. 1). Presumably, the echinoid avoids placing small objects in the area of his madreporite. Although usually covered with sediment, the echinoid can be found because of the sorting of this sediment over the test, the large mound it makes on the bottom, and the lighter color of the sediment on the test. Furthermore, the echinoids leave a conspicuous track (pl. 2: fig. 3), usually two to three feet long, consisting of a furrow with a small ridge of sand on each side.

The echinoids do not occur in great density. On the average, four to six specimens occur in an area of 100 square ft. These sandy patches are usually 1–300 square feet in area and occur quite commonly in the coral-rock areas. Although similar sediment occurs in the noncoral tracts, this echinoid was never found there. At every station except one no weed or large algae was living in the sandy patches with the echinoids. The one exception occurred at a locality

85 feet deep (pl. 2: fig. 2), in which a small amount of algae was present. It may be of significance that, in this deepest area studied, the echinoids were almost completely naked with only a small amount of algae over their tests and no sediment. Perhaps it is because of the decreased amount of light at these depths that the test is not as completely covered.

Schizaster (Paraster) floridiensis Kier and Grant

One dead test was found at a depth of 85 feet on silt bottom devoid of vegetation off Point Guignard. Although no living specimens were found, the great fragility of the paper-thin test suggests that it could not have been carried far from where it once lived. Presumably, this species lives buried as is the case with all schizasterids with known living habits.

Comparison with Echinoids of the Florida Keys

It is of interest to compare the living habits of the Dominican echinoids with individuals of the same species in the Florida Keys, as recently described by Kier and Grant (1965). The echinoid fauna of Dominica was much less varied with only 10 species found, only 5 of which occurred in large numbers, whereas, in the Keys, 17 species were reported, most of which were common. Probably this difference is caused by the small number of different environments in the Caribbean off Dominica.

Meoma ventricosa was never found as deeply buried in Dominica as in the Florida Keys. The Dominican specimens only partially bury with approximately one-fifth of their tests below the general level of the substratum, whereas in the Keys most of the individuals keep their tests almost completely buried, many with an inch or so of sand over the upper surface. In Dominica, *M. ventricosa* lives very much like *Clypeaster rosaceus* does in the Keys, with sand and/or plant material pulled up over its test.

Leodia sexiesperforata lives deeper in the sand in Dominica than in the Keys perhaps because it occurs in shallower water there. In contrast, *Clypaester subdepressus* lives much deeper in Dominica, where it is found three to four inches below the surface, but in the Keys it normally walks along the surface with sand pulled over it or is buried under only an inch of sand. Because of this, they are very difficult to find in Dominica but easy in the Keys.

Diadema antillarum, *Echinometra lucunter*, *Echinometra viridis*, *Tripneustes ventricosus*, and *Eucidaris tribuloides* live in similar habitats in Dominica and the Florida Keys. It is of interest that the two color types of *Echinometra lucunter* found in Dominica are also present in the Keys.

Literature Cited

Kier, P. M., and Grant, R. E.

1965. Echinoid distribution and habits, Key Largo Coral Reef Preserve, Florida. Smithsonian Misc. Coll., vol. 149, no. 6, 68 pp., 16 pls., 15 figs.

Lewis, J. B.

1958. The biology of the tropical sea urchin *Tripneustes esculentus* Leske in Barbados, British West Indies. Canadian Journ. Zool., vol. 36, no. 4, p. 607–621, pls. 8–9, 7 text-figs.

Mortensen, Th.

1928–1951. A monograph of the Echinoidea, 5 vols. and index. Copenhagen: C. A. Reitzel.

U.S. GOVERNMENT PRINTING OFFICE : 1966

Proceedings of the United States National Museum

SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 121 1966 Number 3578

BREDIN-ARCHBOLD-SMITHSONIAN BIOLOGICAL SURVEY OF DOMINICA

2. New Species of Diptera from Dominica (Anisopodidae and Bibionidae)[1]

By Alan Stone [2]

Family Anisopodidae

Recent collecting by J. F. G. Clarke, H. E. Evans, O. S. Flint, Jr., R. J. Gagné, and W. W. Wirth for the Bredin-Archbold-Smithsonian Survey of Dominica resulted in 34 specimens of two apparently undescribed species in two genera of the family Anisopodidae. The *Mycetobia* species is the third one described from the New World and the second from the Neotropical Region. The abundant *Olbiogaster* species has male terminalia apparently identical with those of *O. antillarum* Lane and Andretta from St. Croix, but the color differences are too great to permit determination as that species. A second *Olbiogaster* is represented by a single male with very distinctive terminalia.

Mycetobia limanda, new species

Female: Vertex black, the ocelli yellow; eyes separated by slightly less than width of anterior ocellus; occiput laterally yellow; antenna black, the scape and pedical slightly brownish; face yellow; palpi and

[1] Other faunal studies in this series are: 1, Kier, Proc. U.S. Nat. Mus., 1966, vol. 121, no. 3577, pp. 1–9. A companion series on the flora appears in the "Contributions of the United States National Herbarium."

[2] Entomology Research Division, U S. Department of Agriculture.

mouthparts darkened. Mesonotum subshining, dark reddish brown medially, somewhat paler laterally; pronotum yellowish brown but not contrasting with sides of mesonotum; hairs and setae of mesonotum brown; scutellum yellowish brown with four setae; pleuron, postnotum, and halter yellow brown. Wing hyaline, slightly tinged with yellow; veins dark; subcosta ending just before level of radial sector fork; under side of subcosta with row of long hairs. Foreleg yellow brown, the tarsus slightly darkened; midleg the same but tibia darkened except at extreme base; hindleg mostly yellowish, the coxa posteriorly and femur near apex darkened. Dorsum of abdomen nearly black except for tergum I, tergum II laterally, tergum VIII, and terminalia, which are brownish yellow; venter yellowish with some darkening laterally before apex. Length 2.5–3.5 mm. Wing 3–4 mm.

Male: Coloration as in female. Eyes nearly touching. Genital capsule not as long as terga VI and VII combined whereas this is longer in *M. divergens*. Slightly smaller than female.

Distribution: Dominica, Lesser Antilles; probably Costa Rica.

Holotype: ♀, Clarke Hall, Jan. 18, 1965 (Wirth).

Paratypes: Clarke Hall, Mar. 21–31, 1965, 1 ♀; Clarke Hall, Feb. 11–20, 1965, 1 ♀ (all Wirth). (USNM nos. 68, 116.)

A single specimen bearing the data "La Suiza de Turrialba, Costa Rica, Aug. Pablo Schild" in the U.S. National Museum is apparently this species. It differs only in having the midtibia paler.

Because of the contrasting yellowish tip of the abdomen, I use as a specific name the generic name of the flounder known as the Yellow Tail.

The three New World species of *Mycetobia* may be differentiated by the following key:

1. Subcosta bare (Nearctic) . . . . **divergens** Walker
   Subcosta with numerous long setae ventrally (Neotropical) 2
2. Thorax, abdomen, and legs strongly patterned with dark markings; wing more than 5 mm long . . . . **stonei** Lane and Andretta
   No distinctive pattern except for yellowish at base and tip of abdomen; wing not more than 4 mm long . . . . **limanda,** new species

Olbiogaster danista, new species

Female: Frons and occiput dark, grayish pruinose, only the ocellar triangle shining black; scape and pedicel yellow, flagellum black; face yellow, in some slightly darkened above; palpus and mouthparts yellow. Thorax mostly yellow with yellowish and some brown hairs, with or without a pair of elongate darker markings on mesonotum anteriorly, and a darkened spot on upper mesopleuron; scutellum dark except at base, with a row of many dark hairs; postnotum somewhat infuscated medially; halter with yellow stem, black knob.

Wing hyaline except for dark stigmal spot on anterior inner basal portion of coxa and tarsus; midleg yellow except for dark coxa, apical two-thirds of femur, and tarsus; hindleg yellow except for dark coxa, apical two-thirds of femur, and tarsus. Abdomen with three dark spots on tergum I, usually clearly separated; terga II–V black on basal half, yellow on apical half; terga VI and VII dark except very narrow basally; venter yellow with sterna III–V more or less darkened basally, VI and VII apically. Body and wing length each 6–6.5 mm.

Male: Coloration as in female except abdomen beyond tergum I with wider black areas. Terminalia indistinguishable from those of the type of *O. antillarum*. Lane and Andretta (1958, p. 517, fig. 19) figured those for *antillarum*.

Distribution: Dominica, Lesser Antilles.

Holotype: ♀, Clarke Hall, Jan. 11–20, 1965 (Wirth).

Paratypes: same data, 1 ♀, 3 ♂♂; Clarke Hall, Mar. 1–10, 1965, 1 ♀, 1 ♂, and Mar. 21–31, 1965, 1 ♂ (Wirth); 5 miles south of Pont Casse, Apr. 11, 1964 (Flint), 1 ♀; Clarke Hall, Apr. 12, 1964 (Flint), 1 ♀; Hillsborough Estate, Mar. 15, 1965 (Wirth), 6 ♂♂; Cabrits Swamp, Feb. 23, 1965 (Wirth), 1 ♂; Layou R. mouth, Mar. 8, 1965 (Wirth), 1 ♂; Antrim, 1000 ft. Mar. 12, 1956 (Clarke), 1 ♂; Newfoundland, on road to Rosalie, 1000 ft. Apr. 13, 1966 (Gagné), 1 ♂. (USNM Nos. 68, 117.)

This species would run in the key of Lane and Andretta (1958) to *O. similans* Lane and Andretta, but *similans* has all coxae entirely dark (not implied in key), the base of tergum I broadly dark, the mesonotum and pleura mostly dark, and the stigma not crossing vein R_1. From *antillarum* Lane and Andretta, *danista* differs in having the knob of the halter dark, the sternopleuron entirely yellow, and terga IV and V with broad apical yellow bands rather than with only lateral spots.

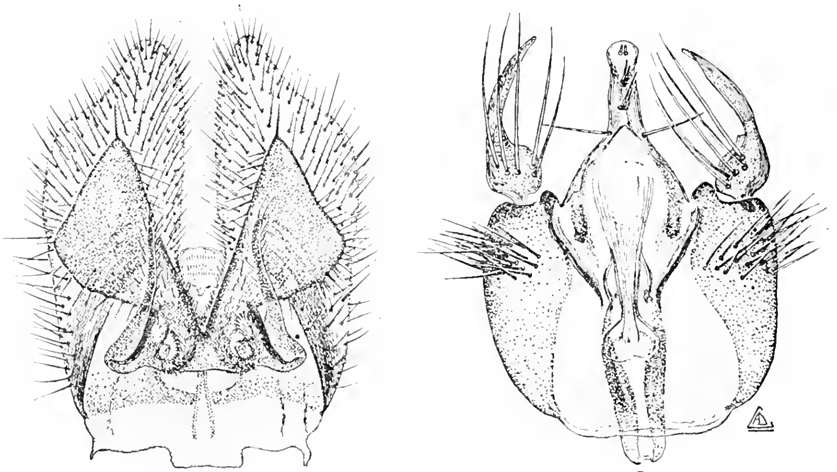
The name of this species (from the Greek word "danista," meaning "money-lender") was suggested by the three dark spots on the first tergum reminiscent of a pawnbroker's sign.

Olbiogaster evansi, new species

Male: Frons and occiput dark, thinly grayish pruinose; scape and pedicel yellow, flagellum black; face yellow; palpus and mouthparts yellow. Thorax mostly blackish with brown hairs; pronotum yellow; mesonotum faintly reddish anterolaterally and before scutellum; area around anterior spiracle and mesepimeron yellowish; mesopleuron shiny black with a few hairs above and a broad transverse band of gray pollinosity. Halter with yellow stem, black knob. Wing hyaline except for narrow stigmal spot crossing cell R_1. Legs mostly dark but with the following yellow: A large patch anteriorly on forecoxa; fore- and midfemora; fore- and midtibiae, but slightly darkened. Abdomen with terga shiny black except for narrow yellow hind margins on I–V, slightly widened laterally; sterna I–V mostly yellow, a dark area on side of sternum II. Wing length 5.5 mm. Terminalia as figured (fig. 1).

Holotype: ♂, South Chiltern, 1600 feet, Feb. 19, 1965 (Evans), (USNM 69076).

This species would run in the key of Lane and Andretta (1958) to *O. chavantesi* Lane and Andretta, but the color pattern of the head, thorax, coxae, and sterna, and the structures of the terminalia are different. The terminalia are closest to those of *similans* Lane and Andretta, but the appendages lying dorsad of the cerci are broad



a b

FIGURE 1.—*Olbiogaster evansi*, new species, male terminalia, dorsal view: *a*, cerci and attached appendages; *b*, aedeagus and attached appendages (drawn by Arthur D. Cushman).

and flat, not narrow and rodlike, and in *similans* the tergal yellow bands are much broader and the sterna are mostly black.

This species is dedicated to the collector, Howard E. Evans.

Family Bibionidae

The only Bibionidae collected on Dominica by the Bredin-Archbold Smithsonian Survey consisted of 21 specimens of an apparently undescribed species of the genus *Plecia* Wiedemann. I take this opportunity to describe it.

Plecia porca, new species

An entirely dark brownish-black species with four shiny stripes on notum and fumose wings. It runs to couplet 5 of Hardy's key (1945,

p. 391) but with very different distimeres (harpagones) from the two species of that couplet.

Male: Head: Antenna black with 7 cylindrical flagellomeres, the first about as long as scape and pedicel combined, the others subquadrate except last, which is reduced in size, hemispherical. Rostrum about equal to antenna in length, shorter than head and sharply turned backward under head, reddish except near apex. Thorax brownish pruinose, the notum dull reddish before scutellum and on sides, the three narrow dorsal stripes somewhat grayish; a submedian pair of raised, narrow, polished black stripes on median half of notum and a pair of similar but broader stripes from just behind the anterolateral depression to corner of scutellum, often slightly reddish poste-

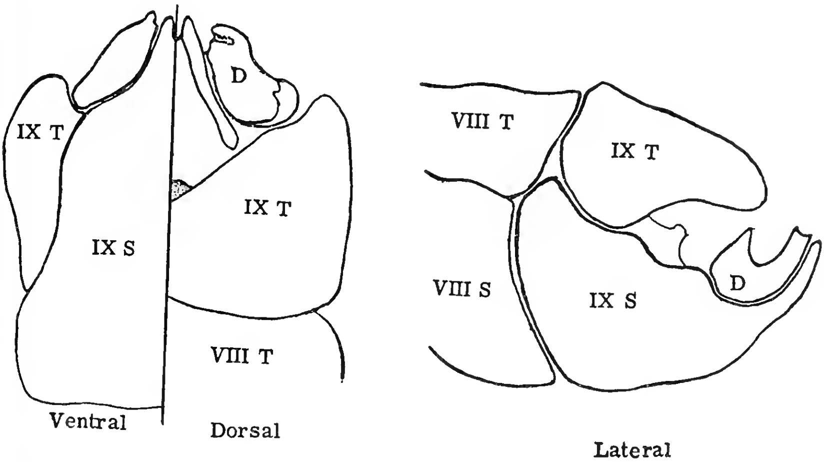


Figure 2.—*Plecia porca*, new species, male terminalia, ventral, dorsal, and lateral views (D=distimere, S=sternum, T=tergum).

riorly; scutellum and postnotum dull; anterior pronotum and upper portion of sternopleuron with hairs; hairs of mesonotal furrows very small. Wing fumose, the stigma and costal cell darker; veins dark with short fine hairs; vein R_3 curved toward apex, shorter than basal portion of radial sector; r-m crossvein about half way between medial crossvein and fork of M. Halter, legs and abdomen nearly black. Terminalia (fig. 2): Ninth tergum with a broad triangular emargination posteriorly with an inwardly turning pair of somewhat shiny protuberances in the median angle; a low protuberance medially near base; ninth sternum slightly concave medially near apex with a pair of marginal ridges each ending in a slender submedian process; distimere rather shiny black but covered with hairs except on the concave dorsal surface; each distimere bilobed, the apico-median lobe with a transverse depression in the apex and the lateral lobe curving dorsally to a point. Length of wing 6.5–7.0 mm.

Female: Coloration and other nonsexual characters as in male except that the antenna has 9 flagellomeres. Frons subshining medially, the sides and occiput with brownish pollinosity; distance between eyes about equal to smallest transverse dimension of eye; rostrum slightly shorter than antenna. Wing length 8.0 mm.

Holotype: Sylvania, Dominica, Jan. 28, 1965 (Clarke and Clarke), ♂, (USNM 68228).

Paratypes: 1800 ft., Pont Casse, Jan. 12, 1965 (Clarke and Clarke), 1 ♂; mouth of Layou River, Jan. 20, 1965 (Clarke and Clarke), 1 ♂; light trap, Sylvania, Jan. 23, 1965 (Wirth), 1 ♂;grassy marsh,Sylvania, Jan. 25, 1965 (Wirth), 6 ♂, 1 ♀; 2.5 miles west of Pont Casse, Jan. 27, 1965 (Wirth), 1 ♂, 1 ♀; 2 miles west of Ponte Casse, Jan. 27, 1965 (Wirth), 1 ♂; Sylvania, Jan. 28, 1965 (Clarke and Clarke), 2 ♂; 0.5 miles west of Point Lolo, Jan. 28, 1965 (Wirth), 2 ♂; 1 mile east of Pont Casse, Jan. 29, 1965 (Wirth), 1 ♀; Clarke Hall, Apr. 5, 1965, (Flint), 1 ♂, 1 ♀.

Literature Cited

Hardy, D. Elmo

1945. Revision of Nearctic Bibionidae including Neotropical Plecia and Penthetria (Diptera). Bull. Univ. Kansas, vol. 30, pp. 367–547, 13 pls.

Lane, J., and d'Andretta, C., Jr.

1958. Neotropical Anisopodidae (Diptera, Nematocera). Stud. Entom., vol. 1, pp. 497–528, illustr.

U.S. GOVERNMENT PRINTING OFFICE:1966

Proceedings of the United States National Museum

SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 121 1967 Number 3579

VALID ZOOLOGICAL NAMES OF THE PORTLAND CATALOGUE

By Harald A. Rehder

Research Curator, Division of Mollusks

Introduction

An outstanding patroness of the arts and sciences in eighteenth-century England was Lady Margaret Cavendish Bentinck, Duchess of Portland, wife of William, Second Duke of Portland. At Bulstrode in Buckinghamshire, magnificent summer residence of the Dukes of Portland, and in her London house in Whitehall, Lady Margaret—a widow for the last 23 years of her life—entertained gentlemen interested in her extensive collection of natural history and objets d'art. Among these visitors were Sir Joseph Banks and Daniel Solander, pupil of Linnaeus. As her own particular interest was in conchology, she received from both of these men many specimens of shells gathered on Captain Cook's voyages. Apparently Solander spent considerable time working on the conchological collection, for his manuscript on descriptions of new shells was based largely on the "Portland Museum."

When Lady Margaret died in 1785, her "Museum" was sold at auction. The task of preparing the collection for sale and compiling the sales catalogue fell to the Reverend John Lightfoot (1735–1788). For many years librarian and chaplain to the Duchess and scientifically inclined with a special leaning toward botany and conchology, he was well acquainted with the collection. It is not surprising he went to considerable trouble to give names and figure references to so many of the mollusks and other invertebrates that he listed. It is interesting to note also that, although the sale of the collection was supposed to begin on April 24 of that year, the auction did not take place until a month later—a delay due probably to the time required to compile and print the catalogue.

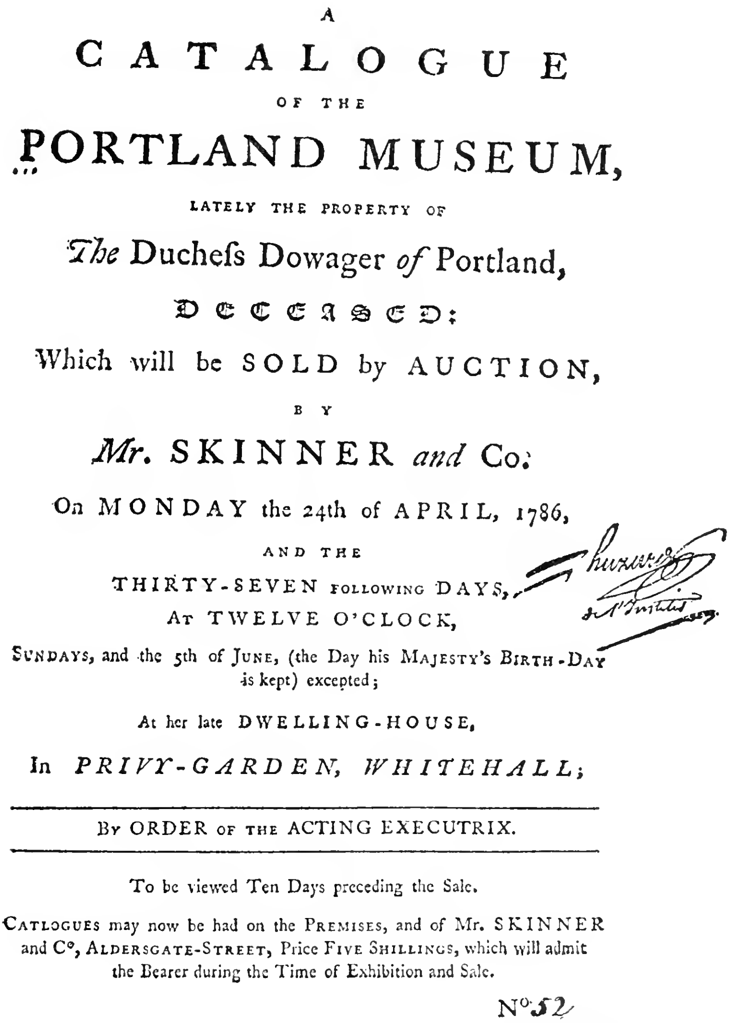
Although the "Portland Catalogue" has been used as a reference source of scientific names almost since its publication—witness its citation by Dillwyn in 1817, Swainson in 1822, and Gray in 1824–28 (Kay, 1965, p. 13) and the use of Solander's names by such a conservative worker as G. W. Tryon in his "Manual of Conchology"—its modern use in malacological nomenclature dates from the appearance of papers by Iredale (1916) and Dall (1921). In spite of some original opposition to the resurrection of these names, the "Portland Catalogue," as Kay has stated (1965, p. 10), is now generally considered a valid source of scientific names.

That the Reverend John Lightfoot was the anonymous compiler of the "Catalogue"—and thus the author of the new names proposed therein—has recently been stated clearly by Dance (1962). The researches of Kay (1965) have confirmed a long-held view of the present writer that the authority to be cited for all new names in the "Catalogue" is the compiler and not Solander. Lightfoot used the names found in Solander's manuscript and possibly also on labels in the collection, which may explain the absence in the manuscripts of some names credited to Solander in the "Catalogue."

The names derived from Solander's manuscripts and labels were designated by Lightfoot in most instances by adding the letter "S" to the scientific name. It must be emphasized, however, that only the names were taken from the manuscripts and rarely did the compiler use a bibliographic reference to a published figure that was given by Solander. In my view, Solander cannot in any way be considered responsible for the principle condition that made the names available—i.e., publication (see Article 50 of the "International Code of Zoological Nomenclature," 2nd edition, 1964)—although he can be considered to have been the source for some of the names in the "Catalogue." Since he was not the compiler (and therefore not the author of the "Catalogue," either solely or in part), he did not validly introduce any of the names in the "Catalogue" into the literature.

Although many names first proposed in the "Portland Catalogue" are now in general use—some have been accepted for over a hundred years—others have been ignored or passed by until fairly recently. In a work that has been accepted as a valid source of scientific names, we cannot, in my estimation, choose to use some of the validly proposed names and not use the others, unless, of course, the latter names are truly nomina dubia.

I, therefore, publish this list of names in the conviction that they have been validly proposed and should enter into the ranks of zoolog-



A

CATALOGUE

OF THE

PORTLAND MUSEUM,

LATELY THE PROPERTY OF

The Duchefs Dowager *of* Portland,

DECEASED:

Which will be SOLD by AUCTION,

BY

Mr. SKINNER *and* Co.

On MONDAY the 24th of APRIL, 1786,

AND THE

THIRTY-SEVEN FOLLOWING DAYS,

AT TWELVE O'CLOCK,

SUNDAYS, and the 5th of JUNE, (the Day his MAJESTY'S BIRTH-DAY is kept) excepted;

At her late DWELLING-HOUSE,

In *PRIVY-GARDEN, WHITEHALL;*

BY ORDER OF THE ACTING EXECUTRIX.

To be viewed Ten Days preceding the Sale.

CATLOGUES may now be had on the PREMISES, and of Mr. SKINNER and C°, ALDERSGATE-STREET, Price FIVE SHILLINGS, which will admit the Bearer during the Time of Exhibition and Sale.

N°. 52

FIGURE 1.—Title page of the "Catalogue of the Portland Museum."

ical nomenclature, to stand or fall on their own merits. Some of these may supplant long-familiar names. If, however, we are to maintain the classification of mollusks and other marine invertebrates on a firm basis, we must adhere as closely as possible to the rule of strict priority and avoid exceptions and suspensions of the Rules.

Dall (1916) and, to a lesser extent, Iredale (1921) attempted to identify the names proposed in the "Portland Catalogue," some identifications of which I comment on in the present paper. Many of the "Catalogue" names listed by Dall are nomina nuda and thus invalid. These I have omitted. Others actually were taken over from Linnaeus or Born in their original sense. In some entries Lightfoot has referred to the second volume of Martyn's "Universal Conchologist," usually dated from 1789, but without citing a figure number. It is probable that he saw the plates of this as yet unpublished volume.

Each entry in the present paper is arranged in the following order: the lot number of the "Portland Catalogue," a verbatim citation of the relevant textual material, the name to be used for the taxon (in boldface type), the principal synonyms (in italics), including the most recent ones in which the name is credited to either Solander, Humphrey, or Lightfoot, and, where necessary, my own remarks.

Lightfoot's name sometimes is enclosed in brackets to follow Recommendation 51A of the International Code of Zoological Nomenclature, which states that the name of the author of a taxon published anonymously "should be enclosed in square brackets to show the original anonymity." Where the trivial name has been transferred to another genus I have replaced the square brackets around the author's name with the required parentheses alone, to avoid the use of both square brackets and parentheses.

In all, 2 genera and 120 trivial names are considered to have been first validly proposed in the "Catalogue." The 2 genera, *Isognomon* and *Placuna*, have been in general use now for some time although usually credited to Solander.

Of the 120 trivial names, 111 pertain to mollusks, 5 to the *Cirripedia* (*Crustacea*), 2 to the *Echinodermata*, and 1 each to the *Madreporaria* (*Coelenterata*) and *Brachiopoda*.

Of these 120 names, I consider 9 to be nomina dubia, 3 junior homonyms, and 46 synonyms of earlier names. This leaves 62 available names that should be credited to Lightfoot as author. Forty-six of these have been used in recent malacological literature, credited either to Solander of Humphrey or, in a few cases, to Lightfoot. Only 16 (or 13%) of all the new names in the "Catalogue" have apparently not come into use. Six of these I have been unable to locate as accepted senior synonyms in the literature of the past 140 years and, thus, they should be considered nomina oblita. The remaining 10, in all cases but one, have been used as senior synonyms in the past 50 years and, thus, are available.

NINETEENTH DAY'S SALE.

MONDAY THE 15th OF MAY, 1786.

SHELLS, CORALS, &c.

LOT

1924 FIFTEEN cards, containing various ſpecies of Nerita, among which are Canrena, albumen, Mamilla, peloronthа, &c.

1925 Four fine Oſtreæ, viz. Eburnea, ſquamoſa, and 2 lurida, *S.—all rare*

1926 Eight fine Petrifactions, viz. 2 Strombus luctator, *Brander's Foſs. Hanton. pl.* 5. *fig.* 64. an Anomia Gryphites, *L.* an Echinites from *Verona*, &c.

1927 Fourteen Bivalves of various genera, among which are 2 Tellina radiata, 2 Oſtrea maxima, *L. fine*, 3 Arcas, &c.

1928 Nine cards of various ſpecies of Engliſh Crabs, viz. Cancer piſum, minutus, phalangium *male and female*, Dorſettenſis; Aſtacus Bernhardus, *all deſcribed by Pennant*, and the eared Crab, *non deſcript.*

1929 A very large and fine Buccinum Galea, *L.* or tun ſhell from the *Mediterranean*

1930 Six different curious Ovaries of marine ſhell-fiſh, and 4 eggs of Helix ovipara, *Liſter*, 23. 21. ſome pearls, &c.

1931 Seven cards containing various ſpecies of Cardium, viz. one valve of hæmicardium, 2 odd valves of retuſum, medium, *L.* muricatum, ciliare & variegatum, *S.*

1932 Fourteen cards of different ſpecies of Needle Buccina, viz. Hecticum, ſtrigilatum, lanceatum, *S.* toroloſum, articulatum, pertuſum, capreolus, cinereum, & fuſus, *S.*

1933 A ſmall Echinus roſaceus and 7 varieties of Echinus orbiculus, *L.—ſome rare*

1934 Six fine ſpecies of Venus, viz. Deflorata, literata, meretrix, &c.

1935 Two pair of very rare ſpecies of Voluta, viz. Sanguiſuga, *L.* and turricula, *S.—fine*

1936 Two fine varieties of Chama Gigas, *L.* or furbelowed clamp

1937 A beautiful Oſtrea nodoſa, or Duck's-foot Pecten, and Oſtrea plica, *L. both rare*

1938 Three fine varieties of Murex ramoſus, viz. the Stag's horn, and 2 others

1939 Three kinds of Pholas, *one imbedded in wood*, a ſmall rare Solen, a Mya, &c.

1940 A fine pair of Voluta cælata and another of Pepo, *S. Martyn, Vol.* III. *fig.* 768—770

1941 A pair of very fine Trochus Solaris, *L.* or Sun ſhell, from the *W. Indies—rare*

1942 Six fine ſpecimens of Trochus, viz. 2 of Granoſus from *New-Zealand, Martyn, Vol.* I. *fig.* 37. *r.* 2 maculatus, *L.* and 2 others

Various teſtaceous and other ANIMALS, VEGETABLES, &c. in SPIRITS.

1943 A fine cluſter of Lepas ſignita, *S.* found in the *Britiſh Channel*, the animal Terebella, *with it's augur*, of the Teredo navalis, or ſhip-worm, and ſundry Ovaria of Buccinum undatum, *L. in* 3 *bottles* 1944 A

FIGURE 2.—A sample page (87) of the "Catalogue of the Portland Museum."

The Valid Names

15 "Strombus Fusus, L. *Persicus*, or Persian Spindle, a pair, *fine*, *Lister*. 854. 12."

Tibia insulachorab Röding, 1798

Strombus Fusus L. *Persicus* [Lightfoot, 1786], p. 3.
Rostellaria curvirostris Lamarck, 1816, p. 4.

Because Lightfoot used *Persicus* as a geographic adjectival trinomial and placed it in italics, I consider this name as invalidly proposed. It should be noted that in almost all cases the geographic origin of the specimens listed is given in italics, and in those cases, relatively few in the "Catalogue," where the scientific names are in italics, the entire name is so printed.

31 "A fine pair of Trochus Onustus, or Carrier Trochus, *rare, Favanne.* Tab. 12. C. 1. 2."

Xenophora conchyliophora (Born, 1780)

Trochus onustus [Lightfoot, 1786], p. 4.
Phorus onustus Reeve, 1842, p. 160.
Not *Trochus onustus* Nilsson, 1827 (=*Xenophora* sp., Createaceous, Sweden).

50 ". . . 2 Strombus tricornis, *Martin* 843. 45. *List.* 873."

Strombus tricornis [Lightfoot, 1786]

Strombus tricornis [Lightfoot, 1786], p. 5.
Strombus tricornis Fischer, 1807, p. 188.
Strombus tricornis Lamarck, 1816, p. 3.
Strombus tricornis Humphrey, 1786.—Abbott, 1960, p. 53.

89 "Voluta Nobilis, S. an extremely rare species of the Music kind, from the *E. Indies. List.* 799.6."

Volutocorona nobilis [Lightfoot, 1786]

Voluta nobilis [Lightfoot, 1786], p. 6.
Voluta scapha Gmelin, 1791, p. 3468.—not *Voluta scafa* Lightfoot, 1786.
Aulica nobilis Solander.—Abbott, 1962, p. 98.
Volutocorona nobilis (Solander, 1786).—Weaver, 1964, p. 6.

Troschel in 1866 had already accepted this trivial name, citing it as "*Voluta* (*Aulica*) *nobilis* (Solander)."

The group *Volutocorona* Pilsbry and Olsson, 1954, is being retained as a distinct genus, until its radular characters are known, although it appears to be very close to *Aulica* Gray, 1847.

97 "A young specimen of Serpula gigantea or great Oriental Worm Shell, with its Operculum, *very rare—Seba, vol.* III. *Tab.* 94."

Kuphus polythalamia (Linnaeus, 1766)

Serpula gigantea [Lightfoot, 1786], p. 6.
Septaria arenaria Lamarck, 1818, p. 437 (not *Serpula arenaria* L., 1758).
Not *Serpula gigantea* Pallas, 1766, as Dall erroneously states (1921, p. 129).

176 "Ostrea isognomon L. called Isognoma lignea by S. *very rare*, with an Oyster adhering."

Isognomon [Lightfoot, 1786]

This is the first use of the generic name *Isognoma* (or *Isognomon*). See lots 968 and 3041, wherein the now generally accepted form *Isognomon* is used. *Ostrea isognomon* L. (=*O. isognomum* L.) becomes the type of the genus by tautonymy.

187 "Three fine specimens of Tellina, viz. . . . cruentae, S. *Knorr VI.* 12. 1. *all very rare.*"

Sanguinolaria cruenta (Lightfoot, 1786)

Tellina cruentae [Lightfoot, 1786], p. 10.
Tellina operculata Gmelin, 1791, p. 3235.
Tellina semiplanata Röding, 1798, p. 186.

Abbott (1954, p. 439), following Dall (1921, p. 99), erroneously used this name for *T. sanguinolenta* Gmelin, in which he has been followed by Shikama (1964, pl. 50, f. 3).

An examination of Knorr's figure shows that the name *cruenta* should be applied to the large, more elongate and unicolored species formerly known as *S. operculata* Gmelin, inhabiting the southern shores of the Caribbean, from Nicaragua south to Brazil.

It is not the Eastern Pacific *S. bertini* Pilsbry and Lowe, as Keen (1958, p. 188) thinks possible.

See lot 1360, wherein Lightfoot spells the trivial name correctly: *cruenta.*

264 "Voluta incrassata, S. Martyn, 499, 500. . . . very rare."

Oliva incrassata (Lightfoot, 1786)

Voluta incrassata [Lightfoot, 1786], p. 13.
Oliva angulata Lamarck, 1811, p. 310.
Voluta incrassata Dillwyn, 1817, p. 516.
Oliva incrassata (Solander, 1786).—Keen, 1958, p. 420.

295 "Echinus anemonoides, or purple Anemony Echinus, *extremely rare,* and one ditto with its spines on *Favanne* 56. H.H."

Podophora atrata (Linnaeus, 1758)

Echinus anemonoides [Lightfoot, 1786], p. 14.

301 "Buccinum Iris, S. *Martyn, vol. I,* fig. 2.b. the *Epidermis of this singular species when wet is of various colors, and it is exceedingly scarce.*"

Latirus iris (Lightfoot, 1786)

Buccinum prismaticum Martyn, 1784, fig. 2 (nonbinomial).
Buccinum iris [Lightfoot, 1786], p. 14.
Murex prismaticus Gmelin, 1791, p. 3559.
Latirus prismaticus Martyn.—Tryon, 1881, p. 93.
Latirus iris Humphrey.—Kaicher, 1957 [sect. 7], pl. 8.

353 "Two fine species of Placuna, *S.* viz. placenta, and Ephippium, the Chinese Window, and Polish Saddle Shells, *both very rare.*"

Placuna [Lightfoot, 1786]

Placenta Retzius, 1788.
Placuna Bruguiere, 1792.

This is the first use of the generic name.

372 "Two fine specimens of Buccinum monodon, *S.* or Unicorn shell, from *Terra del Fuego, Martyn, vol.* I, *fig.* 10e."

Acanthina monodon (Pallas, 1774)

Buccinum monodon Pallas, 1774, p. 33.
Calcar Martyn, 1784, fig. 10 (nonbinomial).
Buccinum monodon [Lightfoot, 1786], p. 17.
Buccinum monoceros Bruguiere, 1789, p. 253.

400 "A large and fine Helix plicata, *undescribed, Favanne,* pl. 61, D. . . . *rare.*"

Pila urceus (Müeller, 1774)

Helix plicata [Lightfoot, 1786], p. 18.
Not *Helix plicata* Born, 1778.

408 "A large and fine Turbo undulatus, from *New Holland, extremely scarce, Martyn,* vol. I. 29. p."

Subninella undulata (Lightfoot, 1786)

Limax undulatus Martyn, 1784, fig. 29 (nonbinomial).
Turbo undulatus [Lightfoot, 1786], p. 18.
Turbo undulatus Gmelin, 1791, p. 3597.
Subninella undulata Solander.—Allan, 1959, pp. 68, 486.

566 "A very large Voluta ponderosa, S. or heavy Volute, with a fine mouth, *Martyn* 916."

Turbinella ponderosa (Lightfoot, 1786)

Voluta ponderosa [Lightfoot, 1786], p. 25.
Xancus pyrum Röding, 1798, p. 134 (not Linnaeus, 1758).
Turbinella rapa Lamarck, 1816, p. 7.

A critical study of large series of this species and *Xancus pyrum* (L., 1758) may show that the former is merely a subspecies of the latter (see Dodge, 1955, pp. 132–134).

601 "Two beautiful specimens of Helix Vitellus *Rum.* 22. 1. . . ."

Polymita picta (Born, 1780)

Helix vitellus [Lightfoot, 1786], p. 26.

610 "A pair of Voluta virescens, *S. Martyn,* 932. 933 from *Guinea.*"

Voluta virescens [Lightfoot, 1786]

Voluta virescens [Lightfoot, 1786], p. 26.
Plejona muta Röding, 1798, p. 60.
Voluta polyzonalis Lamarck, 1811, p. 68.
Voluta virescens Dillwyn, 1817, p. 562.
Voluta virescens Solander.—Abbott, 1954, p. 250.

611 "Voluta arausiaca, S. or Prince of Orange's Flag Music shell, from *Amboyna . . . extremely rare, Rumph.* 37. 2."

Harpulina arausiaca (Lightfoot, 1786)

Voluta arausiaca [Lightfoot, 1786], p. 26.
Voluta arausiaca Shaw, 1790, pl. 52.
Voluta vexillum Gmelin, 1791, p. 3464.
Harpulina arausaica [sic] Solander.—Shikama, 1963, pl. 81.

626 "Mya gigas, *S. List. conch.* 414, with two Gorgoniae adhering to it."

Panope glycimeris (Born, 1778)

Mya gigas [Lightfoot, 1786], p. 27.

707 "Voluta elongata, S. or Midas's ear Land Snail, a very rare terrestrial shell from *New Caledonia, Martyn, vol.* I, *fig.* 25. *n.*"

Placostylus elongatus (Lightfoot, 1786)

Limax fibratus Martyn, 1785, fig. 24 (nonbinominal).
Voluta elongata [Lightfoot, 1786], p. 30.
Bulimus bovinus Bruguiere, 1792, p. 345.
Ellobium australe Röding, 1798, p. 106.
Not *Voluta elongata* Schroeter, 1804 (=?*Aurinia* sp.); not *Voluta elongata* Swainson, 1821 (=*Alcithoe swainsoni* Marwick, 1926).

It is strange that both Franc (1957, p. 152) and Solem (1961, p. 477) use Martyn's name, even though in 1957 the "Universal Conchologist" was officially rejected for nomenclatorial purposes. Neither do they list the three subsequent, earliest names, those of Lightfoot, Bruguiere, and Röding. Since the name *fibratus* is unavailable, the adoption of Lightfoot's name should prove acceptable.

708 "A fine specime of Voluta amphora, *S.* or clouded Persian Crown, from *China, rare . . . Martyn,* 780."

Cymbium (Melo) amphora (Lightfoot, 1786)

Voluta amphora [Lightfoot, 1786], p. 30.
Cymbium flammeum Röding, 1798, p. 151.
Melo diadema Lamarck, 1811, p. 57.
Cymbium (*Cymbium*) *amphorus* (Solander).—Shikama, 1963, pl. 85.

915 "Helix Otis *an extremely rare species,* figured by *Favanne, tab.* 63. *fig.*11."

Lampadion otis (Lightfoot, 1786)

Helix otis [Lightfoot, 1786], p. 38.
Helix labyrinthus Lamarck, 1792, p. 352.
Lampadion labyrinthus Röding, 1798, p. 78.
Helix (*Labyrinthus*) *otis* Soldr. [sic], Beck, 1837.
Pleurodonte (*Labyrinthus*) *otis* (Solander).—Pilsbry, 1910, p. 504

The generic name *Labyrinthus* Beck, 1837, must yield to the earlier name *Lampadion* Röding, 1798. Winckworth (1945, p. 141) lists as type *Lampadion labyrinthus* Röding, citing Gray (1847, p. 173) as authority for this type designation. Although Gray gave *Helix otis* as the type of the genus, which was not one of the originally included species, Winckworth's action is valid ("International Code of Zoological Nomenclature;" art. 69(a)(iv)). Wurtz (1955, pp. 106–107), apparently overlooking Winckworth's statement, designated as type the same species of Röding, *Lampadion labyrinthus,* fixing this name on the figure in Favanne (1780), cited by Röding. Wurtz then goes on to say that this figure represents an unrecognizable species and thus disposes of the name *Lampadion*. Wurtz was unaware of the fact that Röding cited the wrong figure in Favanne for his species. Röding apparently meant to cite F 11 on plate 63 but referred instead to "fig. 2," possibly reading the 11 as a Roman II. That Röding did make an erroneous citation for the species to which he gave the popular name "Das Labyrinth," is proven by the fact that Favanne, in his own later anonymous work (1784, p. 6), cites pl. 63, F 11, of his "Conchylogie" for this species, "Le Labyrinthe."

968 "Three varieties of Isognomon perna S. (Ostrea, L.) enveloped with Sponge, and another curious species of the same genus."

Isognomon

Here Isognomon is used, as it is later (lot 3041) with the same species: *Ostrea perna* L. The type of the genus is, however, *Ostrea isognomum* by tautonymy (see lot 176).

969 "Two fine species of Voluta, viz. Melo, *Martyn, vol.* III. 772, 773 . . . ."

Cymbium (Melo) melo (Lightfoot, 1786)

Voluta melo [Lightfoot, 1786], p. 41.
Voluta anguria Lightfoot, 1786, p. 64.
Voluta indica Gmelin, 1791, p. 3467.
Cymbium maculatum Röding, 1798, p. 152.
Cymbium melo Röding, 1798, p. 152 (in part).
Voluta melo 'Soland.—Lamarck, 1811, p. 59.
Melo melo Solander.—Abbott, 1962, p. 102.

969 " . . . and Scafa b. S. Adans. *Seneg.* 3. 2."

Cymbium cymbium (Linnaeus, 1785)

Voluta scafa [Lightfoot, 1786], p. 41.

Adanson's figure is cited by Lightfoot for Solander's "variety b" of his *Voluta scafa*, which is validated in lot 3039 by a reference to a figure in Martini. Both of these figures represent *Voluta cymbium* Linnaeus.

990 "Two fine Patella Mytiliformis, *Humphrey's Conch. pl.* III. *fig.* 9 from *Falkland's Islands* . . . ."

Nacella mytilina (Helbling, 1779)

Patella mytiliformis [Lightfoot, 1786], p. 42.
Patella mytilina Gmelin, 1791, p. 3698.
Not *Patella mytiliformis* Gmelin, 1791 (=*Crepidula* sp.).

1001 "Two fine specimens of Arca fusca, *S. Gualt.* 87. G. *one of them affixed to a pinna.*"

Nomen dubium (figure indeterminable)

Not *Arca fusca* Bruguiere, 1789 (=*Barbatia amygdalumtostum* (Röding, 1798).

Solander's name was assigned by earlier authors to various species. Donovan (1803, p. 158) gave Solander's name to specimens he believed to be what is now called *Arca imbricata* Bruguiere. In this he was followed by Montagu (1808, p. 51), who assigned certain British specimens to this species, obviously confusing *Arca tetragona* Poli with *imbricata*, since he, like Donovan, cites Lister's figure (1732, pl. 367, fig. 207) of *imbricata* for *Arca fusca*. Dillwyn (1817, p. 227) actually places *A. fusca* Solander (mss.) in the synonymy of *Arca imbricata* Bruguiere, in which he is followed by Iredale (1961, p. 92). Lamy (1907, p. 41), on the other hand, places the "Portland Catalogue" name in the synonymy of *A. tetragona* Poli, 1795, and Dall (1921, p. 98) equates the species with *fusca* Bruguiere, apparently on the sole and uncritical basis of the similar name. An examination of the figure in Gualtieri, the only reference cited by both Solander and Lightfoot (Kay, 1965, p. 15) leaves us in doubt as to exactly what species is represented. The three figures are rather stylized and could represent any of several species of *Arca*. For this reason I feel that I am justified in regarding this name as a doubtful one.

1005 "Five species of Solen . . . pallidus, *S.* (*List. conch. t.* 412 *inferior*) . . . ."

Nomen dubium (figure indeterminable)

Dillwyn (1823, p. 22) says that Lister's figure represents *Solen truncatus* Wood, 1815, but this must be an error, for there is no resemblance between the figures of Wood and Lister.

1005 "Solen . . . plebeius, *S.* (*Lister*, 421. f. 265)."

Tagelus plebeius (Lightfoot, 1786)

Solen plebeius [Lightfoot, 1786], p. 42.
Solen gibbus Spengler, 1794, p. 104.
Solen plebeius 'Solander.'—Dillwyn, 1823, p. 22.
Tagelus plebeius Solander.—Abbott, 1954, p. 440.

1046 "A pair of fine Conus Augur, *S.* or dotted Cone, *Knorr.* VI. *tab.* 13. *fig.* 6."

Conus augur [Lightfoot, 1786]

Conus augur [Lightfoot, 1786], p. 44.
Conus augur Hwass, 1792, p. 685.
Conus augur Solander.—Tomlin, 1937, p. 216.

1055 "Argonauta navicula, Rum. 18. 4 . . . ."

Nomen dubium

This may be the same as *Argonauta gondola* Dillwyn, 1817, but the figure in Rumphius is too crude to identify with certainty the species intended.

1055 " . . . and hians, *S. ibid* 18. B. *both rare.*"

Argonauta hians [Lightfoot, 1786]

Argonauta hians [Lightfoot, 1786], p. 44.
Argonauta hians Dillwyn, 1817, p. 334.
Argonauta hians Solander.—Tryon, 1879, p. 136.

1206 "Two Cypraea pantherina, S. List. 681. 28 . . . ."

Cypraea pantherina [Lightfoot, 1786]

Cypraea pantherina [Lightfoot, 1786], p. 50
Cypraea vinosa Gmelin, 1791, p. 3421.
Cypraea pantherina Solander.—Schilder, 1939, p. 185.

This and the previous species, with Solander given as the author of each, have been in general use for a long time.

1240 "Two scarce varieties of Trochus alveolatus, or Beehive Snail, List. 62. 60 . . . ."

Sagda epistylium (Müller, 1774)

Trochus alveolatus [Lightfoot, 1786], p. 52.

1242 "Four varieties of Ostrea perna, *L.* (Isognomon, S.) . . . ."

Isognomon [Lightfoot, 1786]

See lot 968.

1266 "Three fine species of Balanus . . . Pyramidalis, *S. Ellis, fig.* 9."

Balanus tintinnabulum Linnaeus, 1758

Balanus pyramidalis [Lightfoot, 1786], p. 53.

It seems certain that the above reference refers to the plate illustrating Ellis' paper on barnacles published in the "Philosophical Transactions" (1758, vol. 50, part 2, pp. 845–855, pl. 34).

1301 "Two very large specimens of Patella fungoides or Mushroom limpet, from the *Cape of Good Hope. Humphrey's Conch. pl.* IV. *fig.* 16."

Patella (Scutellastra) barbara Linnaeus, 1758

Patella fungoides [Lightfoot, 1786], p. 55.
Not *Patella fungoides* Röding, 1798 (=*Acmaea jamaicensis* Gmelin, 1791).

1315 "Four fine specimens of Placuna, S. (Anomia, L.) viz. Placenta and Ephippium, both from *China*, and *rare.*"

Placuna [Lightfoot, 1786]

See lot 353.

1358 "A large and fine Cardium robustum, *S.* from Florida, *very scarce . . . Lister*, 328. 165."

Dinocardium robustum [Lightfoot, 1786]

Cardium robustum [Lightfoot, 1786], p. 58.
Cardium magnum Born, 1778, p. 34 (not Linné, 1758).
Cardium ventricosum Bruguiere, 1789, p. 228.
Dinocardium robustum Solander.—Abbott, 1954, p. 401.

1359 "Three fine and rare species of Patella, viz. two of Mytiliformis, *Humphrey's Conchology*, 3. 9 . . . ."
Nacella mytilina (Helbling, 1779)
See lot 990.

1360 "Four curious and uncommon species of Tellina . . . . Cruenta, *S. Knorr* VI. 12. 1."
Sanguinolaria cruenta (Lightfoot, 1786)
See lot 187.
It should be noted that Lightfoot gives here the correct spelling for this specific name.

1448 "Voluta . . . Anguria, S. or great brown African Melon, *Vol. Martyn* III. 767."
Cymbium (Melo) melo (Lightfoot, 1786)
The figure cited for this species represents the adult stage of the shell on which *melo* is based.
See lot 969.

1455 "Buccinum Iris, *S. Martyn vol.* I. *fig.* 2. b. very fine and extremely scarce."
Latirus iris (Lightfoot, 1786)
See lot 301.

1479 "A pair of Murex elongatus, a nondescript species, *extremely scarce. Favanne pl.* 79. H."
Pterynotus (Marchia) elongatus (Lightfoot 1786)
Murex elongatus [Lightfoot, 1786], p. 65.
Murex clavus Kiener, 1841, p. 111 (not Gmelin, 1791).
Murex (Marchia) elongatus (Solander).—Kira, 1959, p. 61.
Not *Murex elongatus* Lamarck, 1816 (=*Chicoreus asianus* Kuroda, 1942).

1501 "—Conus quercinus *S. Martyn*, Vol. II. 657. . . ."
Conus quercinus [Lightfoot, 1786], p. 67.
Conus quercinus Hwass, 1792, p. 681.
Conus quercinus Solander.—Tomlin, 1937, p. 300.

1560 "*Mytilus Castaneus S. List.* 1055. 9. extremely scarce."
Modiolus vagina Lamarck 1819
Mytilus castaneus [Lightfoot, 1786], p. 69 [a nomen oblitum].
Modiola vagina Lamarck, 1819, p. 112.
Modiola castanca Gray, 1825, p. 138.
Mytilus castaneus Solander.—Dillwyn, 1823, p. 47.
Modiolus vagina Lamarck; Lamy, 1937, p. 329.
Not *Modiola castanea* Say, 1822 (=*Lioberus castaneus* Say, 1822).

Dall (1921 p. 128) equates this name with *Elliptio complanatus* (Lightfoot) because in copying Lightfoot's reference to Lister, he changed "1055,9" to "154,9."

1601 "*An extremely fine pair of a species of perforated Patella*, the only two that are known, named *Macroschisma, Humphrey's Conch. Plate* 7. *fig.* 3. 3."

Nomen dubium

Not *Patella macroschisma* Holten, 1802, nor Dillwyn, 1817 (=*Macroschisma maxima* A. Ad., 1850).

An examination of the figures in DaCosta's "Conchology or Natural History of Shells" [for an explanation of the authorship of this work, see the "Catalogue of the Library of the British Museum (Natural History)," 1922, vol. 6, p. 218] shows a species of the genus *Macroschisma* with a strongly sinuate posterior end. At first I felt that Lightfoot's name should replace *Dolichoschisma munita* Iredale (1940, p. 431) restricted to Western Australia (Cotton, 1959, p. 79) since this is the only species known to me with such a sinuate posterior end.

Because, however, this part of Australia was not scientifically explored until Baudin's expeditions at the beginning of the nineteenth century, it seems unlikely that specimens from these coasts could have reached London in the 1770s. As these figures are unaccompanied by any textual material that might furnish us with a clue, I am led to the conclusion that either an abnormal specimen was figured or that the drawing is a poor and misleading one. For this reason I feel this name should be regarded as a doubtful one.

1620 "Three rare species of Conus in pairs . . . Leoninus, *ibid. Knorr* III. 12. 5" . . . ."

Conus striatus Linnaeus, 1758

Conus leoninus [Lightfoot, 1786], p. 72.

See Kohn, 1963, pp. 161–162.

1705 "Four cards of rare species of Voluta, viz. . . . filosa, *S. Martyn, vol.* I. *fig.* 22. 1."

Mitra (Cancilla) filaris (Linnaeus, 1771)

Voluta filosa Born, 1778, p. 212.

Voluta filosa [Lightfoot, 1786], p. 76.

1709 "Patella Calyptra, *vol.* I. *Martyn, fig.* 18, k . . . ."

Nomen dubium

This figure seems to resemble most nearly a specifically indeterminable specimen of *Capulus* which has assumed the nodulose sculpture of the shell that formed its substratum.

1711 "Voluta . . . angulata, *S. Martyn, vol.* IV, 1325."

Turbinella angulata (Lightfoot, 1786)

Voluta angulata [Lightfoot, 1786], p. 76.

Voluta scolymus Gmelin, 1791, p. 3553.

Xancus angulatus Solander.—Abbott, 1950, p. 204.

Not *Voluta angulata* Swainson, 1821 = *Zidona dufresnei* (Donovan), 1823).

I have elsewhere (Rehder, 1967, in press) discussed at some length the unfortunate official restitution of *Turbinella* Lamarck 1799 over *Xancus* Röding, 1798. For the sake of stability and to prevent nomenclatorial anarchy, however, I follow the rulings of the International Commission of Zoological Nomenclature even though I may not agree with some of these decisions.

1714 "A fine pair of Conus araneosus, *S.* or Spider's Web Cones, from *China . . . rare, Martyn, vol.* II. 676."

Conus araneosus [Lightfoot, 1786]

Conus araneosus [Lightfoot, 1786], p. 76.
Conus arachnoideus Gmelin, 1791, p. 3388.
Conus araneosus Solander.—Tomlin, 1937, p. 213.

1718 "*A large and fine, and 2 small specimens of Patella Unguis, L. (Mytilus Lingua, or green Duck's-Bill Limpet, S.) Humphrey's Conchology, Pl. 2. fig. 2. from Amboyna . . . extremely scarce.*"

Lingula lingua (Lightfoot, 1786)

Mytilus lingua [Lightfoot, 1786], p. 77.
Pharctra monoculoides Röding, 1798, p. 159.
Lingula anatina Lamarck, 1801, p. 141.
Mytilus lingua Dillwyn, 1817, p. 322.
Lingula unguis Linnaeus.—Dall, 1920, p. 262 (not *Patella unguis* Linnaeus, 1758).
Lingula lingua (Solander).—Uchinomi, 1956, p. 35.

The use of Solander's name, as initiated by Uchinomi, in place of *L. anatina* Lamarck, is made more acceptable by the knowledge that Lamarck's name would have been otherwise replaced by *monoculoides* Röding, 1798.

Later (see lot 3717) Lightfoot lists the same shell as *Patella unguis* L., a reminder of the long-standing but erroneous application of Linnaeus' name to this species of *Lingula.*

1873 "A neat small pair of Voluta Ancilla, S. from the *Straits of Magellan, very rare, D'Avila's Catalogue, vol.* I. *pl.* 8. *fig.* 5."

Adelomelon ancilla (Lightfoot, 1786)

Voluta ancilla [Lightfoot, 1786], p. 84.
Voluta spectabilis Gmelin, 1791, p. 3468.
Voluta ancilla Lamarck, 1811, p. 69.
Adelomelon ancilla Solander.—Clench and Turner, 1964, p. 152.

1914 "A fine and large variety of Trochus Solaris, *S.* from *New Zealand, very rare . . . Martyn, vol.* I. *fig.* 30. 9."

Astraea imperialis (Gmelin, 1791)

Trochus solaris [Lightfoot, 1786], p. 86.
Not *Trochus solaris* Linnaeus, 1766.

1930 "— 4 eggs of Helix ovipara, *Lister*, 23. 21."

Strophocheilus oblongus (Muller, 1774)

Helix ovipara [Lightfoot, 1786], p. 87.

1940 "A fine pair of Voluta . . . Pepo, *S. Martyn, vol.* III. *fig.* 768–770."

Cymbium pepo (Lightfoot, 1786)

Voluta pepo [Lightfoot, 1786], p. 87.
Voluta neptuni Gmelin, 1791, p. 3467.
Voluta navicula Gmelin, 1791, p. 3467.
Cymbium (Cymba) pepo Solander.—Abbott, 1962, p. 103.

1942 ". . . Trochus . . . granosus from *New Zealand, Martyn, vol.* I. *fig.* 37. r. 2 . . . ."

Modelia granosa (Martyn, 1784)

Trochus granosus [Lightfoot, 1786], p. 87.
Turbo granosus Holten, 1802, p. 69.
Turbo rubicundus Reeve, 1842, p. 168.
Not *Trochus granosus* Lam., 1822 (= *T. ochroleucus* Gmelin, 1791)

Martyn's name, although appearing in a nonbinomial work, was validated in 1957 by the International Commission of Zoological Nomenclature under its Plenary Powers (Opinion 479).

1947 ". . . 2 of Lepas vittata, *S. Seba* IV. *tab.* 16. *no.* 5. *middle figure* . . . ."

Conchoderma virgata (Spengler, 1790)

Lepas vittata [Lightfoot, 1786], p. 88 [nomen oblitum].
Lepas virgata Spengler, 1790, p. 207.
Lepas vittata Wood, 1815, p. 69.
Cineras vittata Leach, 1824, p. 170.
Conchoderma virgata (Spengler).—Pilsbry, 1907, p. 99.

The "IV" in the Seba reference is an error for "III". Wood cites Solander's manuscript as the source for his use of this name, which was used also by certain later authors, among them Brown (1827, pl. 5, fig. 16). Darwin (1851, p. 146) used Spengler's name *virgata*, a designation that has been followed by all subsequent workers.

1960 ". . . a fine Buccinum pustulosum, *S. Rum.* 49. B. *rare.*"

Argobuccinum pustulosum (Lightfoot, 1786)

Buccinum pustulosum [Lightfoot, 1786], p. 88.
Murex argus Gmelin, 1791, p. 3547.
Buccinum pustulosum S.—Dall, 1921, p. 125.

The figure given by Rumphius, which is the first reference cited by Gmelin for his *Murex argus*, represents the form with the markedly ocellated bands, typical of the South African form. Lightfoot's earlier name must, therefore, replace that of Gmelin.

1963 ". . . Balanus, *S.* (Lepas *S.*) . . . ponderosus, *S. Lister.* 442. 284."

Tetraclita squamosa stalactifera Lamarck

Balanus ponderosus [Lightfoot, 1786], p. 89 [nomen oblitum].
Balanus stalactiferus Lamarck, 1818, p. 394.
Tetraclita squamosa stalactifera Lamarck.—Pilsbry, 1916, p. 254.

The form, sculpture, and locality cited under Lister's figure seem to point to this tropical Western Atlantic barnacle, but because Lightfoot's name has never been used for this subspecies, it should be considered a nomen oblitum.

2116 "A large and a small specimen of Voluta incompta, *S.* from the *South Seas, extremely scarce . . . Martyn, vol. fig.* 19. *1.*"
Mitra terebralis Lamarck, 1811

Voluta incompta [Lightfoot], 1786, p. 96 [nomen oblitum].
Voluta tesselata Martyn, 1784 (nonbinominal).
Mitra terebralis Lamarck, 1811, p. 201.

2120 "A very fine specimen of Argonauta nodosa, *S.* or tuberculated Paper Nautilus, from the *Cape of Good Hope, rare—Rum.* 18.1."
Argonauta nodosa [Lightfoot, 1786]

Argonauta nodosa [Lightfoot, 1786], p. 96.
Argonauta tuberculata Röding, 1798, p. 71.
Argonauta tuberculata Shaw, 1812, pl. 995.
Argonauta tuberculosa Schumacher, 1817, p. 260.
Argonauta nodosa Solander.—Tryon, 1879, p. 140.

2122 "A small but fine specimen of Voluta Cithara, *S.* or painted Aethiopian Crown, from *Japan, very rare . . . Seba Mus. Vol.* 3. *t.* 65. *f.* 1. 2."
Cymbium (Melo) amphora (Lightfoot, 1786)

Voluta cithara [Lightfoot], 1786, p. 96.
Voluta armata Lamarck, 1811, p. 57.
Not *Voluta cithara* Lamarck, 1803 =*Athleta* (*Neoathleta*) *citharoedus* Holten, 1802).

I follow Weaver (1964, p. 2) in considering this long-spined form to be a synonym of *amphora* Lightfoot (*diadema* Lamarck).

2132 "A very perfect and finely colored specimen of Chama Lazarus, L. var. *a* pannosus, *S.* Rum. 483 . . . very rare."
Chama lazarus Linnaeus, 1758

Chama lazarus pannosus [Lightfoot, 1786], p. 96.

The figure in Rumphius depicts merely a variant of the common *C. lazarus.*

2148 ". . . two Buccinum testudo, *S. Seba* III. 70. *fig.* 2, 3, and 4. of the *Bucc. Harpa* L."
Nomen dubium

Not *Harpa testudo* Donovan, 1822 (=*H. ventricosa* Lamarck 1816).

The figures referred to by Lightfoot in the "Catalogue" are the last three figures (unnumbered) in the third row from the top on plate LXX (figure 1 of *Harpa* would be the second figure from the right in the second row). Since these three figures represent three different species of *Harpa* (*articularis* Lamarck, 1822; *major* Röding, 1798; *ligata* Menke, 1828, respectively), I suggest that this name be considered a nomen dubium, since we do not know to what species Lightfoot intended his name to be applied. Donovan later applied the name *H. testudo* to still another species (*Harpa ventricosa* Lamarck, 1816).

Dall (1921, p. 98), when he identified Solander's name with *Cassis inflata* Shaw, 1790, based his determination on the numbered figures on Seba's plate, ignoring the last four words of the cited reference.

2150 "Venus Punctata, *S. Rum.* 43. G . . . ."

Meretrix meretrix (Linnaeus, 1758)

Venus punctata [Lightfoot, 1786], p. 98.
Not *Venus punctata* Linnaeus, 1758.

2158 "A fine Arca nodulosa, S. or studded Ark, Gualt. 87. E . . . ."

Anadara granosa (Linnaeus, 1758)

Arca nodulosa [Lightfoot, 1786], p. 98.
Not *Arca nodulosa* Müller, 1776 (=*Acar scabra* (Poli, 1795), fide Lamy, 1907, p. 95).

2190 "Two curious and rare species of Mya, viz. Complanata, *List.* 150. 5. and . . . ."

Elliptio complanatus (Lightfoot, 1786).

Mya complanata [Lightfoot, 1786], p. 100.
Unio violaceus Spengler, 1793, p. 55.
Mya complanata Dillwyn, 1817, p. 51.
Elliptio complanatus (Solander).—Clark and Berg, 1959, p. 21.

2194 "Two very large and fine species of Arca, viz. Nodulosa from *China,* Gualt. 87. E. and . . . ."

Anadara granosa (Linnaeus, 1758)

See lot 2158.

2213 "A fine specimen of Mya Gigas, *S.* from the *Mediterranean.* . . . . *List.* 414. 258."

Panope glycymeris (Born, 1778)

See lot 626.

2216 "A very fine cluster of Lepas Cornu Copiae, *S.* D'Argenville, 26. *D.* . . . *rare.*"

Mitella cornucopiae (Lightfoot, 1786).

Lepas cornucopiae [Lightfoot, 1786], p. 101.
Lepas pollicipes Gmelin, 1791, p. 3213.
Pollicipes cornucopia Leach, 1824, p. 171.
Pollicipes cornucopia: Darwin, 1851, p. 298.
Pollicipes cornucopia: Gruvel, 1902, p. 223.
Mitella pollicipes: Pilsbry, 1907, p. 5.

As will be seen by the above synonymy, the trivial name *cornucopiae* has been used fairly recently by some authors. Dall (1921, p. 127) had already called attention to the fact that this name had precedence over Gmelin's *pollicipes.*

2220 "A fine Trochus Annulatus, or purple-edged Trochus, *Martyn*, Vol. I. fig. 33. r. . . . from *K. George's Sound* on the *N.W. Coast of America* . . . rare."

Calliostoma annulatum (Lightfoot, 1786)

Trochus annulatus [Lightfoot, 1786], p. 101.
Trochus annulatus Martyn, 1784 (nonbinomial).
Trochus virgineus Holten, 1802, p. 67.
Calliostoma annulatum Solander.—Abbott, 1954, p. 115.

2220 ". . . and two [Trochus] Canaliculatus, or bronzed Trochus ibid 33. r. all from *K. George's Sound*, on the *N.W. coast of America* . . . rare."

Calliostoma canaliculatum (Lightfoot, 1786)

Trochus canaliculatus [Lightfoot, 1786], p. 101.
Trochus canaliculatus Martyn, 1784 (nonbinomial).
Trochus doliarius Holten, 1802, p. 67.
Calliostoma canaliculatum (Solander).—Abbott, 1961, p. 63.

The figure cited by Lightfoot for this species is obviously an error for "32." It should be noted that whereas Martyn gave New Zealand as the habitat for this and the previous species, Lightfoot cites the correct locality.

2222 "Three curious and rare species of Solen, viz. . . . Antiquatus, *Pennant*, 46. 25 . . . ."

Solecurtus (Azorinus) chamasolen (Da Costa, 1778)

Solen cultellus Pennant, 1777, p. 85 (not Linnaeus, 1758).
Solen antiquatus [Lightfoot, 1786], p. 101.
Solen antiquatus Pulteney, 1799, p. 28.

Since Pulteney gives the Solander manuscript as the source of his name, Lightfoot must have derived his use of *antiquatus* from the same source although he does not signify this by the usual letter "S."

2274 "An exceedingly fine specimen of Voluta gravis, S. with its Epidermis on, from the *Straits of Malacca, Martyn, Vol.* III. 917."

Turbinella pyrum (Linnaeus, 1758)

Voluta gravis [Lightfoot, 1786], p. 103.
Voluta gravis Wood, 1818, p. 101.

This is not *T. rapa* Lamarck, 1822 (=*ponderosa* Lightfoot, 1786) as Dall states (1921, p. 131).

2284 ". . . Murex plicatus, or plicated Murex, from *Falkland's Islands, undescribed. Favanne, tab.* 79. *I* . . . ."

Trophon plicatus (Lightfoot, 1786)

Murex plicatus [Lightfoot, 1786], p. 104.
Buccinum laciniatum Martyn, 1784, fig. 42 (nonbinomial).
Murex lamellosus Gmelin, 1791, p. 3536.
Trophon laciniatus Martyn.—Strebel, 1904, p. 199.
Murex plicatus S.—Dall, 1921, p. 99.
Not *Murex plicatus* Gmelin, 1791 (="*Thais*" sp.).
Not *Murex plicatus* Dillwyn, 1817 (=*Coralliophila erosa* (Röding), 1798).

2296 "A fine pair of Buccinum muricatum, *Favanne* 33, x. 3 . . . all rare."

Colubraria muricata (Lightfoot, 1786)

Buccinum muricatum [Lightfoot, 1786], p. 104.
Murex maculosus Gmelin, 1791, p. 3458.
Not *Buccinum muricatum* Schröter, 1805 (=*Hebra horrida* Dunker, 1847).

Shikama (1963, pl. 49, fig. 3) follows Dall (1921, p. 125) in considering this to be the same as *Colubraria obscura* (Reeve, 1844); the latter species, however, is more slender and less strongly sculptured.

2297 ". . . Cardium spinosum, S. . . . figured in *Favanne* 52. A. 2."

Acanthocardia echinatum (Linnaeus, 1758)

Cardium spinosum [Lightfoot, 1786], p. 105.
Cardium spinosum Dillwyn, 1817, p. 115.
Cardium crinaceum Lamarck, 1819, p. 8.
Not *Cardium spinosum* Sowerby, 1805.—Link, 1807 (=*Acanthocardia aculeatum* L., 1758).

2302 "Four fine species of Patella, viz. Gorgonica, *Humphrey's Conch*. 3. 8 . . . ."

Patella barbara Linnaeus, 1758

Patella gorgonica [Lightfoot, 1786], p. 105.

2302 ". . . [Patella] Pulchra, or Beauty, *ibid*. 2. 8 . . . ."

Patella miniata Born, 1778

Patella pulchra [Lightfoot, 1786], p. 105.

2302 ". . . and a young one of [Patella] Oculus hirci, *ibid*. 2. 6."

Patella oculus Born, 1778

Patella oculushirci [Lightfoot, 1786], p. 105.

2315 "A fine specimen of Voluta incrassa, *S. Martyn, Vol.* II–*very rare*, f. 499. 500."

Oliva incrassata (Lightfoot, 1786)

See lot 264.

It will be noticed that the trivial name is here misspelled "*incrassa*."

2327 "A small but extremely fine pair of Murex fimbriatus, or furbelowed Murex, from *Falkland's Island, Martyn, Vol.* 1. *fig*. 6. c. *Favanne*, 37. H.I."

Trophon geversianus (Pallas, 1774)

Murex fimbriatus [Lightfoot, 1786], p. 106.
Not *Murex fimbriatus* Brocchi, 1814 (=*Fasciolaria* (*Pleuroploca*) sp.—probably needs a new name).
Not *Murex fimbriatus* Lamarck, 1822 (=?*Ocinebra planilirata* Reeve, 1845).

2328 "A large and fine Conus Araneosus, S. or Spider's Web Cone from *Coromandel, very rare. Martyn.* Vol. II. 676."
Conus araneosus [Lightfoot, 1786]
See lot 174.

2230 [error for 2330] "*Two extremely curious and rare species of Cypraea,* viz. *Pustulata, or orange warted Cowry, from China,* Lister, 710.62 . . . ."
Jenneria pustulata (Lightfoot, 1786)

Cypraea pustulata [Lightfoot, 1786], p. 106.
Cypraea pustulata Lamarck, 1810, p. 101.
Jenneria pustulata (Solander, 1786).—Keen, 1958, p. 333.

2331 "Serpula attrahens or furbelowed Watering-pot. *Humphrey's* Conch. pl. VII [Error for XII] fig. 15. from *Madagascar* . . . very rare.'
Penicillus (Warnea) attrahens (Lightfoot, 1786)

Serpula attrahens [Lightfoot, 1786], p. 106.
Aspergillum vaginiferun Lamarck, 1818, p. 430.
Serpula attrahens S.—Dall, 1921, p. 129.

2481 "A fine Trochus sulcatus, from *New Zealand, Naturforscher, Vol.* IX. *tab.* III. *fig.* 5. 6. *Martyn, Vol.* I. *fig.* 33. [error for 35] r . . . ."
Cookia sulcata (Gmelin, 1791)

Trochus sulcatus Martyn, 1784, fig. 35.
Trochus sulcatus [Lightfoot, 1786], p. 13.
Trochus cookii Gmelin, 1791, p. 3582.
Turbo sulcatus Gmelin, 1791, p. 3592.
Cookia sulcata (Martyn, 1784).—Powell, 1957, p. 90.
Not *Trochus sulcatus* Lamarck, 1804 (=*Astele* sp.—needs new name—Eocene, Paris Basin).

When the name *Turbo sulcatus* Gmelin, 1791 was placed on the "Official List of Specific Names in Zoology" in Opinion 479 (International Commission of Zoological Nomenclature, 1957: p. 372), it was not realized that Lightfoot's name was the first valid taxon for this species after Martyn. It was also overlooked that *Trochus cookii* Gmelin, 1791 is a synonym of *Turbo sulcatus* Gmelin.

2516 "Isognoma rigida, S. from *Pulo Condore, List.* 227, 62. very rare."
Nomen dubium

Because Lister's figure is only an internal view, this name must be considered a nomen dubium.

2550 "Two fine species of Cardium, viz. . . . and Hystrix, *S. Gualt.* 72. B. *both rare.*"

Trachycardium aculeatum (Linnaeus, 1767)

Cardium hystrix [Lightfoot, 1786], p. 116.
Not *Cardium hystrix* Reeve, 1844 (=*Fragum* (*Ctenocardia*) *symbolicum* Iredale, 1929).

2554 "A fine pair of Conus mappa, *S.* from China, *very rare. Knorr.* I. *tab.* 8. 4."

Conus ammiralis Linnaeus, 1758

Conus mappa [Lightfoot, 1786], p. 116.
Not *Conus mappa* Crosse, 1858 (=*C. eldredi* Morrison, 1935).

2961 "A large and very fine variety of Buccinum calcaratum, *S. Gualt.* 31. *F. . . . rare.*"

Melongena (Volema) hippocastanum (Linnaeus, 1758)

Buccinum calcaratum [Lightfoot, 1786], p. 133.
Volema nuxmoschata Röding, 1798, p. 57.
Pyrula hippocastanum Lamarck, 1816, p. 7.
Murex calcaratus Dillwyn, 1817, p. 710.
Pyrula galeodes Lamarck, 1822, p. 144.

Dodge (1957, pp. 137–139) has exhaustively detailed the reasons for the allocation of Linnaeus' name to this species rather than to the species of Muricidae (Thaisinae) to which the Linnean name was given by many later authors.

2965 ". . . Cypraea seriata, (rather a young one of Tigris L.) . . . ."

Cypraea tigris Linnaeus, 1758

Cypraea seriata [Lightfoot, 1786], p. 133.

2965 ". . . [Cypraea] nebulosa, S. (a young one of Mauritiana, L.)."

Cypraea mauritiana Linnaeus, 1758

Cypraea nebulosa [Lightfoot, 1786], p. 133.
Not *C. nebulosa* Gmelin, 1791 (=*C. stercoraria* Linnaeus, 1758).

2967 "Two fine specimens of Strombus truncatus, an undescribed species of L. *showing the different stages of growth,* from the *E. Indies, rare . . . D'Avila, vol.* I, *tab.* 12. 14."

Lambis truncata truncata (Lightfoot, 1786)

Strombus truncatus [Lightfoot, 1786], p. 133.
Strombus bryonia Gmelin, 1791, p. 3520.
Lambis davilae Röding, 1798, p. 66.
Strombus truncatus Dillwyn, 1817, p. 659.
Lambis truncata truncata (Humphrey, 1786).—Abbott, 1961, p. 155.

2983 "Three curious species of Mya, viz. . . . ovalis, *Lister* 146.1 . . ."

Unio ovalis ovalis (Lightfoot, 1786)

Mya ovalis [Lightfoot, 1786], p. 134.
Mya batava Dillwyn, 1823, p. 13 (not Maton and Rackett, 1807.)
Unio cytherea Küster, 1833.
Unio crassa cytherea Küster.—Haas, 1940, p. 129.
Mya ovalis S.—Dall, 1921, p. 128 (in part).
Not *Mya ovalis* Pulteney, 1799 (=*Unio pictorum* Linnaeus, 1758).

A comparison of the figure in Lister, which is accompanied by the words "a Danubio," with various figures and descriptions of the polymorphic species and subspecies of *Unio* occurring in Europe leads me to the conclusion that Lightfoot's name must be used for the subspecies that Haas (1940) called *Unio crassus cytherea* Küster, 1833. Because the name *ovalis* is two years older than *crassus*, the central European, Danubian form becomes the nominate form, and the western European subspecies becomes *Unio ovalis crassus* Retzius. I leave the judgment of the correctness of this assignment to my European colleagues more familiar with this difficult freshwater fauna.

2995 "Patella pulchra, or beauty Limpet, *Humphrey's Conch. pl.* 2. *fig.* 8. from the Cape of Good Hope. . . ."
Patella miniata (Born, 1778)

See lot 2302.

3020 "Voluta virescens, S. an extreme scarce species of the Music kind, from *Guinea—Martyn*, vol. III. fig. 932. 933."
Voluta virescens [Lightfoot, 1786]

See lot 610.

3028 "A large and fine specimen of Placuna Ephippium, S. (Anomia, L.) from *China*—very rare."
Placuna [Lightfoot, 1786]

The "S" signifies that Solander is the author of the combination, but not of the trivial name, whose author is Linnaeus.

3030 ". . . Bulla vesicaria, S. from the *W. Indies, ibid* [*Seba* III. *tab.* 38.], *fig.* 46. 48 . . . *both rare.*"
Hydatina vesicaria (Lightfoot, 1786)
Bulla physis Linnaeus, 1758 (in part).
Bulla vesicaria [Lightfoot, 1786], p. 136.
Hydatina vesicaria Solander.—Abbott, 1954, p. 276.

For a discussion of the status of this species, see Bartsch, 1940, Proc. Biol. Soc. Washington, vol. 53, p. 92.

3039 "A large specimen of Voluta Scafa, S. *in the utmost perfection,* from Guinea . . . *Martyn*, vol. III tab. 70. 764."
Cymbium cymbium (Linnaeus, 1758)

See lot 969.

3040 "A large and fine Pinna rigida, S. *Knorr* II. 26, 1 . . . very rare."
Atrina rigida (Lightfoot, 1786)
Pinna rigida [Lightfoot, 1786], p. 136.
Pinna rigida Dillwyn, 1817, p. 327.
Atrina rigida Solander.—Turner and Rosewater, 1958, p. 312.

3041 "A cluster of Isognoma Perna, S. (ostrea, L.) enveloped in Sponge, from *China*, rare."
Isognomon [Lightfoot, 1786]
See lot 968.

3049 "A large and fine specimen of Tellina marginalis, *S. List.* 387."
Tellina laevigata Linnaeus, 1758
Tellina marginalis [Lightfoot, 1786], p. 137.

3054 "Voluta Haustrum, S. or banded coronated Melon, *very rare*, from *China*, Martyn, III. 781."
Cymbium amphora (Lightfoot, 1786)
See lot 768.

3061 "A very fine specimen of Voluta ancilla, S. from the *Straits of Magellan, extremely scarce, D'Avila, vol.* I. *pl* 8. *fig. s.*"
Adelomelon ancilla (Lightfoot, 1786)
See lot 1873.

3074 ". . . a stone with various specimens of Venus arctica, S. in it, *List.* 426. 427 . . . ."
Hiatella arctica (Linnaeus, 1758)
Venus arctica [Lightfoot, 1786], p. 138.

3091 "A cluster of three, and a single specimen of Ostrea purpurea, S. from *New Holland, very rare—Born. mus. caes. Tab.* 6. *fig.* 11. 12."
Ostrea cucullata Born, 1778
Ostrea purpurea [Lightfoot, 1786], p. 139.

3093 "A large and fine Buccinum monodon, S. or Unicorn, from *Terra del Fuego*, Martyn, vol. I. fig. 10 e . . . ."
Acanthina monodon (Pallas, 1774)
See lot 372.

3117 "A large fine pair of Patella oculus hirci, or Goat's-eye Limpet, *one of them in its native state, the other polished*, from the *Cape of Good Hope* . . . Humphrey's Conch. 2. 6."
Patella oculus Born, 1778
See lot 2302.

3119 "A large and fine specimen of Placuna placenta, S. (Anomia, L.) or the Window Shell, from *China* . . . rare."
Placuna [Lightfoot, 1786]
See lot 3028.

3142 "A fine pair of Voluta muricata, *S. one with the epidermis on, Lister*, 810. 19. from the *W. Indies* . . . rare."
Vasum muricatum (Born, 1778)
Voluta muricata [Lightfoot, 1786], p. 142.

3158 "A pair of large and fine Buccinum taurinum, *S. Lister*, 841. 69. from *China* . . . *very rare.*"
Terebra taurinum (Lightfoot, 1786)
Buccinum taurinum [Lightfoot, 1786], p. 142.
Epitonium feldmanni Röding, 1798, p. 94.
Terebra flammea Lamarck, 1822, p. 284.
Terebra taurinum Solander.—Abbott, 1954, p. 265.

3161 "A fine specimen of Voluta elongata, S. or Midas's ear Land Snail, from *New Caledonia, very rare* . . . *Martyn, vol.* I. *fig.* 25. n."
Placostylus elongatus (Lightfoot, 1786)
See lot 707.

3235 ". . . a fine specimen of Turbo cornutus, a new species allied to Chrysostomus, L. but with a silver mouth, *D'Avila. Vol.* 1. *pl.* 5. *fig.* I."
Turbo (Batillus) cornutus [Lightfoot], 1786
Turbo cornutus [Lightfoot, 1786], p. 147.
Turbo cornutus Gmelin, 1791, p. 3593.
Turbo cornutus Solander.—Shikama, 1963, pl. 12.

3307 "A fine young specimen of Strombus truncatus *D'Avila, vol.* I. *tab.* 12 . . . ."
Lambis truncata truncata (Lightfoot, 1786)
See lot 2967.

3356 "Four curious species of Buccina, viz. . . . one of Iris, *S. Martyn, vol.* I. *fig.* 2. *b.* . . ."
Latirus iris (Lightfoot, 1786)
See lot 30.

3384 "*Patella Auricularia*, an extremely rare species, from *Amboyna* . . . *Rumph.* 40. *N.*"
Dolabella auricularia (Lightfoot, 1786)
Scapula Martyn, 1784, fig. 99 (nonbinomial).
Patella auricularia [Lightfoot, 1786], p. 154.
Dolabella callosa Lamarck, 1801, p. 62.
Dolabella rumphii Blainville, 1819, p. 395.
Dolabella auricularia (Solander).—Kira, 1959, p. 102.

3388 "A fine pair of Helix ovipara, *List.* 1055. 1. from Surinam . . . ."
Strophocheilus ovatus (Müller, 1774)
Helix ovipara [Lightfoot, 1786], p. 155.

3389 "Two fine species of Cardium, viz. . . . impressum, *S. Born. Mus. tab.* 2. *fig.* 15, 16. both from *China* and rare."

Corculum impressum (Lightfoot, 1786)

Cardium impressum [Lightfoot, 1786], p. 155.
Cardium roseum Gmelin, 1791, p. 3245.
Corculum humanum Röding, 1798, p. 189.
Cardium junoniae Lamarck, 1816, p. 17.
Corculum impressum (Solander).—Shikama, 1964, p. 74.
Not *Cardium impressum* Deshayes, 1842 (=*Protocardia* sp., Cretaceous, France).

3494 [error for 3394] ". . . Trochus punctulatus of *Martyn, vol.* I. *fig.* 36. *r.* . . ."

Calliostoma (Mauriella) punctulatum Martyn, 1784

Trochus punctulatus [Lightfoot, 1786], p. 155.
Trochus diaphanus Gmelin, 1791, p. 3580.
Not *Trochus punctulatus* Gmelin, 1791 (=?*Cantharidus turriculum* Phil., 1855).

3494 ". . . [Trochus] *granosus, ibid.* 37. r. . . ."

Modelia granosa (Martyn, 1784)

See lot 1942.

Both of the above two Martyn names were validated by the International Commission of Zoological Nomenclature in Opinion 479 (1957).

3411 ". . . and two fine varieties of [Conus] nocturnus, *S. Martyn,* II. 687. and 688. *all from China, and rare.*"

Conus nocturnus [Lightfoot, 1786]

Conus nocturnus [Lightfoot, 1786], p. 156.
Conus nocturnus Hwass, 1792, p. 611.
Conus nocturnus Solander.—Tomlin, 1937, p. 281.
Conus nocturnus [Lightfoot].—Kohn, 1963, p. 162.

3458 "A most beautiful variety of Mytilus pictus, *S.* or painted Muscle, bright green, waved with brown, from the *Mediterranean . . . rare. Knorr.* IV. *tab.* 15. *fig.* 5."

Perna picta (Born, 1778)

Mytilus pictus [Lightfoot, 1786], p. 158.

Knorr's figure is the only illustration cited by Born (1778, pp. 111–112) for his *Mytilus pictus*. It is also listed by Gmelin, but with a question mark, under his *Mytilus afer* (1791, p. 3358), which is a new name for *Mytilus pictus* Born.

Dall believes this to be the same as *Mytilus ungulatus* Linnaeus, which name, however, seems to have been based on an abnormal specimen of *Mytilus edulis* as Dodge (1952, pp. 214–215) has stated. Lamy (1936, p. 130) places *Mytilus pictus* Born in the synonymy of *M. perna* Linnaeus, but for the present I maintain it as a distinct species although it may turn out to be a subspecies or even ecological form of the latter.

3487 "A large and fine violet Solen, from China . . . extremely rare. Solen rostratus, *S. Valentyn Bivalves*, no. 5."
Hiatula diphos (Linnaeus, 1771)

Solen rostratus [Lightfoot], 1786, p. 160.
Solen rostratus Lamarck, 1818, p. 456.

It has been quite generally overlooked that *Hiatula* Modeer, 1793, is an earlier name for *Soletellina* Blainville, 1824. H. and A. Adams (1856, p. 392) used it correctly in place of *Soletellina*, as did Stoliczka (1870, p. 114) and Tryon (1884, p. 167). Stoliczka (1870) designated *Solen diphos* Linnaeus as the type. Thiele (1934, p. 909) thought it was preoccupied by *Hiatula* Martini, 1774, which is, however, an invalid name. Winckworth (1935, p. 322) in discussing Modeer's genera was unaware of Stoliczka's action and designated *Mya truncata* Linnaeus as type, hoping thereby to bury *Hiatula* in the synonymy of *Mya*.

Although *Hiatula* (as *Soletellina*) has commonly been considered a subgenus of *Sanguinolaria* Lamarck, 1799, I feel that the differences between these two groups in the nature of the hinge, pallial sinus, and general shape are of sufficient magnitude to justify their being considered distinct genera.

3491 "A large and fine specimen of Conus fuscatus, S. or bastard Imperial Crown, from *China, very rare . . . Martyn, vol.* II. *fig.* 693.
Conus imperialis Linnaeus, 1758

Conus fuscatus Born, 1778, p. 126.
Conus fuscatus [Lightfoot, 1786], p. 160.

3553 "Two specimens of a very uncommon species of terrestrial Snail, nearly allied to Helix Ovipara, *List.* 1055. 1. *the country unknown.*"
Strophocheilus ovatus (Müller, 1774)

See lot 3388.

3561 "A very fine specimen of Bulla Zonata, *S. . . . . Born. Mus. Caes. tab.* 9. *fig.* 1."
Hydatina zonata (Lightfoot, 1786)

Bulla amplustre Born, 1780, p. 204 (not Linnaeus, 1758).
Bulla zonata [Lightfoot, 1786], p. 164.
Bulla velum Gmelin, 1791, p. 3433.
Bulla fasciata Bruguiere, 1792, p. 380.
Hydatina (*Hydatoria*) *zonata* Solander.—Habe, 1950, p. 18.
Not *Bulla zonata* Turton, 1834 (=*Scaphander lignarius* L., 1758, young).

The shell figured by Kira (1959, p. 104, pl. 39, fig. 15) as *H. zonata*, lacks the white band, and may be a distinct species (?*H. inflata* Dunker, 1877).

3624 "Seven curious specimens of Solens, viz. a small one of Rostratus, *Valentyn. Bivalves*, no. 5 . . . ."
Hiatula diphos (Linnaeus, 1771)
See lot 3487.

3655 "Two very fine specimens of Strombus truncatus, *showing the different stages of growth*, from China, *very rare—D'Avila, vol.* I. *pl.* 12 and 14."
Lambis truncata truncata (Lightfoot, 1786)
See lot 2967.

3696 "*A very fine pair of Voluta Incrassata, S.* extremely scarce . . . Martyn, vol. II. 499. 500."
Oliva incrassata (Lightfoot, 1786)
See lot 2315.

3711 "A large and complete specimen of Voluta Nobilis, *S.* from *China, extremely scarce* . . . Martyn, vol. III. *fig.* 775. 776."
Aulica nobilis (Lightfoot, 1786)
See lot 89.

3734 "A large and very perfect specimen of Argonauta nodosa, S. or tuberculated paper Nautilus, from the *Cape of Good Hope, very rare*, Rum. 18. 1."
Argonauta nodosa [Lightfoot, 1786]
See lot 2120.

3741 "Two curious varieties of Ostrea purpurea, S. from New Holland, and an odd valve of the same species, from *China, very scarce* . . . *Born. mus. caes. pl.* 6. fig. 11. 12."
Ostrea cucullata Boon, 1778
See lot 3091.

3744 "A very fine and large specimen of Placuna Ephippium, *S.* (Anomia, *L.*) or the Saddle Shell, *very rare*, from China."
Placuna [Lightfoot, 1786]
See lot 3028.

3745 "A very fine variety of Helix Ovipara, *Lister, tab.* 23. having a white margin to the mouth, with three of its eggs, and a young shell as taken out of the Egg from St. *Vincents* . . . *extremely curious* and *very rare.*"
Strophocheilus oblongus (Müller, 1774)
See lot 1930.

3748 "A very perfect specimen of Argonauta hians, S. a scarce variety of the brown paper Nautilus, from *China, very rare* . . . Rum. 18. B."

Argonauta hians [Lightfoot, 1786]

See lot 1055.

3751 "A fine specimen of Voluta virescens, S. or brindled Music, from *Guinea, very rare* . . . Martin, vol. III. *fig.* 932. 933."

Voluta virescens [Lightfoot, 1786]

See lot 610.

3758 "A very fine Bulla Zonata, from *China, extremely rare, enclosed in a small glass case . . . Born, mus. caes. tab.* 9. *fig.* 1."

Hydatina zonata (Lightfoot, 1786)

See lot 3561.

3761 "A large and fine specimen of Venus nimbosa, S. from *Florida, very rare . . . Favanne, pl.* 49, *fig.* I."

Macrocallista nimbosa (Lightfoot, 1786)

Venus nimbosa [Lightfoot, 1786], p. 175.
Venus gigantea Gmelin, 1791, p. 3282.
Macrocallista nimbosa Solander.—Clench, 1942, p. 5.

3794 "Nine curious and rare species of Helix, among which are . . . insignita. *Lister*, 67, 68 . . . *the last undescribed.*"

Carocolus marginella (Gmelin) subsp.

Helix insignita [Lightfoot, 1786], p. 176 [nomen oblitum].

3798 "A very fine specimen of Ostraea purpurea, S. rich in colour, from *New Holland, exceedingly scarce. Born. mus. caes. tab.* 6. *fig.* 11, 12."

Ostrea cucullata Born, 1778

See lot 3091.

3802 "A very fine specimen of Helix undata, a carinated umbilicated Land Shell, the Country unknown. Lister, 76. Favanne, tab. 63. *fig.* G. 3."

Solaropsis undata (Lightfoot, 1786)

Helix undata [Lightfoot], 1786, p. 177.
Helix pellis-serpentis Gmelin, 1791, p. 3620.
Helix undata.—Dall, 1921, p. 99 (in part).
Not *Helix undata* Gmelin, 1791 (a nomen dubium, possibly young *Cochlitoma* sp.).

I am restricting Lightfoot's name to Lister's figure, since the figures in Favanne look to me more like *S. gibboni* Pfeiffer. The replacement of Gmelin's name by *undata* is more readily acceptable since Pilsbry in his "Manual of Conchology" (1889, p. 178) gave the name *pellis-serpentis* erroneously to the species with two deep pits in the last whorl, which must bear the name *S. constrictor* Hupe, 1853. Dall has identified Lightfoot's *undata* with *S. brasiliana* Deshayes, 1832.

3817 "A large and fine specimen of Trochus Onustus, or the Carrier, from *Guadalupe, very rare. Favanne* 12. C. 1. 2."
Xenophora conchyliophora (Born, 1780)

See lot 31.

3825 "A very fine specimen of Cardium protrusum, S. a curious variety of the Venus's Heart Cockle, from *China, very rare. Lister*, 319. 156."
Corculum impressum (Lightfoot, 1786)

Cardium protrusum [Lightfoot, 1786], p. 178.

See lot 3389.

3828 "A large and very fine Turbo undulatus, or waved Emerald Turbo, extremely scarce, from *Van Dieman's Land, New Holland. Martyn, Vol.* 1. *fig.* 29, *P.*"
Subninella undulata (Lightfoot, 1786)

See lot 408.

3830 "A very fine specimen of Patella umbraculum or Umbrella Limpet, from *China, extremely scarce. Humphrey's Conch. pl.* 5, *fig.* 5. *which was taken from this shell.*"
Umbraculum umbraculum (Lightfoot, 1786)

Patella umbraculum [Lightfoot, 1786], p. 178.
Patella sinica Gmelin, 1791, p. 3705.
Patella umbellata Gmelin, 1791, p. 3720.
Patella umbracula Röding, 1798, p. 6.
Umbraculum umbraculum (Humphrey).—Kira, 1959, p. 103.

3844 "A very perfect specimen of Conus pulcher, an undescribed species from the *Coast of Guinea . . . extremely rare*, List. 772."
Conus pulcher [Lightfoot, 1786]

Conus pulcher [Lightfoot, 1786], p. 179.
Conus leoninus Gmelin, 1791, p. 3386 (not Lightfoot, 1786).
Conus papilionaceus Hwass, 1792, p. 665.
Conus pulcher [?Humphrey].—Tomlin, 1937, p. 298.
Not *Conus pulcher* A. Ad., 1854.

3447 [Error for 3847] "A large and fine Anomia Ephippiun, L. (placuna, S.) from *China . . . extremely rare.*"
Placuna [Lightfoot, 1786]

See lot 1315.

3853 "A very fine specimen of Patella pulchra, *Humphrey's Conch.* pl. 2. fig. 8 . . . the first is a native of the *Cape of Good Hope.* . . ."
Patella miniata Born, 1778
See lot 2302.

3866 "Two fine specimens of a curious and beautiful variety of Conus undulatus, *S. extremely scarce,* Gualt. 25. I."
Conus textile Linnaeus, 1758

Conus undulatus [Lightfoot, 1786], p. 180.
Not *Conus undulatus* Sby., 1858 (=?*C. mucronatus* Reeve, 1843).

3874 "A large and beautiful specimen of Voluta Amphora, S. or clouded Aethiopian Crown. Martyn, vol. III. fig. 780."
Cymbium amphora (Lightfoot, 1786)
See lot 708.

3902 "A very fine specimen of Voluta Cithara, S. having its Epidermis on, from *Japan, extremely scarce.*—Seba III. 65. 1, 2."
Cymbium (Melo) amphora (Lightfoot, 1786)
See lot 2122.

3906 "Nautilus scrobiculatus, S. or great umbilicated Nautilus, from *New Guinea, very rare* . . . Lister, 552. 4 . . . Knorr IV. 22. 1."
Nautilus scrobiculatus [Lightfoot, 1786]

Nautilus scrobiculatus [Lightfoot, 1786], p. 182.
Nautilus scrobiculatus Dillwyn, 1817, p. 339.
Nautilus umbilicatus Lamarck, 1822, p. 633 (not Linnaeus, 1758).
Nautilus scrobiculatus Solander.—Shikama, 1964, p. 101.

3911 "A cluster of Balanus Tulipa, Ellis. Philosoph. Trans. fig. 10, partly over-run by a Gorgonia pretiosa, *very curious and rare,* from *Sicily.*"
Balanus tulipiformis Darwin, 1854

Balanus tulipa [Lightfoot, 1786], p. 183.
Balanus tulipa Poli, 1791, p. 24.
Not *Lepas tulipa* Müller, 1776 (=*B. tintinnabulum* L., 1758).

3913 "A capital specimen of *Voluta Imperialis,* S. or Great horned Wild Music, from *Luconia, extremely scarce* . . . Martin, vol. IV. 934. 935."
Aulica imperialis (Lightfoot, 1786)

Voluta imperialis [Lightfoot, 1786], p. 183.
Voluta imperialis Lamarck, 1811, p. 62.
Aulica imperialis Solander.—Abbott, 1962, p. 98.

3924 "A large and finely coloured specimen of Helix Undata, an undescribed species of Land Snail, from whence unknown . . . *Favanne., pl.* 63, *fig. G.* 3."
Solaropsis undata (Lightfoot, 1786)
See lot 3802.

3926 "A large and fine specimen of *Voluta Nobilis, S.* an extremely rare, and very beautiful shell of the Wild Music kind, from China. . . . Lister, 799. 6 . . . Martin III. 774."
Aulica nobilis (Lightfoot, 1786)
See lot 89.

3939 "A fine Serpula Tortuosa, a new and undescribed Species, the country unknown, *Humph. Conch.* pl. 11, fig. 4. unique."
Vermicularia tortuosa (Lightfoot, 1786)

Serpula tortuosa [Lightfoot, 1786], p. 184.
Vermetus costalis 'Rousseau' Chenu, 1844, Vermetus, pl. 3.
Vermetus (Vermicularia) tortuosus Solander.—Tryon, 1885, p. 186.

3947 "A fine specimen of Arca Labiata, S. or valved Ark, called by the French, Coquelochon de Moine, *D'Avila*, vol. I. *pl.* 18. its country unknown."
Cucullaea labiata (Lightfoot, 1786)

Arca labiata [Lightfoot, 1786], p. 185.
Arca concamera Bruguiere, 1789, p. 102.
Arca cucullus Gmelin, 1791, p. 3311.
Cucullaea auriculifera Lamarck, 1801, p. 116.
Arca concamerata Dillwyn, 1817, p. 232.
Cucullaea labiata (Solander).—Shikama, 1964, pl. 20, fig. 2.
Not *Arca labiata* Sowerby, 1833 (=*Scapharca perlabiata* Grant and Gale, 1931).

3955 "A very large and fine specimen of Serpula Gigantea, an undescribed Species, from *Luconia*, 21 inches long, *extremely rare* . . . Seba III. 94. The largest figure."
Kuphus polythalamia Linnaeus, 1766
See lot 97.

3965 "A fine specimen of Voluta Arausiaca, S. or Prince of Orange's Flag Musick from *Amboyna, very rare* . . . *Rum* 37. 2."
Harpulina arausiaca (Lightfoot, 1786)
See lot 611.

3370 [Error for 3970] "A fine pair of Helix Alba a terrestrial Shell from the *E. Indies*, one of them an exceeding great variety, being left handed, or turning the contrary way.—*Lister tab.* 33. 32. and 46.—Favanne, 63. E."
Nomen dubium

Not *Helix alba* Bouillet, 1835.

Each of the three figures cited represents a different species, and the crudeness of their delineation forbids any exact identification.

3973 "A very fine Helix erubescens, a curious non-descript Land Shell, the country unknown . . . Lister 24. 22."
Strophocheilus pudicus (Müller, 1774)

Helix erubescens [Lightfoot, 1786], p. 187.

Bequaert, in his study of the family Strophocheilidae (1948, p. 30) is probably correct in assigning this name to the synonymy of Müller's species.

3982 "A very fine Trochus tectus, *the only perfect specimen known*, from the *Island of All Saints*, in the *West Indies. A. bad specimen is figured in Lister*, 628. 14 . . . 'tis undescribed."
Astraea tecta (Lightfoot, 1786)

Trochus tectus [Lightfoot, 1786], p. 187.
Trochus imbricatus Gmelin, 1791, p. 3581.
Astraea tecta tecta Solander, 1786.—Abbott, 1958, p. 30.
Not *Trochus tectum* Gmelin, 1791 (=*Modulus tectum* (Gmelin), 1791).

As Abbott has pointed out (1958), Lightfoot's name does not preoccupy Gmelin's *Trochus tectum*, since the latter trivial name is a noun (Latin *tectum*=roof) in apposition to the genus, while Lightfoot used the adjective *tectus*(=covered or tiled).

3983 "A very fine specimen of Patella Auricularia, figured *Rumph. tab.* 40. fig. N. and called by that author an operculum, it comes from *China*, and is *extremely scarce.*"
Dolabella auricularia (Lightfoot, 1786)

See lot 3384.

4000 "A very large and fine specimen of Madrepora Agnus, or Lamb Madrepora from *New Holland* . . . *extremely scarce. Seba vol.* III. *tab.* CXI. *fig.* 6."
Polyphyllia talpina (Lamarck, 1801)

Madrepora agnus [Lightfoot, 1786], p. 188 [nomen oblitum].
Fungia talpina Lamarck, 1801, p. 370.
Fungia talpa Lamarck, 1816b, p. 237.
Polyphyllia talpina.—Thiel, 1932, p. 89.

4001 "A large and perfect specimen of Murex Tribulus, L. var. Pecten, or the Venus's Comb, from *China, exceedingly scarce.* Rum. 26. 3."
Murex pecten [Lightfoot, 1786]

Murex tribulus var. *pecten* [Lightfoot, 1786], p. 188.
Murex histrix Röding, 1798, p. 145 (not *Murex hystrix* Linnaeus, 1758).

Aranea gracilis Perry, 1810, pl. 47 (not *Murex gracilis* Montagn, 1803).
Aranea triremis Perry, 1811, pl. 45, no. 3.
Murex tenuispina Lamarck, 1822, p. 158.
Murex triremis Perry.—Abbott, 1962, p. 71
Not *Murex pecten* Montfort, 1811 (=*M. ternispina* Lam., 1822).

Any regret over the loss of the long-well-known name *Murex tenuispina* Lamarck is tempered by the fact that Perry's name *triremis* had priority and has been used by recent workers for this species. *Murex ternispina* Lamarck is once more available since Montfort's earlier name for this species is preoccupied by Lightfoot's name; Kira (1962, p. 63) has so used *ternispina.*

4002 "A very large and fine specimen of Echinus maximus, *extremely scarce, the country unknown. Seba* III, *pl.* 14. *fig.* 5. 6. and *Favanne, pl.* 58. *fig.* A. 2."
Plagiobrissus grandis (Gmelin, 1788)

Echinus maximus [Lightfoot, 1786], p. 188 [nomen oblitum].
Echinus grandis Gmelin, 1788, p. 3200.
Spatangus pectoralis Lamarck, 1816b, p. 29.
Plagiobrissus grandis (Gmelin).—Mortensen, 1951, p. 496.

H. L. Clark (1917, p. 207) had pointed out that Lamarck's *pectoralis,* long in use, must yield to Gmelin's earlier name.

4017 "A fine specimen of Conus Architalassus, *S.* a curious granulated variety of the High Admiral, *extremely scarce,* from *Amboyna. Argenv. Suppl. tab.* 1. *fig.* M. N. *Martyn* II. *tab min.* 26. *fig.* 1. 2. *page* 214."
Conus ammiralis Linnaeus, 1758

Conus architalassus [Lightfoot, 1786], p. 189.
Conus ammiralis coronatus Gmelin, 1791, p. 3389.
Conus archithalassus Hwass, 1792, p. 659.

I follow Kohn (1964, p. 161) in placing this name in the synonymy of *ammiralis* L.

4022 "A very perfect specimen of Strombus sinuatus, or scollop-winged Strombus, *extremely rare. Seba.* III. *pl.* 62. *fig.* 3. Favanne 22. A. 2."
Strombus sinuatus [Lightfoot, 1786]

Strombus sinuatus [Lightfoot, 1786], p. 189.
Lambis lobata Röding, 1798, p. 65.
Strombus laciniatus Dillwyn, 1817, p. 663.
Strombus sinuatus Humphrey, 1786.—Abbott, 1960, p. 60.
Not *Strombus sinuatus* Perry, 1811 (=*Lambis scorpius* Linnaeus, 1758).

4023 "A very fine reversed Voluta ponderosa, *S.* or heavy Volute, *extremely scarce*, from the *East Indies. A direct one is figured in Favanne, pl.* 35. *fig.* I."
Turbinella ponderosa (Lightfoot, 1786)
See lot 566.

4030 "A very perfect specimen of that beautiful species, the Voluta Cithara S. from *Japan . . . extremely scarce Seba* III. *tab.* 65. 1. 2."
Cymbium (Melo) amphora (Lightfoot, 1786)
See lot 2122.

Systematic List

The following list is arranged systematically by phyla, classes, and families. All validly proposed Lightfoot names are included, followed by the modern name of the taxon as I have determined it. In some instances the latter is accompanied by one or two synonyms in current use.

MOLLUSCA-GASTROPODA

Fissurellidae

macroschisma, Patella=Macroschisma sp.

Patellidae

fungoides, Patella=Patella barbara Linnaeus
gorgonica, P.=Patella barbara Linnaeus
mytiliformis, P.=Nacella mytilina (Helbling)
oculus hirci, P.=Patella oculus Born
pulchra, P.=Patella miniata Born

Trochidae

annulatus, Trochus=Calliostoma annulatum (Lightfoot)
canaliculatus, T.=C. canaliculatum (Lightfoot)
punctulatus, T.=C. (Mauriella) punctulatum (Lightfoot)

Turbinidae

cornutus, Turbo=Turbo (Batillus) cornutus [Lightfoot]
granosus, Trochus=Modelia granosa (Lightfoot)
solaris, Trochus=Astraea imperialis (Gmelin)
sulcatus, Trochus=Cookia sulcata (Lightfoot)
tectus, Turbo=Astraea (Astralium) tecta (Lightfoot)

Pilidae

plicata, Helix=Pila urceus (Müller)

Vermetidae

tortuosa, Serpula=Vermicularia tortuosa (Lightfoot)

Capulidaee

calyptra, Patella=Capulus sp.

Xenophoridae

onustus, Trochus=Xenophora conchyliophora (Born)

Strombidae

persicus, Strombus fusus=Tibia insulaechorab (Röding)
tricornis, Strombus=Strombus tricornis [Lightfoot]
truncatus, Strombus=Lambis truncata (Lightfoot)

Cypraeidae

nebulosa, Cypraea=Cypraea mauritiana Linnaeus
pantherina, Cypraea=Cypraea pantherina [Lightfoot]
pustulata, Cypraea=Jenneria pustulata (Lightfoot)
seriata, Cypraea=Cypraea tigris Linnaeus

Cymatiidae

muricatum, Buccinum=Colubraria muricata (Lightfoot)
maculosa (Gmelin)
pustulosum, Buccinum=Argobuccinum pustulosum (Lightfoot)
argus (Gmelin)

Muricidae-Muricinae

elongatus, Murex=Pterynotus (Marchia) elongatus (Lightfoot)
clavus (Kiener)
pecten, Murex tribulus=Murex pecten [Lightfoot]
triremis Perry
tenuispina Lamarck

Muricidae-Thaisinae

monodon, Buccinum=Acanthina monodon (Pallas)

Muricidae-Trophoninae

fimbriatus, Murex=Trophon geversianus (Pallas)
plicatus, Murex=Trophon plicatus (Lightfoot)
laciniatus (Martyn)

Melongenidae

calcaratum, Buccinum=Melongena (Volema) hippocastanum (Linnaeus)

Fasciolariidae

iris, Buccinum=Latirus iris (Lightfoot)

Olividaee

incrassata, Voluta=Oliva incrassata (Lightfoot)

Mitridae

filosa, Voluta=Mitra (Cancilla) filaris (Linnaeus)
incompta, Voluta=Mitra terebralis Lamarck

Turbinellidae

angulata, Voluta=Turbinella angulata (Lightfoot)
gravis, Voluta=Turbinella pyrum (Linnaeus)
ponderosa, Voluta=Turbinella ponderosa (Lightfoot)
rapa Lamarck

Vasidae

muricata, Voluta=Vasum muricatum (Born)

Harpidae

testudo, Buccinum=Harpa sp.

Volutidae-Volutinae

virescens, Voluta=Voluta virescens [Lightfoot]

Volutidae-Cymbiinae

amphora, Voluta=Melo amphora (Lightfoot)
cithara, Voluta=Melo amphora (Lightfoot)
haustrum, Voluta=Melo amphora (Lightfoot)
imperialis, Voluta=Aulica imperialis (Lightfoot)
melo, Voluta=Melo melo (Lightfoot)
nobilis, Voluta=Volutocorona nobilis (Lightfoot)
scapha (Gmelin)
pepo, Voluta=Cymbium pepo (Lightfoot)
scafa, Voluta=Cymbium cymbium (Linnaeus)

Volutidae-Zidoninae

arausiaca, Voluta=Harpulina arausiaca (Lightfoot)
ancilla, Voluta=Adelomelon ancilla (Lightfoot)

226-756—67——4

Conidae

araneosus, Conus=Conus araneosus [Lightfoot]
architalassus, Conus=Conus ammiralis Linnaeus
augur, Conus=Conus augur [Lightfoot]
fuscatus, Conus=Conus imperialis Linnaeus
leoninus, Conus=Conus striatus Linnaeus
mappa, Conus=Conus ammiralis Linnaeus
nocturnus, Conus=Conus nocturnus [Lightfoot]
pulcher, Conus=Conus pulcher [Lightfoot]
papilionaceus Hwass
quercinus, Conus=Conus quercinus [Lightfoot]
undulatus, Conus=Conus textile Linnaeus

Terebridae

taurinum, Buccinum=Terebra taurinum (Lightfoot)

Aplysiidae

auricularia, Patella=Dolabella auricularia (Lightfoot)
callosa Lamarck

Umbraculidae

umbraculum, Patella=Umbraculum umbraculum (Lightfoot)
sinicum (Gmelin)

Hydatinidae

vesicaria, Bulla=Hydatina vesicaria (Lightfoot)
zonata, Bulla=Hydatina zonata (Lightfoot)
velum (Gmelin)

Bulimulidae

elongata, Voluta=Placostylus elongatus (Lightfoot)
fibratus (Martyn)

Strophocheilidae

erubescens, Helix=Strophocheilus pudicus (Müller)
ovipara, Helix=Strophocheilus oblongus (Müller)

Sagdidae

alveolatus, Trochus=Sagda epistylium (Müller)

Camaenidae

insignita, Helix=Caracolus sp.
otis, Helix=Lampadion otis (Lightfoot)
undata, Helix=Solaropsis undata (Lightfoot)

Helminthoglyptidae-Cepolinae

vitellus, Helix=Polymita picta (Born)

Helicidae

alba, Helix=nomen dubium

MOLLUSCA-BIVALVIA

Arcidae

fusca, Arca=Arca sp.
nodulosa, Arca=Anadara granosa (Linnaeus)

Cucullaeidae

labiata, Arca=Cucullaea labiata (Lightfoot)

Mytilidae

castaneus, Mytilus=Modiolus vagina Lamarck
pictus, Mytilus=Perna picta (Born)

Pinnidae

rigida, Pinna=Atrina rigida (Lightfoot)

Isognomonidae

Isognoma=Isognomon [Lightfoot]
Isognomon [Lightfoot]
rigida, Isognoma=Isognomon sp.

Anomiidae

Placuna [Lightfoot]

Ostreidae

purpurata, Ostrea=Ostrea cucullata (Born)

Unionidae

complanata, Mya=Elliptio complanatus (Lightfoot)
ovalis, Mya=Unio ovalis (Lightfoot)
crassa cytherea Küster

Chamidae

pannosus, Chama lazarus=Chama lazarus Linnaeus

Cardiidae

hystrix, Cardium=Trachycardium aculeatum (Linnaeus)
impressum, Cardium=Corculum impressum (Lightfoot)
humanum Röding
protrusum, Cardium=Corculum impressum (Lightfoot)
robustum, Cardium=Dinocardium robustum (Lightfoot)
spinosum, Cardium=Acanthocardia echinatum (Linnaeus)

Solenidae

pallidus, Solen=Solen sp.

Tellinidae

marginalis, Tellina=Tellina laevigata Linnaeus

Garidae

cruenta, Tellina=Sanguinolaria cruenta (Lightfoot)
operculata (Gmelin)
rostratus, Solen=Hiatula diphos (Linnaeus)
Soletellina diphos (L.)

Solecurtidae

antiquatus, Solen=Solecurtus (Azorinus) chamasolen (Da Costa)
plebeius, Solen=Tagelus plebeius (Lightfoot)

Veneridae

nimbosa, Venus=Macrocallista nimbosa (Lightfoot)
punctata, Venus=Meretrix meretrix (Linnaeus)

Myidae

gigas, Mya=Panope glycymeris (Born)

Hiatellidae

arctica, Venus=Hiatella arctica (Linnaeus)

Teredinidae

gigantea, Serpula=Kuphus polythalamia (Linnaeus)

Clavagellidae

attrahens, Serpula=Penicillus (Warnea) attrahens (Lightfoot)
vaginiferum Lamarck

MOLLUSCA-CEPHALOPODA

Argonautidae

hians, Argonauta=Argonauta hians [Lightfoot]
navicula, Argonauta=Argonauta sp.
nodosa, Argonauta=Argonauta nodosa [Lightfoot]

Nautilidae

scrobiculatus, Nautilus=Nautilus scrobiculatus [Lightfoot]

COELENTERATA-ANTHOZOA

Fungiidae

agnus, Madrepora=Polyphyllia talpina (Lamarck)

BRACHIOPODA-INARTICULATA

Lingulidae

lingua, Mytilus=Lingula lingua (Lightfoot)
anatina Lamarck

ECHINODERMATA-ECHINOIDEA

Brissidae

maximus, Echinus=Plagiobrissus grandis (Gmelin)

Echinometridae

anemonoides, Echinus=Podophora atrata (Linnaeus)

ARTHROPODA-CRUSTACEA-CIRRIPEDIA

Lepadidae

cornucopiae, Lepas=Mitella cornucopiae (Lightfoot)
pollicipes (Gmelin)
vittata, Lepas=Conchoderma virgata (Spengler)

Balanidae

ponderosus, Balanus=Tetraclita squamosa stalactifera (Lamarck)
pyramidalis, Balanus=Balanus tintinnabulum (Linnaeus)
tulipa, Balanus=Balanus tulipiformis (Darwin)

Literature Cited

Abbott, R. Tucker

1950. The genera *Xancus* and *Vasum* in the Western Atlantic. Johnsonia, vol. 2, no. 28, pp. 201–220, pl. 89–95.

1954. American sea shells. New York, xiv+541 pp., 40 pl., 100 figs.

1958. The marine mollusks of Grand Cayman Island, British West Indies. Acad. Nat. Sci. Philadelphia, monogr. 11, 138 pp., 5 pls.

1960. The genus Strombus in the Indo-Pacific. Indo-Pacific Mollusca, vol. 1, no. 2, pp. 33–146, pls. 11–117.

1961. How to know the American marine shells. Signet Key Books, New York, 222 pp., 12 pls., 402 figs.

1962. Sea shells of the world: A guide to the better-known species. Golden Nature Guide, New York, 160 pp., 790 figs.

Adams, Henry, and Adams, Arthur

1853–58. The genera of Recent Mollusca. London, 3 vols. (vol. 1: xl+484 pp.; vol. 2: 661 pp.; vol. 3: 138 pls.).

Allan, Joyce

1959. Australian shells, rev. ed. Melbourne, xx+487 pp., 44 pls. (part col.), 112 figs.

Beck, H.

1837. Index molluscorum praes. aevi Mus. Princ. aug. Christiani Frederici, fasc. 1. Copenhagen, 124 pp.

Blainville, H. M. D. de

1819. Dolabelle, Dolabella. (Malacoz.). Dict. Sci. Nat., vol. 13, pp. 394–396.

Born, Ignatius

1778. Index rerum naturalium musei caesarei vindobonensis, pars. 1: Testacea. Vienna, [38]+458+[82] pp., 1 pl.

1780. Testacea musei caesarei vindobonensis. Vienna, xxxvi+442+[17] pp., 18 pls.

Brown, Thomas

1827. Illustrations of the conchology of Great Britain and Ireland. London, [2]+v pp., 52 pls.

Bruguière, J. G.

1789–92. Encyclopedie methodique: Histoire naturelle des vers. Paris, vol. 1, xviii+757 pp.

Chenu, J. C.

1843–53. Illustrations conchyliogiques. Paris, 4 vols.

Clark, H. L.

1917. Hawaiian and other Pacific Echini. Mem. Mus. Comp. Zool. Harvard Coll., vol. 46, no. 2, pp. 85–283, pls. 144–161.

Clarke, Arthur H., and Berg, C. O.

1959. The freshwater mussels of central New York, with an illustrated key to the species of northeastern North America. Cornell Univ. Agric. Exp. Sta. Mem. 367, 79 pp., 7 pls., 1 map.

Clench, William J.

1942. The genera Dosinia, Macrocallista and Amiantis in the Western Atlantic. Johnsonia, vol. 1, no. 3, 8 pp., 6 pls.

Clench, William J., and Turner, Ruth D.
1964. The subfamilies Volutinae, Zidoninae, Odontocymbiolinae and Calliotectinae in the Western Atlantic. Johnsonia, vol. 4, no. 43, pp. 129–180, pls. 80–114.

Cotton, Bernard
1959. South Australian Mollusca: Archaeogastropoda. Handbook of flora and fauna of South Australia. Adelaide, 449 pp., 1 pl., 215 figs.

[Da Costa, Emanuel M.]
1770–72. Conchology: or Natural history of shells . . . . London, 26 pp., 12 col. pls.

Dall, William H.
1920. Annotated list of the recent Brachipoda in the collection of the United States National Museum, with descriptions of thirty-three new forms. Proc. U.S. Nat. Mus., vol. 57, no. 2314, pp. 261–377.
1921. Species named in the Portland Catalogue. Nautilus, vol. 34, pp. 97–100, 124–132.

Dance, S.P.
1962. The authorship of the Portland Catalogue (1786). Journ. Soc. Bibl. Nat. Hist., vol. 4, no. 1, pp. 30–34.

Darwin, Charles
1851. A monograph on the sub-class Cirripedia with figures of all the species: The Lepadidae, or pedunculated cirripedes. London, xii+400 pp., 10 pls.

Dillwyn, L. W.
1817. A descriptive catalogue of recent shells. London, 2 vols., xii+1092 pp., index.
1823. An index to the Historia Conchyliorum of Lister. Oxford, 48 pp.

Dodge, Henry
1952. An historical review of the mollusks of Linnaeus, part I: The classes Loricata and Pelecypoda. Bull. Amer. Mus. Nat. Hist., vol. 100, art. 1, 263 pp.

Donovan, E.
1799–1804. The natural history of British Shells. London, 5 vols., 180 pls.

Ellis, John
1758. An account of several rare species of barnacles. Phil. Trans., vol. 50, pt. 2, pp. 845–855, pl. 34.

Favanne de Montcervelle, Jacque de and Guillaume de
1780. La Conchyliologie, ou histoire naturelle des coquilles . . . , ed. 3. Paris, 2 vols.+atlas (vol. 1: ix+878 pp.; vol. 2: 848 pp.; atlas: 80 pls.).

[Favanne de Montcervelle, Guillaume de]
1784. Catalogue systematique et raisonné, ou description du magnifique cabinet . . . . Paris, xii+558 pp., 9 pls.

Fischer von Waldheim, G.
1807. Museum Demidoff, vol. III. Moscow, ix+330 pp., 6 pls.

Franc, André
1957. Mollusques terrestres et fluviatiles de l'Archipel Neo-Caledonien. Mem. Mus. Nation. Hist. Nat. (Paris), ser. A, vol. 13, 200 pp., 24 pls.

Gmelin, J. F.
1791. Systema naturae, ed. 13. Leipzig, vol. 1, pt. 6, pp. 3021–3909.

Gray, John E.

1825. A list and descriptions of some species of shells not taken notice of by Lamarck. Ann. Phil., vol. 25, pp. 135–140, 407–415.

1847. A list of the genera of Recent Mollusca, their synonyma and types. Proc. Zool. Soc. London, pt. 15, pp. 129–219.

Gruvel, A.

1902. Revision des cirrhipèdes appartenant à la collection du Muséum d'Histoire Naturelle. Nouv. Arch. Mus. Hist. Nat. (Paris), ser. 4, vol. 4, pp. 215–312, pls. 11–14.

Haas, Fritz

1940. A tentative classification of the Palearctic Unionids. Zool. Ser. Field Mus. Nat. Hist., vol. 24, no. 11, pp. 115–141.

Habe, Tadashige

1950. Hydatinidae, Bullidae and Akeridae in Japan. Illustr. Cat. Japanese Shells, vol. 1, no. 3, pp. 17–24, 3 pls., 3 figs.

Hemming, Francis

1957. Opinion 479: Validation under the plenary power of specific names for nine species of the Class Gastropoda occurring in the New Zealand area as published by Martyn (T.) in 1784 in the work entitled *The Universal Conchologist.* Opinions Declar. Int. Comm. Zool. Nomencl., vol. 16, pt. 22, pp. 365–416.

Holten, Hans S.

1802. Enumeratio systematica conchyliorum beat. J. H. Chemnitz. Copenhagen, [iv]+88 pp.

Horst, C. J. van der

1921. The Madreporaria of the Siboga Expedition, pt. 2: Madreporaria Fungida. *In* Weber, *Siboga* Expeditie, Mon. XVI^{b}, 46 pp., 6 pls.

Hwass, Christen H.

1792. Cone, *vulgairement cornet;—Conus*; Linn. [sic]. *In* Bruguière, Encyclopedie methodique: histoire naturelle des vers, vol. 1, pp. 586–757.

Iredale, Tom.

1916. Solander as a conchologist. Proc. Malac. Soc. London, vol. 12, pts. 2 and 3, pp. 85–93.

1940. Marine mollusks from Lord Howe Island, Norfolk Island, Australia and New Caledonia. Australian Zool., vol. 9, pp. 429–443, pls. 32–34.

Kaicher, Sally D.

1956–57. Indo-Pacific Sea Shells. Washington, D.C. and Clearwater, Fla., 7 pts., 113 pp., incl. 54 pls.

Kay, E. Alison

1965. The Reverend John Lightfoot, Daniel Solander and the Portland Catalogue. Nautilus, vol. 79, no. 1, pp. 10–19.

Keen, A. Myra

1958. Sea shells of tropical West America. Stanford, xi+626 pp., 10 col. pls., 1709 figs.

Kiener, L. C.

1841. Spécies générale et iconographie des Coquilles vivantes . . . , pt 3: Genre Rocher (Murex Lin.). Paris, 130 pp., 47 pls.

Kira, Tetsuaki

1959. Coloured illustrations of the shells of Japan, rev. ed. Osaka, [5]+vii+[2]+239 pp., 72 col. pls.

KOHN, ALAN

1963. Type specimens and identity of the described species of *Conus*, 2: The species described by Solander, Chemnitz, Born, and Lightfoot between 1766 and 1786. Journ. Linn. Soc. (Zool.), vol. 45, pp. 151–167, 2 pls.

LAMARCK, J. B. P. A. DE M. DE

1792. Journal d'Histoire Naturelle (Choix de Mémoires . . .). Paris, 2 vols.

1801. Systéme des animaux sans vertèbres. Paris, viii+432 pp.

1810–11. Suite de la détermination des espèces de mollusques testacès: continuation du genre Porcelaine et des genres Ovule, Tarriére, Ancillaire, et Olive. Ann. Mus. Hist. Nat. (Paris), vol. 16, pp. 89–114, 300–328.

1816. Liste des objets représentés dans les planches de cette livraison. *In* Tableau Encyclopedique et Methodique des Trois Regnès de la Nature, pt. 23 (Mollusques et Polypes divers). Paris, 16 pp.

1816a–1822a. Histoire naturelle des animaux sans Vertèbres, vol. 2, 568 pp.; 1816b, vol. 3, 586 pp.; 1818, vol. 5, 612 pp.; 1819–22, vol. 6, vi+343+232 pp.; 1822a, vol. 7, 711 pp.

LAMY, EDOUARD

1907. Révision des *Arca* vivants du Muséum d'Histoire Naturelle de Paris. Journ. de Conch., vol. 55, pp. 1–111, 199–307, pls. 1, 3.

1936–37. Révision des *Mytilidae* vivants du Muséum National d'Histoire Naturelle de Paris. Journ. de Conch., vol. 80, pp. 66–102, 107–198, 229–295, 307–363.

LEACH, WILLIAM ELFORD

1824. Cirripedes. *In* Supplement to Fourth, Fifth, and Sixth Edition, Encyclopedia Brittanica, vol. 3, pt. 1, pp. 168–171.

[LIGHTFOOT, JOHN]

1786. A catalogue of the Portland Museum, lately the property of the Duchess Dowager of Portland, deceased, which will be sold at auction, by Mr. Skinner and Co. . . . . London, viii+194 pp.

LISTER, MARTIN

1770. Histoire sive synopsis methodicae conchyliorum et tabularum anatomicarum, ed. altera. Oxford, iv+12+77+6 pp., 1059+22 pls.

MARTYN, THOMAS

1784. The universal conchologist . . . . London, 2 vols., 27 pp., 80 pls.

MONTAGU, GEORGE

1808. Supplement to Testacea Brittanica, with additional plates. London, v+184 pp., 30 pls.

MORTENSEN, TH.

1951. A monograph of the Echinoidea, vol. 5: Spatangoida, 2. Copenhagen, 6+593 pp., 64 pls., 286 figs.

PALLAS, P. S.

1767–80. Spicilegia zoologica . . . . Berlin, 2 vols.

PENNANT, THOMAS

1776–77. British zoology, ed. 4. Warrington and London, 4 vols.

PERRY, GEORGE

1810–11. Arcana or Museum of Natural History. London, 84 pls.

1811. Conchology or the natural history of shells . . . . London, 4 pp., 61 pls.

PILSBRY, HENRY A.
1889. Manual of conchology, ser. 2, vol. 5 (Helicidae, vol. 3). Philadelphia 216 pp., 64 pls.
1907. The barnacles (Cirripedia) contained in the collections of the U.S. National Museum. U.S. Nat. Mus. Bull. 60, x+122 pp., 11 pls.
1910. Land Mollusca of the Panama Canal Zone. Proc. Acad. Nat. Sci. Philadelphia, vol. 62, pp. 502–509, pl. 37, 6 figs.
1916. The Sessile barnacles (Cirripedia) contained in the collections of the U.S. National Museum, including a monograph of the American species. U.S. Nat. Mus. Bull. 93, xi+366 pp., 76 pls.

POWELL, A. W. B.
1957. Shells of New Zealand, ed. 3. Auckland, 202 pp., 36 pls., illustr.

PULTENEY, RICHARD
1799 Catalogues of the birds, shells and some of the more rare plants, of Dorsetshire. *In* Hutchins, the history and antiquities of the County of Dorset. London, 92 pp.

REEVE, LOVELL
1842. Conchologia systematica, or Complete system of conchology, vol. 2. London, 337 pp., pls. 130–300.

REHDER, HARALD A.
1967. A new genus and two new species in the families Volutidae and Turbinellidae (Mollusca: Gastropoda) from the western Pacific. Pacific Sci., vol. 20 [in press].

RÖDING, P. F.
1798. Museum Boltenianum. Hamburg, viii+199 pp.

SCHILDER, F. A., and SCHILDER, M.
1938–39. Prodrome of a monograph on living Cypraeidae. Proc. Malac. Soc. London, vol. 23, pts 3, 4, pp. 119–231, 9 maps.

SCHUMACHER, CHRISTIAN F.
1817. Essai d'un nouveau système des habitations des vers testacés. Copenhagen, [2]+287 pp., 22 pls.

SHAW, GEORGE, and NODDER, F. P.
1789–1813. Naturalist's miscellany . . . . London, 24 vols.

SHIKAMA, TOKIO
1963–64. Selected shells of the world, illustrated in colours. Tokyo, 2 vols. (vol. 1: 154 pp., 102 col. pls., 192 figs.; vol. 2: 212 pp., 70 pls., 245 figs.).

SOLEM, ALAN
1961. New Caledonian land and freshwater snails: An annotated check list. Fieldiana: Zoology, vol. 41, no. 3, pp. 415–501.

SPENGLER, LORENZ
1794. Nøiere Bestemmelse og Udvidelse af det Linneiske *Genus* Solen. Skr. Naturhist.-Selsk., vol. 3, pt. 2, pp. 81–114.

STOLICZKA, FERDINAND
1870–71. Cretaceous fauna of Southern India, vol. III: The Pelecypoda. Mem. Geol. Surv. India. (Paleontologia Indica), xxii+537 pp., 50 pls.

THIEL, M. E.
1932. Madreporaria. Rés. Sci. Voyage Indes Orientales Néerlandaises, vol. 2, fasc. 12, 177 pp., 21 pls.

THIELE, JOHANNES
1929–35. Handbuch der systematischen Weichtierkunde. Jena, 2 vols, 1154 pp., 897 figs.

TOMLIN, J. R. LEB.
1937. Catalogue of recent and fossil cones. Proc. Malac. Soc. London, vol. 22, pts. 4, 5, pp. 205–330.
TRYON, GEORGE W.
1879,1881. Manual of conchology, vol. 1 (Cephalopoda), 316 pp., 112 pls.; 1881, vol. 3, 310 pp., 87 pls.
1882–84. Structural and systematic conchology. Philadelphia, 3 vols. (vol. 1: viii+312 pp., 22 pls.; vol. 2: 430 pp., pls. 23–91; vol. 3: 453 pp., pls. 92–140).
1885–86. Manual of conchology, vol. 8, 461 pp., 79 pls.
TURNER, RUTH D., and ROSEWATER, JOSEPH
1958. The family Pinnidae in the Western Atlantic. Johnsonia, vol. 3, no. 38, pp. 285–326, pls. 149–171.
UCHINOMI, FUJIO [UTINOMI, HUZIO]
1956. Coloured illustrations of sea shore animals of Japan. Osaka, xvii+[1]+167 pp., 76 pls.
WEAVER, CLIFTON S.
1964. 2nd provisional species list of living Volutidae. Honolulu, 11 pp. [Privately printed.]
WINCKWORTH, R.
1935. Notes on nomenclature, 8: Modeer's genera of Mollusca. Proc. Malac. Soc. London, vol. 21, pt. 5, pp. 321–323.
1945. The types of the Boltenian genera. Proc. Malac. Soc. London, vol. 26, pts. 4, 5, pp. 136–148.
WOOD, WILLIAM
1815. General conchology: Or a description of shells, arranged according to the Linnean system. London, lxi+2+6 pp., 59 pls.
1818. Index Testaceologicus: Or a catalogue of shells, British and foreign. . . . London, viii+188+[2] pp., 8 pls.
WURTZ, CHARLES R.
1955. Labyrinthus Beck vs. Lampadion Röding. Nautilus, vol. 68, no. 3, pp. 106–107.

Index

Acanthina monodon, 8, 24
Acanthocardia echinatum, 20
Adelomelon ancilla, 15, 24
Anadara granosa, 18
Aranea gracilis, 34
  triremis, 34
Arca concamera, 32
  concamerata, 32
  cucullus, 32
  fusca, 10
  imbricata, 11
  labiata, 32
  nodulosa, 18
  tetragona, 11
Argobuccinum pustulosum, 16
Argonauta gondola, 11
  hians, 12, 29
  navicula, 11
  nodosa, 17, 28
  tuberculata, 17
  tuberculosa, 17
Aspergillum vaginiferum, 21
Astraea imperialis, 15
  tecta, 33
Atrina rigida, 24
Aulica imperialis, 31
  nobilis, 6, 28, 32

Balanus ponderosus, 16
  pyramidalis, 12
  stalactiferus, 16
  tintinnabulum, 12
  tulipa, 31
  tulipiformis, 31
Buccinum calcaratum, 22
  iris, 7, 13, 25
  laciniatum, 20
  monoceros, 8
  monodon, 8, 24
  muricatum, 20
  prismaticum, 7
  pustulosum, 16
  taurinum, 25
  testudo, 17
Bulimus bovinus, 9
Bulla amplustre, 27
  fasciata, 27
  physis, 23
  velum, 27
  vesicaria, 23
  zonata, 27, 29

Calcar, 8
Calliostoma annulatum, 19
  canaliculatum, 19
  punctulatum, 26
Caracolus marginella, 29
Cardium erinaceum, 20
  hystrix, 22
  impressum, 26
  junoniae, 26
  magnum, 12
Cardium protrusum, 30
  robustum, 12
  roseum, 26
  spinosum, 20
  ventricosum, 12
Cassis inflata, 18
Chama lazarus, 17
  lazarus pannosus, 17
Cineras vittata, 16
Colubraria muricata, 20
  obscura, 20
Conchoderma virgata, 16
Conus ammiralis, 22, 34
  ammiralis coronatus, 34
  arachnoideus, 15
  araneosus, 15, 21
  architalassus, 34
  archithalassus, 34
  augur, 11
  fuscatus, 27
  imperialis, 27
  leoninus, 14, 30
  mappa, 22
  nocturnus, 26
  papilionaceus, 30
  pulcher, 30
  quercinus, 13
  striatus, 14
  textile, 31
  undulatus, 31

Cookia sulcata, 21
Corculum humanum, 26
  impressum, 26, 30
Cucullaea auriculifera, 32
  labiata, 32
Cymbium amphora, 9, 17, 24, 31, 35
  cymbium, 10, 23
  flammeum, 9
  maculatum, 10
  melo, 10, 13
  pepo, 16
Cypraea mauritiana, 22
  nebulosa, 22
  pantherina, 12
  pustulata, 21
  seriata, 22
  tigris, 22
  vinosa, 12

Dinocardium robustum, 12
Dolabella auricularia, 25, 33
  callosa, 25
  rumphii, 25
Dolichoschisma munita, 14

Echinus anemonoides, 7
  grandis, 34
  maximus, 34
Elliptio complanatus, 13, 18
Ellobium australe, 9
Epitonium feldmanni, 25

Fungia talpa, 33
  talpina, 33

Harpa articularis, 18
  ligata, 18
  major, 18
  testudo, 18
  ventricosa, 18
Harpulina arausiaca, 8, 32
Helix alba, 32
  erubescens, 33
  insignita, 29
  labyrinthus, 9
  otis, 9
  ovipara, 15, 25, 27, 28
  pellisserpentis, 29
  plicata, 8
  undata, 29, 32
  vitellus, 8
Hiatella arctica, 24
Hiatula diphos, 27, 28
Hydatina inflata, 28
  vesicaria, 23
  zonata, 27, 29

Isognoma, 6
  lignea, 6
  perna, 24
  rigida, 21
Isognomon, 6, 10, 12, 24
  perna, 10, 12

Jenneria pustulata, 21

Kuphus polythalamia, 6, 32

Labyrinthus, 9
Lambis davilae, 22
  lobata, 34
  truncata, 22, 25, 28
Lampadion, 9
  labyrinthus, 9
  otis, 9
Latirus iris, 7, 13, 25
  prismaticus, 7
Lepas cornucopiae, 18
  pollicipes, 18
  virgata, 16
  vittata, 16
Limax fibratus, 9
  undulatus, 8
Lingula anatina, 15
  lingua, 15
  unguis, 15

Macrocallista nimbosa, 29
Macroschisma, 14
Madrepora agnus, 33
Melo diadema, 9
  melo, 10
Melongena hippocastanum, 22
Meretrix meretrix, 18
Mitella cornucopiae, 18
  pollicipes, 18
Mitra filaris, 14
  terebralis, 17
Modelia granosa, 16, 26
Modiola castanea, 13
  vagina, 13
Modiolus vagina, 13
Murex argus, 13
  calcaratus, 22
  clavus, 13
  elongatus, 13
  fimbriatus, 20, 21

Murex histrix, 33
lamellosus, 20
maculosus, 20
pecten, 33
plicatus, 19, 20
prismaticus, 7
tenuispina, 34
ternispina, 34
tribulus pecten, 33
triremis, 34
Mya batava, 23
complanata, 18
gigas, 9, 18
ovalis, 22, 23
truncata, 27
Mytilus afer, 26
castaneus, 13
edulis, 26
lingua, 15
perna, 26
pictus, 26
ungulatus, 26

Nacella mytilina, 10, 13
Nautilus scrobiculatus, 31
umbilicatus, 31

Oliva angulata, 7
incrassata, 7, 20, 28
Ostrea cucullata, 24, 28, 29
purpurea, 24, 28, 29

Panope glycymeris, 9, 18
Patella auricularia, 25, 33
barbara, 12, 20
calyptra, 14
fungoides, 12
gorgonica, 20
macroschisma, 14
miniata, 20, 23, 31
mytiliformis, 10, 13
mytilina, 10
oculus, 20, 24
oculushirci, 20, 24
pulchra, 20, 23, 31
sinica, 30
umbellata, 30
umbraculum, 30
unguis, 15
Penicillus attrahens, 21
Perna picta, 26
Pharetra monoculoides, 15
Phorus onustus, 6
Pila urceus, 8
Pinna rigida, 24
Placenta, 7
Placostylus elongatus, 9, 25
Placuna, 7, 12, 23, 24, 28, 30
ephippium, 7, 12, 23, 28, 30
placenta, 7, 12, 14
Plagiobrissus grandis, 34
Plejona muta, 8
Pleurodonte otis, 9
Podophora atrata, 7
Pollicipes cornucopia, 18
Polymita picta, 8
Polyphyllia talpina, 33
Pterynotus elongatus, 13
Pyrula galeodes, 22
hippocastanum, 22

Rostellaria curvirostris, 5

Sagda epistylium, 12
Sanguinolaria, 27
bertini, 7
cruenta, 7, 13
operculata, 7
Scapula, 25
Septaria arenaria, 6
Serpula attrahens, 21
gigantea, 6, 32
tortuosa, 32
Solaropsis brasiliana, 30
constrictor, 30
gibboni, 29
undata, 29, 32
Solecurtus chamasolen, 19
Solen antiquatus, 19
cultellus, 19
diphos, 27
gibbus, 11
pallidus, 11
plebeius, 11
rostratus, 27, 28
truncatus, 11
Soletellina, 27
Spatangus pectoralis, 34
Strombus bryonia, 22
fusus persicus, 5
laciniatus, 34
sinuatus, 34
tricornis, 6
truncatus, 22, 25, 28

Strophocheilus oblongus, 15, 28
ovatus, 25, 27
pudicus, 33
Subninella undulata, 8, 30

Tagelus plebeius, 11
Tellina cruenta, 7, 13
cruentae, 7
laevigata, 24
marginalis, 24
operculata, 7
sanguinolenta, 7
semiplanata, 7
Terebra flammea, 25
taurinum, 25
Tetraclita squamosa stalactifera, 16
Tibia insulachorab, 5
Trachycardium aculeatum, 22
Trochus alveolatus, 12
annulatus, 19
canaliculatus, 19
cookii, 21
diaphanus, 26
doliarius, 19
granosus, 16, 26
imbricatus, 33
onustus, 6, 30
punctulatus, 26
solaris, 15
sulcatus, 21
tectum, 33
tectus, 33
virgineus, 18
Trophon geversianus, 21
laciniatus, 20
plicatus, 20
Turbinella, 15
angulata, 14
ponderosa, 8, 35
pyrum, 19
rapa, 8, 19
Turbo cornutus, 25
granosus, 16
rubicundus, 16
sulcatus, 21
undulatus, 8, 30

Umbraculum umbraculum, 30
Unio cytherea, 23
ovalis crassus, 22
ovalis ovalis, 22
Unio—Continued
violaceus, 18

Vasum muricatum, 25
Venus arctica, 24
gigantea, 29
nimbosa, 29
punctata, 18
Vermetus costalis, 32
tortuosus, 32
Vermicularia tortuosa, 32
Volema nuxmoschata, 22
Voluta amphora, 9, 31
ancilla, 15, 24
angulata, 14
anguria, 10, 13
arausiaca, 8, 32
armata, 17
cithara, 17, 31, 35
cymbium, 10
elongata, 9, 25
filosa, 14
gravis, 19
haustrum, 24
imperialis, 31
incompta, 17
incrassa, 20
incrassata, 7, 28
indica, 10
melo, 10
muricata, 25
navicula, 16
neptuni, 16
nobilis, 6, 28, 32
pepo, 16
polyzonalis, 8
ponderosa, 8, 35
scafa, 6, 10, 23
scapha, 6
scolymus, 14
spectabilis, 15
tesselata, 17
vexillum, 8
virescens, 8, 23, 29
Volutocorona nobilis, 6

Xancus, 15
angulatus, 14
pyrum, 8
Xenophora conchyliophora, 6, 30

U.S. GOVERNMENT PRINTING OFFICE: 1967

Proceedings of the United States National Museum

SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 121 | 1967 | Number 3580

THE MYODOCOPID OSTRACOD FAMILIES PHILOMEDIDAE AND PSEUDOPHILOMEDIDAE (NEW FAMILY)

By Louis S. Kornicker
Associate Curator, Division of Crustacea

Introduction

The Pseudophilomedidae, new family, is represented in the oceans of the world by only one genus, *Pseudophilomedes* Müller, 1894, containing 4 species: 2 in the Mediterranean Sea (Müller, 1894), 1 in the eastern Atlantic (Brady and Norman, 1896), and 1 in the western Atlantic (Kornicker, 1959).

The writer recently received 17 specimens of *Pseudophilomedes ferulanus* Kornicker, 1959, as part of a collection of ostracods obtained by Dr. John H. Day from the Atlantic Shelf off Beaufort, N.C. Four additional specimens from the same area were in a collection made in 1964 by personnel on the U.S. Bureau of Commercial Fisheries R/V *Gosnold.* This material has been used to supplement 3 specimens collected from the Great Bahama Bank, upon which the original description was based (Kornicker, 1959).

I have taken this opportunity to review the genus. Specimens of *Pseudophilomedes foveolatus* Müller, 1894, the type species of *Pseudophilomedes*, were borrowed from the Zoological Museum, Berlin, and the original description by Müller (1894) is supplemented in this paper.

Specimens identified by Brady and Norman (1896) as males of

Pseudophilomedes foveolatus Müller (called *Philomedes foveolata* by Brady and Norman) were borrowed from the collection of the British Museum. It is concluded that they are not congeneric with *Pseudophilomedes* but instead are members of the genus *Euphilomedes* Poulsen, 1962. They are identified as *Euphilomedes asper* (Müller, 1894) and *Euphilomedes* sp. and are described and illustrated in this paper. A supplemental description is given of a syntype of *Euphilomedes asper* (Müller) borrowed from the Zoological Museum, Berlin.

As a result of this study, the subfamily *Philomedinae* Müller, 1912, has been raised to familial rank.

I wish to thank Dr. John H. Day of the Beaufort Marine Laboratory, Duke University, and personnel of the U.S. Bureau of Commercial Fisheries for specimens of *Pseudophilomedes ferulanus* from the Atlantic Shelf, and Dr. J. P. Harding for permission to study specimens in the collection of the British Museum (Natural History), identified as *Philomedes foveolatus* (Müller) by Brady and Norman (1896), and Dr. H. E. Gruner for permission to study syntypes of *Pseudophilomedes foveolatus* Müller and *Philomedes asper* Müller in the collection of the Zoological Museum, Berlin. I wish also to thank Miss Caroline Bartlett Gast for preparing plates for publication from my penciled camera lucida drawings and especially for the carefully stippled drawing of the ventral view of *P. ferulanus* (fig. 1). Criticisms of the manuscript by Mr. I. Gregory Sohn and Doctors Raymond B. Manning, Thomas E. Bowman, and Meredith L. Jones are greatly appreciated.

Discussion of Classification

Classification of myodocopid Ostracoda was reviewed by Skogsberg (1920) and more recently by Poulsen (1962). Of particular concern in the present paper are the taxonomic relationships of *Pseudophilomedes*. Therefore, discussion of classification will be restricted to the superfamily, Cypridinacea Baird, 1850. When Müller (1894) described *Pseudophilomedes*, he referred it to the family *Cypridinidae* Baird, 1850. Two years later, Brady and Norman (1896) described the genus *Paramekodon* (=*Pseudophilomedes*) referring it also to the *Cypridinidae*. Later, Müller (1912) established the subfamily Philomedinae in the Cypridinidae. He referred to the Philomedinae the genera *Philomedes* Liljeborg, 1853, *Pseudophilomedes*, and *Rutiderma* Brady and Norman 1896. Skogsberg (1920) recognized the Philomedinae for *Pseudophilomedes* and *Philomedes* but followed Brady and Norman (1896) in placing *Rutiderma* in the Rutidermatidae Brady and Norman, 1896. The Philomedinae *sensu* Skogsberg has been recognized by Sylvester-Bradley (1961), Poulsen (1962, 1965), and

Hartmann (1964). However, Poulsen (1962, p. 339) perceived that *Pseudophilomedes* might require a higher ranking in the classification:

> . . . according to the description the two genera [*Paramekodon* Brady and Norman, 1896, and *Pseudophilomedes* Müller, 1894] hold a rather unique position in the family Cypridinidae (and in the Rutidermatidae and Sarsiellidae) by having only two endites on the maxilla. Also in the reduced number of bristles on the basale and endopodite of the mandible and by the reduced 1st and 2nd endites and the end-joint of the 6th limb the two genera differ widely from all other Cypridinidae. If further investigations should confirm these differences these two genera may well have to be included in a family of their own.

After reviewing the genus *Pseudophilomedes* I find that I concur with Poulsen; therefore, I have established the new family Pseudophilomedidae. The genus *Pseudophilomedes* Müller, 1984, with its synonym *Paramekodon* Brady and Norman, 1896, is referred to the Pseudophilomedidae.

Müller (1912, p. 33) considered *Paramekodon* Brady and Norman, 1896, to be a synonym of *Pseudophilomedes* Müller, 1894. Skogsberg (1920, p. 348) agreed with Müller and stated: "In the identification of *Paramekodon* with *Pseudophilomedes* Müller certainly is correct." Sylvester-Bradley (1961, p. 399) also considered *Paramekodon* to be a synonym of *Pseudophilomedes*. Poulsen (1962, p. 339) was of the opposite opinion and stated: "If the description of *Paramecodon* [sic] is reliable, it is based on a single specimen conserved dry, the species differs in so many respects from *Pseudophilomedes* that the uniting of the two genera into one—as done by G. W. Müller is hardly admissible."

Differences between *Pseudophilomedes* and *Paramekodon* seem quite minor; therefore, I have followed Müller (1912), Skogsberg (1920), and Sylvester-Bradley (1961) in considering *Paramekodon* to be a synonym of *Pseudophilomedes*. Of possible significance in this regard is the following statement by Brady and Norman (1896, p. 623) in their publication in which the genus *Paramekodon* was established:

> It was not until our Monograph was nearly completed, and on the point of going to press, that there appeared the splendid work of Herr. G. W. Müller on the Ostracoda of the Gulf of Naples. This work has, in the case of some few species, anticipated our descriptions, and we have, as far as possible, rectified our nomenclature in conformity with it. For the rest we have thought it best to let our MS. go to press as it was originally written.

It was in the work mentioned in the above statement that Müller established the genus *Pseudophilomedes*. It is unfortunate that Brady and Norman did not have more time to study Müller's paper before publishing their monograph. The fact that they wrongly considered a species of *Philomedes* to be males of *Pseudophilomedes foveolatus* Müller, 1894, shows that they held a misconception of the morphology of *Pseudophilomedes*. The fact that they state (1896, p. 660) that in their opinion *Pseudophilomedes* is not sufficiently different from *Philomedes* to warrant the establishment of a new genus and, then, on page 670 establish the new genus *Paramekodon* for precisely the same reason Müller established *Pseudophilomedes* must be attributed to confusion resulting from the unexpected publication of Müller's work.

Brady and Norman (1896, p. 665) described a new species, *Streptoleberis favosa* Brady and Norman, 1896, collected at depths of 836 to 2333 meters off the west coast of Morocco. From 2 dried specimens they were able to examine only fragments of appendages. Concerning the 2nd antenna, Brady and Norman (loc. cit.) commented: "The antennae resemble most closely in character the same organs in *Paramekodon*, having no appendicular branch but two setae in its place, the basal joint somewhat smaller than usual, the length exceeding the breadth, first joint of the swimming branch rather slender." Fragments of the furca were illustrated by Brady and Norman (ibid, pl. 62, figs. 20, 21). The distribution of strong and slender claws on the lamella is similar to that of the genus *Pseudophilomedes* and also to some species in the genus *Euphilomedes* Poulsen, 1962. Claw no. 1 of the furca has a large tooth near the middle of the convex margin and bears short spines between the tooth and the tip of the claw. The claw is quite similar to claw no. 1 on species of *Pseudophilomedes*. *Streptoleberis favosa* is probably closely related to *Pseudophilomedes* and may belong in that genus. *Streptoleberis crenulata* (Brady, 1890), the type species of the genus, is known only from its shell and belongs in the category "genera dubia et species dubia" (Müller, 1912, p. 15; Poulsen, 1965, p. 44). *Streptoleberis rectirostris* Brady and Norman, 1896, the third species that has been referred to *Streptoleberis*, is also known only from the shell and Müller (1912, pl. 51) correctly considered it as a species dubia.

At the present state of our knowledge there seems little reason for considering the present subfamily Philomedinae to be more closely related to the Cypridininae than to other subfamilies comprising the Cypridinacea. Therefore, the subfamily Philomedinae is raised to familial rank. Some distinguishing characters between females of the Philomedidae and Pseudophilomedidae are as follows:

	Philomedidae	*Pseudophilomedidae*
Shell, no. of medial bristles behind rostrum	6+	4–5
1st ant. 2nd joint, no. of bristles	2–3	1
2nd ant. endop., no. of joints	1–2	1
2nd ant. endop., no. of bristles	6+	2–4
2nd ant. exop. 9th joint, no. of bristles	4–7	2–3
Mandible, basale, no. of medial plus ventral bristles	10+	4
Mandible, endop. 2nd joint, no. of dorsal bristles	8+	4

(Continued)	*Philomedidae*	*Pseudophilomedidae*
Maxilla, no. of endites	3	2
Maxilla, end joint with process (p) or only spines (s)	s	p
5th limb, no. of endites	3	1?
5th limb, 2nd joint with extremely long fanglike tooth (f) of with shorter tooth (s)	s	f
6th limb, no. of endites	4	3–4
6th limb, end joint, no. of bristles	9–45	7–9
7th limb, terminal with comb opposed by 2 pegs (p) or 2 opposing combs (c)	p	c

Skogsberg (1920), Poulsen (1962, 1965), and Hartmann (1964) are correct in considering the families Rutidermatidae Brady and Norman, 1896, Cylindroleberidae Müller, 1906 (= Asteropidae Brady, 1874), and Sarsiellidae Brady and Norman, 1896, to have coordinate rank. In view of the anatomy of the male *Rutiderma*, recognized for the first time by Poulsen (1965), referral of the genus *Rutiderma* to the Sarsiellidae as done by Sylvester-Bradley (1961) seems no longer tenable. Thus, the families contained in the superfamily Cypridinacea are: Cypridinidae Baird, 1850; Philomedidae Müller, 1912; Rutidermatidae Brady and Norman, 1896; Cylindroleberidae Müller, 1906; Sarsiellidae Brady and Norman, 1896; Pseudophilomedidae, new family.

Key to Families of Cypridinacea

1. Well-developed gills * along posterior of body, protopodite of maxilla elongate with row of ventral bristles . . . . Cylindroleberidae
   Without both well-developed gills and elongate protopodite on maxilla . . . 2
2. Mandible of female with large pincers distally . . . . . . Rutidermatidae
   Mandible without large pincers 3
3. Fifth limb of female with large teeth 4
   Fifth limb of female without large teeth . . . . Sarsiellidae
4. Maxilla with only 2 stout endites . . . . Pseudophilomedidae
   Maxilla with 3 endites 5
5. Lamellar prolongation of selvage with fringe of hair . . . . Philomedidae
   Lamellar prolongation of selvage without fringe of hair . . . . Cypridinidae

* Gills are common to all Cylindroleberidae but are rare in the Cypridinidae.

Pseudophilomedidae, new family

Philomedinae Müller, 1912, p. 24 (part).

Type genus.—*Pseudophilomedes* Müller, 1894.

Diagnosis (female; male unknown).—Shell: Oval in lateral view with rostrum and posterior process. Antennal sinus varies from shallow curvature to deep incisure. Punctate surface smooth or with longitudinal ridges or medial sulcus. Inner lamella with 4 or

5 bristles in row behind rostrum and 1–6 bristles dorsal to posterior process. Lamellar prolongation of selvage with fringe of hairs along anterior and neutral margins of shell.

First antenna: First joint without bristles; 2nd joint with 1 dorsal bristle; 3rd joint with 1 ventral and 1 dorsal bristle; 4th joint with 1 distodorsal and 2 distoventral bristles; 5th joint with 1 distoventral bristle having short terminal filaments; 6th joint reduced, with a short distomedial bristle; 7th joint reduced, with 1 short a-bristle with spines, 1 medium b-bristle, and 1 long c-bristle; 8th joint reduced, with 2 long bare d- and e-bristles and 2 long f- and g-bristles. Sensory bristle on 5th joint, b- and c-bristles of 5th joint, and f- and g-bristles of 8th joint with forked tips and few ringed filaments.

Second antenna: Endopodite single jointed with 1 long hirsute bristle and 1–3 short bare bristles. Exopodite with 9 joints: 2nd to 8th joints each with 1 long bristle; 9th joint with 2–3 bristles.

Mandible: Coxale endite bifurcate at tip. Basale with 4 ventral and 3 dorsal bristles. Exopodite elongate with 2 terminal bristles. Endopodite: 1st joint with 1–4 bristles; 2nd joint with 3–4 dorsal bristles, and 2–3 ventral bristles; end joint with 1 long claw, 2 shorter claws, and about 3 bristles.

Maxilla: Precoxale endite with 3 stout pectinate spines and 2–3 bristles; coxale endite with 2 stout pectinate spines and 2 bristles. Endopodite with slender to stout terminal process.

Fifth limb: Second joint prolonged distally forming long fanglike tooth followed along the inner margin by 3 teeth. Inner margin of protopodite with single endite with 1–2 bristles. Epipodial appendage with numerous bristles.

Sixth limb: End joint with 7–9 bristles; endites 3–4 in number, not more than 1 bristle in place of epipodial appendage.

Seventh limb: Terminus with opposing combs. Number of bristles in distal group 4–6, in lateral group 2–8; total number of bristles 6–14.

Frontal organ: Elongate with or without(?) rings proximally.

Eyes: Large medial eye and small lateral eyes.

Furca: Third claw more slender than 4th. Total number of claws 6–10; all well-developed claws separated from lamella by suture.

Distribution.—Atlantic Ocean off Morocco, on Great Bahama Bank, B.W.I., on Continental Shelf off North Carolina and Georgia, U.S.A., Gulf of Naples (Mediterranean Sea).

Ecology.—The family is benthonic. It has been reported from water with temperatures ranging from about 3° to 29° C., water depths of 6 to 1435 meters, and salinities from about 35 to 38 parts per thousand. Specimens have been collected from shelly sand, sandy mud, and calcareous algae. Some environmental factors concerning each species are presented in table 1.

TABLE 1.—*Environmental factors concerning each species*

Species	Depth meters	Temp. °C.	Salinity ‰	Location	Reference
P. inflatus (Brady and Norman, 1896)	1435	3*	normal marine*	Atlantic Ocean off Morocco	Brady and Norman, 1896
P. foveolatus Müller, 1894	100*	14–15*	36–38*	Gulf of Naples	Müller, 1894; Puri, 1963; Puri, Bonaduce, Malloy, 1964
P. angulatus Müller, 1894	100*	14–15*	36–38*	Gulf of Naples	Müller, 1894; Puri, 1963; Puri, Bonaduce, Malloy, 1964
P. ferulanus Kornicker 1959	6	29	37	Great Bahama Bank	Kornicker, 1959
	80–160	15–21. 4	normal marine	Atlantic shelf off North Carolina	present paper
	43–131		ca 35	Atlantic Shelf off Georgia	Darby, 1964

*Depth, temperature, and salinity are estimates based on general environment of sample locality.

TABLE 2.—*Locality and environmental data of Atlantic Shelf samples*

Sample Station Numbers	Latitude	Longitude	Date	Depth m	Type Bottom	Sediment Temperature °C*	Sampler Type	Number of Specimens
Gosnold Sta. 1857	34°18.7′N	76°00.1′W	June 26, 1964	85			Campbell grab	1
Gosnold Sta. 1817	34°00.0′N	77°14.4′W	June 23, 1964	28			Campbell grab	1
Gosnold Sta. 1877	36°30.9′N	74°46.0′W	June 27, 1964	96			Campbell grab	2
Beaufort Shelf Trans. 30	34°19.6′N	75°56.8′W	April 6, 1965	130	sandy mud	20	VanVeen grab	6
Beaufort Shelf Trans. 55	34°19.5′N	75°56.3′W	April 6, 1965	160	sandy mud	22	VanVeen grab	4
Beaufort Shelf Trans. 102	34°26′N	75°56.5′W	June 28, 1965	80	shelly sand	21. 4	dredge for 10 minutes	1
Beaufort Shelf Trans. 108	34°23.5′N	75°54′W	June 28, 1965	122	shelly sand	15. 0	dredge for 10 minutes	1
Beaufort Shelf Trans. 155	34°23.0′N	75°53.7′W	Sept. 30, 1965	160	sandy mud	19. 5	VanVeen grab	5

*Bottom temperature obtained by thrusting a thermometer into the substrate as soon as it was taken out of the VanVeen grab or dredge.

Pseudophilomedes

Pseudophilomedes G. W. Müller, 1894, p. 211.
Paramekedon Brady and Norman, 1896, p. 670.

Type species.—*Pseudophilomedes foveolatus* Muller, 1894.
Gender.—Masculine.
Diagnosis.—Same as for family.

Key to Species of *Pseudophilomedes*

(species in brackets not described in present paper)

1. Shell with longitudinal ridges . . . . [**P. angulatus** Müller, 1894]
   Shell without longitudinal ridges 2
2. Endopodite of 2nd antenna with 2 short bristles [**P. inflatus** (Brady and Norman, 1896)]
   Endopodite of 2nd antenna with more than 2 short bristles 3
3. Endopodite of 2nd antenna with 3 short bristles . . . . **P. foveolatus**
   Endopodite of 2nd antenna with 4 short bristles . . . . **P. ferulanus**

Pseudophilomedes ferulanus

Figures 1–6; Plate 1

Pseudophilomedes ferulana Kornicker, 1959, p. 235, figs. 46, 1A–B, 2A–B; 56, A–D.—Darby, 1965, pp. 64–70, fig. 10, pls. 11, 12.

Holotype.—USNM 113287; male; complete dry specimen. Specimens from Atlantic Shelf, 8 specimens: USNM 113020–113022.

Material.—The number of specimens, locations of sampling stations, and some environmental factors concerning specimens collected from the Atlantic Shelf are presented in table 2. All specimens sufficiently developed for determining sex were females. Five specimens were dissected for this study.

Supplemental description of female (male unknown).—Shell (fig. 3): Oval, highest anterior to center, widest posterior to center; posterior process slightly below middle of valve; rostrum subtriangular with nearly horizontal lower margin; antennal sinus shallow; surface punctate; each valve with arcuate sulcus extending from dorsal margin to near middle of valve; left valve overlaps right valve along anterodorsal and posterodorsal margins; hinge simple, extending from highest point on valve to posterodorsal corner; about 15 muscle scars in front of and below middle of each valve (fig. 3*c*), additional muscles are attached near anterodorsal corner of valve (fig. 3*h*). Inner lamella broadest behind rostrum and in front of posterior projection; radial pore canals numerous (fig. 3*f*); selvage with lamellar prolongation and fringing hairs (fig. 3*g*); inner lamella behind rostrum with row of 4 bristles with short marginal hairs (fig. 3*d*); inner lamella in front of posterior process with row of 6 hirsute setae (fig. 3*e*); inner lamella below antennal sinus with 1 short bristle; outer surface of each valve with scattered tapered hairs.

Darby (1965 p. 64) states concerning the shell, "About six nodes along the contact margin of both valves slightly dorsal to caudal process." These nodes each contain a hirsute setae, and the nodes are well-defined pores rather than raised structures (pl. 1*i*).

Darby (1965, p. 64) reports 4 or 5 bristles on the inner lamella behind rostrum, indicating variability in the number of bristles in that area; only 4 bristles were observed in the examined specimens.

Shell dimensions (in mm) are as follows (see table 2 for station data):

station	*specimen no.*	*greatest length*	*greatest height*	*greatest width*	*remarks*
BST 30	1	1. 66	1. 16	1. 00	eggs in brood pouch
"	2	1. 30	0. 81		late instar
"	3	1. 54	1. 00		eggs in body
"	4	1. 52	1. 00		eggs in body
"	5	1. 54	0. 96		no eggs
GOS 1857	1	1. 73	1. 15		eggs in brood pouch

First antenna (figs. 4*a–d*): First joint with spines along ventral margin; 2nd joint with dorsal bristle and marginal spines; 3rd joint with 1 ventral and 1 dorsal terminal bristle and marginal spines; 4th joint with 1 subterminal dorsal and 2 terminal ventral bristles; 5th joint with 1 long ventral, terminal sensory bristle with forked tip and 2 proximal, ringed filaments; 6th joint minute and fused to 5th, with 1 short spinous medial bristle; 7th joint reduced and fused to 8th joint, with 1 short spinous a-bristle, 1 medium b-bristle with forked tip and 1 distal filament, and 1 long stout c-bristle with forked tip and 2 proximal filaments; 8th joint reduced, with 2 long bare d- and e-bristles, 1 long f-bristle with forked tip and 3 distal and 1–2 proximal filaments, and 1 long g-bristle with forked tip and 1 distal and 2 proximal filaments; 1st to 4th joints with rows of slender spines on medial surface.

Second antenna (figs. 4*e,f*): Endopodite (fig. 4*f*) single jointed, with long hirsute bristle and 2 short bare bristles. Exopodite (fig. 4*e*) with 9 joints: 1st joint slightly longer than total length of following joints; 2nd to 9th joints trapezoidal, each joint smaller than preceding joints, all without basal spines, 2nd to 8th joints with long bristles, bristle on 2nd joint with spines and natatory hairs, bristles on 3rd to 8th joints with sparse natatory hairs and stout marginal spines near middle; 9th joint with medium spinous bristle and 2 long bristles with natatory hairs; distal margins of 2nd to 8th joints with comb of slender spines. Medial surface and anterior margin of protopodite with clusters of slender spines.

Mandible (figs. 4*g–i*): Coxale endite (fig. 4*h*) bifurcate, 1 prong annulate, other nonannulate, both with spines, more spines on annulate prong. Basale with 7 bristles, 4 ventral, 3 dorsal. Exopodite with 2 bristles, outer bristle about half length of inner bristle. Endop-

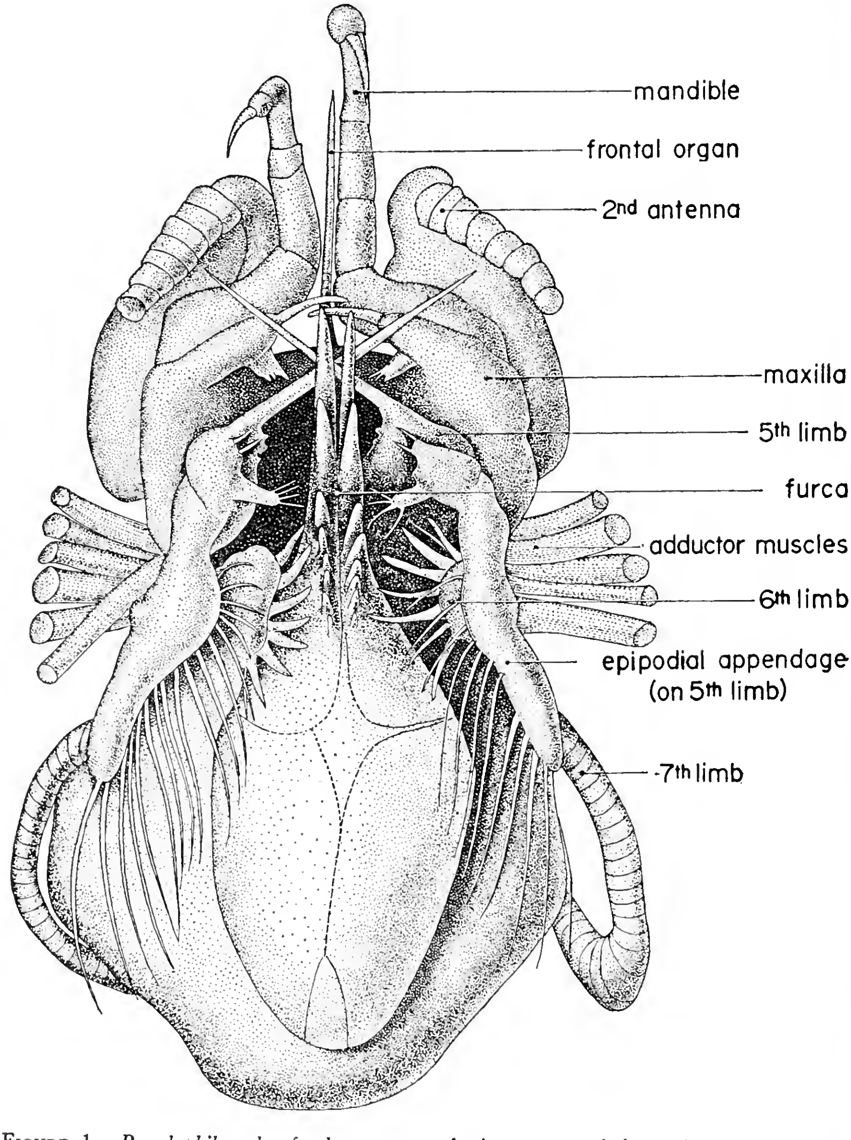


FIGURE 1.—*Pseudophilomedes ferulanus:* ventral view, removed from shell; all bristles, muscles, and appendages not shown; appendages and joint positions generalized. (Spec. 1, Gosnold Sta. 1857.)

odite: 1st joint with 1 short and 2 long ventral bristles distally; 2nd joint with 1 dorsal bristle proximal to middle, 3 dorsal bristles near middle, and 3 short ventral bristles distally; end joint (fig. 4*i*) with 3 bristles and 3 claws, 1 of latter very long, 1 about a third to half length of long claw, 1 on dorsal edge very short. Medial surface of endopodite and basale with clusters of fine hairs.

Maxilla (figs. 1, 5*a–d*): Precoxale endite with 3 stout pectinate

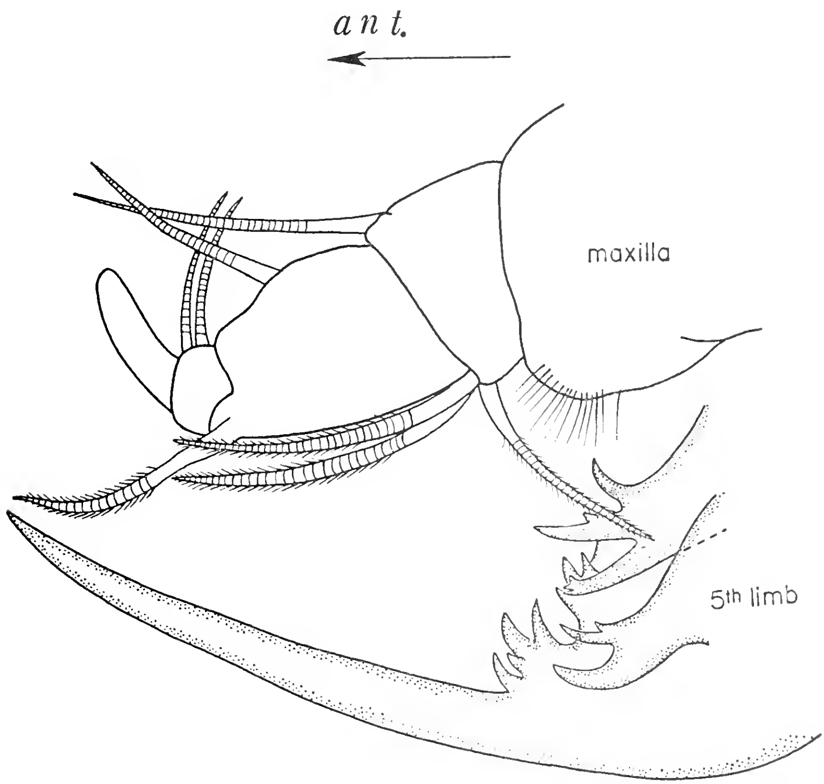


FIGURE 2.—*Pseudophilomedes ferulanus*: lateral view, left maxilla, 5th limb in place; all bristles not illustrated. (Spec. 3, Beaufort Shelf Transect, Sta. 30.)

spines and 2 spinous bristles. Coxale with stout plumose bristle, hirsute epipodial fringe and endite with 2 stout pectinate spines and 2 spinous bristles. Distal edge of basale with 1 spinous medial bristle and 2 on inner margin adjacent to low node with 2 bristles at base of coxale endite, shorter of latter bristles bare, other with several marginal spines. Exopodite consisting of 3 lateral spinous bristles distally on basale (figs. 1, 5*a*). Endopodite: 1st joint hirsute with 2 spinous bristles, 1 near middle and 1 terminally; 2nd joint with 1 short and 2 long terminal spinous bristles and a long stout process with annulations and a rough surface of small pustules distally.

Fifth limb (figs. 5*e–i*): First joint with 2 large teeth: proximal tooth trident with 3 bristles (fig. 5*f*); distal tooth bifid (fig. 5*h*). Second joint prolonged distally forming long fanglike tooth followed along the inner margin by a single tooth and 2 trident teeth (fig. 5*e*); posterior surface with 2 stout spinous bristles and a minute bristle (fig. 5*i*); inner edge of joint with spinous bristle (fig. 5*i*). (It was not possible to discern with certainty that this bristle was not in fact on a proximal margin of the distal tooth of the first joint.) Third joint with 2 short hirsute bristles (fig. 5*i*). Fourth joint hirsute with 1 short and 2 long terminal bristles and 1 short subterminal bristle (figs. 5*g,i*). Epipodial appendage with 42–46 bristles. Single endite with 2 short bristles.

Sixth limb (fig. 6*a*): First endite with 1 to 2 bristles; 2nd endite with 2 bristles; 3d and 4th endites each with 5 to 6 bristles; end joint with 9 to 10 bristles (end joint of late instar with only 7 bristles); single bare bristle in place of epipodial appendage. Surface with clusters of hairs; end joint fringed with hair.

Seventh limb (figs. 6*b–d*): Symmetrical terminus with opposing combs of 5 or 6 teeth (all teeth not shown in figs. 6 *b,c*). Adult with 6 terminal and 6 to 8 lateral bristles (instars with fewer bristles), each bristle with 1 to 5 bells (fig. 6*d*) and short marginal spines distally. Distribution of bristles on seventh limbs of 4 specimens from station BST 30 are as follows:

	limb A	limb B*
specimen no. 1		
terminal bristles	6	6
lateral bristles	8	7
specimen no. 2		
terminal bristles	4	4
lateral bristles	4	6
specimen no. 3		
terminal bristles	6	lost
lateral bristles	6	lost
specimen no. 4		
terminal bristles	6	6
lateral-bristles	8	7

* Limbs A and B are opposing 7th limbs; they have not been classified as either left or right.

Furca (figs. 6*e, f–h*): Each lamella with 8 to 10 claws; 3rd claw thinner than 4th but about the same length; each claw separated from lamella by suture with exception of 9th and 10th claws which, when present, appear as nodes. Claw 1 with stout spines in row proximally on lateral margin, slender spines distally on lateral and medial margins, 1 large spine near middle of medial margin, and groups of slender spines distally on anterior surface; claws 2–8 with spines along medial and lateral margins; lamella, in area of distal and proximal claws, with hairs.

Eyes: Median eye (fig. 6*j*) large, pigmented. Lateral eyes (fig. 6*g*) small, black in preserved specimens.

Frontal organ (figs. 6*j*, *k*): Elongate, proximal part divided into about 8 short segments, distal part (fig. 6*k*) tapered, with short spines near terminus.

Eggs (fig. 6*i*): As many as 8 eggs observed in thoracic region; 2 to 6 eggs in brood pouch.

Parasites: Two larval copepods of genus *Sphaeronella* in brood pouch of 1 specimen having eggs inside body (specimen no. 4, Beaufort Shelf Transect 30).

Pseudophilomedes foveolatus

Figures 7, 8

Pseudophilomedes foveolata Müller, 1894, pp. 211–212, pl. 3, figs. 34, 35, 45–49, 51, 53, 54; pl. 4, figs. 127. [Not *Philomedes foveolata* Brady and Norman, 1896, pp. 659–661, pl. 56, figs. 4, 5.]

Syntypes.—Zoological Museum of Berlin, Division of Crustacea, catalog no. 9154.

Material.—A vial containing 1 whole specimen and a left and right valve in alcohol was received from the Zoological Museum, Berlin. The accompanying label contained the following information: Kat. Nr, 9154; Species *Pseudophilomedes foveolata* G. W. Müller, 1894; Fudort Neapel. An asterisk appears in the upper left-hand corner of the label.

The small size of the specimens leads me to believe that they are late instars of females. I have designated the whole specimen as specimen number 1 in this paper and on the prepared slide.

Description of late instar of female (male unknown).—Shell (figs. 7*a*–*d*): Lateral outline oval, highest anterior to center; posterior process slightly below middle of valve; rostrum subtriangular with nearly horizontal lower margin; antennal sinus shallow; surface punctate; ovoid muscle scars in front of and below middle of each valve. Inner lamella broadest behind rostrum and in front of posterior projection; selvage with lamellar prolongation and fringing hairs unbroken around antennal sinus; inner lamella behind rostrum with row of 4 bristles with short marginal hairs (fig. 7*b*); inner lamella in front of posterior process with 1 (or 2 closely spaced?) hirsute seta (fig. 7*c*); inner lamella below antennal sinus with 1 short bristle; outer surface of each valve with scattered surface hairs.

Müller (1894, pl. 3, fig. 7) illustrates 4 bristles on the inner lamella behind the rostrum but does not show them to be hirsute. He evidently also overlooked the faint seta on the inner lamella in front of the posterior process and the small bristle below the antennal sinus.

Shell dimensions (in mm) are as follows:

specimen no.	*greatest length*	*greatest height*	*remarks*
1	0.73	0.46	whole specimen
2	0.64	0.43	separated left valve
3	0.73	0.48	separated right valve

Müller (1894, p. 212) gives a length of 0.93 mm for this species. The smaller size of specimens available for the present study indicates that they are instars.

First antenna (figs. 7*e,f*): Second joint with 1 spinous dorsal bristle and sparse clusters of spines on medial surface; 3rd and 4th joints each with 1 ventral and 1 dorsal spinous terminal bristle; 5th joint with 1 long ventral, terminal sensory bristle with forked tip; 6th joint minute, welded to 5th joint, and with 1 short medial bristle; 7th joint reduced, welded to 8th joint, and with 1 short spinous a-bristle, 1 short b-bristle with forked tip and 1 distal filament, and 1 long c-bristle with forked tip; 8th joint reduced, with 2 long bare d- and e-bristles, 1 long f-bristle and 1 long g-bristle, both with forked tips.

The illustration of the 1st antenna illustrated by Müller (1894, pl. 3, fig. 48) bears 2 ventral bristles terminally on the 4th joint (considered 5th joint by Müller). The presence of only 1 bristle in that position on the specimen I examined may be due to its not being adult. A few filaments were observed on long bristles of joints 5–8, but it was not possible to determine the exact number and precisely on which bristles they belonged.

Second antenna (figs. 7*g-i*): Endopodite (fig. 7*h*) single jointed, with 1 long hirsute bristle and 1 short bare bristle. Exopodite with 9 joints: 1st joint slightly longer than total length of following joints; 2nd to 9th joints trapezoidal, each joint smaller than preceding joints, all without basal spines; 2nd to 8th joints with long bristles with stout spines along outer margin, becoming shorter, more slender, and numerous at distal end; 9th joint with 1 short and 1 long spinous bristle; all bristles without natatory hairs; distal margins of 2nd to 8th joints with comb of slender spines; tip of bristle on 2nd joint not reaching 9th joint.

The 2nd antenna shown by Müller (1894, pl. 3, fig. 35) is similar to the specimen described in this paper. Müller apparently overlooked the row of short spines along the distal margin of joints 2–8 of the exopodite.

Mandible (figs. 7*j*, *k*): Coxale endite (fig. 7*j*) bifurcate with distal spines. Basale with 7 bristles, 4 ventral, 3 dorsal. Exopodite with 2 bristles, outer bristle shorter than inner bristle and with wreaths of long hairs. Endopodite: 1st joint with 1 short and 2 long ventral bristles terminal; 2nd joint with 1 short dorsal bristle proximal to middle, 3 dorsal bristles near middle, 1 short ventral bristle distally, and 2 short terminal bristles near ventral margin; end joint (fig. 7*k*) with 3 bristles and 2 claws, 1 of latter very long, other about 3rd length of long claw. Terminal end of 1st endopodite joint with spines in row.

The mandible of the species illustrated by Müller (1894, pl. 3, fig. 51) has only 2 ventral bristles distally on the 1st endopodite joint, only 2 dorsal bristles in the distal group on the 2nd endopodite joint, and does not show 2 small bristles terminally on the 2nd endopodite joint or a small centrally located terminal bristle on the end joint. These were probably overlooked by Müller.

Maxilla (fig. 71 *m*): Precoxale endite with 3 stout pectinate spines and 2 bristles. Coxale endite with 2 pectinate spines and 2 bristles. Distally of coxale endite a short lobe with 3 bristles. Basale with 1 medial bristle and 2 bristles on inner margin. Exopodite consisting of 3 lateral bristles located distally on basale. Endopodite: 1st joint with 1 subterminal and 1 terminal bristle; 2nd joint with 1 short and 2 long bristles and a slender process with annulations distally.

Müller (1894, pl. 3, fig. 49) illustrates the slender process on the end joint of the endopodite as a bristle. Although the process resembles a stout bristle, it is ringed only distally and is less tapered than a bristle would be. Müller's illustration does not have the 3 bristles I interpret as the exopodite. The specimen I examined does not have a bristle on the distal margin of the coxale, possibly it broke off during the dissection. Unfortunately the left maxilla was lost so that I had the opportunity to examine only the right maxilla.

Fifth limb (figs. 8*a-e*): First joint with 2 large teeth; proximal tooth trident with 2 or 3 bristles, forward tooth spinous on posterior margin; distal tooth bifid with small secondary tooth above base of lead tooth, forward tooth with spines on leading and posterior margins, spines larger on leading margin. Second joint prolonged distally forming long fanglike tooth followed along the inner margin by a single tooth and 2 trident teeth; posterior surface with 1 long and 1 short bristle. Third joint with 2 spinous bristles near base of 4th joint. Fourth joint hirsute with 4 or 5 bristles. Inner margin of protopodite with single endite with 1 or 2 minute bristles.

The taxonomically important inner margin of the 2nd joint with its 3 teeth is not shown in the view of this appendage illustrated by Müller (1894, pl. 3, figs. 43, 46). The fanglike tooth distally on the 2nd joint is much longer on the specimen I examined than would be suspected from examination of Müller's illustrations. Possibly shortness of that tooth in Müller's illustration is the result of foreshortening, which results when an appendage is mounted obliquely on the slide.

The 2 teeth of the 1st joint of the specimen illustrated by Müller and the one I examined are quite similar. Müller apparently interprets the 2 bristles, which I consider to be on the posterior surface of the 2nd joint, to be on the inner lobe of the 3rd joint. This is quite possible, but difficult to verify, because the suture between 2nd and 3rd joints is not visible on specimens I examined. The 4th joint illustrated by Müller (figs. 43, 46) does not have the short terminal bristle present on the specimen I examined. This may have been overlooked by Müller, or possibly the number of bristles on the 4th joint varies slightly within the species.

Sixth limb (fig. 8*f*): First endite with 2 bristles; 2nd endite with 5 bristles; 3rd endite with 4 bristles; end joint with 5 (?) bristles; single bristle in place of epipodial appendage.

The appendage illustrated by Müller (1894, pl. 3, fig. 54) is quite similar to the one I examined with the exception of bearing 8 bristles on the end joint. Since the end joint I examined belongs to an immature specimen, it is possible that it has fewer bristles; because of the position of the 6th limb on the slide, I was not able to see the end joint clearly, so it is likely that more than 5 bristles are present.

Furca (figs. 8*g–i*): Each lamella with 6 claws; claws 1, 2, 4 being stout claws, and claws 3, 5, 6 slender claws; claw 3 shorter than claw 4; each claw separated from lamella by suture; claw 1 with stout spines in row proximally on lateral margin, slender spines distally on lateral and medial margins, and 1 large spine near middle of medial margin. Remaining claws with spines along medial and lateral margins; lamella, in area of distal and proximal claws, with hairs.

Müller (1894, pl. 3, figs. 34, 53) figures a furca with the 3rd claw almost equal in length to the 4th claw. This suggests that the length of the 3rd claw may be somewhat variable within the species. Müller's figures do not show peripheral spines on claws 3, 5, 6. It seems probable that these were overlooked by Müller. In this regard, it is interesting that Brady and Norman (1896, p. 672) state that the larger furcal claws of *Pseudophilomedes inflatus* are ciliated on the edge and in the figure of this appendage (1896, pl. 59, fig. 10) show claws 3 and 8–10 without marginal spines. In view of Müller's omission of marginal spines on slender claws, it seems likely that they also were overlooked by Brady and Norman. It would be most unusual and seems quite unlikely for spines to be absent from the slender claws, especially claw 3.

Family Philomedidae Müller

Philomedinae Müller, 1912, p. 24 (part).

Type genus.—*Philomedes* Liljeborg, 1853. Gender: Masculine.

Diagnosis.—Shell: Shell variable in outline, but generally elongate with convex dorsal and ventral margins; surface smooth or with complex ornamentation; anterior with rostrum and shallow-to-deep antennal sinus; posterior rounded or with process; lamellar prolongation of selvage with fringe of hairs.

First antenna: First joint without bristles; 2nd joint with 1 distolateral bristle, 1 distodorsal bristle, and usually 1 distoventral bristle; 3rd joint with 1 ventral and 1–4 dorsal bristles; 4th joint with 1–4 distoventral and 1–2 distodorsal bristles; 5th joint of male considerably reduced but always represented ventrally by a sensory bristle broadening proximally and with numerous long filaments; 5th joint of female not reduced, and with a stout distoventral bristle with short filaments; 6th joint of male not reduced, and with a slender distomedial bristle; 6th joint of female considerably reduced but always with a slender distomedial bristle; 7th joint reduced, and with 1 short distodorsal bristle, 1 long distomedial bristle with short filaments, and 1 long distoventral bristle with filaments (a-, b-, and c-bristles respectively); 8th joint reduced and with 2 long bare distolateral bristles (d- and e-bristles), and 2 long distomedial bristles with filaments (f- and g-bristles); c- and f-bristles on male extremely long, about length of shell.

Second antenna: Endopodite of male with 3 joints, each joint with 2 or more bristles; endopodite of female with 1–3 joints having total of 6 or more bristles. Exopodite: 3rd joint of male at least twice length of 2nd joint; in female joints decreasing in length distally; joints usually with basal spines; 2nd to 8th joints each with 1 bristle; 9th joint usually with 6–7 bristles.

Mandible: Coxale in female large, bifurcate at tip, in male reduced or absent. Basale with 5–9 ventral bristles, 1–4 dorsal bristles, and 5–6 medial bristles. Exopodite elongate with 2 terminal bristles. Endopodite: 1st joint with 4–7 ventral bristles; 2nd joint with 5 or more dorsal bristles and ventrally at least 1, but usually about 6 bristles. End joint with 2–3 claws and 3–4 bristles.

Maxilla: Endites 3 in number; exopodite elongate with 3 bristles; maxilla on female usually larger than on male.

Fifth limb: Exopodite: 1st joint of female with 2 or more strong teeth; 2nd joint of female forming large squarish sclerotized process having large inward projecting tooth distally and an inner margin either smooth or with small nodes or 2 large teeth; 1st and 2nd joints of male without stout teeth; 3rd joint with 3 bristles on inner lobe and 2 on outer lobe; 4th joint elongate with 5–6 bristles. Endites 3 in number with a varying number of bristles. Epipodial appendage with numerous bristles (more than 30).

Sixth limb: Endites 4 in number; end joint with 9–45 bristles; 2–4 bristles in place of epipodial appendage.

Seventh limb: Terminus with comb opposed by 2 pegs; cleaning bristles 6–35 in number.

Frontal organ: Elongate with or without rings.

Eyes: Large medial eye. Lateral eyes in female large with numerous ommatidia, in male absent or small without numerous ommatidia.

Furca: Considerable variation in distribution of primary and secondary claws. Total number of claws 6–17; all or some claws separated from lamella by sutures.

The following genera are referred to the Philomedidae: *Philomedes* Lilljeborg, 1853: ?*Pleoschisma* Brady, 1880: ?*Tetragonodon* Brady and Norman, 1896; *Scleroconcha* Skogsberg, 1920; *Euphilomedes* Poulsen, 1962; *Paraphilomedes* Poulsen, 1962.

Euphilomedes Poulsen

Type species.—*Euphilomedes nodosus* Poulsen, 1962, by subsequent designation, Kornicker (in press). Gender: masculine.

Euphilomedes asper, new combination

Figures 9, 10, 11*a–d*, 12

Philomedes aspera Müller, 1894, pp. 210–211, pl. 3, figs. 3, 17, 21; pl. 8, fig. 1.
Philomedes foveolata.—Brady and Norman, 1896, pp. 659–661, pl. 56, figs. 4, 5. [Not *Pseudophilomedes foveolata* Müller, 1894.]

Syntypes.—Zoological Museum of Berlin, Division of Crustacea, catalog no. 9152.

Material.—1. A glass slide in the collection of the British Museum (Natural History) labeled "*Philomedes foveolata* Bra & Nor ♂" at one end of the slide and at the other end "Naples 1887"; a 3rd label bears the number 1900–3–6–452. The slide contains a dissected ostracod with parts under 6 cover slips. This slide probably contains the specimen upon which Brady and Norman (1896) based their description. Because of the poor condition of the slide, another specimen (see paragraph 2, below) was used for the description and most illustrations used in this paper. However, the appendages and carapace on Brady and Norman's slide were carefully compared wherever possible with those from the specimen I dissected. Both specimens are almost identical, but where minor differences were observed they are discussed when the appendage is described.

2. A vial in the collection of the British Museum (Natural History) containing a smaller vial with 2 whole undissected specimens in alcohol. The larger vial contains the label "*Pseudophilomedes foveolata*, Naples 1887, Norman Coll., B. M. regd. no 1911, 11.8. 36962–964." The specimens in this vial are designated in this paper

as specimens A and B. Specimen A was dissected and used in descriptions and illustrations.

3. A jar in the collection of the Zoological Museum of Berlin containing a small vial with 1 whole ostracod and 1 left and 1 right valve. The jar contains the label "Type, *Philomedes aspera* G. W. Müller, *Kat. Nr* 9152, *Fundort* Napoli." The small vial contains the label, "9152." These specimens are syntypes; Müller (1894) did not designate a holotype for the species. The whole specimen is a mature male. The left and right valves are from different specimens; their sex is unknown. I have designated the whole specimen as number 1, the right valve as number 2, the left valve as number 3, and have illustrated each valve. All specimens were returned to the Zoological Museum of Berlin in the same vial in which they were received. The whole specimen was not dissected, but as the furca was projecting from between the valves, it was possible for it to be described and illustrated in this paper.

Supplementary description.—Shell (figs. 9*a–i;* 12*a–f*): Lateral outline oval, elongate with greatest height near middle, prominent rostrum and broad rostral incisure (figs. 9*a*, 12*a–d*); surface of valves with numerous large oval pits (fig. 9*b*). Posterodorsal margin with straight hinge; posterior hinge element of each valve consisting of angular sclerotized process; medial hinge element straight; anterior hinge element not prominent. Adductor muscle scars consisting of about 16 or 17 individual scars below middle of valve (figs. 9*e*, *i;* 12*e*). Inner lamella broadening at posteroventral process and behind rostrum (figs. 9*b*, *c;* 12*e*). Selvage with wide, corrugated, lamellar prolongation having fringe of slender spines along outer margin. Twelve to 14 bristles forming row on inner lamella behind rostrum (figs. 9*b*, *f;* 12*d*); inner lamella below rostrum with small hair followed by a wide space and then 10 hairs on left valve and 14 on right valve (figs. 9*d*, *h*). Posteroventral process with small hairs on inner lamella (figs. 9*c*, *g;* 12*e*); small hairs, singly or in pairs, forming row on list on posteroventral and posterior part of inner lamella (figs. 9*e*, *g*). Radial pore canals numerous but faint. Hairs with taper distributed on lateral surface of rostrum, some forming row near ventral and posterior margins of valves; additional hairs sparsely distributed on valve surface.

Muscle scars were somewhat obscured on all specimens. Four muscle scars located in the anterior part of the central muscle field of Müller's syntypes were not observed on the specimens of Brady and Norman.

Shell dimensions (in mm) are as follows:

collector	*specimen*	*greatest length*	*greatest height*	*remarks*
Brady and Norman	A	1. 34	0. 85	mature male
	B	1. 35	0. 81	" "
Müller	1	1. 30	0. 80	" "
	2	1. 28	0. 78	" "
	3	0. 94	0. 60	instar

Brady and Norman (1896, p. 659) give measurements of length as 1.6 mm and height as 1 mm for specimen BM 1900–3–6–452; because of the poor condition of the mounted specimen, I was unable to measure it.

Müller (1894, p. 211) gives the length of the male as 1.3 mm.

First antenna (fig. 9*j*): First joint with clusters of spines on medial surface; 2nd joint with clusters of hairs on medial surface, short spines projecting from ventral and dorsal margins, and distally with a dorsal, ventral, and lateral bristle; 3rd joint with clusters of hairs on medial surface and 1 ventral and 2 dorsal bristles; 4th joint with clusters of hairs on medial surface and 2 dorsal and 4 ventral bristles distally; 5th joint inferred to be inserted between 4th and 6th joints bearing sensory bristle with broad base and numerous filaments; 6th joint with medial bristle distally; end joints with 2 long stout c- and f-bristles, 1 short spinous dorsal a-bristle, and 2 long b- and g-bristles with filaments and 2 bare d- and e-bristles.

The above description of the 1st antenna differs from Brady and Norman's (1896, p. 660) in having 2 rather than 1 bristle on the dorsal margin of the 3rd joint and in having a total of 7 rather than 6 bristles on the end joint. The 1st antenna on slide no. 1900–3–6–452 containing a specimen dissected by Brady and Norman confirms the presence of 2 dorsal bristles on the 3rd joint and a total of 7 bristles on the end joint.

Second antenna (figs. 9*k*, *l*; 10*a*): Endopodite (fig. 9*k*) with 3 joints: 1st joint with 5 proximal bristles and 1 distal bristle; 2nd joint elongate with 2 bristles near middle; 3rd joint prehensile with a long slender bristle about one-third distance from proximal end of joint and 2 short bristles and about 5 crescentic ridges at distal end. Exopodite with 9 joints; 1st joint elongate with small medial spine distally; 2nd joint about one-third length of 1st with spined bristle reaching 6th joint; 3rd joint about twice length of 2nd; joints 4–9 trapezoidal, each joint smaller than preceding joint; joints 3–8 with slender basal spines and row of short hairs distally on lateral margin; bristles on joints 3–8 with natatory hairs; end joint (fig. 10*a*) with 4 long distal bristles with natatory hairs and 2 smaller mediodorsal bristles with sparse marginal hairs.

Brady and Norman (1896, p. 660) report only 3 bristles on the 1st joint of the endopodite of the 2nd antenna; however, 6 bristles are present on this joint on slide no. 1900–3–6–452 containing a specimen dissected by Brady and Norman. The 1st endopodite joint of Philomedidae usually contains more than 3 bristles, so it is probable that Brady and Norman were unable to make an accurate count of bristles on that joint.

Mandible (figs. 10*b*, *c*): No coxale endite. Basale ventral margin with 7 subequal bristles with wreaths of long hairs, some also with short marginal spines distally; dorsal margin with 1 bristle near middle and 2 distally; subventral medial surface with 4 small proximal bristles and 1 bristle proximal to middle. Exopodite reaching about middle of 1st endopodite joint, with 2 subequal terminal bristles. Endopodite 1st joint with 2 short and 3 long distoventral bristles; 2nd joint with 3 dorsal bristles proximally, 6 dorsal bristles near middle, 2 ventral bristles subdistally and 2 long and 2 short ventral bristles distally. End joint (fig. 10*b*) with 2 large subequal claws, 1 short dorsal claw, and 4 bristles. Medial surface of basale and 1st and 2nd endopodite joints with clusters of hairs.

Maxilla (fig. 10*d*): Three endites: 1st endite with about 8 bristles; 2nd endite with about 7 bristles; 3rd endite with 1 proximal bristle and numerous distal bristles. Coxale with long plumose bristle. Exopodite with 1 short and 2 long bristles.

Fifth limb (figs. 10*e*, *g*): Epipodial appendage with about 33 bristles. Three endites with numerous bristles. Exopodite 1st and 2nd joints each with a flat, transparent, bladelike tooth and several bristles; 3rd joint with 2 stout plumose bristles on outer lobe and about 3 bare bristles on inner lobe; 4th and 5th joints with 6 bristles.

Sixth limb (fig. 10*f*): First endite with 3 bristles; 2nd endite with 1 proximal and 3 distal bristles; 3rd and 4th endites each with 1 proximal and 7 distal bristles; end joint with 14 bristles; 3 plumose bristles in place of epipodial appendage. Lateral and medial surface of end joint with clusters of hairs. Some bristles of end joint broken on specimen examined.

The description of the 6th limb given by Brady and Norman (1896, p. 660) differs from the above. The 1st endite seems to have been pulled off on Brady and Norman's dissected specimen (slide no. 1900–3–6–452), but part of 1 bristle remains to show that the endite was present. The missing 1st endite on the specimen evidently led Brady and Norman to mistakenly consider the 2nd endite to be the 1st endite, the 3rd endite to be the 4th, and the 4th to be part of the end joint. Brady and Norman described the 1st lobe [their terminology] to have 2 setae, and the 2nd lobe to have 1 lateral and 6 distal setae. The dissected specimen (slide 1900–3–6–452) actually has 1 lateral and 3 distal setae on the 1st lobe [their terminology] and 1 lateral and 7 distal setae on the 2nd lobe. The remainder of the description of

Brady and Norman conforms to the above description and describes accurately the appendage on slide 1900–3–6–452. However, Brady and Norman do not mention 2 slender bristles on the end joint; this brings the total number of bristles on this joint to 14, nor do they mention 3 bristles in place of the epipodial appendage; those bristles are present on the specimen on slide 1900–3–6–452.

Some variability was observed in the location of 2 relatively short and slender medial bristles on the margin of the end joint. These bristles occupy positions nos. 5 and 8 (counting from the posterior end of the joint) on the appendage on slide 1900–3–6–452; whereas, on specimen A dissected by the writer, these bristles occupy positions 6 and 9 on the left appendage, and 7 and 9 on the right appendage.

Seventh limb (figs. 10*j*, *k*): Four bristles of subequal length in distal group, each with 5 bells; 4 shorter bristles in proximal group, each with 3 bells (fig. 10*j*); marginal hairs not observed on bristles. Terminal comb with 9 or 10 teeth, some with basal spines and flanges; 2 subequal pegs opposing comb (fig. 10*k*).

Furca (figs. 10*i*, *l*, *m*): Each lamella with 10 or 11 claws: primary claws 1, 2, and 4, remaining claws secondary (fig. 10*l*). Secondary claw no. 3 slightly larger than claws 5 to 10 (figs. 10*i*, *m*), claws 6 to 10 about equal in length. All claws separated from lamellae. Primary claws with lateral and medial row of pointed teeth; tooth length varying only slightly in length on each claw. Secondary claws with row of spines along each margin. Clusters of long hairs medially on lamella between claws 1 to 8.

Specimen number 1 of Müller's syntypes contains 11 claws on the left lamella and 10 on the right, all other specimens examined contain 10 on each lamella. Both Müller (1894) and Brady and Norman (1896) describe their specimens as having 10 claws on each lamella.

Copulatory limbs (fig. 11*a*): Elongate terminating in 3 lobes, each lobe with 2 or more short bristles, 1 lobe with sclerotized tip.

Frontal organ (figs. 11*b*, *c*): Elongate, 2-jointed with 2nd joint tapering distally and having 2 small spines at tip.

Eyes: Medial eye large (fig. 11*b*). Lateral eyes large with about 13 ommatophores, each weakly divided by a suture into 2 parts (fig. 11*d*).

Discussion.—Differences between Brady and Norman's *Philomedes foveolatus* (Müller) and *Pseudophilomedes foveolatus* Müller are too large to be the result of sexual dimorphism. For example, each caudal lamella of Brady and Norman's specimens has 10 or 11 claws, whereas *P. foveolatus* of Müller has only 6; also, upper claws of Brady and Norman's specimens are subequal in length, whereas those on Müller's *P. foveolatus* decrease uniformly in size proximally; in addition, the 3rd claw of the furca on Brady and Norman's specimen is about half the length of the 4th claw, but it is almost the same length of the 4th claw on *P. foveolatus*. Also, Brady and Norman's specimens have 13 to 14 medial bristles on the rostrum of the carapace compared to only 4 on *Pseudophilomedes foveolatus*. Specimens collected and described by Brady and Norman conform in every way to males of *Euphilomedes;* there is no basis for considering them to be males of *Pseudophilomedes*, which unfortunately remain unknown.

Euphilomedes asper (Müller, 1894) was described by Müller from males collected from the Bay of Naples. His description of the species mentions only the 2nd antenna, the furca, and the external morphology of the carapace; the secondary appendage of the 2nd antenna, the furca, and the outside of the carapace are illustrated. It is difficult to identify a species with certainty having so few characters for comparison. The specimens of Brady and Norman considered by me to be *E. asper* (Müller) have a carapace and secondary branch on the 2nd antenna identical to that illustrated by Müller. The furca on Brady and Norman's specimens has the same number of furcal claws as in Müller's illustration and a similar distribution of primary and secondary claws, but it differs in one respect: the 3rd claw of *E. asper* (Müller) is slightly smaller than the 5th claw, whereas the opposite is true on Brady and Norman's specimens. The difference in size of the 3rd and 5th claws is so small in either case, I am inclined to believe that Müller's drawing of the furca is slightly inaccurate. This belief is supported by study of syntypic material of *Philomedes asper* which shows the 3rd and 5th claws to be about the same size (fig. 12*g*).

Euphilomedes sordidus (Müller, 1890) was described from females collected along the coast of northern Japan. Müller (1912, p. 26) in a key to species of *Philomedes* distinguished *P. asper* from *P. sordidus* by the size relationship of the 3rd and 5th furcal claws: on *P. sordidus* the 3rd and 5th claws are about the same size, whereas, on *P. asper*, according to Müller, the 3rd claw is smaller than the 5th. This difference between the species disappears if the 3rd claw of *E. asper* is not actually smaller than the 5th, as is shown to be the case in the present paper. *Euphilomedes sordidus* was inadequately described and most appendages are unknown, so that it is difficult to distinguish it from *E. asper* on the basis of what is presently known about the species. The wide geographic separation of the two species suggests that they are probably not conspecific. The Japanese form (female) has 4 lateral and 6 distal bristles on the 7th appendage, whereas, the Gulf of Naples form (male) has 4 lateral and 4 distal bristles, but to what degree this is due to sexual dimorphism is not known. The antennal sinus of the female *P. sordidus* (Müller, 1890, pl. 25, fig. 17) may be shallower than of *P. aspera* (Müller, 1894, pl. 8, fig. 1).

Euphilomedes species

FIGURES 11*e-j*

MATERIAL.—Vial from British Museum collection containing separated left and right valves and several pieces of the soft parts of an ostracod, and also a label with the number 50002. The vial with the ostracod was in a larger vial with the label "*Pseudophilomedes foveolata* Naples—Shallow water—April 1887, formerly a slide dissected. Norman coll. 1900. 3. 6. 451." All appendages were present in the vial except the caudal furca.

DISCUSSION.—Because of the missing furca and poor condition of the valves, a complete description of the species was not attempted. A few appendages have been illustrated to show that the specimen could not belong to the genus *Pseudophilomedes* and is a female *Euphilomedes*.

No explanation is available for Brady and Norman's statement (1896, p. 660) that only males of *Philomedes foveolatus* (Müller) were collected. In order to disturb the specimen as little as possible, most illustrations were made from the original partly dissected specimen without benefit of cover glass.

DESCRIPTION (incomplete female).—Shell (fig. 11*e*): Oval, elongate, prominent rostrum, and broad rostral incisure; surface with oval pits. Endopodite of second antenna with 2 joints (fig. 11*f*): 1st joint with 1 long and 5 short bristles; 2nd joint elongate with long hirsute bristle near middle and distal bristle (distal bristle represented by stump on specimen examined). Exopodite of 2nd antenna (figs. 11*f*, *g*) with 9 joints: 1st joint elongate, joints 2–9 trapezoidal, each joint smaller than preceding joint; joints 2–8 with row of short hairs along media-distal margin; bristles on joints 2–5 with marginal spines and without natatory hairs; bristles on joints 6–8 with natatory hairs and without marginal spines; joint 9 with 4 stout bristles and 1 slender bristle, all with natatory hairs, and 2 subequal short spinous bristles (fig. 11*g*). Maxilla with 3 endites typical of genus. Fifth limb with large quadrate 2nd joint typical of genus. Sixth limb (fig. 11*h*) with 4 endites and end joint projecting posteriorly. Seventh limb (fig. 11*i*) with 6 lateral and 6 distal bristles; terminal row of teeth with 2 opposing pegs. Frontal organ 2-jointed (fig. 11*j*): 1st joint elongate; 2nd joint tapering from broad base to slender tip.

Shell dimensions: Maximum length 1.42 mm, maximum height 0.88 mm.

The structure of the endopodite of the 2nd antenna, the maxilla, and the 5th and 6th limbs clearly shows that this species does not belong in *Pseudophilomedes*. Without having the furca available, it is not possible to be absolutely certain that the species does not belong to *Philomedes* rather than *Euphilomedes*, but the low number of cleaning bristles on the 7th limb make the latter genus the more probable.

Literature Cited

BRADY, G. S., and NORMAN, A. M.

1896. A monograph of the marine and freshwater Ostracoda of the North Atlantic and of northwestern Europe, 2–4: Myodocopa, Cladocopa, and Platycopa. Trans. Roy. Dublin Soc. Sci., ser. 2, vol. 5, pp. 621–746, pls. 50–68.

DARBY D. G.

1965. Ecology and taxonomy of Ostracoda in the vicinity of Sapelo Island, Georgia. Rept. 2 *in* Four Reports of Ostracod Investigations, pp. iii–vi, 1–76, figs. 1–11, pls. 1–33. [Offset report issued by the University of Michigan.]

HARTMANN, G.

1964. Neontological and paleontological classification of Ostracoda. *In* Puri, Symposium Ostracods as ecological and palaeocological indicators. Pubbl. Staz. Zool. Napoli, suppl. 33, pp. 550–587.

KORNICKER, L. S.

1959. Ecology and taxonomy of Recent marine ostracodes in the Bimini Area, Great Bahama Bank. Publ. Inst. Marine Sci., vol. 5 (1958), pp. 194–399, figs. 1–89.

1967. *Euphilomedes arostrata*, a new mydocopid ostracod from the Maldive Islands, Indian Ocean. Proc. U.S. Nat. Mus.

MÜLLER, G. W.

1890. Neue Cypridiniden. Zool. Jahrb., Abt. f. syst., vol. 5, pp. 211–252, pls. 25–27.

1894. Die Ostracoden des Golfes von Neapel und der angrenzenden Meeres-Abschnitte. Monogr. 21 *in* Fauna und Flora des Golfes von Neapel, viii + 404 pp., 40 pls.

1912. Ostracoda. *In* Das Tierreich, pt. 31, 434 pp., 92 figs.

POULSEN, E. M.

1962. Ostracoda-Myodocopa, 1: Cypridiniformes-Cypridinidae. Copenhagen, Carlsberg Foundation, Dana Report No. 57, 414 pp., 181 figs.

1965. Ostracoda-Myodocopa, 1: Cypridiniformes-Rutidermatidae, Sarsiellidae and Asteropidae. Copenhagen, Carlsberg Foundation, Dana Report No. 65, 483 pp., 156 figs.

PURI, H. S.

1963. Preliminary notes on the Ostracoda of the Gulf of Naples. Experimentia, 19, 368, pp. 1–6.

PURI, H. S.; BONADUCE, G.; and MALLOY, J.

1964. Ecology of the Gulf of Naples. *In* Puri, Symposium Ostracods as Ecological and Palaeoecological indicators. Pubbl. Staz. Zool. Napoli, suppl. 33, pp. 87–199, figs. 1–67.

SKOGSBERG, T.

1920. Studies on marine ostracods, 1: Cypridinids, halocyprids and polycopids. Zool. Bidr. Uppsala, suppl. vol. 1, 784 pp., 153 figs.

SYLVESTER-BRADLEY, P. C.

1961. Ostracoda (part). Pt. 3 *in* Arthropoda *of* Part Q *in* Moore, Treatise on invertebrate paleontology, xxiii + 442 pp., 334 figs.

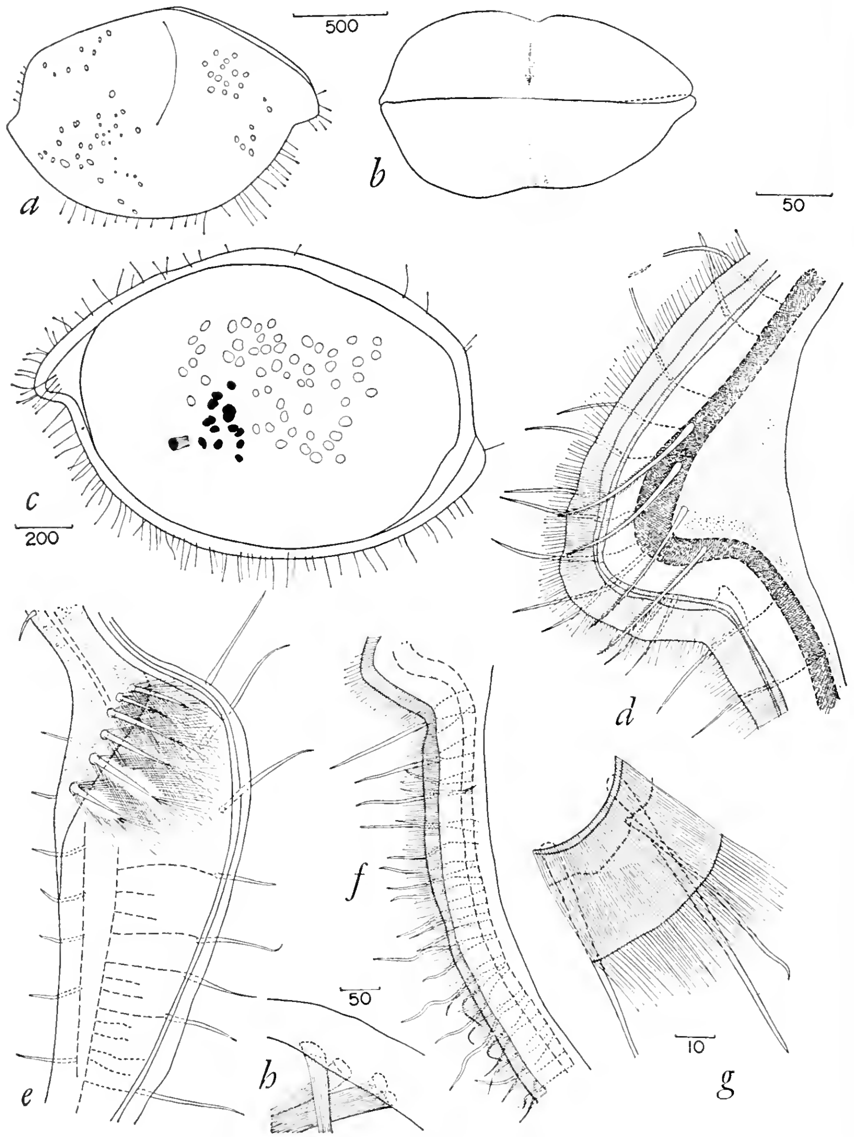


FIGURE 3.—*Pseudophilomedes ferulanus*, complete specimen: *a*, outline, all punctae not shown; *b*, dorsal view, anterior to right. Medial view, right valve: *c*, muscle scars and some punctae; *d*, anterior process; *e*, posterior process; *f*, anteroventral part; *g*, anterior margin rostrum with lamellar prolongation. Medial view left valve; *h*, muscle attachments below anterodorsal corner. (Scale same, in microns: *a*, *b*; *c*; *d*, *e*; *f*, *h*; *g*. Spec. 1, BST Sta. 30.)

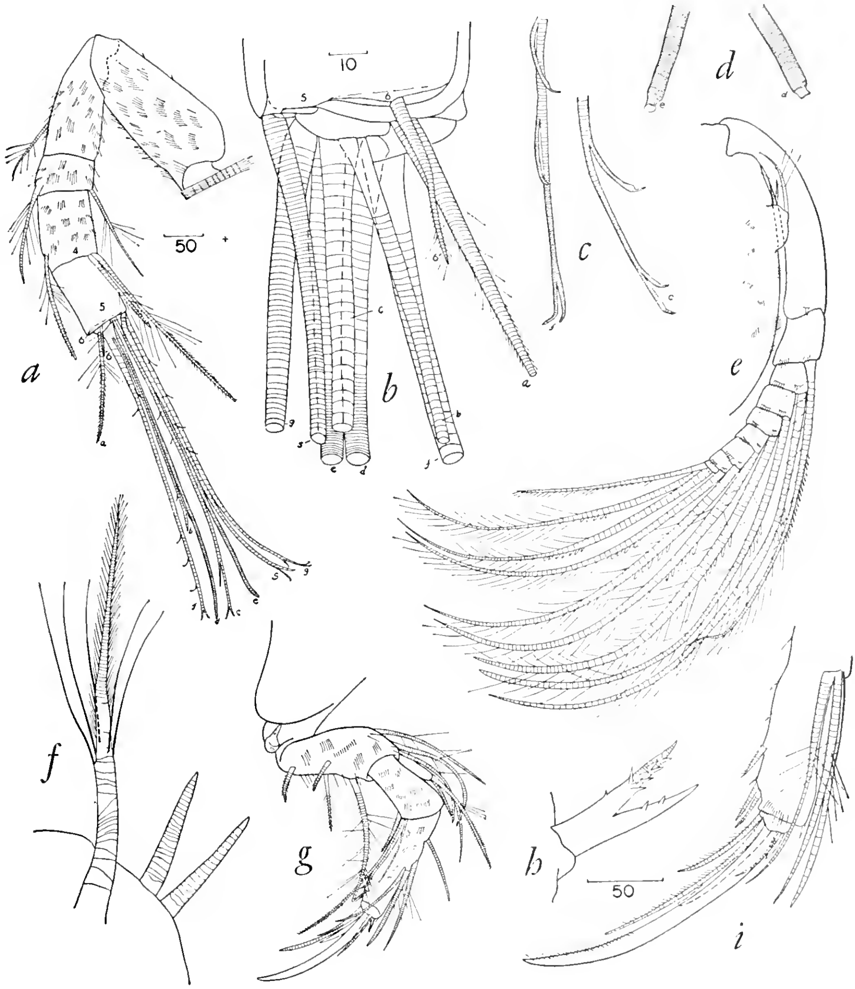


FIGURE 4.—*Pseudophilomedes ferulanus*, 1st antenna: *a*, right; *b*, distal end, 5th and end joints, left; *c*, ciliated bristles on end joints; *d*, tips of closely ringed e- and d-bristles on end joint. 2nd antenna: *e*, medial view; *f*, endopodite. Mandible: *g*, lateral view; *h*, coxale; *i*, distal part. (Same scale, in microns: *a*, *e*, *g*; *b–d*, *f*; *h*, *i*. Figs. *a*, *c–i* from spec. 1, BST Sta. 30; fig. *b* from spec. 2, same station.)

FIGURE 5.—*Pseudophilomedes ferulanus*, maxilla: *a*, left; *b*, distal process of right, anterior to left; *c*, 1st endite, anterior to left; *d*, 2nd endite, anterior to left. 5th limb: *e*, anterior view, part of 2nd joint; *f*, trident tooth on 1st joint; *g*, anterior view, distal part, only 1 bristle of epipodial appendage shown with hairs; *h*, bifid tooth on 1st joint; *i*, posterior view, distal part, only 1 bristle of epipodial appendage shown with hairs. (Same scale, in microns: *a*, *g*, *i*; *b–f*, *h*. Figs. *a–f*, *h* from spec. 1, BST Sta. 30; figs. *g*, *i* from spec. 4, same station. Roman numerals on *a*, *c*, *d* refer to endites; arabic numbers on *e–g*, *i* refer to joints.)

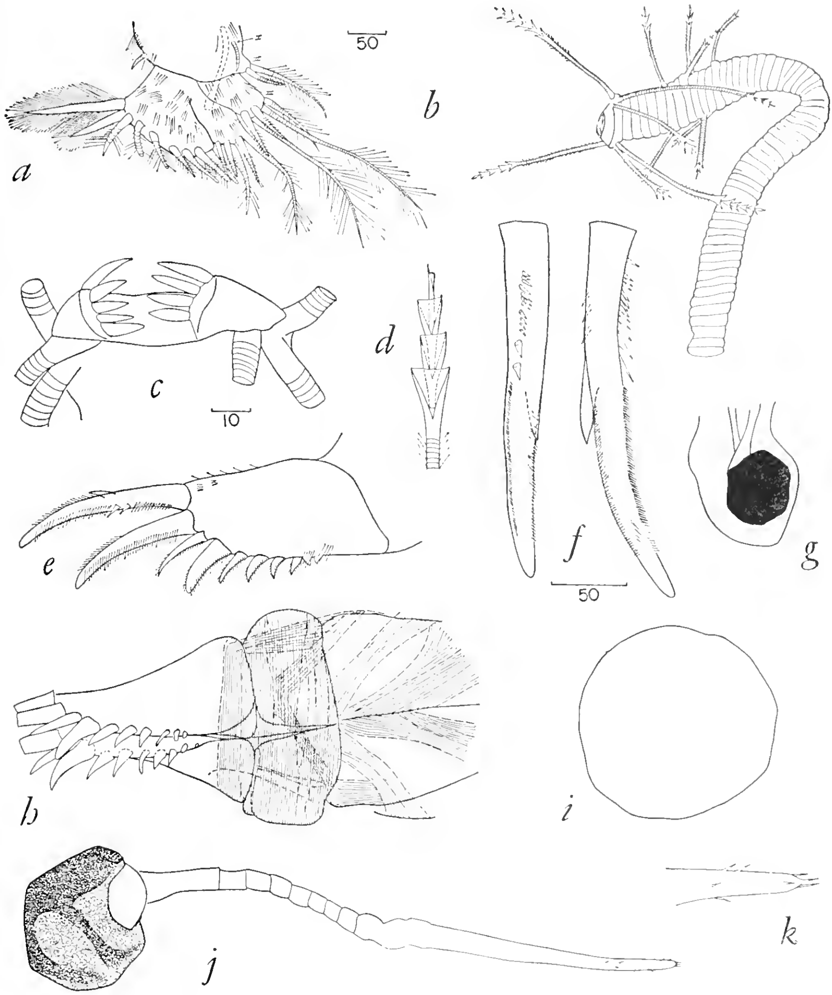


FIGURE 6.—*Pseudophilomedes ferulanus*: *a*, 6th limb; *b*, 7th limb; *c*, distal part of 7th limb; *d*, bell on distal part of bristle of 7th limb; *e*, left lamella of furca; *f*, 1st claw of left and right lamellae; *g*, lateral eye; *h*, subventral view of furca showing muscles; *i*, egg from brood pouch; *j*, medial eye and frontal organ; *k*, tip of frontal organ. (Same scale, in microns: *a*, *b*, *e*, *h*, *i*; *c*, *d*, *k*; *f*, *g*, *j*. Figs. *a–f*, *h*, *i* from spec. 1; fig. *j* from spec. 4; figs. *g*, *k* from spec. 2. All from BST Sta. 30.)

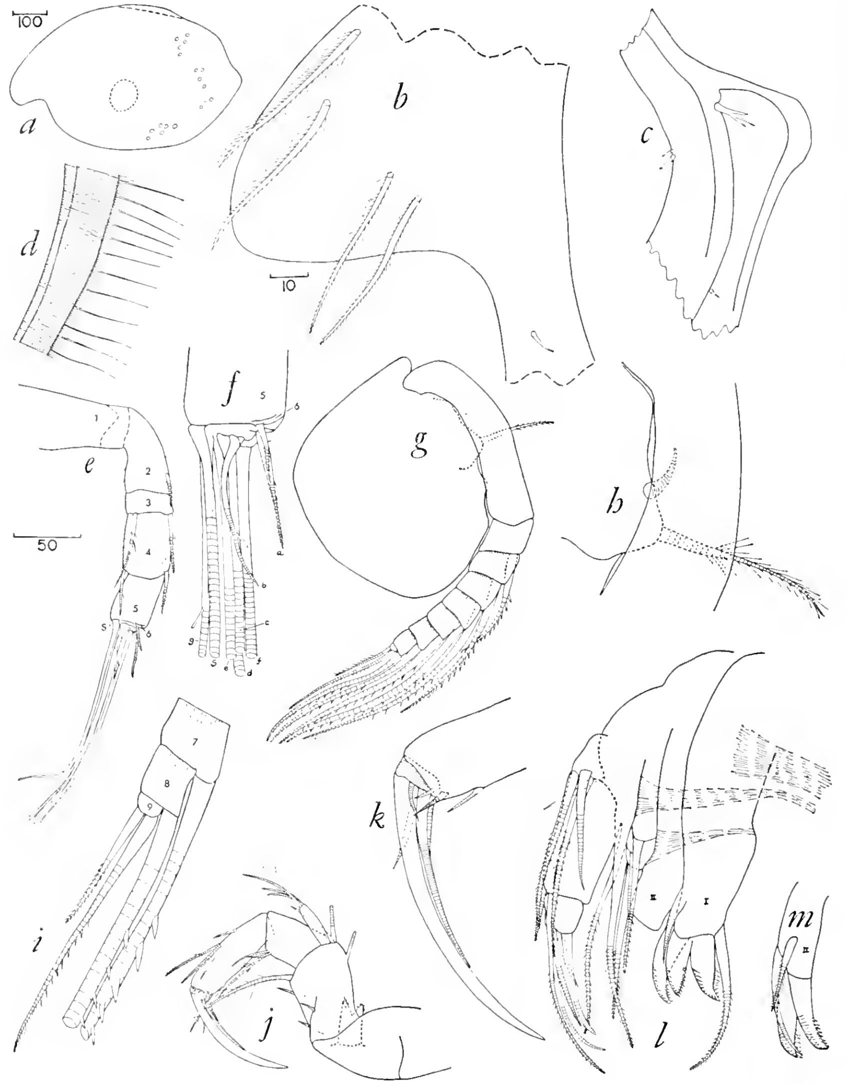


FIGURE 7.—*Pseudophilomedes foveolatus*: *a*, left view of shell, broken circle locates adductor muscles, only representative punctae shown. Medial view of valves: *b*, rostrum of right; *c*, posterior process, right; *d*, lamellar prolongation of selvage on anteroventral margin of left. Antenna: *e*, left 1st; *f*, medial view, joints 5–8 of left 1st; *g*, right 2nd; *h*, endopodite of same; *i*, lateral view, joints 7–9 of right 2nd. Left mandible: *j*, medial view, 2 outer bristles on basale broken; *k*, terminal end. Left maxilla, lateral view: *l*, bristles on endite II not shown; *m*, endite II, anterior margin to left. (Same scale, in microns: *a*; *b–d*, *f*, *h*, *i*, *k–m*; *e*, *g*, *j*. Spec. 1, BST Sta. 30.)

FIGURE 8.—*Pseudophilomedes foveolatus*, 5th limb: *a*, posterior view, right; *b*, oblique view from posterior of left, processes on 1st joint not shown; *c*, posterior view, right, showing only 2nd and distal part of 4th joint; *d*, posterior view, forward bifid tooth of 1st joint; *e*, posterior view, trident tooth of 1st joint. 6th limb: *f*, oblique view, right, not all bristles shown on end joint. Right caudal lamella: *g*, complete; *h*, part; *i*, lateral view, claw 1. (Same scale, in microns: *a–f*, *h*, *i*; *g*. Spec. 1, BST Sta. 30. Roman numerals on *f* refer to endites; Arabic numbers on *a*, *b*, *c* refer to joints, on *h* to claws.)

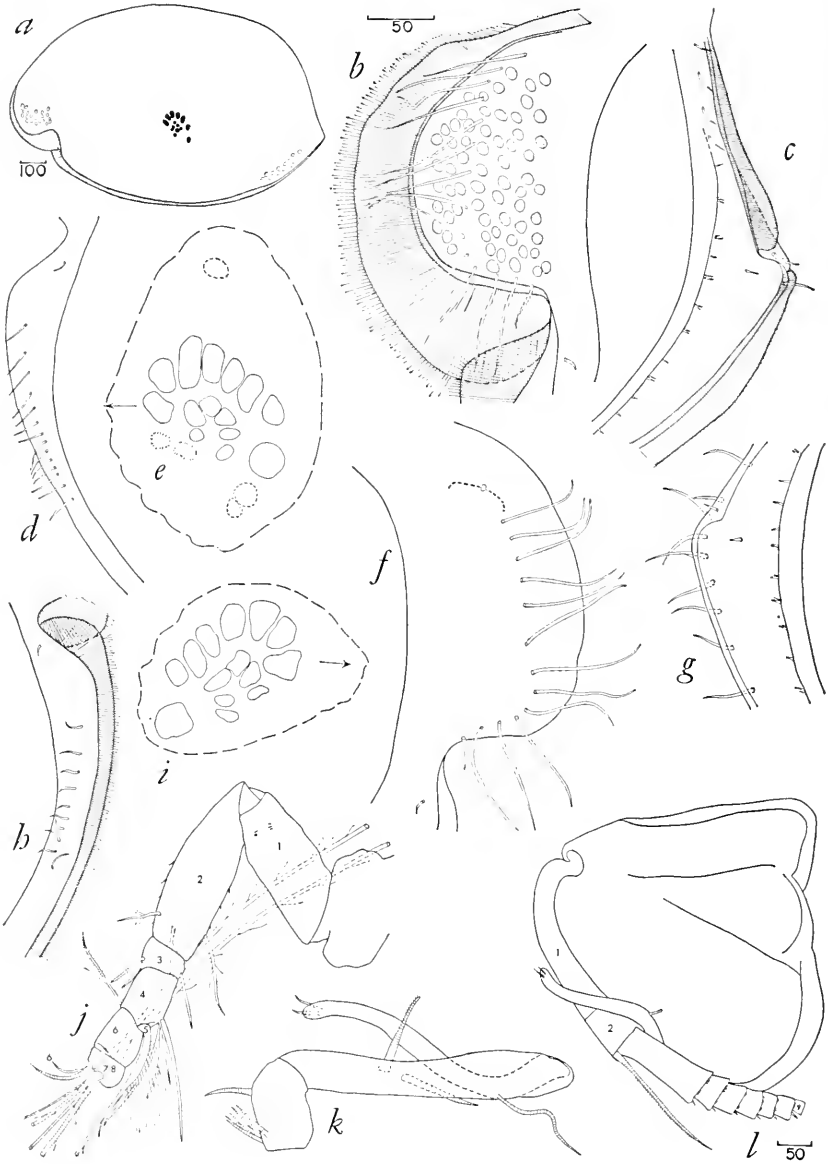


FIGURE 9.—*Euphilomedes asper*, shell: *a*, lateral outline showing muscle scars, punctae only on part of rostrum and along posteroventral margin. Medial view of valves: *b*, rostrum, right; *c*, posterior process, right; *d*, anteroventral part of inner lamella, right; lamellar prolongation of selvage not shown; *e*, muscle scars, right; *f*, rostrum, left, lamellar prolongation of selvage not shown; *g*, posterior process, left, lamellar prolongation of selvage not shown; *h*, anteroventral part of inner lamella, left; *i*, muscle scars, left. Antenna: *j*, right 1st, ends of many bristles not shown; *k*, endopodite of 2nd; *l*, lateral view, protopodite, exopodite, and joint 2 of endopodite of 2nd, bristles on joints 3–9 of exopodite not shown. (Same scale, in microns: *a; b, c, e–g, i, k; d, h, j, l*. All from spec. A.)

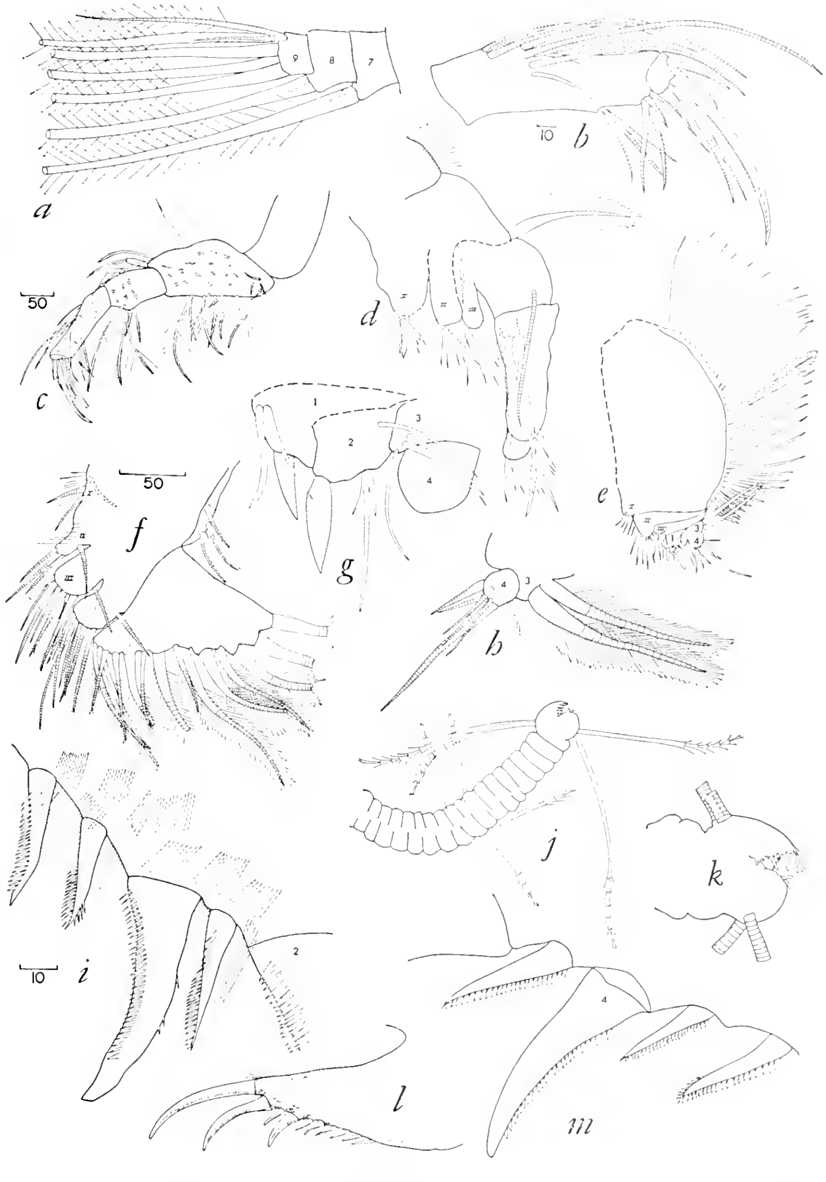


FIGURE 10.—*Euphilomedes asper:* *a*, medial view, joints 7–9, left 2nd antenna; *b*, lateral view, 2nd and end joints of endopodite, right mandible; *c*, right mandible; *d*, left maxilla; *e*, 5th limb; *f*, 6th limb; *g*, joints 1–4, 5th limb, all bristles not shown; *h*, 4th joint and 2 bristles on outer lobe of 3rd joint of 5th limb; *i*, claws 3–6 and part of 2nd claw of furca; *j*, distal part of 7th limb; *k*, terminal of 7th limb; *l*, left lamella of caudal furca; *m*, claws 3–6 and part of 2nd claw. (Same scale, in microns: *a, b, d, h; c, e, l; f, j; g, i, k, m*. Fig. *m* from spec. 1900–3–6–452; remaining figs. from spec. A. Roman numerals on *d–f* refer to endites; Arabic numerals on *a, g, h* refer to joints, on *i, m* to claws.)

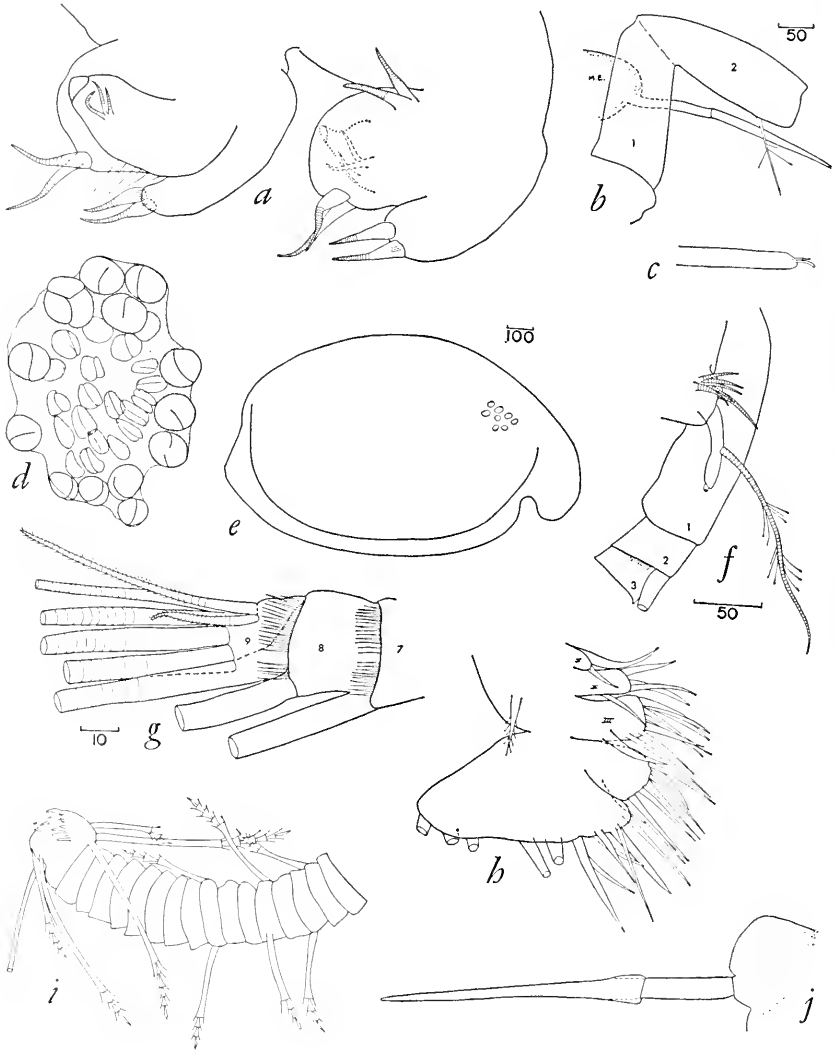


FIGURE 11.—*Euphilomedes asper: a*, copulatory appendage; *b*, frontal organ and medial eye (M. E.) with joints 1–2 of 1st antenna, all bristles on 2nd joint not shown; *c*, tip of frontal organ; *d*, lateral eye. *Euphilomedes* species: *e*, outline of left valve from inside, all punctae not shown; *f*, endopodite and joints 1–3 of exopodite of 2nd antenna, terminal bristle on 2nd joint of endopodite broken; *g*, medial view, joints 7–9, left 2nd antenna; *h*, 6th limb; *i*, distal part of 7th limb; *j*, frontal organ and medial eye. (Same scale, in microns: *a, c, g; d, f, h–j; b; e.* Figs. *a–d* from spec. A; figs. e–*j* from spec. 50002. Roman numerals on *h* refer to endites; Arabic numbers on *b, f, g* refer to joints.)

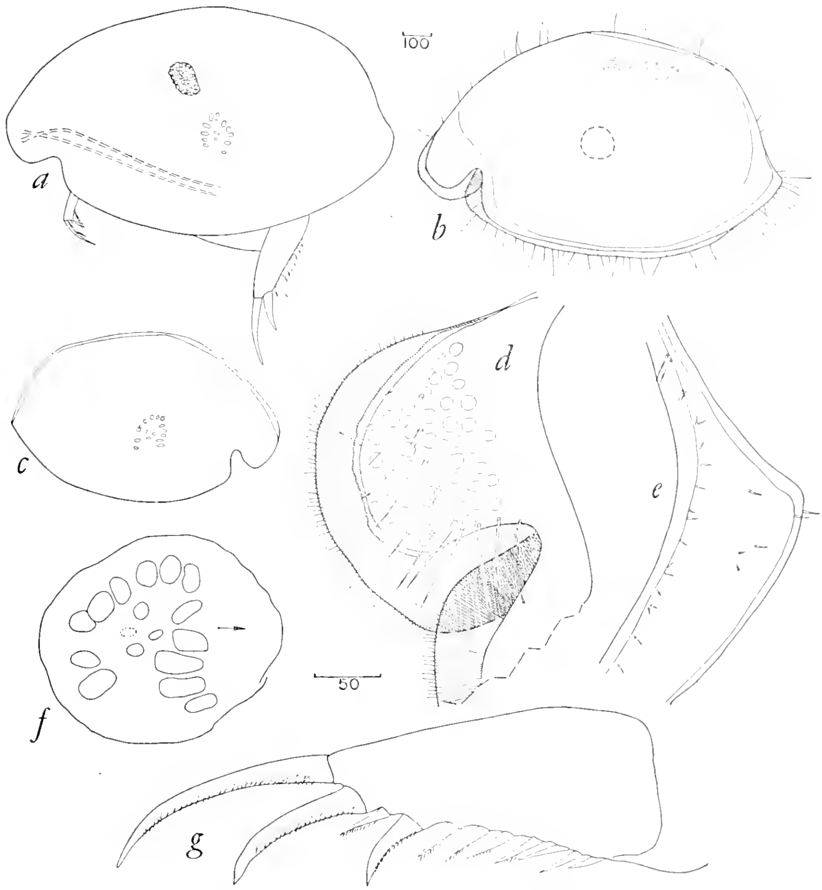
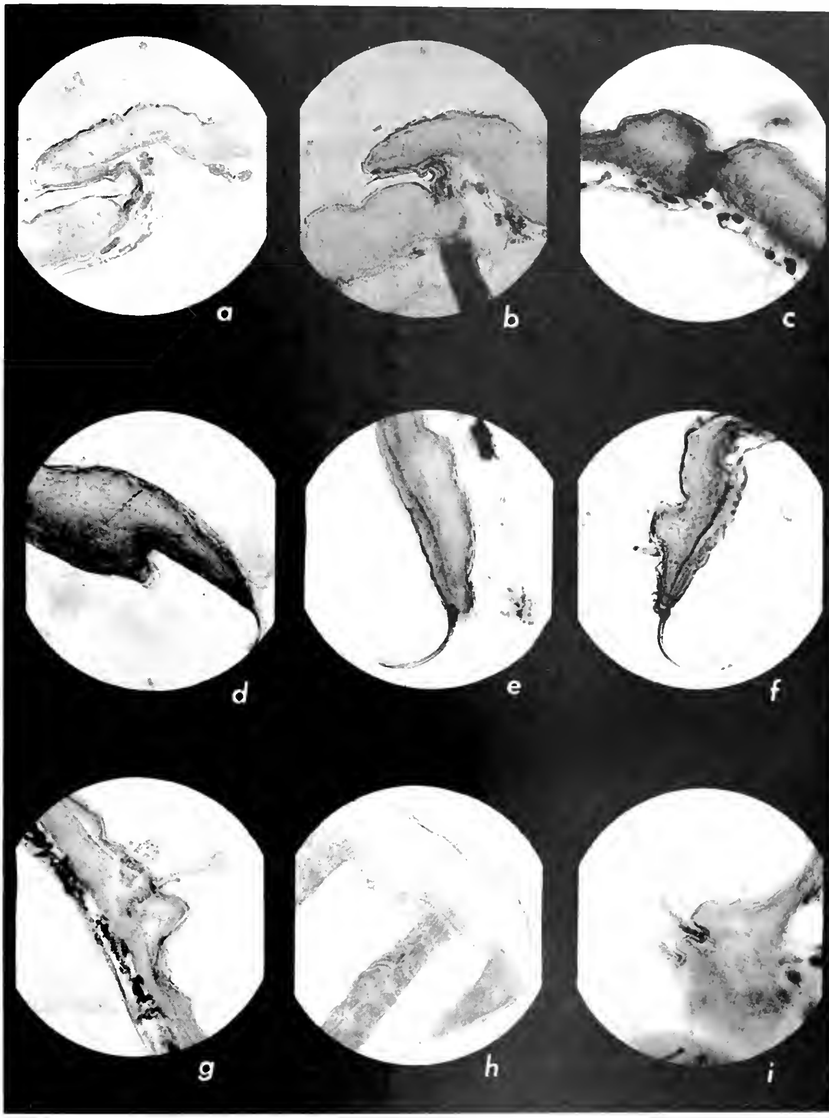


FIGURE 12.—*Euphilomedes asper*, shell: *a*, outline showing central muscle scars and lateral eye; broken lines represent c- and f-bristles. Medial view of valves: *b*, right, broken circle outlines muscle scars, small circles represent punctae; *c*, outline of left, showing muscle scars; *d*, rostrum and incisure of right; *e*, posterior process of right; *f*, muscle scars of left. Caudal furca: *g*, left lamella. (Same scale, in microns: *a–c*; *d–g*. Figs. *a*, *g* from spec. 1; figs. *b*, *d*, and *e* from spec. 2; figs. *c*, *f* from spec. 3. All are syntypes.)



Pseudophilomedes ferulanus, sections: *a*, ligament and left valve overlapping right on anterodorsal margin of carapace; *b*, ligament and muscle to median eye on dorsal margin at highest part of carapace; *c*, hinge and ligament near posterior of hinge; *d*, free margin at anteroventral part of left valve; *e*, free margin at anterodorsal part of left valve; *f*, free margin at ventral part of right valve; *g*, side of left valve showing spiral pore canal leading to hair and reticulate pattern of shell, inner lamella at left; *h*, attachment of adductor muscles on left valve; *i*, sockets of two medial bristles of caudal process. (Photographs taken with oil immersion objective, 100x.)