



















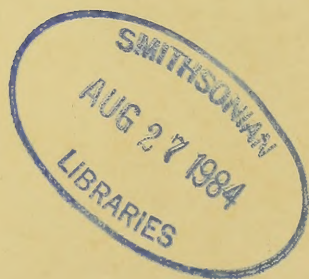






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A REVISION OF THE MILLIPED GENUS  
*DICELLARIUS* WITH A REVALIDATION  
OF THE GENUS *THRINAXORIA*  
(POLYDESMIDA: XYSTODESMIDAE)

Rowland M. Shelley

*Abstract.*—The milliped genus *Dicellarius* consists of the valid species *okefenokensis* (Chamberlin), *atlanta* (Chamberlin), *sternolobus* Loomis, *bimaculatus* (McNeill), and *talapoosa* (Chamberlin), the last two of which are divided into three and two subspecies, respectively. The genus *Thrinaxoria* is revived to accommodate *lampra* (Chamberlin) and *bifida* (Wood). The other two species, *dela* and *leiacantha*, both authored by Chamberlin, are relegated to the synonymy of *D. bimaculatus fictus* (Chamberlin). The seven species are distinguished chiefly by details of the male gonopods, particularly the configurations of the distal elements, but the enlarged pregonopodal sternal lobes distinguish *sternolobus*. Females can also be determined to genus because the two species of *Thrinaxoria* have a receptacle or remnant thereof on the cyphopods, whereas *Dicellarius* lacks this structure. *Dicellarius* is centered in the Gulf Coastal Plain and spreads inland into the southern extremities of the Blue Ridge, Ridge and Valley, and Appalachian Plateau Provinces. *Thrinaxoria* occupies a more northern and western area, ranging from northwestern Louisiana to southwestern North Carolina, and extending southward into the Coastal Plains of Georgia and Alabama. The two species of *Thrinaxoria* are allopatric and separated by over 100 miles. However, specific ranges overlap to a high degree in *Dicellarius*, and only *okefenokensis* is allopatric. *Dicellarius* consists of two lineages, one leading to *talapoosa* and *atlanta*, and the other to *bimaculatus*, *okefenokensis*, and *sternolobus*. Relationships between the three genera in the tribe Pachydesmini are presently unresolved. A new diagnosis is presented for the tribe to reflect improved knowledge of *Dicellarius* and resurrection of *Thrinaxoria*.

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The Gulf Coastal Plain of the southeastern United States is the center of abundance of the milliped tribe Pachydesmini. Two of the component genera, *Pachydesmus* and *Dicellarius*, are the dominant xystodesmids in lowland areas of Mississippi, Alabama, the Florida panhandle, and southern Georgia. *Pachydesmus* has traversed the Mississippi and Tennessee Rivers occurring in northern Louisiana and central Tennessee, but these waterways are distributional barriers for *Dicellarius*. *Pachydesmus* contains the largest American polydesmoids, which grow to over four inches in length, but the forms of *Dicellarius* are only a couple of inches long and equivalent in size to most apheloriine diplopods, though much stiffer. The two taxa possess common anatomical features whose significance was first recognized by Hoffman (1958), and in 1979 he formally united them in the tribe Pachydesmini.

The taxonomy of *Pachydesmus* is stable. It was revised by Hoffman (1958), and Shelley and Filka (1979) reported new distributional records and gonopodal



variants of *P. crassicutis incurtus* Chamberlin. The same cannot be said of *Dicellarius*, however. Its taxonomy is highly confused, and specific names cannot be assigned with any degree of confidence. As with most Nearctic diplopod genera, the existing literature on *Dicellarius* consists of short, vague descriptive accounts accompanied by meaningless illustrations. None of its species has been adequately characterized, and only one, *sternolobus* Loomis, was assigned to *Dicellarius* in its original proposal. The generic validation, moreover, was a single sentence in a paper on other millipeds, so *Dicellarius* has not received a word of diagnosis. Thus, a revision of this genus is needed to stabilize its nomenclature and redescribe the component species, so that the millipeds can be used in field and experimental research in other biological disciplines.

One of the first observations engendered by this study is that *Dicellarius*, as envisioned by Hoffman (1979), is heterogeneous. The Louisiana species formerly in *Thrinaxoria*, *D. lampra* (Chamberlin), is unique in having a sharp caudal bend on the gonopodal acropodite such that the distal elements, widely separated in this species, are discontinuous with the axis. In contrast to the other species, females of *D. lampra* possess a receptacle on the cyphopods, and there is an allopatric eastern form in which both the receptacle and the bend of the acropodite are reduced. The eastern form, occurring in Tennessee, North Carolina, and Georgia, also differs in having a generally longer prefemoral process that is parallel to the acropodite in medial view, as opposed to the Louisiana populations in which the structure angles across the acropodite stem. The magnitude of these and other differences suggests that the two forms are reproductively isolated and that *Thrinaxoria* should be resurrected to accommodate them. Their removal from *Dicellarius* leaves it with a more homogeneous content and results in two generic segregates with comparable differences between their component species. As a consequence of this change and from improved anatomical knowledge of all the species, alterations are necessary in Hoffman's diagnosis (1979:187) of the tribe Pachydesmini. The species of both *Dicellarius* and *Thrinaxoria* lack coxal apophyses, which are therefore an apomorphic feature of *Pachydesmus*. The transverse sternal ridges called "podosterna" for *Pachydesmus* (Hoffman 1958) are reduced and sometimes barely detectable in both *Dicellarius* and *Thrinaxoria*, so their usage as a primary tribal character should be qualified. Hence, I also include a revised diagnosis of this tribe, whose chief features are gonopodal.

The realization that *Thrinaxoria* is a valid genus comprised of two species affords the opportunity to resolve an outstanding enigma in diplopodology and assign the name *Polydesmus bifidus* Wood, heretofore regarded unofficially as a nomen inquirendum. In transferring *bifidus* to *Epeloria*, Chamberlin and Hoffman (1958) predicted that it might be a form of *Thrinaxoria*, and this prophecy can now be confirmed. The types of this species are lost, and Wood's original description and illustration (1864, 1865) do not clearly indicate the identity of the form(s) under study. However, he had material from both Georgia and Texas, which corresponds closely to the known range of *Thrinaxoria*, since *lampra* probably occurs in the northeastern corner of Texas (see species account). Wood's illustration of the *bifidus* gonopod is also very similar to the in situ configuration of the two species of *Thrinaxoria* (compare with Fig. 25), so I think he had both forms on hand and assumed they were conspecific. Wood did not give precise

localities for his material, only the states of Georgia and Texas. However, the Georgia sample was probably from the mountains of north Georgia since the eastern species of *Thrinaxoria* is more common in this section of the state (see Fig. 29). Wood did not indicate which sample he considered the types, so his name could be assigned to either species of *Thrinaxoria*. However, since *lampra* is available for the western species, both names are conserved by assigning *bifida* to the eastern one and changing the gender of the suffix. This resolution is also compatible with the law of priority, which does not apply here, since Georgia precedes Texas in Wood's accounts. In the absence of his material, I designate a neotype for *bifida* from Polk County, Tennessee, which is adjacent to Fannin and Murray counties, Georgia, and the only county where more than one male has been collected.

As with *P. bifidus*, the type specimens of *Fontaria lamellidens* Chamberlin are also lost. However, Chamberlin (1931) reported a precise type locality, Biloxi, Harrison County, Mississippi, and the identity of this nominal species can be determined from near topotypical material. My analysis indicates that *F. lamellidens* is a race of *D. bimaculatus* (McNeill).

In the *Dicellarius* section of this paper, I depart from my usual practice of describing the type-species and comparing and contrasting the others with it. The type-species of *Dicellarius*, *D. okefenokensis* (Chamberlin), is atypical in its small size and gonopodal torsion, and I have therefore chosen *D. bimaculatus* as the basis for anatomical comparisons in this genus. I also show only the medial aspect of the gonopods of most forms because the prefemoral process is masked in lateral view and the positions of the solenomerite and tibiotarsus are merely reversed. This study indicates that *Dicellarius* consists of five valid species, two of which have recognizable geographic races, and that *Thrinaxoria* is comprised of two species. Information on variation and distribution is presented in the species or subspecies accounts along with appropriate synonymies. Acronyms of sources of preserved study material are as follows:

AU—Department of Zoology and Entomology, Auburn University, Auburn, Alabama.

CC—Biology Department, Columbus College, Columbus, Georgia.

FSCA—Florida State Collection of Arthropods, Gainesville, Florida.

MCZ—Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts.

MEM—Mississippi Entomological Museum, Mississippi State University, Starkville, Mississippi.

NCSM—North Carolina State Museum of Natural History, Raleigh, North Carolina. The invertebrate catalog numbers of material in this institution are indicated in parentheses.

NMNH—National Museum of Natural History, Smithsonian Institution, Washington, D.C.

RLH—Private collection of Richard L. Hoffman, Radford, Virginia.

RVC—Private collection of the late Ralph V. Chamberlin, now being accessioned by the NMNH.

UMMZ—Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

WAS—Private collection of William A. Shear, Hampden-Sydney, Virginia.



## Literature Review

The genus *Dicellarius* was established incidentally by Chamberlin (1920) in the introduction to a paper describing a new species of *Eurymerodesmus*. It was mistakenly assigned to the family Leptodesmidae, now a synonym of Chelodesmidae. The single sentence proposing the taxon reads, "The second (new North American leptodesmid genus) may bear the name *Dicellarius*, with *Leptodesmus okefenokensis* Chamberlin the genotype." According to the International Commission of Zoological Nomenclature, this pre-1931 statement validates *Dicellarius* because it was published in combination with an indication, an available specific name. Thus, *Dicellarius* is the oldest genus-group name for forms referable to *Epeloria* and *Spathoria*, and must be retained in modern xystodesmid taxonomy even though no diagnostic statements have ever been published. Its type-species was described by Chamberlin (1918) from Billy's Island in the Okefenokee Swamp, Georgia.

Chamberlin (1931) proposed *Fontaria lamellidens* from Biloxi, Mississippi, and (1939) designated it the type of the new genus *Spathoria*. *Polydesmus bimaculatus*, described by McNeill (1887) from Pensacola, Florida, was transferred into *Spathoria* as the other component species. Chamberlin (1939) also erected *Epeloria* for the new species *E. talapoosa*, misspelling the type locality, Tallapoosa, Georgia, in both the locality citation and the specific name. Since the name was misspelled in both places, it cannot be considered an emendable lapsus, and the error must be retained in modern nomenclature.

During the 1940's, Chamberlin named five new species of *Epeloria* as follows: *fictus* (1943), *dela* and *leiacantha* (1946a), *atlanta* (1946b), and *nannoides* (1949). Chamberlin and Hoffman (1950) erected *Thrinaxoria* for *Fontaria lampra* Chamberlin, listing *Zinaria aberrans* Chamberlin as a synonym. These two nominal species were described from Louisiana by the author in 1918 and 1942, respectively. During this period new locality records of *E. leiacantha* were reported by Chamberlin (1947, 1951), and Causey (1955) published the first Florida locality of *E. fictus*. Causey also transferred *bimaculatus* into *Epeloria* from *Spathoria* and reported new localities for this species from Alabama and Mississippi. Chamberlin and Hoffman (1958) recognized three genera in their checklist—*Dicellarius*, *Epeloria*, and *Thrinaxoria*—and assigned *Spathoria* to synonymy under *Dicellarius*. Thus *Dicellarius* consisted of *okefenokensis*, the type-species; *bimaculatus*, transferred from *Epeloria*; and *lamellidens*, referred there because of the generic synonymy. They listed all the species under *Epeloria* that were then assigned to it except *nannoides*, which was synonymized with *D. okefenokensis*, and also brought *Polydesmus* (*Fontaria*) *bifidus* Wood into the genus, predicting that it might prove to be a form of *Thrinaxoria*. Thus *Epeloria* included *talapoosa*, *dela*, *leiacantha*, *atlanta*, *ficta* and *bifida*. As in 1950, Chamberlin and Hoffman (1958) still considered *Thrinaxoria* to be monotypic, and they added Tuscaloosa, Alabama, as the second locality for *lampra*.

Since 1958 only two authors have dealt with *Dicellarius*. Loomis (1969) proposed *D. sternolobus* from Tallapoosa County, Alabama, and published a key distinguishing *bimaculatus*, *lamellidens*, *okefenokensis*, and *sternolobus*, the four species then in the genus. Hoffman (1979) placed *Epeloria*, *Thrinaxoria*, and *Spathoria* in synonymy under *Dicellarius* and formally proposed the tribe Pachydesmini for *Pachydesmus* and *Dicellarius*. He also stated that *Dicellarius* consisted

of four species in the southeastern states, but since these were not mentioned specifically, the previous taxonomy still stands. Thus at this writing, *Dicellarius* consists of the following 11 species listed chronologically below with their type localities and other reported states of occurrence. Suffix endings have been changed to masculine where necessary for agreement in gender.

*D. bifidus* (Wood, 1864). Described from Georgia and Texas, no definite localities known.

*D. bimaculatus* (McNeill, 1887). Pensacola, Escambia Co., Florida; also reported from Mobile Co., Alabama, and Jackson Co., Mississippi.

*D. okefenokensis* (Chamberlin, 1918). Billy's Island, Okefenokee Swamp, Charlton Co., Georgia; also reported from Gainesville, Alachua Co., Florida.

*D. lamprus* (Chamberlin, 1918). Creston, Natchitoches Par., Louisiana; also reported from Shreveport, Caddo Par., Louisiana; and Tuscaloosa, Tuscaloosa Co., Alabama.

*D. lamellidens* (Chamberlin, 1931). Biloxi, Harrison Co., Mississippi.

*D. talapoosa* (Chamberlin, 1939). Tallapoosa, Haralson Co., Georgia.

*D. fictus* (Chamberlin, 1943). Thomasville, Thomas Co., Georgia; also reported from Tallahassee, Leon Co., Florida.

*D. delus* (Chamberlin, 1946). Morgan, Calhoun Co., Georgia, incorrectly reported as being in Morgan Co. by Chamberlin and Hoffman (1958).

*D. leiacanthus* (Chamberlin, 1946). Along Spring Cr., Decatur Co., Georgia; also reported from Ft. Benning, Muscogee-Chattahoochee cos., Georgia, and an unspecified county in Alabama.

*D. atlanta* (Chamberlin, 1946). Atlanta, Fulton-Dekalb cos., Georgia.

*D. sternolobus* Loomis, 1969. Alexander City, Tallapoosa Co., Alabama.

### Taxonomic Characters

The genera *Dicellarius* and *Thrinaxoria* can be distinguished in either sex. In females of the latter, the cyphopods possess a receptacle or remnant thereof, whereas this structure is absent in *Dicellarius*. In males of *Thrinaxoria* the solenomerite and tibial process of the acropodites, collectively referred to as "distal elements," arise near midlength, are widely separated, and never lie over one another in medial or lateral views. In *Dicellarius* the elements arise distal to the midlength, are moderately separated at best, and one is frequently obscured by the other in these perspectives. *Pachydesmus* differs from both these taxa in the large postgonopodal sternal elevations, the apophyses on the gonopodal coxae, and the proximal origin of the elements of the acropodite, which arise at the juncture with the prefemur.

In *Dicellarius*, body size is useful in distinguishing *D. okefenokensis*, since it is much smaller than any other congener. It is the only species whose adults are less than 30 mm long and 5 mm wide, and female only samples of *D. okefenokensis* and *D. b. fictus* can therefore be separated on this basis. The only other somatic features of taxonomic importance in *Dicellarius* are the pregonopodal sternal projections in *D. sternolobus*. Although variable, these structures are distinctly visible on segments 4 and 5, and are at least subequal in length to the widths of the adjacent coxae (Figs. 19–20). In all the other species, the processes are small and have no taxonomic value (Figs. 1–2).

The remaining taxonomic characters in *Dicellarius* are located on the gonopods.



Aspects that are important include the in situ configuration, the orientation of the prefemoral process, the general curvature and configuration of the acropodite, the course of the prostatic groove, and the shape of the distal elements.

In most forms the tips of the acropodites overlap in situ (Figs. 7, 13), and where they are far enough apart, the distal elements may crisscross (Fig. 15). In *D. atlanta* and *D. bimaculatus fictus*, however, the acropodites do not overlap but lie side by side in a subparallel arrangement (Figs. 5, 17), thus allowing distinction from the other forms.

The prefemoral process is acicular to some degree in most forms of *Dicellarius*, but it is directed differently due largely to the configuration of the acropodite. The process lies parallel to the acropodite stem (above in medial view) in many forms, but it may angle across the stem with the tip either lying over the far side or protruding beyond the opposite margin (Figs. 8, 14, 22). In *D. okefenokensis* and *D. bimaculatus fictus*, the acropodite curves subanteriorly so that the distal elements overhang the level of the prefemoral process in the former (Fig. 10) and overlap the tip of the process in the latter (Fig. 6).

The prostatic groove is typically completely visible in medial view from its origin in the base of the prefemur to its termination at the tip of the solenomerite. In some forms, however, it meets the anterior margin at the base of the solenomerite, where it continues to the terminal opening (Fig. 14, 18). The extreme condition obtains in *D. okefenokensis*, where the groove crosses to the lateral side because of torsion in the acropodite (Figs. 10–12). This situation is convergent with torsion in the tribe Apheloriini, and represents a derived, autapomorphic trait in *D. okefenokensis*.

The configuration of the distal elements and their position relative to each other are very important in the identification of a species or subspecies of *Dicellarius*. They are at most only moderately separated, and either lie parallel to each other or diverge apically. Both structures may be visible in medial or lateral views, in which case the gap between them also shows (Fig. 18), or one may overlies the other, completely obscuring the gap and at least partly hiding the opposite member (Figs. 8, 10). The tibial process may be shorter or longer than the solenomerite, but it is never narrower and sometimes is considerably wider. The configuration of the solenomerite is the most reliable determinant of the highly variable species *D. bimaculatus*. Here the structure is parallel-sided except for the tip, where the outer edge angles abruptly toward the inner forming a subacuminate inner corner (Figs. 4, 6, 8). Another way of describing this condition would be to say that the inner corner is produced or elongated. By contrast, the solenomerite is acicular in *D. talapoosa*, *D. atlanta*, and *D. sternolobus*, and both sides taper smoothly and continuously throughout the length to a subacuminate tip located in the midline (Figs. 14, 16, 18, 22).

In *Thrinaxoria* the taxonomic characters involve the size of the receptacle on the cyphopods, the degree of bend on the acropodites, and the length and orientation of the prefemoral process. *Thrinaxoria lamprea* has a moderate-size receptacle, whereas it is a remnant or vestige in *T. bifida*. The acropodites display a smoother curve in the latter species, and the distal elements are more or less continuous with the curvature. The prefemoral process in *T. lamprea* is shorter than in *T. bifida* and always angles across the acropodite stem in medial view. In

*T. bifida*, however, the structure usually lies parallel to the acropodite and extends linearly along its anterior margin (Figs. 26, 28).

### Tribe Pachydesmini Hoffman

Pachydesmini Hoffman, 1979:158, 187.

*Components*.—*Pachydesmus* Cook, 1895; *Dicellarius* Chamberlin, 1920; *Thrinaxoria* Chamberlin and Hoffman, 1950.

*Diagnosis*.—Relatively stiff, inflexible Xystodesminae of small to large size; sterna broad, with or without variable, transversely oval ridges or elevations on midbody segments; gonopods small to large, with or without dorsal coxal apophysis, telopodite usually linear proximad, curving or bending distal to midlength, with long slender accessory process paralleling acropodite or with slender subterminal branch; cyphopods with or without receptacle or remnant thereof.

*Range*.—Southeastern United States, from the eastern edge of Texas to coastal Georgia, South Carolina, and the southcentral part of North Carolina (Piedmont Plateau) just north of the state line, ranging northward across Tennessee and southward into the central Florida peninsula.

*Remarks*.—This revised diagnosis incorporates several modifications necessitated by validation of *Thrinaxoria* and by improved knowledge of *Dicellarius*. It allows for the small size of *D. okefenokensis*; the absence of the coxal apophysis in all species of *Thrinaxoria* and *Dicellarius*; the reduced sternal ridges in both genera; and the variable condition of the receptacle on the cyphopods. These changes diminish the tribe's distinctiveness from the Apheloriini, over which it has taxonomic priority. An additional diagnostic phrase is therefore inserted on the generally linear telopodites, demonstrated by all species except *D. okefenokensis*, in which the broad curvature is clearly derived. This feature of the telopodites does distinguish the Pachydesmini from the Apheloriini, where as described by Hoffman (1979), the telopodites are either semicircular, sigmoidal, or are bent or curved strongly mesad. The date of proposal of *Dicellarius* is also corrected to 1920.

### Genus *Dicellarius* Chamberlin

*Dicellarius* Chamberlin, 1920:97.—Chamberlin and Hoffman, 1958:30.—Hoffman, 1979:158.

*Epeloria* Chamberlin, 1939:3; 1949:101.—Causey, 1955:24.—Chamberlin and Hoffman, 1958:32.

*Spathoria* Chamberlin, 1939:6.

*Type-species*.—Of *Dicellarius*, *Leptodesmus okefenokensis* Chamberlin, 1918, by original designation; of *Epeloria*, *E. talapoosa* Chamberlin, 1939, by original designation; of *Spathoria*, *Fontaria lamellidens* Chamberlin, 1931, by original designation.

*Description*.—A genus of small to moderately large xystodesmids with the following characteristics:

Body composed of head and 20 segments in both sexes; size varying from 4—



8.5 mm in width and 22–42 mm in length; W/L ratio similarly varying from about 17–22.5%.

Color in life variable; most forms with drab olive-brown base color, lighter margins, and darker stripes along caudal edges of metaterga.

Head of normal appearance, moderately smooth and polished, occasionally finely granulate. Epicranial suture distinct, terminating in interantennal region, not apically bifid; interantennal isthmus variable; genae not margined laterally, with variable central impressions, ends broadly rounded and projecting slightly beyond adjacent cranial margins. Antennae moderately slender, varying in length, becoming progressively more hirsute distally, with 4 conical sensory cones on ultimate article; no other sensory structures apparent. Facial setae with epicranial, frontal, genal, clypeal, and labral series; with or without interantennal and subantennal.

Terga usually smooth and moderately polished; becoming moderately coriaceous on paranota. Collum variable, ends subequal to or extending well beyond those of following tergite. Paranota moderately to strongly depressed, caudolateral corners rounded on anteriormost segments, becoming blunt in midbody regions and progressively more acute posteriorly. Peritremata distinct, strongly elevated above paranotal surface; ozopores located caudal to midlength, opening dorsad to dorsolaterad. Prozonites smaller than metazonites; strictures moderately distinct, slightly costulate.

Caudal segments normal for family.

Sides of metazonites variable, usually granulate, with or without shallow grooves and impressions. Gonapophyses broad, apically expanded. Pregonopodal sterna of males variously modified; that of segment 4 with minute projection, much shorter than widths of adjacent coxae, or large apically divided process, longer than widths of adjacent coxae; sternum of segment 5 with low, transverse ridge or large, ventrally directed process between anterior legs, latter much longer than widths of adjacent coxae, and with variable impressions between posterior legs; 6th sternum with variable impressions between caudal legs to accommodate apices of acropodites. Postgonopodal sterna mildly hirsute, with or without variable low, rounded, longitudinal or transverse elevations in midlines of midbody segments. Coxae without projections; prefemoral spines relatively long and sharply pointed; tarsal claws slightly bisinuate. Hypoproct broadly rounded; paraprocts with margins slightly thickened.

Gonopodal apertures ovoid to elliptical, with or without slight anteriolateral indentations, sides flush with or slightly elevated above metazonal surfaces. Gonopods in situ with apices overlapping, interlocking, or lying parallel to one another; usually with tips of prefemoral processes crossing. Coxae moderate in size, without apophyses, connected by membrane only, no sternal remnant. Prefemora moderate, with variable prefemoral processes arising on anterior or anteriomedial sides. Acropodites moderately thick and robust, well sclerotized; configurations variable, either extending sublinearly from prefemur or curving slightly antieriad; divided at around  $\frac{2}{3}$  length into solenomerite and tibial process, both variable in length, configuration, and position relative to the other. Prostatic grooves arising in pits in bases of prefemora, usually running entirely along medial sides of acropodite stems, crossing to anterior and lateral surfaces in some species; opening terminally on solenomerites.

Cyphopodal apertures elliptical, encircling 2nd legs, sides slightly elevated above metazonal surfaces, without pleurotergal lobes on anteriolateral corners. Cyphopods in situ located lateral to 2nd legs, variably positioned in apertures; without receptacles. Valves moderate to large, subequal, surfaces finely granulate. Opercula relatively large, located on lateral sides of valves.

*Distribution.*—Coastal Plain of Georgia, Florida, Alabama, and Mississippi; southern Ridge and Valley and Appalachian Plateau Provinces of Alabama; Piedmont Plateau and southern fringe of Blue Ridge Province of Georgia and North Carolina. The Tennessee River is a distributional barrier in northern Alabama, and the Savannah River forms the range limit along the Atlantic Coast.

*Species.*—Five, two of which are divided into two and three subspecies.

Key to species of *Dicellarius* (based primarily on adult males)

- 1. Body size small; acropodites with torsion, prostatic groove crossing from medial to lateral sides; tibial process overlying and largely obscuring solenomerite in medial view; southeastern Georgia to central Florida . . . . . *okefenokensis* (Chamberlin)
- Body size moderate; acropodites without torsion, prostatic groove either running entirely on medial side or angling to anteriomedial edge at mid-length; distal elements variable in position and configuration, but tibial process never overlying solenomerite in medial view . . . . . 2
- 2. Sterna of segments 4 and 5 with large, ventrally directed processes, subequal to or longer than widths of adjacent coxae; solenomerite overlying tibial process in medial view, sides tapering smoothly and continuously to subacuminate tip; tibial process with several grooves and ridges on lateral surface; central Alabama . . . . . *sternolobus* Loomis
- Sterna of segments 4 and 5 with at most minute projections, much smaller than widths of adjacent coxae; solenomerite variable, occasionally overlying tibial process in medial view and with sides parallel except apically; tibial process without noticeable ridges and grooves . . . . . 3
- 3. Tibial process broad, spatulate; sides of solenomerite parallel except apically, then narrowing abruptly to subacuminate tip on inner corner; central and eastern Georgia to western Florida, southern Alabama, and southern and eastern Mississippi . . . . . *bimaculatus* (McNeill)
- Tibial process and solenomerite acicular, sides narrowing smoothly and continuously to subacuminate tips located in midlines . . . . . 4
- 4. Acropodite sublinear; distal elements subequal, moderately separated; prefemoral process on anterior side of acropodite; western North Carolina to central Georgia . . . . . *atlanta* (Chamberlin)
- Acropodite curved gently caudad; distal elements contiguous to narrowly separated, solenomerite slightly longer; prefemoral process angling across stem of acropodite to caudal side; north-central Alabama to western Georgia . . . . . *talapoosa* (Chamberlin)

*Dicellarius bimaculatus* (McNeill)

*Diagnosis.*—Acropodite highly variable, either curved subanteriorly, subcaudad, or submedial. Distal elements narrowly separated, continuing general curvature



of acropodite, in some forms overlying one another in medial and lateral views; solenomerite laminate, sides parallel except at apex, then narrowing abruptly to subacuminate tip on inner corner; tibial process laminate and apically rounded, subequal in length to solenomerite.

*Remarks.*—*Dicellarius bimaculatus* is the widely-distributed species along the Gulf of Mexico occurring in the Coastal Plains of Georgia, Alabama, Mississippi, and the Florida panhandle. The type locality is Pensacola, Escambia County, Florida. Forms in the eastern  $\frac{2}{3}$  of the range demonstrate considerable gonopodal stability, but the incidence of variation rises around the Alabama and Escambia Rivers. Populations become increasingly more variable west of this point, and the gonopodal differences between forms at Mobile, Alabama, and Biloxi, Mississippi, a distance of about 45 miles, are much greater than the differences between forms at Savannah, Georgia, and Montgomery, Alabama, a distance of over 300 miles. The situation west of these rivers approaches a clinal transition, particularly along the Gulf Coast, and presents difficulties in making taxonomic decisions. The widespread, anatomically stable eastern form clearly represents a single geographic race, and three Chamberlinian names are available, the oldest being *D. b. fictus*. In the rest of the range, one could justifiably recognize one large, highly variable subspecies or a number of smaller, more stable ones. Two names have been proposed for forms from this area, *D. bimaculatus* the oldest one referable to the complex and hence the specific name, and *D. lamellidens* (Chamberlin). Thus, if subspecies are designated, the nominate will be from this area of anatomical instability. One alternative would be to include the form at Pensacola with the eastern one, enlarge its range slightly, and make it the nominate subspecies. However, I think that the stable eastern morphotype deserves recognition in its own right and that the nominate subspecies should therefore refer to another form. After analyzing males from every sample west of the Alabama and Escambia Rivers, it became evident that a single taxonomic unit could be described from all of this area except the coast of Mississippi. This entity becomes the nominate subspecies and is necessarily much more variable than *D. b. fictus*. However, the much greater variation along the coast of Mississippi clearly requires separate treatment. Since the name *lamellidens* is available, I propose a third subspecies with much smaller range west of the Pascagoula River. East of this boundary and in the city of Pascagoula the forms are intermediate between the "average" variant of *D. b. bimaculatus* and are thus considered intergrades. Other resolutions are possible, but this one maximizes the existing nomenclature and provides a balance between naming nearly every local population west of the Alabama and Escambia Rivers and ignoring subspecies altogether.

*Dicellarius bimaculatus bimaculatus* (McNeill), new status

Figs. 1-4

*Polydesmus bimaculatus* McNeill, 1887:323, figs. 3-5.

*Fontaria bimaculata*.—Attems, 1938:166.

*Spathoria bimaculata*.—Causey, 1955:24.

*Dicellarius bimaculatus*.—Chamberlin and Hoffman, 1958:30.

*Type specimens.*—Three male and 15 female syntypes (NMNH) collected by

C. H. Bollman, Mar–Apr 1886, at Pensacola, Escambia Co., Florida. I have designated one male as the lectotype.

*Diagnosis.*—Gonopods in situ with tips of acropodites curved slightly mediad and overlapping, prefemoral processes overlapping; prefemoral process narrow and acicular, tapering gradually distad, angling across acropodite stem and lying nearly entirely over latter in medial view; acropodite with curvature in medial plane and thus masked in medial view, extending sublinearly from prefemur; distal elements subequal in width and length, continuing linear configuration of acropodite; solenomerite with edge directed mediad.

*Lectotype.*—Length 31.3 mm, maximum width 6.3 mm, W/L ratio 20.1%, depth/width ratio 65.1%. Segmental widths as follows:

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collum	4.9 mm	5th–15th	6.3
2nd	5.4	16th	5.8
3rd	5.8	17th	5.2
4th	6.0	18th	4.1

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Color in life unknown. McNeill (1887) described the dorsum as being “obscure olive or chestnut, the scuta generally marked with an indistinct transverse dark band, with lighter color towards the margins; a well defined oval spot of gray is frequently present on the lateral margins; lateral laminae with a narrow pink border.” This corresponds generally to my observations on living species of *Di-cellarius*.

Head capsule smooth, polished; width across genal apices 3.3 mm, interantennal isthmus 1.4 mm; epicranial suture thin but distinct, terminating above interantennal region, not bifid. Antennae relatively short, reaching back only to middle of 3rd segment, becoming progressively more hirsute distally, first antennomere subglobose, 2–6 clavate, 7 short and truncate, relative lengths of antennomeres 2 > 6 > 3 > 4 > 5 > 1 > 7. Genae not margined laterally, with distinct central impressions, ends broadly rounded and projecting slightly beyond adjacent margin of cranium. Facial setae as follows: Epicranial 2-2, interantennal absent, frontal 1-1, genal 3-3, clypeal about 14-14, labral about 20-20, merging with clypeal series and continuing for short distance along genal borders, about 3 setae on each side.

Terga smooth, polished, becoming moderately coriaceous on paranota. Collum broad, ends extending slightly beyond those of 2nd tergite. Paranota moderately depressed, continuing slope of dorsum, anterior corners blunt with distinct, elevated scapulae, caudolateral corners rounded through segment 5, becoming blunt and progressively more acute posteriorly. Peritremata distinct, strongly elevated above paranotal surface. Ozopores located caudal to midlength of peritremata, opening dorsolaterad.

Sides of metazonites dull and granulate but without noticeable grooves or impressions. Strictures sharp, distinct, prozona elevated slightly above metazona. Gonapophyses broad, apically expanded. Pregonopodal sterna (Figs. 1–2) generally unmodified, without noticeable lobes or projections; 6th sternum recessed slightly between 7th legs to accommodate apices of acropodites. Postgonopodal sterna higher than prozonites, with transverse grooves between leg pairs merging



into low, rounded, longitudinal elevations in midlines, elevations noticeable only on segments 8–15; caudal margins of sterna indented medially. Pregonopodal legs densely hirsute, postgonopodal legs becoming progressively less hirsute caudally. Coxae without projections; prefemoral spines beginning on segment 5, becoming longer and sharper on midbody region; tarsal claws faintly bisinuate. Hypoproct rounded, paraprocts with margins slightly thickened.

Gonopodal aperture 2.0 mm wide and 0.9 mm long at midpoint, indented slightly anteriolaterad, sides flush with metazonal surface. Gonopods in situ (Fig. 3, not this specimen) with acropodites projecting anteriorly from aperture, extending well beyond anterior margin of aperture with tips overlapping between 7th legs, prefemoral processes also overlapping and extending beyond aperture. Gonopod structure as follows (Fig. 4): Prefemur moderate, with long acicular prefemoral process on anterior side angling over acropodite stem, bent anteriorly distally and terminating just beyond base of tibial process, tip directed toward midlength of solenomerite. Acropodite curving submediad and curvature thus masked in medial view, projecting linearly from prefemur, sides narrowing gradually, divided at  $\frac{3}{4}$  length into anterior solenomerite and posterior tibial process. Latter laminate, subequal in length to solenomerite, apically blunt. Solenomerite with sides subparallel except at apex, then narrowing abruptly to subacuminate tip on inner corner, curving broadly mediad with edge visible in medial view. Prostatic groove arising in pit in prefemur extending along medial surface of acropodite onto solenomerite, opening apically.

*Female paralectotype*.—Length 30.8 mm, maximum width 6.9 mm, W/L ratio 22.4%, depth/width ratio 63.8%. Agreeing closely with lectotype in most somatic features, except paranota more strongly depressed, giving appearance of more highly arched body, and sternal elevations greatly reduced, barely detectable.

Cyphopodal aperture elliptical, encircling 2nd legs, sides barely elevated above metazonal surface, without pleurotergal lobe on anteriolateral corners. Cyphopods in situ with valvular openings visible in aperture; valves large, subequal, surface finely granulate. Receptacle absent. Operculum relatively large, located on lateral side of valves, surface finely granulate.

*Variation*.—The length of the prefemoral process varies, and it does not extend to the level of the acropodite division in some males. It is always acicular, but does not always extend across the acropodite stem. In one male there is a small, subterminal spur. In all forms the acropodite curvature visible in situ (Fig. 3) is masked in medial view because it lies in the plane of vision and perpendicular to the plane of drawing. However, not all the acropodites are as straight as that of the lectotype. Some bend anteriorly, as in *D. b. fictus*, while others tend to lean caudad. In the eastern part of the range the distal divisions appear as in the lectotype, but farther west in Mississippi they lean caudad and the anterior surface is seen in medial view. This variation befits the intermediate geographical position of *D. b. bimaculatus* between the other two subspecies.

*Distribution*.—Western Florida, southwestern and west-central Alabama, and east-central Mississippi. The Conecuh-Escambia River forms the approximate eastern boundary, but the western and northern extremes do not correspond with any physiographic features. Most localities are west of the Mobile-Tombigbee River. The subspecies is sympatric and syntopic with *T. lampra* in Washington

County, Alabama, along the Tombigbee River. Specimens were examined as follows:

FLORIDA: *Escambia Co.*, Pensacola, 3M, 15F, Mar–Apr 1886, C. H. Bollman (NMNH), F, Nov 1969, C. Seal (FSCA), and 3M, 7F, 15 Mar 1970, C. Seal (FSCA) TYPE LOCALITY; 3 mi. W Pensacola, 3M, F, 22 Jan 1965, N. B. Causey (FSCA); Atmore, 3M, F, 15 Mar 1962, C. R. Parker (FSCA); along US hwy. 90 E jct. FL hwy. 29, M, 1 Jan 1954, N. B. Causey (FSCA); Cantonment, M, 1 May 1954, N. B. Causey (FSCA); and 3 mi. SE Cantonment M, 25 Nov 1967, M. Tidwell (FSCA).

ALABAMA: *Monroe Co.*, 2.5 mi. E Chrysler, F, 18 Apr 1976, M. R. Cooper (NCSMA735); and 6 mi. S Monroeville, M, 10 Mar 1977, R. E. Woodruff (FSCA). *Conecuh Co.*, 0.8 mi. E Castleberry, along AL hwy. 6 at Murder Cr., M, 24 Apr 1983, R. M. Shelley and P. B. Nader (NCSM A4056); Evergreen, 3M, 10 Apr 1960, L. Hubricht (RLH); and 15 mi. N Evergreen, M, F, 9 Apr 1960, L. Hubricht (RLH). *Baldwin Co.*, Daphne, M, F, 14 Mar 1948, B. A. Maina (RLH); jct. US hws. 90 & 98 W Loxley, 2F, 22 Jan 1955, N. B. Causey (FSCA). *Mobile Co.*, Spring Hill College, several MM, FF, 2 May 1954, C. E. Valentine (FSCA); Grand Bay, 4M, F, 17 Jun 1953, N. B. Causey (FSCA); Mobile, F, Apr 1954, N. B. Causey (FSCA); Theodore, M, 4F, 21 Jun 1961, L. Hubricht (RLH); 2.5 mi. SW Bucks, 2F, 13 May 1962, L. Hubricht (RLH); and along Alligator Cr. nr. Dog R., 2M, 3F, 21 Sep 1952, collector unknown (UMMZ). *Washington Co.*, 3 mi. E Leroy, 3 Jul 1960, L. Hubricht (RLH). *Clarke Co.*, Jackson, M, F, 23 Sep 1910, R. V. Chamberlin (RVC); Walker Springs, 2M, 25 Jul 1965, S. B. Peck (FSCA); and Coffeyville, F, 16 Jun 1959, N. B. Causey (FSCA). *Choctaw Co.*, E of Lavaca nr. Tombigbee R., M, F, 4 Jul 1960, L. Hubricht (RLH).

MISSISSIPPI: *Oktibbeha Co.*, State College, M, 19 Apr 1917, S. B. Pearce (MCZ); Craig Springs, 6M, F, 22 Apr 1980, and 3M, F, 15 May 1980, G. Snodgrass (MEM); and Starkeville, M, 14 May 1982, G. Sullivan (MEM). *Winston Co.*, Noxapater, 3 juvs., 29 Dec 1965, J. B. Black (FSCA). *Lauderdale Co.*, Meridian, 7M, F, 10 Dec 1961, L. Hubricht (RLH). *Jasper Co.*, Louin, 2M, 24 Mar 1963, L. Hubricht (RLH). *Wayne Co.*, 8 mi. E Waynesboro, 3M, 3F, 13 Mar 1963, L. Hubricht (RLH). *Jones Co.*, nr. Laurel, M, 2F, 15 Jul 1980, J. Robbins (MEM). *Lamar Co.*, Oak Grove, F, 12 Apr 1957, L. Smith (FSCA). *Forrest Co.*, Rawls Springs Twp. nr. Hattiesburg, M, 15 Feb 1957, B. D. Valentine (FSCA).

*Dicellarius bimaculatus fictus* (Chamberlin), new combination, new status

Figs. 5–6

*Epeloria ficta* Chamberlin, 1943:37–38, fig. 11.—Chamberlin and Hoffman, 1958:32–33.

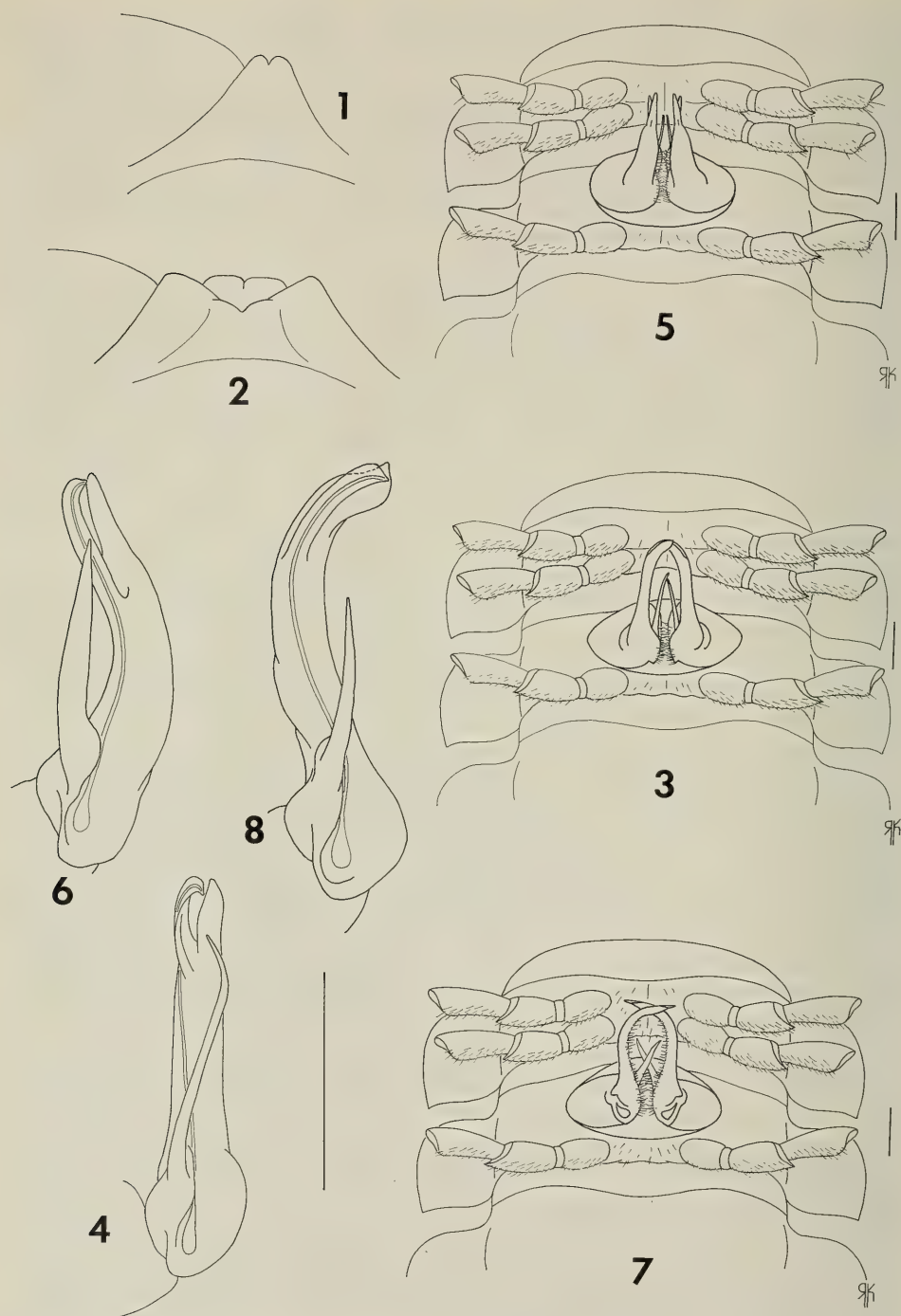
*Epeloria fictus*.—Causey, 1955:24.

*Epeloria dela* Chamberlin, 1946a:139, figs. 1–2.—Chamberlin and Hoffman, 1958:32.

*Epeloria leiacantha* Chamberlin, 1946a:139–140, fig. 3; 1947:29; 1951:28.—Chamberlin and Hoffman, 1958:33.

*Type specimens*.—Male holotype and female allotype (RVC) collected by H. Field, 5–10 Apr 1940, from Thomasville, Thomas Co., Georgia.





Figs. 1-8. *Dicellarius bimaculatus*: 1-4, *D. b. bimaculatus*. 1, Sternum of segment 4 of lectotype, caudal view; 2, Sternum of segment 5 of the same, caudal view; 3, Gonopods in situ, ventral view of male from Lauderdale Co., MS; 4, Telopodite of left gonopod of lectotype, medial view; 5-6, *D. b. fictus*. 5, Gonopods in situ, ventral view of male from Grady Co., GA; 6, Telopodite on left gonopod

*Diagnosis.*—Gonopods in situ in subparallel arrangement, neither acropodites nor prefemoral processes overlapping; prefemoral process stout, wide basally and tapering sharply distad to acute tip, tip overlapping solenomerite; acropodite in medial view curved anteriad and extending over level of prefemoral process, distal elements subequal in width and length; solenomerite with profile visible in medial view.

*Variation.*—The acropodite configuration in this race is more stable than that of the nominate subspecies. All males display the diagnostic acropodal curvature, with the solenomerite, and also the tibial process in some individuals, overhanging the prefemoral process. The latter is the most variable gonopodal feature. It is usually a wide, straight spine as in the holotype, but it is bent distally in some individuals and apically bifurcate with a subterminal spur in others. The orientation of the solenomerite also varies so that the produced inner corner is visible medially in some males and not in others.

*Distribution.*—This subspecies has the widest distribution of any race of *D. bimaculatus*, and it is sympatric with *T. bifida* in Dougherty County, Georgia. The area includes the Fall Zone and Coastal Plain of Alabama east of the Tombigbee and Conecuh Rivers, the panhandle of Florida between the Blackwater and Suwannee Rivers, and the outer Piedmont Plateau and the Coastal Plain of Georgia except for the Suwannee River drainage in the southeastern corner. It abuts the ranges of *D. okefenokensis* in this area and *D. atlanta* and *D. talapoosa* in the north. A peripheral population in Chatham County, Georgia, is isolated from the rest of the range, although some of this hiatus may reflect inadequate collecting. The inner Coastal Plain has received little attention, and the Savannah record may connect with that in Tift County. Specimens were examined as follows:

GEORGIA: *Chatham Co.*, Savannah, Beaulieu Ave., 3M, F, 1 Nov 1959, L. Hubricht (RLH). *Chattahoochee Co.*, Ft. Benning, M, 16 Apr 1950, D. E. Beck (RVC); and along GA hwy. 137 at Bagley Cr., M, 5 Sep 1980, G. E. Stanton (CC). *Muscogee Co.*, Columbus College, M, F, 19 Oct 1977, G. E. Stanton (CC). *Lee Co.*, N of Albany, F, 18 Jun 1959, N. B. Causey (FSCA). *Tift Co.*, many MM and FF, Sep 1967–Oct 1968, J. A. Payne (RLH). *Dougherty Co.*, Albany, 2M, 12F, 12 Jun 1959, N. B. Causey (FSCA). *Calhoun Co.*, Morgan, M, 4 Apr 1946, P. W. Tratt (RVC); and Leary, M, 25 Mar 1961, L. Hubricht (RLH). *Early Co.*, between Saffold and Jakin, 2M, F, 18 Mar 1961, L. Hubricht (RLH); and Kolomoki Mounds St. Pk., 3M, 2F, 1 May 1983, R. M. Shelley and P. B. Nader (NCSM A4024). *Baker Co.*, Pineland Plantation nr. Newton, 3M, F, 30 Mar 1959, D. B. Jester and H. Wyatt (FSCA). *Seminole Co.*, 4.5 mi. SE Iron City, M, F, and Ray's Lake, F, 21 Mar 1954, T. H. Hubbell (UMMZ). *Decatur Co.*, Spring Cr. W of Brinson, 2M, 3 Apr and 20 Aug 1946, P. W. Fattig (RVC), 2M, 2F, 31 Mar 1964, H. W. Levi (MCZ), and several MM and FF, 26 Jan 1965, N. B. Causey (FSCA). *Grady Co.*, 3 mi. W Cairo, 4M, 6F, 26 Jan 1965, N. B. Causey

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of holotype, ventral view; 7–8, *D. b. lamellidens*. 7, Gonopods in situ, ventral view of male from Jackson Co., MS; 8, Telopodite of left gonopod of the same, medial view. Scale line for Figs. 3, 5, and 7 = 1.00 mm; line for other Figs. = 1.23 mm for 1 and 2; 1.00 mm for 4, 6, and 8. Setae are omitted from all dissected gonopod and sternal drawings in this paper.



(FSCA); and 8 mi. NE Cairo, along GA hwy. 188, M, 3F, 15 Sep 1979, R. M. Shelley and P. T. Hertl (NCSM A2875). *Thomas Co.*, Thomasville, M, F, 5-10 Apr 1940, H. Field (RVC) and 2M, 15 Jul 1973, W. A. Shear (WAS) TYPE LOCALITY; Bar-M-Ranch nr. Boston, 8M, 2F, Apr 1968, W. Sedgwick (WAS) and M, F, 15 Jul 1973, W. A. Shear (WAS). *Brooks Co.*, 8 mi. W Quitman, along US hwy. 84, F, 7 Jul 1960, N. B. Causey (FSCA).

ALABAMA: *Marengo Co.*, Chickasaw St. Pk., M, F, 15 Jun 1959, N. B. Causey (FSCA) and 4M, F, 8 Jul 1980, R. M. Shelley (NCSM A3350). *Dallas Co.*, Selma, 2M, 2F, 15 June 1959, N. B. Causey (FSCA). *Wilcox Co.*, nr. Camden, 4M, 2F, 11 Nov 1962, L. Hubricht (RLH); and 5 mi. W Snow Hill, M, 10 Apr 1960, L. Hubricht (RLH). *Lowndes Co.*, 2.5 mi. NE Sandy Ridge, F, 9 Apr 1960, L. Hubricht (RLH); and 8.4 mi. NE Ft. Deposit, 3M, F, 19 Apr 1983, R. M. Shelley and P. B. Nader (NCSM A4029). *Montgomery Co.*, 7 mi. SW Montgomery, 4M, 3F, 16 Apr 1960, L. Hubricht (RLH); and 13.1 mi SSW Montgomery, along US hwy. 31 nr. Pintlalla, M, F, 19 Apr 1983, R. M. Shelley and P. B. Nader (NCSM A4025). *Butler Co.*, McKenzie, M, F, 9 Apr 1960, L. Hubricht (RLH); 15.9 mi. NW Greenville, along AL hwy. 11, 0.2 mi. N jct. AL hwy. 54, 3M, 21 Apr 1983, R. M. Shelley and P. B. Nader (NCSM A4038); and 6 mi NE Searcy, 3M, F, 9 Apr 1960, L. Hubricht (RLH). *Macon Co.*, 11.9 mi. SW Tuskegee, M, 10 May 1973, R. B. Little (AU). *Crenshaw Co.*, Brantley, M, 17 Jul 1960, L. Hubricht (RLH); and Luverne, 4M, 19 Mar 1961, L. Hubricht (RLH). *Pike Co.*, 10.8 mi. NW Troy, M, 26 Apr 1983, R. M. Shelley and P. B. Nader (NCSM A4060). *Russell Co.*, 10.8 mi. SW Phenix City, 2M, 26 Apr 1983, R. M. Shelley and P. B. Nader (NCSM A4063). *Coffee Co.*, jct. US hwy. 84 and AL hwy. 87 nr. Elba, 2M, 8F, 26 Jan 1965, N. B. Causey (FSCA). *Geneva Co.*, 1 mi. E Geneva, along Choctawhatchee R., 2M, 2 Jul 1960, L. Hubricht (RLH); and 5.8 mi. S Hartford, M, 30 Apr 1983, R. M. Shelley and P. B. Nader (NCSM A4078). *Houston Co.*, 1 mi. SE Grangeburg, M, 26 Mar 1961, and 4.5 mi. W Avon, 3M, 18 Mar 1961, L. Hubricht (RLH); 4 mi. E Webb, along Cedar Spring Cr., 3M, 9 Jul 1967, D. R. Whitehead (RLH); and Chattahoochee St. Pk., 2M, 30 Apr 1983, R. M. Shelley and P. B. Nader (NCSM A4079).

FLORIDA: *Walton Co.*, Gaskin, F, 29 Feb 1960, R. Cordle (FSCA); DeFuniak Springs, M, 6F, 7 Oct 1958, collector unknown (FSCA); and 8.5 mi. W DeFuniak Springs, along US hwy. 90, 7M, 2F, 22 Jan 1965, N. B. Causey (FSCA). *Washington Co.*, Chipley, 2M, F, 23 Jan 1965, N. B. Causey (FSCA). *Bay Co.*, Panama City, M, 2 Feb 1960, R. E. Woodruff (FSCA) and 2M, 5 Mar 1961, R. C. Hallman (FSCA). *Jackson Co.*, Florida Caverns St. Pk., M, 3F, 27 May 1968, R. E. Woodruff, and M, 2F, 14 Apr 1960, H. V. Weems (FSCA); Marianna vic., M, 26 Mar 1961, L. Hubricht (RLH) and M, 3 Apr 1968, J. A. Beatty (WAS); Cottondale, M, 31 Jul 1960, L. Hubricht (RLH); Three Rivers St. Pk. and Sneads vic., M, 2F, 7 Sep 1959, and 2M, 2 Mar 1961, L. Hubricht (RLH), M, 15 May 1964, M. Muma (FSCA), and 2M, F, 19 Jul 1973, W. A. Shear (WAS). *Calhoun Co.*, 2 mi. NW Chason, F, 4 Feb 1960, T. E. Kunkle (FSCA). *Liberty Co.*, along Appalachicola R. nr. Bristol, M, F, 24 Jan 1965, N. B. Causey (FSCA) and Torreya St. Pk., M, 15 Mar 1963, H. W. Levi (MCZ), and 5M, 3F, 24 Jan 1965, N. B. Causey, and M, 22 Apr 1967, P. C. Drummond (FSCA). *Leon Co.*, Tallahassee, many MM and FF collected from 1953-1959 by H. A. Denmark, H. V. Weems, and others (FSCA); Tall Timbers Res. Sta., ca. 22 mi. N Tallahassee, M, 2F, 5 Aug

1958, W. W. Baker (FSCA) and M, 30 Jul 1973, D. Harris (FSCA). *Jefferson Co.*, Monticello, M, 4F, 29 Aug 1959, H. W. Collins (FSCA); and Big Bend Horticultural Lab., 8M, date and collector unknown (FSCA) and 2M, 1971, H. Whitcomb (FSCA). *Hamilton Co.*, Suwannee River St. Pk., White Springs, 2F, 29 May 1958, N. B. Causey (FSCA).

*Dicellarius bimaculatus lamellidens* (Chamberlin), new status

Figs. 7–8

*Fontaria lamellidens* Chamberlin, 1931:78–79.—Attems, 1938:167.

*Spathoria lamellidens*.—Chamberlin, 1939:6, pl. 1, fig. 9.

*Dicellarius lamellidens*.—Chamberlin and Hoffman, 1958:30.

*Type specimen*.—The male holotype is missing from the RVC collection where Chamberlin (1931) and Chamberlin and Hoffman (1958) report its deposition. The type locality is Biloxi, Harrison Co., Mississippi, and since there are no paratypes, the following diagnosis is prepared from males from Ocean Springs in adjacent Jackson County.

*Diagnosis*.—Gonopods in situ with acropodites bent strongly mediad, crossing at about  $\frac{3}{4}$  length and extending beyond each other; prefemoral process short, terminating below level of acropodite division, moderately wide basally and tapering to acuminate tip, directed across acropodite stem; acropodite in medial view curved subcaudad, solenomerite overlying tibial process, latter longer and wider than solenomerite, profile visible.

*Variation*.—The degree of caudal curvature of the acropodite, as seen in medial view, varies and is stronger in the Stone County males.

*Distribution*.—Known only from a small area in coastal Mississippi west of the Pascagoula River. It has not been taken west of Long Beach, a suburb of Gulfport-Biloxi, but it could conceivably extend to the Pearl River and possibly even into southeastern Louisiana. Specimens were examined as follows:

MISSISSIPPI: *Stone Co.*, between Harrison Co. line and MS hwy. 26, 3M, 21 Jan 1965, N. B. Causey (FSCA). *Jackson Co.*, Ocean Springs, Gulf Hills, 3M, 2F, 2 Oct 1958, and 3M, 1 Jun 1961, N. B. Causey (FSCA); and Gulf Coast Research Lab. nr. Ocean Springs, M, 16 Mar 1957, D. Moore; 2M, F, 1 Oct 1958, collector unknown; M, F, 30 May 1959, N. B. Causey; 2M, F, 27 November 1964, C. Guise; and M, 21 Nov 1965, D. E. Hahn (all FSCA). *Harrison Co.*, Long Beach, F, 20 Mar 1910, collector unknown (RVC).

*Remarks*.—In medial view the acropodite of *D. b. lamellidens* curves in the opposite direction to that of *D. b. fictus* (compare Figs. 6 and 8). However, the two forms connect through a series of intermediate stages along the Gulf Coast and therefore represent geographic races of a single species rather than different species.

*Dicellarius bimaculatus* intergrades

Intergrade populations of *D. bimaculatus* occur east of the Pascagoula River in Jackson County, Mississippi. The acropodites curve less than those from Ocean Springs (Fig. 8) and the gap between the distal elements is slightly visible in medial view. This configuration is intermediate between the nominate subspecies and *D. b. lamellidens*. Specimens were examined as follows:



MISSISSIPPI: *Jackson Co.*, Pascagoula, M, Sep 1953, E. Waitt (FSCA) and 3M, F, 1 Jan 1954, N. B. Causey (FSCA); and Spanish Fort, 2M, 4F, 15 Jun 1953, collector unknown (FSCA) and 2M, F, 21 Jan 1965, N. B. Causey (FSCA).

*Dicellarius okefenokensis* (Chamberlin)

Figs. 9–12

*Leptodesmus okefenokensis* Chamberlin, 1918:370–371.

*Dicellarius okefenokensis*.—Chamberlin, 1920:97.—Chamberlin and Hoffman, 1958:31.

*Epeloria nannoides* Chamberlin, 1949:101, fig. 24.

*Type specimens*.—Male holotype (MCZ) taken by unknown collector, Dec 1913, on Billy's Island in the Okefenokee Swamp, Charlton Co., Georgia.

*Diagnosis*.—Prefemoral process not extending across stem of acropodite; latter bent broadly anteriad at midlength, overhanging and extending slightly beyond level of prefemoral process, with torsion, prostatic groove crossing from medial to lateral sides at anterior bend; tibial process overlying and masking most of solenomerite in medial view.

*Holotype*.—Length 22.0 mm, maximum width 4.2 mm, W/L ratio 19.1%, depth/width ratio 73.8%. Segmental widths as follows:

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collum	3.4 mm	11th–16th	4.0
2nd	3.6	17th	3.6
3rd	3.9	18th	2.9
4th–10th	4.2		

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Color in life unknown.

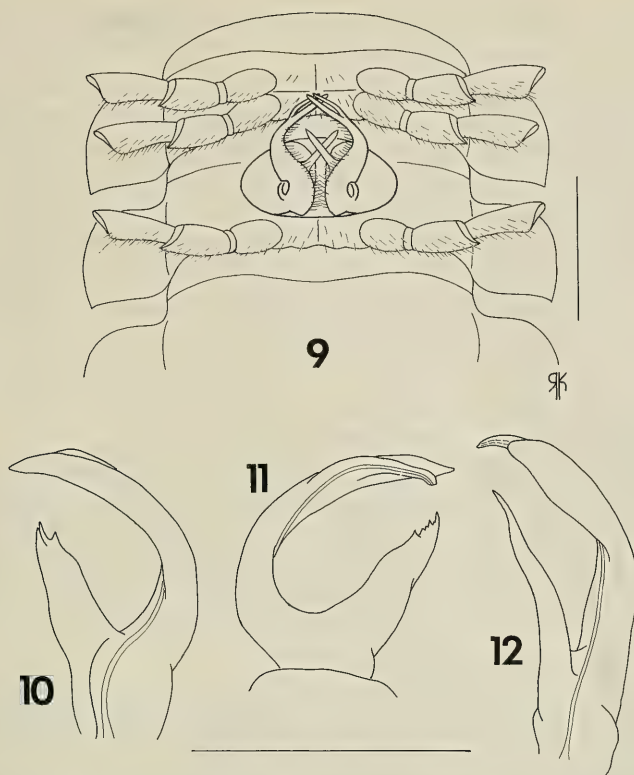
Somatic features similar to those of *D. b. bimaculatus* with following exceptions:

Width across genal apices 2.4 mm, interantennal isthmus 0.9 mm. Antennae reaching back nearly to caudal edge of 4th segment, relative lengths of antennomeres  $2 > 6 > 5 > 4 = 3 > 1 > 7$ . Genae with very slight medial impression. Facial setae as follows: Epicranial 3-3, interantennal 1-1, frontal 1-1, genal 3-3, clypeal about 12-12, larbral about 16-16.

Collum moderately broad, ends extending slightly beyond those of following tergite. Peritremata extremely thick and conspicuous, enlarged caudad.

Sternum of segment 5 with 2 moderately elevated areas between 4th legs and slight recession between 5th legs, 6th sternum with convex recession between both leg pairs, 7th legs set slightly farther apart than 6th. Postgonopodal sterna with slight midline elevation on segments 11–17, elevation oriented transversely rather than longitudinally as in other species.

Gonopodal aperture elliptical, 1.6 mm wide and 0.5 mm long at midpoint, indented anteriolaterally, sides flush with metazonal surface. Gonopods in situ (Fig. 9, not this specimen) with acropodites curving broadly mediad at midlength and extending beyond anterior margin of aperture, apices overlapping above 6th sternum; prefemoral processes directed anteriomedial, crossing at midlength in midline of aperture, apices extending slightly beyond anterior margin of aperture. Gonopod structure as follows (Figs. 10–11): Prefemoral process wide and long,



Figs. 9–12. *Dicellarius okefenokensis*: 9, Gonopods in situ, ventral view of male from Columbia Co., FL; 10, Telopodite of left gonopod of holotype, medial view; 11, The same, lateral view; 12, Telopodite of left gonopod of male from Hernando Co., FL, medial view. Scale line for Fig. 9 = 1.00 mm; line for other Figs. = 1.00 mm for each.

about  $\frac{2}{3}$  length of acropodite, spatulate basally with sinuous margins narrowing at midlength, apex with several minute teeth directed toward tip of acropodite. Acropodite in form of broadly curved arc with torsion, overhanging and extending slightly beyond level of prefemoral process, prostatic groove crossing to lateral surface proximad, distal division masked in medial and lateral views, located at about  $\frac{2}{3}$  length. Distal elements widely separated, diverging continuously with greatest separation apically, gap visible mostly in ventral or dorsal perspectives; solenomerite anterior to, and slightly shorter than, tibial process, sides narrowing smoothly to tip; tibial process overlying and largely obscuring solenomerite in medial view, broader than latter, sides parallel for most of length, apically acute. Prostatic groove arising in pit in prefemur, running along medial surface of acropodite basally, crossing to lateral side at anterior bend, terminating apically on solenomerite.

*Description of females.*—Since the type collection contains no females and none have been encountered in Georgia, the following description has been prepared from females from Baker County, Florida, the closest available to the type locality. Length 23.2 mm, maximum width 4.0 mm, W/L ratio 17.2%, depth/width ratio 72.5%. Agreeing essentially with males in somatic features except paranota more



strongly depressed, creating appearance of more highly arched body, and sternal elevations greatly reduced barely visible.

Cyphopods in situ with opening of valves visible in aperture. Receptacle absent. Valves relatively large, subequal, surface finely granulate. Operculum relatively large, located under dorsolateral corner of valves, surface finely granulate.

*Variation.*—Southern populations vary considerably from those north of Gainesville. The prefemoral process is longer but of the same length relative to the acropodite since the latter is also longer; its width also varies, as it becomes much narrower and more acicular with decreasing latitude. The acropodite bends more abruptly at midlength (Fig. 12), and the solenomerite is longer relative to the tibial process, projecting beyond the latter in medial view.

*Ecology.*—According to the labels in the vials, *D. okefenokensis* is typically found under logs in moist, predominantly hardwood habitats. The sample from Waycross, Georgia, was discovered under trash in a yard.

*Distribution.*—Southeastern Georgia and peninsular Florida nearly to the level of Tampa. Except for the Waycross sample, all specimens have come from south of the Suwannee River or its headwaters in the Okefenokee Swamp. The known Florida localities all lie north of highway I-4. Specimens were examined as follows:

GEORGIA: *Ware Co.*, Waycross, under trash in yard, 2M, 8 Feb 1962, M. Barnette (FSCA). *Charlton Co.*, Billy's Island, Okefenokee Swamp, M, Dec 1913, collector unknown (MCZ) TYPE LOCALITY.

FLORIDA: *Nassau Co.*, Austin Cary Forest, M, 30 Jun 1960, W. J. Platt (FSCA). *Baker Co.*, Macclenny, M, 26 Dec 1960, E. W. Holder (FSCA); and Glen St. Mary, 2M, 3F, 18 Jan 1961, E. W. Holder (FSCA). *Columbia Co.*, Osceola Nat. For., 6M, 15 Feb and 16 Mar 1977, J. R. Wiley (FSCA). *Hamilton Co.*, White Springs, M, F, 1959, A. Williams (FSCA). *Suwannee Co.*, along Rocky Cr. at rd. S-136, M, F, 16 Mar 1977, J. R. Wiley (FSCA). *Clay Co.*, no further locality, 2F, 7 Jan 1961, H. A. Denmark (FSCA). *Marion Co.*, Confederate Cave, M, 19 Feb 1959, R. Cumming (FSCA). *Alachua Co.*, 1 mi. N Newberry, along US hwy. 27, F, 14 Jan 1967, J. E. Lloyd (FSCA); and Gainesville, many MM and FF collected mostly during Oct–Feb from 1933–1965, by about 10 collectors (RVC, MCZ, RLH, & FSCA). *Putnam Co.*, Ocala Nat. For., Johnson Field, F, 21 Jan 1973, R. Skinner (AU). *Seminole Co.*, Sanford, M, 14 Feb 1960, G. W. Desin (FSCA). *Hernando Co.*, Brooksville, M, 25 Jan 1960, L. Hill (FSCA); and 10 mi. S Floral City, along US hwy. 41, 2M, 23 Dec 1973, W. A. Shear (RLH). *Pasco Co.*, Dade City, M, 15 Feb 1972, K. C. Lowery (FSCA), and M, 14 Jun 1983, R. M. Shelley and J. L. Staton (NCSM A4160).

*Remarks.*—*Dicellarius okefenokensis* is the only allopatric species in the genus. Its range does not overlap that of any other species, though it abuts *D. b. fictus* in the west.

The acropodite of *D. okefenokensis* is unique to both the genus and tribe in displaying two features typically found and convergent in the tribe Apheloriini: the broadly curved acropodite that overhangs the prefemoral process in medial view, and torsion, which causes the prostatic groove to cross from medial to lateral sides at  $\frac{1}{3}$  length. Just as the acropodite in *D. b. lamellidens* is turned counterclockwise so that the solenomerite overlies the tibiotarsus in medial view, the acropodite of *D. okefenokensis* probably evolved from eastern populations of *D. bimaculatus* in which the reverse, or clockwise, twisting occurred. Such rotation

would place the tibiotarsus over the solenomerite in medial view, and an early stage in this torsion is apparent in some males of *D. b. fictus*, where the edge rather than the side of the solenomerite is visible medially. Thus, I think *D. okefenokensis* represents an eastern population of *D. bimaculatus* in which the distal half of the acropodite has turned about 90° clockwise, just as *D. b. lamellicidens* represents ones in which 90° counterclockwise rotation has occurred. The latter still links with other populations of *D. bimaculatus* by intermediate or intergrade forms, and consequently is only a geographic race. Connections between *D. okefenokensis* and *D. bimaculatus* have disappeared, however, and the former has achieved reproductive isolation as evidenced by the torsion, the broadened curvature of the acropodite, and reduced body size.

*Dicellarius talapoosa* (Chamberlin)

*Diagnosis*.—Acropodite with slight but continuous curve; distal elements narrowly separated or touching, continuing general curvature of acropodite, never overlying one another in medial or lateral views; solenomerite acicular, with sides tapering smoothly and continuously to subacuminate tip; tibial process acicular, shorter than solenomerite; prefemoral process angling across stem of acropodite, relatively short, extending at most to base of distal elements, tip overlying tibial process.

*Remarks*.—*Dicellarius talapoosa* occurs inland from *D. bimaculatus* in Alabama and Georgia. Its range abuts that of *D. b. fictus* in the south, and it is sympatric in parts of the range with both *D. atlanta* and *D. sternolobus*. In the material available to me a consistent difference exists in the degree of separation of the distal elements in populations east and west of the Coosa River. In the eastern populations they are contiguous for most of their lengths, whereas in the western ones they are narrowly, but completely, separated. One sample from St. Clair County, an intermediate geographical position, displays an intermediate degree of separation that I consider an intergrade. This situation is a much clearer indication of geographic races than that of *D. bimaculatus*, and since Chamberlin's type is the eastern form, it becomes the nominate subspecies and a new subspecific name is needed for the western form. I hereby propose *D. t. separandus* to signify the greater separation of the solenomerite and tibial process.

*Dicellarius talapoosa talapoosa* (Chamberlin), new combination, new status  
Figs. 13–14

*Epeloria talapoosa* Chamberlin, 1939:3, pl. 1, fig. 1.—Chamberlin and Hoffman, 1958:33.

*Type specimens*.—Male holotype and one male paratype (RVC) collected by R. V. Chamberlin, 29 Jul 1910, from Tallapoosa, Haralson Co., Georgia. Chamberlin (1939) reported that a female allotype was taken in addition to the holotype, which is what the sample label says, but the vial actually contains two males, one of which must be a paratype.

*Diagnosis*.—Distal elements closely appressed together, touching for most of length except for slight basal gap.

*Holotype*.—Body badly fragmented and unmeasurable, segmental widths taken



from male from Cleburne Co., Alabama, the closest whole specimen to the type locality, and listed under variation.

Color in life unknown.

Somatic features similar to those of *D. b. bimaculatus*, with following exceptions:

Width across genal apices 4.4 mm. Antennae extending to caudal edge of 3rd tergite, relative lengths of antennomeres  $6 > 5 > 3 = 4 = 2 > 1 > 7$ . Facial setae as in *D. b. bimaculatus* except subantennal 1-1, genal 2-2, and clypeal about 12-12.

Collum moderately broad, ends extending well beyond those of following tergite.

Fourth sternum without process; 5th sternum with two elevated, medially coalesced flattened areas between 6th legs and deep convex recession between 7th legs. Postgonopodal sterna with midline elevations in form of narrow, longitudinal ridges, distinct on segments 10-15.

Gonopodal aperture 2.4 mm wide and 0.8 mm long at midpoint, indented slightly anteriolaterally, sides flush with metazonal surface. Gonopods in situ (Fig. 13, not this specimen) with acropodites projecting anteriorly from aperture, extending well beyond anterior margin of aperture, with apices crossing between 7th legs, prefemoral processes also overlapping and extending beyond aperture. Gonopod structure as follows (Fig. 14): Prefemur moderate in size, with relatively short, acicular prefemoral process extending in medial view across stem of acropodite approximately half the length of the latter, terminating near level of distal division of latter. Acropodite curving slightly caudad, sides narrowing gradually and divided at about  $\frac{2}{3}$  length into distal elements; latter subspiniiform and apically acute, closely appressed together, touching for most of length, with slight basal separation visible in subanterior view; solenomerite slightly longer and more acute. Prostatic groove arising in pit in prefemur, running along medial side of acropodite stem to level of distal elements, curving toward anterior margin of acropodite and entering solenomerite, opening apically.

*Male paratype*.—The male paratype agrees with the holotype in all particulars and is also fragmented and unmeasurable.

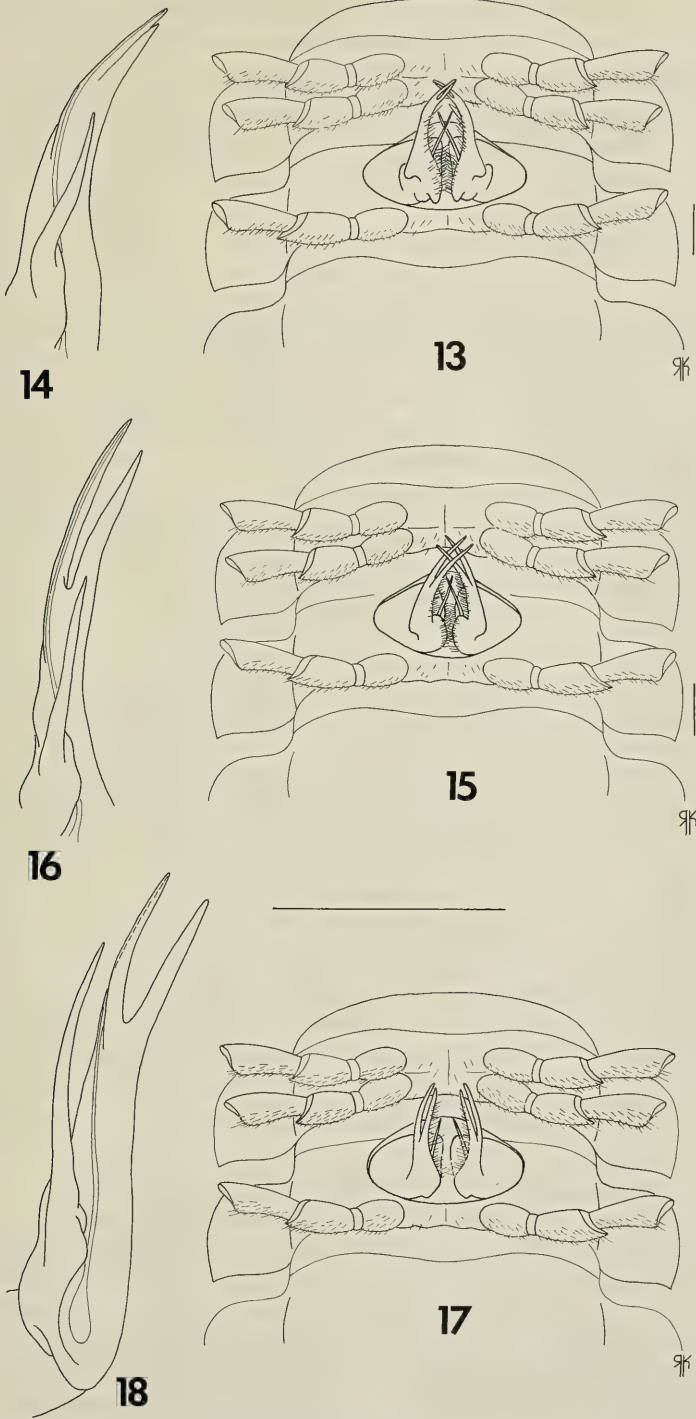
*Description of Females*.—Since the type collection contains no females, the following description was prepared from specimens from Randolph County, Alabama, the closest females available to the type locality. Length 42.1 mm, maximum width 8.8 mm, W/L ratio 20.9%, depth/width ratio 72.7%. Agreeing essentially with holotype in most somatic feature, except paranota more strongly depressed, giving appearance of more highly arched body, and sternal elevations greatly reduced, barely detectable.

Cyphopods in situ with valvular openings visible in aperture; valves large, subequal, surface finely granulate. Receptacle absent. Operculum small, located on lateral side of valves, surface finely granulate.

*Variation*.—The sample from Cheaha State Park, Cleburne Co., Alabama (NCSM

→

Figs. 13-16. *Dicellarius talapoosa*: 13-14, *D. t. talapoosa*. 13, Gonopods in situ, ventral view of male from Cleburne Co., AL; 14, Telopodite of left gonopod of holotype, medial view; 15-16, *D. t. separandus*. 15, Gonopods in situ, ventral view of paratype; 16, Telopodite of left gonopod of holotype,



medial view. Figs. 17–18, *Dicellarius atlanta*: 17, Gonopods in situ, ventral view of male from Peach Co., GA; 18, Telopodite of left gonopod of holotype, medial view. Scale lines for Figs. 13, 15, and 17 = 1.00 mm; line for other figs. = 1.00 for Fig. 14, 1.14 mm for 16, and 0.80 mm for 18.



A3117), is the closest to the type locality with whole males, one of whose measurements are as follows: Length 34.8 mm, maximum width 7.7 mm, W/L ratio 22.1%, depth/width ratio 66.2%. Segmental widths as follows:

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collum	5.8 mm	6th-13th	7.7
2nd	6.3	14th	6.8
3rd	7.1	15th	6.6
4th-5th	7.3	16th	6.3
		17th	5.8
		18th	5.1

---

The gonopods of this subspecies are quite uniform. The prefemoral processes tend to be longer and the acropodites more distinctly curved in western populations. However, the distal elements are always closely appressed together, except for the slight gap at their bases, and their lengths relative to each other and to the overall acropodite do not change.

*Distribution.*—The range of *D. t. talapoosa* lies in the Piedmont Plateau and Fall Zone of west-central Georgia and east-central Alabama, east of the Coosa River. It crosses the Coosa River in the north and extends onto Lookout Mountain along the northern Alabama-Georgia boundary. Specimens were examined as follows:

GEORGIA: *Dekalb Co.*, Oglethorpe Univ., M, date unknown, A. L. Cain (FSCA). *Haralson Co.*, Tallapoosa, 2M, 29 Jul 1910, R. V. Chamberlin (RVC) TYPE LOCALITY; and Bremen, M, 29 Jul 1910, R. V. Chamberlin (RVC).

ALABAMA: *Dekalb Co.*, 4.4 mi. SE Mentone, along AL hwy. 117 at Anna Branch Cr., M, F, 15 Apr 1978, R. M. Shelley and R. E. Ashton (NCSM A18442). *Etowah Co.*, 1.5 mi. W Hokes Bluff, along Coosa R., 2M, 28 Feb 1961, L. Hubricht (RLH). *Cleburne Co.*, 3.4 mi. N Shoal Cr. Camping Area, M, 28 Oct 1960, L. Hubricht (RLH); 4 mi. W Heflin, M, 5 Mar 1961, L. Hubricht (RLH); and summit Cheaha Mtn., Cheaha St. Pk., M, 10 Jun 1953, L. Hubricht (RLH) and 13 M, F, 20 May 1980, R. M. Shelley (NCSM A3117). *Talladega Co.*, 5 mi. W Sylacauga, M, 3 Mar 1973, W. Redmond (AU). *Lee Co.*, 3 mi. N Auburn, along AL hwy. 143 at Saugahatchee Cr., M, 7 Mar 1973, T. French (AU). *Randolph Co.*, 0.7 mi. W Wadley, F, 1 Oct 1960, L. Hubricht (RLH). *Macon Co.*, Tuskegee Nat. For., M, 2F, 14 May 1973, R. B. Little (AU); and Tuskegee, Tuskegee Institute Campus, 2M, 14 Mar 1978, S. B. Ruth (NCSM A3891).

*Remarks.*—I collected 13 males on the roadway near the summit of Cheaha Mountain early in the morning of 20 May 1980. The animals must have ventured forth in the cool weather of the preceding night, and six had been freshly decapitated by an unknown predator. The head and first three to four segments had been removed, but the bite stopped short of segment 5 and the anteriormost defensive glands. I have seen this phenomenon twice before, with individuals of *Croatania catawba* Shelley from Chester Co., South Carolina, and *Gyalostethus monticolens* (Chamberlin) from the Great Smoky Mountains National Park, Swain Co., North Carolina. In all instances the segments seem to have been removed by a single, clean bite, as there is no evidence of continuous chewing. At Cheaha Mountain the millipeds were exposed on the pavement away from protective cover, but in the other sites they were in forests lying on top of the litter.

*Dicellarius talapoosa separandus*, new subspecies

Figs. 15–16

*Type specimens*.—Male holotype (NCSM A3132) and 4 male and 4 female paratypes collected by R. M. Shelley, 23 May 1980, at Rickwood Caverns State Park, Blount Co., Alabama. Male and female paratypes deposited in FSCA.

*Diagnosis*.—Distal elements subparallel but not touching, separated for entire lengths, diverging apically.

*Variation*.—The degree of separation of the distal elements varies, but otherwise all males are closely similar to the holotype.

*Distribution*.—This subspecies occurs generally west of the Coosa River, in the Cumberland Mountains around Birmingham and the Appalachian Plateau. It is sympatric and syntopic with *T. lampra* in Tuscaloosa. Specimens were examined as follows:

ALABAMA: *Dekalb Co.*, 3.7 mi. NW Collinsville, along AL hwy. 68 at Little Cr., 2.5 mi. W jct. I-59, M, 15 Apr 1978, R. M. Shelley and R. E. Ashton (NCSM A1841). *Morgan Co.*, 8 mi. S Decatur, along Flint Cr., M, 24 May 1980, R. M. Shelley (NCSM A3143). *Blount Co.*, Rickwood Caverns St. Pk., 5M, 4F, 23 May 1980, R. M. Shelley (NCSM A3132) TYPE LOCALITY. *Jefferson Co.*, Birmingham, 3M, 16–25 Nov 1958, collector unknown (FSCA). *Tuscaloosa Co.*, Tuscaloosa, M, 2 juvs., 29 Mar 1948, G. Ball (RLH).

*Remarks*.—The in situ gonopodal configuration of this subspecies is the same as that of the nominate, except the wider gap between the distal elements allows them to crisscross (Fig. 15, of paratype). The acropodites simply overly each other in *D. t. talapoosa* (Fig. 13).

The sample from Birmingham had the following note about the smell of the defensive secretion: “odor good, strong, pineapple, with dash of shoe polish; not too unpleasant, sweetish.”

*Dicellarius talapoosa* intergrades

In two males from St. Clair County, the basal gap between the distal elements is larger than in *D. t. talapoosa*, but they still touch distally. I regard these specimens as intergrades, and they are indicated by the northernmost “X” in Fig. 29. They were taken about 5 miles west of the Coosa River, which generally forms the boundary between the subspecies. The data are as follows:

ALABAMA: *St. Clair Co.*, Steele, 2M, 4 Apr 1948, H. E. Evans (RLH).

*Dicellarius atlanta* (Chamberlin), new combination

Figs. 17–18

*Epeloria atlanta* Chamberlin, 1946b:151–152, fig. 7.—Chamberlin and Hoffman, 1958:32.

*Type specimens*.—Male holotype and female allotype (RVC) collected by P. W. Fattig, 1 Dec 1945, from Atlanta, Georgia. The label in the vial states 1946, but this must be incorrect since it would not have allowed publication in that year. Neither the publication nor the label in the vial gives the county, but since Atlanta was much smaller in the 1940's and its center is in Fulton Co., the type specimens were probably collected there rather than in Dekalb Co.



*Diagnosis*.—Acropodite relatively straight, sublinear; distal elements widely separated, either continuous with sublinear acropodite or very slightly curved, never overlying one another in medial or lateral views; solenomerite acicular, sides tapering smoothly and continuously to subacuminate tip; tibial process acicular, subequal in length to solenomerite; prefemoral process straight, not angling across acropodite stem but lying over or near anterior margin, relatively long, extending well beyond base of distal elements with tip either over solenomerite or on anterior side of latter.

*Holotype*.—Length 30.3 mm, maximum width 6.0 mm, W/L ratio 19.8%, depth/width ratio 66.4%. Segmental widths as follows:

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collum	5.0 mm	16th	5.8
2nd–4th	5.5	17th	5.5
5th	5.8	18th	4.6
6th–15th	6.0		

---

Color in life unknown.

Somatic features similar to those of *D. b. bimaculatus*, with following exceptions:

Width across genal apices 4.1 mm, interantennal isthmus 1.3 mm. Antennae extending back to caudal edge of 3rd tergite, relative lengths of antennomeres  $6 > 5 > 4 = 3 = 2 > 1 > 7$ . Genae with distinct, linear, diagonal impression. Facial setae as in *D. b. bimaculatus* except genal 2-2, clypeal about 11-11, labral about 18-18.

Collum moderately broad, ends extending slightly beyond those of following tergite.

Sternum of segment 5 with small elevated area between 4th legs and depression between 5th legs; 6th sternum with wide, flattened, elevated area between 6th legs and deep, convex recession between 7th legs. Postgonopodal sterna with midline elevations generally large and distinct, acute and subconical, largest on segments 11–14, lower and more rounded before and after.

Gonopodal aperture ovoid, 2.4 mm wide and 1.0 mm long at midpoint, indented anteriolaterad, sides nearly flush with segmental surface. Gonopods in situ (Fig. 17, not this specimen) with acropodites projecting anteriad from aperture, subparallel, not overlapping or crossing, extending beyond anterior margin of aperture to between 7th legs. Gonopod structure as follows (Fig. 18): Prefemur moderate, with long, acicular prefemoral process extending well beyond level of distal division of acropodite on anterior side. Acropodite extending sublinearly from prefemur, bent slightly caudad at level of division, sides parallel, not tapering, divided roughly at  $\frac{2}{3}$  length. Distal elements well separated, diverging apically; tibial process apically blunt; solenomerite slightly longer, tapering distad to subacuminate tip. Prostatic groove arising in pit in prefemur, running along medial surface of acropodite to level of division, crossing to anterior side and opening terminally on solenomerite.

*Female allotype*.—Length 31.3 mm, maximum width 5.4 mm, W/L ratio 17.4%, depth/width ratio 77.8%. Agreeing closely with male except paranota more strongly depressed, creating appearance of more highly arched body, and sternal elevations greatly reduced, barely detectable.

Cyphopods in situ with openings of valves visible in aperture; valves large, subequal, surface finely granulate. Receptacle absent. Operculum relatively large, located under lateral end of valves, surface finely granulate.

*Variation.*—The gonopods of *D. atlanta* are uniform. The acropodite always extends linearly from the prefemur, and the solenomerite is always slightly longer than the tibial process. The distal elements continue in the axis of the acropodite stem, although they lean slightly caudad in some males; they converge apically in specimens from Paulding County, and the solenomerite is bowed outward basally away from the tibiotarsus. In medial view the prefemoral processes lean anteriad basally away from the acropodite then curve back toward the latter at midlength.

*Distribution.*—*Dicellarius atlanta* is the only species occurring in the southern Blue Ridge Province (Appalachian Mountains) and ranges from western North Carolina to central Georgia and eastern Alabama. Its range overlaps those of *D. b. fictus* and *D. t. talapoosa* in central Georgia, and it is sympatric and syntopic with *T. bifida* in Dawson and Houston Counties, Georgia. The range spans the Chattahoochee River and the headwaters of the Ocmulgee River, and may also traverse the Savannah River into Oconee County, South Carolina.

NORTH CAROLINA: *Graham Co.*, 2 mi. NW Milltown, nr. Snowbird Picnic Area, 2M, 10 May 1961, L. Hubricht (RLH).

GEORGIA: *Rabun Co.*, Tallulah Falls, M, 28 Apr 1943, W. Ivie (RVC). *Habersham Co.*, Clarkesville, F, 4 Apr 1943, collector unknown (RVC). *Dawson Co.*, Amicalola Falls St. Pk., 2M, 2F, 16 Apr 1978, R. M. Shelley and R. E. Ashton (NCSM A1855). *Jackson Co.*, NW of Pendergrass, M, 23 Apr 1943, W. Ivie (RVC). *Clarke Co.*, Athens, Univ. of GA campus, F, 27 Feb 1944, E. P. Odum (RVC); and 9 mi. W Athens, M, 6 May 1961, L. Hubricht (RLH). *Oconee Co.*, Watkinsville, M, 26 Mar 1959, M. Pitken (FSCA). *Fulton Co.*, Atlanta, M, F, 1 Dec 1946, P. W. Fattig (RVC), and Ft. McPherson, 2F, 9 Dec 1943, D. E. Beck (RVC). *DeKalb Co.*, Atlanta, 2M, 2F, 7 Oct 1960, E. Davidson (FSCA); and Stone Mountain, M, F, 20 Oct 1946, and M, 6 Apr 1947, P. W. Fattig (RVC). *Douglas Co.*, Sweetwater Creek St. Pk., M, 21 Nov 1977, R. M. Shelley (NCSM A1796). *Paulding Co.*, Dallas, M, 30 Mar 1947, P. W. Fattig (RVC). *Clayton Co.*, 6.4 mi. S Corely, M, 4 Dec 1960, L. Hubricht (RLH). *Butts Co.*, Indian Springs St. Pk., M, 4F, 20 Nov 1977, R. M. Shelley (NCSM A1789). *Bibb Co.*, Macon, M, 4 Mar 1961, L. Hubricht (RLH). *Peach Co.*, 2 mi. W Fort Valley, along GA hwy. 96, 4M, F, 12 Apr 1978, R. M. Shelley (NCSM A1834). *Houston Co.*, Perry, 50M, 9F, 26–28 Dec 1982, J. A. Payne (RLH). *Meriwether Co.*, 3.5 mi. S Woodbury, M, 11 Mar 1961, L. Hubricht (RLH). *Harris Co.*, Franklin D. Roosevelt St. Pk., M, 2 May 1983, R. M. Shelley and P. B. Nader (NCSM A4083). *Muscogee Co.*, Columbus College, M, 2 Nov 1977, G. E. Stanton (CC).

ALABAMA: *Lee Co.*, Auburn, M, Mar 1966, H. B. Cunningham (AU); Prather's Pond nr. Auburn, 8M, 2F, Mar 1973, T. French (AU); and 3 mi. N Auburn, along AL hwy. 143 at Saugahatchee Cr., 3M, Apr 1973, T. French (AU).

*Remarks.*—As shown in Figs 16 and 18, the gonopod of *D. atlanta* is closely similar to that of *D. t. separandus*, the main differences being the orientation of the prefemoral process, the degree of separation of the distal elements, and the curvature of the acropodite. In *D. t. separandus* the prefemoral process angles across the stem of the acropodite, whereas in *D. atlanta* it is located entirely on



the anterior side. The distal elements are subequal and more widely separated in *D. atlanta*, and the acropodite is more linear in this species. These similarities suggest that *D. atlanta* originated as a subspecies of *D. talapoosa*, and has since achieved reproductive isolation as evidenced by the range overlap with *D. t. talapoosa*.

*Dicellarius sternolobus* Loomis

Figs. 19–23

*Dicellarius sternolobus* Loomis, 1969:247–248, figs. 5–7.

*Type-specimen*.—Male holotype (NMNH) taken by unknown collector, 27 Oct 1944, from Alexander City, Tallapoosa Co., Alabama. The fragmented, immature paratype in the FSCA does not appear to be this species.

*Diagnosis*.—Sterna of segments 4 and 5 with large, ventrally directed processes, usually longer than widths of adjacent coxae; solenomerite overlying tibial process in medial view, much narrower than latter with sides tapering smoothly and continuously to subacuminate tip; lateral surface of tibial process irregular, with several grooves and ridges.

*Holotype*.—Length 36.8 mm, maximum width 6.8 mm, W/L ratio 18.5%, depth/width ratio 75.0%. Segmental widths as follows:

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collum	5.4 mm	7th–15th	6.8
2nd	6.0	16th	6.5
3rd–5th	6.2	17th	5.9
6th	6.6	18th	5.4

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Color in life unknown.

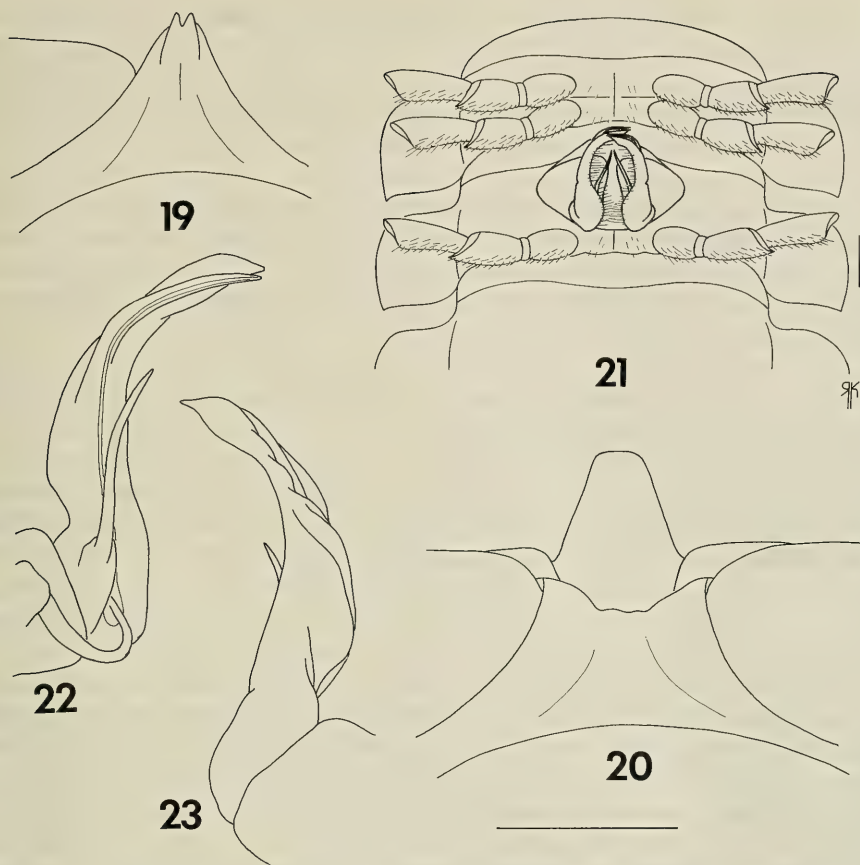
Somatic features similar to those of *D. b. bimaculatus*, with following exceptions:

Width across genal apices 4.5 mm, interantennal isthmus 1.2 mm. Antennae reaching back to middle of 4th tergite, relative length of antennomeres  $2 > 3 > 6 = 5 = 4 > 1 > 7$ . Genae with distinct medial depression. Facial setae as in *D. b. bimaculatus* except subantennal 1-1, genal 2-2, clypeal about 14-14, labral about 20-20.

Collum broad, ends extending slightly beyond those of following tergite. Dorsum smooth and polished, glossy.

Sternum of segment 4 with large, apically divided process between 3rd legs, greater in length than widths of adjacent coxae (Fig. 19); 5th sternum with similar process between 4th legs, longer than widths of adjacent coxae, and with slight recession between 5th legs (Fig. 20); 6th sternum with two low, transverse ridges between 6th legs and depression between 7th, 7th legs set slightly farther apart than 6th. Postgonopodal sterna with lowly rounded, faint midline elevations noticeable on segments 8–13, undetectable on remaining segments.

Gonopodal aperture ovoid, 2.1 mm wide and 1.0 mm long at midpoint, indented anteriolaterad, sites flush with metazonal surface. Gonopods in situ (Fig. 21, not this specimen) with acropodites bending mediad distad, apices overlapping; prefemoral processes angling mediad but not touching. Gonopod structure



Figs. 19–23. *Dicellarius sternolobus*: 19, Sternum of segment 4 of holotype, caudal view; 20, Sternum of segment 5 of the same, caudal view; 21, Gonopods in situ, ventral view of male from Shelby Co., AL; 22, Left gonopod of holotype, medial view; 23, Telopodite of the same, lateral view. Scale line for Fig. 21 = 1.00 mm; line for other Figs. = 0.81 mm for Fig. 19, 1.00 mm for Figs. 20 and 22–23.

as follows (Fig. 22–23): Prefemoral process acicular, curved slightly at midlength and angling across stem of acropodite to level of distal division. Acropodite curved gently caudad at midlength, overhanging and extending well beyond level of prefemoral process; stem widening basally then narrowing gradually to level of division at  $\frac{1}{3}$  length. Distal elements subparallel and subequal in length, narrowly separated, gap obscured in medial and lateral views but visible from dorsal and ventral perspectives; solenomerite located medial to tibial process and overlying it in this perspective, narrow and acicular, continuing general curvature of acropodite and tapering smoothly to acuminate tip; tibial process broad, spatulate in shape but with grooves and ridges forming several smooth edges, one irregularly scalloped, obscuring solenomerite in lateral view, continuing general curvature of acropodite, widening distad, anterior margin apically flattened and forming acuminate tip with caudal margin. Prostatic groove arising in pit in prefemur, running along medial sides of acropodite and solenomerite, opening terminally.



*Description of female.*—There are no samples of *D. sternolobus* with both males and females from the same locality, so there are no certifiable females of this species. The one described here was taken about 9 mi. NW of the locality in Talladega Co. where a male was collected and is identified as *D. sternolobus* instead of the proximal *D. talapoosa* on the basis of size, since *D. sternolobus* is much larger than the latter. Length 39.9 mm, maximum width 8.4 mm, W/L ratio 21.0%, depth/width ratio 69.0%. Agreeing essentially with holotype in somatic features with following exceptions: Paranota more strongly depressed, creating appearance of more highly arched body; without sternal projections comparable to pregonopodal processes of male; postgonopodal sternal elevations of male absent, female sterna flat.

Cyphopods in situ with valvular openings visible in aperture. Receptacle absent. Valves relatively large, subequal, surfaces finely granulate. Operculum relatively large, located under lateral end of valves.

*Variation.*—There is considerable variation in the size of the sternal projections, one of the prime diagnostic features of the species. The one on segment 4, between the 3rd leg pairs, is highly variable and largest on the holotype. In the Shelby County males, this lobe is reduced to two widely separated knobs that are subequal in length to the adjacent coxal widths. The process between the anterior legs of segment 5 (4th legs) is less variable but still smaller than that of the holotype in the Talladega County male and the one from near Montevallo.

On the gonopods the prefemoral processes are relatively uniform, some curving less than others. The acropodite of the Talladega County male is more linear and massive, and the solenomerite is twisted so that the groove crosses to the lateral side about midlength of the structure. On the non-type males, the tibial process is produced apically into a subacute tip.

*Ecology.*—The male I collected in Shelby County was taken in a valley in a mesic hardwood forest not far from a creek.

*Distribution.*—Known only from six localities in the southern extremity of the Ridge and Valley Province in central Alabama. Most sites lie between US highways 280 and I-65, but the species probably occurs in adjacent counties in all directions. Specimens were examined as follows:

ALABAMA: *Shelby Co.*, Oak Mountain St. Pk., M, 22 May 1980, R. M. Shelley (NCSM A3130); and 7.3 mi. NW Montevallo, M, 29 Dec 1962, collector unknown (FSCA). *Coosa Co.*, 10 mi. N Rockford, M, F, 20 Apr 1983, R. M. Shelley and P. B. Nader (NCSM A4034). *Talladega Co.*, 2.8 mi. NW Sylacauga, 2F, 6 May 1954, L. Hubricht (RLH); and 6 mi. SE Sylacauga, M, 7 May 1975, L. Hubricht (RLH). *Tallapoosa Co.*, Alexander City, M, 27 Nov 1944, collector unknown (NMNH) TYPE LOCALITY.

*Remarks.*—Loomis (1969) was correct in stating that *D. sternolobus* was the largest species of *Dicellarius*. However, his remark about a sternal lobe between the 6th legs is somewhat misleading. This structure is more of a narrow transverse ridge, divided medially, than a ventrally produced, apically tapering lobe.

The affinities of *D. sternolobus* are unclear, but as in *D. b. lamellidens*, the acropodite curves caudomedial in situ and the solenomerite overlies the tibiotarsus in medial view. Perhaps *D. sternolobus* also evolved from a form of *D. bimaculatus* that became reproductively isolated in central Alabama, in similar fashion to the evolution of *D. okefenokensis* in southeastern Georgia and Florida.

Genus *Thrinaxoria* Chamberlin and Hoffman

*Thrinaxoria* Chamberlin and Hoffman, 1950:4; 1958:51.

*Type-species.*—*Fontaria lamprea* Chamberlin, 1918, by original designation.

*Description.*—A genus of moderate-size xystodesmids with the following characteristics:

Body composed of head and 20 segments in both sexes. Head of normal appearance, moderately smooth and polished. Antennae moderately slender, becoming progressively more hirsute distally, with 4 conical sensory cones on ultimate article; no other sensory structures apparent. Facial setae with or without epicranial, frontal, and genal series, with clypeal, and labral series; without interantennal and subantennal series.

Terga finely granulate, not polished; paranota moderately coriaceous. Collum moderately broad, ends subequal to those of following tergite. Paranota flattened to moderately depressed, interrupting slope of dorsum, caudolateral corners rounded on anteriormost segments, becoming blunt in midbody regions and progressively more acute posteriorly. Peritremata distinct, strongly elevated above metazonal surface; ozopores located caudal to midlength, opening dorsolaterad. Prozonites smaller than metazonites; strictures moderately distinct, slightly costulate.

Caudal segments normal for family.

Sides of metazonites granulate, without grooves or impressions. Gonapophyses broad, apically expanded. Pregonopodal sterna modified as follows: that of segment 4 with minute projection, much shorter than widths of adjacent coxae; that of segment 5 with small variable lobes or low transverse ridges between 4th legs and slight impression between 5th legs; that of segment 6 with impressions between both leg pairs. Postgonopodal sterna mildly hirsute, with or without low midline elevations. Coxae without projections; prefemoral spines relatively long and sharply pointed; tarsal claws slightly bisinuate. Hypoproct broadly rounded; paraprocts with margins slightly thickened.

Gonopodal apertures ovoid to elliptical. Gonopods in situ with apices crisscrossing in midline over 6th sternum. Coxae moderate in size, without apophyses, connected by membrane only, no sternal remnant. Prefemora moderate, with variable prefemoral processes arising on anterior or anteriomedial sides, either angling across acropodite stem or extending linearly along anterior margin. Acropodites moderately thick and robust, configurations variable, either bent strongly mediocaudad at midlength (level of distal division), slightly curved, or nearly linear; divided near  $\frac{1}{2}$  length into variable solenomerite and tibial process, continuous or discontinuous with axis of acropodite. Prostatic grooves arising in pits in bases of prefemora, running entirely along medial sides of acropodites onto solenomerites, opening terminally.

Cyphopodal apertures elliptical, encircling 2nd legs, sides slightly elevated above metazonal surfaces, without pleurotergal lobes on anteriolateral corners. Cyphopods in situ located lateral to 2nd legs, variably positioned in apertures. Receptacles varying from remnant to moderate structure cupped around part of valves, surfaces irregular, with slight lobes. Valves moderate and subequal, variously oriented in aperture, surfaces finely granulate. Opercula large, located under lateral end of valves.



*Distribution*.—Northwestern Louisiana to central Georgia, ranging northward into southwestern North Carolina (Blue Ridge Province) and west-central and southeastern Tennessee, and southward into the Coastal Plains of Alabama and Georgia. The Tennessee River is a distributional barrier in Tennessee and Alabama, as *T. lampra* has not been encountered in the Nashville Basin and Highland Rim Provinces on the “inside” of the loop as has *Pachydesmus* (Hoffman 1958). This barrier effect of the Tennessee River is interesting since the genus spans many large rivers, most notably the Mississippi.

*Species*.—Two, distinguished by the characters set forth in the following diagnoses.

*Thrinaxoria lampra* (Chamberlin)

Figs. 24–26

*Fontaria lampra* Chamberlin, 1918:371–372.

*Thrinaxoria lampra*.—Chamberlin and Hoffman, 1950:4; 1958:52.—Causey, 1963:77.

*Zinaria aberrans* Chamberlin, 1942:4, pl. 1, fig. 7.

*Type-specimens*.—Male paratypes (RVC, RLH) taken by K. P. Schmidt, 9 Mar 1915, from Creston, Natchitoches Par., Louisiana. The male holotype, collected at this locality on 26 Mar 1915 (Chamberlin 1918) and reported to be in the MCZ (Chamberlin and Hoffman 1958), is lost, since it is not at Harvard nor in the Chamberlin collection. Two female paratypes from Creston, supposedly of *T. lampra*, are in the MCZ, but they were taken on 5 Mar 1915 the same date that the type of *Pachydesmus clarus* (Chamberlin) was collected there (Chamberlin 1918). Since the features of females of *T. lampra* and *P. clarus* are nearly identical, it is impossible to tell which species these females belong to.

*Diagnosis*.—Prefemoral process short, angling across stem of acropodite; distal elements bent abruptly caudomedial, discontinuous with general curvature of acropodite; cyphopods with moderate receptacle.

*Paratype*.—Length 35.5 mm, maximum width 7.2 mm, W/L ratio 20.3%, depth/width ratio 61.1%. Segmental widths as follows:

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collum	6.2 mm	16th	6.9
2nd	6.8	17th	6.1
3rd	7.0	18th	4.6
4th–15th	7.2		

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Color in life unknown.

Head capsule smooth, polished; width across genal apices 4.2 mm, interantennal isthmus 1.6 mm; epicranial suture thin but distinct, terminating above interantennal region, not bifid. Antennae moderately long, reaching back to middle of 4th segment, relative lengths of antennomeres  $2 > 3 > 4 = 5 = 6 > 1 > 7$ . Genae not margined laterally, with distinct, linear, central impressions, ends broadly rounded and projecting slightly beyond adjacent cranial margin. Facial setae as follows: Epicranial 2-2, interantennal absent, frontal 1-1, genal 2-2, clypeal about 12-12, labral about 22-22.

Collum relatively broad, ends not extending beyond those of adjacent tergite. Dorsum finely granulate, not polished. Paranota relatively flattened, interrupting slope of dorsum and subparallel to substrate, anterior corners rounded through segment 5, becoming blunt and progressively more acute posteriorly. Peritremata distinct, strongly elevated above paranotal surface. Ozopores located caudal to midlength of peritremata, opening dorsolaterad.

Sides of metazonites dull and granulate but without noticeable grooves or impressions. Strictures sharp, distinct, prozona elevated slightly above metazona. Sternum of segment 4 with minute projection; that of segment 5 with two low, widely separated, transverse ridges between 4th legs and with slight impression between 5th legs (Fig. 24); 6th sternum with distinct impressions between both leg pairs. Postgonopodal sterna flattened, without trace of midline elevations; caudal margins indented medially.

Gonopodal aperture ovoid, 2.2 mm wide and 1.2 mm long at midpoint, without anteriolateral indentations, sides flush with metazonal surface. Gonopods in situ (Fig. 25, not this specimen) with acropodites projecting anteriad and bending mediad, apices crisscrossing in midline over 6th sternum; prefemoral processes extending mediad and overlapping at midlength, tips projecting just beyond anterior margin of aperture. Gonopod structure as follows (Fig. 26): Prefemoral process short, terminating well below distal division of acropodite, angling across stem of acropodite and directed toward distal extremity of tibial process. Acropodite bent sharply mediocaudad at level of distal division, distal elements discontinuous with curvature of acropodite, overhanging and extending well beyond level of prefemur; stem relatively narrow and parallel-sided proximal to bend. Distal elements widely separated by subovoid space, converging apically, directed generally mediocaudad; tibial process slightly longer and more proximal, with slight basal curve, flattened distally and produced into blunt tip; solenomerite flattened basally, sides roughly parallel then tapering and curving apically to blunt tip, tip directed toward tibial process. Prostatic groove arising in pit in prefemur, running entirely along medial side of acropodite onto solenomerite, opening terminally.

*Female topotype*.—Length 35.0 mm, maximum width 6.3 mm, W/L ratio 18.0%, depth/width ratio 76.2%. Agreeing essentially with males in somatic features except paranota much more strongly depressed, angling sharply ventrad, creating appearance of more highly arched body; without trace of sternal elevations.

Cyphopods in situ with corner of valves and receptacle visible in aperture. Receptacle cupped around medial end of valves, surface moderately irregular and rugulose, with slight lobes. Valves moderate and subequal, oriented subperpendicularly to body axis in aperture, surface finely granulate. Operculum large, located under lateral end of valves.

*Variation*.—The sternal ridges between the 4th legs of segment 5 vary and become lobe-like in Alabama, resembling their condition in *T. bifida*. The prefemoral processes of *T. lampra* are all short as in the holotype, in contrast to the variation in the congener.

*Distribution*.—*Thrinaxoria lampra* is known from two allopatric populations, a fairly continuous one in northwestern Louisiana and one with widely separated samples from west-central Tennessee to southwestern Alabama. In Alabama it occurs sympatrically and syntopically with *D. t. separandus* in Tuscaloosa and



*D. b. bimaculatus* along the Tombigbee River in Washington County. The Tennessee River constitutes a range boundary because the known localities are all on the "outside" of the loop formed by the river as it passes through Alabama and northward into western Tennessee. The species can be listed as probable for eastern Texas and southwestern Arkansas, since Miller County, Arkansas, and Cass, Marion, Harrison, Panola, and Shelby counties, Texas, are only a few miles from known localities in Caddo, Desoto, and Sabine Parishes, Louisiana. Thus, *T. lampra* becomes the third species whose occurrence in northeastern Texas can be predicted from distributions in adjacent states, the others being *Pleurolooma flavipes* Rafinesque and *Auturus l. louisianus* (Chamberlin) (Shelley 1980, 1982). Specimens were examined as follows:

LOUISIANA: *Caddo Par.*, 5 mi. NW Shreveport, M, 13 Apr 1936, L. Hubricht (RVC). *DeSoto Par.*, 11 mi. N Mansfield, 2M, 25 Aug 1966, R. E. Tandy (FSCA). *Sabine Par.*, 8 mi. W Noble, M, 5 Apr 1969, D. C. Marizot and R. M. Blaney (FSCA). *Red River Par.*, 4 mi. NW Coushatta, M, 10 Apr 1971, P. Kimmick (FSCA). *Natchitoches Par.*, no further data, 2F, 22 Mar 1957 and 20 Apr 1961, collector unknown (FSCA); Moreland, M, 16 Oct 1954, collector unknown (FSCA); and Creston, 2M, F, unknown date in 1915, K. P. Schmidt (RVC), M, 9 Mar 1915, K. P. Schmidt (RLH), and 2M, 2F, 26 Mar 1915, K. P. Schmidt (MCZ) TYPE LOCALITY.

TENNESSEE: *Henderson Co.*, Natchez Trace St. Pk., 2M, 3F, 26 May 1980, R. M. Shelley (NCSM A3159).

MISSISSIPPI: *Tishomingo Co.*, Tishomingo St. Pk., M, 15 May 1964, L. Hubricht (RLH).

ALABAMA: *Walker Co.*, Jasper, 800 Airport Rd., 3M, 21 Jun 1975, B. R. Wall (NCSM A596), and M, 29 Apr 1978 (NCSM A2591). *Tuscaloosa Co.*, Tuscaloosa, M, F, 29 Mar 1948, G. E. Ball (RLH) and 2M, 3F, tunneling in Zoyzia grass, 13 Apr 1982, E. A. Cross (NCSM A3933). *Washington Co.*, 3 mi. E Leroy, near Tombigbee R., M, F, 3 Jul 1960, L. Hubricht (RLH) and M, 28 Apr 1983, R. M. Shelley and P. B. Nader (NCSM A4048).

*Remarks.*—Because of the general gonopodal similarity with *Pleurolooma flavipes*, *T. lampra* was described as a species of *Zinaria* (now a synonym of *Pleurolooma*) by Chamberlin (1942). This similarity is merely coincidental, however, and a relationship between *Thrinaxoria* and *Pleurolooma* was discounted by Chamberlin and Hoffman (1950) and Shelley (1980).

*Thrinaxoria bifida* (Wood), new combination

Figs. 27–28

*Polydesmus* (*Fontaria*) *bifidus* Wood, 1864:7; 1865:223, fig. 52.

*Epeloria bifida*.—Chamberlin and Hoffman, 1958:32.

*Type-specimen.*—As stated in the introduction, Wood's types are lost. I therefore designate a neotype as follows: Male neotype (NCSM A2339) collected by R. M. Shelley and W. B. Jones, 8 Jul 1978, along road to Chilowhee Campground, 1.9 miles NW of the junction with US highway 64, 0.2 miles NE Parksville, Polk Co., Tennessee. The other specimens from Polk Co. in the locality listing are designated neoparatypes.

*Diagnosis.*—Prefemoral process variable, short to long, usually extending lin-

early along anterior margin of acropodite stem, rarely angling across latter; distal elements continuous with and continuing overall curvature of acropodite; cyphopods with remnant of receptacle.

*Neotype*.—Length 35.8 mm, maximum width 7.8 mm, W/L ratio 21.2%, depth/width ratio 64.1%. Segmental widths as follows:

collum	6.7 mm	14th–15th	7.4
2nd	6.9	16th	7.2
3rd	7.1	17th	6.8
4th	7.6	18th	5.5
5th–13th	7.8		

Color in life: Dorsum generally bright orange in color, with darker and lighter hues blending across metaterga.

Somatic features similar to those of *T. lampra*, with following exceptions:

Width across genal apices 4.5 mm, interantennal isthmus 1.1 mm. Antennae reaching back to middle of 4th tergite, relative lengths of antennomeres 2 > 3 > 4 = 5 = 6 > 1 > 7. Genae with slight central impressions. Facial setae as follows: Epicranial, interantennal, frontal, and genal not detected and presumed absent, clypeal about 10-10, labral about 15-15.

Collum broad, ends extending well below those of following tergite. Peritremata relatively indistinct, only slightly elevated above paranotal surface.

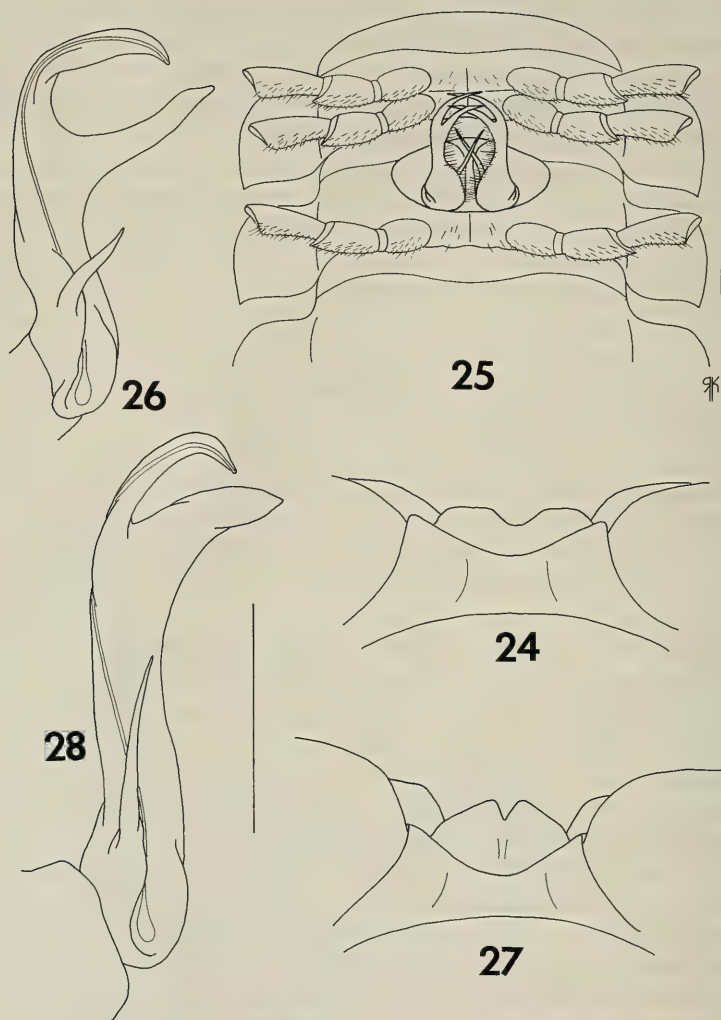
Sternum of segment 5 with two apically separated paramedial lobes between 4th legs, height subequal to widths of adjacent coxae, and with moderate recession between 5th legs (Fig. 27); 6th sternum convexly recessed between both legs, 7th legs set slightly farther apart than 6th. Postgonopodal sterna with low, almost undetectable, longitudinal elevations on segments 8-15.

Gonopodal aperture elliptical, 2.6 mm wide and 1.3 mm long at midpoint, indented anteriolaterally, sides elevated above metazonal surface. Gonopods in situ with acropodites extending anteriad from aperture, distal elements curving mediad and crossing those of opposite member in midline over 6th sternum. Gonopod structure as follows (Fig. 28): Prefemoral process moderately long but terminating well below distal division of acropodite, angling slightly across stem of acropodite but not crossing caudal margin. Acropodite curving gradually mediocaudad at midlength proximal to distal division, distal elements continuous with curvature and acropodite stem, extending well beyond level of prefemur; stem relatively narrow and parallel-sided basally, sides diverging gradually at beginning of curve. Distal elements separated by moderate space, generally diverging and directed mediocaudad; tibial process longer and more proximal, broad and laminate, apically subacute; solenomerite with sides parallel, continuing curvature of acropodite but bent abruptly dorsad distally, tip directed toward tibial process. Prostatic groove arising in pit in prefemur, running entirely along medial side of acropodite onto solenomerite, opening terminally.

*Description of females*.—Since no females have been taken in Polk County, Tennessee, a composite description of their characters has been prepared from the three specimens in adjacent Cherokee County, North Carolina.

Length 37.7 mm, maximum width 7.1 mm, W/L ratio 18.8%, depth/width ratio 73.2%. Agreeing closely with males in somatic features except paranota more





Figs. 24–28. *Thrinaxoria* spp. 24–26, *T. lampra*: 24, Sternum of segment 5 of paratype, caudal view; 25, Gonopods in situ, ventral view of male from Henderson Co., TN; 26, Telopodite of left gonopod of paratype, medial view. 27–28, *T. bifida*: 27, Sternum of segment 5 of neotype, caudal view; 28, Telopodite of left gonopod of the same, medial view. Scale line for Fig. 25 = 1.00 mm; line for other Figs. = 1.33 mm for 24 and 27, 1.00 mm for 26, and 1.14 mm for 28.

strongly depressed, creating appearance of more highly arched body, and without trace of sternal elevations.

Cyphopods in situ with opening of valves directed ventrad. Receptacle much smaller than in *T. lampra*, a thin darkened remnant of tissue located mediad or anteromediad to the valves. Valves moderate and subequal, surface finely granulate. Operculum large, located under lateral end of valves.

*Variation.*—The prefemoral processes vary, and in males from Whitfield and Dougherty counties, Georgia, they are long and acicular, projecting beyond the division of the acropodite. In most males this structure is linear and directed

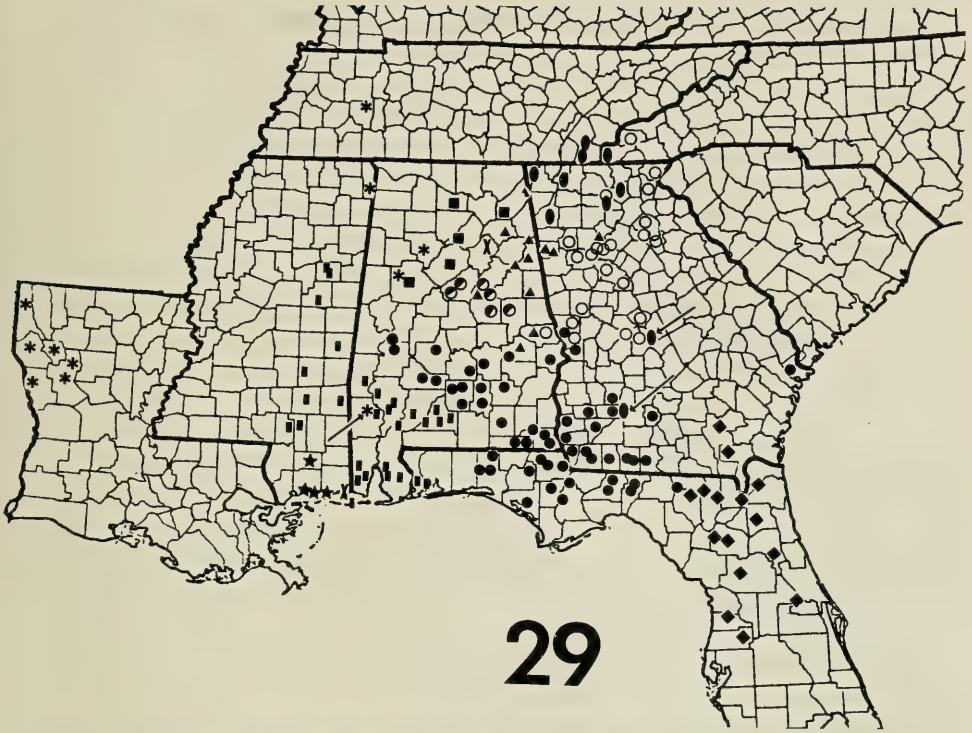


Fig. 29. Distribution of *Dicellarius* and *Thrinaxoria*. rectangles, *D. b. bimaculatus*; dots, *D. b. fictus*; stars, *D. b. lamellidens*; lower X, *D. bimaculatus* intergrades; triangles, *D. t. talapoosa*; squares, *D. t. separandus*; upper X, *D. talapoosa* intergrades; circles, *D. atlanta*; half shaded circles, *D. sternolobus*; diamonds, *D. okefenokensis*; asterisks, *T. lampra*; ovals, *T. bifida*. The arrows indicate apparently isolated populations of the species of *Thrinaxoria* within the range of *Dicellarius*.

along the anterior margin of the acropodite. The neotype is thus an exception in having the process angle across the stem. In other males from Polk County the distal elements are more widely separated, and the solenomerite is broadly curved toward the tibial process instead of being abruptly bent. The overall curvature of the acropodite is similar in all males, but the solenomerite in the one from Dougherty County is nearly upright, with only a slight apical bend. The elements are thus more widely separated so that the overall configuration resembles that of *D. atlanta*.

**Distribution.**—Southern extremity of the Blue Ridge and Ridge and Valley Provinces to the Coastal Plain, from southeastern Tennessee and southwestern North Carolina to southern Georgia. Specimens were examined as follows:

**TENNESSEE:** *Polk Co.*, 6.5 mi. NE Benton, Chilowhee Rec. Area, Cherokee Nat. For., M, 20 Jun 1950, L. Hubricht (RLH); Oswald Dome, Bean's Mtn., 2M, 12 Jun 1953, L. Hubricht (RLH); and 0.2 mi. NE Parksville, along rd. to Chilowhee Cpgd., 1.9 mi. NW jct. US hwy. 64, M, 8 Jul 1978, R. M. Shelley and W. B. Jones (NCSM A2339) **NEOTYPE LOCALITY**.

**NORTH CAROLINA:** *Cherokee Co.*, Wolf Creek vic., ca. 1 mi. E TN st. line, F, 16 May 1979, R. M. Shelley and R. K. Tardell (NCSM A2706); and 6 mi.



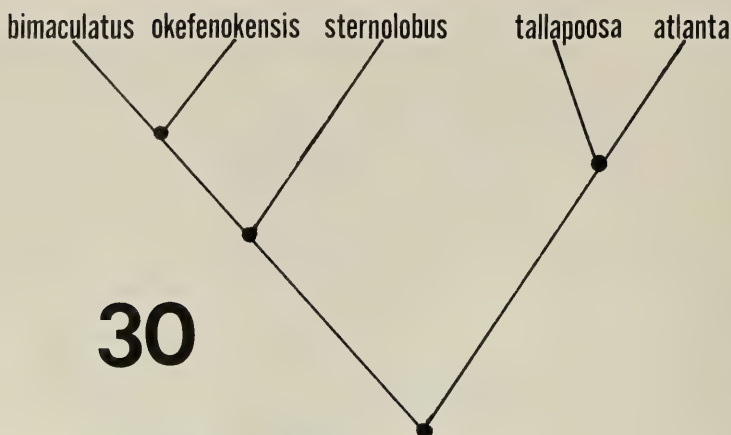


Fig. 30. Relationships in *Dicellarius*.

WNW Culberson, along co. rd. 1107, 0.2 mi. N jct. co. rd. 1108, F, 27 Jul 1974, R. M. Shelley (NCSM A2405) and F, 6 Jul 1978, R. M. Shelley and W. B. Jones (NCSM A2330).

GEORGIA: *Dade Co.*, Cloudland Canyon St. Pk., F, 27 Apr 1979, R. M. Shelley (NCSM A2607). *Whitfield Co.*, Dalton, along creek off I-75 at jct. GA hwy. 52, M, 16 Apr 1978, R. M. Shelley and R. E. Ashton (NCSM A1847). *Dawson Co.*, along Amicalola River, 1.5 mi. E Amicalola Falls, M, 15 Apr 1961, L. Hubricht (RLH). *Lumpkin Co.*, 16 mi. NW Dahlonega, M, F, 17 Jun and 2 Jul 1973, A. LaVallee and R. Duffield (RLH). *Floyd Co.*, Rome vic., F, 13 Oct 1954, P. J. Darlington (RLH). *Houston Co.*, Perry, M, 26–28 Dec 1982, J. A. Payne (RLH). *Dougherty Co.*, 8.4 mi. S Albany, just inside Mitchell Co. line on GA hwy. 3, M, 15 Sep 1979, R. M. Shelley and P. T. Hertl (NCSM A2877).

### Relationships

At present I cannot resolve the generic relationships in the Pachydesmini. Of the three other eastern xystodesmid tribes, the Apheloriini is chosen as the out-group because of the synapomorphic absence of a sternal remnant between the gonopodal coxae. The genera of the Rhysodesmini possess such a remnant, a plesiomorphic trait, and the Nannariini, with small size, modified tarsal claws anteriorly in males, and subcoxal sternal spines, is clearly a derived, specialized group. Since apheloriine diplopods have a receptacle on the cyphopods, *Pachydesmus*, which possesses this structure, could be considered sister to *Thrinaxoria*, which has a vestigial to moderate receptacle, and *Dicellarius*, which lacks the feature. However, since apheloriines have generally unmodified midbody sterna, *Thrinaxoria*, which has the most poorly developed elevations, could be considered sister to *Dicellarius* and *Pachydesmus*. These seem the only useful characters to resolve the question because others are not shared significantly with the out-group. For example, very few apheloriine taxa have a divided acropodite, and the coxal apophyses are autapomorphous in both *Pachydesmus* and *Deltotaria*. Consequently, until other features are discerned that clarify this matter, the relationships in the Pachydesmini are best considered an unresolved trichotomy.

Within *Dicellarius* there are two obvious branches based primarily on the configurations of the tibial processes. One line leads to *D. talapoosa* and *D. atlanta*, in which the process tapers continuously to a subacuminate tip, and the other leads to *D. bimaculatus*, *D. okefenokensis*, and *D. sternolobus*, in which it is broad for most of its length, narrowing only near the tip. These two lineages are geographically plausible, since their members are situated proximally to each other (Fig. 29). The key species appear to be *D. bimaculatus* and *D. talapoosa*; the others appear to represent segregated populations of these that have achieved reproductive isolation. *Dicellarius atlanta* is very similar to forms of *D. talapoosa*, but their overlapping ranges are proof of reproductive isolation. Similarly, the acropodal curvature of *D. okefenokensis* is an augmentation of that exhibited by eastern populations of *D. bimaculatus* (*b. fictus*), and the torsion culminates the west to east, counterclockwise to clockwise, rotation cline of the latter. These observations suggest that *D. okefenokensis* was once connected to *D. bimaculatus* by intergrades that have disappeared, leaving it reproductively isolated. Less conclusive evidence is available for *D. sternolobus*, but its caudally curved acropodite and the overlying of the tibiotarsus by the narrow solenomerite in medial view are similar to the conditions in *D. b. lamellidens*. Since this pattern exists in known populations of *D. bimaculatus*, it could also have evolved a second time in interior populations that are now fully isolated. These ideas on relationships are depicted in Fig. 30.

#### Acknowledgments

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NEW SPECIES OF MAMMALS FROM NORTHERN  
SOUTH AMERICA: A LONG-TONGUED BAT,  
GENUS *ANOURA* GRAY

Charles O. Handley, Jr.

*Abstract.*—A new species of long-tongued bat, *Anoura latidens*, related to and sympatric with *Anoura geoffroyi* Gray is described. It is widespread and abundant in Venezuela, but elsewhere it is known only by single specimens from Colombia and Peru. The species of *Anoura* are keyed.

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Mammals and their ectoparasites were collected in Venezuela between 1965 and 1968 by the Smithsonian Venezuela Project (SVP), supported in part by a contract (DA-49-MD-2788) of the Medical Research and Development Command, Office of the Surgeon General, U.S. Army. Numerous papers have described the ectoparasites and mammals of the Project. Throughout these papers undescribed species of mammals have been referred to by alphabetical designations. Some of these have been named subsequently by Handley and Ferris (1972), and Handley and Gordon (1979). In this paper I deal with another, a long-tongued bat of the genus *Anoura* Gray.

When I named *Anoura cultrata* (Handley, 1960) the genus *Anoura* was believed to include only two other species, *A. caudifera* É. Geoffroy St.-Hilaire and *A. geoffroyi* Gray. Then for several years the genus was thought to include five species (Jones and Carter 1976), but Nagorsen and Tamsitt (1981), with whom I agree, regarded *A. brevirostrum* Carter (1968) and *A. werckleae* Starrett (1969) as synonyms of *A. cultrata*. Now I describe another species, this one related to *A. geoffroyi*. It was discovered in a survey of the mammals of the Parque Nacional Henry Pittier ("Rancho Grande") in Venezuela in 1960. Later, many more specimens were collected in Venezuela by SVP personnel.

The cranial measurements reported here were taken as outlined by Handley (1959:98). Hind foot, tibia, calcar, and forearm were measured in the museum on dry specimens or on specimens preserved in alcohol. Other external dimensions were measured on fresh specimens in the field. All measurements are in millimeters. Coloration was determined under Examolites (Macbeth Corp., Newburg, New York 12553) with natural light excluded. Capitalized color terms are from Ridgway (1912).

*Anoura latidens*, new species

*Holotype.*—USNM No. 370119, adult female, skin and skull, collected 18 Aug 1965, by A. L. and M. D. Tuttle, on Pico Ávila, 2150 m, 5 km NNE Caracas (= "Hotel Humbolt, 9.4 km N Caracas"), Distrito Federal, Venezuela, in mist net across trail through open forest; original number, SVP 629. This bat was pregnant when captured.

*Etymology.*—Latin, *latus*, broad, and *dens*, tooth, referring to the unusual breadth



Table 1.—Measurements of adult female *Anoura latidens* and *Anoura geoffroyi* of SVP collections from north (Los Venados, Pico Ávila, Mirimire) and south (Km 125, 68–85 km SSE El Dorado) of the Río Orinoco. For each measurement line 1 includes the mean plus or minus two standard errors, line 2 the extremes, and line 3 sample size in parentheses.

Total length	Hind foot (dry)	Ear	Forearm	Greatest length	Zygomatic breadth	Postorbital breadth
<i>Anoura latidens</i> : Km 125						
66.3 ± 1.46	11.9 ± 0.26	14.8 ± 0.54	43.7 ± 0.46	24.5 ± 0.14	10.6 ± 0.10	5.0 ± 0.04
62–72	11–13	13–17	41.8–45.7	23.9–25.3	10.2–11.2	4.8–5.3
(18)	(18)	(18)	(18)	(27)	(23)	(27)
<i>Anoura latidens</i> : Los Venados and Pico Ávila						
67.6 ± 2.24	11.4 ± 0.28	13.4 ± 0.78	42.3 ± 0.48	23.9 ± 0.30	10.4 ± 0.12	4.9 ± 0.08
61–77	11–12	11–15	40.3–43.3	22.1–24.6	9.9–10.7	4.6–5.2
(14)	(14)	(14)	(14)	(15)	(15)	(15)
<i>Anoura geoffroyi</i> : Km 125						
65.9 ± 1.24	11.9 ± 0.26	15.2 ± 0.52	42.5 ± 0.50	25.2 ± 0.16	10.7 ± 0.14	4.9 ± 0.06
61–70	11–13	13–17	41.3–44.9	24.4–25.8	10.2–11.2	4.6–5.2
(17)	(16)	(17)	(16)	(22)	(20)	(22)
<i>Anoura geoffroyi</i> : Mirimire						
74.7 ± 2.30	11.6 ± 0.40	16.4 ± 0.60	42.0 ± 1.10	24.6 ± 0.26	10.4 ± 0.26	4.9 ± 0.06
70–79	11–12	15–17	39.2–43.9	24.2–25.0	9.9–10.6	4.8–5.0
(7)	(7)	(7)	(7)	(7)	(5)	(7)

Table 1.—(Continued).

Braincase breadth	Braincase depth	Maxillary tooththrow	Postpalatal length	Width at molars	Width at canines	Tibia
<i>Anoura latidens</i> : Km 125						
9.7 ± 0.06	7.6 ± 0.08	9.3 ± 0.08	9.1 ± 0.08	6.2 ± 0.06	4.1 ± 0.06	14.2 ± 0.20
9.3–10.1	7.2–8.0	8.7–9.6	8.6–9.5	5.7–6.5	3.8–4.4	13.3–15.0
(27)	(27)	(27)	(26)	(26)	(26)	(18)
<i>Anoura latidens</i> : Los Venados and Pico Ávila						
9.6 ± 0.10	7.4 ± 0.10	9.2 ± 0.12	8.8 ± 0.16	6.0 ± 0.12	4.0 ± 0.08	14.4 ± 0.26
9.1–10.0	7.1–7.8	8.6–9.4	8.0–9.3	5.7–6.3	3.8–4.2	13.5–15.0
(15)	(15)	(15)	(15)	(15)	(15)	(14)
<i>Anoura Geoffroyi</i> : Km 125						
9.8 ± 0.08	7.6 ± 0.08	9.6 ± 0.08	8.9 ± 0.18	6.2 ± 0.08	4.2 ± 0.08	13.8 ± 0.16
9.5–10.2	7.3–8.0	9.2–10.0	8.1–9.6	5.9–6.5	4.0–4.6	13.4–14.5
(22)	(22)	(20)	(21)	(22)	(18)	(16)
<i>Anoura Geoffroyi</i> : Mirimire						
9.6 ± 0.12	7.4 ± 0.20	9.4 ± 0.12	8.8 ± 0.26	6.0 ± 0.12	4.2 ± 0.08	13.8 ± 0.28
9.3–9.8	7.0–7.7	9.1–9.5	8.4–9.3	5.8–6.2	4.1–4.4	13.2–14.2
(7)	(6)	(7)	(6)	(6)	(7)	(7)



Table 2.—Measurements of adult male *Anoura latidens* and *Anoura geoffroyi* of SVP collections from north (Los Venados, Pico Ávila, Mirimire) and south (Km 125, 68–85 km SSE El Dorado) of the Río Orinoco. For each measurement line 1 includes the mean plus or minus two standard errors, line 2 the extremes, and line 3 sample size in parentheses.

Total length	Hind foot (dry)	Ear	Forearm	Greatest length	Zygomatic breadth	Postorbital breadth
<i>Anoura latidens</i> : Km 125						
65.4 ± 1.46	12.0 ± 0.00	15.0 ± 0.38	43.7 ± 0.84	24.4 ± 0.20	10.7 ± 0.24	5.0 ± 0.08
63–68	12–12	14–16	42.0–45.7	24.0–25.1	10.0–11.1	4.8–5.2
(8)	(8)	(8)	(8)	(11)	(9)	(11)
<i>Anoura latidens</i> : Los Venados and Pico Ávila						
64.8 ± 2.70	11.2 ± 0.34	13.7 ± 1.42	41.3 ± 0.54	23.8 ± 0.28	10.5 ± 0.18	4.9 ± 0.08
59–68	11–12	11–16	40.2–42.0	23.5–24.4	10.2–10.8	4.8–5.0
(6)	(6)	(6)	(6)	(6)	(6)	(6)
<i>Anoura geoffroyi</i> : Km 125						
65.2 ± 2.32	11.9 ± 0.46	15.3 ± 0.60	42.7 ± 0.46	25.4 ± 0.36	10.8 ± 0.16	4.9 ± 0.12
58–72	11–13	14–17	41.5–43.6	24.4–26.5	10.4–11.5	4.6–5.2
(10)	(10)	(10)	(10)	(12)	(12)	(12)
<i>Anoura geoffroyi</i> : Mirimire						
72.0 ± 2.32	11.8 ± 0.50	16.9 ± 0.26	42.5 ± 0.56	25.0 ± 0.26	10.8 ± 0.18	4.8 ± 0.14
68–76	11–13	16–17	41.3–43.6	24.3–25.4	10.4–11.2	4.4–5.0
(8)	(8)	(8)	(8)	(8)	(7)	(8)

Table 2.—(Continued).

Braincase breadth	Braincase depth	Maxillary tooththrow	Postpalatal length	Width at molars	Width at canines	Tibia
			<i>Anoura latidens</i> : Km 125			
9.6 ± 0.08	7.4 ± 0.16	9.2 ± 0.12	9.0 ± 0.16	6.2 ± 0.06	4.4 ± 0.06	14.1 ± 0.50
9.4–9.8	7.0–7.9	8.8–9.5	8.7–9.5	6.0–6.4	4.2–4.5	13.2–15.1
(10)	(11)	(11)	(10)	(11)	(11)	(8)
			<i>Anoura latidens</i> : Los Venados and Pico Ávila			
9.7 ± 0.16	7.5 ± 0.10	9.3 ± 0.20	8.8 ± 0.24	6.2 ± 0.14	4.3 ± 0.06	13.7 ± 0.58
9.6–10.1	7.3–7.6	8.9–9.6	8.5–9.2	6.0–6.4	4.2–4.4	12.5–14.6
(6)	(6)	(6)	(6)	(6)	(6)	(6)
			<i>Anoura geoffroyi</i> : Km 125			
9.9 ± 0.10	7.6 ± 0.16	9.7 ± 0.18	9.2 ± 0.16	6.3 ± 0.16	4.5 ± 0.08	14.0 ± 0.26
9.5–10.1	7.2–8.2	9.1–10.2	8.8–9.6	5.8–6.7	4.2–4.8	13.4–14.8
(11)	(12)	(12)	(11)	(11)	(12)	(10)
			<i>Anoura geoffroyi</i> : Mirimire			
9.8 ± 0.16	7.7 ± 0.06	9.5 ± 0.10	9.0 ± 0.26	6.2 ± 0.14	4.5 ± 0.10	13.8 ± 0.12
9.5–10.3	7.5–7.8	9.4–9.8	8.5–9.5	6.0–6.5	4.4–4.7	13.6–14.0
(8)	(8)	(7)	(8)	(7)	(7)	(8)



of P<sub>4</sub> and the other premolars. This taxon has been referred to as "*Anoura* sp. A" in previous publications dealing with the collections of the SVP.

*Distribution.*—Widely distributed in Venezuela—in the foothills of the Sierra de Perijá and the Mérida Andes, at medium and high elevations in the Sierra de la Costa and in mountains in the Northeast, at three localities in Bolívar state, and in the Ventuari Basin. Outside Venezuela, known only by a single specimen each from Colombia and central Peru. Probably also extends to adjacent parts of Brazil, Guyana, and Ecuador.

SVP collectors netted *Anoura latidens* (n = 105) most often in moist situations (93 percent); in evergreen forest (71 percent), but also in yards and orchards (28 percent), and once in arid thorn scrub (1 percent). Elevation range 50–2240 m (81 percent below 1500 m). Holdridge life zones (Ewel and Madriz 1968): Tropical dry forest (3 percent), Tropical humid forest (28 percent), Premontane thorny forest (1 percent), Premontane humid forest (2 percent), Premontane very humid forest (48 percent), and Lower Montane humid forest (18 percent).

*Description.*—In size similar to *Anoura geoffroyi*: skull averages slightly smaller, but body averages slightly larger (Tables 1 and 2). Dorsal coloration resembles that of *A. geoffroyi* but averages paler and browner, less blackish (between Verona Brown and Warm Sepia); hair bases on nape near Cartidge Buff, on remainder of dorsum somewhat grayer; chin, throat, and chest paler than remainder of underparts, often whitish; abdomen near Sepia; bases of abdominal hairs brown to gray-brown, not well differentiated from buffy tips; and ears and membranes average paler than in *A. geoffroyi*.

Skull, mandible, and teeth similar to those of *Anoura geoffroyi* but rostrum relatively short, nearly parallel-sided, and with little bulge at canine bases; braincase relatively inflated; zygomatics always incomplete; posterolateral edges of palate (behind tooththrows) strongly pointed; horizontal ramus of mandible shallow and usually depressed anteriorly; coronoid-articular distance of ascending ramus short; P<sub>3</sub> and P<sub>4</sub> relatively wide (thick) and usually shortened; anterobasal cusp of P<sub>3</sub> usually reduced; and medial internal cusp of P<sub>4</sub> enlarged, rendering basal outline of tooth approximately triangular; P<sub>3</sub> and P<sub>4</sub> wide and usually long.

*Measurements.*—Holotype female, adult: Total length 66, tail vertebrae 0, hind foot (dry) 11, ear from notch 13, forearm 42.3, tibia 14.7, calcar 4.5.

Greatest length of skull 24.0, zygomatic breadth 10.7, postorbital breadth 4.8, braincase breadth 9.5, braincase depth 7.5, maxillary tooththrow length 9.1, postpalatal length 8.5, palatal breadth outside of M<sub>3</sub> 5.8, rostral breadth at base of canines 4.0.

Additional measurements: Tables 1 and 2.

*Comparisons.*—*Anoura latidens* is sympatric with three other species of *Anoura*. From *Anoura caudifera* it is easily recognized by its larger size (e.g., forearm 40–45 vs. 35–39, maxillary tooththrow 8.6–9.7 vs. 7.8–8.7), lack of tail, incomplete zygomatics, presence of medial internal cusp on P<sub>4</sub>, presence of anteroexternal cusp and crest on M<sub>1</sub>, and comparatively long, low P<sub>4</sub>. Note that most authors, following Husson (1962:139), have used the name *Anoura caudifer* on the grounds that this was the spelling of the specific name originally proposed by É. Geoffroy St.-Hilaire (1818:418, *Glossophaga caudifer*). However, É. Geoffroy St.-Hilaire was in error and so have been all authors (including me) who have used the masculine form "*caudifer*" in combination with the generic names *Glossophaga*, *Loncho-*

*glossa*, or *Anoura*, all feminine nouns. In this instance, the specific name is an adjectival modifier, and as such it must agree in gender with the generic name. Thus, *Anoura caudifera*.

Compared with *Anoura cultrata*, *Anoura latidens* has coloration paler throughout, tail absent, skull much less robust, zygomata incomplete, upper canine much smaller, postcanine teeth (except P<sub>1</sub>) more robust, and P<sub>1</sub> not enlarged or blade-like.

*Anoura latidens* is most like *A. geoffroyi*, but it can be distinguished by numerous characteristics: P<sub>3</sub> and P<sub>4</sub> (both upper and lower) thicker and more robust; lingual cusp of P<sub>4</sub> enclosed in more or less triangular basal outline of tooth (vs. prominently protruding from narrow basal outline of tooth); P<sub>4</sub> nearly crescent-shaped, with both front and hind ends flexed inward (vs. nearly straight or with the hind end flexed outward); rostrum shorter; canine slightly smaller and less bulging at base; posterolateral edge of palate usually more strongly pointed (vs. usually more rounded and often with multiple points); zygoma always incomplete (vs. always complete in southern Venezuelan and variable in northern Venezuelan *A. geoffroyi*); horizontal ramus of mandible shallower and usually depressed (not straight) anteriorly; dorsal coloration usually paler, grayish-brown rather than blackish-brown; chin, throat, and chest pale (vs. undifferentiated from remainder of underparts); bases of abdominal hairs not well differentiated from tips, which are seldom whitish and never impart a "frosted" appearance as they often do in *A. geoffroyi*.

Both *A. geoffroyi* and *A. latidens* show a slight amount of geographical variation between northern and southern Venezuelan populations, isolated from one another by the Llanos. The degree of differentiation is a little greater in *Anoura latidens*, suggesting a different evolutionary history (Tables 1 and 2).

### Key to Species of *Anoura*

1. First lower premolar greatly enlarged and blade-like; upper canine unusually large and with prominent longitudinal sulcus on anterior face . . . . . *Anoura cultrata*
- First lower premolar approximately same size and shape as other premolars; upper canine not enlarged and its anterior face flat . . . . . 2
2. P<sub>4</sub> without medial internal cusp; M<sub>1</sub> without anteroexternal cusp and crest; tail present . . . . . *Anoura caudifera*
- P<sub>4</sub> with medial internal cusp; M<sub>1</sub> with anteroexternal cusp and crest; tail absent . . . . . 3
3. Medial internal cusp of P<sub>4</sub> enclosed in broad triangular base of tooth; upper and lower P<sub>3</sub> and P<sub>4</sub> thick . . . . . *Anoura latidens*
- Medial internal cusp of P<sub>4</sub> prominently protrudes from narrow base of tooth; upper and lower P<sub>3</sub> and P<sub>4</sub> narrow . . . . . *Anoura geoffroyi*

*Ecology.*—In the SVP collections *Anoura latidens* proved to be almost as numerous and widespread in Venezuela as *A. geoffroyi*, its closest relative. Surprisingly, *A. latidens* is represented by only two specimens in the extensive collections of *Anoura* in the American Museum of Natural History and by none at all in the collections of the British Museum (Natural History) and the Field Museum of



Natural History. Although I have seen hundreds of specimens of *A. geoffroyi* that were collected in the 19th and early 20th centuries, I have found only one *A. latidens* AMNH 69187, San Juan de Río Seco, Colombia, December 1923, Br. Niceforo María) that was collected prior to 1960.

Either *Anoura geoffroyi*, or *A. latidens*, or both inhabited 26 localities in forested portions of Venezuela sampled by SVP. *Anoura geoffroyi* proved to be more widespread. It was found at 22 of the 26 localities, while *A. latidens* was taken at only 14. However, *A. latidens* outnumbered *A. geoffroyi* at six of the ten localities where the two species were taken together.

The SVP records do not reveal any ecological or geographical segregation of *Anoura latidens* and *A. geoffroyi* in Venezuela. Although taken frequently in lowlands, both species were found most often (60 percent) at montane localities: *A. geoffroyi* to 2550 m near Tabay in the Andes and *A. latidens* to 2240 m on Pico Ávila in the Coast Range. Both were most numerous in the 1000–1500 m interval. Both were taken most often in moist situations in evergreen forest. About 30 percent of the total catch of each species was in openings.

*Specimens examined (Anoura latidens).*—**Colombia:** CUNDINAMARCA, San Juan, Río Seco, (1 AMNH). **Peru:** JUNÍN, Prov. Tarma, 2 km NW San Ramón, 884 m, (1 AMNH). **Venezuela** (all USNM unless otherwise noted): ARAGUA, El Limón, 4 km NW Maracay, 524 m, (3); Est. Biol. Rancho Grande, Paso El Portochuelo and Pico Guacamayo, 13 km NW Maracay, 1130 m, (6). BARINAS, Altamira, 794 m, (1). BOLÍVAR, El Manaco, 59 km SE El Dorado, 150 m, (12); Hato la Florida, 47 km ESE Caicara, 50 m, (3); Km 125, 85 km SSE El Dorado, 1032–1165 m, (44). CARABOBO, La Copa, 4 km NW Montalbán, 1537 m, (4); Montalbán, 598 m, (2). DTO. FEDERAL, Los Venados, 4 km NNW Caracas, 1465–1524 m, (9); Pico Ávila, nr. Hotel Humboldt, and Boca de Tigre, 5 km NNE and 6 km NNW Caracas, 2092–2240 m, (13). FALCÓN, nr. La Pastora, 16 km ENE Mirimire, 70 m, (1). LARA, La Concordia, 47 km NE El Tocuyo, 592 m, (1). MONAGAS, Caripe, 1000 m, (2); Pico de Cerro Negro, Dto. Caripe, 2200 m, (1 UCV); Finca San José, 10 km NE Caripe, (1); San Agustín, 3 km NW Caripe, 1345 m, (1). SUCRE, Manacal, 26 km ESE Carúpano, 366–380 m, (2). T. F. AMAZONAS, San Juan, Río Manapiare, 163 km ESE Pto. Ayacucho, 155 m, (15). ZULIA, Novito, 19 km WSW Machiques, 1135 m, (2). Total 117.

#### Acknowledgments

I am grateful to the following persons who helped me with this paper. Linda Gordon prepared the tables of measurements and assisted in the specimen examinations. George Steyskal reviewed the nomenclature of *Anoura* with me. Carolyn Gamble, A. L. Gardner, Darelyn Handley, Dan Nicholson, Pippa Vanderstar, and David Webster read early drafts of the manuscript and made many helpful suggestions. Curators of the following collections kindly permitted me to study specimens under their care in the preparation of this description: American Museum of Natural History (AMNH), British Museum (Natural History) (BM), Carnegie Museum of Natural History (CM), Field Museum of Natural History (FMNH), Museum of Comparative Zoology, Harvard University (MCZ), Universidad Central de Venezuela (UCV), University of Michigan Museum of Zoology (UMMZ), and United States National Museum of Natural History (USNM). A portion of the SVP specimens have been returned to Venezuela.

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## *OPAEOPHACUS ACROGENEIUS*, A NEW GENUS AND SPECIES OF ZOARCIDAE (PISCES: OSTEICHTHYES) FROM THE BERING SEA

Carl E. Bond and David L. Stein

*Abstract.*—*Opaeophacus* (with *O. acrogeneius*, a previously undescribed zoarcid from the Bering Sea) is a new genus close to *Nalbantichthys* Schultz, *Andriashevia* Fedorov and Neyelov, and *Puzanovia* Fedorov. It differs from all known fishes in having a slot-like, vertically-oriented cavity in the lens of the eye. *Opaeophacus* has firm skin, normal penultimate and ultimate vertebrae, lacks scales, lacks palatine and vomerine teeth, has lateral neuromast organs, pectoral fins, gill opening entirely above the pectoral fin, and six branchiostegal rays. Those characters in combination differentiate the genus.

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Four specimens of a new fish from near Seguam Island in the Bering Sea, and another collected north of Umnak Island were presented to Oregon State University. Comparison of the new form with the known genera of Zoarcidae showed that it is clearly distinct and we therefore propose a new monotypic genus for it.

### Methods

Specimens were fixed at sea in 10% formalin-seawater solution and later transferred to 50% isopropanol. Counts and measurements follow Hubbs and Lagler (1958). All specimens were radiographed, and one (USNM 260321) was cleared and counterstained with alizarin and alcian blue by the method of Dingerkus and Uhler (1977). The ranges of counts and ratios are given first, followed by the values for the holotype in parentheses. Specimens are on deposit at the National Museum of Natural History, Washington, D.C. (USNM), the California Academy of Sciences, San Francisco (CAS), and the Department of Fisheries and Wildlife, Oregon State University, Corvallis (OS).

### *Opaeophacus*, new genus

*Type-species.*—*Opaeophacus acrogeneius*, n. sp.

*Diagnosis.*—Optic lens with vertical, slot-like cavity, filled with soft hyaline gelatinous material; no pelvic fins or lateral jaw lobes; ultimate and penultimate vertebrae normal; scales, palatine teeth and vomerine teeth absent; body lateral line present, of free lateralis organs; pectoral fin present, with 4–5 rays; 6 branchiostegal rays; no opening behind last gill arch; gill openings entirely dorsal to base of pectoral fin; small pseudobranchiae present; only unbranched soft rays in all fins, with those in caudal, pectoral and posterior one-third of dorsal and anal fins segmented; no pyloric caeca.

*Comparisons.*—This genus is part of the “natural group” suggested by Fedorov and Neyelov (1978) to contain *Nalbantichthys* Schultz, 1967, *Puzanovia* Fedorov, 1975, and *Andriashevia* Fedorov and Neyelov, 1978. It shares the general shape,

massive lower jaw, blunt head, reduced pectoral fin, reduced gill opening, and reduced lateral line of those genera. It differs from all three in the absence of scales; from *Nalbantichthys* in having lateral sensory neuromasts, six branchiostegals, and firm skin; from *Puzanovia* in having the gill opening entirely dorsal to the base of the pectoral fin; and in the absence of vomerine teeth, scales, and an opening behind the fourth gill; and from *Andriashevia* in having pectoral fins, in the absence of palatine teeth and an opening behind the fourth gill, and in having segmented soft rays.

It also differs from all related genera in having a slot-like, vertical pit extending halfway to the center of the lens of the eye.

*Etymology*.—The generic name is taken from the Greek 'opaeos,' "with a hole" and 'phakos,' "lens."

*Opaeophacus acrogeneius*, new species

Fig. 1

*Holotype*.—USNM 260320, 145 mm SL, female collected off Seguam Island, Bering Sea at 52°42'N, 172°15'W, depth of capture 500–800 m, by G. Hewitt, aboard M/V *Mito Maru* 82, a long-liner, 12 Apr 1979. It was associated with an unidentified orange colonial coelenterate.

*Paratypes*.—USNM 260321, 137 mm SL, male and 147 mm SL, male, cleared and stained; CAS 52802, 151 mm SL male; same collection data as holotype. OS 10000, 154 mm SL, female, Bering Sea, North of Umnak Island, 53°33'N, 169°18'W, at 600–700 m by R. McClure, M/V *Shintoko Maru* 37, 27 Sep 1982. It was associated with unidentified black coral and basket starfish snagged by a hook of a long-line.

*Diagnosis*.—Same as for genus.

*Counts*.—Vertebrae 144–149 (148), 25–26 (26) precaudal; dorsal fin rays 141–148 (146); anal fin rays 121–124 (123); caudal fin rays 8–9 (9); pectoral fin rays 4–5 (4); branchiostegals 6 (6); gill rakers 11 + 0 + 3 on first arch. Ratios as % of SL. Head 11.2–12.0 (11.2); depth of head 7.4–8.3 (7.4); snout 3.0–3.5 (3.2); eye 1.5–1.7 (1.5); width of lower jaw 5.8–6.8 (5.9). Distance from pectoral fin base to gill opening 1.4–2.0 (1.4); snout to anus 24.4–25.4 (24.5).

*Description*.—Body elongate, tapering from blunt head to pointed tail, greatest depth about 8% SL. Skin thick and firm in newly preserved specimens. Head about 12% SL, broader ventrally. Massively fleshed lower jaw slightly longer than upper jaw; rictus of mouth extends to below posterior margin of eye; maxillae completely covered by skin; no separate lips. Eye small, about 14% HL, covered by membrane continuous with skin of head; lens with elongate vertical pit filled with soft gelatinous material extending into lens about 25% of its diameter (Fig. 1). One pair of tubular nostrils, directed forward. Cephalic lateralis pores small; one interorbital pore; 3 pores in occipital commissure; postorbital pores 3, one over gill opening; suborbital pores 5; supraorbital pores 2; preoperculomandibular pores 6; no lateral lobes, ridges or cirri on head. Teeth on dentaries and premaxillae sharp and recurved at tip, those at jaw symphyses larger; dentary teeth nearly hidden by tissue of jaws; palatine and vomerine teeth absent. Both upper and lower oral valves large; glossohyal covered by thick "tongue." No slit behind last gill arch; pseudobranchiae present; gill opening small, entirely dorsal to pectoral



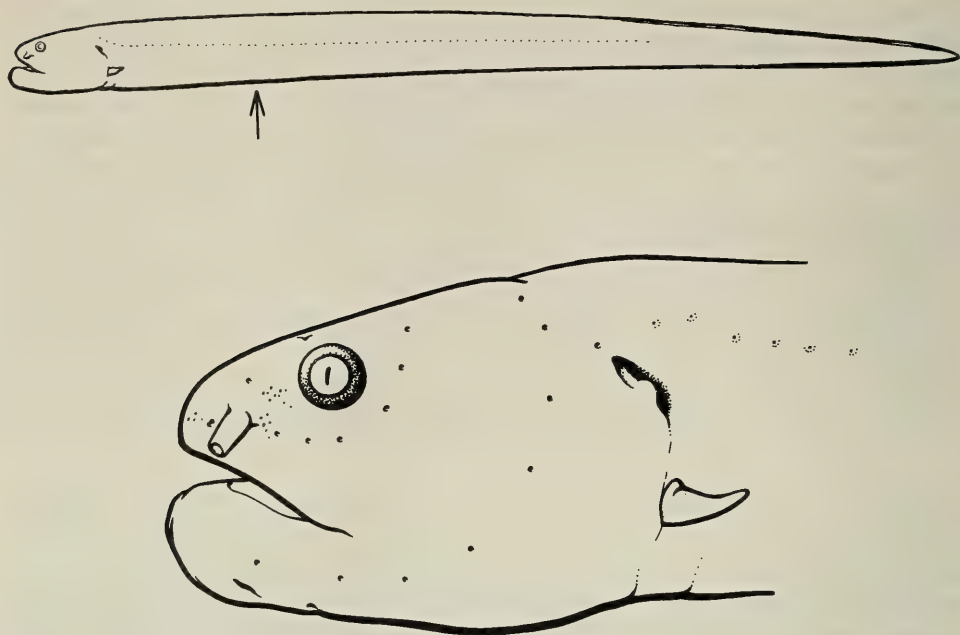


Fig. 1. Above. *Opaephagus acrogeneius*, holotype, USNM 260320, 145 mm SL, showing disposition of lateral neuromasts. Arrow indicates position of anus. Below. Head of holotype showing slit in eye lens and the disposition of cephalic sensory pores. Drawings by Bonnie Hall.

fin. Lateral line midlateral with about 65 tiny crater-like pits extending posteriorly for about 65 to 70% of SL. Scales and pelvic fins absent. Pectoral fins small and slender; dorsal and anal fins completely hidden in skin. Only soft rays present, unbranched; those in caudal, pectoral, and posterior third of dorsal and anal fins segmented. Pyloric caeca absent. Vertebrae inequiamphicoelous; penultimate vertebra normal.

Color in life and soon after fixation bright tangerine orange, very closely resembling the color of the colonial coelenterate from which the specimens from Seguam Island were collected. Color faded in alcohol to light tan within a few months.

*Etymology*.—From the Greek ‘akrogeios’, meaning “with prominent chin.”

*Remarks*.—The strange eye lens of *Opaephagus* with its slot-like vertical cavity constitutes a puzzling adaptation. If the soft gelatinous material that fills the cavity has a refractive index different from that of the lens, light striking the cavity would not be focused on the fundus of the retina but would be scattered to the anterior and posterior of the retina. Unless some unknown specialization provides otherwise, that would seem to have the effect of destroying visual acuity, but would spread any available light over a greater number of visual cells. A possible advantage could be the detection of silhouettes of organisms moving against a dimly lighted background.

#### Acknowledgments

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McClure, also of NMFS, for the specimen from Umnak Island. We thank Eric Anderson for his many helpful comments about the new species and its relationships, and for reviewing the manuscript. This work was supported by Oregon Agricultural Experiment Station (CEB) and OSU College of Oceanography (DLS). This is OAES Technical Paper 6919.

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## BIOLUMINESCENCE IN THE FRESHWATER AMPHIPOD, *HYALELLA AZTECA*, CAUSED BY PATHOGENIC BACTERIA

Thomas E. Bowman and Fanny Phillips

*Abstract.*—Bioluminescence is reported from a freshwater amphipod for the first time. Individuals in a culture of *Hyalella azteca* emitted a continuous greenish-yellow glow, usually at night. Luminescence was always followed by death of the amphipod and is attributed to pathogenic bacteria.

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“Living light” is emitted by members of almost all major groups of animals. Monera, Protista, and virtually all metazoan phyla have marine or terrestrial representatives that are bioluminescent. However, luminescence in freshwater animals is uncommon, and to our knowledge has not been reported in a freshwater amphipod. However, bacteria-based luminescence is known in at least one freshwater crustacean, the caridean shrimp *Xiphocaridina compressa*. In Japan, in Lake Suwa and in a stream in rice fields near Sawara, these shrimp become luminescent en masse on hot summer nights. The luminescence is so attractive that the shrimp are protected by the government (Hanada 1955).

### Observations

We report herein observations on bioluminescence in the freshwater amphipod *Hyalella azteca* (Saussure) and our reasons for believing that the bioluminescence is produced by pathogenic bacteria. We are not certain of the source of the amphipods or the bacteria. At least some, and probably most of the amphipods came from plants taken from a small spring-fed trout pond on U.S. route 15 about 3 miles north of Leesburg, Loudoun County, Virginia. The amphipods were placed in an aquarium containing guppies that was kept in the second author's house in Silver Spring, Maryland, next to a window with southern exposure. Other possible sources of the amphipods are with plants purchased from local aquarium stores and with plants collected by the second author and her husband, Craig Phillips, from several hot, peaty, rather stagnant pools in Florida.

Whatever the source, the amphipods did not luminesce while the water in the aquarium remained cool. In July and August, however, when the aquarium water reached temperatures as high as 35°C and became cloudy, 1-3 luminescent amphipods were observed during an evening.

Luminescence was a continuous emission of a greenish-yellow glow. It was rather dim, and a darkened room was necessary to observe it. Almost all luminescence occurred at night, but a few daytime occurrences were noted. Some time after an instance of luminescence was noted, usually in the morning following a nighttime observation, a moribund luminescent amphipod or one or more dead amphipods were found at the surface.

The continuous rather than periodic or flashing luminescence, together with the inevitable death of the luminescent amphipods, indicates that the light was



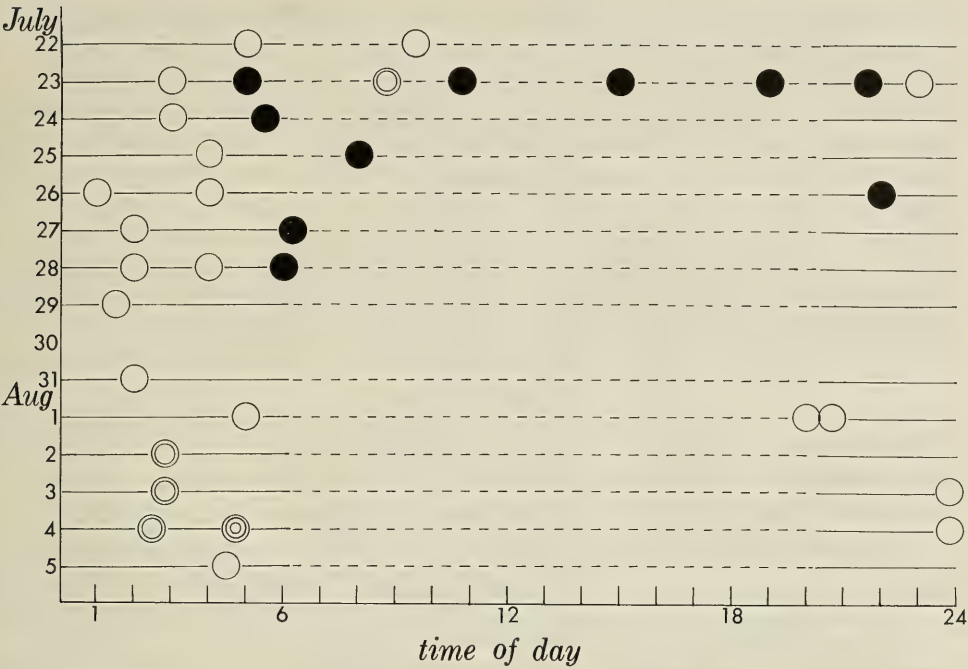


Fig. 1. Observations of luminescence in a gallon jar culture of *Hyalella azteca*. Open circles, luminescence seen; closed circles, no luminescence seen. Concentric circles, 2 or 3 specimens seen luminescing. Daytime (sunrise to sunset) indicated by dashed lines; nighttime (sunset to sunrise), by solid lines.

produced by bacteria that killed the host amphipods. No other explanation appears possible. The light produced by the bacteria was not evident until the latter reached a concentration on the host amphipods that led to the latter's death. Why this concentration was almost always reached nocturnally is not known. Possibly multiplication of the bacteria is inhibited by light. Lacking facilities, we did not attempt to culture and identify the bacteria.

As for the source of the pathogenic luminescent bacteria, the trout pond near Leesburg remains cool in the summer and successfully supports water-cress and introduced rainbow trout. We think it likely that the bacteria came from the Florida plants, or possibly, but less likely, from aquarium store plants.

A series of observations was made on a number of amphipods removed from the aquarium to a gallon jar and monitored for 15 days, from 22 July to 5 August. The jar was kept next to the first author's bed and observed whenever he woke up. Some observations were made in a darkened closet during the day. The results are summarized in Fig. 1. At least one and as many as three amphipods were seen to luminesce each night. During the 15 days, at least 12 amphipods luminesced and died.

Discussion

Luminescence is widespread among marine pelagic amphipods (Herring 1982), but is produced by luminescent organs rather than by luminescent bacteria. Ac-

counts of luminescence in amphipods that must have been caused by pathogenic bacteria date from the early 18th century and are summarized by Harvey (1952). Most of the amphipods involved are beach hoppers of the superfamily Talitroidea, to which *Hyaletta* belongs. A recent account is that of Bousfield and Klawe (1963) for the beach hopper *Orchestoidea gracilis*. Beach hoppers inhabit sandy beaches above the wave line and are terrestrial, in contrast to the completely aquatic *Hyaletta*.

We are unable to explain why, in a culture of dozens of amphipods, only one or two per day developed a growth of bacteria sufficient to produce visible luminescence. Whatever the proximate cause, this pattern of infestation has adaptive value for the bacteria in prolonging the availability of the host.

### Acknowledgments

We are grateful to Louis S. Kornicker and David Lapota for helpful reviews of the manuscript.

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A REDESCRIPTION OF *ICHTHYOTACES PTEROISICOLA*  
SHIINO (CRUSTACEA: COPEPODA: PHILICHTHIIDAE)  
FROM THE LIZARDFISH *SYNODUS VARIEGATUS*  
LACÉPÈDE (SYNODONTIDAE)

Roger F. Cressey

*Abstract.*—In 1932 Shiino described a new parasitic copepod from the scorpionfish *Pterois lunulata*. This gall-producing parasite has not been reported since. The author recently collected another specimen from *Synodus variegatus* during his recent studies of Indo-West Pacific lizardfishes.

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Parasitic copepods of the family Philichthiidae are characterized by their presence in the canals of the lateral line system of their hosts. The single female and male described below were recovered from a gall located on the right upper surface of the head behind the right eye of the host.

*Ichthyotaces pteroisicola* Shiino  
Figs. 1-9

*Ichthyotaces pteroisicola* Shiino, 1932:417.

*Material examined.*—A single female and single male from a gall on the head of a specimen of *Synodus variegatus* (CAS 30617) from Viet Nam housed in the collections of the California Academy of Sciences (Fig. 1).

*Description.*—Female: Body form as in Fig. 2, about as wide as long (4mm). Ventral aspect with series of bulbous processes arranged symmetrically as in figure.

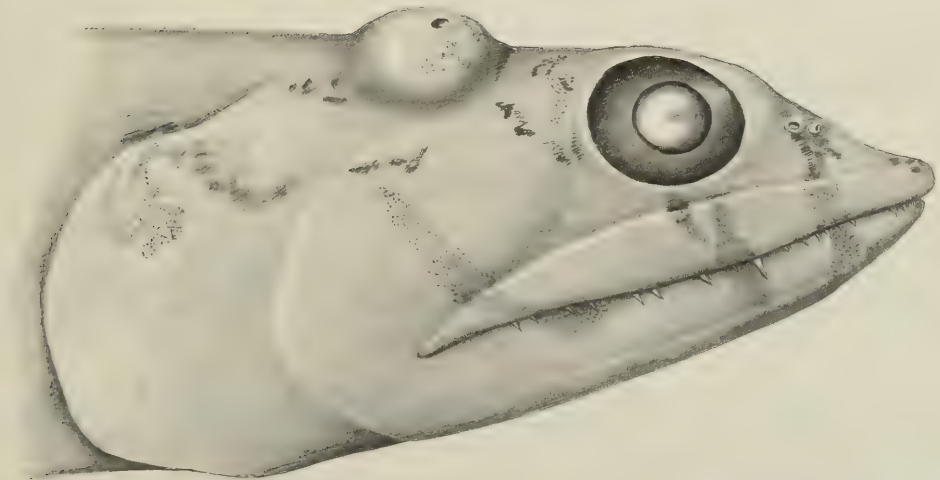
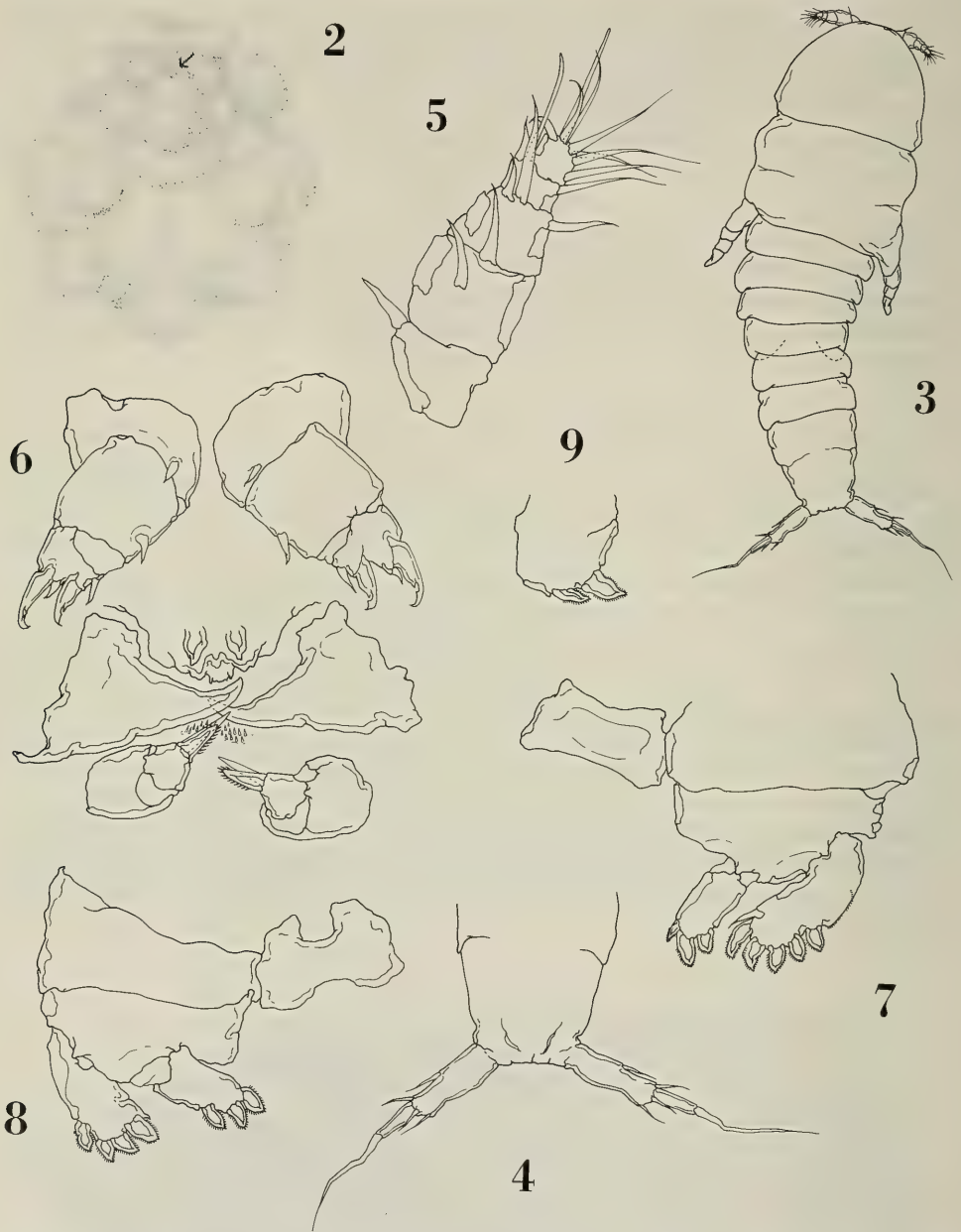


Fig. 1. *Synodus variegatus* Lacépède (CAS 30617) infested with *Ichthyotaces pteroisicola* Shiino.





Figs. 2-9. *Ichthyotaces pteroisicola*: 2, Female, ventral view; 3-9, Male: 3, Dorsal view; 4, Last abdominal segment and caudal rami, ventral; 5, First antenna; 6, Oral area; 7, Leg 1; 8, Leg 2; 9, Leg 3.

Oral area indicated by arrow on Fig. 2. (I was unable to dissect out the mouthparts from the single specimen as they are extremely small and difficult to see). No thoracic appendages could be found unless the bulbous processes represent them and the caudal ramus.

Male: Body form as in Fig. 3. Total length 896  $\mu\text{m}$ , greatest width 251  $\mu\text{m}$ , measured at widest part of free thoracic segments. Thoracic segments bearing legs 1 and 2 fused, bearing articulated process at each posterior corner. Thoracic segment bearing leg 3 free. Following 2 thoracic segments without appendages. Genital segment bilobed ventrally and about 3 times as wide as long. Abdomen 3- or 4-segmented (last segment partly divided). Caudal rami (Fig. 4) longer than wide ( $83 \times 32 \mu\text{m}$ ) bearing 1 outer lateral seta, 3 small terminal-subterminal setae, and 1 longer, subdivided seta, all setae naked.

First antenna (Fig. 5) 5-segmented, segments bearing 1, 2, 3, 2, 7 setae respectively and aesthete on each of last 2 segments, all setae naked. Second antenna and oral area as in Fig. 6. Second antenna oriented towards oral area indicating possible feeding appendage rather than for attachment as in other groups of parasitic copepods. Labrum bearing 2 sclerotized processes similar to single process recently described as representing the labrum in *Colobomatus* by Cressey and Schotte (1983). Mandible represented by heavily sclerotized triangular process. First maxilla not found but possibly represented by 2 medial patches of spinules between mandible and second maxillae. Second maxilla bearing 2 terminal processes, largest bearing row of stout spinules along posterior border.

Leg 1 (Fig. 7) rami 1-segmented, exopod outer edge with 2 short rows of spinules as in figure, 5 outer to terminal, short, stubby fringed spines and inner naked spine/seta, endopod with 3 terminal fringed spines as in exopod. Leg 2 (Fig. 8) as in leg 1 except outer rows of spinules on exopod not seen, 1 less terminal spine, and no inner spine/seta. Leg 3 (Fig. 9) simple lobe bearing 2 terminal fringed spines.

*Remarks.*—This parasite is apparently rare as this is only the second reporting of it in over 50 years and seems especially so since the parasite causes the host to produce an obvious gall, not easily overlooked. During the course of my examinations of lizardfish (*Synodus*) for a revision of the Indo-West Pacific species I examined over 1000 fish. The infestation by this parasite on only one examined fish indicates its rarity. The previous record from the scorpionfish *Pterois* also indicates that it is not host-specific.

#### Acknowledgments

The line illustrations were done by Hillary B. Cressey. The halftone was done by Jack Schroeder.

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*TECTASQUILLA LUTZAE*, NEW GENUS AND SPECIES  
(CRUSTACEA: STOMATOPODA: LYSIOSQUILLIDAE)  
FROM THE GULF OF MEXICO

Daniel L. Adkison and Thomas S. Hopkins

*Abstract.*—A new genus and species of stomatopod is described based on two specimens collected from the western North Atlantic and the eastern Gulf of Mexico. *Tectasquilla lutzae* can be distinguished from other lysiosquilloids by the combination of the following characters: 1) eyes covered by rostral plate; 2) mandibular palp and five epipods present; 3) dactylus of raptorial claw with four teeth; 4) proximal portion of outer margin of uropodal endopod without strong fold; and 5) telson with false eave.

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In a recent faunal survey of the eastern Gulf of Mexico, a unique stomatopod specimen was collected. On examination, it became apparent that the specimen represented a new species. While similar to *Heterosquilloides*, the new species was difficult to place in any described genus, therefore a new genus is diagnosed for it.

*Tectasquilla*, new genus

*Diagnosis.*—Size moderate, maximum length at least 70 mm. Eye cornea bilobed. Rostral plate elongate, with apical spine. Antennal protopod with 1 mesial and 2 ventral papillae. Exposed thoracic somites lacking longitudinal carinae; eighth thoracic somite with median ventral keel. Mandibular palp and 5 epipods present. Raptorial claw, dactylus with 4 teeth. Endopods of pereopods of 2 articles, distal article elongate. Abdomen depressed, compact, smooth, unarmed except on sixth somite; sixth abdominal somite with spines at posterolateral angles, with ventrally directed process anterior to each uropod. Telson broader than long, with false eave; marginal armature on either side of midline consisting of row of slender submedian denticles, movable submedian tooth, 2 intermediate denticles, 1 intermediate tooth, 1 lateral denticle and 1 lateral tooth. Uropod, proximal article with dorsal spine; proximal article of exopod with slender movable spines on outer margin and setae on rounded lobe on inner distal margin; endopod without strong proximal fold on outer margin; basal prolongation produced into 2 spines, triangular in cross section, inner longer.

*Type-species.*—*Tectasquilla lutzae* new species

*Remarks.*—*Tectasquilla* contains only the type-species.

*Tectasquilla* only superficially resembles the nannosquillid genera which have a false eave on the telson. *Tectasquilla* can be easily differentiated from these genera by having a bilobed cornea, the mandible with palp, papillae on the antennal protopod, the endopods of pereopods slender, and a uropodal endopod without strong proximal fold on the outer margin.

Of the lysiosquillid genera, *Tectasquilla* most closely resembles *Heterosquilla* Manning, 1963, and *Heterosquilloides* Manning, 1966. *Tectasquilla* will key out



as *Heterosquilla* in Manning's (1969) key to American Lysiosquillidae. In 1980, Manning elevated the subgenus *Heterosquilloides* to generic rank. *Tectasquilla* can be easily distinguished from *Heterosquilla* and *Heterosquilloides* by having: 1) eyes covered by the rostral plate; 2) 5 epipods present; 3) one mesial antennal papilla; 4) dactylus of raptorial claw with 4 teeth; and 5) telson with false eave.

*Etymology*.—The name is derived from the Latin *tectus*, meaning "covered, roof" alluding to the false eave on the telson, and the name *Squilla*. The gender is feminine.

*Tectasquilla lutzae*, new species

Figs. 1, 2

*Material examined*.—Eastern Gulf of Mexico, Bureau of Land Management station 2529, sample 2529191880208; 29°55'55"N, 86°06'29"W; capetown dredge; 38 m; 8 Feb 1978; T. S. Hopkins coll; 1 ♂ (holotype) USNM 204717. —Atlantic Ocean off Florida, R/V *Delaware II* station 23; 31°55'N, 79°43'W; tumbler dredge; 36–38 m; 22 Jun 1982; W. G. Lyons collector, 1 (paratype, anterior fragment) USNM 204716.

*Description*.—Eye elongate; cornea bilobed, set slightly obliquely on stalk; ocular scales fused into rectangular plate with median notch; eyes reaching beyond middle of antennular peduncle.

Antennular peduncle short, about  $\frac{1}{3}$  length of carapace; antennular process with broad, blunt, anteriorly directed spines. Antennal scale slender, about  $\frac{1}{3}$  length of carapace; antennal protopod with 1 mesial and 2 ventral papillae. Rostral plate subrectangular, elongate, extending beyond eyes; apical spine present. Mandible palp 3 articles.

Raptorial claw, dactylus with 4 teeth, outer margin with basal notch; propodus with 4 movable spines proximally, proximal by far the longest, second and third spines approximately same length and half length of first, fourth spine half length of third spine; dorsal ridge of carpus poorly defined, terminating in blunt projection; merus much longer than ischium, both unarmed.

Lateral process of fifth thoracic somite blunt lobe, directed ventrally; lateral processes of sixth and seventh somites rounded; eighth thoracic somite with median ventral keel as low conical projection; distal article of endopods of walking legs elongate, most slender on last leg; basal article of walking legs unarmed.

Abdomen depressed, compact, unarmed except on posterolateral angles of sixth somite; sixth somite with broad, blunt projection anterior to articulation of uropods; sixth somite with pair of broad low carinae, parallel to lateral margin and terminating in blunt lobe.

Telson thick, with false eave, nearly twice as broad as long; ventral surface with strong spine on midline posterior to anus; 1 pair of tubercles present on anterolateral dorsal surface; false eave with median trilobed prominence bearing 2 carinae, one carina terminating with 1 spine, the other carina with 2 spines; 2 prominences laterally, each terminating in broad acute lobes; 7 to 10 spines on each side of midline between false eave and true posterior margin and between middle 2 prominences of false eave and submedian and intermediate teeth of posterior margin of telson; marginal armature of telson consists of row of 5 submedian denticles, inner denticle much the smallest, outer 2 denticles movable;

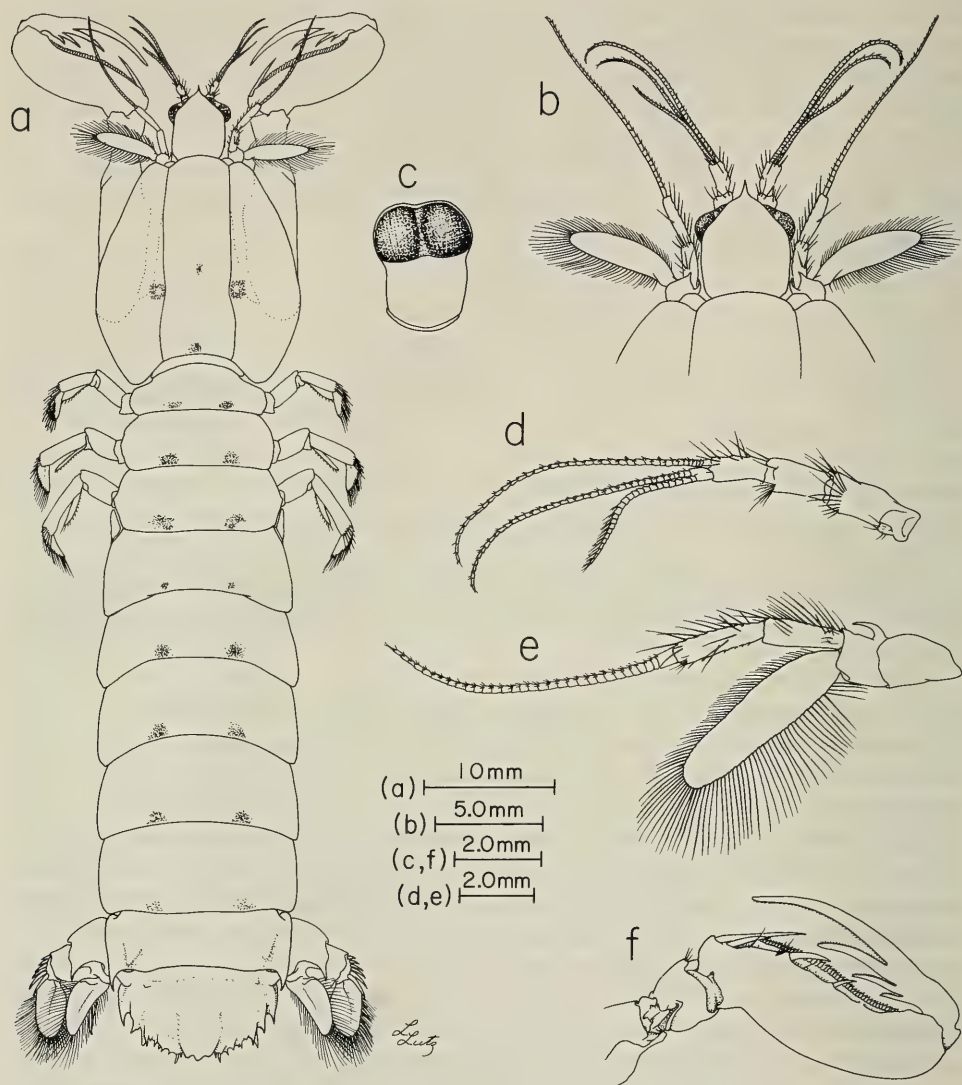


Fig. 1. *Tectasquilla lutzae*, holotype. a, Dorsal view; b, Anterior part of body; c, Eyestalk; d, Antennule, ventral view; e, Antenna, dorsal view; f, Claw, medial view. Scales as indicated.

movable submedian tooth; 2 intermediate denticles; 1 intermediate tooth; 1 lateral denticle; and 1 lateral tooth.

Uropod, basal article segment thick, outer dorsal carina broad, inner dorsal carina terminating in strong spine, basal prolongation produced into 2 spines, triangular in cross section, inner spine longer; proximal article of exopod swollen dorsally, with row of 7 slender spines, distal spine not reaching middle of distal segment of exopod, ventrally with 1 broad spine distoventrally, inner margin with broad lobe fringed with setae; distal article of exopod nearly twice length of proximal article; endopod elongate, inner margin slightly concave, outer margin convex, proximal portion of outer margin curled dorsally (not folded).

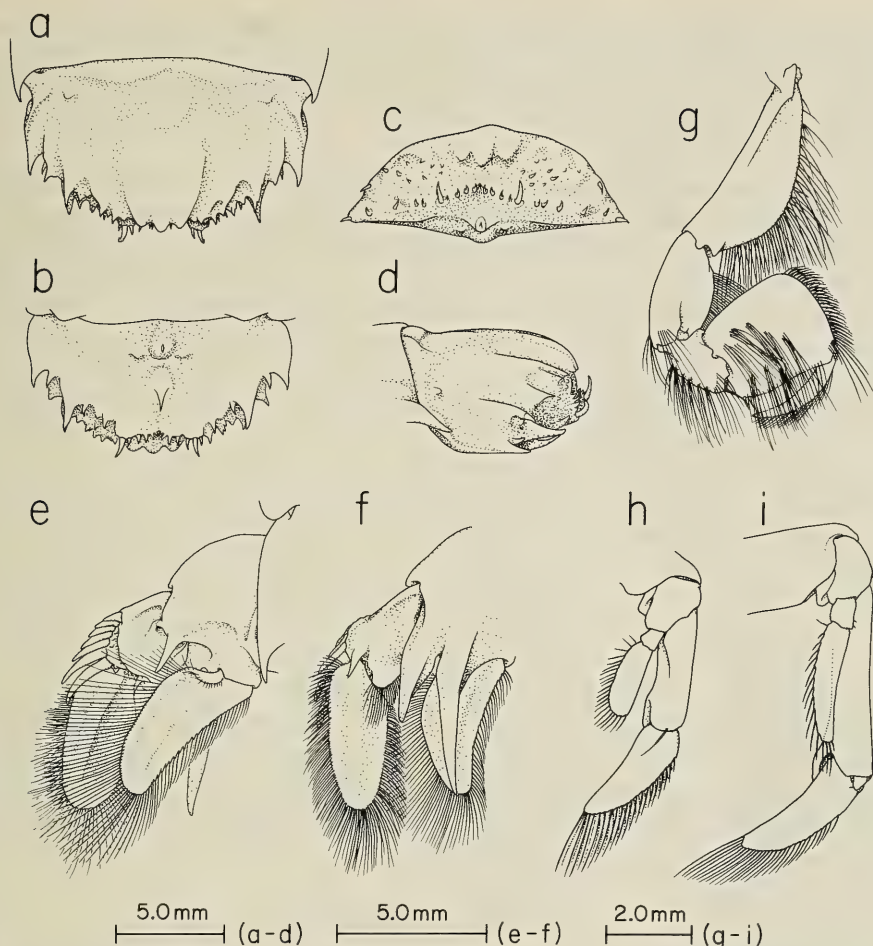


Fig. 2. *Tectasquilla luzae*, holotype. a, Telson, dorsal view; b, Telson, ventral view; c, Telson, posterior view; d, Telson, lateral view; e, Uropod, dorsal view; f, Uropod, ventral view; g, Maxilliped 5, lateral view; h, Walking leg 1, medial view; i, Walking leg 3, medial view. Scales as indicated.

**Remarks.**—The paratype is a fragment consisting of the anterior part of body from rostral plate to fifth thoracic somite plus a part of the sixth somite and right first walking leg.

**Etymology.**—This species is named for Ms. Linda B. Lutz, who has illustrated several crustaceans for us.

**Measurements.**—Male, holotype, total length 73 mm; carapace length 16 mm; cornea width 2.2 mm; rostral plate length 5.6 mm, width 4.0 mm; fifth abdominal somite width 15.8 mm; telson length 3.5 mm, width 6.1 mm. Paratype, carapace length 17.8 mm; cornea width 2.6 mm; rostral plate length 6.3 mm, width 4.6 mm.

**Color.**—In life, body not heavily pigmented; overall color straw (light red-brown) with scattered yellow to tan chromatophores. Rostral plate heavily pigmented, dark brown to black. Carapace with 2 darker bands, anterior margin of



brown broad V-shaped band, laterally indistinct. Posterior margin of carapace darker.

Four pigmented areas on posterior half of carapace (Fig. 1a) lateral pair of spots less distinct than spots on midline. Lateral spots with unpigmented or light yellow semicircular areas centrally.

Posterior 3 thoracic somites and anterior 5 abdominal somites with paired pigmented spots dorsally (Fig. 1a), and with more diffuse pigmented area laterally. Sixth abdominal somites and telson without pigment spots.

Antennal scale with distal pigment spot. Propodus of maxillipeds darker pigmented than body, dactylus with few chromatophores. Raptorial claw, dactylar margins and teeth pale yellow-orange, central region pigmented like body; propodus yellow-orange distally, opposable margin also yellow-orange; walking legs bases only slightly darker than body, distal article much lighter than body, setae yellow. Uropods pigmented like body.

*Discussion.*—In *T. lutzae*, the number of intermediate denticles is interpreted to be two but might be three. A rounded projection occurs between and just dorsal to the intermediate denticles. Since the posterior margin of the telson is not sharply defined in this area, this projection may in fact be the third denticle. The number of intermediate denticles present is an important character since *Heterosquilla* has two intermediate denticles and *Heterosquilloides* has four intermediate denticles. With respect to the other characters listed by Manning (1969), *Tectasquilla* appears closer to *Heterosquilloides* than *Heterosquilla*.

*Tectasquilla lutzae* appears most similar to *Heterosquilloides mccullochae* (Schmitt, 1940). It shares a similar color pattern, an ornate posterior telsonal margin, four teeth on the dactylus of the claw, and five epipods. In addition to the differences noted above, *T. lutzae* can be distinguished from *H. mccullochae* by the presence of three not four antennal papillae.

#### Acknowledgments

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NEW SPECIES OF FRESHWATER CRABS  
(CRUSTACEA: DECAPODA: PSEUDOTHELPHUSIDAE)  
FROM COLOMBIA

Martha R. Campos and Gilberto Rodríguez

*Abstract.*—Two new species of Pseudothelphusidae are described from Colombia. *Strengeriana chaparralensis*, n.sp. adds a fifth species to a primitive group of crabs from the Central Cordillera; its gonopod resembles that of its nearest geographic relative, *S. tolimensis* Rodríguez and Díaz, 1981. *Chaceus davidi*, n.sp. also belongs to a small genus of primitive crabs from the Sierra de Santa Marta; the gonopod has characters of both *Chaceus* and *Hypolobocera*. A geographical record is given for *Hypolobocera martelatani* Pretzmann, 1965, which was originally described from an unknown locality in "Columbia."

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The northern Andes of Colombia is an area of high taxon density for the family Pseudothelphusidae (Rodríguez 1982). Of the three groups that occur sympatrically in the Andes proper and in the Sierra de Santa Marta, the Strengerianini is a primitive one that displays considerable variability in the structure of the male gonopod, while the other two groups, consisting of the genera *Neostrengeria* and *Hypolobocera*, exhibit a more homogeneous gonopod structure, but at the same time they appear very fragmented and are dispersed over a wider area. During examination of material in the Museo de Historia Natural, from the Instituto de Ciencias Naturales, Bogotá (ICN-MNH), we found two new Strengerianini. One of them is of particular interest since it displays characters in gonopod structure that are intermediate between the genera *Chaceus* and *Hypolobocera*.

Tribe Strengerianini Rodríguez, 1982  
Genus *Strengeriana* Pretzmann, 1971  
*Strengeriana chaparralensis*, new species  
Figs. 1, 4a, d

*Material.*—Quebrada Piedras Blancas, Municipio Rioblanco, 900 m above sea level, Tolima Department, Colombia; 29 Sep 1983; M. R. Campos : 1 male holotype, cb. 35.3, cl. 21.2 mm (ICN-MHN N° CR 0525).—Vereda Betania, Municipio Chaparral, 850 m above sea level, Tolima Department, Colombia; 17 Jul 1983; M. R. Campos : 2 males, cb. 33.4 and 28.2 mm, cl. 25 and 17.5 mm.

*Description.*—The cervical groove is straight and shallow, deeper in its posterior half; it does not reach the margin of the carapace. The anterolateral margin has a shallow depression behind the orbit, followed by approximately 8 papillae regularly spaced on the anterior half, and approximately 8 minute teeth on the posterior half. The frontal lobes are wide but ill defined. The median groove is absent. The surface of the carapace behind the front is moderately inclined anteriorly and towards the midline. The upper border of the front is almost straight in dorsal view, well marked with a row of conspicuous, irregularly placed tubercles. The lower margin is strongly sinuous in frontal view. The surface of the front



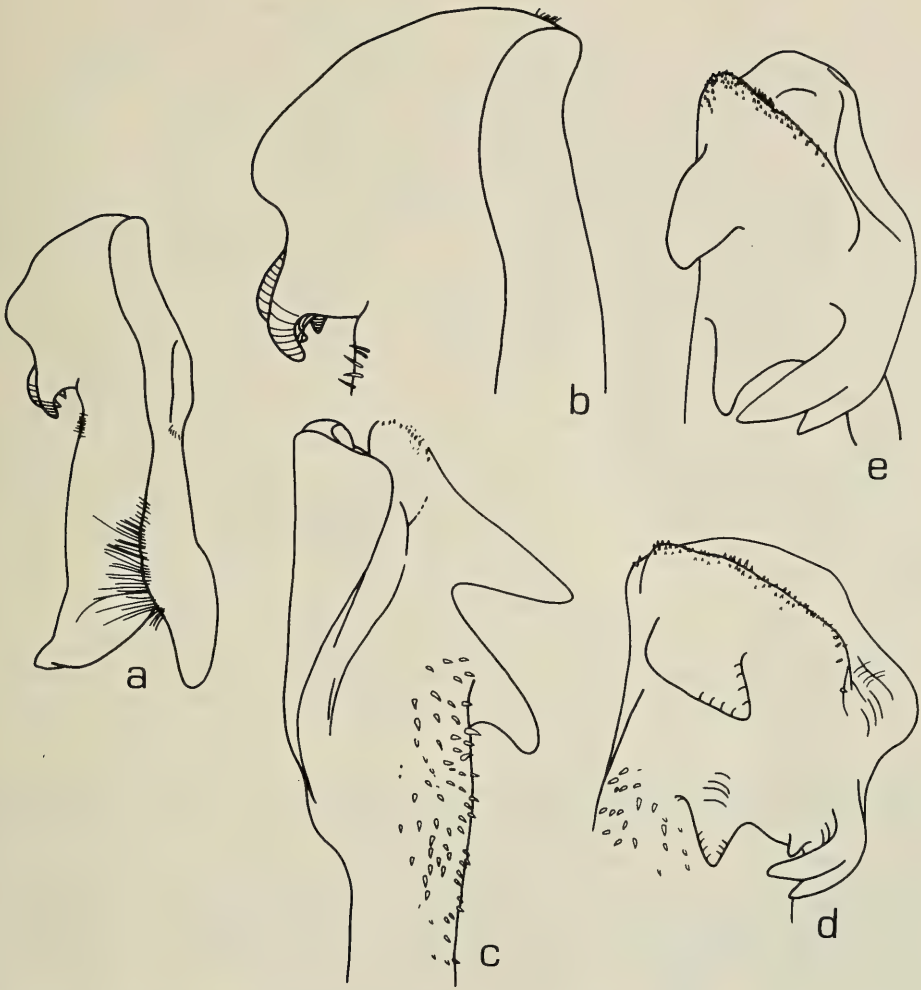


Fig. 1: *Strengeriana chaparralensis*, holotype, ICN-0525, left gonopod: a, Total view, caudal; b, Detail of apex, caudal; c, Lateral; d, Cephalic; e, Mesial.

between the upper and the lower borders is very narrow. The surface of the carapace is smooth, sometimes covered by small papillae not visible to the naked eye.

The palm of the larger chela is moderately inflated; the fingers do not gape. The exopod of the third maxilliped overreaches the lateral margin of the ischium. The orifice of the efferent branchial channel is almost closed by a spine at the jugal angle and by the production of the lateral lobe of the epistome.

The male gonopod is short and stocky; the marginal lobe is simple, with a short ridge on its lateral surface; the lateral lobe is produced cephalically to form with the cephalic lobe a long slit where the genital pore is located; the cephalic lobe bears 2 strong cephalically directed conical spines on its lateral surface, and another long and bifid spine on its mesial surface which is recurved and directed laterad and bears at its base a small spine. In addition to the strong caudal setae and the

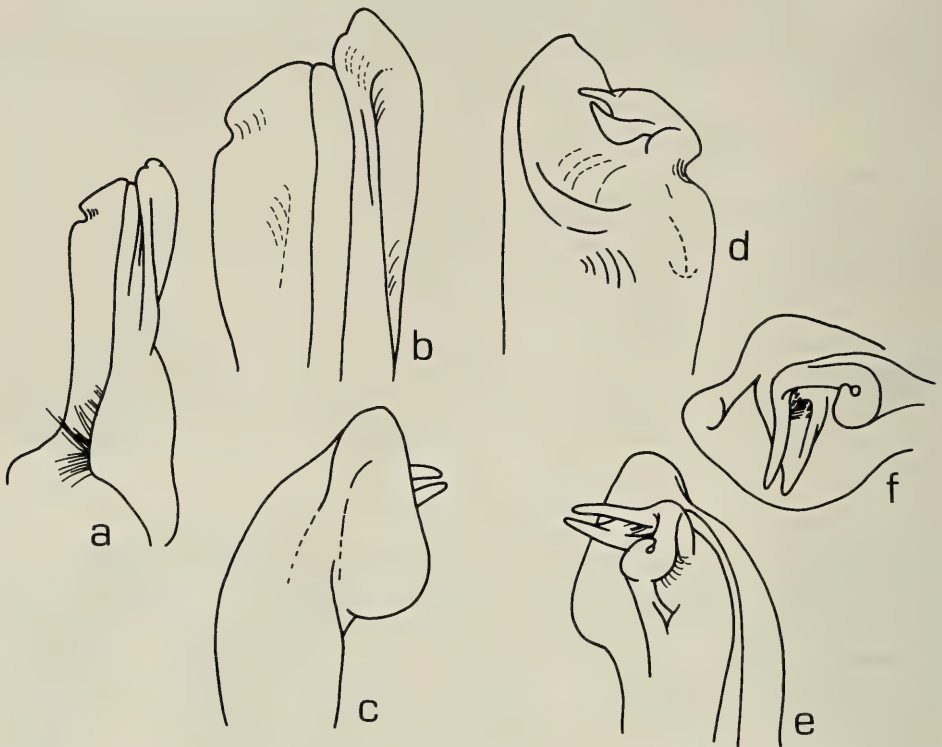


Fig. 2. *Chaceus davidi*, holotype. ICN-0083, left gonopod: a, Total view, caudal; b, Detail of apex, caudal; c, Lateral; d, Cephalic; e, Mesial; f, Apex in distal view.

small spines of the genital pore, the gonopod bears a large patch of small dark spines on the lateral side, small spinules over the distal border of the cephalic lobe, and a few tiny setae on the mesial side.

*Size*.—This is a small species, cb. 35.3 mm, but even so, it is the largest yet recorded for the genus.

*Remarks*.—The species is most closely related to *Strengeriana tolimensis* Rodríguez and Díaz, 1981. In both species the gonopod has two spines on the lateral side and a recurved bifid spine on the mesial side, with a small spine at its base, but all of these spines are weaker in *S. tolimensis*. The main difference between the gonopods of the two is the presence of a strong spinous process that extends laterally beyond the marginal process in *S. tolimensis*, but is lacking in *S. chaparralensis*.

*Chaceus davidi*, new species

Figs. 2, 4b, e

*Material*.—Ciudad Perdida, Sierra de Santa Marta, Magdalena Department, Colombia; 25 Jan 1982; C. Mejia: 1 male holotype: cl. 16.5 mm, cb. 29.0 mm (ICN-MHN N° CR-0083).

*Description*.—The cervical groove is shallow and almost straight, and reaches

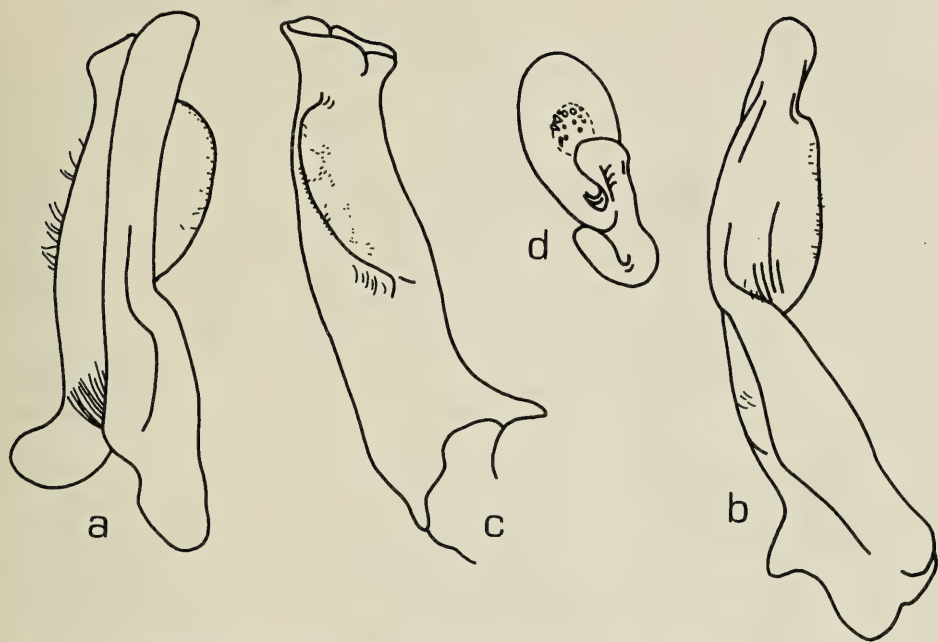


Fig. 3. *Hypolobocera marthelatani* (Pretzmann, 1965), from Inza, Cauca Department, Colombia, left gonopod: a, Caudal view; b, Lateral view; c, Cephalic view; d, Apex in distal view.

the lateral margin of the carapace. The anterolateral margin has a shallow notch behind the orbit, and a sharp angle at the place where the cervical groove meets the margin; it is completely devoid of teeth on its anterior half; the posterior half bears 20 small, ill defined teeth. The post-frontal lobes are weakly marked, the median groove is shallow and wide. The surface of the carapace behind the front is moderately inclined anteriorly and towards the midline. The front has a defined upper margin with ill defined tubercles; in dorsal and frontal view it is slightly bilobed; the lower margin is visible in dorsal view; it is strongly sinuous in frontal view. The carapace is smooth and shiny, with small punctae scattered all over its surface, not visible to the naked eye.

The chelipeds are very unequal in size; the palm of the larger chela is moderately swollen, without a tubercle at the base of the fingers; the fingers are moderately gaping towards midlength. The merus of the third maxilliped does not have a low angle on the distal half of its external margin; the exognath is 0.7 the length of the ischium. The orifice of the efferent branchial channel is closed by a spine on the jugal angle and by the production of the lateral lobe of the epistome. The male gonopod is stocky; the caudal lobe is strongly produced beyond the apex, with a strong ridge on its middle part; the spermatic channel is bordered by a finger-like projection and another triangular projection; the caudal margin behind these projections is typically rolled.

*Size*.—This is a small species. The holotype and only specimen has a cb. of 29.0 mm.

*Remarks*.—The species is most closely related to *Chaceus pearsei* (Rathbun,



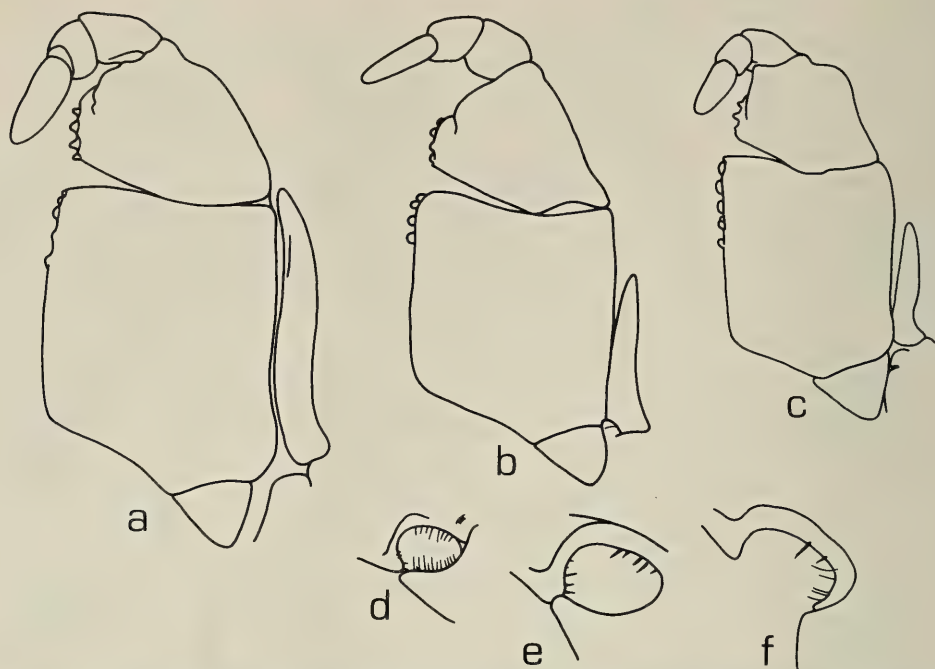


Fig. 4. Third maxilliped and left opening of branchial channel: a, d, *Strengeria chaparralensis*; b, e, *Chaceus davidi*; c, f, *Hypolobocera marthelatani*.

1915). The main differences between the gonopod of this species and the other in the genus is in the caudal lobe, which in *C. davidi* is strongly produced beyond the apex, and in the finger-like projection near the spermatic channel, which is smaller in this species, approximately of the same length of the triangular projection located below it. The gonopods of all species of *Chaceus* have the same basic elements. Rodríguez (1982) has theorized on the possible derivation of the genus *Hypolobocera* from an ancestral *Chaceus* based on the homology of the finger-like and triangular projections with the two papillae found near the spermatic channel in *Hypolobocera*. The present new species offers new support to this theory since these projections are surrounded by a ridge that somewhat resembles the button-shaped apex of *Hypolobocera* (Fig. 2c, f), and in caudal view there is an indication of the caudal ridge of this same genus.

*Etymology*.—The species is named in honor of David Campos.

*Hypolobocera marthelatani* (Pretzmann, 1965)

Fig. 3, 4c, f

*Strengeria* (*Strengeria*) *marthelatani* Pretzmann, 1965:6.

*Hypolobocera* (*Hypolobocera*) *marthelatani* Pretzmann, 1971:17; 1972:50.

*Hypolobocera marthelatani* (Pretzmann).—Rodríguez, 1982:52.

*Material*.—Municipio Inza, Cauca Department, Colombia; 12 Oct 1982: 1 male cl. 23.0 mm, cb. 14.2 mm (ICN-MHN N° CR-0087), 1 female cl. 25.5 mm, cb. 15.5 mm.

*Descriptions.*—Our specimens from the Cauca Department agree well with Pretzmann's description. The cervical groove is ill defined, consisting of a shallow oval depression on the posterior half, obsolescent on the anterior half. The anterolateral border of the carapace has approximately ten ill defined small papillae. The postfrontal lobes are small, round, almost obsolete. The median groove is absent. The carapace is regularly inclined towards the middle; this surface in frontal view forms a sinuous line which parallels the line, also sinuous, of the lower frontal margin. The upper margin of the front is strongly bilobed in dorsal view; there is not a defined ridge, but the carapace in this area curves regularly downwards. The front is low. The lower margin in frontal view is sinuous. The third maxilliped has a well developed external angle. The exognath is 0.9 the length of the ischium. The surface is smooth and shiny, with numerous pores not visible to the naked eye. The chelae in our specimens are moderately swollen. In Pretzmann's illustrations (1972, figs. 243, 244) they are considerably more inflated.

*Size.*—This is a small species. A mature female has a cb. of 25.5 mm.

*Remarks.*—The species is very similar to *Hypolobocera orientalis* Pretzmann, 1968, from which it can be distinguished only by the shape of the gonopod apex, which in *H. orientalis* is more evenly rounded (see Rodríguez 1982, fig. 26d), not elongate as in *H. marthelatani*. The original spelling of the species name was *marthelatani* (Pretzmann, 1965) although Pretzmann (1971, 1972) latter used the spelling *marthelatami*.

#### Acknowledgments

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A NEW SPECIES OF THE GENUS *CAMBARINCOLA*  
(CLITELLATA: BRANCHIOBDELLIDA) FROM  
CALIFORNIA

Perry C. Holt

*Abstract.*—*Cambarincola pamela*e, new species, is described and compared with its near relative, *C. mesochoreus* Hoffman, 1963. Specimens from California previously assigned to *C. mesochoreus* are reassigned to *C. pamela*e and the status of presumptively eastern species of the branchiobdellids on the Pacific versant is discussed.

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The branchiobdellids of the Pacific versant in the United States have been studied most recently in a series of papers (Hoffman 1963; Holt 1960, 1967, 1974a, b, a, b, 1981a, b) with no pretensions that these efforts describe the totality of the branchiobdellid fauna of the region. Recently specimens were received for identification from Dr. Pamela Roe of California State College, Stanislaus, Turlock, California. Among them were specimens at first identified as *Cambarincola mesochoreus* Hoffman, 1963. Further examination revealed a distinct difference between the structure of the male bursal complex of the western worms and their more easterly congeners of the Mississippi Valley. This opportunity is taken to describe the new species from California.

*Cambarincola pamela*e, new species

Figs. 1-2

*Cambarincola mesochorea* Hoffman, 1963:307-311 (in part).

*Cambarincola mesochoreus*.—Holt, 1973:10; 1981:689 (in part).

*Type-specimens.*—Holotype, USNM 080687, 4 paratypes, USNM 080688-080691, and 10 paratypes, PCH 4065, taken on *Procambarus* (*Scapulicambarus*) *clarkii* (Girard, 1852) from an irrigation canal that drains into the San Joaquin River in the western part of Stanislaus County, California, by J. A. Meeuwse, 2 Dec 1982.

*Diagnosis.*—Medium-sized worms (holotype 2.3 mm in length); lips entire; no oral papillae; no dorsal ridges; jaws subequal in size, small, dental formula 5/4; bursa about  $\frac{1}{3}$  body diameter in length, elongate ovoid, atrial fold present, penial sheath more than  $\frac{1}{2}$  total length of bursa, retracted penis greater in length than penial sheath; spermiducal gland short, thick, with deferent lobes, reflexed; prostate greater in length than spermiducal gland, subequal to latter in diameter, composed of granular cells, without ental bulb; spermatheca with long ectal duct, ovate bulb, subequal to body diameter in total length.

*Etymology.*—For the discoverer, Pamela Roe.

*Description.*—Five specimens of *Cambarincola pamela*e, including the holotype, have the following approximate dimensions: total length, 2.6 mm; greatest diameter, 0.5 mm; head length, 0.4 mm; head diameter, 0.3 mm; diameter, segment I, 0.3 mm; diameter, sucker, 0.3 mm.



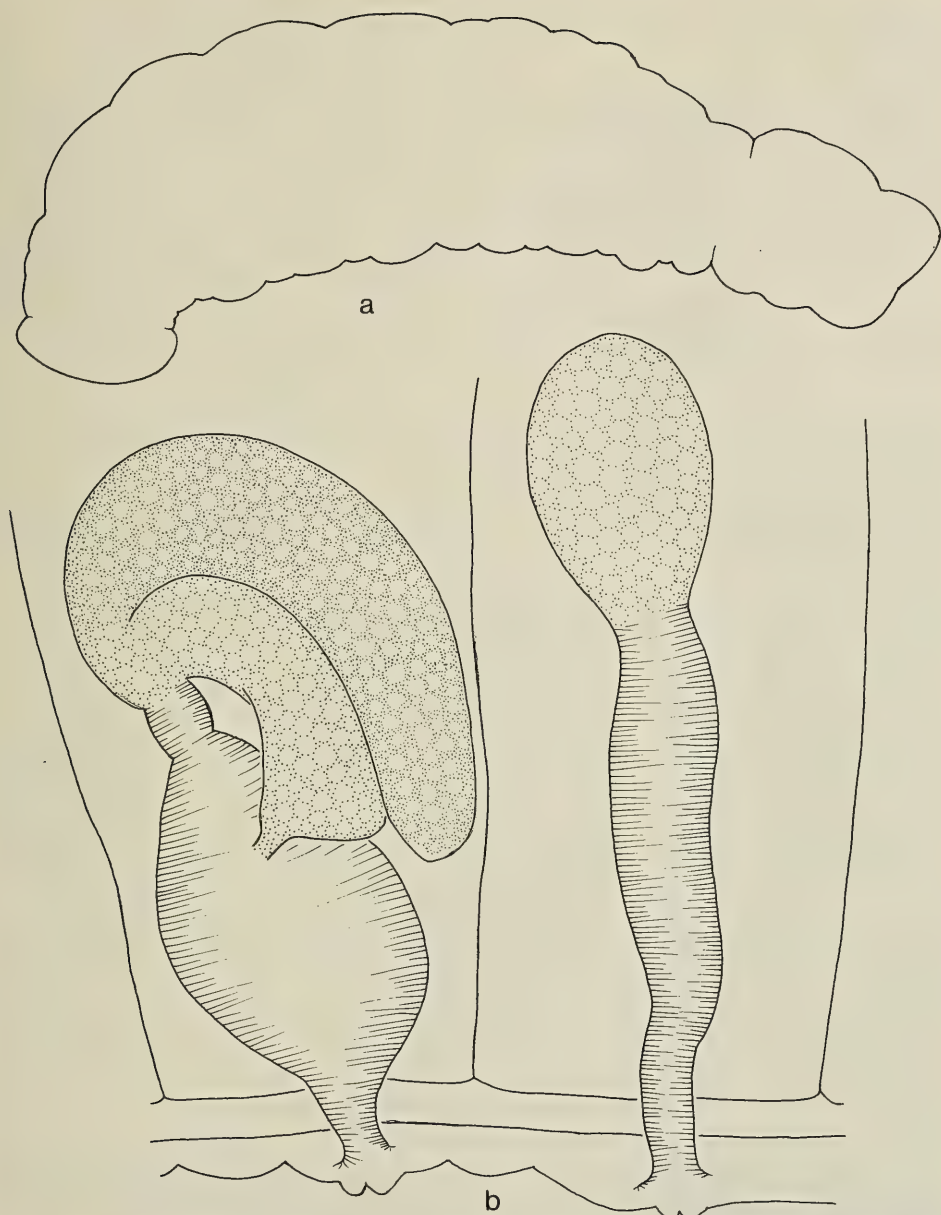


Fig. 1. *Cambarincola pamelae*: a, Lateral view of holotype; b, Lateral view of reproductive systems of holotype.

The lips are without lobes; the margins of the mouth without oral papillae. Mid-ventrally there is a shallow sulcus of the head and internally there is a prominent pharyngeal one. There are no supernumerary muscles, hence the body outline is smooth.

The jaws are small, about  $\frac{1}{20}$  that of the head in length, and subequal in size. The dental formula is  $5/4$ .

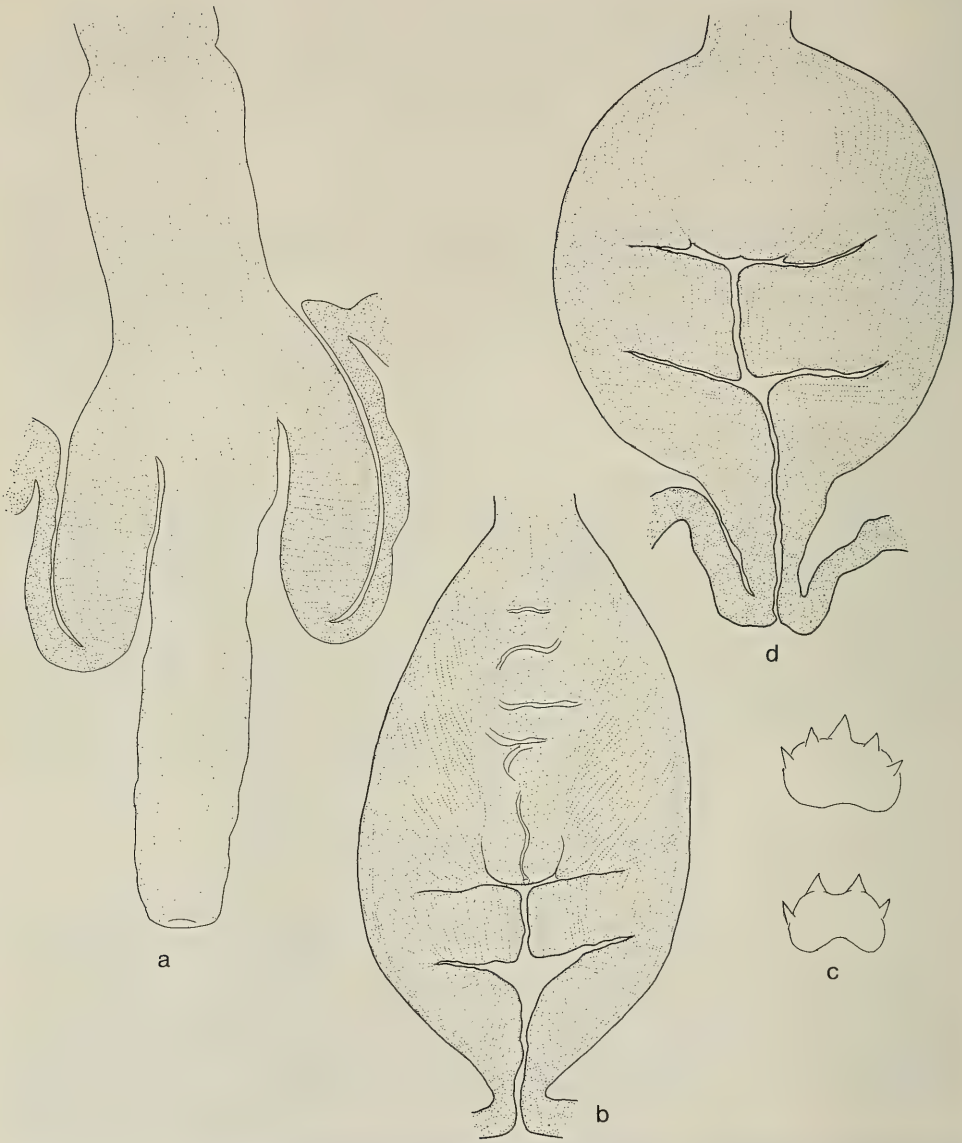


Fig. 2. a-c. *Cambarincola pamelae*: a, Everted bursa and penis of a paratype; b, Optical section through bursa and penis of holotype; c, Jaws; d, *Cambarincola mesochoreus*, optical section through bursa and penis of paratype.

The spermiducal gland is kidney-shaped and often extends to the dorsal border of the gut. Deferent lobes are present. The ental end of the posterior deferent lobe is often expanded with a wider lumen than the ectal part of the gland.

The prostate is about  $\frac{2}{3}$  that of the spermiducal gland in width and greater than the latter in length. The lumen of the ental end, as in the spermiducal gland, is in some specimens expanded and in the holotype a clear ental bulb is present.

The prostate is of the type known as "non-differentiated"; its glandular cells are granular instead of vacuolated.

The bursa is elongate ovoid, approximately 3 times its diameter and  $\frac{2}{5}$  of the diameter of the body in length. Somewhat more than half of the organ constitutes the penial sheath. The penis, though similar to that of other members of the genus, is folded or looped and parts of its lumen are seen in optical sections as narrow transverse spaces within the penial sheath. In specimens with an everted bursa, the penis is protruded as a relatively slender tube with strands of tissue (? muscular) extending internally its length (Fig. 2A).

The ejaculatory duct is a relatively wide tube of the usual type.

The spermathecal ectal duct is approximately equal to the body diameter in length, the bulb is ovoid.

*Variations.*—The posterior deferent lobe of the spermiducal gland is dilated in some specimens, as is the ental end of the prostate. In some animals the prostate has an ental bulb (this is so for the holotype), but others just as clearly do not. Such variations have not been recorded for other species of the genus and their significance here is not clear; perhaps the ental bulb of the prostate should be re-evaluated as a specific character.

*Affinities.*—*Cambarincola pamela*e is closely related to *Cambarincola mesochoreus* Hoffman, 1963:307, and the specimens of the type-series were at first identified as *C. mesochoreus*. The expanded lumen of the ental end of the prostate or of the spermiducal gland (absent in *C. mesochoreus*) in some of these specimens occasioned a more careful study and the difference in the structure of the penis and its enclosing sheath was noted. That of *C. mesochoreus* is of the more common type; the bursa is subspherical and the penis short and muscular. Holt (1981a: 689) said in his modification of Hoffman's (1963:308) original diagnosis of *C. mesochoreus* that the spermiducal gland is slender and without deferent lobes. It is slender only in the sense that it is usually less in diameter than the prostate and never greater in this dimension. The deferent lobes ascribed to the species by Hoffman (1963:308) are either absent or obscure in four paratypes from Spencer County, Indiana (PCH 817), but are not prominent in *C. pamela*e. The spermatheca of *C. mesochoreus* was described in the original diagnosis as "subfusiform" and as having a "blunt ental process." The paratypes from Indiana fail to confirm these statements; the spermathecal bulb varies in shape from subfusiform to broadly oval and no ental process can be seen; there are no obvious differences between the spermathecae of these species. The jaws of *C. mesochoreus* are perhaps marginally larger than those of *C. pamela*e. Hoffman's specimens ranged in length from 2.8–4.2 mm; the length of the holotype and four paratypes of *C. pamela*e extends from 2.5 to 3.3 mm, probably an insignificant difference. The two species are closely related and can be distinguished reliably only by the difference in the penes (Fig. 2b, d).

*Host.*—*Procambarus (Scapulicambarus) clarkii*.

*Distribution.*—The type-series of *C. pamela*e is from the western part of Stanislaus County, California, in the irrigated portion of the San Joaquin Valley. The specimens assigned by Holt (1981a:689) to *C. mesochoreus*, and herewith re-assigned to *C. pamela*e, were all taken from the introduced crayfish, *Procambarus (Scapulicambarus) clarkii*, in Santa Barbara, Merced and Sonoma counties, Cal-



ifornia. The assumption that *C. pamela* is likewise an introduction is easily made, but not necessarily valid; *Cambarincola gracilis* Robinson, 1954, is undoubtedly indigenous to the Pacific versant, is known from Santa Barbara County northward to southern British Columbia and is associated with *C. pamela* in Santa Barbara and Stanislaus counties on the same host. *Cambarincola barbarae* Holt, 1981, is also associated with *C. pamela* in Santa Barbara and Sonoma counties (Holt 1981a:678–679) and is not known from the east. The report of (Holt 1981a:680) of *Cambarincola fallax* Hoffman, 1963, from Sonoma County, California, from these considerations, becomes suspect: the specimen was identified on the basis of the tentaculated upper lip and the 5/5 dental formula, diagnostic of *C. fallax* in the east. Perhaps *C. pamela* and *C. mesochoreus* form another case of the phenomenon exemplified by *Cambarincola shoshone* Hoffman, 1963, and *Cambarincola branchiophilus* Holt, 1954; *Cambarincola macrocephelus* Goodnight, 1940, and *Cambarincola holti* Hoffman, 1963: pairs of very similar species, one western and the other eastern.

The eastern crayfishes introduced into western waters might be expected to carry their branchiobdellid symbionts with them. But great care is often required to bring branchiobdellids from the field to the laboratory for even short distances. Since it is likely that these introductions were made by people unaware of the worms, it is unlikely that they took the care (moving the animals at low temperatures and avoiding overcrowding) necessary to assure the survival of the branchiobdellids. But the range of none of the species involved is well enough known to allow reasonable conjectures as to the origin of the symbionts of the eastern crayfish introduced into the west. *Cambarincola pamela* may be, though it probably is not, an eastern, introduced species.

*Material examined.*—The types from Stanislaus County, California, and that previously assigned to *Cambarincola mesochoreus* (Holt, 1981a:689).

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*PROBOPYRINELLA HEARDI* N. SP.  
(ISOPODA: BOPYRIDAE) A BRANCHIAL  
PARASITE OF THE HIPPOLYTID SHRIMP  
*LATREUTES PARVULUS* (DECAPODA: CARIDEA)

Daniel L. Adkison

*Abstract.*—The bopyrid isopod *Probopyrinella heardi* n. sp. occurs in the branchial chambers of the shrimp *Latreutes parvulus* in coastal waters off Georgia, Mississippi, and eastern Florida. *Probopyrinella heardi* can be distinguished from *P. latreuticola*, the only other described species in the genus, by the asymmetrical development of the posterior lamina and first oostegite of the female of *P. heardi*.

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Chopra (1923) first recognized from published descriptions that *Bopyroides latreuticola* Gissler, 1882, represented a distinct genus, but he did not name the genus since specimens of *B. latreuticola* were unavailable for study. Based on the study of material, Nierstrasz and Brender à Brandis (1929) followed Chopra's suggestion and proposed the new genus *Probopyrinella* with *B. latreuticola* as the type and only species.

Markham (1977) reviewed the taxonomic history of *Bopyroides latreuticola* and also clarified the differences between *Probopyrinella* and the four genera (*Bopyrella* Bonnier, 1900; *Bopyrina* Kossmann, 1881; *Bopyroides* Stimpson, 1884; and *Probopyrus* Giard and Bonnier, 1888) to which *P. latreuticola* had previously been assigned.

An amended generic diagnosis is presented for *Probopyrinella* based on study of *P. heardi*, *P. latreuticola* and previous generic diagnoses.

*Probopyrinella* Nierstrasz and Brender à Brandis, 1929

*Generic diagnosis.*—Female: Anterolateral edge of head acutely pointed on reduced side; frontal lamina only slightly developed; posterior ventral lamina, 1 pair of projections. Eyes present. Maxilliped with palp. Head fused with pereomere 1 in one species, other pereon segments distinct. Coxal plates and dorsal bosses absent. Lateral margin of expanded side of pereon distinct; margin on reduced side less distinct. Pereopods of reduced side visible in dorsal view. Oostegite 1, posterior plate more than half width of anterior plate; oostegite 5 on reduced side large, sickle-shaped; other oostegites small, only marginally enclosing brood chamber. Pleon of 6 segments, fused dorsally, well defined laterally by incisions only on expanded side. Pleopods 4 and 5 biramous pairs, except last pair either uniramous or biramous. Uropods absent.

Male: head slightly narrower than pereomere 1. Pereon with 7 distinct segments. Pleon, 6 segments at least laterally indicated. Pleopods, 5 uniramous pairs, reduced to low protuberances. Uropods absent.

*Discussion.*—The large fifth oostegite appears to be an important generic character (Heard, pers. comm.) that has not previously been recognized. If in further



study the enlarged fifth oostegite proves to be an important character, then many of the Bopyridae parasitic on caridean shrimps of the family Hippolytidae are more closely related than is now thought.

*Probopyrinella heardi*, new species

Figs. 1, 2

Bopyridae sp. A, Camp, Whiting and Martin. 1977:7, 27.

*Material examined*.—(All are paratypes except holotype.) All infesting *Latreutes parvulus*. Georgia: Pass Warsaw Sound, Cabbage Island, Chatham County; 81°55'N 31°55'W; 4–8 m; 30 Aug 1972; R. W. Heard collected and determined host; 1 ♀ (gravid, no male), USNM 172452 (holotype, host present). Same location; 4–8 m; 13 Oct 1972; R. W. Heard collected and determined host; 2 ♀, 2 ♂, USNM 172453 (host present).—Florida: East of Florida Power and Light electrical generating plant, Hutchison Island, St. Lucie County; Station 1, EJ-72-132; 27°21'06"N 80°13'08"W; 8.5 m; 5 Jul 1972; R. M. Gallagher, F. S. Kennedy collected; D. K. Camp determined host; 2 ♀, 2 ♂, FSBC I 20838 (host FSBC I 16102). Same location, EJ-72-190; 6.7 m; 2 Nov 1972; R. M. Gallagher, C. R. Futch, N. H. Whiting collected; D. K. Camp determined host; 1 ♀, 1 ♂, FSBC I 20839 (host FSBC I 16103). Marco Island, Collier County; Station 18, 2, 1 (station location not known; 81°42'N 25°56'W; Nov 1972; D. L. Adkison determined host; 2 ♀, 1 ♂, MNHN Ep. 112, 113; 2 ♀ (gravid), 1 ♂, ZMC. Near pass, Lemon Bay; 82°21'N 26°54'W; trawl; 29 Jan 1983; O. Hartman collected; L. B. Holthuis determined host; 1 ♀, 1 ♂, USNM 172416 (host present).—Alabama: Pass, west end of Dauphin Island, Mobile County; 30°14'N 88°23'W; A-frame dredge net; 4–7 m; 14 Feb 1977; R. W. Heard collected and determined host; 1 ♀ (no male), USNM 172454.—Mississippi: Approximately 19 km south of Mississippi River; approximately 29°11'N 88°37'W; trawl 22–26 m; 10 Oct 1977; collected by shrimper; D. L. Adkison determined host; 1 ♀, 1 ♂, USNM 172455 (host present).

*Description*.—Female (Figs. 1, 2a, b): Body asymmetrical, distortion angle 40–65°; length 1.7–2.0 mm; width across pereomere 3, 1.2–1.5 mm.

Head fused with first pereomere; anterolateral corner of head acute on reduced side, other side with corner broader. First antenna, 3 or 4 segments; basal segment, no setae; second segment, 2 apical setae; distal segment, 4 setae as terminal tuft. Second antenna, 2 segments; no setae; distal segment, 3 to 6 setae. Second antenna greater than ½ length of first antenna. Maxilliped quadrate, anterior plate larger than posterior plate; small palp present. Posterior lamina, 1 pair of projections; projection on reduced side longer than that on expanded side.

Pereon segmentation often medially indistinct between pereomeres 2 and 3 (2 specimens). Lateral margins of pereomeres of expanded side well defined, notch often present in posterior ⅓ of pereomeres 2 and 3. Lateral margin on reduced side curled dorsally creating shallow trough medial to margin and exposing pereopods to dorsal view. Dorsal bosses absent. Coxal plates absent (present only on pereomere 1 of expanded side in 2 specimens). Tergal area of pereomere 1 on reduced side with conical projection. Pereopods with basal carina; pereopods decreasing in size from pereopods 4 or 5; pereopods smaller on reduced side. First oostegite, posterior plate width nearly equal to width of anterior plate; internal

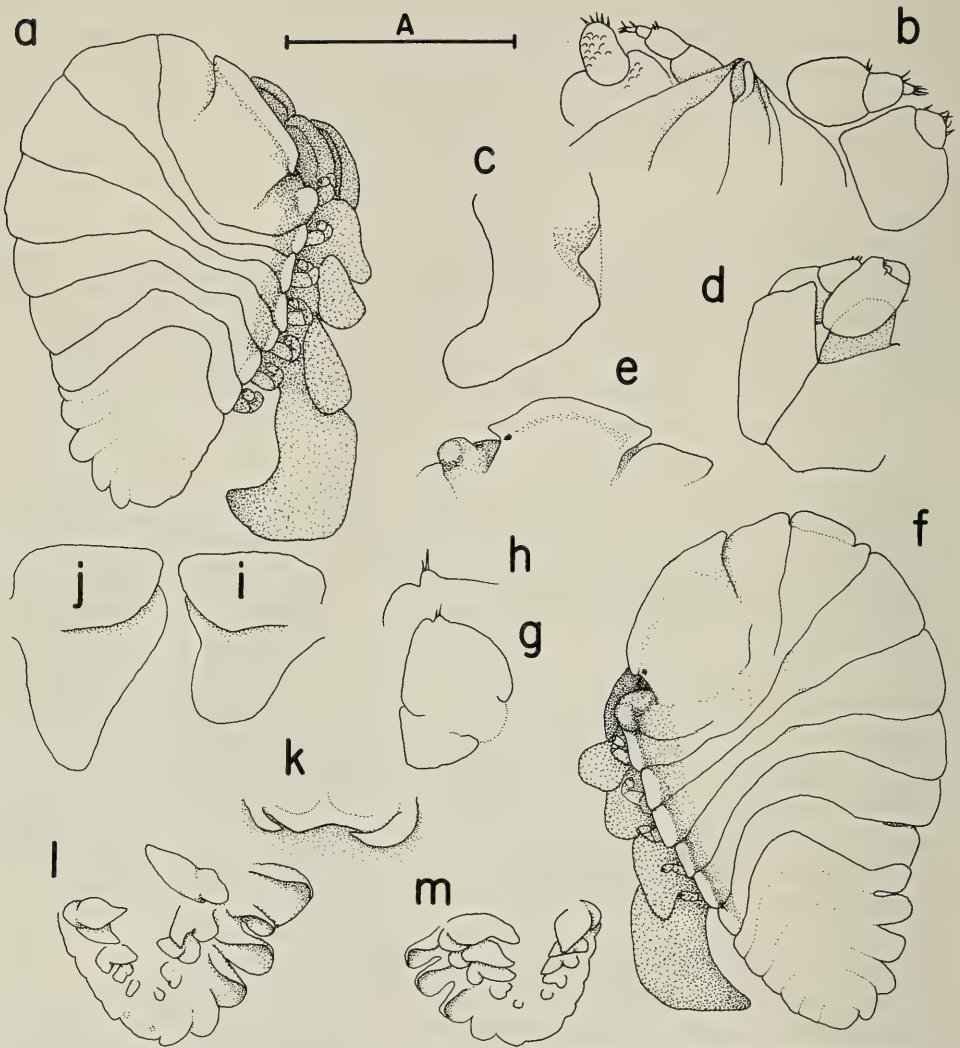


Fig. 1. *Probopyrinella heardi*, female: a, Dorsal view; b, Antennae and oral cone; c, Oostegite 5 from reduced side; d, Pereopod 4, expanded side; e, Head, viewed in dorsal plane of head; f, Holotype, dorsal view; g, Maxilliped; h, Maxilliped palp; i, Oostegite 1 from expanded side, internal view; j, Oostegite 1 from reduced side, internal view; k, Posterior lamina; l, Pleon of a, ventral view; m, Pleon of f, ventral view. Figures from holotype, e-k, m. Figures from paratype FSBC I-20839, a and l. Figures from USNM 172453, b-d. Scale: A = 1.0 mm (Figs. a, d, f, i, j, m).

ridge unornamented; first oostegites asymmetrically developed, oostegite on reduced side enlarged. Fifth oostegite on reduced side enlarged; other oostegites reduced, only fringing brood chamber.

Pleon deeply set in pereomere 7. Six segments laterally indicated. Segments 1-5 on expanded side defined by deep notch, anterior edge of segments curled ventrally. Pleomeres on reduced side and the sixth pleomere less clearly defined than on expanded side. Pleopods, 4 or 5 pairs, anterior pairs biramous, last pair

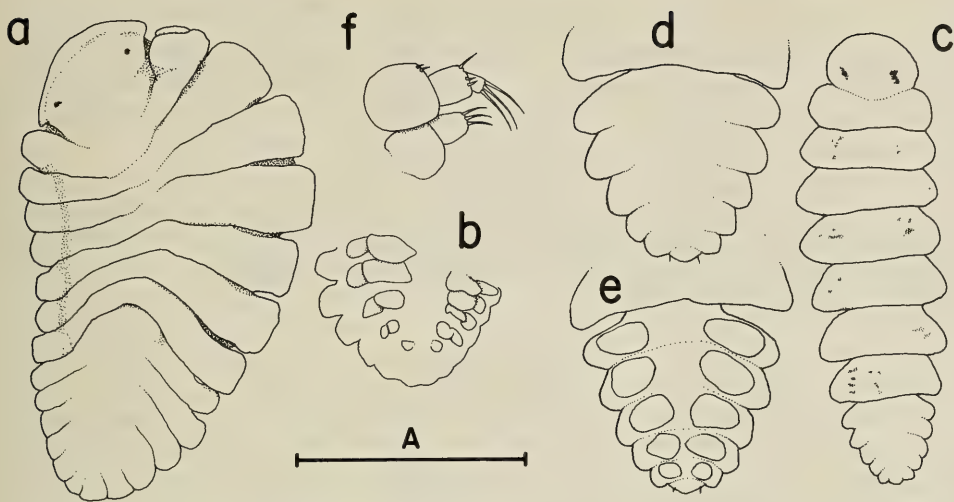


Fig. 2. *Probopyrinella heardi*, a, b, female, immature; c–f, male: a, Dorsal view; b, Pleon, ventral view; c, Dorsal view; d, Pleon, dorsal view; e, Pleon, ventral view; f, Antenna. Figures from USNM 172454, a and b. Figures from FSBC I-20838, c–f. Scale = 1.0 mm.

uniramous; pleopods decreasing in size posteriorly until posterior pair only small tubercle or ridge. Uropods absent.

Male (Fig. 2c–f): Length 0.7–1.1 mm; width across pereomere 3 or 4, 0.2–0.4 mm.

Head wider than long, distinct from first pereomere. Eyes present. First antenna, 3 segments; basal segment, 0 to 2 setae; second segment, 2–4 setae; distal segment, 3 to 5 setae. Second antenna, 2 segments; basal segment, 1 or 2 setae; distal segment, 2–4 setae. Second antenna  $\frac{1}{2}$  to  $\frac{2}{3}$  length of first antenna. Maxillipeds not seen.

Pereon 7 segments, increasing in width until pereomere 3 or 4, thereafter decreasing in width posteriorly; pigment spots on dorsal surface of most pereomeres. Pereopods decreasing in size both anteriorly and posteriorly from pereopod 4.

Pleon 6 segments indicated laterally by notches, medially fused; pleomere 1 subequal in width to pereomere 7. Pleopods, 5 uniramous pairs, decreasing in size posteriorly. Uropods absent.

*Etymology*.—This species is named for Richard W. Heard who collected many of the specimens and who first recognized this species as undescribed.

*Type series*.—The holotype and some paratypes have been deposited in the National Museum of Natural History, Smithsonian Institution (USNM). The remaining paratypes have been deposited in Florida Department of Natural Resources, St. Petersburg (FSBC); Muséum National d'Histoire Naturelle, Paris (MNHN); and Universitetets Zoologiske Museum, Copenhagen (UZM).

*Type-locality*.—Warsaw Sound (off Cabbage Island) Chatham County, Georgia, U.S.A.

*Distribution*.—*Probopyrinella heardi* is known from the coastal waters of the southeastern United States from Georgia to Mississippi.

*Discussion*.—While the two species of *Probopyrinella* are very similar in dorsal



view, *Probopyrinella heardi* can be distinguished from *P. latreuticola* by the following characters for the former: (1) female with head and first pereomere fused, (2) female with second antenna of 2 segments, (3) female with posterior lamina and first oostegite asymmetrically developed, (4) male with second antenna of two segments, and (5) male with segmentation of pleon less distinct.

*Probopyrinella heardi*, *P. latreuticola*, and the two undescribed species mentioned by Chopra (1923:537), all infest members of the hippolytid genus *Latreutes* Stimpson, 1860: *P. heardi* on *L. parvulus*, *P. latreuticola* on *L. fucorum* (Fabricius, 1798), and the undescribed species on *L. mucronatus* (Stimpson, 1860) and *L. pygmaeus* Nobili, 1904.

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## NEW SPECIES OF PHYLLODOCIDAE AND HESIONIDAE (POLYCHAETA), PRINCIPALLY FROM FLORIDA

Thomas H. Perkins

*Abstract.*—The following new species are described: *Eumida* (*Eumida*) *parvicirrus*, *Eumida* (*Pirakia*) *hutchinsonensis*, *Paranaitis* *gardineri*, *Heteropodarke lyonsi*, *H. formalis*, *Kefersteinia haploseta*, and *Podarkeopsis levifuscina*. *Kefersteinia* sp. is informally described. *Oxydromus arenicolus glabrus* Hartman, previously referred to *Oxydromus brevipalpa* Hartmann-Schröder, is a distinct species which, with *O. brevipalpa*, *Oxydromus capensis* Day, and *Gyptis maraunibinae* Gibbs, are species of *Podarkeopsis* Laubier, and new combinations.

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This report is one of several (Perkins 1979, 1980, 1981, 1984) based primarily on collections made between September 1971 and July 1973 in an environmental baseline study of marine biota near the Florida Power and Light Company nuclear power plant at Hutchinson Island, St. Lucie County, Florida. Additional specimens collected later at Hutchinson Island and specimens from North Carolina and the eastern Gulf of Mexico are included. A species of Hesionidae, *Microphthalmus hartmanae*, has been described previously from these collections (Westheide 1977), and another *Microphthalmus* species awaits description (Winfried Westheide, in litt.).

The study area and methods were described by Gallagher and Hollinger (1977). Sediments were described by Gallagher (1977). Other aspects of the physical and chemical environment were reported by Worth and Hollinger (1977). Brief descriptions of benthic sampling stations and methods were also given by Perkins (1979).

Types and other material available for study are deposited in the Allan Hancock Foundation, University of Southern California (AHF); British Museum (Natural History) (BMNH); Invertebrate Reference Collection of the Florida Department of Natural Resources Bureau of Marine Research (FSBC I); Marine Environmental Sciences Consortium, Dauphin Island, Alabama (MESC); Mote Marine Laboratory, Sarasota, Florida (MML); U.S. National Museum of Natural History, Smithsonian Institution (USNM); Universitetets Zoologiske Museum, Copenhagen (ZMC); and Zoologisches Institut und Zoologisches Museum, Hamburg University (ZMH).

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to me. Kristian Fauchald, Karen A. Steidinger and William G. Lyons critically read the manuscript. Many other individuals from the Bureau of Marine Research and from Applied Biology, Inc., participated in the Hutchinson Island study for which Florida Power and Light Company provided partial funding.

Family Phyllodocidae Williams, 1851

Genus *Eumida* Malmgren, 1865, emended

*Diagnosis.*—Body usually long, with numerous segments. Prostomium cone-shaped, oval, pear-shaped, or heart-shaped, with 2 eyes and 5 antennae. First segment reduced dorsally, visible laterally and ventrally, other tentacular segments complete and distinct from one another; 4 tentacular cirri, all cirriiform, or ventral cirri of segment 2 slightly flattened and oval in cross section. Tentacular formulae:

$$1 + S \frac{01}{al} + S \frac{01}{an} \quad \text{or} \quad 1 + 0 \frac{01}{al} + S \frac{01}{an}$$

Parapodia uniramous, with only compound setae; dorsal cirri oval, lanceolate or heart-shaped, ventral cirri originating near ventral margin, and equal to or smaller than setal lobes in posterior view, with axis parallel to aciculum or diverging ventrally. Proboscis smooth or nearly so or diffusely covered with conical, rounded, or cylindrical papillae, not divided into 2 regions when everted. (Diagnosis modified from Hartmann-Schröder 1971, incorporating characters of ventral cirrus suggested by Banse 1973.)

*Remarks.*—The systematics of *Eumida* Malmgren, 1865, s.s., and related genera (e.g., *Pirakia* Bergström, 1914; *Sige* Malmgren, 1865; and *Pterocirrus* Claparède, 1868) is complicated and somewhat confused. A system based on principles proposed by Bergström (1914), with minor emendations and additions by later authors, was given by Fauchald (1977:45–51). Fauchald retained the identities of most genera maintained or described by Bergström. Other authorities (e.g., Day 1967; Hartmann-Schröder 1971; Uschakov 1972; Banse and Hobson 1974) included some related genera of Fauchald's system within the genus *Eumida*, with or without subgeneric status, or included these, *Eumida*, and still other genera of Fauchald's system as subgenera of *Eulalia* Savigny, 1817. *Eumida* and related genera differ from *Eulalia* in having a dorsally reduced first segment; however, see Banse (1973) for a discussion of reservations concerning the importance of this character.

Of the four generic taxa I consider related, *Pirakia* differs from *Eumida* in the degree and type of papillation of the proboscis. This may be an important generic character; Hartmann-Schröder (1971) stated that the proboscis of the type-species of *Eumida*, *Eulalia sanguinea* Örsted, 1843, was smooth or wrinkled only from contraction, whereas the proboscis of the type-species of *Pirakia*, *Phyllodoce (Eulalia) punctifera* Grube, 1860, was diffusely covered with small, conical papillae. However, there may be intermediate conditions of this character; other authorities (e.g., Pettibone 1963; Day 1967; Uschakov 1972) have described oval bumps or scattered papillae of various shapes on specimens reported as *Eumida sanguinea* and other *Eumida* species. These may prove to be incorrectly identified, and the apparent intermediate conditions may not exist. Therefore, I am retaining *Pirakia*, but only as a subgenus of *Eumida*.

*Sige* and *Pterocirrus*, the two remaining similar generic taxa, differ from *Eumida*



in having broadly lamellate ventral tentacular cirri on segment 2; I consider this an important generic character. In the strict sense, these genera differ from each other in the setation of tentacular segments, *Sige* having setae on segments 2 and 3, and *Pterocirrus* lacking setae but apparently having acicula on those segments (Banse 1959; Uschakov 1972). However, a form described from Japan [*Sige macroceros* (Grube, 1860) variety *orientalis* Imajima and Hartman, 1964:70, pl. 14, figs. c–f] is apparently intermediate between these character states. (This varietal designation has no status according to the International Code of Zoological Nomenclature 1964, Article 45.) The form has setae on segment 3, suggesting that setation of anterior segments is not an important generic character for this group, and that *Sige* and *Pterocirrus* constitute but a single genus without subgenera. This is in strict agreement with the system of Uschakov (1972). Lack of importance of setation of anterior segments as a generic character is further supported by intraspecific variation in this character noted in the species of *Eumida* (*Pirakia*), below.

Uschakov used *Pterocirrus* Claparède rather than the older name *Sige* Malmgren for this taxon. He believed, after examination of a specimen from the Öresund, near the type-locality, that Malmgren's original description and figure of *Sige fusigera* (Malmgren 1865:100, pl. 14, fig. 27), the type-species, were correct and concluded that *Sige fusigera* was a species of *Eumida* Malmgren. However, Bergström (1914) stated earlier that he had examined the holotype of *S. fusigera* deposited in the Swedish State Natural History Museum and other specimens of the species from the type-locality north northwest of the Öresund along the southern Norwegian and Swedish west coast. The "holotype" he examined [which should only be considered part of Malmgren's original material, according to Kristian Fauchald (pers. comm.)] was damaged. The proboscis was torn loose from the mouth, and the part visible was the inner coelomic lining. This is suggested by Malmgren's figure and is a condition common on one of the species described below. Bergström also stated that ventral tentacular cirri of the second segment were lamelliform and that the proboscis was diffusely papillate. At this time, Bergström's arguments are more convincing than those of Uschakov, and I continue to maintain Bergström's concept of *Sige* Malmgren, but as modified by Uschakov under the name *Pterocirrus* Claparède. However, it is certainly possible that Malmgren had both the species reported as *Eumida fusigera* by Uschakov (1972) [here considered a *Eumida* species] and also the species reported by Bergström (1914) as *Sige macroceros* [not *Phyllodoce* (*Eulalia*) *macroceros* Grube, 1860, fide Banse (1959) but here considered to be *Sige fusigera* Malmgren, 1865]. This matter warrants further investigation.

Additionally, I include in *Eumida* species having slightly flattened ventral tentacular cirri on segment 2. These occur on the species of *Eumida* (*Pirakia*) described below, on the species reported as *Eulalia* (*Eumida*) *sanguinea* [not *Eulalia sanguinea* Örsted, 1843] by Day (1967:155, fig. 5.5.A–C) from southern Africa, and probably on *Eulalia* (*Sige*) *falsa* Day (1960:303, fig. 6A–C; 1967:155, fig. 5.5.D–F). There is a great difference between the slightly flattened ventral tentacular cirri of these species and the broadly lamellate ones of *Sige* (see Claparède 1868:560–562; 1869: pl. 17, fig. 2; and Bergström 1914:70, text figure 23f–g for descriptions and figures of ventral tentacular cirri of segment 2 of *Sige*).

Finally, the intraspecific variation in setation of anterior segments noted in the

description of the species of *Eumida* (*Pirakia*), below, seems to require that the limits of *Eumida* be expanded. Accordingly, I have emended the generic diagnosis to include all specimens of this species by the addition of a second setal formula indicating that setae may be absent from segment 2.

Subgenus *Eumida* Malmgren, 1865

*Diagnosis*.—Proboscis smooth or with scattered papillae, bumps, wrinkles, folds, or warts of various shapes.

*Eumida* (*Eumida*) *parvicirrus*, new species

Fig. 1

*Material examined*.—FLORIDA: Hutchinson Island Sta II, 27°21.6'N, 80°13.2'W, 11 m, coarse calcareous sand, holotype (USNM 80510). Same, Sta V, 27°22.9'N, 80°13.9'W, 11 m, coarse calcareous sand, paratype (USNM 80511).

*Description*.—Dorsum of holotype brown on segments 2–6, posterior lobes of brain mass brown (Fig. 1A), internal pigmented areas ventromedial to ventral cirri (Fig. 1C). Holotype complete, 3 mm long excluding proboscis, 30 segments; complete paratype smaller, about 2 mm long, 20 segments. Prostomium oval-pentagonal (Fig. 1A), about twice as broad as long; posterior margin almost straight; frontal antennae moderately slender, subulate; median antenna shorter and more slender than frontal ones, originating slightly in front of level of eyes; eyes posterolateral. First segment reduced dorsally, visible only laterally and ventrally. Tentacular formula:

$$1 + S \frac{01}{al} + S \frac{01}{an}$$

Setal lobes of segment 2 small, conical, with several setae. Tentacular cirri slender, subulate, about  $\frac{2}{3}$  as long as prostomial width on segment 1; upper cirri on segment 2 longest, extending to about segment 7; ventral cirri of segment 2 slightly longer than those of segment 1; dorsal tentacular cirri of segment 3 almost as long as upper cirri of segment 2. Dorsal cirri (Fig. 1B, C) similar throughout, only slightly smaller on anteriormost and far posterior setigers, on short cirrophores, pyriform, extending to tips of setal lobes or shorter, about  $1\frac{1}{2}$  times longer than wide, with thickness equal to  $\frac{1}{2}$  width. Setigerous lobes conical; each with short filiform presetal lobe above aciculum, with obscure, rounded, postsetal lobe, with relatively long, slender aciculum extending into presetal lobe. Ventral cirri subulate or fusiform, about as long as dorsal cirri, about  $\frac{1}{2}$  as wide, not extending past tips of setigerous lobes. Setae (Fig. 1D–F) numbering about 20 per parapodium in middle segments, with slender shafts and slender, spinigerous blades; shafts with about 6 short, slender spines on tips; blades with short serrations on edge. Anal cirri missing.

Proboscis (Fig. 1A) relatively short and bulbous when everted, with smooth surface; distal opening, when fully everted, surrounded by 15–20 soft, semicircular lobes.

*Remarks*.—*Eumida parvicirrus* is a small species for the genus. Setigerous lobes, ventral cirri, and possibly setae are similar to those of the specimen reported as

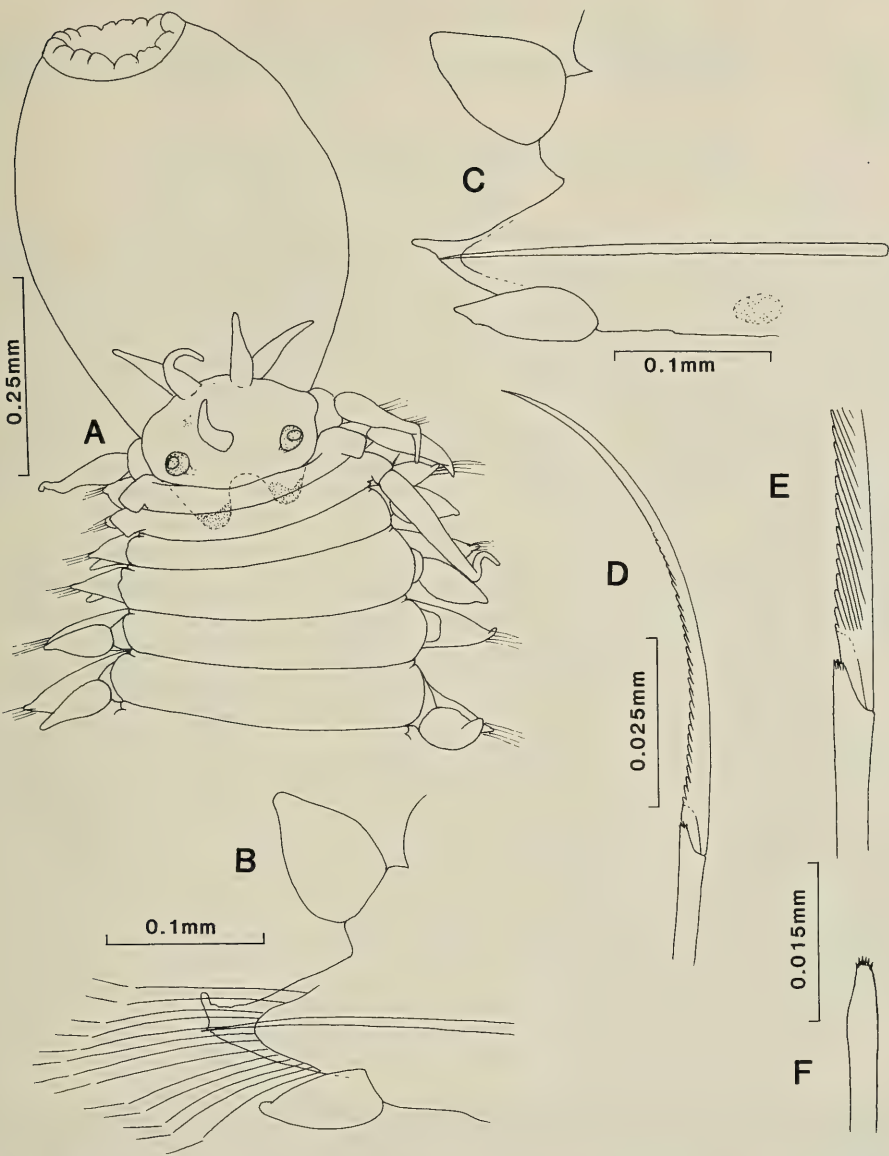


Fig. 1. *Eumida (Eumida) parvicirrus*, holotype: A, Anterior end, dorsal view; B, Parapodium, middle segment, posterior view, with about half of setae figured; C, Same, setae omitted; D, Seta, lateral view; E, Same, enlarged view of hinge region; F, Tip of shaft, face view.

*Eumida fusigera* by Uschakov (1972) [not *Sige fusigera* Malmgren]. However, the proboscis of *E. parvicirrus* is smooth and dorsal cirri are not as slender. *Eumida parvicirrus* appears to be unique in the genus in having relatively large posterior lobes of the brain mass, the posterior parts of which are pigmented.

*Etymology*.—The specific name is derived from the Latin *parvus*, small, and *cirrus*, curl, and refers to the small cirri of setigerous segments.



Subgenus *Pirakia* Bergström, 1914

*Diagnosis*.—Proboscis diffusely covered with conical, rounded, or cylindrical papillae.

*Eumida* (*Pirakia*) *hutchinsonensis*, new species

Figs. 2, 3

*Material examined*.—FLORIDA: Hutchinson Island Sta V, 27°22.9'N, 80°13.9'W, 11 m, coarse calcareous sand, holotype (USNM 80515), 29 paratypes (USNM 80517, 80519, 80520; AHF Poly 1390; BMNH 1983.931–937; FSBC I 30418; ZMC; ZMH P-17602). Same, Sta II, 27°21.6'N, 80°13.2'W, 11 m, coarse calcareous sand, 17 paratypes (USNM 54278, 80516, 80518; FSBC I 30419, 30420). Same, Sta IV, 27°20.7'N, 80°12.8'W, 11 m, coarse calcareous sand, 1 paratype (FSBC I 30421). Off Cape Canaveral, 28°35.9'N, 80°18.6'W, 26 m, on scallops, 9 specimens (FSBC I 17407). Off Palm Beach County-Broward County line S of Boca Raton, on *Phragmatopoma lapidosa* Kinberg, 1 specimen (USNM 80521).

*Description*.—Color variable, tan to dark brown; tan specimens with few scattered pigment spots more prominent on antennae, tentacular cirri, dorsal cirri, and ventral cirri; dark-brown specimens with numerous pigment spots on prostomium and dorsum of body; spots prominent in transverse segmental bands; dorsal and ventral cirri of dark-brown specimens also strongly pigmented, darker than body; many specimens with color intermediate between these extremes. Complete type-specimens less than 10 mm long, with maximum of 75 segments. Prostomium (Fig. 2A, B) rounded-pentagonal, longer than wide, with posterior margin almost straight; frontal antennae moderately stout, similar; median antenna originating from near middle of prostomium well in front of eyes, much shorter and more slender than frontal ones; pair of moderately large, brown, lensed eyes near posterior margin; moderately large, triangular lobe behind eyes. Segment 1 reduced dorsally, visible only laterally and ventrally, with tentacular cirri lateral to eyes. Tentacular formulae:

$$1 + S \frac{01}{al} + S \frac{01}{an} \quad \text{or} \quad 1 + 0 \frac{01}{al} + S \frac{01}{an}$$

Segment 2 parapodia with 0–3 setae; some specimens with setae on both parapodia, others with setae on only one; about half of specimens without setae on this segment. Ventral tentacular cirri of segment 2 slightly flattened, oval in cross section; remaining tentacular cirri cirriform; dorsal cirri of segment 2 longest, reaching to about segment 8; setal lobes of segment 2 reduced or absent. Parapodia after segment 3 (Fig. 2C, D) with dorsal and ventral cirri, slightly bilobed presetal lobes and shorter, rounded postsetal lobes; single neuroaciculum and composite setae. Dorsal cirri short on anterior segments, gradually longer on anterior  $\frac{1}{3}$  of body, shorter near far posterior end, about twice longer than wide on middle segments, flattened, lanceolate to cordiform in outline, on cirrophores of moderate length; ventral cirri somewhat flattened, oval in outline, extending almost to tips of setal lobes, on short cirrophores; parapodia of middle segments with less than 10 setae. Setae (Fig. 3B–D) composite, with short, flattened, awl-shaped blades; blades with very fine, short serrations on edge, with pointed tips; shaft tips asymmetrical with several spines all of same size. Anal cirri (Fig. 3A) similar to dorsal

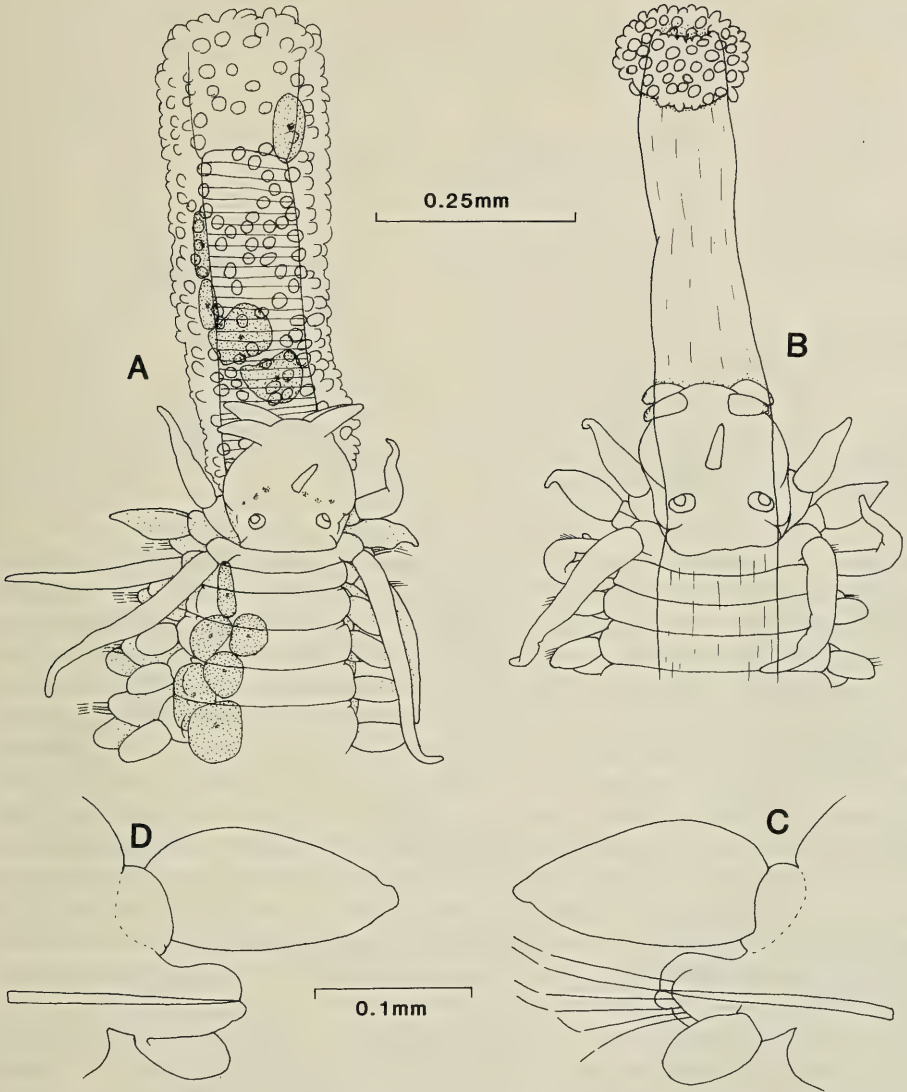


Fig. 2. *Eumida (Pirakia) hutchinsonensis*: A, Anterior end, dorsal view; B, Same, with proximal part of proboscis torn from mouth; C, Parapodium, middle segment, posterior view; D, Same, anterior view, setae omitted (A, USNM 80517; B, USNM 80516; C, D, USNM 80519).

cirri of middle segments, slightly thicker and longer, almost oval in outline on holotype.

Proboscis (Fig. 2A, B) in about anterior 23 segments when inverted, formed of papillate region in anterior 13 segments and thickly muscled region with numerous circular muscle rings in last 10 or so segments; proboscis when everted showing numerous, irregularly arranged, short papillae on all except possibly short proximal part near mouth, with distal opening surrounded by 12 rounded, soft papillae attached at anterior end of muscular part. Proboscis missing on several specimens; papillate part broken away from mouth on some others (Fig. 2B).

Many specimens with polygonal eggs in coelomic cavity (Fig. 2A).

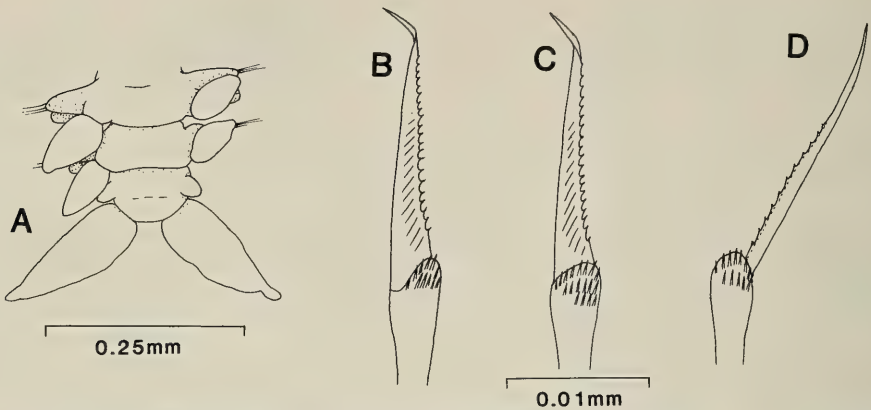


Fig. 3. *Eumida (Pirakia) hutchinsonensis*: A, Posterior end, dorsal view; B–D, Setae, various views (A, USNM 80516; B–D, FSBC I 30419).

**Remarks.**—Ventral tentacular cirri of segment 2 on most type-specimens of *Eumida (Pirakia) hutchinsonensis* are slightly flattened and oval in cross section. They are definitely flattened on a few type-specimens, but on another specimen (USNM 80521) collected north of Boca Raton, Florida on *Phragmatopoma*, they are cylindrical in cross section. The specimen is larger than the type-specimens, 17 mm long with about 100 segments, but I am certain the specimen is the same species. The structure of the proboscis is the same. The origin of the median antenna is the same, although it is relatively longer than on the smaller type-specimens. The shape of the setae is identical, although there are about 15 per parapodium on middle segments rather than 10 or less as on the type-specimens. There are no notopodial lobes on segment 2 of the larger specimen, and only two setae were found on one side of that segment, then only after removal of the parapodium. Parapodial lobes are similar, but dorsal cirri are more pointed on the larger specimen. Finally, the larger specimen is a female whose eggs are identical with those of the smaller specimens.

*Eumida (Pirakia) hutchinsonensis* differs from *E. (P.) punctifera* (Grube, 1860) (*Phyllodoce (Eulalia) punctifera*.—Grube, 1861:142, pl. 3, fig. 5; *Eumida (Pirakia) punctifera*.—Hartmann-Schröder, 1971:113, 114, Fig. 36A–C) in having a prostomium which is much longer than wide, in having a median antenna which originates from the middle of the prostomium rather than from between the eyes, and in having parapodia with only slightly bilobed presetal lobes. *Eumida (P.) hutchinsonensis* differs from *E. (P.) fuscescens* (Saint-Joseph, 1888) (*Eulalia fuscescens* Saint-Joseph, 1888:296, 297, pl. 12, figs. 163–165; *Eumida (Pirakia) fuscescens*.—Hartmann-Schröder, 1971:113) in having subulate rather than filiform antennae and tentacular cirri and in having none to very few, rather than several, setae on parapodia of the second segment.

*Eumida (P.) hutchinsonensis* differs from *E. (P.) lanceolata* (Hartman and Fauchald, 1971:44–46, pl. 7) in having eyes and broader dorsal cirri and in lacking setal lobes on segment 2. *Eumida (P.) hutchinsonensis* differs from *E. (P.) brunnea* (Fauchald, 1972:53, 54, pl. 4, figs. c, d) in having eyes, numerous proboscidal papillae and broader dorsal cirri, and in lacking filiform lobes on tips of parapodia.



*Eumida* (P.) *hutchinsonensis* may have been previously reported from Florida by Rullier (1974:23, 24) as *Eulalia punctifera*, but I cannot confirm this.

*Etymology*.—The specific name refers to the type-locality.

Genus *Paranaitis* Southern, 1914

*Paranaitis gardineri*, new species

Fig. 4

*Paranaitis polynoides*.—Gardiner, 1976:110, fig. 6M–P [not *Anaitis polynoides* Moore, 1909].

*Material examined*.—NORTH CAROLINA: Cape Lookout, intertidal, sand mixed with gravel and shell fragments, S. L. Gardiner & C. J. Jenner, coll., 6 Apr 1974, holotype (USNM 52876), paratype (USNM 80523). Same, E. Powell, coll., 14 Feb 1975, paratype (USNM 52878). Intracoastal Waterway, Wrightsville Beach, intertidal, muddy sand, T. Fox and S. L. Gardiner, coll., 9 Mar 1974, 2 paratypes (USNM 52877). FLORIDA: Hutchinson Island Sta II, 27°21.6'N, 80°13.2'W, 11 m, coarse calcareous sand, 5 paratypes (FSBC I 30422–30424; USNM 80524; ZMH P-17600). Same, Sta IV, 27°30.7'N, 80°12.8'W, 11 m, coarse calcareous sand, 3 paratypes (AHF POLY 1391; BMNH 1983.938; FSBC I 30425). Same, Sta V, 27°22.9'N, 80°13.9'W, 11 m, coarse calcareous sand, 2 paratypes (FSBC I 30426, 30427).

*Description*.—Specimens from North Carolina (collected intertidally) highly colored (Fig. 4A, C) with diffuse purple spots on prostomium, tentacular segments, tentacular cirri, dorsum and ventrum of posttentacular segments, and dorsal cirri; color spots often on cirrophores of dorsal cirri and on proximal parts of ventral cirri. Segmental spots on dorsum often coalesced, forming almost uniform trapezoidal groups with anterior side narrower; medial and pair of lateral irregular lines of pigment spots on ventrum; dorsal cirri with up to 10 diffuse pigment spots on medial half of cirrostyles. Florida specimens (collected subtidally) almost all without color pattern; trace of color pattern noted above present on one specimen. Maximum length 95 mm, width 4 mm (Gardiner 1976); maximum length of preserved specimens 60 mm, width 3 mm, 180 segments; specimens from North Carolina more than twice as long as Florida specimens. Prostomium (Fig. 4a) about as long as wide; posterior half surrounded on dorsal side by fused segments 1 and 2, with nuchal papilla. Tentacular cirri of segment 3 longest, extending to about setiger 8; dorsal pair of segment 2 often about as long as ones on segment 3. Dorsal cirri (Fig. 4C–F) on distinct cirrophores; cirrostyles imbricated, thin, about as broad as or shorter than length of aciculum, small anteriorly, gradually longer toward middle, smaller near posterior end, with margins gradually curved or with obscure dorsolateral angle, with dorsal margin slightly longer than ventrolateral margin. Imbricated cirri exposing most of dorsum of body anteriorly,  $\frac{1}{3}$ – $\frac{1}{2}$  of body on middle segments,  $\frac{1}{4}$ – $\frac{1}{3}$  of body on posterior segments. Setigerous lobes conical, with distally notched presetal lobes; upper parts of presetal lobes longer and broader than lower parts; postsetal lobes shorter, rounded. Ventral cirri extending about to tips of presetal lobes or slightly shorter, flattened, elongate-oval, with rounded tips, with dorsal margins usually concave, with ventral margins convex, originating on short, broad cirrophores or extensions of ventral parts of parapodia. Up to 30 compound spinigers per parapodium depending on body

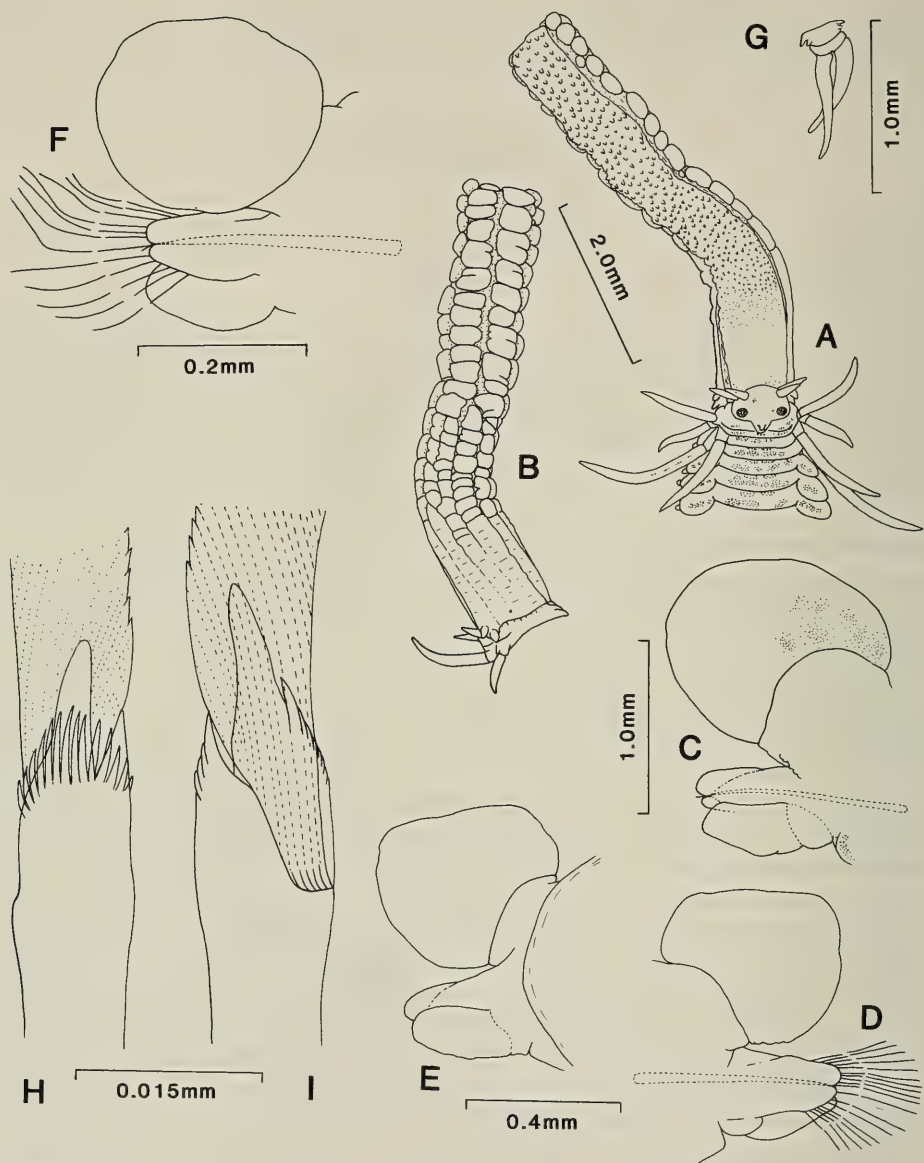


Fig. 4. *Paranaitis gardineri*: A, Anterior end, dorsal view; B, Ventrolateral view of same; C, Parapodium, posterior view; D, Same, anterior view; E, Same, posterior view; F, Same, anterior view, small specimen; G, Pygidium, dorsal view; H, Hinge region of seta, anterior view; I, Same, posterior view (A-C, G, holotype; D, E, BMNH 1983.938; H, I, USNM 80524).

size (Fig. 4D, F, H, I); blades flattened, serrated; shafts enlarged near tips, with large round-tipped tooth on anterior side, with row of numerous long spines below large tooth, and short, triangular tooth on same side of shaft as serrated margin of blade. Acicula gradually tapered to slender tips; tips often emergent from setal lobes, if not broken, in preserved specimens. Pygidium (Fig. 4G) on specimens

of greater than 10 mm length with pair of long, slender, cirriform or tapered anal cirri; cirri 6–8 times longer than wide, about as long as ventral tentacular cirri of segment 2, but not as stout; often shorter, almost cylindrical on some small specimens.

Proboscis (Fig. 4A, B), observed everted on 2 specimens from North Carolina, dissected on specimen from Florida; dorsal surface with scattered, chitinous papillae, with region of small papillae proximally, then short, smooth region more distally, then papillate region extending toward tip; papillae of distal region smaller proximally, gradually larger distally; 2 pairs of small, subulate, soft papillae laterally at proximal end; lateral and ventral surface proximally smooth, with about 6 indistinct, muscular ribs, changing to 6 rows of rectangular pads medially, then to 4 rows of rectangular pads distally; shape of anterior margin of proboscis when fully everted not satisfactorily observed.

*Remarks.*—*Paranaitis gardineri* differs from *P. polynoides* (Moore, 1909), to which specimens of *P. gardineri* from North Carolina had been referred, in having dorsal cirri which are not as broad and in having anal cirri which are much longer and more slender. Dorsal cirri of *P. polynoides* are much broader than the lengths of acicula and conceal the parapodia and entire dorsum posteriorly, whereas on *P. gardineri* dorsal cirri are about as broad as the lengths of acicula and leave the middle  $\frac{1}{4}$ – $\frac{1}{3}$  of the body exposed posteriorly. Anal cirri of *P. polynoides* are stout, cylindrical, and about four times longer than wide, whereas anal cirri of *P. gardineri* are slender, gradually tapered, and 6–8 times longer than wide.

The proboscis of the holotype of *P. polynoides* (Moore) is not everted. I dissected a specimen of *P. polynoides* from Puget Sound, Washington, identified by Dr. M. H. Pettibone (USNM 26839), and examined the proboscis. Although I could not exactly determine the details, the proboscis of the dissected specimen appeared similar to that of *P. gardineri*.

*Paranaitis gardineri* is also similar to *P. kosteriensis* (Malmgren, 1865), but the latter species has spheroidal anal cirri (Bergström 1914).

*Etymology.*—The species is named in honor of Dr. Stephen L. Gardiner, who was instrumental in collecting the excellent specimens of this and many other species from North Carolina.

Family Hesionidae Sars, 1862

Genus *Heteropodarke* Hartmann-Schröder, 1962

*Heteropodarke lyonsi*, new species

Figs. 5, 6

*Material examined.*—FLORIDA EAST COAST: Hutchinson Island Sta II, 27°21.6'N, 80°13.2'W, 11 m, coarse calcareous sand, holotype (USNM 80525), 2 paratypes (USNM 80530; FSBC I 30429), 2 specimens (USNM 80532; FSBC I 30430). Same, Sta III, 27°22.0'N, 80°12.4'W, 7 m, medium calcareous sand, 2 paratypes (BMNH 1983.939; ZMH P-17599), 3 specimens (FSBC I 30431–30433). Same, Sta IV, 27°20.7'N, 80°12.8'W, 11 m, coarse calcareous sand, 6 paratypes (USNM 80527, 85029; AHF Poly 1398; ZMH P-17598), 1 specimen (FSBC I 30434). GULF OF MEXICO (U.S. Bureau of Land Management, Mississippi, Alabama, Florida Study, 1975–76, box core samples): off Florida, Sta 28, 29°55'N, 86°05'W, 38 m, coarse calcareous sand-rubble, 2 paratypes (BMNH 1983.940–



941), 4 specimens (MESC). Same, Sta 29, 29°56'N, 86°06'W, 38 m, coarse calcareous sand-rubble, 6 paratypes (MESC; BMNH 1983.942; ZMH P-17605; FSBC I 30435), 2 specimens (MESC). Same, Sta 30, 29°51'N, 86°06.5'W, 41 m, coarse calcareous sand-rubble, 6 paratypes (MESC; USNM 80526; AHF Poly 1399), 2 specimens (MESC). Same, Sta 31, 29°48'N, 86°09.5'W, 45 m, coarse calcareous sand-rubble, 1 paratype (USNM 80528), 1 specimen (MESC). Same, Sta 32, 29°46'N, 86°12.5'W, 45 m, coarse sand, 3 paratypes (FSBC I 30436, 30437), 3 specimens (MESC). Same, off Alabama, Sta 40, 29°43.5'N, 87°54.5'W, 36 m, coarse sand, 1 specimen (MESC). Same, Sta 41, 29°45.5'N, 87°36.5'W, 37 m, medium sand, 1 paratype (USNM 80531). NORTH CAROLINA: off Beaufort, 34°34'N, 76°25'W, 19 m, fine sand and shell, J. H. Day, coll., BST 88X, 1 paratype (USNM 51078).

*Description.*—Body without color pattern. Holotype complete, about 8 mm long, 75 setigers; largest paratype (USNM 80530) incomplete, in 2 pieces, about 20 mm long, about 200 setigers; remaining paratypes and specimens incomplete; single large pygidial fragment (USNM 80532). Body almost cylindrical, slightly flattened ventrally. Prostomium slightly longer than wide, rectangular, with broadly rounded corners on specimens with proboscis everted (Fig. 5A), shorter, pyriform on specimens with proboscis inverted (Fig. 5B),  $\frac{1}{2}$ – $\frac{2}{3}$  width of body without parapodia. Antennae and palps tapered, not articulated, perhaps pseudoarticulated on few partially dried specimens; lateral antennae attached on anterior margin at about middle of each side, about as long as prostomium; median antenna attached slightly back from anterior margin, slightly shorter than lateral antennae; palps attached on anterior margin on short palpophores at about lateral sides of prostomium, similar to lateral antennae. One or 2 pairs of minute eyespots usually present laterally on posterior  $\frac{1}{3}$  of prostomium. First segment reduced dorsally, visible only laterally and ventrally; tentacular cirri 4–6 pairs on 2–3 laterally visible, indistinctly marked segments, upper ones on long cirrophores; longest upper ones on segment 2, with about 25 articles, extending to about setiger 6; upper ones on segment 1 about  $\frac{2}{3}$  as long; upper ones on posterior tentacular segment about  $\frac{1}{2}$  as long; lower ones all about same length,  $\frac{1}{3}$ – $\frac{1}{2}$  length of longest upper ones, with about 10 articles. Parapodia (Figs. 5C, D; 6A–C) lateral on anterior segments, gradually changing to dorsolateral orientation on posterior segments, sesquiramous; each with articulated dorsal and ventral cirri, with blunt neuropodial lobe, with distinct presetal lobe on anterior 3 and middle and posterior setigers, with composite, heterogomph setae consisting of spinigers and falcigers, with blunt-tipped neuroaciculum, with tapered notoaciculum; internal structure of shafts of setae uniform, unmarked, similar to that of Syllidae. Dorsal cirri all similar, on moderately long cirrophores, about twice as long as neuropodial lobes, with up to 15 articles; ventral cirri  $\frac{1}{3}$ – $\frac{1}{2}$  as long as dorsal cirri, on short cirrophores, with about half their length extending past neuropodial lobes; notoacacula solitary, short, slender on anterior segments, gradually longer, stouter in middle segments, very stout, emergent, and crossing one another middorsally on posterior segments. Spinigers (Fig. 6F, G) solitary, beginning on setiger 3, continuing to middle of body or beyond, or up to about setiger 80, with blades slightly longer and more strongly serrated on middle segments, aligned above aciculum on posterior side. Falcigers 4–7, almost always 5 per parapodium. Falcigers on setigers 1–3 (Fig. 6D, E) moderately stout; blades with rounded tips, without serrations on margins;

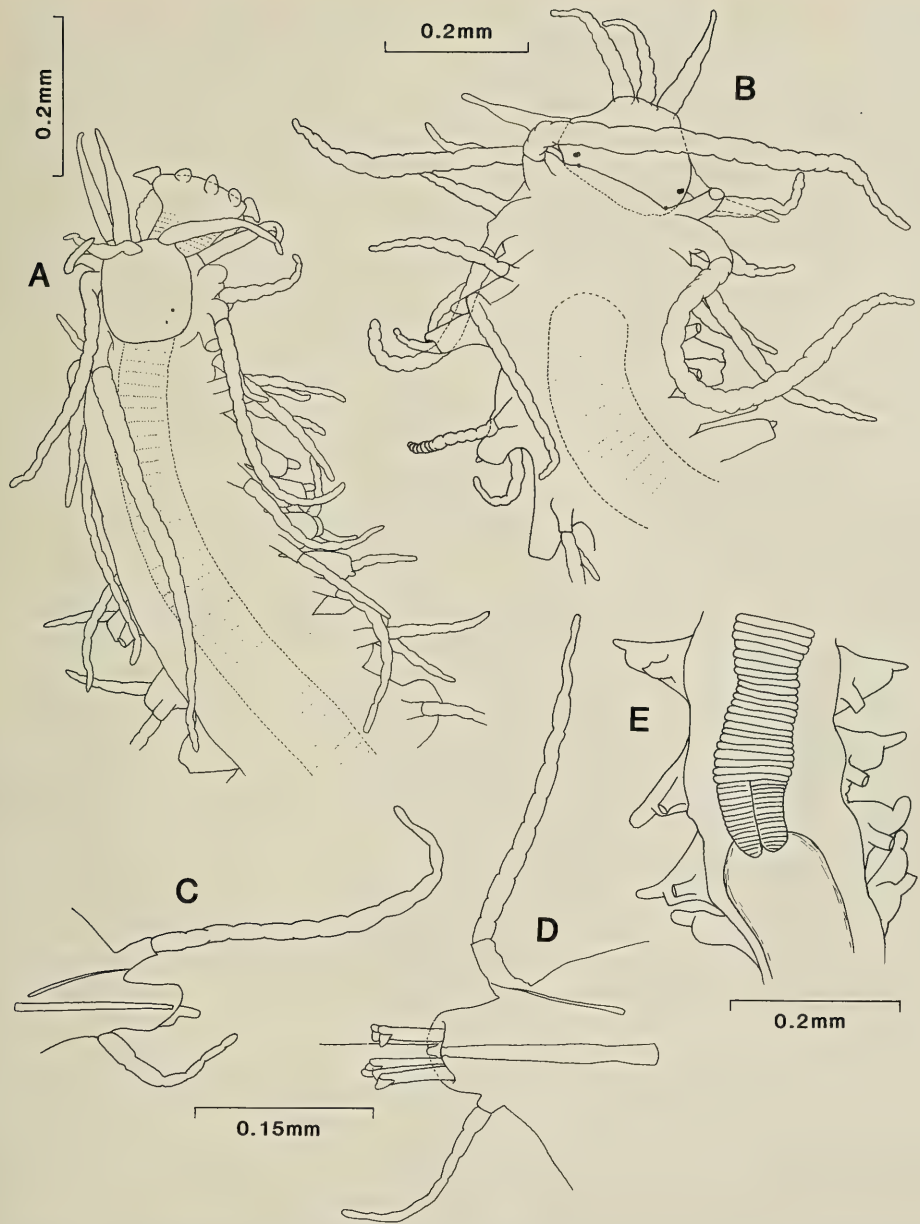


Fig. 5. *Heteropodarke lyonsi*: A, Anterior end, dorsal view, small paratype; B, Same, large paratype; C, Parapodium, setiger 3, posterior view; D, Same from region of enlarged falcigers, anterior view; E, Posterior end of foregut, cirri omitted (A, B, USNM 80529; C, D, AHF Poly 1399; E, holotype).

shafts with bifid tips, with one bifurcation strongly hooked laterally. Very stout golden brown falcigers beginning on setiger 4 (Fig. 6H) and extending for variable number of segments depending on size, maximally to setiger 37 on largest specimen, to setiger 12–37 on all specimens, with rounded or concave-edged, smooth,

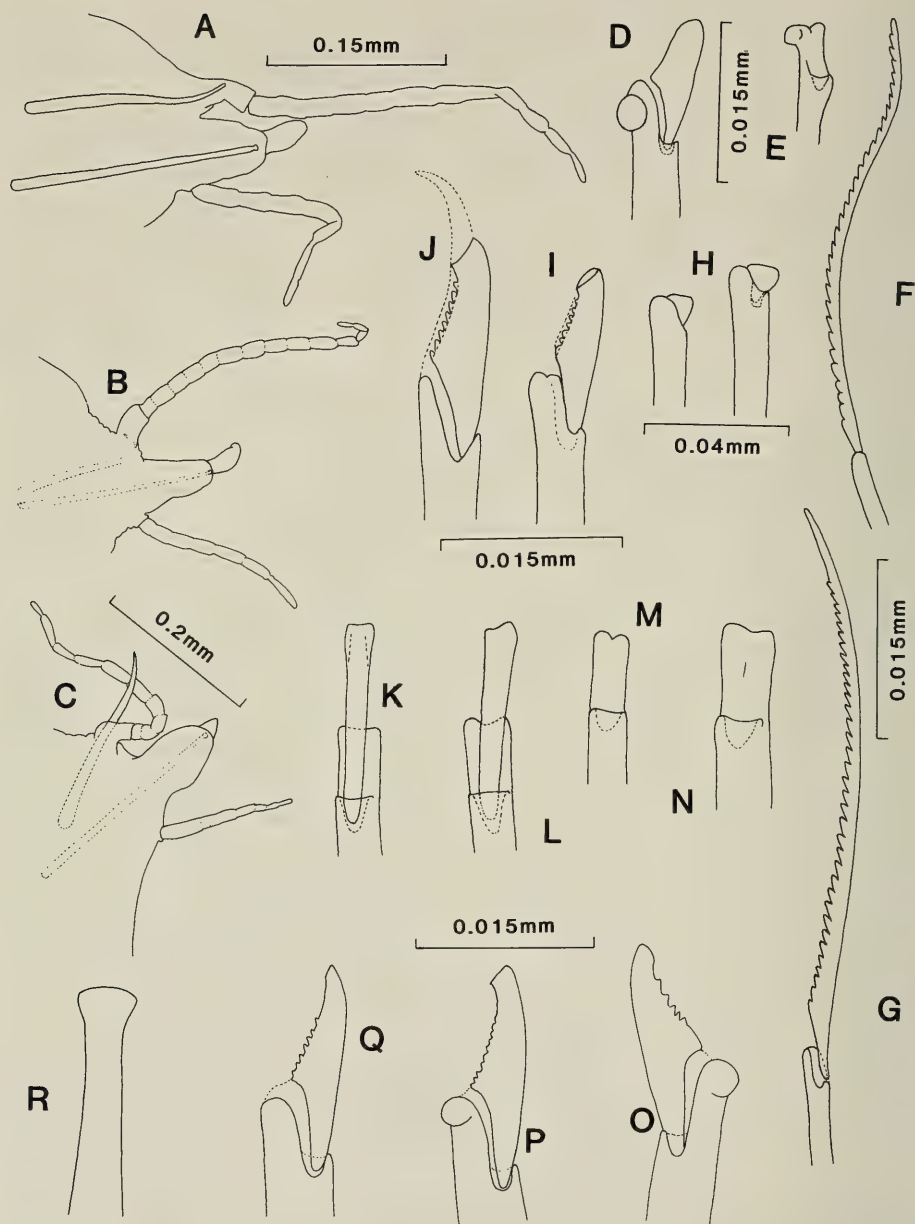


Fig. 6. *Heteropodarke lyonsi*: A, Parapodium, about setiger 50, posterior view; B, Same, setiger 75, posterior view; C, Same, posterior parapodium, posterior view; D, Falciger, setiger 3; E, Shaft of falciger, setiger 3; F, Spiniger, setiger 4; G, Same, middle segment; H, Enlarged falcigers; I, Falciger, setiger 75; J, Subemergent falciger with sickle-shaped hood, setiger 75; K, L, Falcigers, middle segment, face view; M, N, Tips of shafts of falcigers, middle segment, face view; O, Upper falciger, posterior parapodium; P, Subacicular falciger of same; Q, Lower falciger of same; R, Neuroaciculum, setiger 75 (A, AHF Poly 1399; B, C, USNM 80530; D, E, FSBC I 30431; F, G, K-N, FSBC I 30430; H, FSBC I 30433; I, J, O-R, holotype).



triangular blades; blades on setiger 4 twice as large as those on setiger 3, gradually larger to about setiger 10; shafts of very stout falcigers with broadly rounded tips, with diameter greater nearer tips than proximally. Falcigers of middle segments (Fig. 6I–N) with moderately stout blades; blades with hooded tips, with tips straight in lateral view but cupped in face view; tips of shafts slightly bifid, with similar bifurcations; hood of emerging setal blades long, pointed (Fig. 6J). Falcigers of posterior segments (Fig. 6O–Q) with blades more strongly hooked than on middle segments and with smaller, blunt tips or hooded areas, with shafts bifid but with one bifurcation strongly knobbed or hooked as on shafts of anterior-most falcigers. Neuroacicula solitary, very stout on parapodia with very stout falcigers, slightly constricted near tips and knobbed (Fig. 5D); remaining ones more slender with similar tips (Fig. 6R).

Foregut with 10 soft papillae surrounding anterior margin when everted, extending posteriorly to a few segments past segments having very stout falcigers, maximally to about setiger 40, ringed with thick muscle bands (Fig. 5E).

*Remarks.*—*Heteropodarke lyonsi* is similar to *H. heteromorpha* Hartmann-Schröder, 1962, the type-species, and *H. heteromorpha africana* Hartmann-Schröder, 1974, in having a variable number of tentacular cirri, single spinigers on some but not all parapodia, and greatly enlarged falcigers on anterior parapodia. *Heteropodarke lyonsi* and *H. heteromorpha* have up to six pairs, whereas *H. heteromorpha africana* has up to eight pairs of tentacular cirri. *Heteropodarke heteromorpha* and *H. heteromorpha africana* have spinigers distributed approximately in the region of enlarged falcigers (Hartmann-Schröder 1974; Dorsey 1978), whereas such setae on *H. lyonsi* have a much more extensive distribution, from setiger 3 to about the middle of the body. *Heteropodarke lyonsi* differs from both *H. heteromorpha* and *H. heteromorpha africana* in having enlarged, emergent notoacicula on about the posterior  $\frac{1}{3}$ – $\frac{1}{4}$  of the body. *Heteropodarke heteromorpha* is known from Peru, New Caledonia, and California; *H. heteromorpha africana* is known from Natal; and *H. lyonsi* is known from North Carolina, the east coast of Florida, and the northeastern Gulf of Mexico.

*Etymology.*—The species is named in honor of William G. Lyons, Supervisor of Invertebrate Research of the Florida Department of Natural Resources Bureau of Marine Research.

### *Heteropodarke formalis*, new species

Fig. 7

*Material examined.*—FLORIDA EAST COAST: Hutchinson Island Sta II, 27°21.6'N, 80°13.2'W, 11 m, coarse calcareous sand, holotype (USNM 80533), 81 paratypes (USNM 80536, 80537; AHF Poly 1396; BMNH 1983.943–951; FSBC I 30440, 30441; MESC; ZMC; ZMH P-17606, P-17607), 5 specimens (FSBC I 30438, 30439). Same, Sta IV, 27°20.7'N, 80°12.8'W, 11 m, coarse calcareous sand, 35 paratypes, (AHF Poly 1397; BMNH 1983.952–956; FSBC I 30443–30445; USNM 80535; ZMC), 4 specimens (FSBC I 30442). Same, Sta V, 27°22.9'N, 80°13.9'W, 11 m, coarse calcareous sand, 7 paratypes (FSBC I 30448), 10 specimens (FSBC I 30446, 30447). GULF OF MEXICO (U.S. Bureau of Land Management Mississippi, Alabama, Florida Study, 1975–76, box core samples): Off

Florida, Sta 28, 29°55'N, 86°05'W, 38 m, coarse calcareous sand-rubble, 1 paratype (USNM 80538). Same, Sta 29, 29°56'N, 86°06'W, 38 m, coarse sand-rubble, 1 specimen (MESC). Same, Sta 30, 29°51'N, 86°06.5'W, 41 m, coarse sand-rubble, 2 paratypes (MESC; FSBC I 30449), 2 specimens (MESC). Same, off Alabama, Sta 41, 29°45.5'N, 87°36.5'W, 37 m, medium sand, 1 paratype (MESC). NORTH CAROLINA: off Beaufort, 34°34'N, 76°25'W, 19 m, fine sand and shell, J. H. Day, coll., BST 88X, 1 paratype (USNM 80534).

*Description.*—Body without color pattern; maximum length about 9 mm, about 0.3 mm wide excluding parapodia, about 0.8 mm wide including parapodia and setae, about 75 setigers; body almost cylindrical, rounded dorsally, flattened ventrally. Prostomium (Fig. 7A) indistinctly bilobed, slightly wider than long, almost straight anteriorly and posteriorly, rounded laterally, almost as wide as body excluding parapodia. Antennae and palps subulate or tapered, irregularly wrinkled, but not articulated; lateral antennae attached near anterolateral margins of prostomium, about as long as prostomial width; median antenna attached on anterior margin, perhaps half as long and much more slender than lateral antennae. Palps attached on short palpophores ventrolateral to lateral antennae, about on line with lateral margins of prostomium, similar and perhaps slightly longer than lateral antennae. Two pairs of small lensed eyes usually present in trapeziform arrangement open anteriorly, near lateral margins of prostomium slightly posterior to midtransverse line. Tentacular cirri articulated, 6 pairs on 3 laterally visible segments, with first not visible dorsally and second and third indistinctly separated from each other dorsally; upper ones all similar, slightly longer than segmental width excluding parapodia, with about 13 articles, attached on moderately long cirrophores; lower ones about half as long, on short cirrophores. Pair of transverse segmental ciliary bands visible dorsally anterior and posterior to parapodia. Parapodia (Fig. 7B, C) similar throughout body, sesquiramous; each with articulated dorsal and ventral cirri, with slender blunt-tipped neuropodium, with papilliform presetal and rounded postsetal lobes, with heterogomph, compound setae consisting of spinigers and falcigers, with blunt-tipped neuroaciculum, with slender, tapered notoaciculum extending into base of dorsal cirrophore; internal structure of shafts of setae uniform, unmarked. Dorsal cirri about as long as body width excluding parapodia, with 10–15 articles, attached on moderately long cirrophores; ventral cirri  $\frac{1}{2}$ – $\frac{1}{3}$  as long as dorsal cirri, with about 5 articles, attached directly to about middle of lower side of parapodia. Spinigers (Fig. 7E) on all parapodia, usually solitary, rarely 2, aligned above neuroaciculum, with shafts much more slender but similar to those of falcigers. Falcigers (Fig. 7F–I) 6–8 per parapodium, usually 4 above and 2 below neuroaciculum, slightly stouter on setigers 4 to 12 or 14 (Fig. 7F), but similar to others; blades short, unidentate, with short, triangular serrations; shafts with tips almost equally bifurcate. Neuroacacula of setigers 4–14 slightly stouter than others. Pygidium (Fig. 7D) with pair of anal cirri similar to dorsal cirri.

Foregut not divided into anterior and posterior parts by constriction, extending to about setiger 14, ringed with thick muscle bands, with 10 soft papillae surrounding anterior margin when everted.

*Remarks.*—*Heteropodarke formalis* differs from other members of the genus in having a constant six pairs of tentacular cirri, in having falcigers only slightly enlarged on some anterior segments, and in having spinigers on all parapodia.

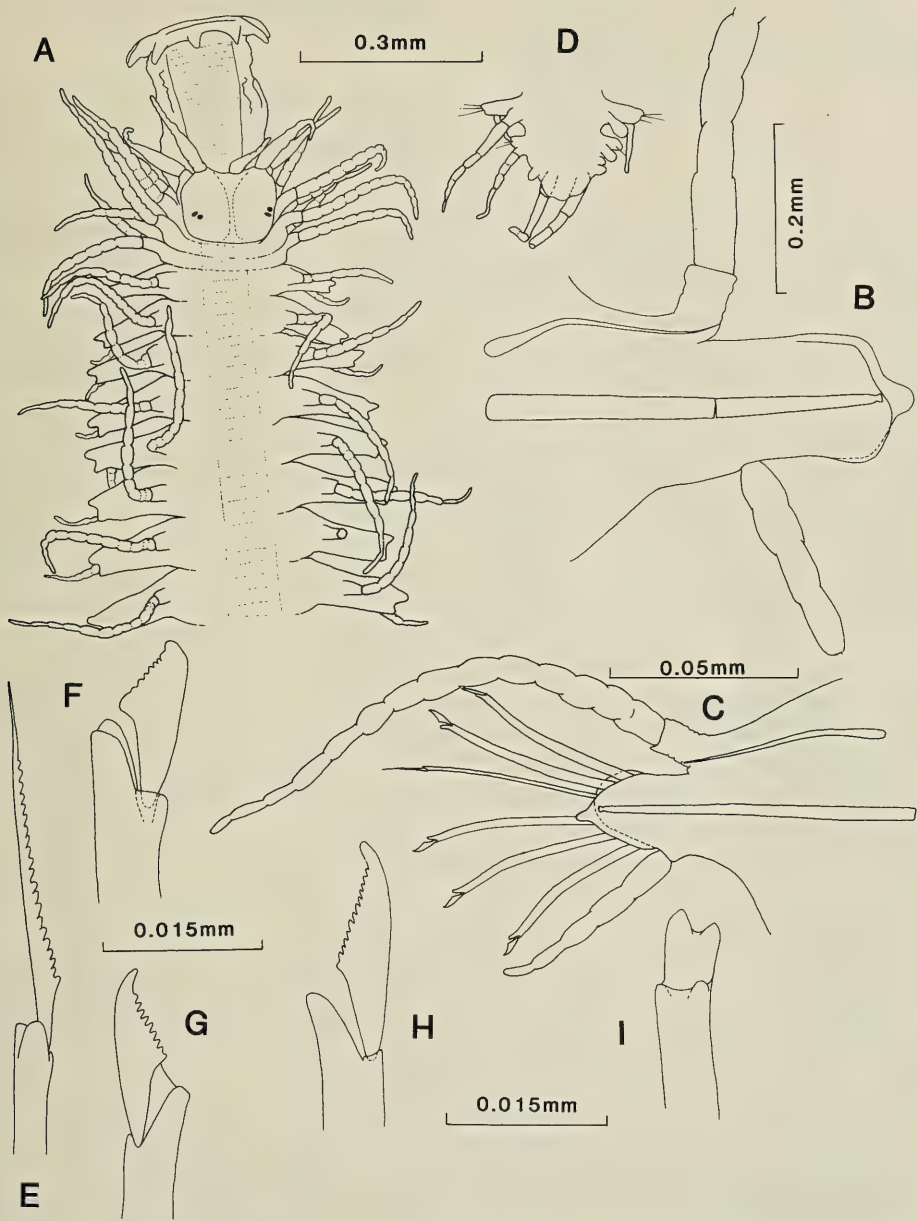


Fig. 7. *Heteropodarke formalis*: A, Anterior end, dorsal view; B, Parapodium, setiger 7, posterior view; C, Same, middle segment, anterior view; D, Posterior end, dorsal view; E, Spiniger, middle segment, blade turned; F, Falciger, setiger 7; G, Same, middle segment; H, Same, posterior segment; I, Tip of shaft of falciger, face view (A, C, D, holotype; E, I, FSBC I 30444; F-H, USNM 80536).



*Etymology.*—The specific name is derived from the Latin and refers to the lack of variation in the number of tentacular cirri.

Genus *Kefersteinia* Quatrefages, 1865

*Kefersteinia haploseta*, new species

Fig. 8

*Material examined.*—FLORIDA: Hutchinson Island Sta II, 27°21.6'N, 80°13.2'W, 11 m, coarse calcareous sand, Applied Biology, Inc., coll., holotype (USNM 80513), paratype (USNM 80514).

*Description.*—Body without color pattern. Complete paratype about 4.5 mm long, 0.22 mm wide excluding parapodia, 0.64 mm wide including parapodia at setiger 5, 30 setigers; holotype incomplete posteriorly, 29 setigers, about as wide as paratype. Body slightly narrower posteriorly for first 9–10 setigers, widest in middle (from reproductive products), tapered posteriorly. Prostomium (Fig. 8A, B) wider than long, slightly convex anteriorly, anterolaterally straight, rounded posterolaterally on paratype, slightly incised posteriorly on holotype. Antennae originating dorsally near anterior margin at about middle of each side, slender, gradually tapered, about as long as prostomial width; palps originating slightly ventrolateral to antennae; palpophores about twice diameter of antennae, less than half as long; palpostyles oval, slightly longer than palpophores; two pairs of large, lensed eyes on posterior half of prostomium near lateral margins, with anterior and lateral pair larger; nuchal organs behind posterolateral margins of prostomium possible. First tentacular segment reduced, visible only laterally and ventrally (Fig. 8A); three indistinctly marked tentacular segments visible dorsally, with first dorsally visible segment half as long as following one (proboscis everted in both specimens). Tentacular cirri 8 pairs; upper ones all similar, longer than body width including parapodia; lower ones less than half as long; all articulated distally like dorsal cirri, with proximal articles 4 times longer than broad and smooth, with distal articles slightly longer and pseudoarticulated; diameter of dorsal ones 1½ times that of dorsal cirri; diameter of ventral ones slightly less than that of dorsal ones. Parapodia (Fig. 8C) sesquiramous, all similar, shorter on anterior few setigers and on posterior end; each with distinctly articulated dorsal cirrus, with smooth ventral cirrus, with notopodial lobe reduced to notoaciculum extending into anterior part of base of dorsal cirrophore, with slender, conical neuropodial lobe, without notosetae, with neurosetae consisting of compound falcigers and slender spines. Dorsal cirri slightly longer than parapodia, on moderately long cirrophores; proximal articles 3–4 times longer than broad, smooth; distal articles longer, indistinctly divided into 4 pseudoarticles. Ventral cirri originating on ventral margins of neuropodia near neurosetae, slender, extending ventrolaterally almost to tips of neuropodia. Neurosetae consisting of long to short-bladed falcigers on first 5 setigers, falcigers and slender spines thereafter (Fig. 8D–G). Falcigers with slender blades; blades shorter above and below, gradually longer near middle, with serrated margins and unidentate, hooded tips; shafts slender, internally cross-barred, with bifid tips. Simple spines solitary, slender, smooth, round-tipped, with embedded part aligned above neuroaciculum on anterior side and separated from fan of falcigers, internally cross-barred; neuroacicula numbering 1–2 in middle parapodia, stouter than notoacicula, pointed, ending

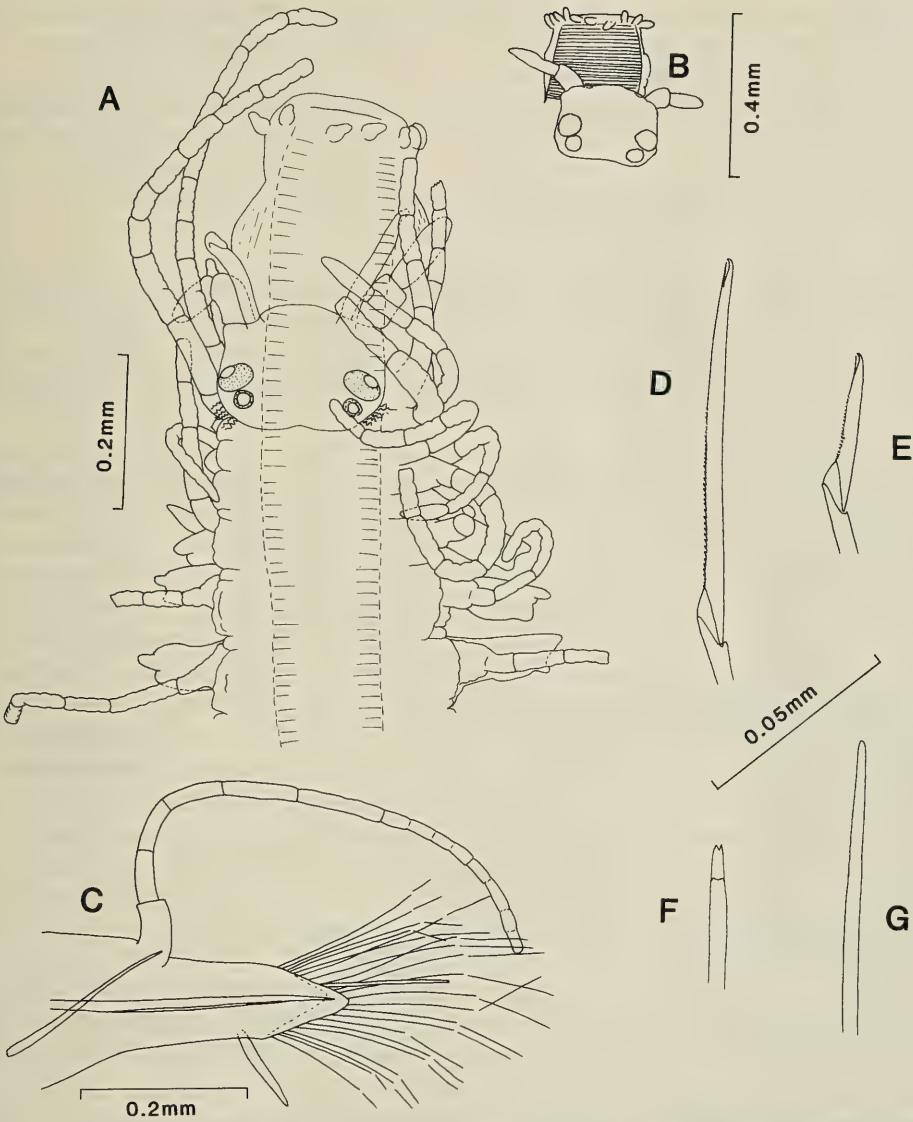


Fig. 8. *Kefersteinia haploseta*: A, Anterior end, dorsal view; B, Prostomium and everted pharynx; C, Parapodium, middle segment, anterior view; D, Compound seta from middle of bundle, middle segment; E, Upper compound seta of same; F, Tip of shaft of compound seta of same; G, Simple seta of same (A, holotype; B–G, paratype).

near tips of presetal lobes, internally cross-barred. Pygidium with pair of long anal cirri similar but slightly stouter than upper tentacular cirri.

Everted proboscis (Fig. 8A, B) with margin surrounded by circle of about 20 papillae on paratype, fewer papillae on holotype; thickly muscled with circular muscle bands, extending to setiger 4 or 5; distal and proximal parts not separated by distinct groove or constriction.

Both specimens sexually mature, but sex undetermined, with reproductive products beginning in setiger 9 or 10 and extending for 10 segments in paratype, to posterior end of incomplete holotype.

*Remarks.*—Hesionid genera diagnosed by Fauchald (1977:73–77) as having two antennae, eight pairs of tentacular cirri, sesquiramous parapodia and an unarmored pharynx are as follows: *Hesione* Savigny, 1818; *Kefersteinia* Quatrefages, 1865; *Dalhousiella* McIntosh, 1901; and *Wesenbergia* Hartman, 1955. *Hesione* has minute, conical antennae and lacks palps. *Wesenbergia* is similar to *Hesione*, but has a pair of minute, simple palps about the same size and shape as antennae (*Hesionella problematica* Wesenberg-Lund, 1950:14, pl. 3, fig. 15a). *Kefersteinia* and *Dalhousiella* have longer, subulate antennae and biarticulate palps. *Dalhousiella*, *Hesione* and *Wesenbergia* all have an eversible pharynx which is distally smooth; only *Kefersteinia* has an eversible pharynx surrounded distally by a circlet of papillae.

The type-species of *Kefersteinia* is *Psamathe cirrata* Keferstein, 1862. Descriptions of this species available to me [*Psamathe cirrata*.—Claparède, 1863:55, 56, pl. 14, figs. 1–7; 1868:537; *Kefersteinia cirrata*.—Fauvel, 1923:238–240, Fig. 89a–e, in part (parts comprised of citations of *Kefersteinia cirrata* of Saint-Joseph, 1888, *Castalia fusca* var. of Southern, 1914, and *Kefersteinia cirrata* of Fauvel, 1913, are probably examples of *Hesiospina* Imajima and Hartman, 1964); Hartmann-Schröder, 1971:131, fig. 42] show that *K. cirrata* has the first three segments reduced dorsally and visible only laterally and ventrally. Thus, setae are first present on the second dorsally visible segment rather than on the fourth such segment as diagnosed by Fauchald (1977:76). In contrast to *K. cirrata*, *Kefersteinia fauveli* Averincev (1972: 146, 147, pl. 20 figs. 1–4; not *K. fauveli* of Hartman, 1978:145–148, fig. 12), and *K. haploseta* have only the first segment dorsally reduced, and *Kefersteinia* sp., described briefly below, has the first two segments dorsally reduced. Although dorsal reduction of anterior segments is usually considered to be an important generic character, the above may represent a continuum of closely related species, and I prefer not to erect another genus without additional evidence.

Further, the distal margin of the pharynx of the type-species is surrounded by a circlet of fimbriae (Fauchald 1977:76), here defined as slender filiform papillae. *Kefersteinia haploseta* and *Kefersteinia* sp. have a circlet of at most about 20 relatively stouter marginal papillae. *Kefersteinia fauveli* has a circlet of 11–12 small marginal papillae and a pair of dorsolateral bunches of 4–5 papillae back from the margin. It is my opinion that differences in number and size of marginal papillae from those of the type-species should not preclude assignment of species to *Kefersteinia*. However, the bunches of papillae back from the margin of the pharynx of *K. fauveli* are apparently unique among Hesionidae, and a re-evaluation of the importance of this character may be required.

Simple neurosetae occurring on most parapodia of *Kefersteinia haploseta* are absent on *K. cirrata*, *K. fauveli*, and *Kefersteinia* sp., below. Similarly, simple neurosetae are present on *Kefersteinia similis* Hessle, 1925, the type-species of *Hesiospina* Imajima and Hartman, 1964, but Fauchald (1977:76) did not consider such setae to be important enough to include in the diagnosis he gave for that genus. Likewise, I do not consider them to be of generic importance in *Kefersteinia*. However, the position and alignment of these simple setae suggest that they may



be homologous with acicula, and a re-evaluation of the importance of this character also may be required.

*Etymology.*—The specific name is formed of a combination of the Greek *haplos*, meaning simple, and the Latin *seta*, meaning bristle, and refers to the simple neurosetae of this species.

*Kefersteinia* sp.

Fig. 9

*Material examined.*—FLORIDA: Hutchinson Island Sta V, 27°22.9'N, 80°13.9'W, 11 m, coarse calcareous sand, 1 specimen (FSBC I 30450). Gulf of Mexico off S.W. Florida, 25°45.7'N, 83°11.1'W, 54 m, coarse calcareous sand, Mote Marine Laboratory personnel, coll., 3 specimens (USNM 80512; MML).

*Diagnosis.*—Complete specimen 6 mm long, 1.1 mm wide, 40 segments. Pro-stomium (Fig. 9A) longer than wide, with 4 eyes; all antennae lost; nuchal organs present. All tentacular cirri lost; first 2 segments reduced dorsally. Parapodia (Fig. 9B) similar to those of *K. cirrata* (Keferstein); dorsal cirri indistinctly articulated proximally, medially with long distinct articles formed of four indistinct pseudoarticles, distally distinctly articulated. Setae all compound falcigers (Fig. 9C–F), all hooded, almost all with bidentate blades, few ventral ones with unidentate blades; shafts with bifid tips.

*Remarks.*—This species differs from *K. cirrata* and *K. haploseta* in having falcigers with bidentate blades and from *K. fauveli* in lacking dorsolateral bunches of papillae back from the margin of the pharynx. It is not named because material is inadequate.

Genus *Podarkeopsis* Laubier, 1961

*Podarkeopsis levifuscina*, new species

Fig. 10

*Gyptis vittata.*—Taylor, 1971:155–159.—Day, 1973:25.—Hall and Saloman, 1975: 11 [list] [not Webster and Benedict, 1887].

*Gyptis brevipalpa.*—Gardiner, 1976:119, 120, figs. 8q–t, 9a [not *Oxydromus brevipalpa* Hartmann-Schröder, 1959].

*Material examined.*—NORTH CAROLINA: Cape Lookout, intertidal, sand mixed with gravel and shell fragments, S. L. Gardiner, coll., 10 Nov 1973, holotype (USNM 52897). Banks Channel, Wrightsville Beach, intertidal, in burrow of *Glycera robusta*, Gardiner, coll., Feb 1972, 1 paratype (USNM 52895). Intra-coastal Waterway, Wrightsville Beach, intertidal, in burrow of *Leptosynapta tenuis*, T. Fox, coll., Mar 1973, 1 paratype (USNM 52896). FLORIDA EAST COAST: Hutchinson Island Sta II, 27°21.6'N, 80°13.2'W, 11 m, coarse calcareous sand, 1 paratype (ZMH P-17601). Same, Sta III, 27°22.0'N, 80°12.4'W, 7 m, medium calcareous sand, 1 paratype (FSBC I 30451). Same, Sta IV, 27°20.7'N, 80°12.8'W, 11 m, coarse calcareous sand, 1 paratype (AHF Poly 1392). Same, Sta V, 27°22.9'N, 80°13.9'W, 11 m, coarse calcareous sand, 9 paratypes (BMNH 1983.957; FSBC I 30452–30454; USNM 55586, 55587; ZMC). GULF OF MEXICO: Florida, U.S. National Marine Fisheries Service Tampa Bay Area Study, 1963–64, C. H. Saloman and J. L. Taylor, coll., exact locality unknown, 9 paratypes (USNM 45531).

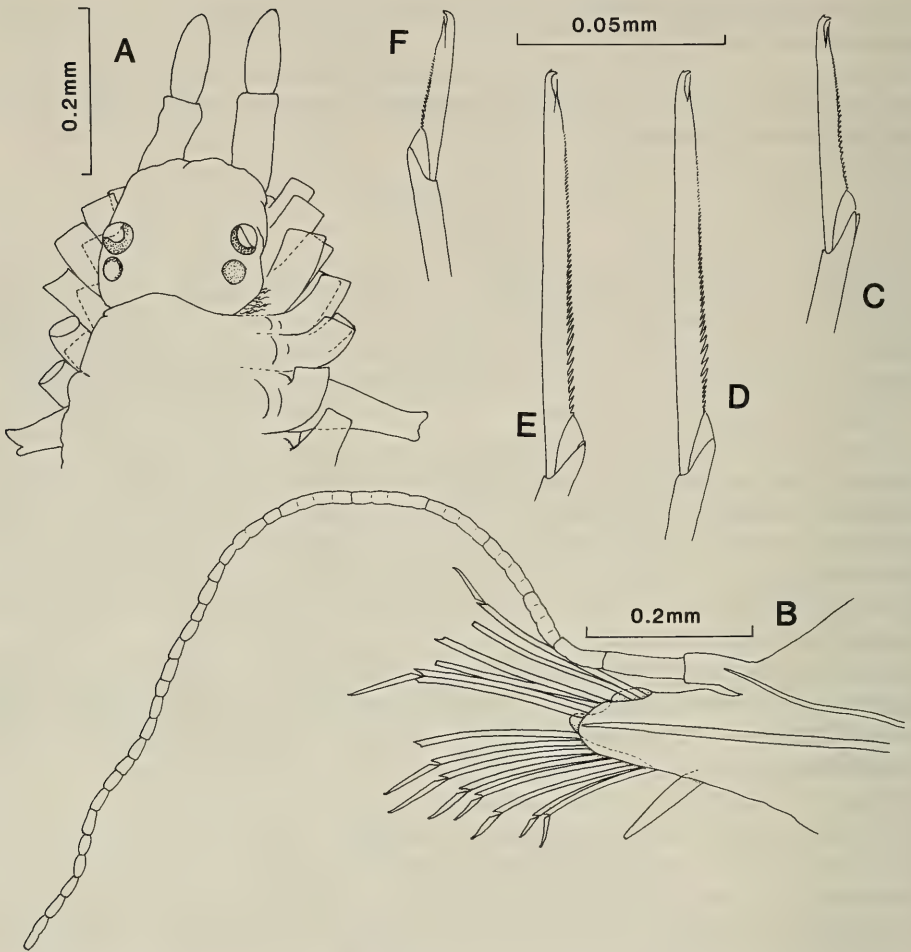


Fig. 9. *Kefersteinia* sp.: A, Anterior end, dorsal view; B, Parapodium, middle segment, posterior view; C, Upper seta, middle segment; D, Lower seta of upper group, middle segment; E, Upper seta of lower group, middle segment; F, Lower seta, middle segment (A, B, USNM; C–E, FSBC I).

Same, Hillsborough Bay, 5 paratypes (AHF Poly 1393; BMNH 1983.958–959). Same, Upper Tampa Bay, 10 paratypes (AHF Poly 1395; FSBC I 12054; ZMH P-17603). Same, Old Tampa Bay, 22 paratypes (AHF Poly 1394; BMNH 1983.960–963; FSBC I 10375; ZMC; ZMH P-17604). Same, Boca Ciega Bay, 1 paratype (ZMC). Anclote Anchorage, Tarpon Springs, Pinellas County, 28°12.6'N, 82°47.6'W, 3.5 m, 4 paratypes (FSBC I 17397).

*Description.*—Usually without color pattern; body of one paratype (USNM 52895) tinged with scattered brown pigment spots dorsally, more prominent laterally above parapodia. Maximum length greater than 18 mm, width 2 mm including parapodia, about 60 segments; body broadest anteriorly, gradually tapered posteriorly, almost cylindrical but flattened ventrally. Prostomium (Fig. 10A, B) slightly wider than long, concave anteriorly, rounded laterally, covered posteriorly by fold of second segment,  $\frac{2}{3}$ – $\frac{3}{4}$  as wide as body excluding parapodia.

Median antenna originating just below anterior margin, short,  $\frac{1}{3}$  as long as lateral antennae, about half as broad, fusiform, broader proximally and gradually tapered or acuminate distally; lateral antennae originating below anterior margin about  $\frac{1}{3}$  distance from middle to lateral margins, about twice as thick as median antenna at base, about half as thick as palps, gradually tapered, about  $\frac{2}{3}$  as long as prostomium and equal in length to palps; antennae perhaps irregularly wrinkled, but not articulated. Palps attached below lateral antennae, each with broad palpophore  $\frac{2}{3}$  of total length and narrow, rounded palpostyle. Two pairs of moderately large, lensed eyes near lateral margins on posterior half of prostomium, in trapezoidal arrangement open anteriorly, anterior ones about twice as large as posterior ones. Ciliated nuchal organs present laterally between prostomium and tentacular segments. First tentacular segment (Fig. 10A, B) reduced dorsally, visible only laterally and ventrally, 3 indistinctly marked tentacular segments visible dorsally; tentacular cirri 8 pairs, distinctly to very indistinctly articulated, with articles shorter than broad; dorsal tentacular cirri longest on segment 2, extending to setiger 8–11, about half as long on segment 1,  $\frac{2}{3}$ – $\frac{3}{4}$  as long on segment 4, those on segment 3 about as long as on segment 1; ventral tentacular cirri on segment 1 about half as long as dorsal ones on same, about same length on segment 2, perhaps slightly longer on segment 4, about  $\frac{2}{3}$  as long as ventral cirri of segment 1 on segment 3; upper tentacular cirrophores long, perhaps  $\frac{2}{3}$  length of anterior parapodia, each housing tips of 2–3 slender acicula on larger specimens, 1–2 on smaller ones. Lower tentacular cirrophores shorter, shortest on segment 3, slightly longer on segments 1, 2 and 4; acicula not observed except in segment 1. Parapodia sesquiramous on setigers 1–4, biramous and similar in all remaining setigers (Fig. 10C), each with dorsal and ventral cirri, with small rounded notopodial lobes anteroventrally on tips of dorsal cirrophores beginning on setiger 5, with conical neuropodial lobes, with triangular presetal and rounded postsetal lobes, with notosetae consisting of simple spines and forked setae (Fig. 10D–H), with neurosetae consisting of compound falcigers (Fig. 10I–K), with slender, pointed notoacacula extending into dorsal cirrophores on setigers 1–4 and into bases of notopodial lobes beginning on setiger 5, and with slender, pointed neuroacacula extending into neuropodial lobes. Dorsal cirri smooth to indistinctly articulated, on moderately long cirrophores; relative lengths of dorsal cirri of anterior setigers, often obscured by regeneration or loss, as follows: cirri of setiger 1 about  $\frac{1}{3}$  as long as upper tentacular cirri of segment 1; cirri of setiger 2 abruptly shorter than those of setiger 1; following cirri gradually longer to setiger 4; cirri of setiger 4 slightly shorter than cirri of setiger 1; cirri of setiger 5 slightly shorter than cirri of setiger 4; following cirri gradually longer to setiger 8; cirri of setiger 8 similar in length to cirri of setiger 4; cirri of setiger 9 slightly shorter than cirri of setiger 8 on some specimens; remaining cirri more or less similar to those of setiger 8, slightly exceeding or exceeding tips of neuropodial lobes by up to almost  $\frac{1}{2}$  their length on middle segments. Ventral cirri smooth, originating at about midlength of neuropodial lobes near posterior side, usually directed ventrally, not exceeding tips of neuropodial lobes on anterior and middle segments, similar in length to those before but exceeding tips of neuropodial lobes on posterior segments. Notopodial spines (Fig. 10G, H) numbering 1–3, extending from upper part of notopodial lobe, moderately stout to slender, stiff, smooth with rounded tips; forked setae (Fig. 10D–F) below spines, numbering 4–8, slender, each with bifid-long



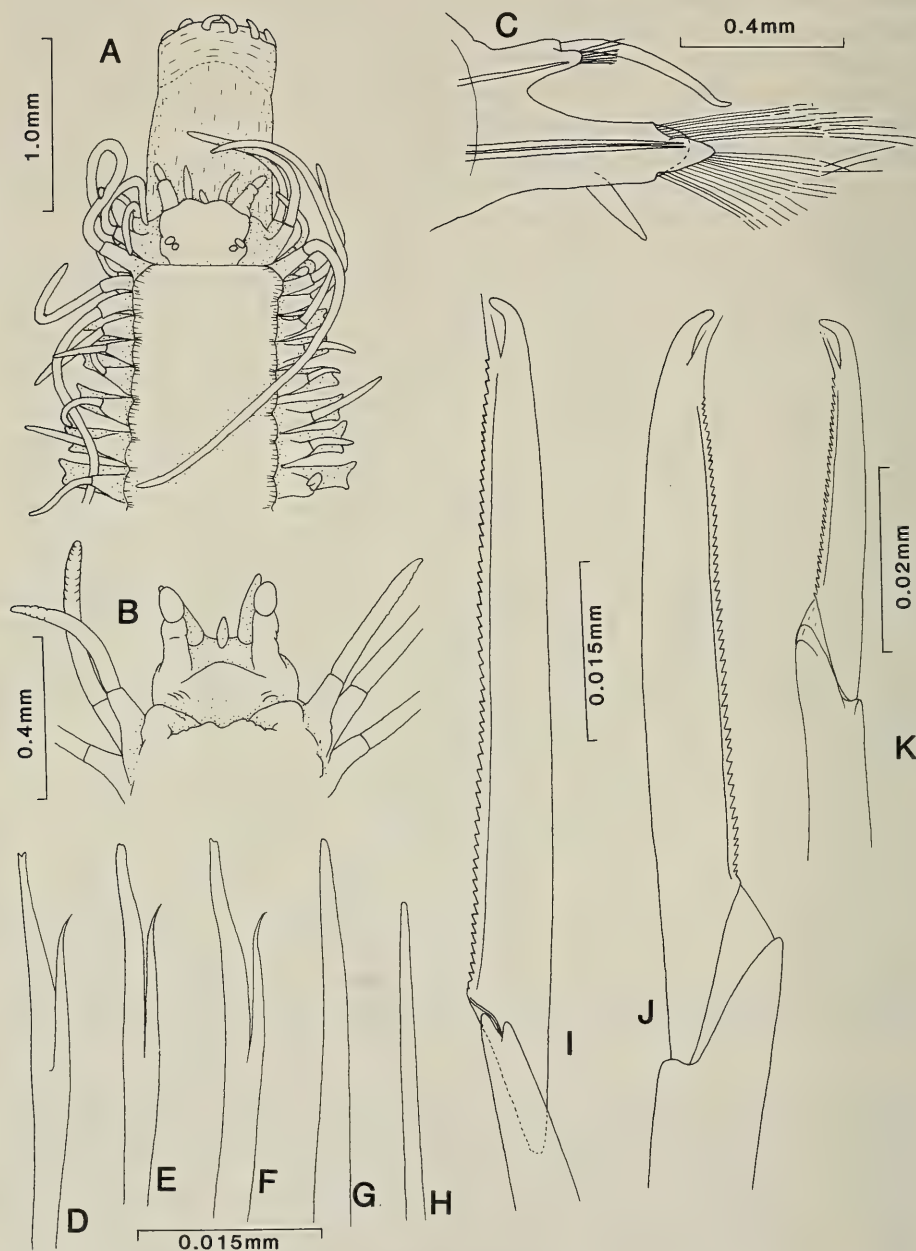


Fig. 10. *Podarkeopsis levifuscina*: A, Anterior end, dorsal view; B, Same, ventral view, proboscis inverted; C, Parapodium, middle segment; D, Notopodial forked seta, middle segment, slightly turned; E, F, Same, in lateral view; G, Stout simple notopodial spine, middle segment; H, Slender spine of same; I, Compound neuroseta, upper group, middle segment; J, K, Same, lower group (A, I, J, USNM 52895; B, holotype; C, F, K, FSBC I 12054; D, E, G, H, BMNH 1983.957).

tine, with pointed short tine, without serrations on shaft proximal to tip of short tine. Neurosetae consisting of numerous compound heterogomph falcigers (Fig. 10I–K), separated into upper and lower groups by acicula; blades moderately short above and below, long in middle, longest in lower part of upper group, with hooded, hooked, unidentate tips and finely serrated borders; shafts long, smooth with notched tips; hoods on few falcigers long, pointed, completely covering and exceeding tips of blades. Notoacicula in parapodia of setigers 1–4 numbering 2–3 on large specimens, 1–2 on small specimens, single thereafter; neuroacicula numbering 2 per parapodium in middle segments.

Foregut moderately long, extending through setigers 1–10 in holotype (inverted), through segments 1–6 in small specimens, to setiger 7 or 8 in large specimens with proboscis completely everted (USNM 52895), ringed with thick muscle bands, divided into anterior and posterior parts when everted by more or less distinct transverse groove or constriction, with anterior border when everted surrounded by 10 moderately long, conical soft papillae.

*Remarks.*—In defining the monotypic genus *Podarkeopsis*, Laubier emphasized the importance of notopodial forked setae as a generic character on the type-species, *P. galangau* Laubier, 1961. Presence of such setae has not been considered an important generic character in the Hesionidae, but, in conjunction with other characters, this character appears to establish the close phylogenetic relationship of a widely distributed group of species and tends to support the correctness of Laubier's arguments regarding its importance.

Previously described species herein referred to *Podarkeopsis* Laubier are *Oxydromus brevipalpa* Hartmann-Schröder (1959:105–197; *Gyptis brevipalpa*.—Banse and Hobson, 1968:12, 13, in part, fig. 3B–E), *Oxydromus arenicolus glabrus* Hartman (1961:68, 69; *Gyptis brevipalpa*.—Banse and Hobson, 1968:12, 13, in part, fig. 3F–H), *Oxydromus capensis* Day (1963:397, fig. 4E–J; *Gyptis capensis*.—Day 1967:231, 232, fig. 11.2. L–O.—Gibbs and Probert, 1973:397, 398, fig. 2A;?in part), and *Gyptis maraunibinae* Gibbs (1971:137, 138, fig. 5).

Banse and Hobson (1968) examined types of *Podarkeopsis glabrus* (Hartman), new combination, and referred the species to *P. brevipalpa* (Hartmann-Schröder). Forked setae of the two species, which were first described by Banse and Hobson for *P. glabrus* and by Hartmann-Schröder in Banse and Hobson (1968) for *P. brevipalpa*, are distinctly different, and in my opinion the two species are not the same. Gibbs and Probert (1973) examined the holotype of *Podarkeopsis capensis* (Day). The forked setae they described resemble those of *P. galangau* Laubier, and thus the two species may be the same. However, Laubier's figure of the anterior end of *P. galangau* (Laubier 1961: fig. 1A) and Day's figure of the anterior end of *P. capensis* (Day 1967: fig. 11.2.N) suggest differences that may involve two species. Day's figure shows the first two segments to be dorsally reduced, whereas Laubier's figure shows only the first tentacular segment to be reduced dorsally. The two figures also suggest differences in relative lengths of tentacular cirri and dorsal cirri between *P. galangau* and *P. capensis*. Therefore, I tentatively continue to consider them separate species. *Podarkeopsis maraunibinae* (Gibbs) apparently differs from *P. brevipalpa* in having enlarged papillae on the anterior end of the proboscis and smooth notopodial spines.

*Podarkeopsis levifuscina* differs from other members of the genus in having

unique notopodial forked setae on which short prongs are smooth and long prongs are bifid. Notopodial spines of *P. levifuscina* are similar to those of *P. capensis*, *P. galangau* and *P. maraunibinae* in being smooth. Arrangement of tentacular and dorsal cirri appears similar to that of *P. capensis*.

*Etymology*.—The specific name is derived from the Latin *levis*, meaning smooth, and *fuscina*, meaning a three-pronged spear or trident, and refers to the forked setae.

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NEW SCYPHOZOAN RECORDS FOR HAWAII:  
*ANOMALORHIZA SHAWI* LIGHT, 1921, AND  
*THYSANOSTOMA LORIFERUM* (Ehrenberg, 1835);  
WITH NOTES ON SEVERAL OTHER RHIZOSTOMES

William J. Cooke

*Abstract.*—Several adult specimens of the scyphomedusa *Anomalorhiza shawi*, unknown since the original collections in the Philippines during the 1920's, have recently been collected in Hawaii. An adult specimen of the wide ranging oceanic species, *Thysanostoma loriferum*, previously collected from the Red Sea to the western Pacific, has also been collected in Hawaii. *Anomalorhiza shawi* is believed to be the latest example of several neritic scyphozoans introduced into Hawaii from the western Pacific. An earlier introduction, a *Mastigias* close to *M. papua*, was misidentified as *Thysanostoma flagellatum* in a recent handbook.

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Recent collections in Hawaii of two rhizostome medusae, *Anomalorhiza shawi* Light, 1921, and *Thysanostoma loriferum* (Ehrenberg, 1835), have increased the number of rhizostome species known from the central Pacific. This note records their collection, suggests the mode of introduction for *A. shawi*, and clarifies some previously published errors in the literature.

*Anomalorhiza shawi* was described by S. F. Light (1921) on the basis of two complete specimens collected from Manila Bay, Philippine Islands. There are only two subsequent mentions of the species: Stiasny (1924) referred it to *Lychnorhiza*; Kramp (1961) maintained it in *Anomalorhiza*. Apparently there are no published collection records other than from the original location.

The oceanic genus *Thysanostoma* was known from Hawaii on the basis of several Nineteenth Century collections of *T. flagellatum* (Haeckel, 1880). A recent *T. loriferum* collection established the presence of two species in the Hawaiian fauna.

The medusa figured in Devaney and Eldredge (1977, figs. 8, 9) as "(?)*Thysanostoma flagellatum*" is actually a *Mastigias* close to *M. papua* (as figured by Hamner 1982).

*Anomalorhiza shawi* Light, 1921

Fig. 1

*Material examined.*—One adult specimen collected 27 Apr 1983 by J. Brock from beach at northeast side of Coconut (Moku O Loe) Island, Kaneohe Bay, Oahu (21°26'18.5"N, 157°47'23"W). Accession 830004HA/1 Processing Center, Naval Ocean Systems Center-Hawaii Laboratory (NOSC).

Two adult specimens collected 6 Jan 1984 by D. Krupp from lagoon on southwest side of Coconut Island (21°26'10"N, 157°47'34"W). Accession 830004HA/2 Processing Center, NOSC.

*Description.*—The specimens range from 50 cm to 87 cm in diameter. The



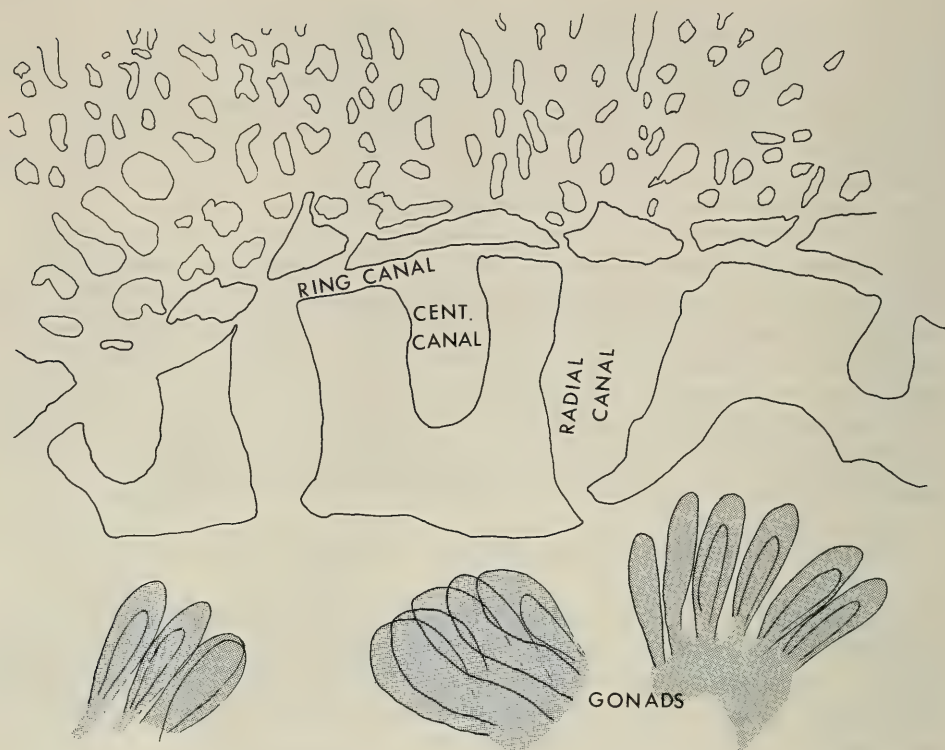


Fig. 1. *Anomalorhiza shawi* canal system (traced from a color transparency) showing canal system in subumbrellar view and the gonads. Cent. Canal, centripetal canal between the radial canals. Rhopalial radial canal is indistinguishable within the anastomosing marginal canal; inter-rhopalial radial canal constricted at its inner end.

exumbrella of the clear, fragile bell is marked by numerous low, warty bumps, each ringed with a light chocolate brown set against a general light purple ground color. The mouth arms are a deep purple while the gonads are a lighter pink-purple. No zooxanthellae were seen in examination of the bell and mouth arms. The single blind centripetal canal between each radial canal is especially obvious and clearly separates this species from all other daktyliophorans. The very complete original description is amended and extended only slightly as follows.

Light's (1921, fig. 2) rhopalial radial canals were distinguishable beyond the ring canal, but in one specimen some are indistinguishable from the general anastomosing marginal canal (Fig. 1). The present specimens have several thick brownish filaments on the subumbrellar surface between the mouth arms where Light (1921) mentions, "small, very slender threadlike filaments." The mouth arms of the present specimen are unbranched for about  $\frac{2}{3}$  ( $66\% \pm 2\%$ ,  $n = 9$ ; 95% limits) of their total length (excluding terminal filament), while Light's smaller and larger specimens were unbranched for 71% and 82% respectively. (Most terminal filaments on the present specimens had lost their club-shaped distal part.)

The cnidome of the species is unexceptional with ovoid "a" atrichs, 4–6  $\mu\text{m}$  by 3–4  $\mu\text{m}$ ; small heterotrichous microbasic euryteles, 7–9  $\mu\text{m}$  by 6–7  $\mu\text{m}$ ; and almost spherical holotrichous isorhizas 10–11  $\mu\text{m}$  by 9–10  $\mu\text{m}$  (live, undischarged measurements). No large "A" atrichs (Weill 1934), polyspira atrichs (Spangenberg 1964), or " $\alpha$ " atrichs (Calder 1971) were seen. The stinging potential of this species seems low as several test subjects (including the author) experienced no pain or redness when live mouth-arm fragments were rubbed on the skin of the inner wrist.

*Thysanostoma loriferum* (Ehrenberg, 1835)

Fig. 2

*Rhizostoma lorifera* Ehrenberg, 1835:260.

*Himanostoma lorifera*.—Haeckel, 1880:628, (additional bibliography see Kramp, 1961).

*Lorifera arabica* Haeckel, 1880:628.

*Lorifera lorifera*.—Mayer, 1910:694 (additional bibliography see Kramp, 1961).

*Thysanostoma lorifera*.—Stiasny, 1940:24.

*Thysanostoma loriferum*.—Kramp, 1961:364.

*Material examined*.—One adult specimen collected 5 Nov 1982 by M. Morioka, Waikiki Aquarium from Kuuloa Beach Park (21°30'43"N, 157°50'16"W) Oahu, Hawaii. Accession 830010HA, Processing Center, NOSC.

*Description*.—The specimen (Fig. 2) is 18 cm in diameter with a quite stiff, low-hemispherical bell of uniform pink-purple color. The ex-umbrellar surface is smooth. The broadly rounded marginal lappets are united by a thin common membrane. Each lappet pair is a darker purple than the purple of the exumbrella of the bell, from which it is delineated by a clear translucent circumferential band. The rhopalia and rhopaliar lappets are transparent and colorless.

The circumferential bell muscles are well developed, clearly visible in sub-umbrellar view. The canal system is very finely meshed, with radial and perradial rhopaliar canals clearly distinguishable.

The subumbrellar surface is smooth and translucent white. The subgenital ostia are approximately twice as broad as the mouth-arm pillars which are also translucent white. The barely developed gonads in the present specimen are light pink.

Distal parts of mouth arms were lost in present specimen. Their central stem is dark purple with fringes very dark (almost black) purple in life, fading to white in preserved material.

This species has a cnidome of ovoid "a" atrichs 4–5  $\mu\text{m}$  by 3–4  $\mu\text{m}$ , small heterotrichous microbasic euryteles, 6–8  $\mu\text{m}$  by 5–6  $\mu\text{m}$  and almost spherical holotrichous isorhizas, 8–10  $\mu\text{m}$  by 8–9  $\mu\text{m}$  (formalin preserved, undischarged measurements).

*Thysanostoma loriferum* is differentiated from *T. flagellatum* (Haeckel, 1880) by having marginal lappets united into a membrane, and a short terminal filament on each mouth arm. The original description of *T. flagellatum* by Haeckel (1880) was quite short and had no figure. Stiasny (1940) provided clear diagnoses of both based on comparative material as well as detailing their color differences. Figure 2 clearly shows the lash-like weakly frilled nature of the mouth arms which



Fig. 2. *Thysanostoma loriferum* showing the bell margin and the proximal portions of the mouth-arms. Note the characteristic sparse fringing along the edges of the mouth-arms. (Original photo a color transparency courtesy Mr. L. Matsuura, Waikiki Aquarium.)

distinguishes the Thysanostomatidae from all other rhizostomes. The endings *-ferum* and *-latum* agree (after Kramp 1961) in neuter gender with the generic name.

#### Discussion

Including the present species, there are now eight species of rhizostome medusae recorded from Hawaiian waters (Devaney and Eldredge 1977). Of these, *Cephe cephea* (Forskål, 1775), *T. flagellatum* (Haeckel, 1880) and *T. loriferum* (Ehrenberg, 1835) are oceanic species capable of reaching Hawaii as adult medusae.

*Thysanostoma flagellatum* has been collected on only two occasions from Hawaii (Haeckel 1880), but rather often (Kramp 1961) from the western Pacific (Philippines, Malaysian Archipelago). *Thysanostoma loriferum* had previously been recorded from the Red Sea to the western Pacific so its presence in Hawaii is not unexpected. It is probable that these oceanic species occur infrequently in Hawaii under favorable conditions but are more commonly seen in the island groups to the west and south.

A different situation exists with the remaining rhizostome species whose morphology and habits suggest ecological restriction to plankton-rich, quiet neritic waters with little likelihood of transoceanic migration by adult medusae. Clearly,



the two *Cassiopea* species, *C. medusa* Light, 1914 and *C. mertensii* Brandt, 1835, with their pseudobenthic habits are the most improbable adult immigrants. Scyphistomal introduction from the Philippines has been suggested (Cutress in Doty 1961) for *C. medusa* and the species identified as *Phyllorhiza punctata* von Lendenfeld, 1884, in Devaney and Eldredge (1977, fig. 7). This medusa has also been identified as *Cotylorhizoides pacificus* by Cutress (in Doty 1961), as *Phyllorhiza pacifica* by Cutress (in Mansueti 1963), as *Mastigias ocellatus* by Walsh (1967), and *M. papua* by Reed (1971; fig. 14). It is quite clearly a mastigid, as is the species identified as "(?) *Thysanostoma flagellatum* (Haeckel, 1880)" in Devaney and Eldredge (1977, figs. 8, 9). Quite similar mastigids are well figured in Faulkner (1970 p. 20) and Hamner (1982:264, 276, 277). Reexamination of the numerous species in the Mastigiidae on a world-wide basis is clearly imperative, thus any attempt at more precise identifications of these two forms would be unwise. Clearly these mastigids (as well as *C. mertensii*) are also likely candidates for scyphistomal introduction as all are rather fragile-bodied species commonly found in lagoons and shallows.

All of these species are now much less abundant than they were several years ago, but they are still believed to be present in the fauna.

*Anomalorhiza shawi*, with its large distinctive medusa is also a recent introduction. Personal observations and discussions with long-time fishermen and others with several decades of experience in Kaneohe Bay confirmed that this medusa was not seen before 1983. The medusa is quite fragile, tearing and breaking under even gentle tension, and would be unable physically to withstand the forces of the open ocean. This fact and the collections and numerous other observations all in the sheltered waters of Kaneohe Bay reinforce the conclusion of a neritic or estuarine habitat for the species. In this case, introduction by scyphistome in fouling communities transported from the Philippines to Hawaii is the most probable route of introduction. The presence of these adult specimens suggests the potential for permanent establishment should they be able to breed successfully.

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*OSTRINCOLA AND PSEUDOMYICOLA*  
(CRUSTACEA: COPEPODA: POECILOSTOMATOIDA)  
ASSOCIATED WITH MARINE BIVALVE  
MOLLUSKS ON THE PACIFIC COAST OF PANAMA

Arthur G. Humes

*Abstract.*—Two myicolid copepods occur in the mantle cavity of Bivalvia on the Pacific coast of Panama. *Ostrincola falcatus*, new species, is described from *Protothaca asperrima*, *Mytella guyanensis*, and *Anadara obesa*. The species is distinguished by the falciform seta on the third segment of the maxilliped of the male. A key to the species of *Ostrincola* is given. The widespread *Pseudomyicola spinosus* is recorded from a new host, *Anadara obesa*.

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The genus *Ostrincola* Wilson, 1944, contains several species, all of which live in the mantle cavity of bivalve mollusks in intertidal or shallow-water areas of tropical and subtemperate regions. More than 20 species of bivalves serve as hosts.

*Pseudomyicola spinosus* (Raffaele and Monticelli, 1885) is known from the Mediterranean, the North and South Atlantic, and the Indo-Pacific, where it is associated with numerous bivalve hosts (Humes 1968).

The copepods reported here were found in bivalves purchased in the market in Balboa. The localities on the Pacific side of Panama from which the bivalves came are known, however, and are indicated below.

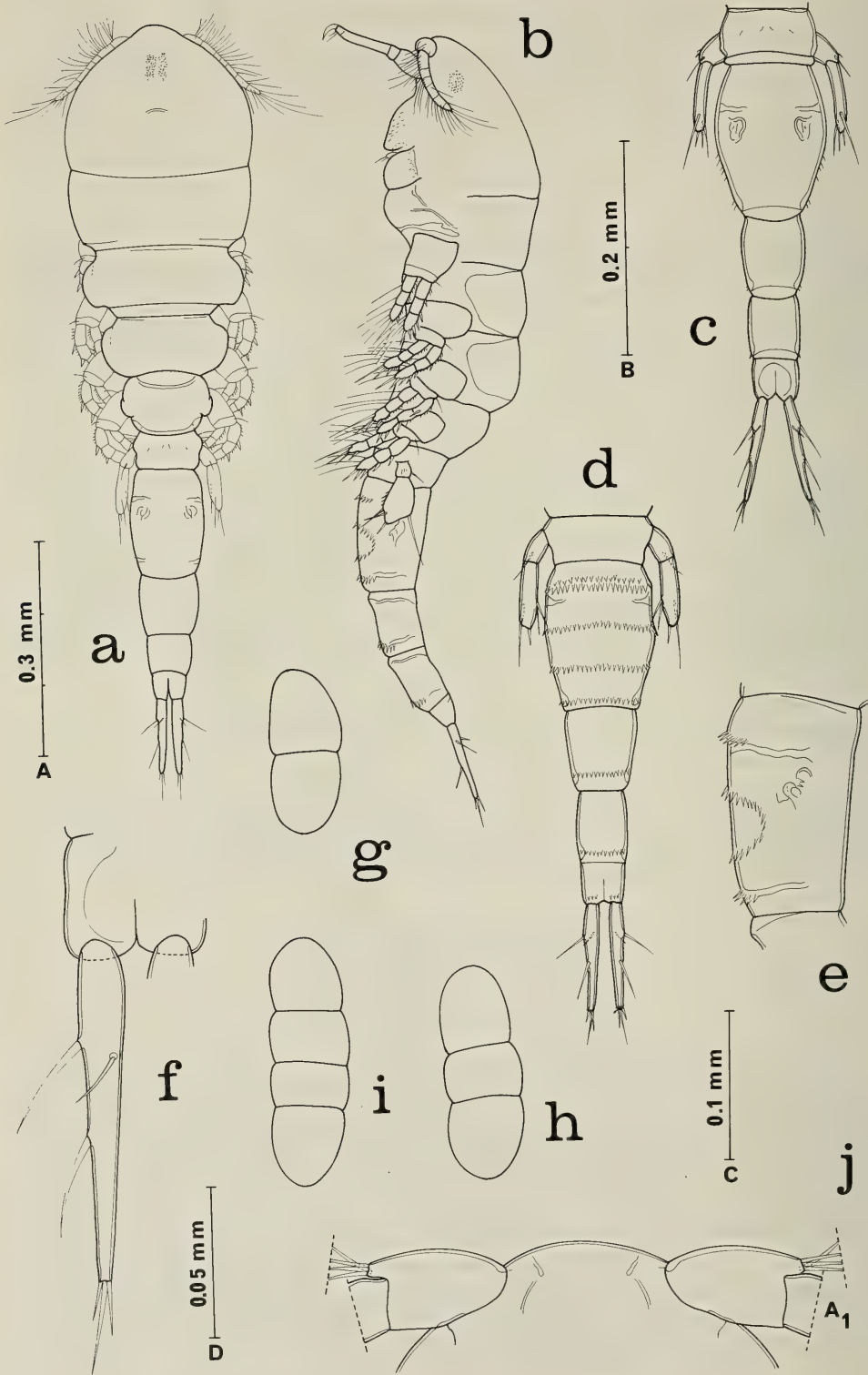
The copepods were studied in lactic acid and the figures were drawn with the aid of a camera lucida. The letter after the explanation of each figure refers to the scale at which it was drawn. The abbreviations used are: A<sub>1</sub> = first antenna, A<sub>2</sub> = second antenna, L = labrum, MX<sub>2</sub> = second maxilla, and P<sub>1</sub> = leg 1.

Myicolidae Yamaguti, 1936  
*Ostrincola* C.B. Wilson, 1944  
*Ostrincola falcatus*, new species  
Figs. 1a-j, 2a-h, 3a-e, 4a-h

*Type-material.*—193 ♀♀ (including 75 ovigerous), 146 ♂♂, from 127 *Protothaca asperrima* (Sowerby), Chiman, Darien, Panama (Pacific side), approximately 100 km east of canal entrance, 5 Nov 1981. Holotype ♀, allotype, and 331 paratypes (188 ♀♀, 143 ♂♂) deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C.; the remaining paratypes (dissected) in the collection of the author.

*Other specimens.*—40 ♀♀, 59 ♂♂, from 155 *Protothaca asperrima*, type locality, 26 Oct 1981; 22 ♀♀, 30 ♂♂, from 60 *Mytella guyanensis* (Lamarck), Vera Cruz, approximately 10 km west of Panama City, Panama, 26 Oct 1981; 22 ♀♀, 15 ♂♂, from 60 *Mytella guyanensis*, same locality, 5 Nov 1981; 2 ♀♀, from *Anadara obesa* (Sowerby), Vera Cruz, Panama, 5 Nov 1981.





*Female*.—Body (Fig. 1a, b) elongate, widest in cephalosome. Length (not including setae on caudal rami) 0.99 mm (0.91–1.11 mm) and greatest width 0.26 mm (0.24–0.29 mm), based on 10 specimens from *Protothaca* in lactic acid. Ratio of length to width of prosome 2.2:1. Ratio of length of prosome to that of urosome 1.21:1. Segment of leg 1 weakly separated dorsally from cephalosome. Epimera of segments bearing second and third legs broadly rounded and projecting slightly in dorsal view. Small median sclerotized bar dorsally on head behind eye. Segment of leg 5 (Fig. 1c)  $44 \times 86 \mu\text{m}$ . Genital segment elongate,  $140 \times 96 \mu\text{m}$ , with slightly expanded lateral margins. Genital areas located dorsally just anterior to middle of segment and bearing 2 minute setae about  $3 \mu\text{m}$  long (Fig. 1c, e). Dorsal surface of genital segment smooth, but ventral surface ornamented with anterior and posterior transverse rows of spines joining laterally (Fig. 1d, e), thus forming circlet. Three postgenital segments from anterior to posterior  $68 \times 65$ ,  $65 \times 52$ , and  $38 \times 42 \mu\text{m}$ , each segment ventrally with posterior transverse row of spines.

Caudal ramus (Fig. 1f) elongate,  $94 \mu\text{m}$  long,  $14 \mu\text{m}$  wide proximally,  $10 \mu\text{m}$  wide medially, and  $4.5 \mu\text{m}$  wide distally. Ratio of length to greatest width 6.7:1. Armature consisting of proximal outer seta  $34 \mu\text{m}$ , distal outer seta  $33 \mu\text{m}$ , dorsal seta  $14 \mu\text{m}$ , and 3 terminal setae from outer to inner 11, 33, and  $14 \mu\text{m}$ . All setae smooth.

Body surface unornamented except for 4 minute hairs (setules ?) on dorsal surface of segment bearing fifth legs.

Egg sac (in females from *Protothaca*) with seriate eggs, 2 eggs in sac measuring  $218 \times 96 \mu\text{m}$  (Fig. 1g), 3 eggs in sac  $286 \times 110 \mu\text{m}$  (Fig. 1h), and 4 eggs in sac  $330 \times 110 \mu\text{m}$  (Fig. 1i). Most females with 3 eggs in each sac.

Rostrum (Fig. 1j) broad and not well defined.

First antenna (Fig. 2a)  $151 \mu\text{m}$  long, 7-segmented. Lengths of segments (measured along posterior margin): 16.5 ( $45 \mu\text{m}$  along anterior margin), 22, 11, 14, 26, 17, and  $20 \mu\text{m}$ , respectively. Formula for armature: 4, 14, 5, 3, 4 + 1 aesthete, 2 + 1 aesthete, and 7 + 1 aesthete. All setae smooth.

Second antenna (Fig. 2b)  $160 \mu\text{m}$  long, 3-segmented. First segment with diagonal row of spinules. Small second segment with minute seta. Elongate third segment slightly recurved,  $96 \times 16 \mu\text{m}$ , ratio 6:1, bearing 1 minute seta near middle of concave edge, 3 small subterminal setae, and terminal claw  $37 \mu\text{m}$ . Segment ornamented along proximal half of convex side with small spinules.

Labrum (Fig. 2c) with 2 hyaline posteroventral lobes and bearing prominent spines on outer lateral angles. Mandible (Fig. 2d) with 4 elements. Convex side having small process followed by unilaterally haired seta. Another longer unilaterally haired seta nearby on dorsal surface. Distally mandible extended as long setiform element haired along one side and having bilaterally haired seta near its base. Paragnath not seen. First maxilla (Fig. 2e) with 4 setae. Second maxilla (Fig. 2f) 2-segmented. First segment large, ornamented with 3 groups of spinules. Second segment small, with minute proximal seta, smooth subterminal seta, and 2 unequal unilaterally haired terminal setae.

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Fig. 1. *Ostrincola falcatus*, new species, female. a, Dorsal (scale A); b, Lateral (A); c, Urosome, dorsal (B); d, Urosome, ventral (B); e, Genital segment, lateral (C); f, Caudal ramus, dorsal (D); g, Egg sac, dorsal (A); h, Egg sac, dorsal (A); i, Egg sac, dorsal (A); j, Rostral area, ventral (D).

Maxillipeds absent. Arrangement of appendages of cephalosome as in Fig. 2g. Legs 1–4 (Figs. 2h, 3b, c, d) with 3-segmented rami. Armature as follows (Roman numerals indicating spines, Arabic numerals representing setae):

P <sub>1</sub>	coxa	0–I	basis	1–I	exp enp	I–0; 0–1;	I–1; 0–1;	IV, 4 I, 5
P <sub>2</sub>	coxa	0–I	basis	1–0	exp enp	I–0; 0–1;	I–1; 0–2;	IV, 5 III, 3
P <sub>3</sub>	coxa	0–I	basis	1–0	exp enp	I–0; 0–1;	I–1; 0–2;	III, 5 IV, 2
P <sub>4</sub>	coxa	0–I	basis	1–0	exp enp	I–0; 0–1;	I–1; 0–2;	III, 5 IV, 1

Coxa in all 4 legs with finely barbed inner spine. Basis in leg 1 with stout barbed spine and adjacent outer row of spinules, but in legs 2–4 this area without spine or spinules. Contour of margin of basis medial to endopod slightly indented in legs 3 and 4. Outer margins of segments of both rami bearing rows of spines, spines on endopods more prominent than those on exopods. Row of hairs in addition to spines on segments of endopods. In one female third segment of right exopod of leg 1 with IV, 3 (Fig. 3a), but left exopod with usual IV, 4.

Leg 5 (Fig. 3e) 2-segmented. First segment 28 × 23 μm, bearing 1 dorsal seta and ornamented with 3 small spines. Second segment broad, 65 × 39 μm, ratio 1.67:1, bearing 2 smooth setae and 2 finely barbed spines, lengths of these elements from dorsal to ventral 54, 20, 22, and 43 μm. This segment ornamented only with few small spinules distally on ventral edge.

Leg 6 represented by 2 minute setae on genital area (Fig. 1e).

Color in living specimens in transmitted light opaque gray, eye dark blue, egg sacs dark gray.

*Male*.—Body (Fig. 4a, b) resembling that of female. Length (excluding setae on caudal rami) 0.86 mm (0.83–0.89 mm) and greatest width 0.21 mm (0.19–0.22 mm), based on 10 specimens from *Protothaca* in lactic acid. Ratio of length to width of prosome 2.2:1. Ratio of length of prosome to that of urosome 1.08:1.

Segment of leg 5 21 × 75 μm (Fig. 4c). Genital segment 120 × 96 μm, smooth dorsally but ventrally with band of spines in anterior half and row of spines on

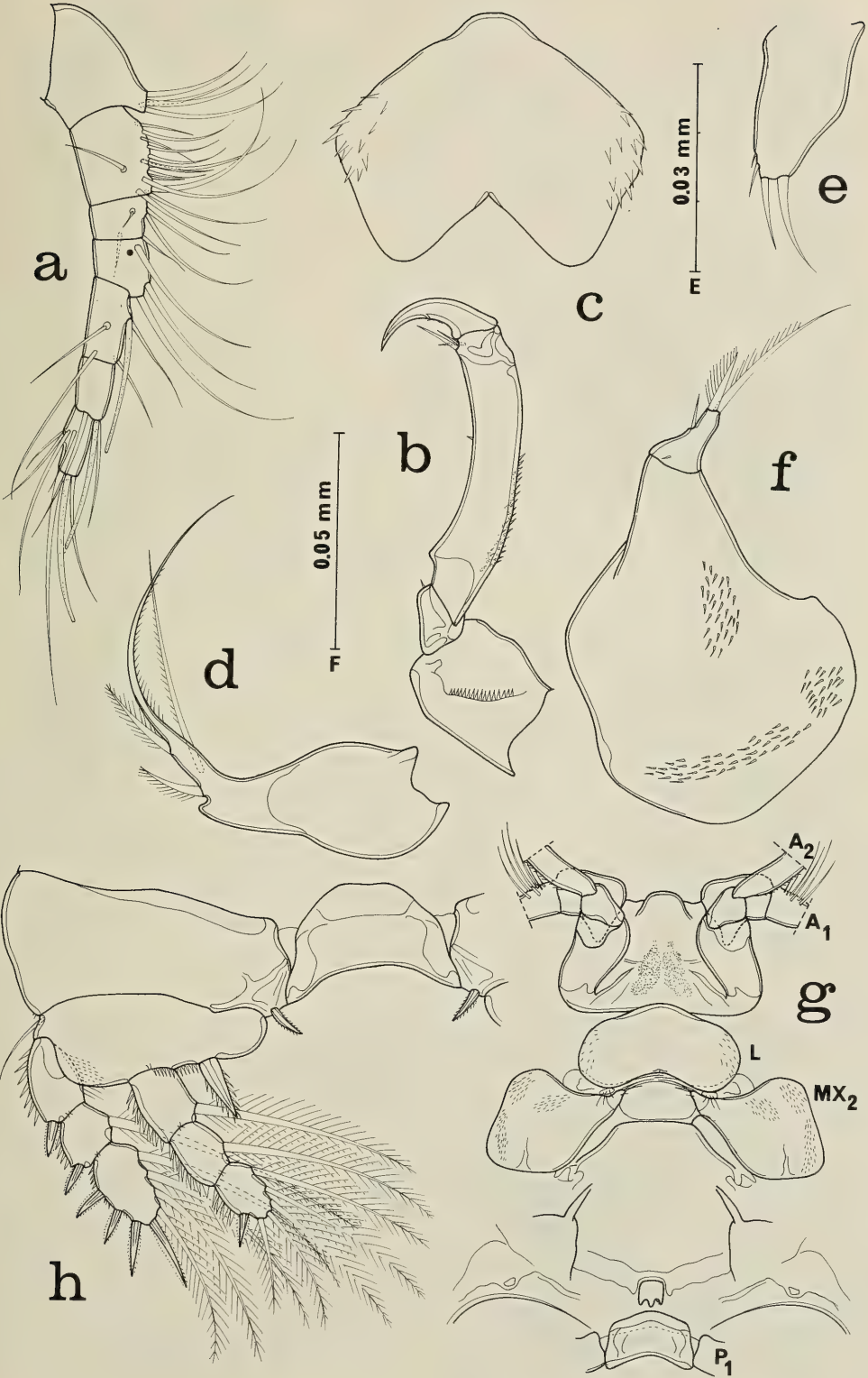
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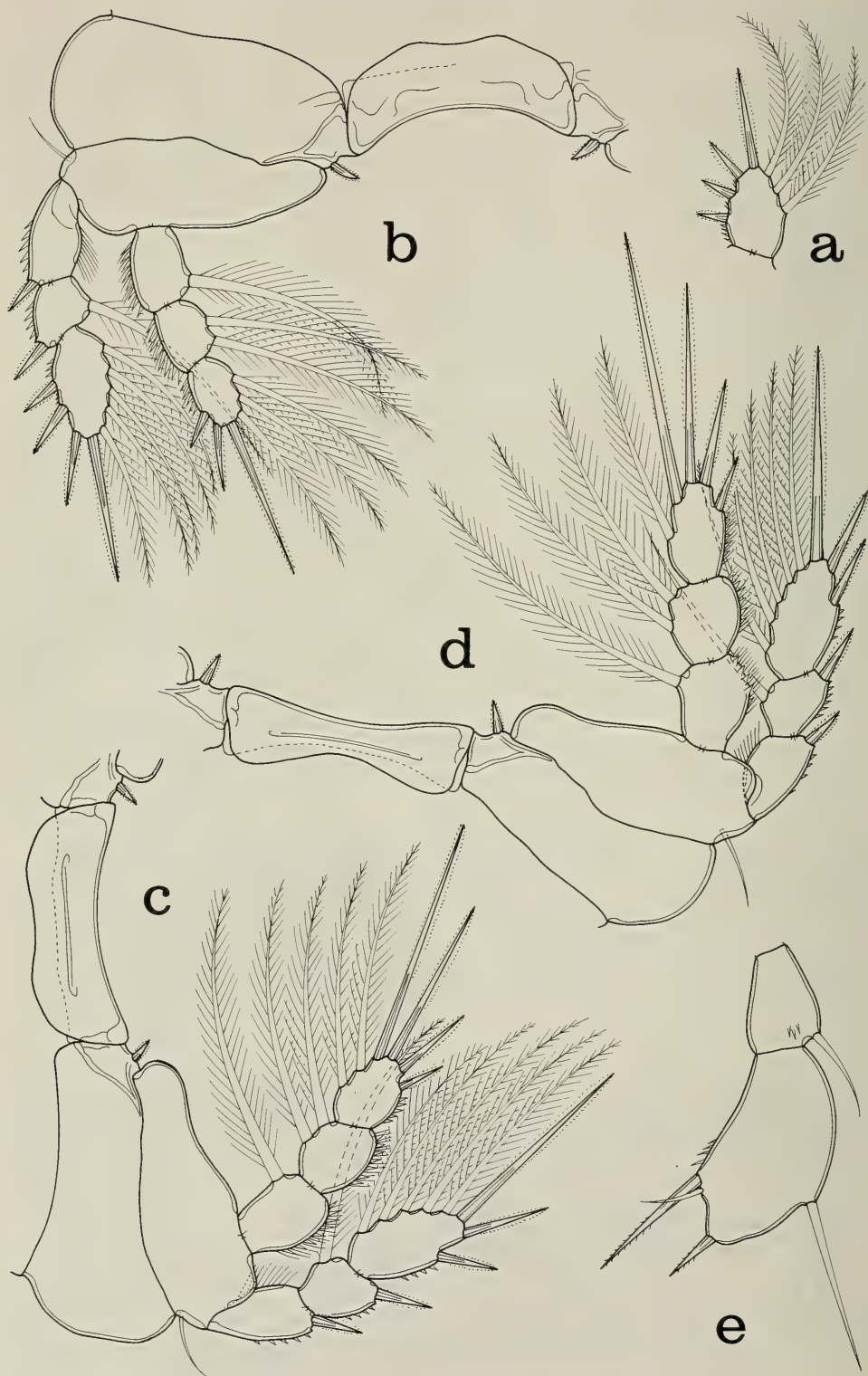
Fig. 2. *Ostrincola falcatus*, new species, female. a, First antenna, ventral (scale D); b, Second antenna, antero-outer (D); c, Labrum, ventral (D); d, Mandible, ventral (E); e, First maxilla, ventral (E); f, Second maxilla, ventral (F); g, Midregion of cephalosome showing arrangement of appendages, ventral (C); h, Leg 1 and intercoxal plate, anterior (D).

Fig. 3. *Ostrincola falcatus*, new species, female. A, Abnormal third segment of left exopod of leg 1, anterior (scale D); b, Leg 2 and intercoxal plate, anterior (D); c, Leg 3 and intercoxal plate, anterior (D); d, Leg 4 and intercoxal plate, anterior (D); e, Leg 5, lateral (D).

Fig. 4. *Ostrincola falcatus*, new species, male. a, Dorsal (scale A); b, Lateral (A); c, Urosome, ventral (C); d, Genital segment, lateral (A); e, Maxilliped, anterior (F); f, Maxilliped, posterior (F); g, Seta on third segment of maxilliped, posterior (E); h, Leg 5, lateral (F).







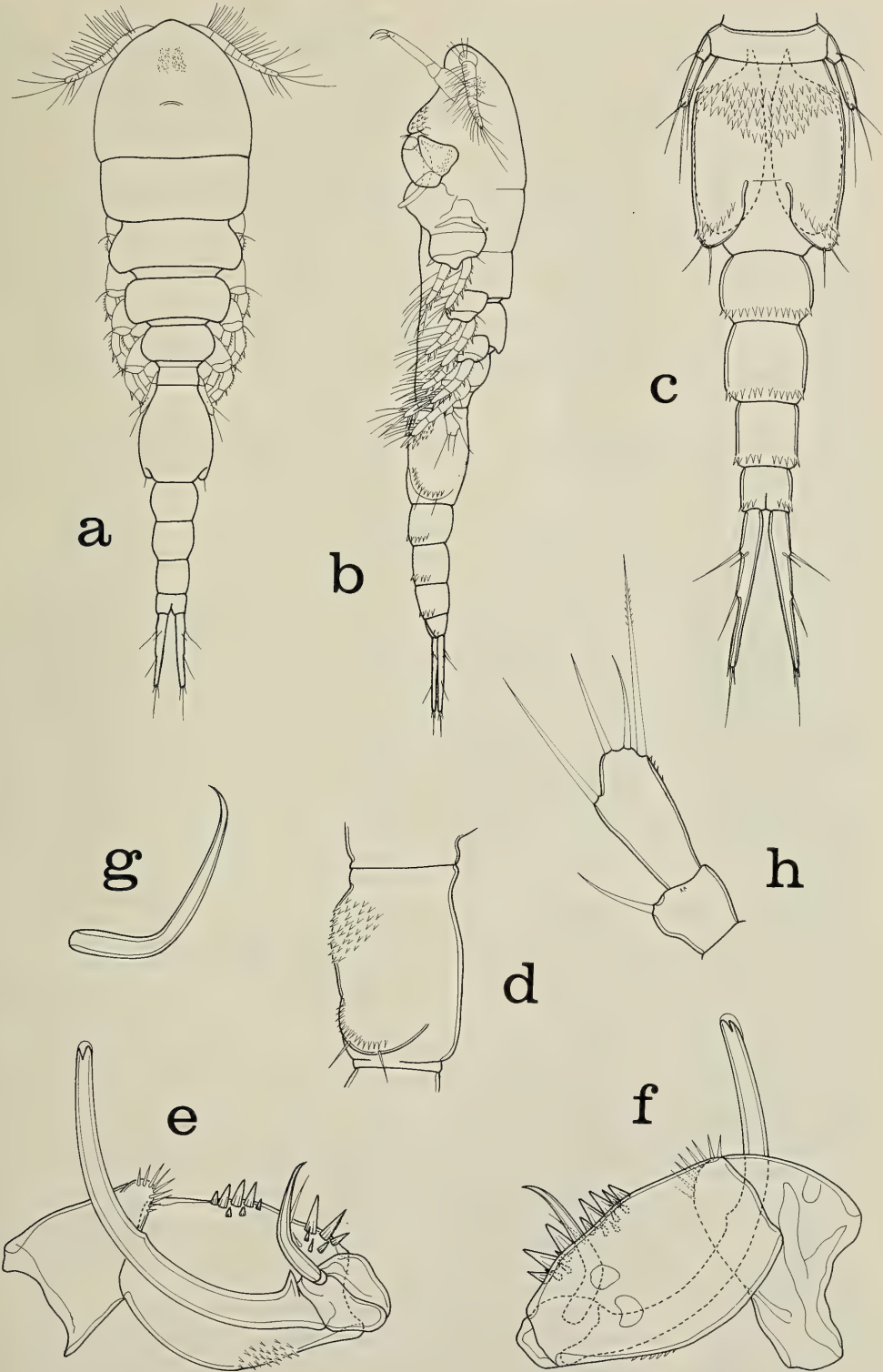




Table 1.—Bivalve hosts, localities, and sources for the species of *Ostrincola*.

Species	Host	Locality	Source
<i>O. gracilis</i> Wilson, 1944	<i>Ostrea virginica</i> Gmelin	Beaufort, North Carolina	Wilson (1944)
<i>O. gracilis</i> Wilson, 1944	<i>Crassostrea virginica</i> (Gmelin)	Barataria Bay, Louisiana	Humes (1953)
<i>O. gracilis</i> Wilson, 1944	<i>Modiolus demissus granosissimus</i> Sowerby	Barataria Bay, Louisiana	Humes (1953)
<i>O. gracilis</i> Wilson, 1944	<i>Mytilus recurvus</i> Rafinesque	Barataria Bay, Louisiana	Humes (1953)
<i>O. gracilis</i> Wilson, 1944	<i>Venus mercenaria mercenaria</i> Linnaeus	Barataria Bay, Louisiana	Humes (1953)
<i>O. gracilis</i> Wilson, 1944	<i>Tagelus gibbus</i> (Spengler)	Cotuit, Massachusetts	Humes and Cressey (1960)
<i>O. clavator</i> Humes, 1959	<i>Ostrea</i> sp.	Nosy Bé, Madagascar	Humes (1959)
<i>O. simplex</i> Humes, 1959	<i>Ostrea</i> sp.	Nosy Bé, Madagascar	Humes (1959)
<i>O. koe</i> Tanaka, 1961	<i>Paphia</i> ( <i>Paratapes</i> ) <i>undulata</i> (Born)	Sakibe, near Sasebo, Japan	Tanaka (1961)
<i>O. koe</i> Tanaka, 1961	<i>Paphia</i>	Tsuyazaki, near Fukuoka, Japan	Tanaka (1961)
<i>O. koe</i> Tanaka, 1961	<i>Meretrix lusoria</i> (Röding)	Near Saga, Ariake Bay, Japan	Kô, Murakami, and Daiku (1962)
<i>O. koe</i> Tanaka, 1961	<i>Cyclina sinensis</i> (Gmelin)	Hiroshima, Japan	Kô, Murakami, and Daiku (1962)
<i>O. koe</i> Tanaka, 1961	<i>Tapes japonica</i> Deshayes	Sakibe, Sasebo Bay, Japan	Kô, Murakami, and Daiku (1962)
<i>O. koe</i> Tanaka, 1961	<i>Claudiconcha japonica</i> (Dunker)	Sakibe, Sasebo Bay, Japan	Kô, Murakami, and Daiku (1962)
<i>O. koe</i> Tanaka, 1961	<i>Caecella chinensis</i> Deshayes	Sakibe, Sasebo Bay, Japan	Kô, Murakami, and Daiku (1962)
<i>O. koe</i> Tanaka, 1961	<i>Macra veneriformis</i> Reeve	Yue, Ariake Bay, Japan	Kô, Murakami, and Daiku (1962)
<i>O. koe</i> Tanaka, 1961	<i>Arcopagia</i> ( <i>Merisca</i> ) <i>diaphana</i> (Deshayes)	Hiroshima, Japan	Kô, Murakami, and Daiku (1962)
<i>O. koe</i> Tanaka, 1961	<i>Tapes japonica</i> Deshayes	Saga, Nagoya, Tsuyazaki, Ôsaki, Japan	Kô (1961)
<i>O. koe</i> Tanaka, 1961	<i>Tapes japonica</i> Deshayes	Sasebo Bay, Japan	Kô (1969a, b, c)
<i>O. koe</i> Tanaka, 1961	<i>Tapes</i> ( <i>Amygdala</i> ) <i>philippinarum</i> Adams and Reeve	Japan	Kô, Yoshikoshi, and Ito (1974)
<i>O. japonicus</i> Tanaka, 1961	<i>Ostrea echinata</i> Quoy and Gaimard	Sasebo, Japan	Tanaka (1961)
<i>O. japonicus</i> Tanaka, 1961	<i>Saxostrea echinata</i> (Quoy and Gaimard)	Sakibe, near Sasebo, Japan	Kô, Murakami, and Daiku (1962)
<i>O. japonicus</i> Tanaka, 1961	<i>Ostrea</i> ( <i>Crassostrea</i> ) <i>gigas</i> Thunberg	Hiroshima, Japan	Kô, Murakami, and Daiku (1962)
<i>O. portonoviensis</i> Reddiah, 1962	<i>Meretrix meretrix</i> (Linnaeus)	Puddupeta, Portonovo, South India	Reddiah (1962)
<i>O. portonoviensis</i> Reddiah, 1962	<i>Meretrix casta</i> (Chemnitz, nec Deshayes)	Puddapeta, Portonovo, South India	Reddiah (1962)
<i>O. portonoviensis</i> Reddiah, 1962	<i>Meretrix casta</i> (Chemnitz, nec Deshayes)	Adyar estuary, near Madras, India	Reddiah and Mammen (1966)

Table 1.—(Continued).

Species	Host	Locality	Source
<i>O. portonoviensis</i> Reddiah, 1962	<i>Sanguinolaria</i> ( <i>Soletellina</i> ) <i>diphos</i> (Gmelin)	Puddupeta, Portonovo, South India	Reddiah (1962)
<i>O. (?) portonoviensis</i> Reddiah, 1962	<i>Mesodesma trigona</i> (Deshayes)	Quilon, Kerala, India	Pillai (1968)
<i>O. falcatus</i> , new species	<i>Protothaca asperrima</i> (Sowerby)	Chiman, Darien, Panama	present paper
<i>O. falcatus</i> , new species	<i>Mytella guyanensis</i> (Lamarck)	Vera Cruz, Panama	present paper
<i>O. falcatus</i> , new species	<i>Anadara obesa</i> (Sowerby)	Vera Cruz, Panama	present paper

flap of leg 6 (Fig. 4d). Four postgenital segments from anterior to posterior 44 × 58, 49 × 52, 42 × 41, and 26 × 35 μm, each segment with posteroventral row of spines.

Caudal ramus similar to that of female.

Rostrum like that of female. First antenna resembling that of female but 1 aesthete added on fourth segment (at point indicated by dot in Fig. 2a). Second antenna like that of female.

Labrum, mandible, first maxilla, and second maxilla similar to those of female. Maxilliped (Fig. 4e, f) with 3 segments and long terminal claw. First segment with distal inner process bearing prominent spines. Second segment relatively short, bearing on inner side 2 groups of spines and 2 unequal setae, and on outer side patch of small spines. Small third segment with prominent sickle-shaped seta (Fig. 4g) 30 μm long. Claw 83 μm, with small spurlike sclerotization at inner base and slight prominence midway along concave margin. Tip of claw blunt with small hyaline cap.

Legs 1–4 like those of female.

Leg 5 (Fig. 4h) with first segment 13 × 15.5 μm. Second segment not as broad as in female, 33 × 17 μm, ratio 1.94:1, armed as in female.

Leg 6 (Fig. 4c, d) represented by 2 small setae on posteroventral flap of genital segment.

Color as in female.

*Etymology*.—The specific name *falcatus*, Latin meaning sickle-shaped, alludes to the shape of the seta on the third segment of the maxilliped of the male.

*Remarks*.—Six species of *Ostrincola* have been described, all associated with bivalve mollusks. Records of these species are summarized in Table 1. (Pillai's 1963 record of *Ostrincola portonoviensis* Reddiah, 1962, from *Mesodesma trigona* in India needs confirmation, since there are discrepancies between Reddiah's original description and Pillai's subsequent description. For example, contrary to the original description, Pillai shows spines on a process of the first segment of the maxilliped of the male, the third segment of the endopod of leg 3 with IV, 2, and the same segment of the endopod of leg 4 with IV, 2.)

Although it is sometimes impossible to determine various details from the published descriptions of the several species of *Ostrincola*, it appears that the falciform seta on the third segment of the maxilliped of the male of *O. falcatus*

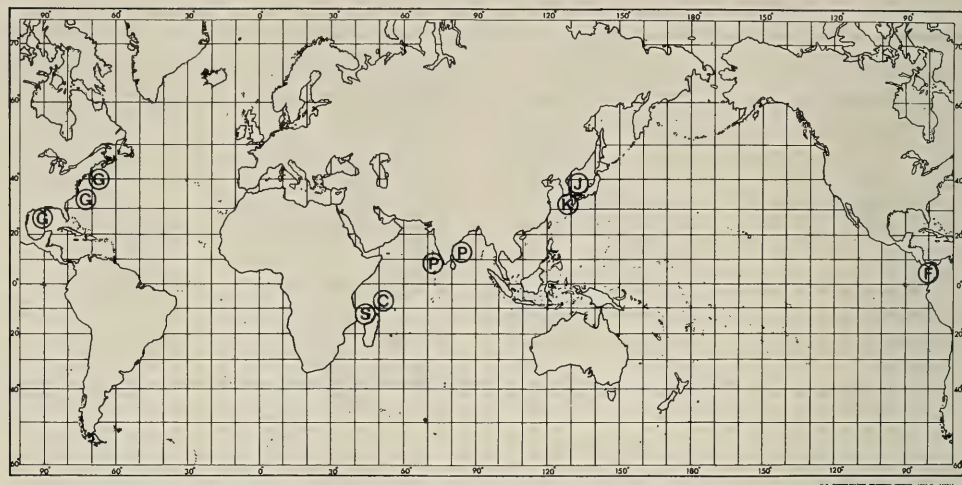


Fig. 5. Distribution of *Ostrincola*. C = *clavator*, F = *falcatus*, G = *gracilis*, J = *japonicus*, K = *koe*, P = *portonoviensis*, and S = *simplex*.

is diagnostic. In other species of the genus this seta is straight or only slightly recurved (this seta not described in *O. japonicus*). The spurlike sclerotization at the base of the claw of the maxilliped of the male also seems characteristic of the new species.

Specimens from *Mytella guyanensis* are often somewhat larger than those from *Protothaca asperrima*. Twenty females from *Mytella* had a length of 1.15 mm (1.01–1.35 mm) and greatest width of 0.32 mm (0.29–0.38 mm) and 20 males a length of 0.93 mm (0.75–1.01 mm) and greatest width of 0.24 mm (0.22–0.26 mm). Their size ranges overlap with specimens from *Protothaca*. A combination of the specimens from *Protothaca* with those from *Mytella* shows a length of 1.09 mm (0.91–1.35 mm) and greatest width of 0.30 mm (0.26–0.38 mm) for females and a length of 0.91 mm (0.75–1.01 mm) and greatest width of 0.23 mm (0.19–0.26 mm) for males.

Only two females from *Mytella* were ovigerous, but both of these had elongate egg sacs with the eggs arranged in a cluster rather than seriate. In one female the sac contained 11 eggs and measured  $485 \times 215 \mu\text{m}$ .

The ranges of the bivalve hosts are of interest since presumably *Ostrincola falcatus* may occur over part or all of their ranges. *Protothaca asperrima* is found from the Gulf of California to Peru, *Mytella guyanensis* occurs from Lower California to northern Peru and on the coast of Venezuela southward to Brazil, and *Anadara obesa* ranges from Mexico to northern Peru (Olsson 1961).

The various species of *Ostrincola*, whose geographical distribution is shown on the accompanying map (Fig. 5), may be distinguished by the use of the following key:

#### Key to the species of *Ostrincola*

- |  |   |
|--|---|
| 1. Endopod of leg 1 with third segment armed with II,4 ..... | 2 |
| – Endopod of leg 1 with third segment armed with I,5 .....   | 3 |



- 2. Endopod of leg 3 with third segment armed with IV,1 . . . . . *O. clavator*
- Endopod of leg 3 with third segment armed with III,3 . . . . . *O. simplex*
- 3. Endopod of leg 3 with third segment armed with II,4 and that of leg 4 with II,3 . . . . . *O. portonoviensis*
- Endopod of leg 3 with third segment armed with IV,2 and that of leg 4 with IV,1 . . . . . 4
- 4. Leg 5 in female with second segment round, flattened, ratio 1:1 . . . *O. gracilis*
- Leg 5 in female with second segment longer than wide, at least 1.36:1 . . . 5
- 5. Leg 5 in female with second segment having several spinules on both sides . . . . . 6
- Leg 5 in female with second segment with few spinules only on one side . . . . . *O. falcatus*
- 6. Second antenna with third segment long and slender, ratio approximately 7:1 . . . . . *O. japonicus*
- Second antenna with third segment relatively short, ratio approximately 4:1 . . . . . *O. koe*

*Pseudomyicola* Yamaguti, 1936

*Pseudomyicola spinosus* (Raffaele and Monticelli, 1885)

*Material studied.*—1 ♀, 1 ♂, from 60 *Anadara obesa* (Sowerby), Vera Cruz, Panama, 5 Nov 1981.

*Remarks.*—Humes (1968) listed 39 hosts for this copepod. Since then the copepod has been reported in Japan from *Mytilus edulis* (Linnaeus) and *Septifer virgatus* (Wiegmann) by Ho (1980), who regarded *Pseudomyicola ostreae* Yamaguti, 1936, as a synonym. On the southern Californian coast *P. spinosus* is common in *Mytilus edulis* and *Mytilus californianus* Conrad (Ho 1980). In New Zealand it is abundant in *Crassostrea glomerata* Gould (Dinamani and Gordon 1974). Furthermore, I have seen specimens of *P. spinosus* from *Chione (Austrovenus) stutchburyi* (Gray) from Cox's Creek, Westmere, Auckland, New Zealand (collected by Dr. Philippa M. Black in 1971 in the upper reaches of Waitemata Harbor, within the city).

The addition of these four new hosts increases the number of bivalves serving as hosts for *P. spinosus* to 44.

Acknowledgments

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## A REVIEW OF THE GENUS *PLATYNEUROMUS* (INSECTA: NEUROPTERA: CORYDALIDAE)

Michael J. Glorioso and Oliver S. Flint, Jr.

*Abstract.*—The genus *Platyneuromus* consists of three species: *soror* (Hagen), *honduranus* Navas, and *reflexus* n.sp. *Doeringia christel* Navas is synonymized with *P. soror*, and *P. auritus* Kimmins with *P. honduranus* for which a neotype is designated. The male genitalia and postocular flanges of all species are figured and described. The flange of *P. soror* and *P. honduranus* varies greatly in size, but analysis shows that the variation is in direct relationship to gross size of the head.

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In 1979 the authors met and discussed various problems and projects in the Megaloptera. At that time a single specimen of an undescribed species of *Platyneuromus* in the collection of the junior author served as the focus of an agreement between us to review this genus. Michael Glorioso began his study of the species, investigating characters, making measurements, and writing preliminary descriptions, while I (OSF) borrowed and forwarded material to him. On 17 October 1980, Michael died very suddenly. Dr. C. A. Triplehorn invited me to visit Ohio State University to work with them in sorting-out material and notes. I obtained all Michael's notes and recovered the material of *Platyneuromus*.

Study of these materials revealed considerable progress with this project on the part of the senior author. He had segregated the species, recognized the genitalic differences in the males, prepared many inked drawings of the male genitalia, made many measurements of various head dimensions and worked out the table of relationship between head size and flange width, and prepared preliminary descriptions of the genus and species. I have taken these notes and illustrations and filled them out to produce a uniform treatment of all species.

### Systematic Account

Three genera of dobsonflies, *Chloronia*, *Corydalus*, and *Platyneuromus*, occur in Mexico and Central America. The first is known from northern Mexico to southern Brazil including the Lesser Antilles, and the second is widespread from southern Canada to northern Argentina, but is not known from the West Indies. The genus *Platyneuromus* is, however, totally restricted to middle America, being known from northeastern Mexico as far south as northern Panama.

The genus *Platyneuromus* is readily distinguished by the postocular flange, the flattened lateral margin of the head (Glorioso 1981). The flange is developed to varying degrees depending on the species, sex, and, not surprisingly, the size of the example. The relationship between gross size and development of a sexually correlated structure is paralleled in *Corydalus* by the relationship between body size and length of male mandible in certain species. The very large postocular flange of a large example of *P. soror* (Hagen) led Navas (1925) to describe the example as a new species, genus and tribe—*Doeringia christel*, Doeringiini!



We here describe the new species, and provide descriptions and figures of the male genitalia for all known species, and report on the size relationship of the postocular flange.

*Platyneuromus* Weele

*Platyneuromus* Weele, 1909:252; 1910:23.—Lestage, 1927:94.—Penny, 1977:8.—Glorioso, 1981:282 (type-species *Corydalus soror* Hagen, by monotypy).  
*Doeringia* Navas, 1925:207.—Lestage, 1927:94.—Penny, 1977:8.—Glorioso, 1981:282 (type-species *Doeringia christel* Navas, by monotypy; synonymized Glorioso, 1981:282).

*Diagnosis.*—This genus, restricted to Mexico and Central America, is the only Corydalidae with notable flattened lateral margins of the head.

*Description.*—Size: length 20–55 mm; wingspan 50–140 mm. Coloration: luteus to fulvus; pronotum margined laterally with fuscous to piceus vitta, vitta often on postocular flange; wings fulvus with darker tessellations.

Head: broad, extremely flattened; posterior tentorial pit arcuate; postocular flange at least width of eye; antenna filiform, about length of forebody with 40–55 articles; clypeal margin feebly to moderately incised medially; labrum broadly truncate, rounded at corners; maxilla relatively long and narrow; stipes with indistinct setae; lacinia with three long apical setae; galeal sensory peg well developed; maxillary palp five-segmented, with distinct palpifer; labium with moderately setose ligula, four-segmented labial palp; terminal labial and maxillary palpal segments broadly rounded, with two sensory areas. Prothorax: notum more or less quadrate, prosternum often with 1 pair anterior acuminate spines, more pronounced in male. Wings: radial sector with 6–9 branches, last bifurcate;  $M_{1+2}$  and  $M_{3+4}$  each with 2 branches;  $Cu_1$  with 4–5 accessories,  $Cu_2$  unbranched; 1A 2 branched; 3 crossveins between  $R_1$  and  $R_s$  and between  $R_s$  and  $M$ ; 2 medial crossveins, 4 m-cu's; 1 cubital crossvein, 24–30 costal crossveins; first  $R_1$  cell one to one and a half times length of third. Males: ninth sternite nearly quadrate, broadly rounded or moderately incised posteriorly, membrane behind sternite thickened, bilobate; genital papillae weakly developed or absent; ninth tergite sparsely setose, internal inflection inverted, V-shaped; ninth gonostyli densely setose, clavate or unguiform, with terminal, glabrous, chitinous point; tenth tergites densely setose, clavate, occasionally with crenulate inner margin; tenth sternite broad, glabrous, moderately sclerotized; gonostyli long, digitiform, sparsely setose. Female: semicircular sternal pouch present between sixth and seventh segments; lateral sclerite well sclerotized; gonostylus fused with gonocoxite; bursa saclike, separate from spermathecal duct; accessory glands absent.

*Flange width.*—A bivariate regression analysis was run in which the flange width was regressed on the interocular distance (as an indication of general body size) for 25 specimens of *P. soror*. Figure 4 shows the scattergram, regression line, regression equation, coefficient of correlation ( $R$ ),  $R$  squared, and significance values. The coefficient of correlation for flange width on interocular distance is very high (.895) and the probability that there is only a random relationship between the measurements is less than 0.00001. The  $R$  squared value indicates that 80% of the variance in flange width is explained by the variance in interocular distance. Conclusion: it is almost certain that flange width is merely a function



Figs. 1-2. *Platyneuromus honduranus* (the holotype of *P. auritus*): 1, Habitus; 2, Head and pronotum.

of body size as expressed in interocular distance. The analysis of the flange width in *P. honduranus* is not quite as clear cut (Fig. 5). We suggest that this may be explained by a smaller sample size, in which the measurements are clustered at two extremes. We expect that specimens intermediate in size exist, but they were not available to us. Nevertheless, the results do corroborate the findings with *P. soror*, although at a lower R squared value—75%.

*Platyneuromus soror* (Hagen)

Figs. 3-4, 6-15

*Corydalis soror* Hagen, 1861:193

*Neuromus soror* (Hagen): Davis, 1903:467.

*Neuromus* (*Chloronia*) *soror* (Hagen): Banks, 1908:30.

*Platyneuromus soror* (Hagen): Weele, 1909:252; 1910, 23.—Stitz, 1914:199.—

Navas, 1928:62.—Penny, 1977:8.—Glorioso, 1981:282.

*Doeringia christel* Navas, 1925:29 (new synonymy).

**Diagnosis.**—Male tenth tergites divergent basally, parallel distally; usually larger than *P. honduranus*; postocular flange with dark vitta, especially well developed in females.

**Description.**—Size: body length 28–55 mm; forewing length males 34–59 mm [ave. 20 Mexican males, 43.9 mm; ave. 6 Costa Rican and Panamanian males 53.3 mm], females 42–63 mm [ave. 17 Mexican females, 50.2 mm; ave. 4 Costa Rican and Panamanian females 60.0 mm]. Coloration: luteus to fulvus, fuscous to piceus vitta on lateral margin of pronotum and postocular flange. Postocular flange: in female barely exceeding eye, weakly concave anteriorly, moderately convex laterally, distinct from postocular spine; small males similar to females; flange much broader in large males, obliterating postocular spine. Pretarsus: unguitractor longer than wide; median lobe of pulvillus with 2–4 setae. Male genitalia: ninth sternite broadly rounded posteriorly; genital papilli poorly developed, often apparently absent; ninth gonostyli short, arcuate; tenth tergites diverging proximally, parallel distally; tenth sternite broad, moderately sclerotized, more heavily sclerotized anteriorly, styli long, digitiform, sparsely setose.

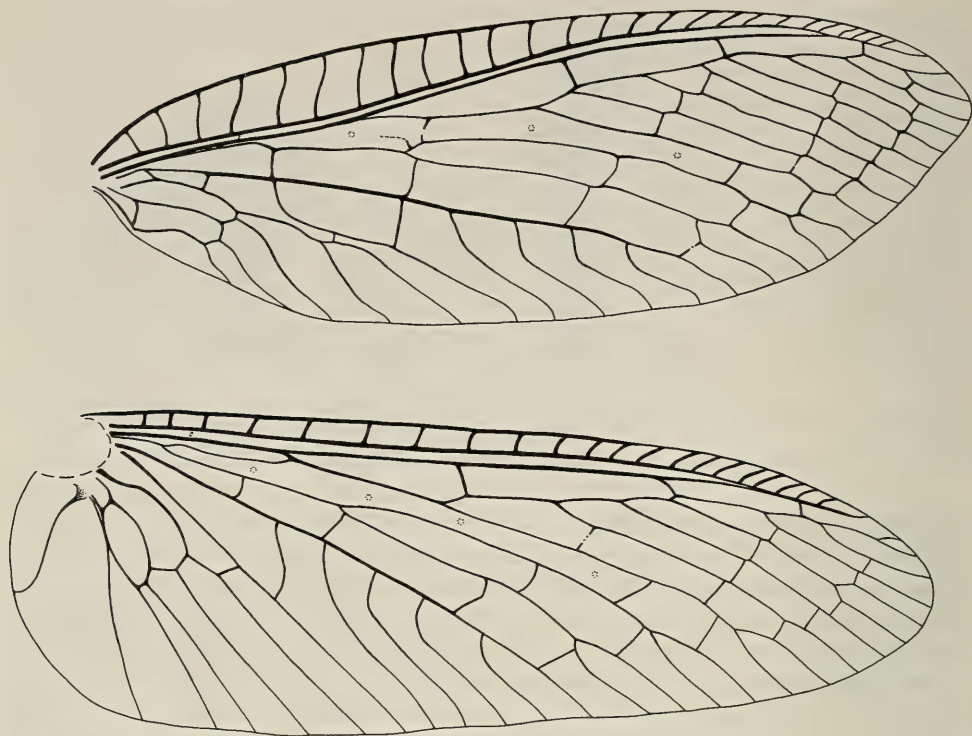


Fig. 3. *Platyneuromus soror*, fore- and hindwings.

*Variation.*—The development of the postocular flange is relatively constant in females, but varies in males. The flange of small males is similar to that of females, while that of large males may be four times greater than the width of the eyes, with intermediate flange width in intermediate sized males (Figs. 6–9). Occurrence of large males with extremely large postocular flanges is greatest in southern Central America, where the species averages almost 10 mm larger in forewing length, although large-flanged males are infrequently collected at more northern localities.

The dark vitta on the postocular flange may be restricted to half the width of the flange, or may cover the entire flange. Rarely the vitta is faintly developed or obscured by melanized areas on the head.

*Distribution.*—The species is found from northeastern Mexico through central Mexico south to Chiapas, generally on the eastern coast. Records are then available from central Costa Rica south to northern Panama. It is not known if the lack of records from intermediate localities is an artifact of poor collecting or a true hiatus in the distribution of the species. Adults have been found flying together with those of *P. honduranus* in Chiapas, Mexico. In Mexico the species has been taken from late March to early September, and in southern Central America from late April into July. However, the peak of abundance would seem to fall between May and early July.

*Material examined.*—Costa Rica, [Pcia. Cartago], Turrialba, May, 900 m, 1 ♂ [DEI, holotype *D. christel*, 58 mm]. Pcia. Heredia, Finca La Selva, 21–30 Jul 1976, J. C. Solomon, 1 ♀ [USNM, 62 mm].



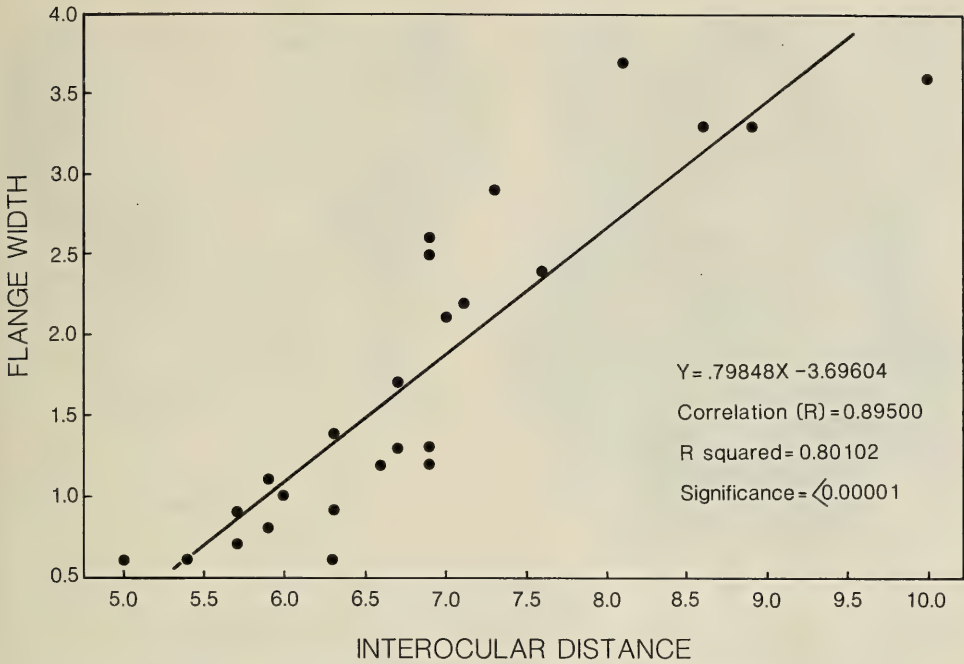


Fig. 4. *Platyneuromus soror*, regression of flange width on interocular distance.

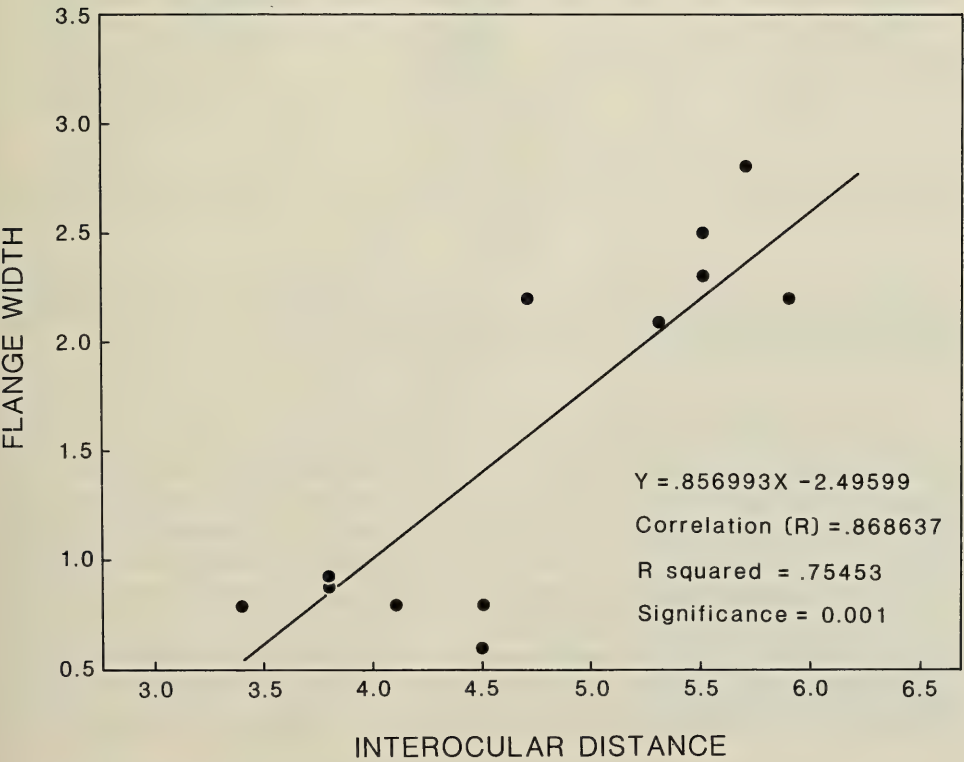
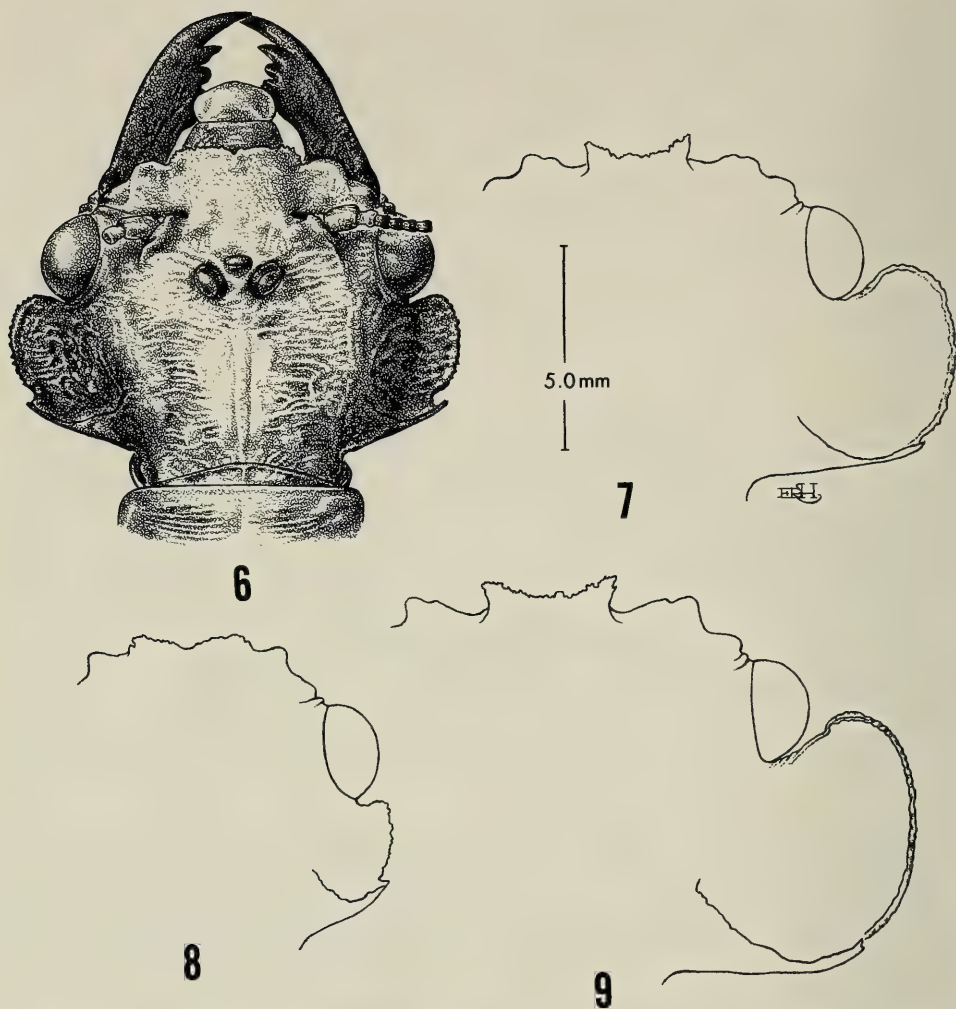
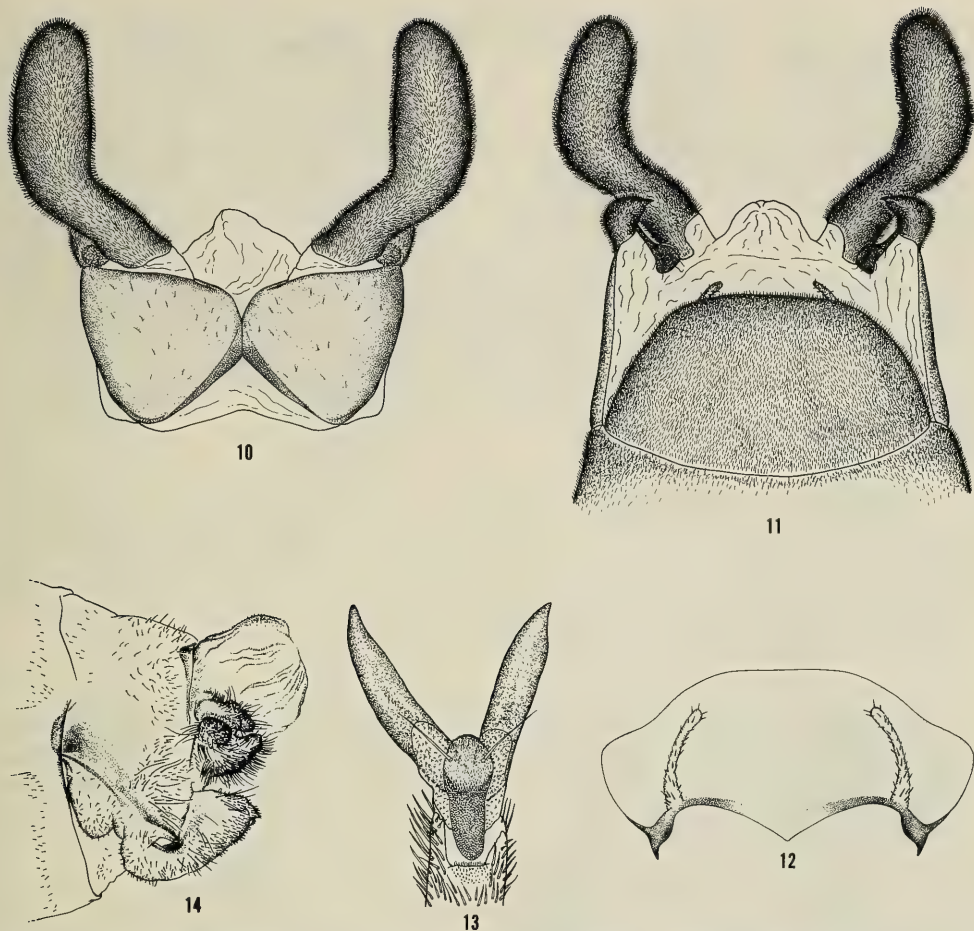


Fig. 5. *Platyneuromus honduranus*, regression of flange width on interocular distance.



Figs. 6-9. *Platyneuromus soror*: 6, Head of male from Cuesta de Misantla, Mexico (wing, 49 mm); 7, Head of male from Santa Clara, Panama (wing, 51 mm); 8, Head of female from El Salto Falls, Mexico (wing, 48 mm); 9, Head of male from Santa Clara, Panama (wing, 59 mm).

Mexico, 1 ♂ [MCZ, holotype *C. soror*, 45 mm]. Distrito Federal, J. R. Inda, 1 probably ♀ [USNM, 62 mm]. Edo. Chiapas, 6 mi. S Puebla Nueva, 20 Mar 1953, Bechtel & Schlinger, 1 ♂ [CAS, 48 mm]. Edo. Chiapas, Palenque, 8 Jun 1969, Campbell & Bright, 1 ♂ [CNC, 45 mm]. [Edo. Mexico], Temascaltepec, 11 Jul 1933, Hinton & Usinger, 1 ♂, 2 ♀ [CAS, ♂ 42, ♀ 53, 58 mm]. Edo. San Luis Potosí, El Salto Falls, west Antiguo Morelos, ca. 2000 ft., 8 Jun 1961, U. Kans. Mex. Exped., 1 ♂, 1 ♀ [UKAL, ♂ 43, ♀ 51 mm]; same, but 17 Jun 1965, U. Kans. Mex. Exped., 2 ♀ [UKAL, 48, 54 mm]; same, but 29 Jun 1965, P. J. Spangler, 2 ♂, 1 ♀ [USNM, ♂ 39, 40, ♀ 45 mm]; same, but 11-14 Jul 1963, Duckworth & Davis, 2 ♀ [USNM, 43, 48 mm]; same, but 15-16 Jul 1963, U. Kans. Mex. Exped., 1 ♂, 4



Figs. 10–14. *Platyneuromus soror*: 10, Male genitalia; dorsal; 11, Same, ventral; 12, Male tenth sternite and styli; 13, Pretarsus, ventral; 14, Female genitalia, lateral.

♀ [UKAL, ♂ 38, ♀ 42, 43, 44, 45 mm]; same, but 4 Sep 1962, Ordway & Marston, 2 ♂, 1 ♀ [UKAL, ♂ 34, 42, ♀ 42 mm]. Edo. San Luis Potosi, Palitla, 3 Aug 1966, O. S. Flint, Jr., 1 ♂ [USNM, 43 mm]. Edo. San Luis Potosi, La (? Candiela), camino a Xilitla, 1 ♂ [IBUNAM, 50 mm]. Edo. Veracruz, Teocelo, Sep, E. A. Smyth collection, 1 ♀ [USNM, 61 mm]. Edo. Veracruz, Arroyo Claro, "Los Tuxtles," 15 May 1977, 2 ♂ [IBUNAM, 45, 47 mm]. Edo. Veracruz, Balzapote, "Los Tuxtles," 8 Sep 1977, J. Bueno, 2 ♂ [IBUNAM, 38, 40 mm]. [Edo. Veracruz], Cuesta de Misantla, M. Trujillo, 2 ♂ [BMNH, 47, 49 mm]. [Edo. Veracruz], Jalapa, M. Trujillo, 1 ♀ [BMNH, 58 mm]. [Edo. Veracruz], Rinconada, Sharis, 1 ♂ [BMNH, 55 mm]. Edo. Veracruz, Ciudad Mendoza, 24 Apr 1953, Bechtel & Schlinger, 1 ♀ [CAS, 57 mm]. Edo. Veracruz, 5 mi. N Huatusco, 29 Jun 1971, Clark *et al.*, 1 ♂ [TAMU, 48 mm].

Panama, Pcia. Chiriqui, Fortuna, 8°44'N: 82°15'W, 1050 m, 29 Apr 1978, H. Wolda, 1 ♂ [USNM, 53 mm]. Pcia. Chiriqui, El Valle de la Sierpe, 8°45'N: 82°15'W,



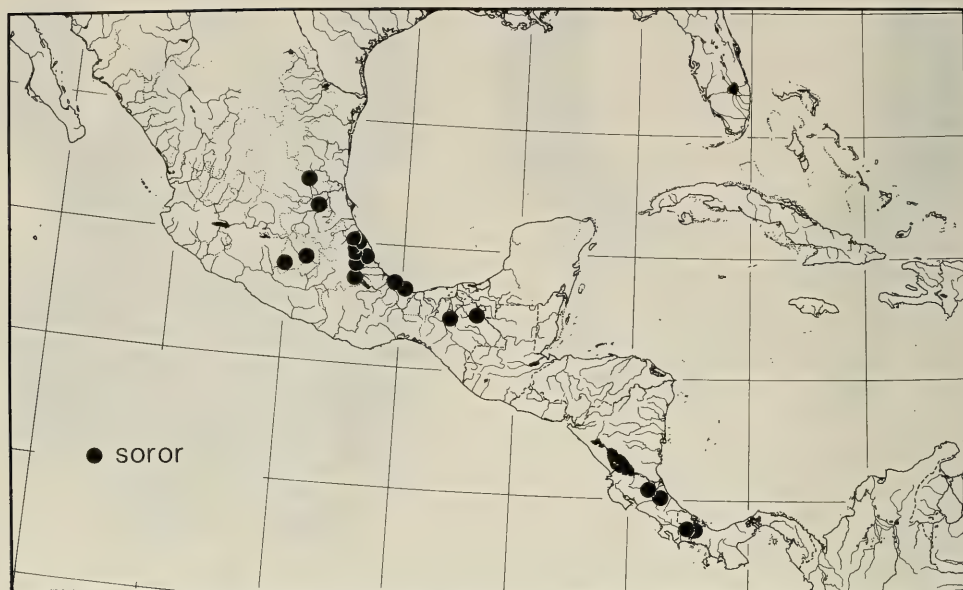


Fig. 15. Known distribution of *Platyneuromus soror*.

5 May 1980, J. Peterson, 1 ♂, 1 ♀ [INPA, ♂ 50, ♀ 56 mm]. Pcia. Chiriqui, Santa Clara, 18 May 1977, Thurman, 3 ♂, 1 ♀ [INPA, USNM, ♂ 49, 51, 59, ♀ 63 mm]. [Pcia. Chiriqui], Volcan de Chiriqui, below 4000 ft., Champion, 1 ♀ [BMNH, 59 mm].

*Platyneuromus honduranus* Navas, new status

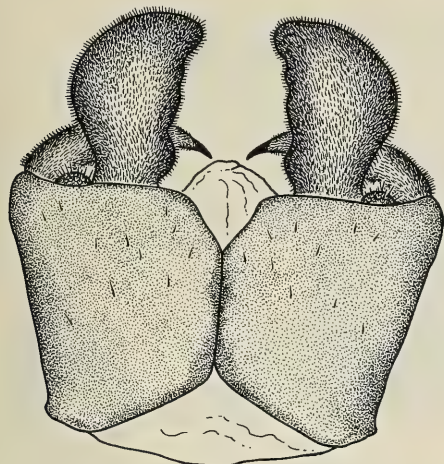
Fig. 1-2, 5, 16-22, 31

*Platyneuromus soror hondurana* Navas, 1928:63.

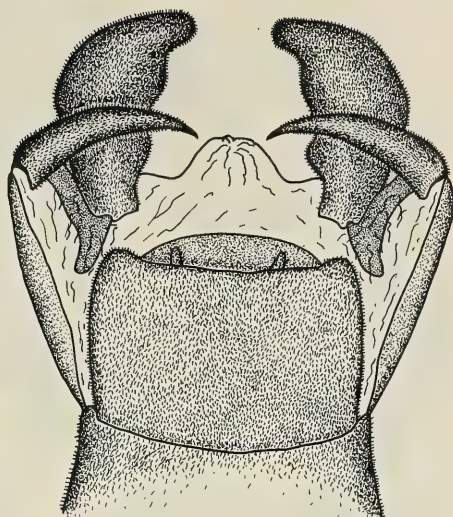
*Platyneuromus auritus* Kimmins, 1928:369 (new synonymy).

**Diagnosis.**—Male tenth tergites with crenulate inner margins; ninth gonostyli unguiform; generally smaller than *R. soror*; vitta across postocular flange obscure or absent especially in females.

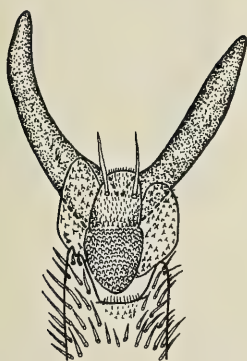
**Description.**—Size: body length 20–28 mm; forewing length males 26–36 mm [ave. 14 ♂, 31.0 mm], females 32–40 mm [ave. 13 ♀, 35.8 mm]. Coloration: luteus to fulvous, fuscus to piceus vitta on lateral margin of pronotum; vitta on postocular flange obscure or absent, especially in females. Postocular flange: in females, barely exceeding eye, concave anteriorly, moderately convex laterally, distinct from postocular spine; small males similar to females, flange much broader in large males, obliterating postocular spine. Pretarsus: unguitractor as wide as long, median lobe of pulvillus with 2 setae. Male genitalia: ninth sternite broadly and weakly incised posteriorly; genital papilli poorly developed, often apparently absent; ninth gonostyli long, unguiform, directed medially; tenth tergites nearly parallel, with crenulate inner margins; tenth sternite broad, moderately sclerotized, more heavily sclerotized anteriorly, styli long, digitiform, sparsely setose.



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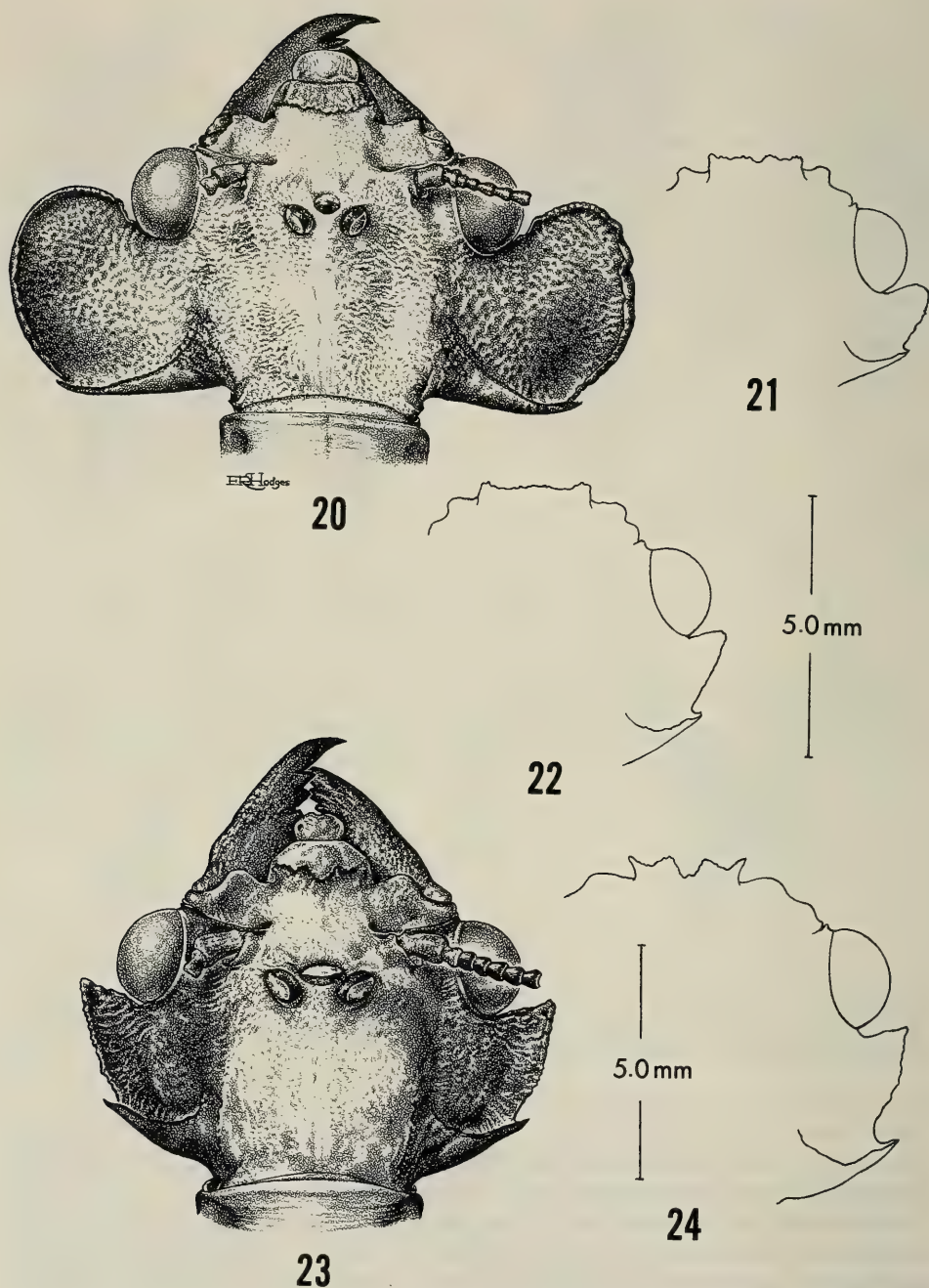
Figs. 16–19. *Platyneuromus honduranus*: 16, Male genitalia, lateral; 17, Same, ventral; 18, Male tenth sternite and styli; 19, Pretarsus, ventral.

*Variation.*—Development of postocular flange varies with size as in *P. soror*, although the clinal pattern seen in *P. soror* is not evident.

*Distribution.*—The species is only known from southern Mexico through Guatemala to northwestern Honduras. In Chiapas, Mexico it has been taken flying together *P. soror* or *P. reflexus*, but not yet with both at the same time. Collection dates range from the end of February to late May.

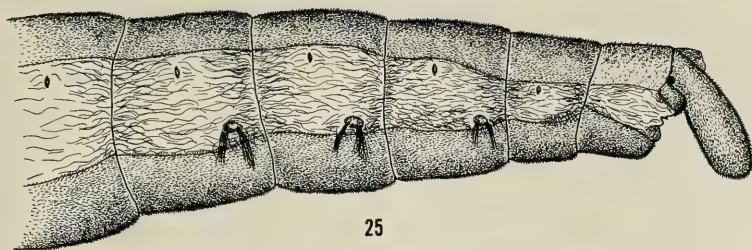
*Material examined.*—Neotype, male, Honduras [Depto. Cortes], La Lima, 23 Feb 1965, C. Evers Q. [USNM 101511, 32 mm].

Guatemala, 1915, Wm. Schaus, 1 ♂ [USNM, 28 mm]. [Depto. Alta Verapaz], Panzos, Apr 1918, 1 ♀ [USNM, 37 mm]. [Depto. Izabal], Quirigua, Mar 1915,

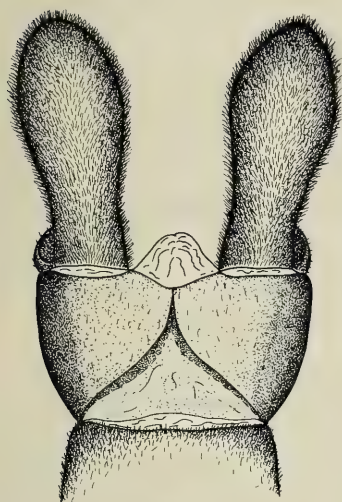


Figs. 20-24. *Platyneuromus honduranus*: 20, Head of male from Agua Azul, Mexico (wing, 33 mm); 21, Head of male from Bonampak, Mexico (wing, 27 mm); 22, Head of female from Rio Tulija, Mexico (wing, 35 mm). *Platyneuromus reflexus*: 23, Head of male from Cascada Misolja, Mexico (wing, 40 mm); 24, Head of female from same locality (wing, 42 mm).





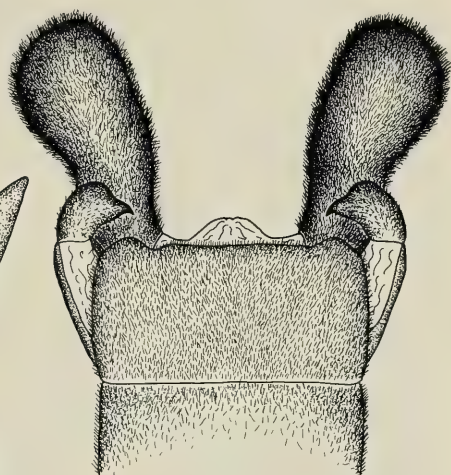
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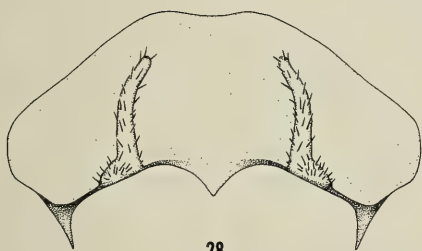
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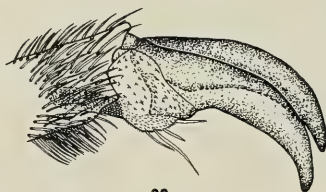
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Figs. 25–30. *Platyneuromus reflexus*: 25, Male abdomen, lateral; 26, Male genitalia, dorsal; 27, Same, ventral; 28, Male tenth sternite and styli; 29, Pretarsus, ventral; 30, Same, lateral.

Wm. Schaus, 2 ♀ [USNM, 34, 36 mm]. [Depto. Izabal], Cayuga, Mar, Schaus & Barnes, 1 ♂ [USNM, 36 mm].

Honduras, 2 ♂, 1 ♀ [BMNH accession number 1921-503, ♂ holotype *P. auritus*, second ♂ with replacement abdomen from another order, ♂ 32, 36, ♀ 39 mm]. [Depto. Atlantida], Lombardia, Wm. Mann, 1 ♀ [USNM, 37 mm].

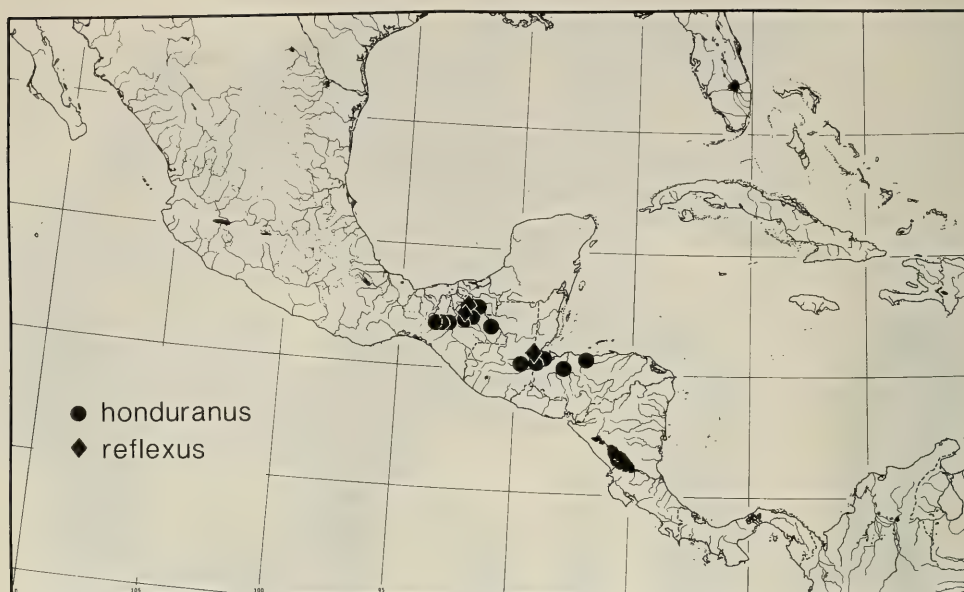


Fig. 31. Known distributions for *Platyneuromus honduranus* and *P. reflexus*.

Mexico, Edo. Chiapas, Palenque, 8 May 1969, Campbell & Bright, 1 ♀ [CNC, 38 mm]. Edo. Chiapas, Rio Tuliya, 48 km S Palenque, 17 May 1981, C. M. & O. S. Flint, Jr., 1 ♀ [USNM, 35 mm]. Edo. Chiapas, Agua Azul, [50 km S Palenque], 1 May 1978, C. R. Beutelspacher, 2 ♂, 1 ♀ [IBUNAM, ♂ 28, 29, ♀ 32 mm]; same, but 22 May 1979, L. Rivera, 1 ♂, 1 ♀ [IBUNAM, ♂ 33, ♀ 33 mm]. Edo. Chiapas, Bonampak, 2–4 May 1978, C. R. Beutelspacher, 5 ♂ [IBUNAM, USNM, 26, 27, 30, 31, 35 mm]; same, but 20–25 May 1980, J. Bueno S., 1 ♀ [IBUNAM, 32 mm]. Edo. Chiapas, Tuxtla [Gutierrez], 7 May 1947, 1 ♂ [PAAC, 31 mm]. Edo. Chiapas, Chiapa [de Corzo], 13 Mar 1953, Bechtel & Schlinger, 2 ♀ [CAS, 39, 40 mm]. Edo. Chiapas, Ocozocautla, 853 m, 17 May 1972, D. E. Breedlove, 1 ♀ [CAS, 34 mm].

*Platyneuromus reflexus*, new species

Figs. 23–31

*Diagnosis*.—Postocular flanges pointed anterolaterally and slightly to strongly reflexed; male abdomen bearing setose tubercles laterally on segments 5, 6, 7; male tenth tergites gradually divergent.

*Description*.—Size: body length 27–38 mm; forewing length males 38–47 mm [ave. 4 ♂, 42.8 mm], females 41–48 mm [ave. 4 ♀, 45.0 mm]. Coloration: luteus to fulvous, fuscous to piceus vitta on lateral margin of head and pronotum. Postocular flange: in females width barely exceeding that of eye, anterolateral angle pointed and directed slightly anteriorly, lateral margin almost straight; males with flange broad and more strongly reflexed dorsad. Pretarsus: unguitractor longer than wide; median lobe of pulvillus with 4 setae. Male genitalia: ninth sternite broad, posterior margin broadly and slightly rounded; genital papillae strongly developed, often projecting as large, rounded, membranous lobes; ninth gonostyli

short, arcuate, ending in sharp spine directed mesally; tenth tergites elongate, slightly inflated and slightly divergent apicad; tenth sternite broad, more heavily sclerotized anteriorly, with small, lightly sclerotized anteromesal projection, gonostyli long, digitiform, sparsely setose, bases with distinct, lateral enlargement more strongly setose.

*Variation.*—The series is quite uniform, but the smaller males have a slightly narrower and less reflexed postocular lobe, as in the other species of the genus.

*Distribution.*—This poorly known species appears to have the most limited distribution of any in the genus, being known only from Chiapas, Mexico, and adjacent Guatemala. Adults of the species have been found flying with *P. honduranus* in southern Mexico. The species has only been collected in late May and June.

*Material examined.*—Holotype, male, Mexico, Edo. Chiapas, Cascada Misolja, 20 km S Palenque, 17–18 May 1981, C. M. & O. S. Flint, Jr. [USNM 101510, 38 mm]. Paratypes: Same, data, 1 ♂, 2 ♀ [USNM, ♂ 40, ♀ 41, 47 mm]. Edo. Chiapas, Agua Azul [50 km S Palenque], 22 May 1979, L. Rivera, 1 ♂, 2 ♀ [IBUNAM, ♂ 47, ♀ 44, 48 mm]. Guatemala, [Depto. Alta Verapaz], Trece Aguas, Jun 1907, O. F. Cook, 1 ♂ [USNM, 46 mm].

#### Acknowledgments

We thank the following institutions and individuals that made material available: BMNH, British Museum (Natural History), London, P. C. Barnard; CAS, California Academy of Sciences, San Francisco, D. H. Kavanaugh; CNC, Canadian National Collection, Ottawa, J. E. H. Martin; DEI, Institute für Pflanzenschutzforschung, Eberswalde, L. Diekmann; IBUNAM, Instituto de Biología, Universidad Nacional Autónoma de México, J. Bueno Soria; INPA, Instituto Nacional de Pesquisas da Amazonia, Manaus, N. D. Penny; MCZ, Museum of Comparative Zoology, Cambridge, M. Pearce & M. Thayer; PAAC, Philip A. Adams, Fullerton, California; TAMU, Texas A&M University, College Station, S. J. Merritt; UKAL, University of Kansas, Lawrence, G. W. Byers; USNM, National Museum of Natural History, Washington.

Dr. R. Blum searched the collection of the Zoologisches Institut und Zoologisches Museum, Hamburg, for the type of *P. honduranus*, and reported its absence. Dr. Jerry A. Louton ran the statistical computations and analyzed their significance. The Entomology staff artist, Mrs. Elaine R. Hodges, completed or corrected many of the genitalic figures and the wings, and executed the exquisite illustrations of the head. Mr. Victor E. Krantz photographed the type of *P. auritus*.

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A NEW SPECIES OF *POTAMOCYPODA*  
(CRUSTACEA: BRACHYURA: OCYPODIDAE) FROM  
MALAYSIA

Ai-yun Tai and Raymond B. Manning

*Abstract.*—*Potamocypoda parapugil*, the second species of the genus, is described. The new species differs from *P. pugil* in having the chelae equal and similar in both sexes.

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The crab characterized below was found in the collections of the Smithsonian by one of us (A.T.) during a visit to the United States in 1982. The holotype and some paratypes are in the collections of the Smithsonian; paratypes also have been deposited in the Institute of Zoology, Academia Sinica, Beijing.

*Potamocypoda parapugil*, new species  
Fig. 1

*Material.*—Kuching, Sarawak, Malaysia [1°33'N, 110°20'E], in ditch by bridge, J. Crane, leg., 8 Aug 1955: male holotype, USNM 137241; 3 male, 6 female, and 1 juvenile paratypes, USNM 195341; 1 male and 1 female paratypes, Academia Sinica.

*Description.*—Carapace subrectangular, length 0.75 times width in holotype, greatest width at or slightly posterior to midlength. Carapace convex from front to back, almost straight from side to side on anterior half, sloping down to lateral margin on posterior half. Lateral margin a raised, tuberculate ridge lined with setae, forming a curved crest over pterygostomian region, extending posteriorly from outer orbital angle to form anterolateral margin, then sharply turning ventrally toward base of fourth leg, there turning posteriorly to form sinuous posterior margin. Posterolateral part of carapace with carina extending laterally, then curving anteriorly as sharp ridge falling short of lateral margin. Low, transverse carina present on each branchial region above this ridge. Short curved carina extending mesially from point where lateral carina turns ventrally and meets posterolateral carina. Central part of carapace with broad, H-shaped depression. Cardiac and intestinal regions marked on each side by irregular depression ornamented with deep pits. Posterior margin paralleled by transverse ridge on carapace. Front broad, about  $\frac{1}{2}$  carapace width, deflected ventrally, appearing almost straight in dorsal view, with 2 low, short postfrontal ridges, 1 on each side of midline. Front marked with pits and an irregular linear depression. Dorsal surface of carapace smooth medially, pitted laterally, pits increasing in size posterolaterally. Pterygostomian region smooth but covered with short scattered hairs. Interantennular septum very small, inconspicuous. Orbits well formed, orbital margin a raised ridge lined with short setae. Eyes slender, tapering distally, cornea terminal.

Third maxillipeds broad, mouthfield gaping slightly when closed. Ischium and merus very broad, former with oblique hairy ridge across surface. Palp much

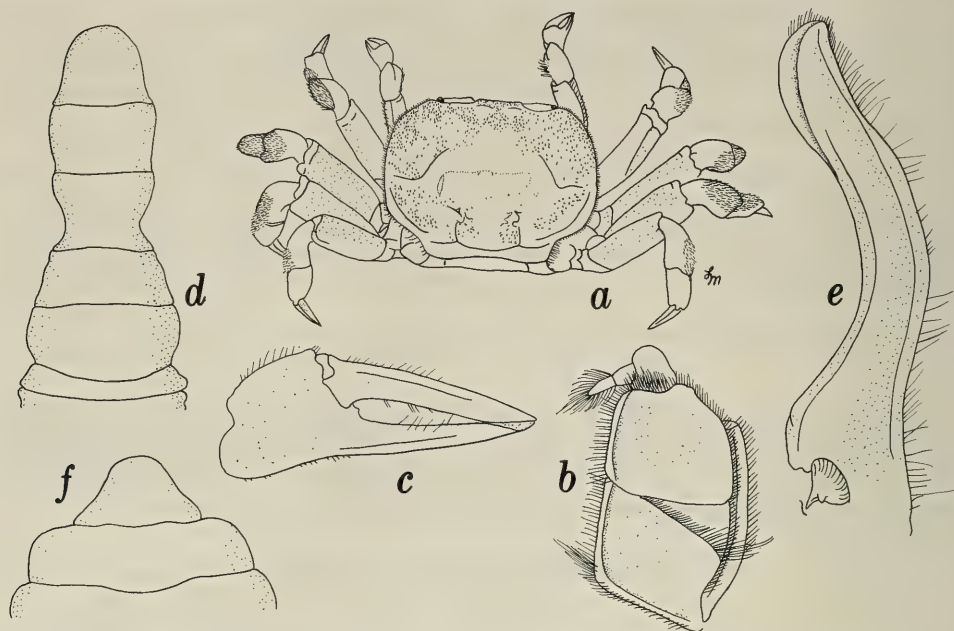


Fig. 1. *Potamocypoda parapugil*: a–e, Male holotype: a, Dorsal view; b, Third maxilliped; c, Chela; d, Abdomen; e, Gonopod. f, Female paratype, terminal two segments of abdomen.

narrower than basal 2 segments, carpus oval with central depression, propodus and dactylus much more slender. Second maxilliped slender, segments longer.

Chelipeds small, slender, equal in both sexes. Fingers almost 2 times as long as palm, longitudinally ridged, gaping, unarmed, tips spatulate. Palm quadrangular, length and depth subequal, surface with few punctations, upper surface with curved ridge. Carpus about twice as long as palm, measured dorsally, with raised inner ridge dorsally. Merus rather stout and short.

Walking legs stout and short, second pair longest, fourth pair shortest. Merus tuberculate dorsally. Carpus longer than propodus, both with dense tomentum dorsally, heavier in males. Dactylus longer than propodus, diamond-shaped in cross-section, with 4 longitudinal ridges, tips corneous, sharp.

Male abdomen with first 2 segments fused, not extending laterally to bases of fifth legs, crossed by sharp ridge. Abdomen constricted between second and third segments and at fifth segment, exposing gonopods, third and fourth segments broader than fifth to seventh segments. Female abdomen broad, but not extending to bases of fifth legs. Gonopod as illustrated, short, not extending to base of sternum of second leg.

*Measurements.*—Male holotype,  $8.0 \times 10.7$  mm (cl  $\times$  cb); male paratypes ranging from  $5.1 \times 6.4$  mm to  $7.7 \times 10.0$  mm; female paratypes ranging from  $5.8 \times 7.8$  mm to  $8.1 \times 10.9$  mm; juvenile  $4.2 \times 5.4$  mm.

*Remarks.*—This new species shares most features with *Potamocypoda pugil*, the only other species in the genus, differing mainly in having the chelae equal and similar in both sexes. It also differs in having a short, curved carina dorsally on each branchial region and in having much stouter walking legs.



Tweedie (1938) erected the genus *Potamocypoda* for a single new species, *P. pugil*. He considered this genus to differ from all other members of the ocypodid subfamily Scopimerinae, except *Pseudogelasimus* Tweedie, 1937, in having the chelipeds strongly unequal in the male. Of the eight scopimerine genera listed by Serène (1968:98, 99), members of all but two, *Potamocypoda* and *Pseudogelasimus*, have equal chelae in the males. In both of these latter genera, each of which contains only one species, the chelae in males are markedly unequal. Species assigned to both members of these genera also lack the tympana on the meri of the walking legs, a characteristic of most of the other species in the subfamily.

We suspect that the new species described herein actually should be assigned to a new genus because of the differences in the chelae. However, until all of the genera of the Scopimerinae can be reviewed, we prefer to assign the species to *Potamocypoda*.

*Etymology*.—The specific name is formed from the Latin, *para*, meaning near, and the specific name *pugil*, reflecting the similarities of the two species assigned to *Potamocypoda*.

#### Acknowledgments

We thank Lilly King Manning for preparing the final illustrations.

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STUDIES IN THE HELIANTHEAE (ASTERACEAE).  
XXXI. ADDITIONS TO THE GENUS  
*DIMEROSTEMMA*

Harold Robinson

*Abstract.*—Eleven species are recognized in the South American genus *Dimerostemma* including two species, *D. grazielae* and *D. virgosum* described as new and three species, *D. annuum*, *D. episcopale* and *D. humboldtianum* newly transferred from *Oyedaea*. A key to species and a listing of synonymy and specimens seen is provided.

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The Helianthean genera have traditionally been more accurately circumscribed than those of most tribes of the Asteraceae because of the presence of many obvious characters that mark natural groups. The members of the helianthean subtribe Ecliptinae have not been as fortunate as most others in the tribe, however, and the members of that subtribe in Brazil have been particularly afflicted since generic concepts applied in the area by traditional systems of classification are almost entirely typified by species far outside the borders of Brazil.

The genus *Dimerostemma* is a particularly good example of the problem. The genus was named by Cassini in 1817 on the basis of a single Brazilian species, but was retained in the traditional treatments of the tribe by Bentham (Bentham and Hooker 1873) and Hoffmann (1890-1894) primarily because of lack of information. Most material of the genus was actually placed in the broad traditional concept of *Oyedaea* on the basis of the sterile ray flowers and the marginally winged achenes. The Gardner genus *Serpaea*, lectotypified by the same species as Cassini's genus, came to be treated as a subgenus of *Oyedaea* in the traditional treatments.

When Blake (1917) revived the genus *Dimerostemma*, he recognized six species, five from central Brazil (Goiás, Minas Gerais, and Mato Grosso) and one from adjacent eastern Bolivia. Blake, in distinguishing the genus from *Oyedaea*, emphasized the rather quadrangular disk achenes, the lack of squamellae in the pappus between the awns, and the presence of a distinct outer involucre bract series of foliar nature. Of these characters, the squamellae were evidently considered most significant by Blake, since he separated many other genera on this basis.

*Dimerostemma*, as delimited by Blake, was suspect on a number of counts. The quadrangular nature of the disk achenes represents only a thickened form shaped by the confines of the florets in the head. The squamellae have proven an unreliable character in many other Heliantheae such as *Otopappus* and *Notoptera*, or *Rhysolepis*. Also, at the time of the recent description of two new Brazilian species, one technically a *Dimerostemma* and the other an *Oyedaea*, Robinson (1981) noted the many characters in common between the species and suggested that a future concept would place the two together. The one character mentioned by Blake that remains potentially useful is the differentiated foliate outer involucre, but it is notable that a differentiated outer involucre is present in the Brazilian species that Blake left in *Oyedaea* as well as in those he placed in *Dimerostemma*.

In the process of studying material of another undescribed Brazilian species closely related to that recently described in *Oyedaea*, additional characters have been noted that impel the abandonment of the unnatural generic concept and mandate the expansion of *Dimerostemma* to its natural limits. In the present effort, some of the species that have been placed in *Oyedaea* from Guatemala and Mexico are provisionally excluded (Robinson 1978), and the genus is considered to be a strictly Andean group having a type-species, *O. verbesinoides*, ranging westward into Panama and Costa Rica. These plants can be distinguished from the expanded concept of *Dimerostemma* in the following ways:

<i>Oyedaea</i>	<i>Dimerostemma</i>
1. Corollas narrowly funnelform above basal tube.	Corollas campanulate and cylindrical above short basal tube.
2. Outer surface of corolla lobes scabrid with numerous sharp-tipped hairs.	Outer surface of corolla lobes not or scarcely scabrid.
3. Inner surface of corolla lobes with numerous long papillae distinctly longer than wide.	Inner surface of corolla lobes with mamillae or short papillae.
4. Resin ducts of corolla throat obvious, broad.	Resin ducts of corolla throat narrow, usually indistinct.
5. Style branches laxly recurved when mature.	Style branches becoming strongly coiled or contorted.
6. Anther collar only slightly narrowed at upper end, scarcely offset outwardly from base of connective.	Anther collar abruptly and strongly narrowed above to less than 1/3 its width, forming distinct basal tube.
7. Style branches without evident capitate glands on back.	Style branches usually bearing numerous glands on back.
8. Involucre without sharply differentiated outer series of foliose bracts.	Involucre with sharply differentiated outer series of foliose bracts.
9. Pappus awns slender above base, rather terete.	Pappus awns stout and tapering, triquetrous, sometimes lacking.
10. Body of achene constricted above into neck.	Body of achene not constricted above into neck.
11. Andean.	Brazil, Paraguay, and eastern Bolivia.

The genus *Dimerostemma*, as presently conceived, includes all species in the area of Brazil that have traditionally been placed in *Oyedaea*. The relationship to the Andean *Oyedaea* is probably more remote than the traditional placement of the species would suggest, although a slight enlargement of the anther collar, of the type seen in *Dimerostemma*, has been noted in one Bolivian specimen of *O. lanceolata* (Rusby) Blake. Also, both genera lack the fiber sheaths along the veins of the corolla throat seen in many other Ecliptinae. Still, actual closest relationship of *Dimerostemma* appears to be to other species in Brazil that have



been placed in *Angelphytum* and *Zexmenia* which have the same general corolla characters, expanded anther collars, and contorted style branches. The latter groups differ from *Dimerostemma* primarily by the fertile rays or peripheral flowers and by the lack or near lack of distinct foliose outer involucre bracts. Sterility versus fertility of the ray flowers, used here in conjunction with the involucre, seems to define a natural group, but the character does vary in other members of the Heliantheae and cannot automatically be regarded as a generic distinction.

The species of *Dimerostemma* show a comparative uniformity, being plants of savanna-type habitats, but some significant variation is seen in the genus. Most species seem to possess a xylopodium. Still, such a structure is not mentioned in collection data for *D. episcopale* or the closely related new species. The slender shrubby habit of the latter two species is sufficiently different to suggest that a xylopodium is not present. Most of the species have numerous glands on the backs of the style branches, but these are lacking in specimens seen of *D. humboldtianum*, where they are evidently a lost character. Though all members of the genus have a distinct outer series of involucre bracts, the shapes of the bracts differ. The species placed in *Dimerostemma* by Blake (1917) have broad and suborbicular bracts, while the bracts in the *D. episcopale* and *D. humboldtiana* groups are narrow and usually elongate.

#### Key to the species of *Dimerostemma*

1. Bracts of differentiated outer involucre series oblong to linear; pappus with large squamellae between the awns ..... 2
2. Small branching shrubs without obvious xylopodium; style branches with numerous glands abaxially ..... 3
3. Differentiated outer involucre bracts oblong, scarcely longer than inner bracts; paleae with mostly rounded tips ..... *D. episcopale*
3. Differentiated outer involucre bracts linear, much longer than inner involucre bracts; paleae with pointed tips ..... *D. graziellae*
2. Plants erect and scarcely branched, with an obvious basal xylopodium; style branches without numerous glands abaxially ..... 4
4. Leaves broadly elliptical to oblong, distinctly narrowed to a short petiole 1–3 mm long ..... *D. humboldtianum*
4. Leaves narrowly elliptical to narrowly oblanceolate, with a long slender base ..... *D. annuum*
1. Bracts of differentiated outer series broadly ovate to suborbicular; pappus without large squamellae between the awns ..... 5
5. Plants much-branched with mostly pseudodichotomous branching, without obvious xylopodium ..... *D. virgosum*
5. Plants erect and scarcely branched, with obvious basal xylopodium ..... 6
6. Leaves ovate with acute to slightly acuminate tips; achene without evident wing ..... *D. bishopii*
6. Leaves mostly rounded with obtuse or rounded tips; achenes usually winged ..... 7
7. Plants greenish in aspect, with slight strigillose or appressed-puberulous pubescence; leaves alternate ..... *D. retifolium*

7. Plants cinereous with longer or spreading hairs; leaves opposite below ..... 8
8. Heads with distinct slenderly acuminate tips on paleae ....  
..... *D. rotundifolium*
8. Heads with short-acuminate or acute tips on paleae ..... 9
9. Heads usually numerous on branches, usually less than  
1.5 cm wide, usually with narrow flexuose peduncles ...  
..... *D. brasilianum*
9. Heads few or solitary on branches, usually 1.5–3.0 cm  
wide, born on stout peduncles ..... 10
10. Undersurfaces of leaves and outer involucre bracts  
usually densely velutinous to tomentose with soft flex-  
uose hairs; heads born on branches that are leafy near-  
ly to the head ..... *D. vestitum*
10. Undersurfaces of leaves and outer involucre bracts  
incompletely covered by pubescence, mostly hispid  
or pilosulous; heads usually born on elongate leafless  
peduncles ..... *D. asperatum*

The following eleven species are recognized, including three transferred at this time from *Oyedaea* and two described as new. Because of some previous mis-identifications of material in the genus, specimens in the U.S. National Herbarium are cited below to indicate their correct identity and at the same time give some indication of the distribution.

*Dimerostemma annuum* (Hassler) H. Robinson, comb. nov.

*Oyedaea annua* Hassler, Repert. Nov. Sp. 14:175. 1915. PARAGUAY: In campis rupestribus calcareis in regione collis "Margarita." Hassler 11030 (G, Photo US).

The species apparently is known only from the type. Appearance would suggest that relationship is closest to *D. humboldtianum*.

*Dimerostemma asperatum* Blake, Contr. Gray Herb. n.s. 52:12. 1917

BOLIVIA: East Velasco, 200 m, Jul 1892, *O. Kuntze* (Holotype US). More recent collections: BRAZIL: Distrito Federal: Cerrado, immediately south of Brasília, elev. 975 m. *Irwin, Souza & Reis dos Santos 11112*; Campo, north end of Lagoa Paranoá, Brasília, elev. 975 m. *Irwin, Grear, Souza & Reis dos Santos 13950*; 46 km N of the bridge at Asa Norte in Brasília on the dirt road to Vila Buritis, elev. 3100 ft. *King & Almeda 8224*; Vicinity of the University of Brasília campus, elev. 2700 ft. *King & Almeda 8230*; Ecological Reserve S of Brasília, elev. 3300 ft. *King & Bishop 8921, 8927*; Chapada da Contagem, 13 km nordeste de balão em BR 020 por estrada, 20.5 km nordeste de torre de televisão, Brasília. *Kirkbride & Kirkbride 3098*; Goiás: Luziania (Saida da cidade). *Heringer 18198*; Campo, ca. 2 km N of Cristalina, elev. 1250. *Irwin, Grear, Souza & Reis dos Santos 13294*; 2 km S of Cristalina, elev. 2400 ft. *King, Almeda & Eiten 8256*; 13 km N of Cristalina along road to Brasília, elev. 2800 ft. *King & Bishop 8951*.

The species seems most notable for the large usually solitary heads on elongate leafless peduncles. The Bolivian type seems superficially different in appearance, but this is apparently because of the poor condition of the specimen. After careful examination I have found no essential difference.

*Dimerostemma bishopii* H. Robinson, *Phytologia* 49:275. 1981

BRAZIL: Goiás: 68 km NW along road from Iaciara to Nova Roma, elev. 1400 ft. *King & Bishop* 8803 (Holotype UB, isotype US).

The species can be distinguished by its broad sharply acute to slightly acuminate leaves and by the lack of wings on the achenes. The lack of wings was passed over too lightly at the time the species was described, being a feature unique in the entire related group of *Dimerostemma* and *Angelphytum*, and a character that might cause the species to be placed in *Aspilia* according to more traditional concepts. Nevertheless, the species has all other characters of *Dimerostemma* and lacks any trace of the apical narrowing of the achene or the fiber sheaths in the throat of the corolla that are found in most species of *Aspilia* including all those seen from Brazil.

*Dimerostemma brasilianum* Cassini, *Bull. Soc. Philom.* 1818:58. 1818. *Serpaea ovata* Gardn., *Lond. J. Bot.* 7:296. 1848. *Oyedaea ovata* (Gardn.) Benth. ex Baker in Mart., *Fl. Bras.* 6(3):207. 1884. *Oyedaea lippoides* Baker in Mart., *Fl. Bras.* 6(3):208. 1884. *Dimerostemma lippoides* (Baker) Blake, *Contr. Gray Herb.* n.s. 52:14. 1917. BRAZIL: Distrito Federal: Bacia do Rio São Bartolomeu, cerrado às margens da rodovia DF 15. *Heringer, Filgueiras, Mendonca & Pereira* 6369; Goiás: Portelandia. *Hatschbach* 34239; 20 km N of Corumbá de Goiás on road to Niquelândia, in valley of Rio Corumbá, elev. ca. 1150 m. *Irwin, Maxwell & Wasshausen* 18790; Cerrado ca. 35 km NE of Catalão, elev. 900 m. *Irwin, Onishi, da Fonsêca, Souza, Reis dos Santos & Ramos* 25266; 12 km S of Alto Paraíso de Goiás, along road to São João da Aliança, elev. 3400 ft. *King & Bishop* 8865; 20 km N of Cristalina along road to Brasília, elev. 2200 ft. *King & Bishop* 8946; Minas Gerais: Serra do Espinhaço, about 8 km N of Gouveia on road to Diamantina, elev. 1220 m. *Anderson, Stieber & Kirkbride* 35273; Ca. 4 km W of Campos Altos along Highway 262 to Uberaba, elev. 1160 m. *Davidse & Ramamoorthy* 10860; Morro das Pedras, ca. 25 km NE of Patrocínio, elev. 1050 m. *Irwin, Onishi, da Fonsêca, Souza, Reis dos Santos & Ramos* 25502; Serra do Espinhaço, 13 km E of Diamantina, elev. 1000 m. *Irwin, da Fonsêca, Souza, Reis dos Santos & Ramos* 27510; Serra do Espinhaço, 3 km N of São João da Chapada, road to Inhai, elev. 1200 m. *Irwin, da Fonsêca, Souza, Reis dos Santos & Ramos* 28463; 10 km S of Diamantina, elev. 3600–4000. *King & Bishop* 8541; 75 km SE along road from Cristalina to Paracatu, elev. 2400 ft. *King & Bishop* 8979; Araxá, Barreiro?. *Macedo* 3138; Caldas. *Widgren s.n.*; Morro das Pedras, near Belo Horizonte. *Williams & Assis* 5999.

Blake (1917) was convinced that *D. brasilianum* and *D. lippoides* were separate species, so much so that he had difficulty understanding where Cassini had obtained his type material of a species that Blake considered to be restricted to Goiás in the interior of Brazil. A careful review of the material now available shows that *D. lippoides* is at best a form with somewhat larger heads in eastern Minas Gerais and according to literature and photographs in eastern São Paulo. There



seems to be no significant discontinuity between such eastern specimens and material with smaller heads occurring as far east as central Minas Gerais.

*Dimerostemma episcopale* (H. Robinson) H. Robinson, comb. nov.

*Oyedaea episcopalis* H. Robinson, Phytologia 49:276. 1981. BRAZIL: Bahia: 14 km NW from the town of Rio das Contas along road to Pico das Almas, elev. 3300 ft. *King & Bishop 8633* (Holotype UB, isotype US). Additional specimens: BRAZIL: Bahia: 12–14 km N of town of Rio das Contas on the road to Mato Grosso, elev. ca. 1200 m. *Harley, Renvoize, Erskine, Brighton & Pinheiro 15163A*; Lower northern slopes of the Pico de Almas, ca. 25 km WNW of the town of Rio de Contas, elev. 1500 m. *Harley et al., 15402*; Ca. 3 km south of small town of Mato Grosso on the road to Vila do Rio de Contas, elev. ca. 1200 m. *Harley, Mayo, Storr, Santos & Pinheiro 19936*.

For notes on distinctions from the closest relative see the discussion under the following species.

*Dimerostemma grazielae* H. Robinson, sp. nov.

Plantae fruticosaе plerumque ad 1.5 m altae mediocriter ramosae. Caules rufo-brunnescentes subteretes dense hirtelli vel antrorse scabridi, internodis plerumque 1.5–5.0 cm longis. Folia opposita, petiolis distaliter indistincte demarcatis ca. 0.5–1.0 cm longis; laminae ellipticae vel ovatae plerumque 2.5–7.0 cm longae et 1.0–4.0 cm latae base acuminatae margine dense serrulatae vix anguste reflexae apice acutae vel breviter acutae supra atro-virides subbullatae dense antrorse scabridae subtus pallidae dense hispidulo-subtomentosae et glandulo-punctatae in nervis et nervulis dense exsculpto-reticulatae, nervis ascendentiter pinnatis vel supra basem subtrinnatis. Inflorescentiae plerumque multi-capitatae, pedunculis plerumque 2–4 cm longis raro ca. 6 cm longis dense antrorse pilosis vel lanatis et glandulo-punctatis. Capitula ad 1.5–2.0 cm lata (radiis exceptis); bractae involucri 12–14 exteriores patentiores foliiformes linearis 10–20 mm longae et 1–2 mm latae margine reflexae, bractae 10–14 interiores appressae oblongae ca. 6 mm longae et 2.3 mm latae margine scariosae apice breviter cuspidatae extus ad medio scabridae vel breviter lanatae et glandulo-punctatae; paleae cum bracteis interioribus similes apice distincte apiculatae. Flores radii 16–20 steriles; corollae flavae extus dense glandulo-punctatae, tubis ca. 1.5 mm longis superne sparse pilosulis, limbis anguste ellipticis ca. 10–12 mm longis et 3 mm latis; achaenia radii triangularia ca. 2.5 mm longa apice tridenticulata interdum in aristis 1–2 ad 0.5 mm longis producta. Flores disci ca. 70 in capitulo; corollae sordido-flavae 5.0–5.5 mm longae extus inferne glabrae, tubis brevibus ca. 1 mm longis, faucibus cylindricis ca. 3.5 mm longis base abrupte campanulatis, lobis ca. 0.9 mm longis et 0.7 mm latis intus praeter basem breviter papillosis extus scabridis et sparse glandulo-punctatis; filamenta in partibus superioribus ca. 0.5 mm longa; thecae antherarum nigrescentes ca. 2.7 mm longae; appendices antherarum nigrescentes late ovatae ca. 0.3 mm longae et 0.25 mm latae extus multo glanduliferae; rami stylorum abaxialiter multo glanduliferi apice in acuminis breviter appendiculatae, lineis stigmataceis adaxialibus contiguis; achaenia disci complanata ca. 4.0–4.5 mm longa et ca. 1.5 mm lata (ala excepta) margine distincte integriter pallide alata in superficiis lateralibus inferne glabra superne sparse pustulifera apice breviter bi-

dentata et in marginis lateralibus multo minute squamulifera. Grana pollinis in diametro ca. 25–27  $\mu\text{m}$ .

TYPE: BRAZIL: Goiás: Chapada dos Veadeiros, ca. 19 km N of Alto do Paraíso, cerrado on steep rocky slopes, surrounded by campo, outcrops, elev. ca. 1250 m. Shrub ca. 1.5 m tall. Ligules yellow; discs yellow-brown. 29 Mar 1971. *H. S. Irwin, R. M. Harley & G. L. Smith 32779* (Holotype UB; isotypes NY, US). PARATYPES: BRAZIL: Goiás: Chapada dos Veadeiros, ca. 20 km W of Veadeiros, Rocky slopes and wet campo, elev. 1000 m. Shrub ca. 1 m tall. Rays and disc yellow. 11 Feb 1966. *Irwin, Grear, Souza & Reis dos Santos 12608* (NY); Ca. 7 km W of Veadeiros, Burned-over campo, elev. ca. 950 m. Frequent. Shrub ca. 1.5 m. Heads nodding; rays yellow; disc yellow-brown. 15 Feb 1966. *Irwin et al. 12903* (US); Ca. 42 km N of Alto do Paraíso. Riacho margin in cerrado. Cerrado on rocky slopes and adjacent campo, elev. ca. 1250 m. Subshrub to ca. 2.5 m tall. Ligules yellow; disc yellow-brown. 25 Mar 1971. *Irwin, Harley & Smith 33151* (US).

*Dimerostemma grazielae* is closely related to the preceding *D. episcopale* which has a similar habit and which occurs in very similar but disjunct crystalline rock habitats in the state of Bahia to the east. The new species is easily distinguished by the long narrow outer involucre bracts with recurved margins that greatly exceed the length of other parts of the head. The plants of the new species also tend to have a more branched inflorescence with more heads on shorter peduncles. More detailed differences include the paleae of the head having distinctly pointed rather than rounded tips, the punctate glandular hairs having a much more prominent apical cell, and the stigmatic lines of the style branches being contiguous with almost no evidence of the longitudinal division characteristic of other members of the genus. The Bahian species has the broad central groove between its stigmatic lines and has the stalk cells of the glandular hairs much more prominent with a very tenuous apical cell. Collection data on one specimen indicates the heads are nodding, but the consistency of the character is not known.

*Dimerostemma humboldtianum* (Gardn) H. Robinson, comb. nov.

*Viguiera humboldtiana* Gardn., Lond. J. Bot. 7:398. 1848. *Oyedaea humboldtiana* (Gardn) Benth. ex Baker in Mart., Fl. Bras. 6(3):206. 1884. BRAZIL: Goiás: Arid upland Campos near Nossa Senhora d'Abadia. *Gardner 4239* (Isotype US). Additional specimens: BRAZIL: Goiás: Distrito Federal: Burned-over cerrado between Brasília and Sobradinho, elev. 1000 m. *Irwin, Souza & Reis dos Santos 9193*; Cerrado em frente ao Zoobotânico. *Sucre 874*.

The species represents a comparatively glabrous element in the genus. The closest relative is evidently *D. annuum* which has much narrower leaves and comparatively longer outer involucre bracts.

*Dimerostemma retifolium* (Sch. Bip.) Blake,  
Contr. Gray Herb, n.s. 52:11. 1917

*Viguiera? retifolia* Sch. Bip. ex Baker in Mart., Fl. Bras. 6(3):223. 1884. BRAZIL: Mato Grosso: Fields along the Rio Pardo. *Riedel* (Holotype K, photo US).

Material of the species has not been seen. The species was transferred to *Dimerostemma* by Blake, and the key characters given here are those of Blake (1917).



The species appears to belong to the more typical element of the genus, but the leaves are less densely pubescent than any other members of that series.

*Dimerostemma rotundifolium* (Baker) Blake,  
Contr. Gray Herb. n.s. 52:13. 1917

*Oyedaea rotundifolia* Baker in Mart., Fl. Bras. 6(3):208. 1884. BRAZIL: São Paulo: near San Carlos. *Riedel* 1852 (Lectotype selected by Blake 1917, G; islectotypes K, P; photo & frag. US). Additional specimens: BRAZIL: Minas Gerais: Belo Horizonte, Villa Independencia. *Barreto* 2292; Serra do Curral, municipio de Belo Horizonte. *Magalhães* 1509.

The specimens cited all show slender acuminate tips on the paleae of the heads that are not seen on the closely related *D. brasilianum*.

*Dimerostemma vestitum* (Baker) Blake,  
Contr. Gray Herb. n.s. 52:11. 1917

*Oyedaea vestita* Baker in Mart., Fl. Bras. 6(3):207. 1884. BRAZIL: Goiás: Fields near Goiás. *Burchell* 6815 (Lectotype K, photo US). Additional specimens: BRAZIL: Distrito Federal: Reserva Ecológica do IBGE. *Heringer et al.* 5897; Taguatinga. *Heringer et al.* 16731; Cerrado and gallery forest, immediately E of Lagoa Paranoá, elev. 975 m. *Irwin, Souza & Reis dos Santos* 11165; Cerrado, summit of Chapada da Contagem, elev. 1100 m. *Irwin et al.* 11678; 46 km N of the bridge at Asa Norte in Brasília on the dirt road to Vila Buritis, elev. 3100 ft. *King & Almeida* 8219; Chapada da Contagem. 19.5 km NNW of central Brasília, elev. ca. 3400 ft. *King, Almeida & Eiten* 8319; Lado norte de vale de Ribeirão Bananal, elev. 1060 m. *Kirkbride* 3183; Na região de Barra Alta, este do Córrego São Gonçalo, elev. 950 m. *Kirkbride* 3891a; Goiás: Campo and cerrado, sandstone summit, Serra Dourada, ca. 20 km SE of Goiás Velho, elev. 800 m. *Irwin, Souza & Reis dos Santos* 11836; Serra dos Cristais, ca. 10 km W of Cristalina, elev. 1200 m. *Irwin, Grear, Souza & Reis dos Santos* 13556; Serra do Morcêgo, Córrego Estreme, ca. 42 km NE of Formosa, elev. 800 m. *Irwin et al.*, 15141; Serra dos Pirineus, 15 km N of Corumbá de Goiás on road to Niquelândia, in valley of Rio Corumbá, elev. ca. 1150 m.

The species seems closest to the sympatric *D. asperatum* in its few or solitary large heads. As indicated by the name, the species has a distinctive dense pubescence on its leaves and outer involucre bracts, but almost all the specimens can be distinguished more easily by the branches that bear leaves nearly or completely up to the bases of the heads.

*Dimerostemma virgosum* H. Robinson, sp. nov.

Plantae fruticosae ca. 0.7–1.0 m altae multo plerumque pseudodichotome ramosae. Caules pallide brunnescentes teretes antrorse strigosi, internodis ad 10 cm longis in ramis sensim sub 1 cm longis. Folia opposita, petiolis prebrevibus ca. 1 mm longis distaliter indistincte demarcatis; laminae ovato-lanceolatae plerumque 2.0–8.5 cm longae 0.7–1.9 cm latae base late cuneatae margine minute interdum remote serrulatae apice anguste acutae fere ad basem ascendentiter trinervatae supra dense pilosulae persparse glandulo-punctatae subtus dense subvelutinae multo glandulo-punctatae in nervis primariis et secundariis dense



strigosae. Inflorescentiae in ramis terminales unicapitatae, pedunculis 1.5–8.5 cm longis antrorse strigosis. Capitula ad 10–12 mm alta et lata (bractee et flores radii excepta); bractee involucri exteriores ca. 8 late patentes oblongae 5–12 mm longae et 2.5–4.0 mm latae supra dense scabridulae subtus leniter pallidiores dense scabrido-pilosulae, bractee interiores ca. 17 anguste ovatae ca. 5 mm longae et inferne 1.5 mm latae apice anguste acutae vel acuminatae extus planae persparse vel mediocriter breviter pilosulae superne glandulo-punctatae; paleae bracteis interioribus similes superne margine scabridulae apice indurate anguste acutae extus ad medio distincte alatae. Flores radii ca. 17 steriles; corollae flavae extus dense glandulo-punctatae, tubis ca. 1 mm longis infundibularibus puberulis et superne scabrido-pilosulis, limbis linearibus ca. 15 mm longis et 3 mm latis margine in sinis interioribus dense puberulis in nervis pilosulis; achenia radii minute triangularia ca. 1.5 mm longa apice truncata. Flores disci ca. 90 in capitulo; corollae flavae ca. 4 mm longae extus plerumque glabrae, tubis ca. 0.4–0.8 mm longis, faucibus cylindricis ca. 2.5 mm longis base subabrupte campanulatis, lobis ca. 0.8 mm longis et 0.6 mm latis intus praeter basem breviter papillosis extus sparse glandulo-punctatis; filamenta in partibus superioribus ca. 0.4–0.5 mm longa; thecae antherarum nigrescentes ca. 1.7 mm longae; appendices antherarum flavae ovatae ca. 0.5 mm longae et 0.3 mm latae extus multo glanduliferae; rami stylorum abaxialiter et scapi stylorum apice multo glanduliferi, lineis stigmataceis adaxialibus distincte non-contiguis; achenia disci complanata ca. 3 mm longa et 1.2–1.4 mm lata margine irregulariter lobato-alata base anguste cuneata superne in superficiis lateralibus sparse pustulifera apice truncata et dense minute scabridula. Grana pollinis in diametro ca. 25–27  $\mu$ m.

TYPE: BRAZIL: Mato Grosso do Sul: Mun. de Ladário, pantanal. Subarbusto da parte seca, capítulo amarelo, bem ramoso, ocorre formando populações. 8 Nov 1982. *J. Elias de Paula & Claudio A. Conceição* (Holotype IBGE; isotype US).

The pale stems with pseudodichotomous branching and the narrowly ovate leaves with narrowly acute tips are unique in the genus. The shape of the disk corollas, the paleae with a narrow vertical median wing, and the contorted glanduliferous branches of the style, however, are thoroughly characteristic of the genus. The achene seems to have neither awns nor squamellae, but the minute scabrae of the truncated apical surface might be mistaken by some for vestigial squamellae. The species occurs in a comparatively isolated location in the pantanal along the Paraguayan border.

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*CALLOGOBIUS CRASSUS*, A NEW FISH FROM THE  
INDO-PACIFIC REGION  
(TELEOSTEI: GOBIIDAE)

James F. McKinney and Ernest A. Lachner

*Abstract.*—A new gobioid fish, *Callogobius crassus*, is described from New Guinea, and the Philippine, Molucca, and Society islands. This stout-bodied, trenchantly dark and light mottled species is compared with six other species of *Callogobius*. The seven species comprise a group within the genus characterized by stout bodies, ctenoid scales, and a reduced number of segmented dorsal fin elements. *Callogobius crassus* is unique in this group because it lacks cephalic sensory pores.

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In our continuing work on several gobioid genera, we encountered a new species of *Callogobius* from the Philippine Islands, Indonesia, New Guinea, and Tahiti. This new species is most closely allied with a group of *Callogobius* species that is characterized by having a relatively stout body, ctenoid scales and VI-I,9 or fewer dorsal fin elements. Of the species listed by McKinney and Lachner (1978a, Table 1) with the above combination of characters, we presently consider five species to be valid, these being *Callogobius centrolepis* Weber, *C. flavobrunneus* (J. L. B. Smith), *C. maculipinnis* (Fowler), *C. plumatus* (J. L. B. Smith) and *C. sclateri* (Steindachner). Junior synonyms of *C. maculipinnis* include *Callogobius snelli* Koumans, *C. shunkan* Takagi, *Drombus irrasus* J. L. B. Smith, *Intonsagobius kuder* Herre, and *I. vancleve* Herre. *Drombus tutuilae* Jordan and Seal is most likely a junior synonym of *C. sclateri*, while *Callogobius trifasciatus* Menon and Chatterjee is synonymous with *C. flavobrunneus*. We cannot ascertain the validity of *Gobiomorphus illotus* Herre, as the type was destroyed during World War II. The five valid species listed above plus the recently described *Callogobius bauchotae* Goren (1979) and the new species described herein appear to form a discrete group of species within *Callogobius*.

The methods of recording meristic and morphometric data and identification of cephalic sensory structures are given in Lachner and McKinney (1974, 1978) and McKinney and Lachner (1978a, 1978b).

*Callogobius crassus*, new species

Fig. 1

*Holotype.*—National Museum of Natural History (USNM) 220088, male (26.3), Papua-New Guinea, southern tip of Massas Island, 05°10'18"S; 145°51'24"E, depth of capture 0-18 m, collected by V. G. Springer, sta VGS 78-21, 6 Nov 1978.

*Paratypes.*—Philippine Islands: USNM 220086, male (17.5), Bali-casag Island, W side at drop-off, 09°31'14"N; 123°40'00"E, depth of capture 0-24 m, collected by V. G. Springer, sta SP 78-38, 10 Jun 1978; USNM 220087, male (17.2), same locality and collector as above, sta SP 78-39, 11 Jun 1978. Indonesia, Molucca



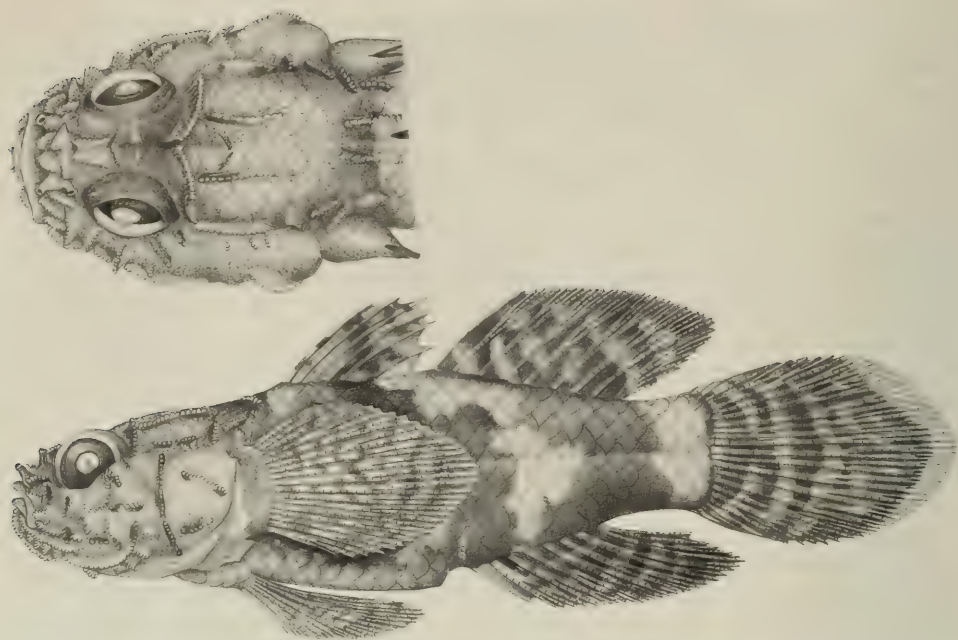


Fig. 1. *Callogobius crassus*, USNM 220088, holotype, a male 26.3 mm SL; dorsal view of head and anterior portion of trunk showing the papillose sensory ridges dorsally and laterally (above); lateral view of entire specimen showing papillose sensory ridges and contrasting color pattern of the trunk and fins (below).

Islands: USNM 210005, male (14.7), Ceram, just off shore and W of Tandjung Namatatuni, collected by V. G. Springer and M. F. Gomon, sta VGS 73-15, 19 Jan 1973; Bernice P. Bishop Museum (BPBM) 18535, male (18.9), Ambon, Eri, SE side of Ambon Bay, collected by J. E. Randall and G. R. Allen, 31 Jan 1975. Tahiti, Society Islands: American Museum of Natural History (AMNH) 51499, male (17.2), female (16.0), not sexed (10.4), reef off Papeari, collected by C. L. Smith, sta S 70-48, 22 Apr 1970.

*Diagnosis.*—Cephalic sensory pores absent; dorsal fin elements almost always VI-I,8; inner rays of pelvic fins connected only at their bases; pelvic frenum absent; scales in lateral series reduced, numbering 19–21; a stout-bodied species with highly mottled trunk and fin coloration.

*Description.*—Dorsal fin elements VI-I,7(1), VI-I,8(6); VII-I,8(1); anal fin elements I,6(1), I,7(7); pectoral fin elements 17 (7), 18 (5), 19 (2); pelvic fin elements I,5(8), segmented caudal fin elements 17(7); branched caudal fin elements 15(4), 16(1), 17(2); lateral scale rows 19–21(2); transverse scale rows 10–11(2), predorsal scales 9–11(3).

Scales on posterior portion of body ctenoid with 1–3 ctenii along posterior margin of each scale; scales on anterior portion of trunk cycloid; scales very eccentric, focal area narrow; 6–10 primary radii and 6–7 secondary radii in large anterior field, 0–3 primary radii and no secondary radii in small posterior field.

Vertebrae 10 + 15(6), 10 + 16(1), pterygiophore formula 3(22110) in 5 specimens, 3(221110) in 1 specimen.



Table 1.—Selected measurements of type specimens of *Callogobius crassus* expressed in thousandths of the standard length.

	Holotype USNM 220088 male	Paratype BPBM 18535 male	Paratype AMNH 51499 female
Standard length (mm)	26.3	18.9	16.0
Head length	354	328	344
Snout length	80	74	75
Bony interorbital width	30	32	31
Greatest diameter of orbit	89	79	81
Upper jaw length	95	101	100
Snout to dorsal-fin origin	414	434	413
Greatest depth of body	270	234	225
Pectoral fin length	346	349	363
Pelvic fin length	285	265	250
Caudal fin length	350	365	419
Pelvic fin insertion to anal fin origin	350	339	350

Measurements for the holotype and two paratypes are given in Table 1.

A small, stout-bodied species of *Callogobius*. Head slightly depressed, body compressed. Interorbital width less than diameter of eye; lower jaw slightly protruding, gape oblique, jaw length short, not reaching posteriorly to vertical through anterior margin of eye; anterior and posterior nares open at end of short tubes whose bases are located close to each other; tongue rounded anteriorly, tip free; gill opening extending to slightly below and slightly anterior to ventral limit of pectoral fin insertion; first dorsal fin distinctly separate from second dorsal fin, second dorsal fin slightly higher than first dorsal fin, origin of second dorsal fin slightly anterior to vertical through anal opening; adpressed pectoral fin extends slightly beyond vertical through origin of anal fin; pectoral fin longer than deep, its posterior margin somewhat pointed; pelvic fin moderate in length, extending about three-fourths distance from pelvic fin insertion to anal fin origin; pelvic frenum absent, innermost rays connected by membrane only at their bases; anal fin almost as high as second dorsal fin, posteriormost rays longest; caudal fin length about equal to that of head, its posterior margin rounded. Genital papilla of male slender, tapering to point, that of female short and bulbous.

Teeth in upper jaw consisting of outer row of about 20 slightly recurved caninoid teeth, spaces between them equal to half their length; two rows of closer spaced teeth behind outer row, inner row teeth about one-half the size of teeth of outer row. Teeth in outer row in lower jaw consisting of about 24 slightly recurved caninoid teeth more closely spaced than those of outer row of upper jaw. Lower jaw with two rows of small, villiform teeth behind outer row. No vomerine or palatine teeth.

The number, size, shape and distribution of papillose ridges on the head are illustrated in Fig. 1. There are no cephalic sensory pores in this species.

*Color in preserved specimens.*—Prominent color pattern consisting of dark brown mottling in form of 2 irregular patches and vertical bar on trunk and black mottling or bars on fins (Fig. 1). Head laterally and dorsally mostly dusky; long dusky mark sometimes extending posteriorly from eye to upper gill opening and another

extending from eye across middle of preopercle and opercle; chin and lower jaw pale to slightly dusky. Prominent trunk marks: dusky transverse bar on nape anterior to origin of dorsal fin; irregular dusky patch from first dorsal fin to anal area, nearly divided at mid-body; another patch, somewhat more regular or bar-like, from posterior half of second dorsal fin to lower peduncle; narrow to broad dusky vertical bar on posterior portion of peduncle and base of caudal fin. Dusky marks separated by pale to cream colored areas. First dorsal fin with broad dark vertical bar through middle portion; remainder of fin with dark and light irregular patches. Second dorsal fin with about 5 dark, wavy, oblique bars, some of which weakly joined, interspaces pale, forming irregular color pattern. Anal fin with 5 or 6 dark, oblique bars, somewhat more regularly arranged than those of second dorsal fin. Caudal fin with 4 or 5 arc-like dark bars with narrow, pale interspaces, outer 2 bars more or less coalesced to form broad area; posterior margin of caudal fin pale. Pectoral and pelvic fins with numerous, narrow, irregular dark and light bars. Specimens with frayed fins and eroded scales showing only remnants of trunk coloration and broken pattern of fin bars into fine, dark spots.

*Etymology.*—The specific name *crassus* is Latin, meaning thick, fat or stout, and refers to the stout body of this species.

*Geographic distribution.*—The new species is known from the southern Philippine Islands to the Society Islands.

*Remarks.*—*Callogobius crassus* is a stout-bodied species with ctenoid scales and a reduced number of segmented dorsal fin elements. In these characters, *C. crassus* agrees with the following six *Callogobius* species: *C. bauchotae*, *C. centrolepis*, *C. flavobrunneus*, *C. maculipinnis*, *C. plumatus*, and *C. sclateri*. The new species can be distinguished from these six species by the absence of cephalic sensory pores. Additionally, the modal counts of VI-I,8 dorsal fin elements and 10 + 15 vertebrae in *C. crassus* contrast sharply with counts of VI-I,9 dorsal fin elements and 10 + 16 vertebrae for the other species (vertebral count not known for *C. bauchotae*). *Callogobius crassus* can be separated from *C. centrolepis* and *C. maculipinnis* on the basis of pelvic fin structure, the latter two species having a typical gobiid pelvic disc and a well developed pelvic frenum. *Callogobius crassus* has 19–21 scales in the lateral series, while all of the other six species except *C. maculipinnis* have 22 or more scales in the lateral series.

Of the six species compared with *C. crassus*, *Callogobius bauchotae* Goren seems to agree most closely with this new species. We have not had the opportunity to examine the holotype, the only known specimen of *C. bauchotae*, but Goren's short description of this species states that it has two median interorbital pores and VI-I,9 dorsal fin elements. Additionally, aspects of the body physiognomy and coloration shown by Goren (1979, Fig. 1) differ from conditions found in *C. crassus*. The figure of *Callogobius bauchotae* shows the first dorsal fin considerably higher than the second dorsal fin and apparently weakly joined to it, lanceolate caudal and pectoral fins, a reduced pattern of papillose ridges on the head considerably different from that of *C. crassus*, and the median fins uniformly colored.

#### Acknowledgments

We thank the staffs of the American Museum of Natural History, New York, and the Bernice P. Bishop Museum, Honolulu, for the loan of specimens of *C.*

*crassus*. The drawing of the holotype was expertly rendered by Jack Schroeder. The manuscript was reviewed by Leslie W. Knapp.

In our description of *Callogobius stellatus* (McKinney and Lachner, 1978b), we erroneously omitted special thanks to Carter Gilbert, Florida State Museum, Gainesville, for exchange of the holotype to the National Museum of Natural History, and we take the opportunity to thank him at this time.

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AN UNUSUAL INDO-WEST PACIFIC CARDINALFISH  
OF THE GENUS *APOGON*  
(TELEOSTEI: APOGONIDAE)

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*Abstract.*—A deep dwelling cardinalfish, *Apogon gularis*, with an unusually positioned anus is described as new from the Red Sea, Indian Ocean, and the Philippine Islands. *Apogon gularis* appears most similar to *A. atrogaster* in body shape and gillraker count but differs from that species in having six first dorsal fin spines, anus near the anal fin, and different color pattern. The presence of two basic types of a forward positioned anus in seven orders in other fishes is discussed.

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The known anatomical diversity of the cardinalfish family Apogonidae is expanded by the description of this unusual deep dwelling species. The advanced position of the anus, tubercle-like organs on the scales, and whitish zone encircling the black tissue around the anal aperture are characteristics of prime interest. Based on our present knowledge the first two characteristics are unique to this species in the family. Nevertheless, other anatomical data do not support generic recognition.

Methods

All measurements were made with dial calipers. Gillraker counts include all rudiments. The raker at the angle of the arch is included in the lower arch count. The last dorsal and anal rays are a composite of two elements divided to the base; in each case they were counted as one. Measurements follow the methods presented in Schultz et al. (1953:xxii), except that the body depth was taken from the dorsal-fin origin to the pelvic fin base. Cleared and stained material was prepared and radiographs of selected material were examined for skeletal comparisons with other Apogonidae.

Type material out of USNM 225678 (National Museum of Natural History) is deposited in the following institutions: Academy of Natural Sciences, Philadelphia; Australian Museum, Sydney; Bernice P. Bishop Museum, Honolulu; California Academy of Sciences, San Francisco; Museum National d'Histoire Naturelle, Paris; British Museum (Natural History), London; Rhodes University, J. L. B. Smith Institute of Ichthyology, Grahamstown, South Africa.

*Apogon gularis*, new species  
Figs. 1-2

*Material examined.*—Holotype: USNM 225672 (36.1 mm SL), Red Sea, 14°55'N, 42°28'E, 13 Jun 1958, R/V ATLANTIS.

Paratypes: USNM 225673, 8 (25.0-29.1), data same as for holotype. Indian Ocean: USNM 225674, 6 (43.2-48.2), 26°35'N, 52°25'E, 73 m, 1 Dec 1963, sta 259A, cruise 4B, R/V Anton Bruun. USNM 225676, 20 (38.2-54.7), 9°54'N,



Fig. 1. *Apogon gularis*, new species, USNM 225672, holotype, 36.1 mm SL, from the Red Sea.

97°42'E, 24 Mar 1963, sta 21, cruise 1, R/V Anton Bruun. USNM 225678, 146 (34.4–57.3), 10°39'N, 97°06'E, 290 m, 24 Mar 1963, sta 22A, cruise 1, R/V Anton Bruun. USNM 225677, 1 (50.5), 10°37'N, 97°34'E, 96 m, 24 Mar 1963, sta 22, cruise 1, R/V Anton Bruun. USNM 203774, 26 (28.7–47.5), 14°07'N, 97°05'E, 30 Mar 1963, sta 38, cruise 1, R/V Anton Bruun (2 specimens cleared and stained). USNM 225679, 31 (35.0–51.5), 13°28'N, 97°19'E, 30 Mar 1963, sta 37, cruise 1, R/V Anton Bruun. USNM 225675, 4 (31.6–36.7), 15°08'N, 94°04'E, 1 Apr 1963, sta 43, cruise 1, R/V Anton Bruun. West Pacific Ocean: USNM 225680, 1 (54.1), Philippine Is., Viscayan Sea, 11°28'42"N, 123°28'42"E, 69.5 m, 5 Jun 1978, "Sting Ray," sta T-4.

*Material of other species examined.*—*Apogon atrogaster* (Smith and Radcliffe, 1912). Holotype, USNM 70249 (46.8). Paratypes, USNM 163227, 7 (35.0–47.5), Philippine Is., Western Luzon, 16°30'N, 120°11'E, 11 May 1909, 83 m.

*Diagnosis.*—Anus shifted forward, located just behind the pelvic-fins' origins; urogenital opening in normal position; 6 first dorsal-fin spines; developed gill-rakers 20–24; 0–3 rudiments; 4–5 rakers on upper arch; 16–19 rakers, 0–2 rudiments on lower arch; total gillrakers 23–26.

*Description.*—For general body shape see Fig. 1. Range of proportions (as percentages of standard lengths): greatest body depth 32.3–34.5; head length 39.2–42.9; eye length 10.0–11.6; snout length 8.9–9.6; bony interorbital width 8.6–9.4; upper jaw length 16.5–18.6; caudal peduncle depth 14.0–15.3; caudal peduncle length 24.7–29.2; first dorsal-fin spine length 10.0–12.0; second dorsal-fin spine length 14.8–17.2; third dorsal-fin spine length 14.7–16.0; fourth dorsal-fin spine length 11.7–13.4; first anal-fin spine length 2.0–2.7; second anal-fin spine length 11.6–12.8; pectoral fin length 23.4–25.5; pelvic fin length 17.8–21.2.

Dorsal fin VI-I,9; anal fin II,8; pectoral fin usually 14–14, rarely 15–14; pelvic fin I,5; principal caudal rays 9 + 8; pored lateral line scales 25; transverse scale rows above lateral line 2; transverse scale rows below lateral line 6; median predorsal scales 5; circumpeduncular scale rows 12–13 (5 + 2 + 5 or 6). The frequency of certain counts is given in Table 1.

Villiform teeth in several rows on the premaxilla; two rows on the dentary; one row on the palatine and vomer; none on ectopterygoid, entopterygoid or basihyal.



Vertebrae 10 + 14. Five free hypurals, one pair of slender uroneurals, three epurals, a free parhypural. Three predorsals, one spine on first dorsal pterygiophore. Basisphenoid present. Supramaxilla absent. Posttemporal serrate on posterior margin. Preopercle serrate on vertical and horizontal margins. Infraorbital shelf present on third bone.

Scales ctenoid, except cycloid below and in front of pectoral fin base and on pelvic fin base. Some individuals have tubercle-like organs on the scales, median pelvic scales, some pelvic fin rays, around the genital papilla, on scales above and below the pectoral fin base and on dorsal-fin rays.

Life colors unknown. In 70% ethanol three closely spaced lines of pigmentation on body extend from just behind opercle posteriorly about length of pectoral fin; snout with horizontal bar extending onto tip of lower jaw; fin membranes behind the second and third spines of first dorsal fin black distally; spots from cheek extend onto opercle in a diagonal fashion. Body otherwise uniformly pale. Stomach and intestine black, anus surrounded by a whitish zone indicative of possible luminous tissue.

*Distribution.*—Apparently a deep dwelling species, our collections from about 60–290 meters. *Apogon gularis* is known from the Red Sea, Western and Eastern Indian Ocean and the Philippine Islands.

*Etymology.*—The specific name is adapted from the Latin word *gula*, meaning throat or gullet, used in reference to the position of the anus which approaches the thoracic region.

*Remarks.*—*Apogon gularis* is unique among all apogonines in having the anus located just behind the pelvic fins' origins. Only *Cheilodipterus nigrotaeniatus* Smith and Radcliffe, and *C. zonatus* Smith and Radcliffe have the anus closer to the pelvic fin base than the anal fin (Radcliffe 1912).

A brief review of other fishes with forward displaced anal openings reveals two basic types in seven Orders: (1) those with both the anus and urogenital openings in the forward position, for example, *Acropoma* (Acropomatidae, Perciformes), *Aphredoderus* (Aphredoderidae, Percopsiformes), *Paratrachichthys* (Trachichthyidae, Beryciformes), *Prosoproctus* (Aploactinidae, Scorpaeniformes), in various gymnotoids (Cypriniformes) and phallostethids (Atheriniformes), (2) those with only a displaced anal opening, the urogenital opening in the typical position just in front of the anal fin, for example, *Steindachneria* (Macrouridae, Gadiformes) and *Apogon gularis* (Perciformes).

Most taxa that have this unusual anal position have generally been accorded generic status. Such taxa, however, have other characteristics that support such treatment. *Apogon gularis* alternatively can be clearly distinguished from other *Apogon* only on the basis of the advanced anal opening. All other characteristics indicate that it is a member of the large subgenus *Nectamia* as defined by Fraser (1972). The only species of *Apogon* that has a similar body shape and has similar gillraker counts is *Apogon atrogaster* (Smith and Radcliffe), in Radcliffe (1912). It has seven first dorsal spines, apparently different color patterns and does not appear to have a forward-positioned anus. The specimens are in poor condition probably as a result of being collected at 83 m by a beam trawl.

Examination of the holotype and paratypes of *A. atrogaster* lead us to believe that there are at least two species represented. The dorsal spines are damaged on the holotype and several paratypes so that we cannot tell if there were seven first



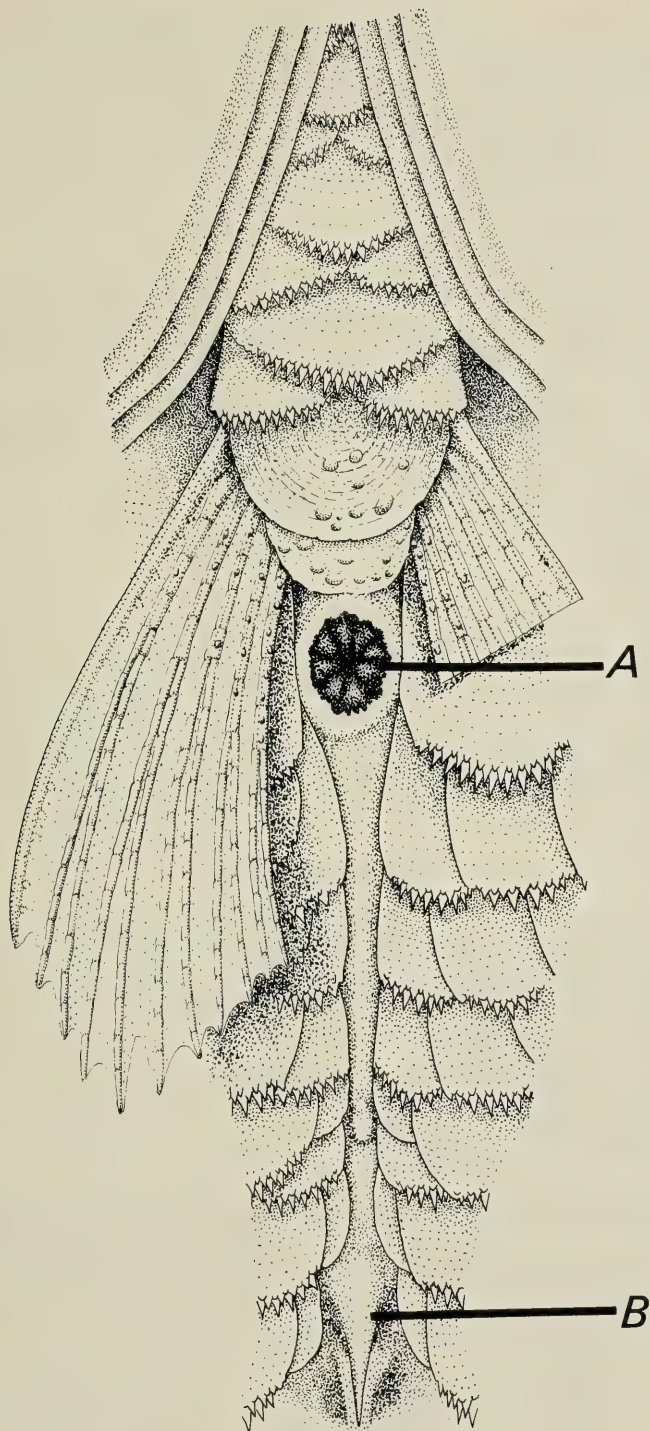


Fig. 2. Ventral view of *Apogon gularis* showing forward position of anus (a) near pelvic fin base. Specimen now cleared and stained, a paratype, out of USNM 225673. The urogenital papilla (b) is shown about 2 scale rows anterior to base of first spine of anal fin.

dorsal fin spines. The description and illustration of the holotype indicate seven. Two paratypes have seven dorsal spines but one has a gillraker count ( $2 + 3$ ;  $13 + 2$ ) which is much lower than the holotype, and we believe it a different species, possibly *A. apogonides* (Bleeker). Our concept of *A. atrogaster* is a seven-spined species with a total gillraker count of 26–27 and an anal opening close to the anal fin origin. This includes only the holotype and largest paratype (47.5 mm). All other type material with six first dorsal spines but with the fin damaged cannot be identified with certainty by us.

*Apogon gularis* has some superficial similarities with species of the subgenus *Rhabdamia* (Fraser, 1972:28) in body shape and color pattern in preservation. However, a number of anatomical differences were mentioned by Fraser (1972: 21, 28).

Tubercle-like organs occur on the large pelvic scales and on the ventral side of the pelvic fin rays as shown in Fig. 2. Close examination of other specimens revealed the presence of the organs also around the genital papilla, on scales above the pectoral fin, on scales between the pectoral and pelvic fins and on the dorsal fins. These structures have not been reported to our knowledge in cardinalfishes.

#### Acknowledgments

We thank James F. McKinney and Susan L. Jewett for taking radiographs of the specimens and for the prints of Fig. 1. The senior author gratefully acknowledges a Smithsonian post-doctoral fellowship that provided the opportunity to work on the systematics of the genus *Apogon*, and subsequent support from General Development Corporation. The drawing (Fig. 2) was rendered by Paul Mazer.

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NEW RECORDS OF THE TROGLOBITIC MYSID GENUS  
*STYGIOMYSIS*: *S. CLARKEI*, NEW SPECIES,  
FROM THE CAICOS ISLANDS, AND  
*S. HOLTHUISI* (GORDON) FROM GRAND BAHAMA  
ISLAND (CRUSTACEA: MYSIDACEA)

Thomas E. Bowman, Thomas M. Iliffe, and Jill Yager

*Abstract.*—*Stygiomysis clarkei*, is described from Conch Bar Cave, Middle Caicos Island, and Snake Cave, Providenciales Island. *Stygiomysis holthuisi*, previously reported from the Antilles (St. Martin, Anguilla, Puerto Rico), is recorded from Lucayan Caverns, Grand Bahama Island, including a female with four fully developed oostegites, a number unique among the Mysidacea.

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The species of *Stygiomysis*, the only genus in the family Stygiomysidae, are blind, troglobitic mysidaceans characterized by a rather vermiform body, a reduced carapace, endopods of thoracopods 2-4 (=pereopods 1-3) prehensile, and protopod of uropod produced into a long distomedial process. The known species are *S. hydruntina* Caroli, 1937, from the Salentine Peninsula, Italy; *S. holthuisi* (Gordon, 1958) from St. Martin, Puerto Rico (Bowman 1976), and Anguilla (Botosaneanu 1980); *S. major* Bowman, 1976, from Jamaica, and *Stygiomysis*, sp. Pesce, 1975, from the Salentine Peninsula, Italy. We describe herein a new species from the Caicos Islands and extend the known range of *S. holthuisi* to Grand Bahama Island.

*Stygiomysis clarkei*, new species

Figs. 1-3

*Material.*—Turks and Caicos Islands: Middle Caicos Island, Conch Bar Cave, 28 Oct 1982, leg. Jill Yager and Thomas M. Iliffe, female holotype 6.2 mm (USNM 204900) and female paratype 4.8 mm (USNM 204901) collected by hand from very small pools, about 1.5 m in diameter, in a totally dark section of the cave; Providenciales Island, Snake Cave, 31 Oct 1982, leg. Thomas M. Iliffe, fragments of paratype (length and sex uncertain-USNM 204902) were collected from depths to several meters using a suction bottle while free diving.

*Distribution.*—Known only from anchialine habitats of inland caves on the Caicos Bank, Turks and Caicos Islands.

*Habitat.*—The Turks and Caicos Islands are geologically and geographically a southeastward extension of the Bahamas. Two shallow water platforms, the Caicos and the Turks banks are separated by a 35 km wide deep water channel, the Turks banks are separated by a 35 km wide deep water channel, the Turks Island Passage. The major islands consist of a broad expanse of low lying flat land facing the interior of the platform, while a range or series of ranges of eolian carbonate hills 20 to 40 m in elevation front the seaward margin, parallel to the long axis of the islands. The youngest hills closest to the seashore are unconsolidated dunes con-



sisting of reef-derived carbonate sand washed ashore and then blown inland by the prevailing trade winds. Those hills further inland are older, probably Pleistocene in age, and have been lithified into a hard eolian limestone. Caves are situated within these lithified dunes, while "Blue Holes," large circular collapse shafts, are found in shallow waters of the interior platform.

Conch Bar Cave, reportedly in excess of 2.5 km long (Gregor 1981), is the largest and most significant cave in the Turks and Caicos group. The cave is developed in a coastal dune-derived hill (Conch Bar Hill) located 500 m inland and consists of multiple levels, the lowest of which is flooded with tidal brackish waters 10 or more meters deep. Our specimens of *Stygiomysis clarkei* were collected from a small shallow pool about 5 cm deep also containing large numbers of juvenile *Barbouria cubensis*. These animals appear to have been stranded in the pool by receding, probably tidal, water levels. The pools are in the main room of the cave system but far enough from the entrance to be in almost complete darkness. Considerable amounts of organic detritus including leaves, twigs, and land snail shells were observed in the sediments in all parts of the cave. Surface water salinity was 23‰. Other animals found in the cave include the amphipod *Spelaeonicippe provo*, the shrimp *Typhlatya garciai*, a new species of polychaete being described by Marian Pettibone, and several copepods now under study.

Snake Cave is located about 1.5 km inland and 1.1 km north of the new airport runway on Providenciales Island. The cave is a long but narrow fissure, mostly water-filled, that forms one margin of a larger collapse sink. Parts of the cave pool are dimly illuminated although the back section remains in near total darkness. Maximum observed water depth was 8 m. In addition to *Stygiomysis clarkei*, the pool also contains the amphipod *Spelaeonicippe provo*, an uncollected shrimp, probably *Typhlatya garciai*, and an undetermined hadziid amphipod now under study by John Holsinger.

*Description.*—In general appearance very similar to *S. holthuisi* and *S. major* but smaller; largest specimen (holotype) 6.2 mm, *S. holthuisi* up to 10 mm, *S. major* up to 20.8 mm. Telson length and width subequal; posterior margin armed as in *S. holthuisi*, having central group of 3 long spines with middle spine longest flanked by group of 3 short subequal spines and lateral group of 3 long spines with inner spine shortest.

Antenna 1 about as long as carapace; outer flagellum slightly longer than inner, 17–19 segmented, all segments except first and last with single very long esthete; inner flagellum 10-segmented. Antenna 2 with small oval scale armed with 1 apical and 2 medial setae; flagellum about as long as antenna 1 inner flagellum, 13-segmented.

Labrium triangular, with very shallow emargination on posterior border. Left mandible with 3-cusped incisor and lacinia; spine-row with 5 spines. Right mandible with 4-cusped incisor plus accessory cusp (fixed lacinia of Gordon 1960); spine-row with 5 spines. Maxilla 1 inner lobe with 4 subequal slender spines; outer lobe with strong spine flanked by pair of slender spines and medially by 7 spines. Maxilla 2 proximal endite with 8 setae; distal endite divided into lobes with 6 and 3 setae; proximal, middle, and distal segments of endopod with 2, 2, and 1 setae; exopod with 7 plumose marginal setae, none of them on medial margin. Maxilliped (first thoracopod) with sparse setation; propus and dactyl relatively short.

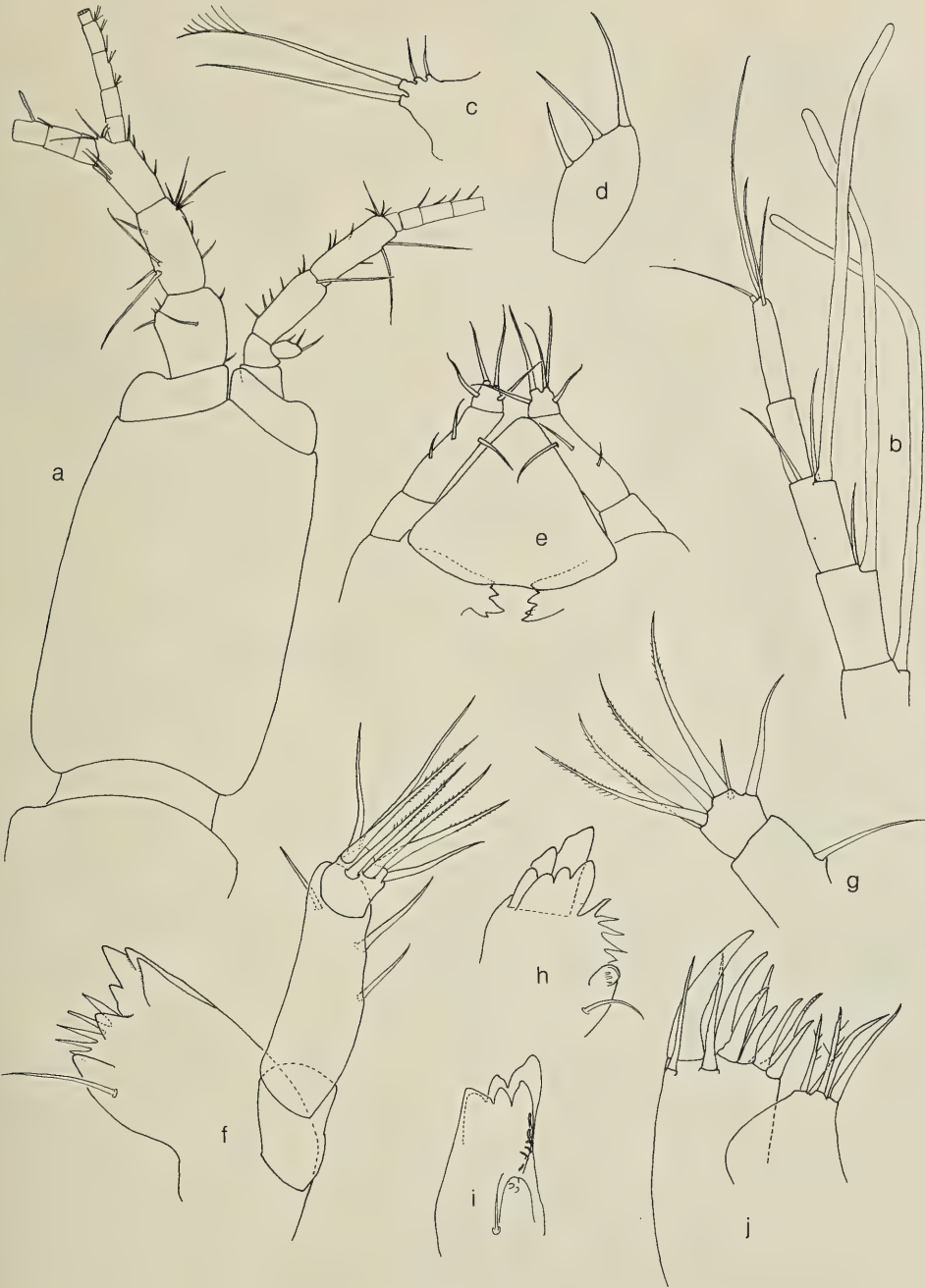


Fig. 1. *Stygiomysis clarki*: a, Anterior end, dorsal; b, Antenna 1, distal segments; c, Antenna 1, apical process of 3rd segment of peduncle; d, Antenna 2 scale; e, Labrum and mandibles in situ; f, Right mandible; g, Left mandible, apex of palp; h, i, Left mandible; j, Right maxilla 1.

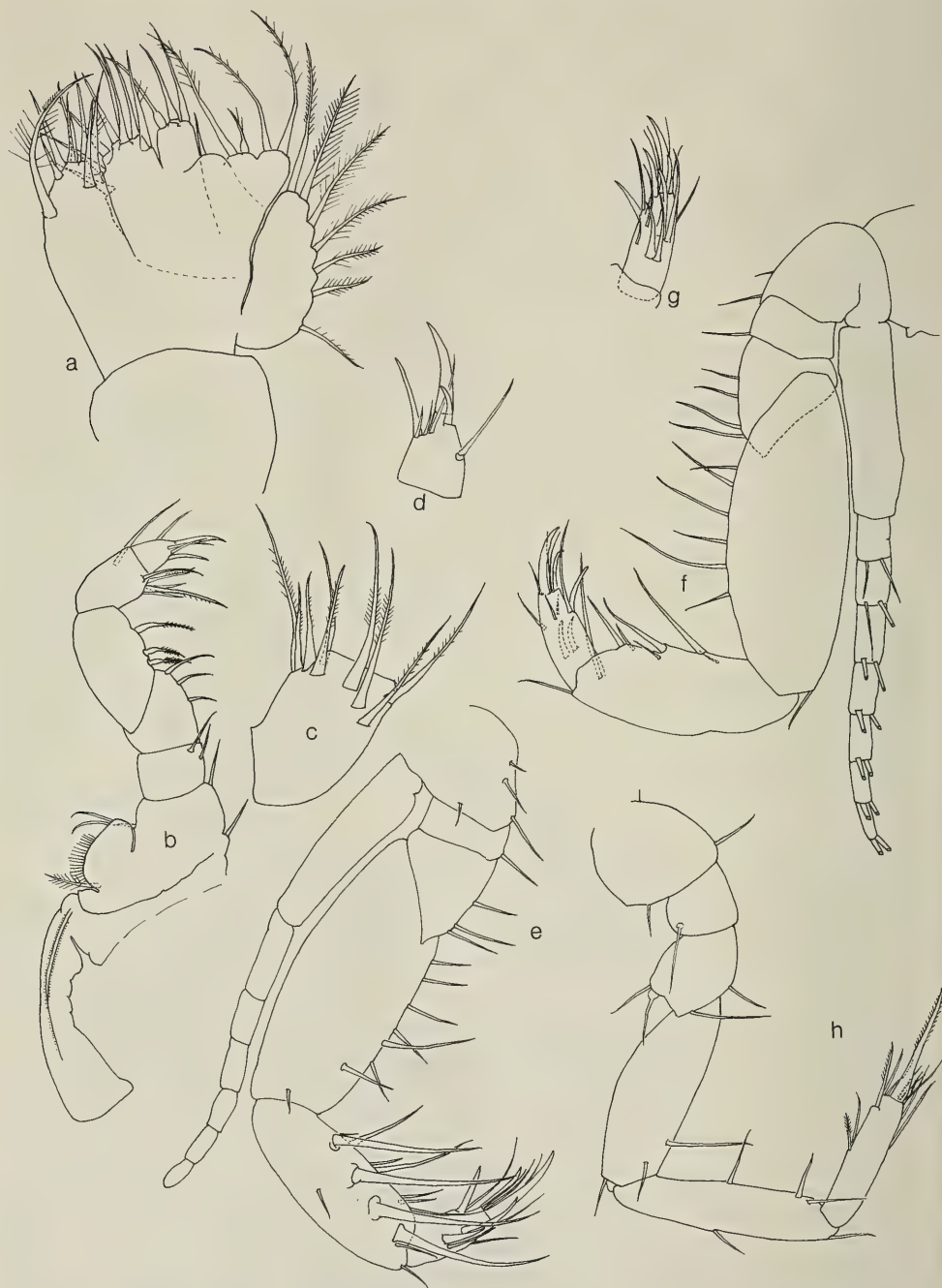


Fig. 2. *Stygiomysis clarkeri*: a, Right maxilla 2; b, Right maxilliped; c, Same, penultimate segment of palp; d, Same, apical segment of palp; e, Right pereopod 1; f, Right pereopod 2, g, Same, dactyl; h, Right pereopod 4.



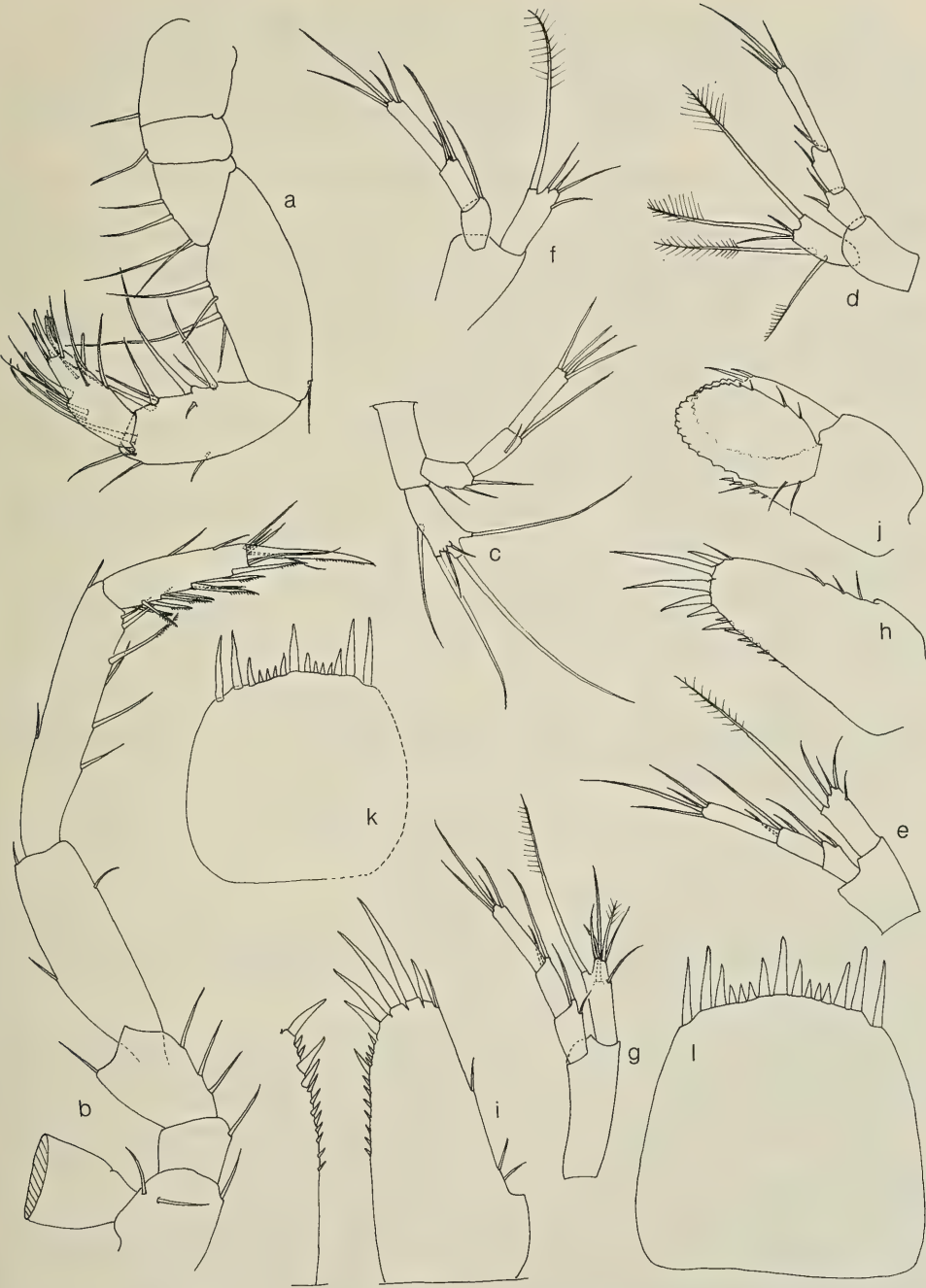


Fig. 3. *Stygiomysis clarkei*: a, Right pereopod 3; b, Pereopod 7; c-g, Pleopods 1-5; h, Protopodal process of uropod, Snake Cave specimen; i, Same, Conch Bar Cave specimen; j, Uropod, Snake Cave specimen; k, Telson, Snake Cave specimen; l, Telson, Conch Bar Cave specimen.

Pereopod 1 (thoracopod 2), apical claw and body of dactyl subequal in length; accessory claw about 0.6 length of apical claw. Pereopod 2, apical claw about 0.7 length of body of dactyl; accessory claw about 0.6 length of apical claw. Pereopod 3, apical claw nearly half length of body of dactyl; 2 accessory claws 0.75 length of apical claw.

Pleopods with 1-segmented endopods and 3-segmented exopods, with setation as in Fig. 3c–g.

Protopodal process of uropod with lateral apical seta and 5 apical spines separated from 1–2 medial spines by 1–4 spinules; medial spine(s) followed proximally by 6–8 spinules. Exopod and endopod relatively short and broad.

*Etymology*.—Named for the late William D. Clarke, in recognition of his contributions to the study of Mysidacea, and for composing and mailing to fellow specialists between 1962 and 1971 15 issues of the useful newsletter “Mysidacea.”

*Comparisons*.—*Stygiomysis clarkei* is easily distinguished from *S. holthuisi* and *S. major* by the proportions of the telson, which is slightly wider than long in *S. clarkei* and longer than wide in *S. holthuisi* and *S. major*. The rami of the uropods are also shorter in relation to their length in *S. clarkei*. Ratios of length to width in the exopod are *clarkei* 1.7, sp. 1.7, *holthuisi* 2.4, *major* 2.6. In the endopod ratios are *clarkei* 2.0, sp. 2.0, *holthuisi* 2.4, *major* 2.7.

*Stygiomysis hydruntina* is incompletely described, but differs from all other species in that the long spines on the dactyl of pereopod 1 exceed the claw in length.

Pesce's *Stygiomysis* sp. most closely resembles *S. clarkei*, but the scale on antenna 2 is hemispherical in shape, and the telson has two rather than three short spines on either side of the central group of three spines.

#### *Stygiomysis holthuisi* (Gordon)

Fig. 4

*Rhopalonurus holthuisi* Gordon, 1958:1552.

*Stygiomysis holthuisi*.—Gordon, 1960:287–299, figs. 1–18, 23–24, pl. 3.—Bowman, 1976:372–373, figs. 31–37.—Botosaneanu, 1980:128–132, figs. 32–37.

*Stygiomysis* sp.—Yager, 1981:328.

*Material examined*.—Bahama Islands: Grand Bahama Island, Lucayan Caverns, Nov 1980, leg. Jill Yager, USNM 204919: female with fully developed oostegites, 7.0 mm; female without oostegites, 4.8 mm; female? in 2 pieces, about 9.2 mm; female? lacking pereonites 6–7, pleon, and telson, estimated complete body length 4.1 mm. (Estimated length derived from proportional measurements of 7.0 mm female).

*Habitat*.—The Bahama Islands consist of shallow water banks with islands similar in topography to those from the geologically and geographically related Turks and Caicos islands described previously. Grand Bahama Island is situated at the northern end of the Bahamas on the Little Bahama Bank and is separated by the deep-water Northeast Providence Channel from the central and southern Bahamas. Lucayan Caverns is the world's longest known underwater cave with more than 10 km of surveyed passages. The main entrance is inland, about 1 km from the sea. A surface lens of fresh water about 14 m in depth is found in rooms and passages throughout the cave. *Stygiomysis holthuisi* was observed crawling

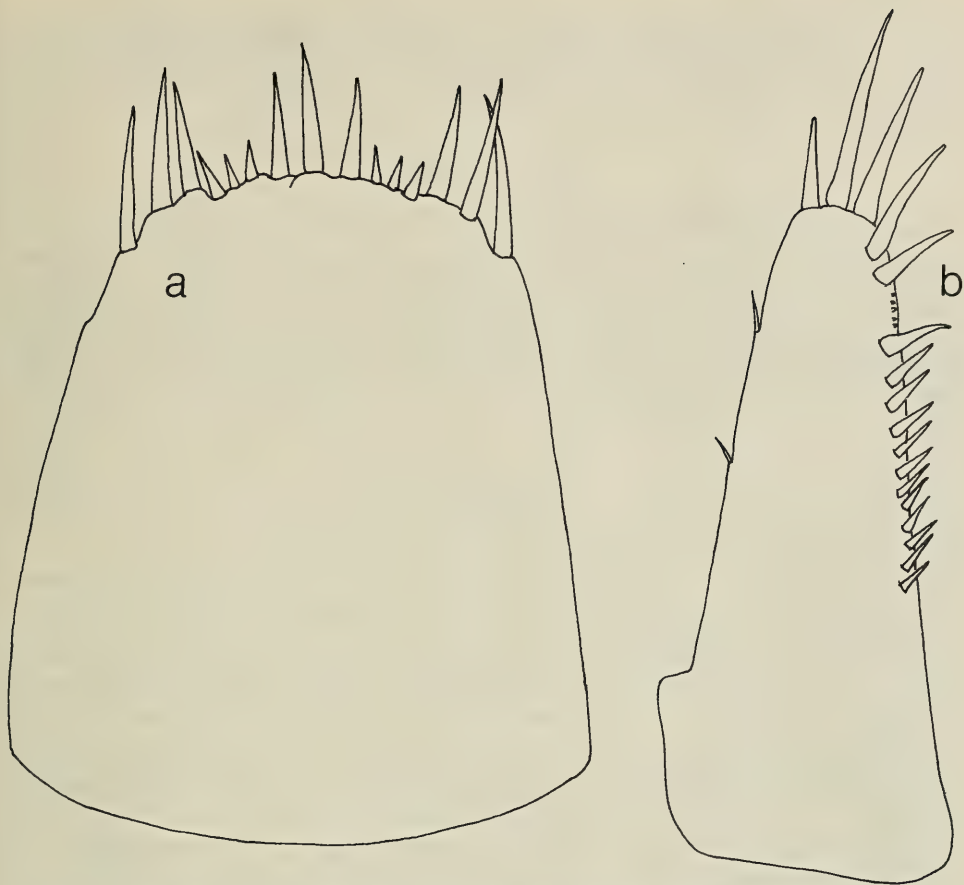


Fig. 4. *Stygiomysis holthuisi*: a, Telson; b, Protopodal process of uropod.

along the rock rubble on the floor of a freshwater passage at a depth of about 4 m.

*Remarks.*—Only the 7.0 mm female is well preserved. The pattern of posterior marginal spines on the telson agrees with previous accounts, but the 4.8 mm female has three small spines to the right and four to the left of the central three spines. The protopodal process of the uropod has more spines proximal to the small spines than previously reported.

The 7.0 mm female is the first *Stygiomysis* found with fully developed oostegites. The oostegites are large, with marginal setae, and occur on pereopods 3–6. Caroli (1937) and Gordon (1960) also found four pairs of developing oostegites on the same pereopods of *S. hydruntina* and *S. holthuisi* respectively, but were uncertain as to how many oostegites would be present on fully differentiated adults. Caroli believed that a full complement of seven would be found as in the Lophogastrida, Lepidomysidae, Petalophthalmidae, and Boreomysinae; Gordon thought there would prove to be at least five pairs. Our female confirms that the number is four, unique among the Mysidacea, and is further evidence for the distinctiveness of the Stygiomysidae.



*Stygiomysis holthuisi* is known to occur on the West Indian islands of St. Martin (Gordon 1960), Anguilla (Botosaneanu 1980), and Puerto Rico (Bowman 1976). The discovery of the Grand Bahama specimens extends the known range by about 1500 km.

### Acknowledgments

Collection of specimens from caves in the Turks and Caicos islands was supported in part by a National Science Foundation Grant (BSR 8215672) to Thomas M. Iliffe. We especially thank Paul and Shirley Hobbs for arranging accommodations and helping us with cave location and collections and Dennis Williams for flying us to various islands as well as also assisting with field collections. This paper is contribution number 989 of the Bermuda Biological Station for Research, Inc.

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HOST, SYNONYMY, AND PARASITIC INCIDENCE  
OF *BOPYRELLA CALMANI* (RICHARDSON)  
FROM CENTRAL CALIFORNIA  
(ISOPODA: EPICARIDEA: BOPYRIDAE)

Clay Sassaman, George A. Schultz, and Ronald Garthwaite

*Abstract.*—*Bopyrella calmani* (Richardson) has been frequently collected along the central California coast, commonly as a branchial parasite of the snapping shrimp *Synalpheus lockingtoni* Coutière. *Bopyrella macginitiei* Shiino is considered a junior synonym of *B. calmani*. The type-host of *B. calmani*, not previously identified, is most probably an ovigerous female among the syntypes of *S. lockingtoni*. Information on parasite-host interactions between *B. calmani* and *S. lockingtoni* is presented. The natural history of this interaction differs in several aspects from that previously reported in many other bopyrid-shrimp interactions.

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Two species of *Bopyrella* Bonnier have been described from the eastern Pacific Ocean, both from the Channel Islands off southern California. *Bopyriscus calmani* Richardson (1905) was described from a single female (with attached male) collected off San Nicholas Island at *Albatross* station 4421. The identity of the host was not recorded in the original description. Bourdon (1980) redescribed the holotype female and allotype male (USNM 32073) and placed the species in *Bopyrella*. He listed the host as *Alpheus* sp. on the basis of a U.S. Fish Commission label contained with the type-material. *Bopyrella macginitiei* Shiino (1964) was described from two females (neither with males) collected off Santa Cruz Island. Both individuals were branchial parasites of the snapping shrimp *Alpheopsis equidactylus* (Lockington).

Individuals of the snapping shrimp *Synalpheus lockingtoni* Coutière (1909) parasitized by a species of *Bopyrella* have been regularly encountered in wharf fouling communities in Monterey Bay, California. Additional parasitized specimens have been collected along other parts of the central California coast. Studies on a series of 36 female isopod parasites (31 with attached males) indicate that there is sufficient morphological variability among these isopods to consider *B. macginitiei* a junior synonym of *B. calmani*. The discovery of *B. calmani* as a parasite of *S. lockingtoni* prompted a search for the type-host of the isopod. Evidence is presented that the host of the type-specimen of *B. calmani* is an ovigerous female discovered among the syntypes of *S. lockingtoni*, which also were collected at *Albatross* station 4421. Aspects of the general biology of *B. calmani* and its parasitic interaction with *S. lockingtoni* are briefly discussed.

*Bopyrella calmani* (Richardson)

Figs. 1A-H, 2A-F

*Bopyriscus calmani* Richardson, 1905:562-563, figs. 617-619.—Shiino, 1949: 49.—Danforth, 1963:7, 38-39, pl. 6, figs. 1-2.—Schultz, 1969:336, fig. 543.—Danforth, 1970:10, 44, 65-66, 150, fig. 13d-e.—Wallerstein, 1980:235.

*Bopyrella macginitiei* Shiino, 1964:22–24, fig. 2a–c.—Schultz, 1969:332, fig. 534c.—Danforth, 1970:9, 43, 60, 151, fig. 7a–b.—Bourdon, 1980:227, 229–230.—Wallerstein, 1980:235.

*Bopyrella calmani* (Richardson).—Bourdon, 1980:185, 187, 225–227, 229–230, fig. 17a–c.

*Female*.—Body axis bent to right or left (18 individuals each). Eye spots present. Body surface generally smooth. Length-width ratio about 1–0.65 to 1–0.75. Cephalon with slightly sinuate frontal margin set slightly in front of anterior border of peraeonal segment I and separated from it only by short lateral notches. Lateral process on anterolateral corner of cephalon usually on short side of body only. Maxilliped with setose palp, setae primarily terminal in larger specimens; extending toward inner margins of maxilliped in small specimens. Posterior border of cephalon (ventral view) slightly indented in midline and with 2 lateral projections on each side smoothly tapering to point. Posterior part of first oostegite with posterolaterally directed thin lobe. Internal ridge of first oostegite smooth medially; rough to tuberculate laterally. All pairs of oostegites on both sides with row of setae on posterior borders. Setae long and organized into well-developed setal fringe only on oostegite pair 5.

Body widest at peraeonal segments II and III. Coxal bosses strongly indicated on segments I–IV, lateral plates usually indicated on segments II–IV of expanded side and I–IV of shorter side. Outer surface of basis of peraeopods of longer side with shieldlike expansion and row of teeth on posterior border. Marginal tubercles posterior to peraeopods V–VII on longer side. Pleon with variable configuration: indications of complete sulci between segments on expanded side in some specimens; only partial marginal separation on edges of others. Marginal segmentation only slightly to moderately indicated on shorter side. (Pleonal segments well separated on both sides in immature females.) Pleotelson entirely set within curves of pleonal segment 5. Biramous oval to oblong pleopods with endopod larger than exopod in first pair, ratio changing progressively so that exopod longer than endopod in last 2 or 3 pairs. (Male adheres to open area between pleopods of female.) Immature females with all endopods longer than exopods. Uropods absent.

*Male*.—Small dark pigment spots as eyes. Frontal margin ranging from slightly concave to slightly convex. Dorsal surface of male (SEM) with slitlike depressions near posterior border of cephalon (over eyes); additional pair of pits on anterior part of cephalon. Antenna 1 with 3 articles. Antenna 2 with 2 articles, both covered with scales. Generally with peraeonal segments I–VII free (in several individuals segment I broadly fused to cephalon). All peraeonal segments with rounded lateral margins; peraeopods subequal in size. Peraeopods with moderately well developed dactyli; patches of scales on inner surfaces of each merus and propodus, sometimes on carpus. Pleon with 3 large free segments, with additional one partially indicated by grooves on pleotelson. In smallest male, pleon with 4 free segments with fifth indicated on pleotelson. Four pairs of pleopods (as oval swellings) on ventral surface of pleotelson (SEM). Underside of anal cone covered with scales, upper surface smooth. Uropods absent.

*Measurements*.—Holotype female 5 mm long by 3 mm wide; attached male 1.1 mm long (Richardson 1905). Other females to 8.0 mm long; males to 2.2 mm



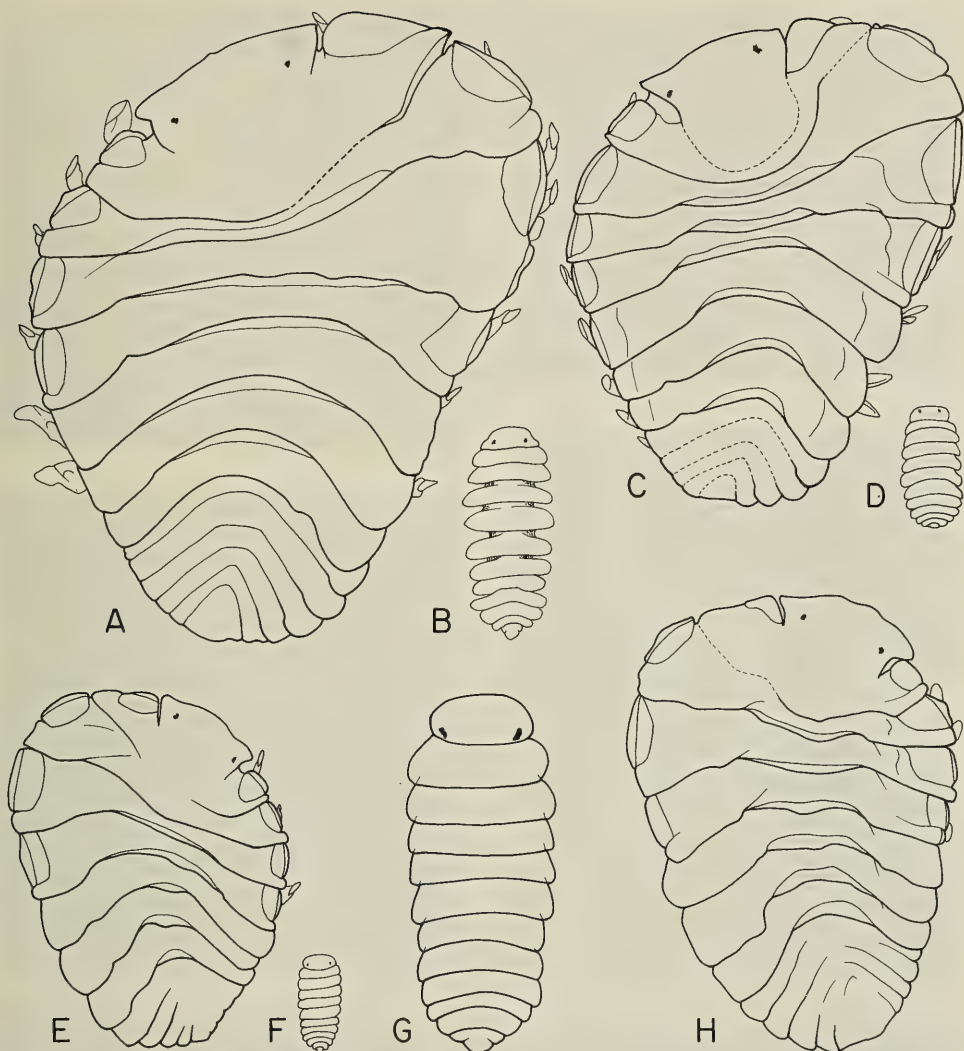


Fig. 1A-H. *Bopyrella calmani*: A, Dextral female 6.3 mm long; B, Male 2.2 mm long from female in A; C, Dextral female 5.0 mm long; D, Male 1.4 mm long from female in C; E, Sinistral female 3.7 mm long; F, Male 1.0 mm long from female in E; G, Projected image of male in F; H, Sinistral female 4.7 mm long.

long. Male length ( $y$ ) is related to female length ( $x$ ) by the expression:  $y = 0.46 + 0.17x$  with high linear correlation ( $r = 0.99$ ).

*Type-locality*.—Albatross station 4421 (Bureau of Fisheries 1906); 12 Apr 1904; 10' Blake Beam Trawl; 419–545 m; 8 km to southeast of easternmost tip of San Nicholas Island, Channel Islands, California.

*Disposition of type-specimens*.—The holotype female and allotype male are in the National Museum of Natural History; USNM 32073.

*Materials and methods*.—Type-specimens in National Museum; 27 females and 23 males from Monterey Bay, California; 9 females and 8 males from Santa

Barbara, California. Three males were examined by scanning electron microscopy—two in ventral and one in dorsal aspect. The ventral surface of one female was also examined. Alcohol-preserved specimens were frozen, lyophilized, and gold-coated prior to examination with a JEOL Stereoscan microscope at 15 Kv. This procedure caused little distortion in males, but much distortion in females. Air-drying after dehydration with alcohol and acetone was generally less satisfactory than lyophilization.

Specimens of the isopods described here (with hosts) have been deposited in the National Museum of Natural History (USNM).

*Distribution.*—*Bopyrella calmani* has been recorded from San Nicholas Island and Santa Cruz Island in southern California. It has also been collected along the central California coast at Coal Oil Point, Santa Barbara Co., at 11 m; at San Simeon, San Luis Obispo Co., in the lower intertidal zone (P. Van Wyk, U. C. Santa Barbara, pers. comm.); and at Monterey Bay, Monterey Co., at depths of 1–9 m.

*Host identity.*—The discovery of *Bopyrella calmani* in *Synalpheus lockingtoni* at Monterey suggested that it might also have been the host of the type-specimen. In 1909, Coutière revised the American species of *Synalpheus*, drawing heavily upon those from the *Albatross* collections. He redescribed *S. lockingtoni* on the basis of specimens from *Albatross* station 4421, the type location of *Bopyrella calmani*. Prior to Coutière's redescription, *S. lockingtoni* was known as *Alpheus leviusculus* Lockington; therefore the initial identification of the host of the isopod as *Alpheus* sp. would have been consistent with the nomenclature of the time.

Fortunately the syntypes upon which Coutière based his redescription of the shrimp are in the collections of the National Museum of Natural History (USNM 41738). One of the four specimens (an ovigerous female measuring 5.3 mm from the middle of the eye to the posterior edge of the carapace) has an enlarged left branchial chamber as is typical of a shrimp infected with a bopyrid. The holotype of *B. calmani* is distorted with the characteristic asymmetry of a bopyrid from the left branchial chamber of a shrimp host. The enlarged swelling on the shrimp includes much of the lateral surface of the carapace and some of pleonal segment 1. The swelling measures approximately 4.9 by 2.9 mm, and is in good agreement with Richardson's (1905) measurements of the isopod of 5 by 3 mm. A thin membrane lining the inner surface of the carapace is broken in places and resembles similar material adhering to the ventral surface of the female type-specimen. The shape, location, and texture of the swollen carapace leave little doubt that the ovigerous female of *S. lockingtoni* from the syntype collection is the type-host of *B. calmani*.

*Synalpheus lockingtoni* is also the host at Santa Barbara, San Simeon, and Monterey. The isopods described by Shiino (1964) were collected from another snapping shrimp, *Alpheopsis equidactylus* (Lockington). *Synalpheus lockingtoni* has been reported from Ecuador to Monterey Bay (Standing 1981). Its depth range is low intertidal to about 530 m (*Albatross* station 4421). *Alpheopsis equidactylus* is reported from the Channel Islands (Shiino 1964) and along the California coast from Palos Verdes to Monterey at depths from the low intertidal to 60 m (Word and Charwat 1976).

*Remarks.*—There are some substantial discrepancies between the initial description of the holotype of *Bopyrella calmani* (Richardson, 1905) and the sub-



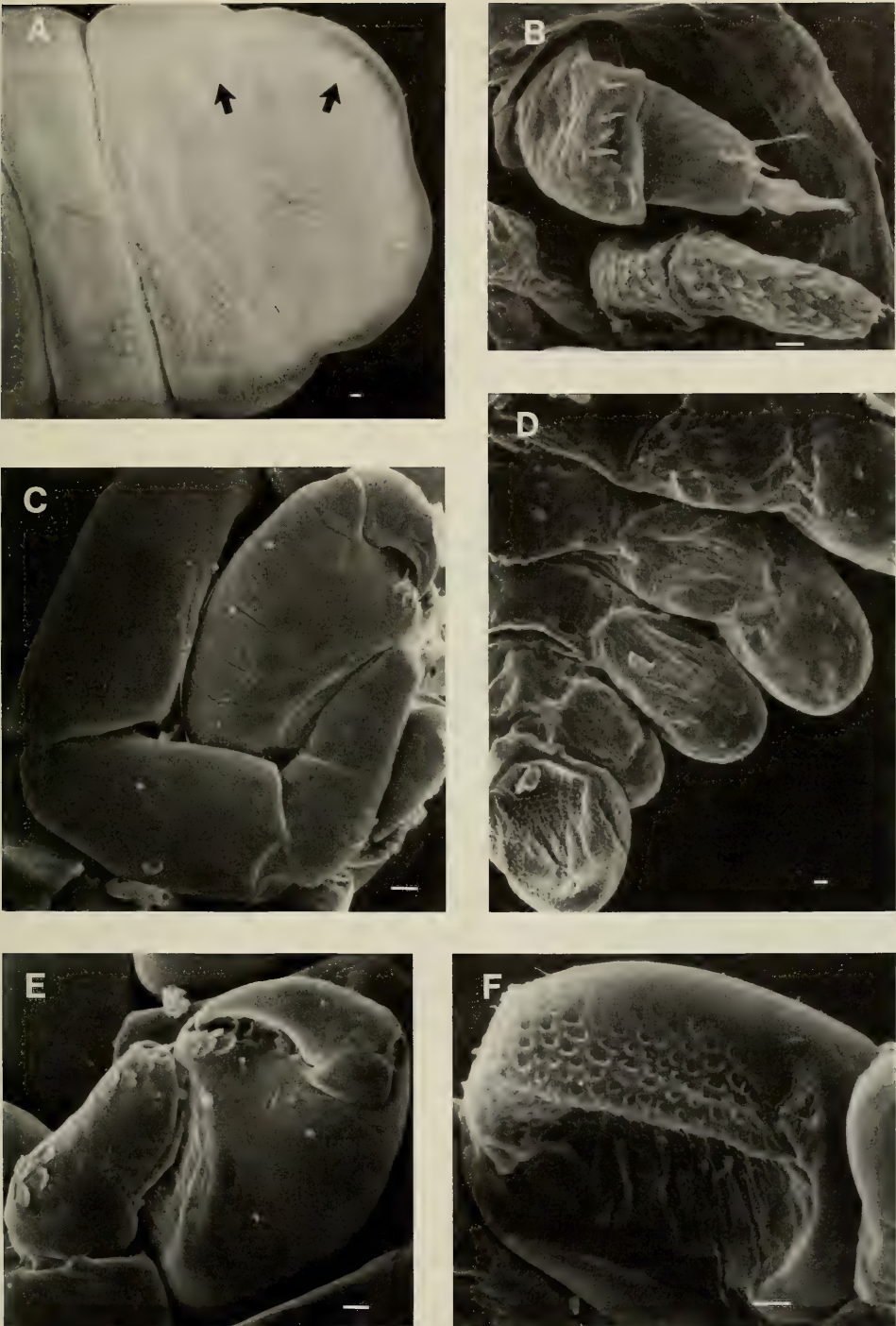


Fig. 2A-F. *Bopyrella calmani*, scanning electron micrographs of the male, scale bars 10  $\mu$ m: A, Fusion of cephalon and pereopod segment I, arrows indicate dorsal pits of the left side; B, Ventral view of antennae; C, Pereopod 7; D, Ventral view of pleopods and anal cone; E, Distal articles of pereopod 2; F, Ventrolateral view of anal cone.



Table 1.—Incidence of *Bopyrella calmani* in monthly samples of *Synalpheus lockingtoni*.

Location	Date	Number of <i>S.</i> <i>lockingtoni</i>	% parasitized by <i>B.</i> <i>calamani</i>	Carapace lengths of shrimp (mm)			
				Infected		Uninfected	
				$\bar{x}$	(SD)	$\bar{x}$	(SD)
Monterey Bay	1 Aug 82	30	26.7	7.08	(1.17)	7.00	(1.22)
	12 Nov 82	17	17.6	7.66	(1.97)	6.79	(1.66)
	7 Jan 83	16	6.3	—	—	—	—
	4 Mar 83	31	6.5	—	—	—	—
	29 May 83	52	7.7	6.76	(0.87)	5.57	(2.00)
	10 Sep 83	52	9.6	7.32	(1.08)	5.69	(1.70)
Santa Barbara	4 Dec 82	14	64.3	5.11	(0.63)	4.43	(0.39)

sequent redescription of it by Bourdon (1980). Richardson indicated the presence of eye spots, and figured all the peraeonal segments as free. Bourdon depicted indistinct separation of the peraeonal segments (particularly along the midline), and did not indicate eye spots (although noting their mention in the original description). The two authors also disagree about the extent of separation of the pleonal segments. It is possible that some of the differences between the two descriptions represent artifacts due to the length of storage of the types. Preservation of isopod specimens in alcohol does cause the eye pigment to leach, and in *B. calmani* has led to some differential shrinkage of the female type-specimen. Richardson recorded the holotype as 5 mm long; Bourdon recorded it as 4.2 mm. Furthermore, the body is not closely applied to the cuticle. The differences in description of the peraeonal and pleonal segmentation patterns could be due, in part, to an imperfect alignment of the cuticular pattern of segments relative to the pattern of lines and creases in the underlying tissues. Alternatively (or additionally) some of the discrepancy could be due to differences in interpretation. Our series of specimens (Fig. 1) indicates a great deal of variability associated with the segmentation of both the pleon and peraeon. Some specimens (Fig. 1C) have a partially discernible posterior border to the cephalon, whereas in others (Fig. 1E) the first 2 peraeonal segments are incompletely defined. Similarly a range of variation is present in the degree of separation of the pleonal segments (Fig. 1A, E). In immature females, the lateral borders of the pleon are considerably more symmetric with separations of the edges being distinct on both sides of the body.

For the male, our specimens closely resemble the description of the allotype by Bourdon (1980) with some exceptions. First, although most of the males examined have a free peraeonal segment I, several individuals had the cephalon fused to peraeonal segment I (Fig. 2A). Second, our SEM examinations indicated four pairs of pleopods (Fig. 2D) rather than three pairs as reported by Bourdon (1980). Variation in the shape of males is common (Fig. 1B, D, F). Also immature males have four free pleonal segments rather than three as do typical adult males. Fusion of the pleonal segments apparently occurs during development in males and pleonal segment number is reduced.

In general, however, the specimens of both sexes from Monterey and Santa

Barbara exhibit a range of morphological variation which can easily include the characters of both *B. calmani* and *B. macginitiei*. Accordingly, *B. macginitiei* Shiino (1964) is a junior synonym of *B. calmani* (Richardson, 1905).

*Affinities.*—*Bopyrella calmani*, *B. harmopleon* Bowman and Diaz-Ungria, and *B. malensis* Bourdon appear on male and female pleonal characteristics to represent a natural grouping of species within the genus as suggested by Bourdon (1980). All are parasites of snapping shrimps of the genus *Synalpheus*; *B. calmani* is also reported from *Alpheopsis*. Within this grouping, *B. calmani* is closest in morphology to *B. harmopleon*, a species of the western Atlantic Ocean. The principle differences are that in *B. calmani* the body axis is less distorted than in *B. harmopleon*, males of *B. harmopleon* more often have the cephalon fused to pereopod segment I, and *B. harmopleon* males are reported to lack pleopods (Bowman and Diaz-Ungria 1956; Lemos de Castro 1965).

### General Biology

In nine of ten collections made at Monterey, California, between March 1981 and September 1983, specimens of *Synalpheus lockingtoni* parasitized by *Bopyrella calmani* were obtained. Only one sample (January 1982) did not contain any parasitized shrimp. Most parasitized shrimp (26) were removed from wharf fouling communities dominated by the polychaete *Phyllochaetopterus prolifica* Potts collected from Wharf #2 at 1–5 m deep. One was removed from a kelp holdfast from about 9 m deep. The presence of *Synalpheus lockingtoni* itself at Monterey Bay is noteworthy, since only one individual of this shrimp has ever been recorded north of Point Conception (Standing 1981). Two other alpheid shrimps (*Betaeus gracilis* Hart and *Alpheus clamator* Holmes) were collected along with *S. lockingtoni*; neither were infected by bopyrids. A second species of bopyrid, *Aporobopyrus muguensis* Shiino, was common in both the wharf and holdfast communities, being found primarily in the porcellanid crab *Pachycheles rudis* Stimpson and occasionally in *P. pubescens* Holmes.

The incidence of parasitization of *Synalpheus lockingtoni* by *Bopyrella calmani* was monitored from August 1982 to September 1983. The numbers of shrimp and the frequency of parasitism in each collection are given in Table 1. Although the data suggest a possible seasonal pattern of infestation similar to that reported in San Francisco Bay populations of the bopyrid *Argeia pauperata* Stimpson (Gifford 1934), the variation in incidence frequencies is not statistically significant (G-statistic). The average frequency of parasitism for all six samples from Monterey Bay was 12%, which differed significantly from the incidence in a small collection from Santa Barbara in December 1982 (Table 1). Mature female isopods were found in all months sampled, but only the November 1982 and May 1983 collections contained immature individuals. Cryptoniscus larvae were never found.

*Bopyrella calmani* differentially infected larger individuals of *S. lockingtoni*. In two of the individual collections (December 1982 and May 1983) the average lengths of infected shrimp were significantly greater than those of uninfected ones (Table 1). Two-way analysis of variance of shrimp lengths over all of the collections indicated a highly significant difference, with infected shrimp being larger than uninfected shrimp. No hosts less than 4 mm in carapace length were parasitized. The lengths of mature female isopods were highly correlated with host length (Fig. 3). This correlation did not extend to immature female parasites. They were found

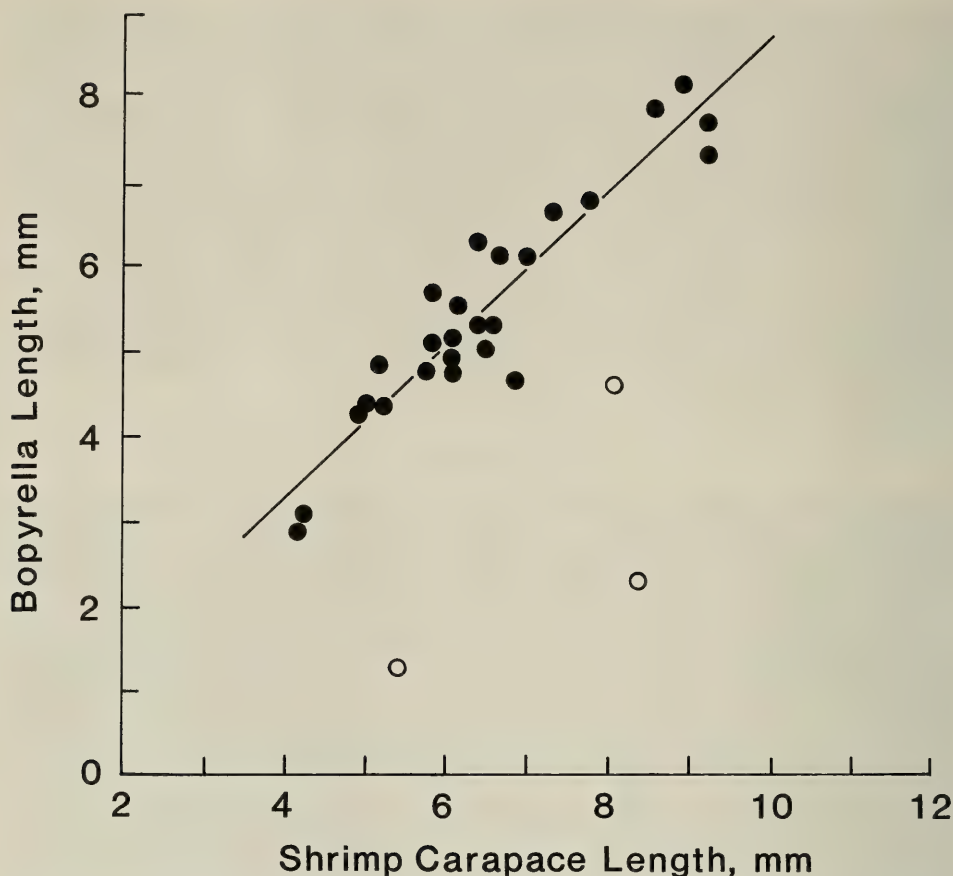


Fig. 3. Correlation between female isopod length and host carapace length. Filled symbols represent mature female isopods, open symbols are immature female isopods.

in large hosts (Fig. 3), suggesting that primary infection by *B. calmani* occurs in relatively large hosts. This pattern is unlike that in many other bopyrid host-parasite systems in which primary infection occurs only in smaller hosts (for review, see Beck 1980).

Brood sizes of *B. calmani* were determined, by direct count, for six gravid females of the August 1982 sample. Brood size averaged 6145, and ranged from 2119 to 13082. Brood size was highly correlated ( $r = 0.97$ ) with female length, the relationship between brood size ( $y$ ) and isopod length in mm ( $x$ ) following the relationship:

$$y = 10.3 x^{3.47}.$$

The average brood size of *B. calmani* was comparable to that previously reported for other bopyrids of comparable body length (Bourdon 1968; Beck 1980; Truesdale and Mermilliod 1977; Wenner and Windsor 1979).

*Bopyrella calmani* does not cause parasitic castration of female *S. lockingtoni*. One quarter of all shrimp with brood embryos were parasitized by *B. calmani*.



Van Wyk (1982) has recently reported that although brood size in the crab *Pachycheles rudis* is reduced on parasitization by *Aporobopyrus muguensis*, female reproductive function is not completely destroyed. A similar instance has been reported in *Argeia pugettensis* (Dana), another bopyrid which is common along the Pacific coast (Danforth 1963).

### Acknowledgments

We thank Dr. M. K. Wicksten (Texas A&M University) for the identification of *Synalpheus lockingtoni* and for helpful comments about alpheid nomenclature, Dr. T. E. Bowman (National Museum of Natural History) for making available type-material, Mr. P. Van Wyk (U.C. Santa Barbara) for specimens and range records, Ms. M. Heinold (U.C. Riverside) for library assistance, and Mr. M. Norris (Sea Life Supply Co., Sand City, CA) for his willingness to collect material for us.

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THE STATUS OF THE HIPPOLYTID SHRIMP  
GENERA *BARBOURIA* AND *LIGUR*  
(CRUSTACEA: DECAPODA):  
A REEVALUATION

Raymond B. Manning and C. W. Hart, Jr.

*Abstract.*—The genera *Barbouria* and *Ligur* are considered to be monotypic. *Parhippolyte* is removed from the synonymy of *Ligur*, and a new genus, *Janicea*, is recognized to receive *Barbouria antiguensis* Chace. These four genera and *Somersiella* comprise a homogeneous grouping of five monotypic genera within the Hippolytidae.

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The status and relationships of the hippolytid shrimp genera *Barbouria* Rathbun and *Ligur* Sarato have long puzzled students of these shrimps. Until now, each of these genera contained two species: one in marine and subtidal habitats and one anchialine, confined to land-locked saltwater caves and pools. Holthuis (1963: 272-277) remarked that *Barbouria* resembled *Ligur* "in almost every detail" (p. 272). In features "like the shape of the mandibular palp, with the long last joint, the long and slender legs, the multiarticulate carpus of the second pereopods and the arrangement of antennal and branchiostegal spines on the carapace, there is the closest resemblance between *Ligur* and *Barbouria*" (p. 277).

Chace (1972) described a second species of *Barbouria*. He remarked (p. 110) that Holthuis' observations were strengthened by the finding of *B. antiguensis*, and concluded "It is possible that *Barbouria* eventually will be relegated to the synonymy of *Ligur* or perhaps that *Barbouria* will revert to its previous monotypic status and that *B. antiguensis* will be transferred to *Ligur*." In his account, he noted that *B. antiguensis* agrees with *B. cubensis* [and differed from species of *Ligur*] in lacking arthrobranchs on the pereopods, but differs in having the carpus and propodus of the third to fifth pereopods multiarticulate and in having a terminal cluster of coupling hooks on the endopod of the first pleopod of the male. Further, although *Ligur uveae* has prominent arthrobranchs on the pereopods, it agrees with *B. antiguensis* in having a multiarticulate propodus on the walking legs as well as terminal coupling hooks on the endopod of the first male pleopod.

In 1977 Buden and Felder reported that although the coupling hooks are absent in some specimens of *B. cubensis* from Providenciales, they are present in others. They concluded (p. 111) that "The presence of these coupling hooks in both species of *Barbouria* is further evidence that this genus and *Ligur* are closely allied and increases the likelihood that *Barbouria* will eventually be placed in synonymy of *Ligur*."

The status of the two species assigned to *Ligur* also has been questioned by some authors. *Ligur* was established in 1885 for a deep water species from the Mediterranean, *L. edwardsii* Sarato, a species previously described by Risso (1816) as *Palaemon ensiferus* (see Holthuis 1977:50, for an historical account of this species). A second species, *L. uveae* (Borradaile), originally described in the mono-



typic genus *Parhippolyte* by Borradaile (1899), was transferred to *Ligur* by Kemp (1914:83, 122, 123), without comment. Gordon (1936) presented some observations on the two species of *Ligur*, and commented (p. 102) that "*L. uveae* was first recorded from the Loyalty Islands and briefly described by Borradaile, who, however, omitted to mention that the propodi of the slender walking legs are multiarticulate. This omission was later made good by the same author when he recorded the species from Aldabra in the western Indian Ocean. But he did not mention that, in having the propodi of pereopods 3–5 segmented, *Ligur uveae* is unique amongst the Caridea."

Monod (1968), in recording additional material of *L. uveae* from the Loyalty Islands, commented on the differences between the two species then assigned to *Ligur*, and remarked (p. 777):

"Bien des détails sont comparables ou identiques chez les 2 espèces, par exemple les pléopodes ♂, mais la différence dans les périopodes est très importante (P 3–5 à propode segmenté dans *L. uveae*, simple dans *L. ensiferus*).

"Cette différence est-elle ou non de valeur générique, ou, au moins, sub-générique? Je n'ai pas l'intention d'en décider ici et préfère, pour le moment, suivre l'opinion des divers auteurs (BORRADAILE, KEMP, GORDON, HOLTHUIS) qui ont tenu les deux espèces pour congénériques. Au cas où la multi-articulation du propode P 3–5, unique chez les Crevettes comme le rappelait GORDON (1936), se verrait attribuer une valeur supra-spécifique, le taxon *Parhippolyte* Borradaile, 1900 [sic] reste, évidemment, disponible.

"Peu après d'ailleurs, CALMAN (1939:210), après avoir signalé la présence de *Ligur edwardsii* dans la région des Maldives, suggérait que *Ligur uveae* pourrait bien être génériquement distinct de *L. edwardsii*; *L. uveae* redeviendrait dans ce cas *Parhippolyte uveae* Borradaile. Je n'ai pas cru pouvoir aller encore jusque là, mais quand les plus nombreux spécimens des deux espèces, *ensiferus* (= *edwardsii*) et *uveae* seront connus, l'éventualité d'une séparation des deux genres est nullement à écarter."

Thus each of these two genera was considered to contain two species, one marine, one anchialine, one with normal walking legs, one with the carpus and/or propodus of the walking legs multiarticulate. In *Barbouria*, the species with multiarticulate walking legs was marine, the other confined to anchialine habitats. In *Ligur* the species with multiarticulate walking legs was anchialine, the other living in the open sea.

The discovery of a fifth species in this complex, described as new by us (Hart and Manning 1981) and assigned to the monotypic genus *Somersiella*, and the subsequent discovery of *Barbouria antiguensis* in a marine cave in Bermuda (Iliffe, Hart, and Manning 1983), has prompted us to reevaluate the species of *Barbouria* and *Ligur* as part of our long-term studies of the anchialine shrimps of Bermuda. We consider the grouping of species in *Barbouria* and *Ligur* to reflect poorly at best the relationships of the four species involved; it seems to us highly unlikely that multiarticulate segments on the walking legs would evolve independently in different members of each of two genera. We have already noted (1981:446) that "We suspect that *B. antiguensis* should be referred to a new genus." In our opinion the multiarticulate walking legs, in combination with other characteristics of the species of *Barbouria*, *Ligur*, and *Somersiella*, must be considered as generic characters.

Here we present the results of our examination of material of each of these species. We remove *Parhippolyte* from the synonymy of *Ligur*, and we assign *Barbouria antiguensis* to a new genus. Thus, in this complex of closely related shrimps, we recognize five monotypic genera: *Barbouria*, containing only *B. cubensis*; *Janicea*, new genus, containing *Barbouria antiguensis*; *Ligur*, with *L. ensiferus*; *Parhippolyte*, with *P. uveae*; and *Somersiella*, with *S. sterreri*.

Accounts of the Genera  
*Barbouria* Rathbun, 1912  
Fig. 1

*Barbouria* Rathbun, 1912:455. (Type-species *Barbouria poeyi* Rathbun, 1912, a subjective junior synonym of *Hippolyte Cubensis* von Martens, 1872, by original designation and monotypy). Gender feminine.

*Habitat*.—Anchialine caves and sinks.

*Distribution*.—Western Atlantic: Cuba, Bahamas, Turks and Caicos Islands, Cayman Brac, and Bermuda (Hobbs, Hobbs, and Daniel 1977; Viña and Dávila 1980; Hart and Manning 1981).

*Definition*.—Carapace with antennal and branchiostegal spines. Rostrum slender, about 5 times longer than high, but short, extending slightly beyond end of basal segment of antennular peduncle, with 4–7 dorsal (3 postorbital) and 1–4 ventral teeth. Eyes pigmented, cornea narrower than stalk. Anterior 4 abdominal pleura rounded, fifth and sixth with posteroventral corner produced into spine. Telson with 2 pairs of dorsal spines and 3 pairs of terminal spines, middle longest. Epipods (5): present on third maxillipeds and anterior 4 pereopods. Pleurobranchs (5): present on all pereopods. Arthrobranchs (2): on third maxilliped. Podobranch (1): on second maxilliped. Mandible lacking incisor process, with 3-jointed palp. Pereopods 1 and 2 chelate; merus, carpus, and propodus of second leg multiarticulate. Pereopods 3–5 with merus, carpus, and propodus undivided. Endopod of first pleopod of male lacking appendix interna, with or without distal coupling hooks. Endopod of second pleopod of male with appendix masculina shorter than appendix interna.

*Janicea*, new genus  
Fig. 2

*Type-species*.—*Barbouria antiguensis* Chace, 1972.

*Etymology*.—We consider it appropriate to dedicate this genus to Janice Chace, who has provided encouragement for her husband, Fenner A. Chace, Jr., throughout a career spanning more than five decades.

*Habitat*.—Marine, sublittorally on seawalls or in marine caves.

*Distribution*.—Western Atlantic: Antigua and Bermuda (Chace 1972; Iliffe, Hart, and Manning 1983).

*Definition*.—Carapace with antennal and branchiostegal spines. Rostrum slender, about 5 times longer than high, but short, extending about to end of basal segment of antennular peduncle, with 3–4 dorsal (1–2 postorbital) and 1 ventral teeth. Eyes pigmented, cornea broader than stalk. Anterior 4 abdominal pleura rounded, fifth acute posteroventrally with posteroventral corner produced into

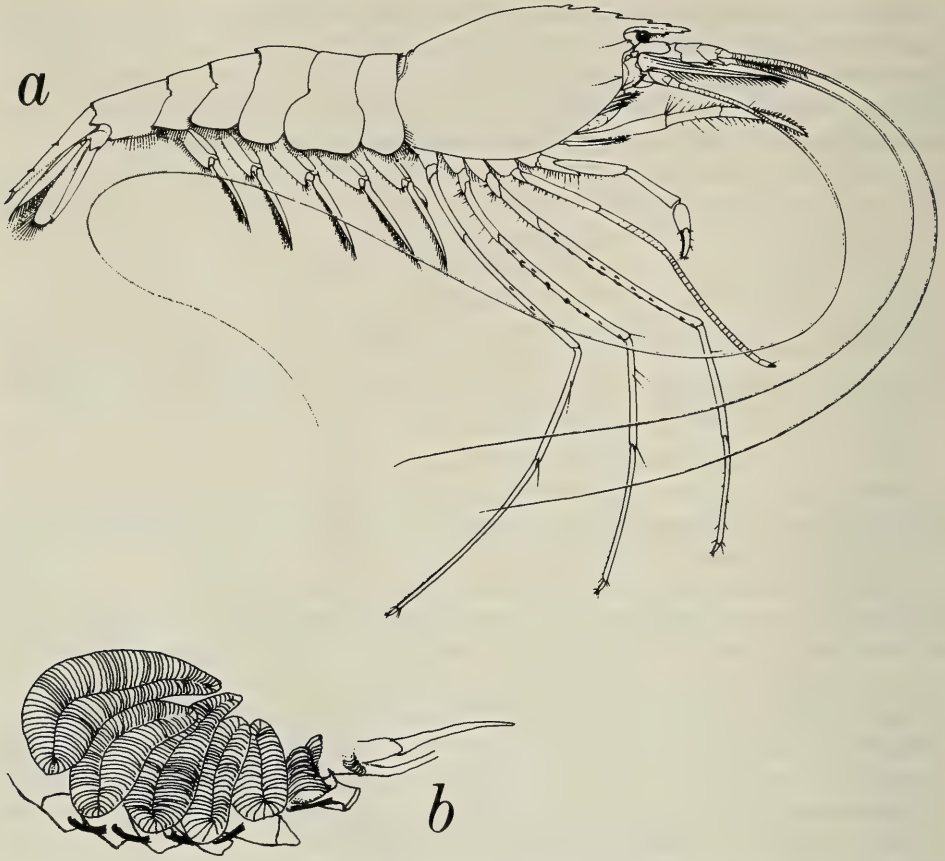


Fig. 1. *Barbouria cubensis* (von Martens): *a*, Animal in lateral view (from Hobbs, Hobbs, and Daniel 1977: fig. 33); *b*, Gill complement (*b* from a specimen from San Salvador, Bahamas, USNM 181659).

sixth spine. Telson with 2 pairs of dorsal spines and 3 pairs of terminal spines, middle longest. Epipods (6): on second and third maxillipeds and anterior 4 pereopods. Pleurobranchs (5): present on all pereopods. Arthrobranchs (2): on third maxilliped. Podobranch (1): on second maxilliped. Mandible lacking incisor process, with 3-jointed palp. Pereopods 1 and 2 chelate; merus, carpus, and propodus of second leg multiarticulate. Pereopods 3–5 with carpus and propodus multiarticulate. Endopod of first pleopod of male without appendix interna but with distal coupling hooks. Endopod of second pleopod of male with appendix masculina longer than appendix interna.

*Ligur* Sarato, 1885

Fig. 3

*Ligur* Sarato, 1885:2. (Type-species *Ligur edwardsii* Sarato, 1885, a subjective junior synonym of *Palaemon Ensiferus* Risso, 1816, by monotypy). Gender masculine.



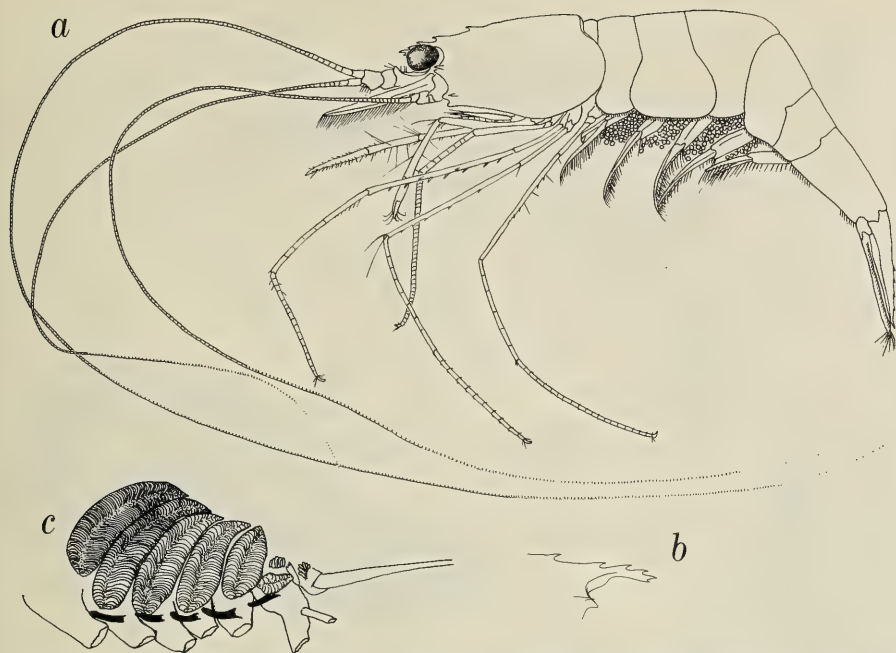


Fig. 2. *Janicea antiguensis* (Chace): a, Animal in lateral view; b, Rostrum (from Chace 1972: fig. 40b); c, Gill complement (a and c from paratypes from Antigua, USNM 135376).

*Habitat*.—Marine, sublittoral in ca. 300 to 772–860 meters.

*Distribution*.—Western Indian Ocean, western Mediterranean, northeastern Atlantic off the Cape Verde Islands and Senegal (Crosnier and Forest 1973), and western Atlantic, Cay Sal Bank (Lemaitre 1983).

*Definition*.—Carapace with antennal and branchiostegal spines. Rostrum slender, length about 5 times depth, long, overreaching antennular peduncle, extending almost to apex of antennal scale, with 3–4 dorsal (1 postorbital) and 4–5 ventral teeth. Eyes pigmented, cornea broader than stalk. Anterior 4 abdominal pleura rounded, pleura of fifth and sixth segments with posteroventral corner produced into spine. Telson with 2 pairs of dorsal spines and 2 pairs of terminal spines, outer longer. Epipods (7): present on all maxillipeds and anterior 4 pereopods. Pleurobranchs (5): present on all pereopods. Arthrobranchs (6): present on third maxilliped (2) and 1 each on anterior 4 pereopods. Podobranch (1): on second maxilliped. Mandible lacking incisor process, with 3-jointed palp. Pereopods 1 and 2 chelate; merus, carpus, and propodus of second leg multiarticulate. Pereopods 3–5 with merus, propodus, and carpus undivided. Structure of endopod of first and second pleopods of male unknown to us.

*Parhippolyte* Borradaile, 1899

Fig. 4

*Parhippolyte* Borradaile, 1899: 414. (Type-species *Parhippolyte uveae* Borradaile, 1899, by monotypy). Gender feminine.

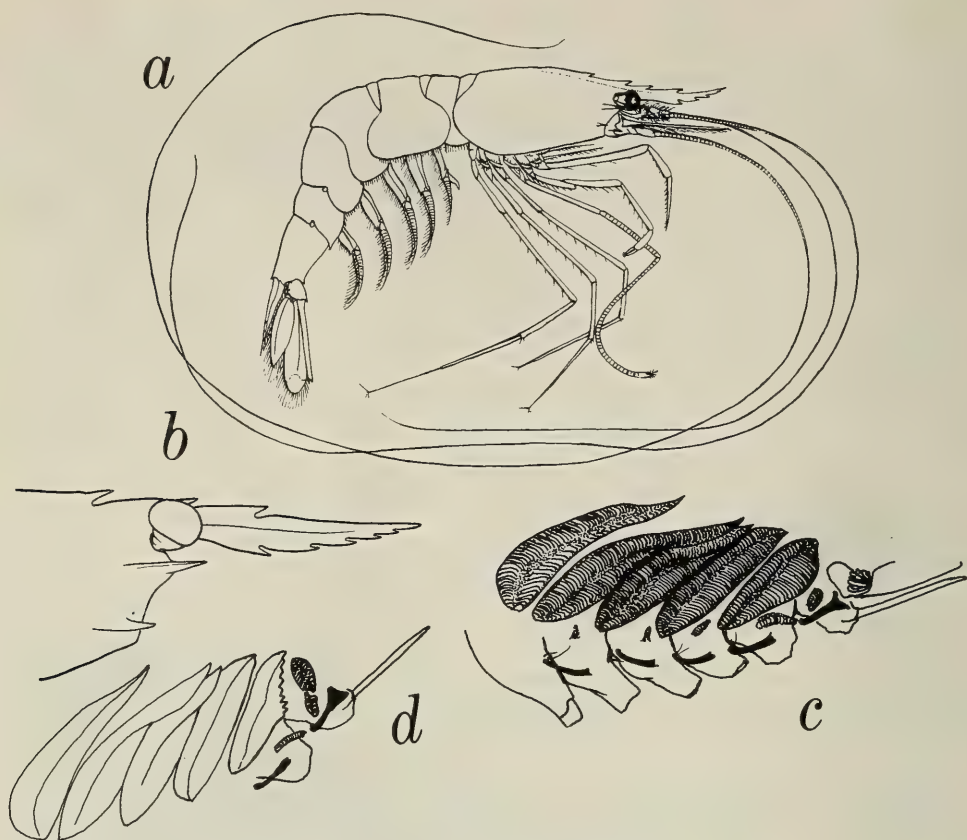


Fig. 3. *Ligur ensiferus* (Risso): *a*, Animal in lateral view (from Senna 1902: pl. 17, fig. 1); *b*, Rostrum (from Gordon 1936: fig. 2a); *c*, Gill complement; *d*, Pleurobranch partly removed to show second arthrobranch on third maxilliped. (*c* and *d* from specimen from Sicily, USNM 152112).

*Habitat*.—Anchialine pools.

*Distribution*.—Indo-West Pacific, from scattered localities between western Indian Ocean and Hawaii (Holthuis 1973; Wear and Holthuis 1977; Maciolek 1983).

*Definition*.—Carapace with antennal and branchiostegal spines. Rostrum broad, length about 2.5 times depth, short, reaching to or beyond base of second segment of antennular peduncle, with 3 dorsal (2 postorbital) and 1–6 ventral teeth. Eyes pigmented, cornea broader than stalk. Anterior 3 abdominal pleura unarmed, pleura of fourth to sixth segments with posteroventral corner produced into spine. Telson with 3 pairs of dorsal spines, 1 subterminal, and 2 pairs of terminal spines, outer longer. Epipods (7): present on all maxillipeds and anterior 4 pereopods. Pleurobranchs (5): present on all pereopods. Arthrobranchs (6): present on third maxilliped (2) and 1 each on anterior 4 pereopods. Podobranch (1): on second maxilliped. Mandible lacking incisor process, with 3-jointed palp. Pereopods 1 and 2 chelate; merus, carpus, and propodus of second leg multiarticulate. Pereopods 3–5 with propodus multiarticulate. Endopod of first pereopod of male without appendix interna but with distal coupling hooks. Endopod of second pleopod of male with appendix masculina shorter than appendix interna.

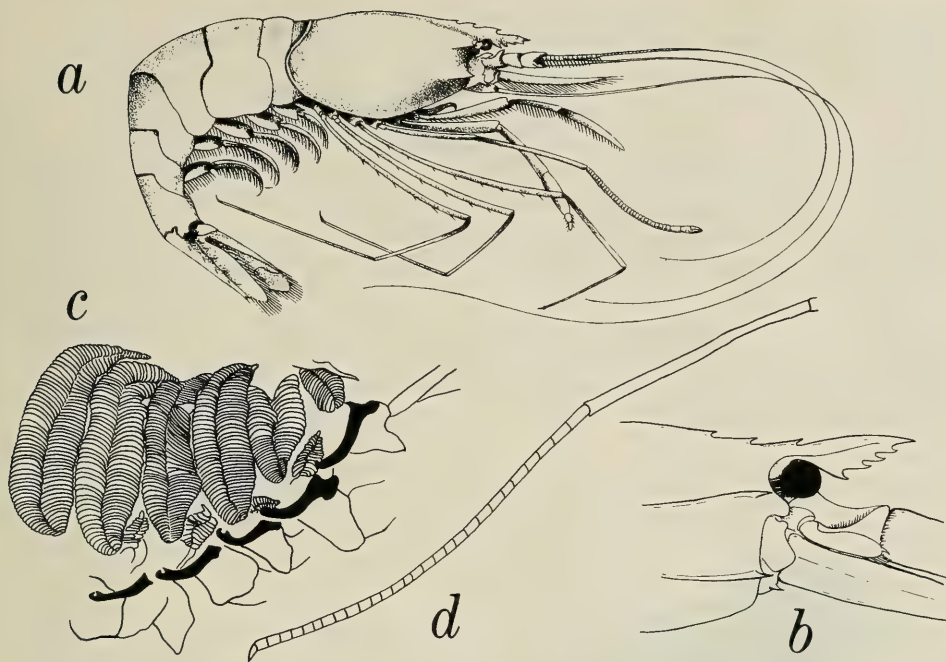


Fig. 4. *Parhippolyte uveae* (Borradaile): *a*, Animal in lateral view (from Borradaile 1899: pl. 38, fig. 11*a*; propodi of walking legs erroneously shown to be undivided); *b*, Front (from Monod, 1968: fig. 1); *c*, Gill complement; *d*, Carpus, propodus, and dactylus of fifth pereopod. (*c* and *d* from specimen from Bikini Atoll, USNM 95043).

### *Somersiella* Hart and Manning, 1981

#### Fig. 5

*Somersiella* Hart and Manning, 1981:442. (Type-species *Somersiella sterreri* Hart and Manning, 1981, by original designation and monotypy). Gender feminine.

*Habitat*.—Anchialine caves.

*Distribution*.—Western Atlantic: Bermuda (Hart and Manning 1981).

*Definition*.—Carapace with antennal and branchiostegal spines. Rostrum broad, length about 2.5 times depth, short, scarcely overreaching basal segment of antennular peduncle, with 3–4 dorsal (1–2 postorbital) and 4–5 ventral teeth. Eyes pigmented, cornea broader than stalk. Anterior 4 abdominal pleura rounded, fifth with posterolateral spine, sixth armed posterolaterally in female. Epipods (6): present on first and third maxillipeds and anterior 4 pereopods. Pleurobranchs (5): present on all pereopods. Arthrobranchs (7): on second (1) and third (2) maxillipeds and anterior 4 pereopods. Podobranchs absent. Mandible lacking incisor process, with 3-jointed palp. Pereopods 1–2 chelate; merus, carpus, and propodus of second leg multiarticulate. Pereopods 3–5 with propodus multiarticulate. Endopod of first pleopod of male lacking appendix interna, with distal coupling hooks. Endopod of second pleopod of male with appendix masculina subequal in length to appendix interna.

*Remarks*.—The gill arrangement, summarized below and shown in Figs. 1–5, is different in each genus. All five genera have five pleurobranchs, one on each



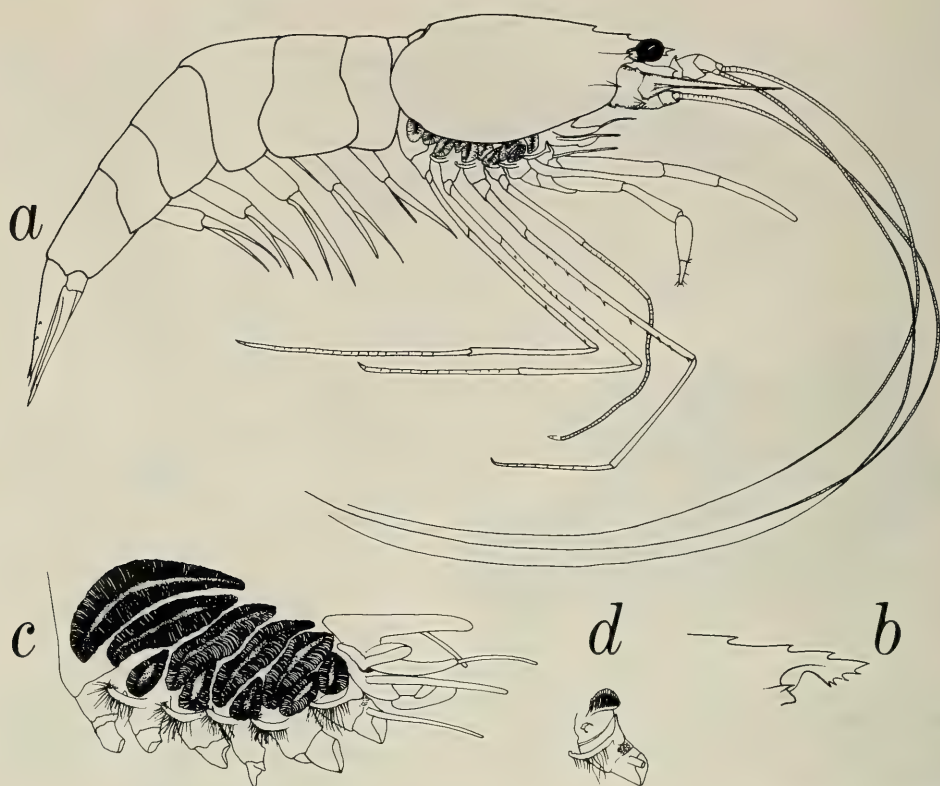


Fig. 5. *Somersiella sterreri* Hart and Manning: *a*, Animal in lateral view; *b*, Rostrum; *c*, Gill complement; *d*, Base of third maxilliped with larger arthrobranch removed to show smaller, more dorsal one. (From Hart and Manning 1981: figs. 1, 2, 4, 5).

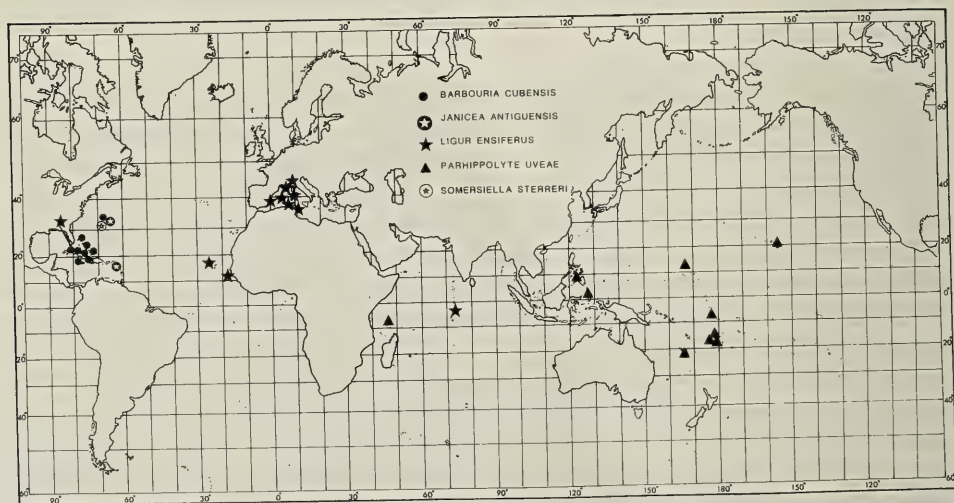


Fig. 6. Distribution of the genera *Barboursia*, *Janicea*, *Ligur*, *Parhippolyte*, and *Somersiella*. Data from: Chace 1972; Crosnier and Forest 1973; Hobbs, Hobbs, and Daniel 1977; Viña and Dávila 1980; Hart and Manning 1981; Iliffe, Hart, and Manning 1983; Lemaitre 1983; Maciolek 1983; and present paper.

pereopod. *Barbouria* and *Janicea* have only two arthrobranches, both on the third maxilliped, whereas *Ligur* and *Parhippolyte* have six arthrobranches, two on the third maxilliped, one on each of the anterior four pereopods. In contrast, in *Somersiella* there are seven arthrobranches, one on the second maxilliped, two on the third, and one on each of the anterior four pereopods. *Somersiella* lacks podobranchs, but the other genera each have one on the second maxilliped. All five genera have epipods on the anterior four pereopods, and also on one or more of the maxillipeds; in *Ligur* and *Parhippolyte* there is an epipod on each maxilliped, in *Somersiella* on the first and third, in *Janicea* on the second and third, and in *Barbouria* on the third.

Overall, the gill complements are as follows (r = reduced):

	<i>Barbouria</i>	<i>Janicea</i>	<i>Ligur</i>	<i>Parhippolyte</i>	<i>Somersiella</i>
Epipods	5	6	7	7	6
Pleurobranches	5	5	5	5	5
Arthrobranches	2	2	6	6	7
Mxp 1	—	—	—	—	—
Mxp 2	—	—	—	—	1
Mxp 3	2	2	2	2	2
P 1	—	—	r	1	1
P 2	—	—	r	1	1
P 3	—	—	r	1	1
P 4	—	—	r	1	1
P 5	—	—	—	—	—
Podobranchs					
Mxp 2	1	1	1	1	—

We consider other features, especially the subdivision of the carpus and propodus of the walking legs, to be particularly important at the generic level, possibly even more important than the differences in the gill formulas. *Barbouria* and *Ligur* have the carpus and/or the propodus of the walking legs undivided, whereas in the other three genera either the propodus or the carpus and propodus are multiarticulate. In *Barbouria*, *Janicea*, and *Ligur* the rostrum is slender, about five times longer than high, whereas in *Parhippolyte* and *Somersiella* it is much deeper, about two and one-half times longer than high. The cornea is narrower than the stalk in *Barbouria*, broader in the other four genera. The appendix masculina is shorter than the endopod in *Barbouria* and *Parhippolyte*, subequal to it in *Somersiella*, and longer than the endopod in *Janicea*. The length of the appendix masculina has not been recorded for *Ligur*.

These genera exhibit what we interpret as a Tethyan distribution pattern (Fig. 6). Often in such patterns, the largest number of species occurs in the Indo-West Pacific area. Curiously, four of the five species considered here occur in the western Atlantic, and three are found in Bermudan caves, whereas only one species occurs in the Pacific.

As pointed out by Iliffe, Hart, and Manning (1983), some of the invertebrates frequenting marine caves in Bermuda appear to have affinities with deep-sea organisms. In the group of shrimps reported here, most of which inhabit caves

and anchialine pools, actually interstitial habitats in rock, one of the species, *L. ensiferus*, lives in deep water, on the outer shelf or upper slope.

### Acknowledgments

Our studies of the Bermudan cave shrimps, carried out in cooperation with T. Iliffe, Bermuda Biological Station, have been supported by grants from the National Geographic Society (2485-82) and the Scholarly Studies Program of the Smithsonian Institution. We thank Horton H. Hobbs, Jr., Brian Kensley, and Austin B. Williams for comments on the manuscript. The figures were compiled by Lilly King Manning, who also prepared some of the original illustrations. Figure 5 is reprinted, with permission, from the *Journal of Crustacean Biology*. This paper is contribution 986 from the Bermuda Biological Station for Research.

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## GERYON FENNERI, A NEW DEEP-WATER CRAB FROM FLORIDA (CRUSTACEA: DECAPODA: GERYONIDAE)

Raymond B. Manning and L. B. Holthuis

*Abstract.*—*Geryon fenneri*, a species from off Florida formerly identified with *G. affinis* A. Milne Edwards and Bouvier, is described. This new species supports a newly established commercial fishery in the Gulf of Mexico. Characters are given to help distinguish *G. fenneri* from *G. quinquedens* Smith, which also occurs off Florida.

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In 1940, Fenner A. Chace, Jr., identified a crab taken off the east coast of Florida with the East Atlantic *Geryon affinis* A. Milne Edwards and Bouvier, and showed the features distinguishing this species from the similar but distinct *Geryon quinquedens* Smith, reported from localities between Nova Scotia and Brazil (Rathbun 1937). Until then all West Atlantic specimens of *Geryon*, with the exception of the problematic *G. incertus* Miers from off Bermuda (see comments in Chace 1940:39), had been identified with *G. quinquedens* (see Rathbun 1937:271 and Table 87); all of the material from Florida identified by Rathbun with *G. quinquedens*, including the figured specimen, proved to belong to the new species described below. Most authors have overlooked the fact that A. Milne Edwards and Bouvier (1894:41), in their original account of *G. affinis*, had pointed out that *G. affinis* differed from *G. quinquedens* in the form of the dactyli of the walking legs. In *G. affinis* the dactyli are narrow and compressed anteroposteriorly, with the height greater than the width, whereas in *G. quinquedens* the dactyli are broad and depressed dorsoventrally, with their width much greater than their height. In her account of *G. quinquedens*, Rathbun had included material with distinctly different dactyli on the walking legs.

The species characterized below is forming the basis for a newly developed and rapidly expanding fishery in the Gulf of Mexico, where it and *G. quinquedens* are known to occur. Because of its potential commercial importance, we present here a preliminary account to make the name available to those working on its biology and the development of the fishery. A fuller account will be provided in a review of all of the species of *Geryon* now in progress.

In the account below, carapace length is abbreviated to cl.

### *Geryon fenneri*, new species

Figs. 1, 2a, b, 3a-c, 4a, b

*Geryon quinquedens*.—Rathbun, 1937:271, pls. 85, 86 [part: specimens from Florida, including figured specimen].—Boone, 1938:199, 201, 236, pls. 93-95. [Not *Geryon quinquedens* Smith, 1879.]

*Geryon affinis*.—Chace, 1940:39.—Springer and Bullis, 1956:20.—Schroeder, 1959:275.—Christiansen, 1969:87 [part].—Pequegnat, 1975:46.—Wigley, Theroux, and Murray, 1975:3. [Not *Geryon affinis* A. Milne Edwards and Bouvier, 1894.]

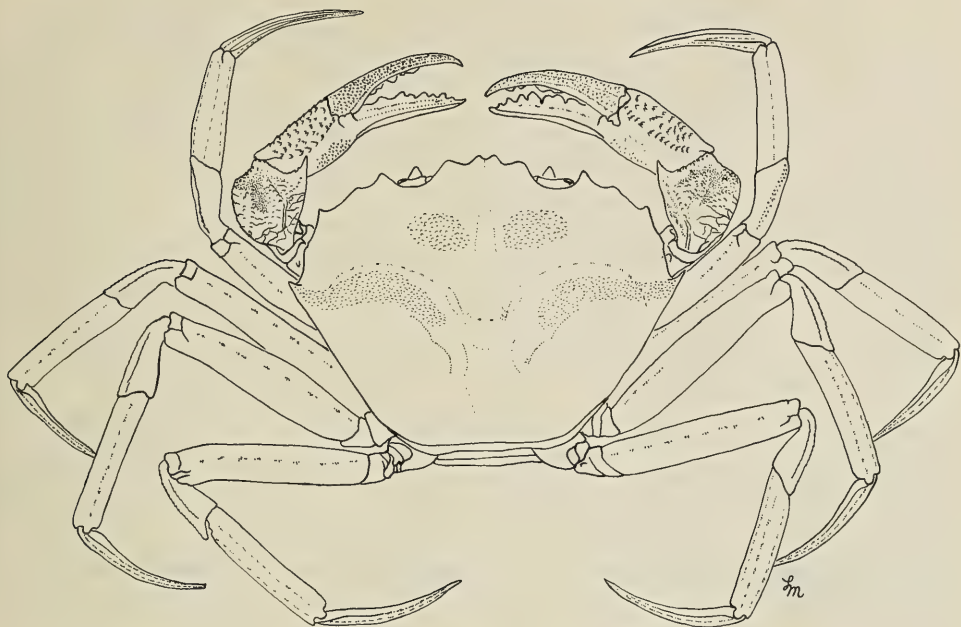


Fig. 1. *Geryon fenneri*, male, cl. 87 mm, USNM 11363: dorsal view.

**Material.**—EAST FLORIDA: Off Fernandina; 31°09'N, 79°33'30"W; 352 fms (644 m); gray sand, dead coral; *Albatross* Sta 2669; 5 May 1886: 1 ♂, cl. 121 mm (USNM 14373).—Off Fernandina; 30°47'30"N, 79°49'W; 270 fms (494 m); gray sand; *Albatross* Sta 2666; 5 May 1886: 1 ♂, cl. 124 mm (holotype; USNM 14376).—Off St. Augustine; 29°38'N, 79°53'W; 520 m; Bureau of Land Management survey; 3 Sep 1977: 2 ♀, cl. 47–83 mm (USNM 174458).—Off Daytona Beach; 29°24'N, 79°50'W; 400 fms (732 m); *Oregon* Sta 5755; 19 Nov 1965: 1 ♂, cl. 34 mm, 2 ♀, cl. 31–39 mm (USNM 210900).—Off Daytona Beach; 29°17'N, 80°03'W; 200–202 fms (366–370 m); *Silver Bay* Sta 3076; 29 Apr 1961: 1 ♀, cl. 53 mm (USNM 210901).—About 5.4 nautical miles ESE of Ponce de Leon Inlet; 415–421 m; *Delaware II* Sta 113; 26 Jun 1982: 2 ♀, cl. 87–94 mm (FSBC I 30811).—Off Fort Pierce; 27°42.5'N, 79°45.6'W to 27°37'N, 79°46.5'W; 417–425 m; *Gosnold* Sta 262/777; 13 Aug 1975: 5 ♂, cl. 47–97 mm, 2 ♀, cl. 67–85 mm (IRCM 89:2295).—Off Fort Pierce; 27°27'N, 79°45.6'W to 27°37'N, 79°46.5'W; 379–392 m; *Gosnold* Sta 262/776; 13 Aug 1975: 1 ♀, cl. 69 mm (IRCM 89:2296).—Off Carysfort; 25°20'30"N, 79°58'W; 217 fms (397 m); gray sand; *Albatross* Sta 2642; 9 Apr 1886: 1 ♂, cl. 87 mm, 1 ♀, cl. 69 mm (USNM 11363).—Off Cape Florida; 3.5 miles E of Fowey Rocks Light; 160 fms (293 m); fine gray sand; *Fish Hawk* Sta 7515; 30 Mar 1903: 1 ♂, cl. 122 mm (USNM 33464).—Off Cape Florida; 3½ miles SE × E½E of Fowey Rocks Light; 170 fms (311 m); soft bottom; *Fish Hawk* Sta 7512; 25 Mar 1903: 1 ♂, cl. 135 mm (USNM 33465).—Off Cape Florida; 6 miles E of Fowey Rocks Light; 200 fms (366 m); gray mud; *Fish Hawk* Sta 7514; 5 Mar 1903: 1 ♂, cl. 134 mm, 1 ♀, cl. 83 mm (USNM 33466).

KEY WEST/DRY TORTUGAS: Off Key West; 24°23'N, 82°42'W; 200 fms



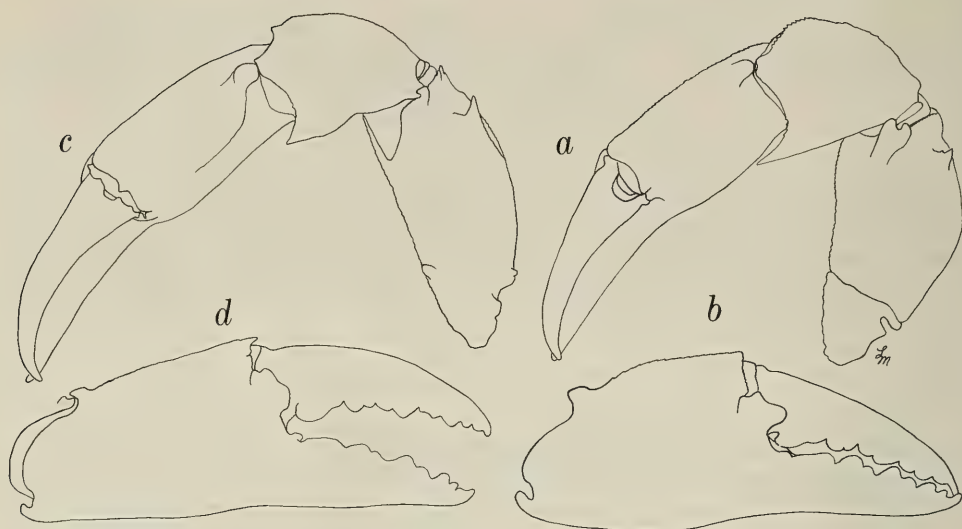


FIG. 2. Cheliped (a, c) and chela (b, d) of: a, b, *Geryon fenneri*, and c, d, *G. quinquedens*.

(366 m); Oregon Sta 5791; 27 Nov 1965: 1 ovigerous ♀, cl. 104 mm (USNM 210899).—Gulf Stream, off Key West; 24°15'N, 81°47'30"W; 306 fms (560 m); sand; Fish Hawk Sta 7285; 19 Feb 1902: 1 ♂, cl. 121 mm (USNM 54047).—S of Key West; 24°11'N, 81°36'W to 24°15'N, 81°20'W; 594–604 m; Gerda Sta 289; 3 Apr 1964: 1 ♂, cl. 137 mm, 1 ♀, cl. 81 mm (USNM 151084).—Dry Tortugas; 220–237 fms (403–434 m); W. L. Schmitt #38; 31 Jul 1930: 2 ♂, cl. 91–93 mm (USNM 71112).—Dry Tortugas; Paul Bartsch; 1931: 1 ovigerous ♀, cl. 105 mm (USNM 68204).—Dry Tortugas; 205–221 fms (375–404 m); W. L. Schmitt; 3 Jul 1931: 1 ♂, cl. 133 mm (USNM 171397).—Dry Tortugas; 18 miles due S from no. 2 red buoy; 205–221 fms (375–404 m); W. L. Schmitt #18; 3 Jul 1931: 1 ♂, cl. 134 mm, 1 ovigerous ♀, cl. 101 mm (USNM 68205).—Dry Tortugas; 197 fms (361 m) and deeper; W. L. Schmitt #60–32; 1 Aug 1932: 1 ♂, cl. 132 mm (USNM 71004).—Dry Tortugas; 334 fms (611 m); W. L. Schmitt #69; 3 Aug 1932: 1 ♂, 136 mm (USNM 107017).—S of Dry Tortugas; 135–156 fms (247–285 m); W. L. Schmitt #30–32; 2 Jul 1932: 2 ♂, cl. 91–102 mm (USNM 71003).—S of Dry Tortugas; 295–315 fms (540–576 m); W. L. Schmitt #54–32; 19 Jul 1932: 2 ♂, cl. 84–88 mm (USNM 71005).—S of Dry Tortugas; 250 fms (458 m); commercial fisherman; 10 May 1969: 2 ♂, cl. 136–139 mm (FSBC I 30809).—Due S of Tortugas Light; 210–237 fms (384–434 m); Anton Dohrn; 6 Jun 1939: 1 ♂, cl. 93 mm (USNM 78363).—SW of Dry Tortugas; 24°N, 83°W; 200–220 fms (366–403 m); Oregon Sta 1537–1551; 15–18 Jun 1956: 1 ♀, cl. 80 mm (USNM 99733).

GULF OF MEXICO, OFF FLORIDA: About 120 miles W of Florida coast; 26°50'N to 27°50'N; 240–300 fms (439–549 m); traps; W. Steven Otwell; 1982: 3 ♂, cl. 125–132 mm, 3 ♀ (2 ovigerous), cl. 97–100 mm (2 ♂, 2 ♀ USNM 210903; 1 ♂, 1 ♀ UF/FSM 123, 124).—Off St. Petersburg; 27°30'N to 27°45'N, 85°10'W; 1500 ft to 355 fms (457–629 m); M/V Margarita B., Capt. O. G. Oakleaf; Sep 1980: 3 ♂, 125–133 mm (FSBC I 30810).—Off St. Petersburg; 27°44'N, 85°09'W; 254 fms (465 m); Oregon Sta 489; 29 Sep 1951: 3 ovigerous ♀, cl. 97–114 mm

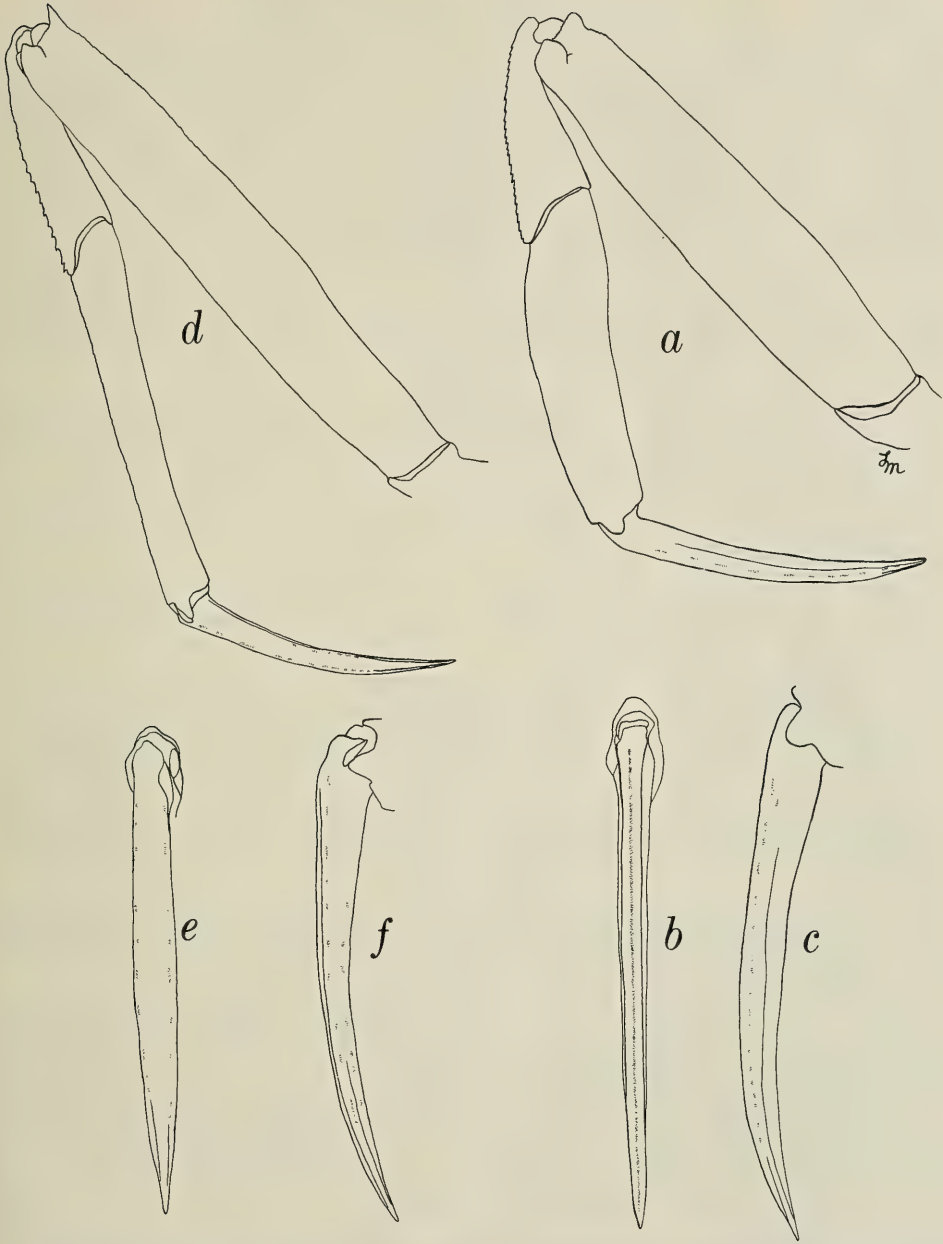


Fig. 3. Fifth pereopod (*a*, *d*) and dactyls of fifth pereopod in dorsal (*b*, *e*) and lateral (*c*, *f*) views of: *a*–*c*, *Geryon fenneri*, and *d*–*f*, *G. quinquedens*.

(USNM 92652).—Off Clearwater; 28°01'N, 85°27'W; 275 fms (503 m); *Oregon II* Sta 10168; 9 Sep 1968: 1 ovigerous ♀, cl. 103 mm (USNM 210902).—Off Clearwater; 28°04'N, 85°34'W; 549 m; *Oregon II* Sta 10169, W. Lyons; 9 Sep 1968: 1 ovigerous ♀, cl. 94 mm (FSBC I 6670).

*Diagnosis*.—A large *Geryon*, carapace length to at least 150 mm in adults. Carapace broader than long, length 0.74 to 0.88, usually 0.79–0.82, times width. Median pair of frontal teeth separated by a wide sinus, teeth scarcely overreaching obtuse lateral frontal teeth. Orbits usually more than  $\frac{3}{4}$  frontal width. Anterolateral teeth 5, second and fourth reduced, distance between first and third usually smaller than distance between third and fifth (range 0.84–1.10). Cheliped with blunt lobe on upper margin of merus, carpus lacking outer spine, propodus lacking distal dorsal spine. Meri of walking legs lacking distal dorsal spine. Fifth leg: merus broad, less than  $\frac{2}{3}$  carapace width (range 0.42–0.58); propodus broad, length less than 4.5 times width (range 2.8–4.1 times); propodus and dactylus subequal in length, or dactylus slightly longer. Dactyli of walking legs compressed, narrow, height at midlength much greater than width.

*Size*.—Carapace lengths of examined specimens: males 34–139 mm, non-ovigerous females 31–102 mm, ovigerous females 94–114 mm. Maximum carapace widths of males 185 mm, of females 147 mm (W. Steven Otwell, pers. comm.).

*Color*.—A cream to tan colored species, often mottled with darker pigment, in contrast with the deep sea red crab *G. quinquedens*, which is red to deep orange in life (Schroeder 1959:275).

*Remarks*.—*Geryon fenneri*, the western Atlantic counterpart of *G. affinis* A. Milne Edwards and Bouvier, with which it has been identified in the past, differs from the latter species as follows:

1. The frontal teeth of *G. fenneri* are closer together than those of *G. affinis*. In *G. fenneri* the distance between the frontal teeth is  $\frac{1}{2}$  to  $\frac{3}{4}$  the distance between each frontal tooth and the nearest inner orbital tooth. In *G. affinis* these two distances are about equal. In *G. fenneri* the gap between the frontal teeth is shallower than in *G. affinis*. In *G. fenneri* the frontal teeth are much smaller and narrower than the inner orbital teeth; in *G. affinis* this difference is much less noticeable.

2. In *G. fenneri* the orbits appear to be shallower and wider than in *G. affinis*. In *G. fenneri* the orbits usually are more than  $\frac{3}{4}$  the width of the front, whereas in *G. affinis* they are less than  $\frac{3}{4}$  the frontal width.

3. The distance between the outer orbital tooth (=first anterolateral tooth) and the third anterolateral tooth in *G. fenneri* is smaller to slightly larger than that between the third and fifth anterolateral teeth (range 0.84–1.10); in *G. affinis* the distance between the first to third and that between the third to fifth anterolateral teeth is larger (range 1.11–1.21). In *G. fenneri* the anterolateral teeth are broader and less conspicuous than in *G. affinis*, where they are more triangular.

4. In *G. fenneri* the granules on the protogastric region are larger and fewer than in *G. affinis*.

5. In *G. affinis* there is a second, narrower ridge behind the ridge that extends inward from the fifth anterolateral tooth. This second ridge is completely absent in *G. fenneri*.

6. The fourth (=penultimate) segment of the antennal peduncle is more slender in *G. fenneri* than in *G. affinis*.

7. Granules on the pleural ridge (separating the subhepatic from the pterygostomian region) before the pleural suture are more conspicuous and in a single row in *G. fenneri*, smaller and more irregularly placed in *G. affinis*.



8. Granules on the upper surface of the palm and carpus of the cheliped are more conspicuous in *G. fenneri* than in *G. affinis*.

9. The dactyli of the second to fifth pereopods are more slender in *G. affinis* than in *G. fenneri*, but the grooves are narrower and deeper in the latter species. In *G. fenneri* the dorsal groove appears to be wider distally.

10. The male gonopods of *G. affinis* are more strongly curved laterally, pointing to the base of the second or third leg; in *G. fenneri* the gonopods are directed more anteriorly, in the direction of the base of the chelipeds.

11. The sixth abdominal segment is somewhat higher and less wide in *G. affinis* than in *G. fenneri*.

Chace (1940:40) listed the differences he observed between this species (as *G. affinis*) and *G. quinquedens*; the major differences can be summarized as follows:

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<i>G. quinquedens</i>	<i>G. fenneri</i>
1. Color in life pink to reddish brown.	1. Color in life tan to cream.
2. Carpus of cheliped with sharp tooth on outer half of upper anterior margin (blunt and inconspicuous in older specimens) (Fig. 2c).	2. Carpus of cheliped lacking tooth on outer half of upper anterior margin (Fig. 2a).
3. Palm of cheliped with dorsal margin ending anteriorly in a tooth (often reduced or absent in old specimens) (Fig. 2c, d).	3. Palm of cheliped with dorsal margin unarmed anteriorly (Fig. 2a, b).
4. Dactyli of walking legs dorsoventrally flattened, wider than high (Fig. 3e, f).	4. Dactyli of walking legs laterally compressed, higher than wide (Fig. 3b, c).
5. Merus of walking legs bearing anterodorsal tooth (Fig. 3d). (Tooth sometimes indistinct, often so on second and fifth legs).	5. Merus of walking legs lacking anterodorsal tooth (Fig. 3a).
6. Merus of fifth leg about $\frac{3}{4}$ carapace width.	6. Merus of fifth leg less than $\frac{3}{5}$ carapace width.
7. Propodus of last leg 5 to 7 times as long dorsally as high (Fig. 3d).	7. Propodus of last leg less than 4.5 times as long dorsally as high (Fig. 3a).

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Some of the characters that distinguish *G. fenneri* and *G. quinquedens* are shown together in Figs. 2–4, which are based on the following specimens: *G. fenneri*, ♀, cl. 47 mm, USNM 174458, from off Florida; *G. quinquedens*, ♀ 36 mm, and ♂, cl. 46 mm, USNM 18751, from off Martha's Vineyard, Massachusetts.

We have reexamined the material from Florida identified with *G. quinquedens* by Rathbun (1937), and all of those specimens proved to be *G. fenneri* rather than *G. quinquedens*. We have seen no material of this species from outside the waters of the continental shelf off Florida, where it occurs in depths ranging from

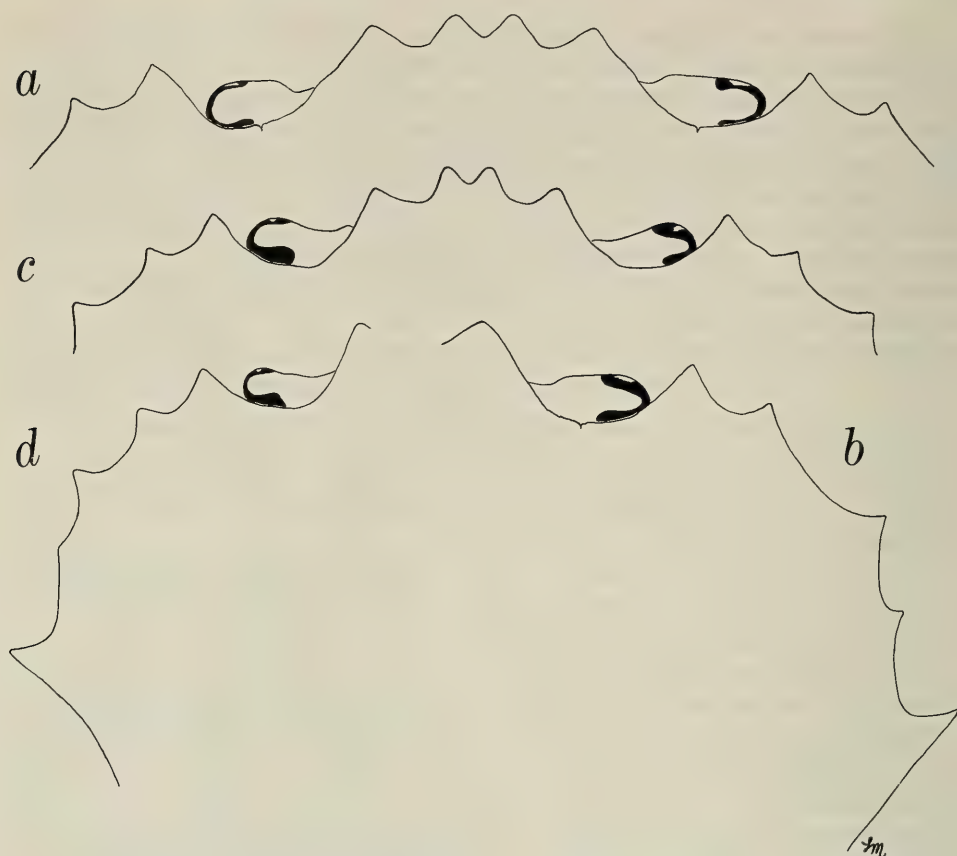


Fig. 4. Outlines of front (*a*, *c*) and anterolateral margin of carapace (*b*, *d*) of: *a*, *b*, *Geryon fenneri*, and *c*, *d*, *G. quinquedens*.

as shallow as 247–285 m to as deep as 778–787 m. Most of our records for this species come from depths between 350 and 500 m.

*Etymology*.—We take great pleasure in dedicating this species to our colleague, Fenner A. Chace, Jr., who was the first to recognize it in the western Atlantic.

*Types*.—The holotype is the male specimen from *Albatross* Sta 2669, off Fernandina, Florida (USNM 14376); it is the specimen figured by Rathbun (1937: pls. 85, 86). Other specimens from the collections of the National Museum of Natural History, Smithsonian Institution (USNM), and six lots collected in the Straits of Florida by the R/V *Gerda* deposited in the Rijksmuseum van Natuurlijke Historie, Leiden, The Netherlands, as well as all other specimens listed are paratypes.

*Records in the literature*.—In addition to the records from Florida given by Rathbun (1937) and cited above under “*Material*,” we have found only the following records, all from off Florida: 2 ♂, E of St. Augustine, 30°58'N, 79°34'W, 265–290 fms (485–531 m), and 30°03'N, 78°37'W, 425–430 fms (778–787 m) (Chace 1940); 1 ♂, 1 ♀, off Fowey Rocks, 100–200 fms (183–366 m) (Boone 1938); Florida Straits (Christiansen 1969); Gulf of Mexico, off St. Petersburg, 27°44'N, 85°09'W, 254 fms (465 m) (Springer and Bullis 1956).

The species also was mentioned by Schroeder (1959), Pequegnat (1975), and Wigley, Theroux, and Murray (1975), but no records were given by these authors.

### Acknowledgments

We thank W. Steven Otwell, Marine Advisory Program, Florida Cooperative Extension Service, University of Florida, Gainesville, for informing us about the commercial importance of this species and for providing us with color slides and specimens; David K. Camp, Florida Department of Natural Resources, St. Petersburg (FSBC), for the loan of material; L. Richard Franz, Florida State Museum (UF/FSM), for providing material; Paula Mikkelsen, Indian River Coastal Zone Museum (IRCZM), Harbor Branch Foundation, Fort Pierce, Florida, for allowing us to study material housed there; and R. G. J. Shelton, Marine Laboratory, Aberdeen, Scotland, for making available material of *G. affinis*. We thank Austin B. Williams for his comments on the manuscript. The illustrations were prepared by Lilly King Manning.

Part of this work was carried out at the Smithsonian Field Station, Fort Pierce, Florida; this paper constitutes contribution no. 130 from that station. Studies on the genus *Geryon* are being supported by a grant from the Food and Agriculture Organization of the United Nations, Rome; that support is gratefully acknowledged.

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*ARABANTHURA ENIGMATICA*, A NEW GENUS AND  
SPECIES OF ANTHURID ISOPOD FROM THE  
ARABIAN GULF

Brian Kensley and Janet Reid

*Abstract.*—*Arabanthura enigmatica* is described from the northern Gulf of Arabia. The genus is characterized especially by the possession of a biarticulate mandibular palp, and a nonserrate lamina dentata. Females are blind, but premales develop eye-pigment, while mature males have well developed eyes of numerous ommatidia. The small overall size of males and premales as compared with ovigerous females, leads to speculation on the existence of primary males in the species.

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Among the isopods collected by Dr. John McCain in the Arabian Gulf and submitted to the Smithsonian Institution for identification, was a species of anthurid, the generic placement of which proved difficult.

The material was collected during an intertidal and subtidal sampling program by Tetra Tech, Inc. in the northern Arabian Gulf. The station numbers used are those of this program. Type material has been deposited in the collections of the Smithsonian Institution, and given USNM catalogue numbers.

*Arabanthura*, new genus

*Diagnosis.*—Eyes and eye-pigment absent in female; eye pigment present in premale; eye-pigment and ommatidia present in male. Antenna 1, flagellum of 3 articles in female, of 26 articles in male. Antenna 2, flagellum of single article. Mandibular palp of 2 articles. Maxilliped of 4 articles; endite lacking. Pereopod 1 subchelate, propodus expanded. Pereopods 2 and 3 ambulatory. Pereopods 4-7, carpi with posterior margin longer than anterior margin. Pleopod 1, exopod operculiform. Pleonites 1-5 fused, pleonite 6 free. Telson with 2 basal statocysts.

*Gender.*—Feminine.

*Type-species.*—By present designation: *Arabanthura enigmatica*, new species.

*Etymology.*—The generic epithet is a combination of 'Arab-' from the Gulf of Arabia, and the frequently used suffix 'anthura.'

*Remarks.*—Of all the genera of the Anthuridae, only two possess a biarticulate mandibular palp, viz. *Venezanthura* Kensley, 1978, and *Rhiganthura* Kensley, 1978.

The latter genus possesses a pleon of five free short anterior pleonites and a large sixth pleonite fused with the telson, pleopod 1 having both rami forming the operculum, and a 5-articulate maxilliped with a strong endite. These three major features immediately separate *Rhiganthura* from *Arabanthura*.

*Venezanthura*, while having a similar pleonal structure to *Arabanthura*, possesses a biarticulate flagellum of antenna 1 in the female, a serrate lamina dentata, a 3-articulate maxilliped with endite, antennae 1 and 2 strongly interlocked, and

a strong palmar tooth on pereopod 1. These easily discerned features separate *Venezanthura* from *Arabanthura*.

The broad setose articles of pereopods 2–7 are reminiscent of *Centranthura caeca* (Kensley) from South Africa. This similarity probably reflects the fact that both species are infaunal sediment inhabitants.

*Arabanthura enigmatica*, new species

Figs. 1–3

*Material*.—Holotype, USNM 211343, ovig. ♀, TL 10.8 mm, Sta 4G3, Apr 1982, middle Manifa Bay, 1.3 m, seagrass and sand bottom, 26.6°C, salinity 42 ppt.

Paratypes, USNM 211344, 3 ♂, TL 6.1–6.5 mm, 7 pre-♂, TL 6.8–7.0 mm, 2 ovig. ♀, TL 9.0–10.0 mm, 24 non-ovig. ♀, 12 juvs., Sta 5G1, Mar 1982, north-eastern Manifa Bay, 1.3 m, seagrass and sand bottom, 18.3°C, salinity 42 ppt.

Paratypes, USNM 211345, 2 pre-♂, TL 6.7–7.0 mm, 2 ovig. ♀, TL 9.6–10.1 mm, 3 non-ovig. ♀, 2 juvs., sta 5G2, Mar 1982, northeastern Manifa Bay, 1.3 m, seagrass and sand bottom, 18.3°C, salinity 42 ppt.

Other material: Sta 1G3, Nov 1981, 1 juv., off Manifa GOSP, 3 m, seagrass and sand bottom, 21.1°C, salinity 45 ppt.—Sta 5S3, Nov 1981, 1 non-ovig. ♀, 4 juvs., northeastern Manifa Bay, 2 m, sand bottom, 20.0°C, salinity 50 ppt.—Sta 5G2, Nov 1981, 8 non-ovig. ♀, 12 juvs., northeastern Manifa Bay, 1.3 m, seagrass and sand bottom, 20.0°C, salinity 50 ppt.—Sta 2G3, Mar 1982, 1 juv., near Ras Tanajib marine facility, 2 m, seagrass and sand bottom, 18.3°C, salinity 41 ppt.—Sta 4G1, Apr 1982, 2 ovig. ♀, TL 8.1–8.6 mm, 3 non-ovig. ♀, middle Manifa Bay, 1.3 m, seagrass and sand bottom, 26.6°C, salinity 42 ppt.—Sta 4G2, Apr/May 1982, 3 ovig. ♀, TL 9.0–9.8 mm, 1 non-ovig. ♀, 1 juv., 40 manca, middle Manifa Bay, 1.3 m, seagrass and sand bottom, 26.6°C, salinity 42 ppt.—Sta 4G3, Mar 1982, 2 non-ovig. ♀, middle Manifa Bay, 1.3 m, seagrass and sand bottom, 18.3°C, salinity 44 ppt.—Sta 4G3, Apr 1982, 8 ovig. ♀, TL 8.1–10.2 mm, 1 juv., middle Manifa Bay, 1.3 m, seagrass and sand bottom, 26.6°C, salinity 42 ppt.—Sta 5G3, Mar 1982, 2 pre-♂, TL 6.1–7.1 mm, 3 non-ovig. ♀, 8 juvs., northeastern Manifa Bay, 1.3 m, sand and seagrass bottom, 18.3°C, salinity 42 ppt.—Sta 8G2, Mar 1982, 1 non-ovig. ♀, off Bandar al Mishab, 2.3 m, sand and seagrass bottom, 17.7°C, salinity 41 ppt.

*Description*.—Ovigerous female: Body 11 times longer than wide; proportions:  $C < 1 < 2 < 3 < 4 < 5 > 6 > 7 < P$ . Head with broadly triangular rostrum extending anteriorly as far as anterolateral lobes. Pereonite 1 with shallow middorsal pit in anterior half. Dorsal articulation hollows between pereonites 1 and 2, and 2 and 3; pereonites 4–6 each with shallow middorsal pit. Pleonites 1–5 fused, fused pleonites indicated by faint undulations of ventrolateral margin. Pleonite 6 short, free, with middorsal notch in posterior margin (Fig. 1a). Telson dorsally gently convex, widest at midlength; posterior margin broadly rounded-truncate, with 6 elongate simple setae (Figs. 1a, 2g).

Antenna 1, peduncle of 3 broad articles; terminal flagellar article with 3 aesthetascs (Fig. 1d). Antenna 2, peduncle article 2 grooved to accommodate antenna 1; flagellar article setose (Fig. 1e). Distal mandibular palp article slightly less than half length of proximal article, with 1 or 2 elongate setae; right incisor consisting of single convex sclerotized plate, left incisor weakly trilobed, sclerotized; lamina

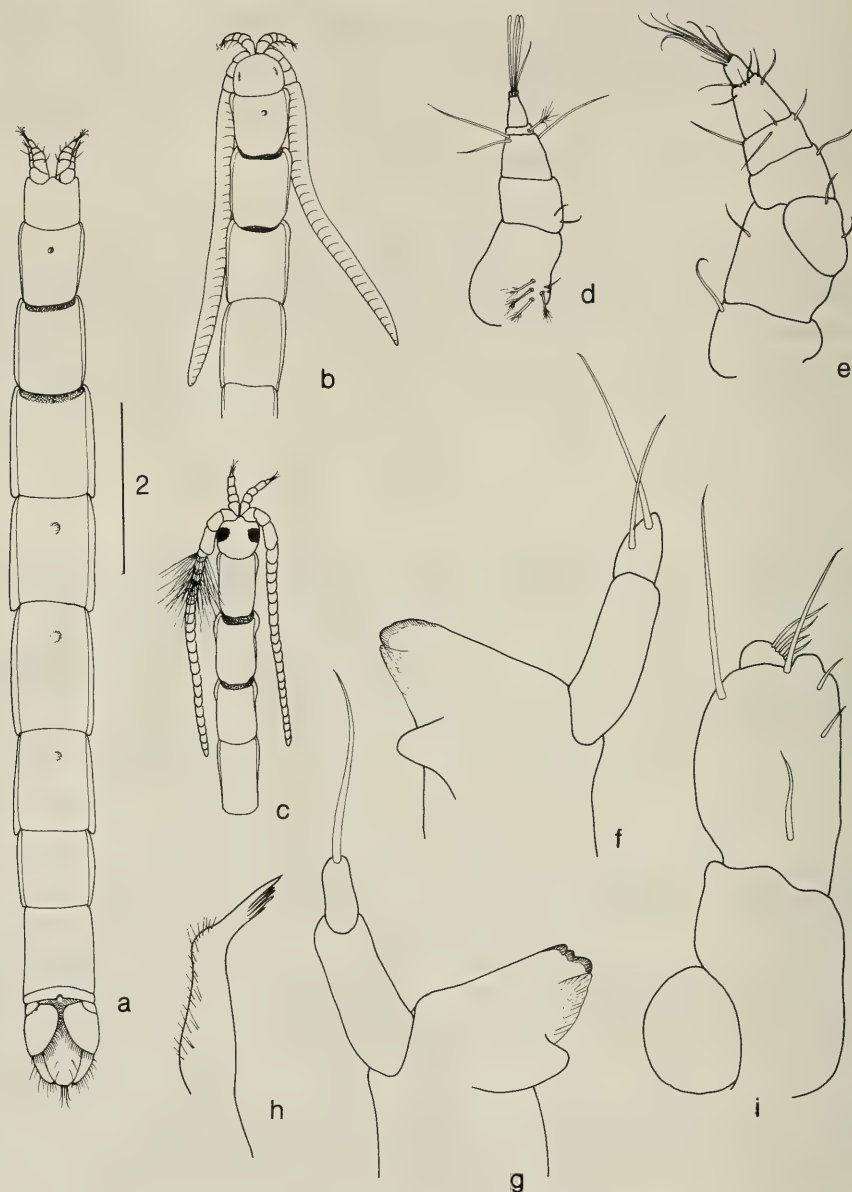


Fig. 1. *Arabanthura enigmatica*: a, Ovigerous female in dorsal view; b, Head and anterior pereonites of premale; c, Head and anterior pereonites of male; d, Antenna 1 ♀; e, Antenna 2; f, Right mandible ♀; g, Left mandible ♀; h, Maxilla; i, Maxilliped ♀.

dentata broad-based, triangular, lacking marginal teeth; molar low, rounded (Figs. 1f, g). Maxilla with 1 strong and 4 smaller apical spines (Fig. 1h). Maxilliped of 4 articles, terminal article small, set on distal margin of penultimate article, semi-circular, bearing 4 setae; penultimate article with rounded mediolateral lobe, bearing 2 elongate distal setae (Fig. 1i). Pereopod 1 more robust than following per-



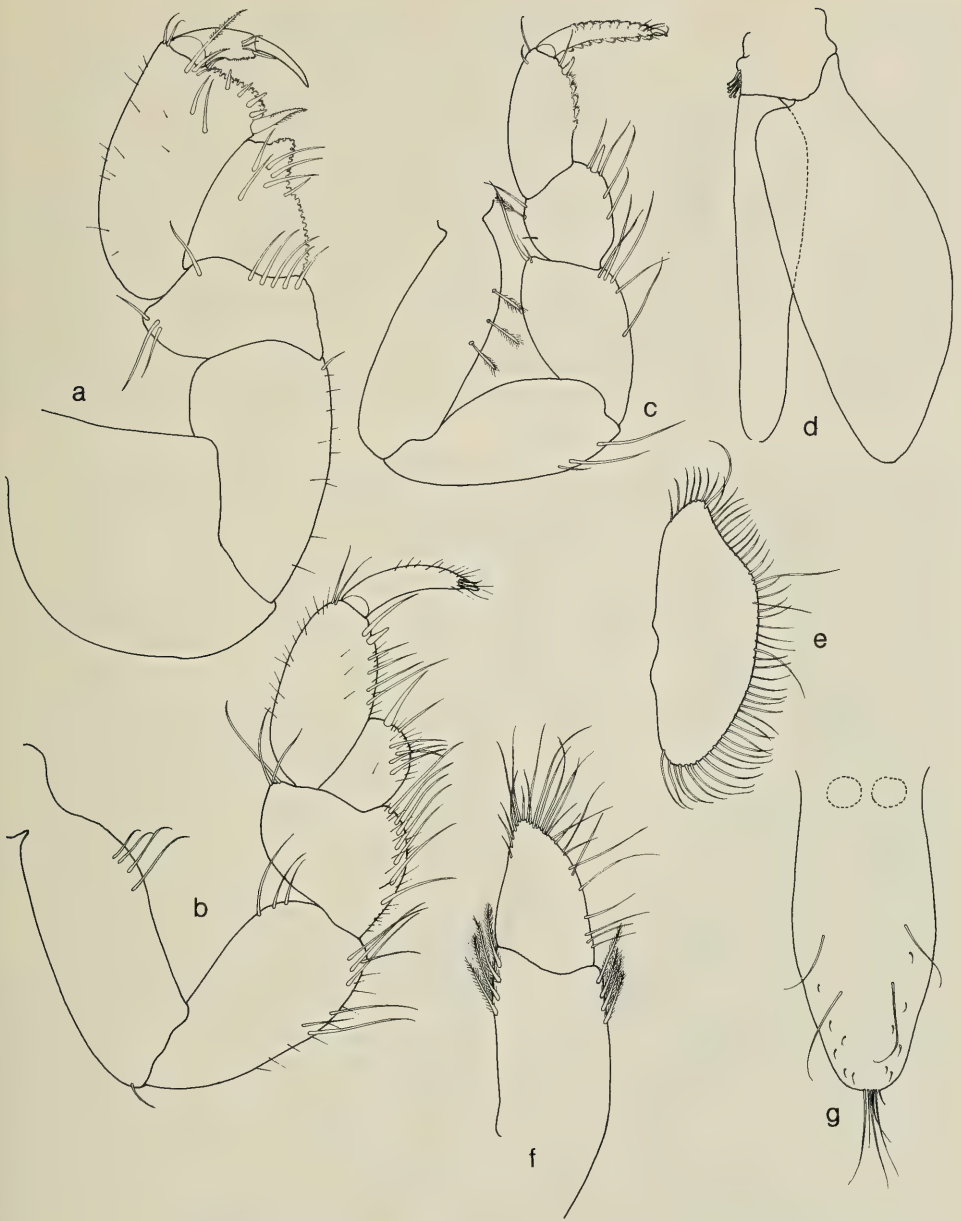


Fig. 2. *Arabanthura enigmatica* ♀: a, Pereopod 1; b, Pereopod 2; c, Pereopod 7; d, Pleopod 1; e, Uropodal exopod; f, Uropodal endopod and protopod; g, Telson.

eoopods; merus with 5 submarginal distal setae; carpus with posterior margin bearing fringed scales, produced posterodistally into triangular lobe; propodus expanded, palm proximally convex, bearing fringed scales, 4 short submarginal spines on medial surface, strong fringed proximal spine; unguis equal in length to rest of dactylus (Fig. 2a). Pereopods 2 and 3 similar; ischia, meri, carpi, and

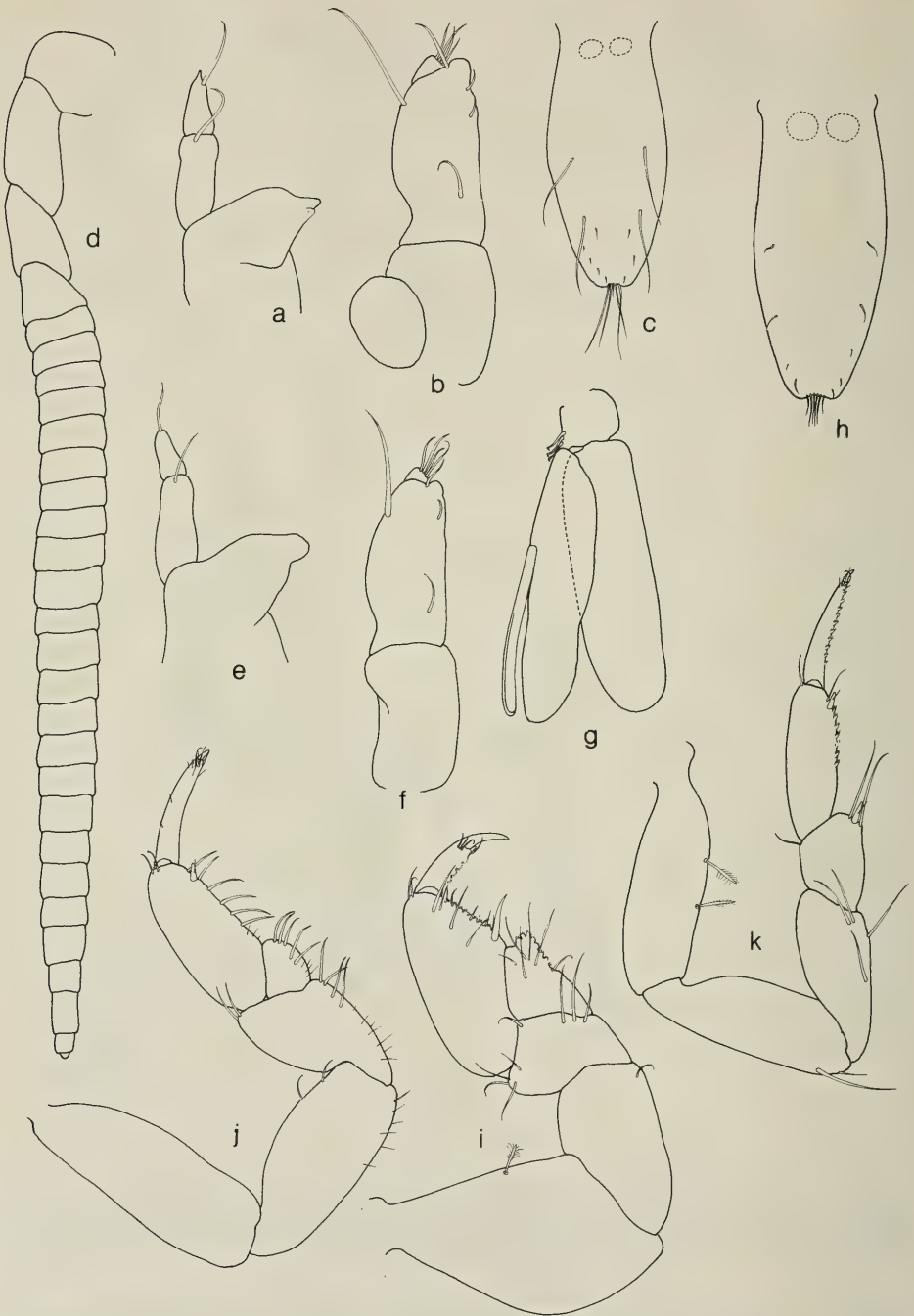


Fig. 3. *Arabanthura enigmatica*: a, Mandible, pre- $\delta$ ; b, Maxilliped pre- $\delta$ ; c, Telson pre- $\delta$ ; d, Antenna 1,  $\delta$ ; e, Mandible  $\delta$ ; f, Maxilliped  $\delta$ ; g, Pleopod 2  $\delta$ ; h, Telson  $\delta$ ; i, Pereopod 1  $\delta$ ; j, Pereopod 2  $\delta$ ; k, Pereopod 7  $\delta$ .

propodi bearing elongate setae on posterior margins; carpi with broadly convex posterior margins; propodi not expanded as in pereopod 1, with short serrate posterodistal spine; dactyli with very short unguis (Fig. 2b). Pereopods 4–7 with ischia, meri, and carpi each having 3–4 elongate setae on posterior margins; carpi with anterior margins free but shorter than posterior margins; propodi with fringed scales on posterior margins, and short serrate posterodistal spine; dactyli having fringed scales on anterior and posterior margins; unguis very short (Fig. 2c). Marsupium formed by 3 pairs of oostegites on pereonites 3–5. Pleopod 1, operculiform exopod subequal in length to, but more than twice wider than basal width of endopod; both rami bearing elongate plumose marginal setae (Fig. 2d). Uropodal exopod elongate-oval, with outer (dorsal) margin sinuous, margins having dense plumose setae (Fig. 2e); endopod triangular, reaching telsonic apex, with numerous distal setae; protopod having distal plumose setae on anterior and posterior margins (Fig. 2f).

**Premale:** Head with anterior margin convex. Faint subintegumental eye-pigment present. Antenna 1, flagellum reaching posteriorly to posterior margin of pereonite 4, articles incompletely indicated (Fig. 1b). Mandible with biarticulate palp, each article bearing single seta; incisor and lamina dentata reduced to non-sclerotized rounded lobes; molar absent (Fig. 3a). Maxilliped similar to female but penultimate article more elongate (Fig. 3b). Pereopods as in female.

**Male:** Head (Fig. 1c) with rounded rostrum; well-pigmented eyes, each of 20–22 ommatidia. Antenna 1, flagellum of 26 articles each bearing whorl of aesthetascs (Fig. 1c, 3a). Mandible with incisor and lamina dentata not differentiated; molar absent (Fig. 3e). Maxilliped as in premale (Fig. 3f). Pereopod 1, merus, carpus, and propodus less expanded than in female; merus with 3 submarginal distal setae; posterior margin of carpus smooth proximally, posterodistally produced into triangular lobe bearing fringed scales as in female; propodal palm very slightly convex, bearing strong smooth proximal spine and fringed scales as in female, otherwise only few setae on medial surface; unguis about  $\frac{3}{5}$  length of dactylus (Fig. 3i). Pereopods 2 and 3 similar, more slender and bearing fewer setae than in female (Fig. 3j). Pereopods 4–7 also more slender and with fewer setae than in female; propodi and dactyli with fringed scales on posterior margins (Fig. 3k). Pleopod 2, endopod with copulatory stylet rod-shaped, not reaching beyond apex of ramus, articulating in proximal half of media margin (Fig. 3g). Telson dorsally less convex than, proportionally broader than, and with posterior setae less elongate than in female (Fig. 3h).

**Remarks.**—Two features of this species, neither of which have previously been reported in the Anthuridea, require comment.

1. The females lack eyes or eye-pigment, while the premales have subintegumental eye-pigment, and males have well pigmented eyes of numerous ommatidia. This feature, along with enormously elongate flagellum of antenna 1 in the male, would suggest that females are permanent members of the infauna, while males probably leave the sediments and swim in active search of mature females.

2. Combining the numbers of males, premales, ovigerous females, non-ovigerous females, juveniles, and manca from all stations by collecting season (see following table) suggests that premales and males appear in March, and that the highest number of ovigerous females appears in April/May.



	♂	pre-♂	ovig. ♀	non- ovig. ♀	juvs	mancas
Nov 1981	—	—	—	9	17	—
Mar 1982	3	11	4	33	23	—
Apr/May 1982	—	—	14	4	2	40

This could be interpreted in two ways: Primary males appear in the population just prior to the production of eggs in the females (i.e., in time for fertilization) or, ovigerous females from the previous breeding season become males in time for the production of eggs in the following April/May. If protogynous hermaphroditism exists in this species, there would seem to be a progressive shortening of the total body length in the change from ovigerous female to premale to male, as borne out by the following dimensions:

18 ovig. ♀, TL 8.1–10.8 mm, (mean 9.1 mm, mode 9.0 mm)

11 pre-♂, TL 6.7–7.1 mm, (mean 6.8 mm, mode 7.0 mm)

3 ♂, TL 6.1–6.5 mm, (mean 6.2 mm, mode 6.1 mm)

This is contrary to the documented cases of anthurid protogyny, e.g., in *Cyathura polita* (Burbanck and Burbanck 1974), *C. carinata* (Wägele 1979), and *C. profunda* (Kensley 1982). The possible existence of primary males in anthuridean species presumed to be protogynic hermaphrodites has yet to be ruled out. The available data on *Arabanthura enigmatica* demand further investigation of the life-cycle, even though the sex ratio (4.4 ♀ to 1 ♂ or pre-♂) for all the samples combined would indicate protogyny.

*Etymology.*—The specific epithet refers to the puzzling feature of progressive body-length decrease noted above.

#### Acknowledgments

We are grateful to Dr. John McCain, of Tetra Tech, Inc., who collected and made the material and data available for study, and to Dr. Thomas E. Bowman for commenting on the manuscript.

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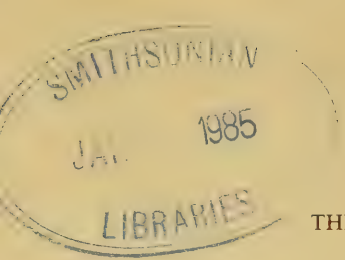
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## THREE NEW SPECIES OF *SONORELLA* (GASTROPODA: PULMONATA: HELMINTHOGLYPTIDAE) FROM ARIZONA

Walter B. Miller

*Abstract.*—*Sonorella reederi*, *S. russelli*, and *S. bradshaveana* are described from Arizona. Relationships within the genus are discussed.

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Although the genus *Sonorella* has been intensively studied in Arizona since the beginning of the century, new populations have continued to be discovered in remote, isolated areas. In many instances, however, the procurement of scarce, live specimens for positive identification has entailed repeated expeditions over a period of many years. This was the case for the following three new species, described below. The following abbreviations for repositories of specimens are employed: ANSP—Academy of Natural Sciences of Philadelphia; CAS—California Academy of Sciences; FMNH—Field Museum of Natural History; RLR—personal collection of Richard L. Reeder; USNM—National Museum of Natural History; UTEP—University of Texas at El Paso; WBM—personal collection of Walter B. Miller.

### *Sonorella reederi*, new species

Figs. 1A–C, 2

*Description of holotype.*—Shell depressed-globose, heliciform, light tan, with chestnut-colored spiral band on rounded shoulder; widely umbilicate, umbilicus contained  $7\frac{1}{2}$  times in diameter of shell, only about  $1/10$ th covered by reflected columellar lip. Embryonic shell of  $1\frac{1}{2}$  whorls, lustrous, with surface microscopically roughened by radial wrinkles and numerous papillae. Post-embryonic whorls also lustrous, marked with light growth wrinkles, with fewer and smaller papillae gradually replaced on penultimate whorl by shallow, spirally-arranged pits. Body whorl silky-lustrous above, becoming glossy underneath, marked with light growth wrinkles and, above shoulder, with closely-spaced, parallel, shallow, spiral grooves. Peristome thickened and slightly expanding. Aperture oblique, rounded, with margins converging; parietal callus thin. Shell measurements in mm: diameter 19.4, height 11.0, umbilicus 2.7;  $4\frac{1}{2}$  whorls.

*Reproductive anatomy of holotype.*—Ovotestis and distal structures as in other *Sonorella*. Proximal structures show diagnostic characters. Penis 5.0 mm long, containing stout verge, 2.5 mm long; verge with smooth sides and rounded conical tip. Thin penial sheath encases lower 2.0 mm of penis. Epiphallic caecum miniscule, 0.25 mm in length. Short spermathecal diverticulum, 1.0 mm in length, present; common spermathecal duct below diverticulum highly convoluted internally. 30 mm long spermathecal duct leads to typical, spherical spermatheca, 2.0 mm in diameter.

*Variations in paratypes.*—A total of 23 adult paratype shells were collected in two separate visits to the type-locality. The largest paratype measures 20.8 mm in diameter, the smallest 18.4 mm. All show remarkably similar sculpture, shape,



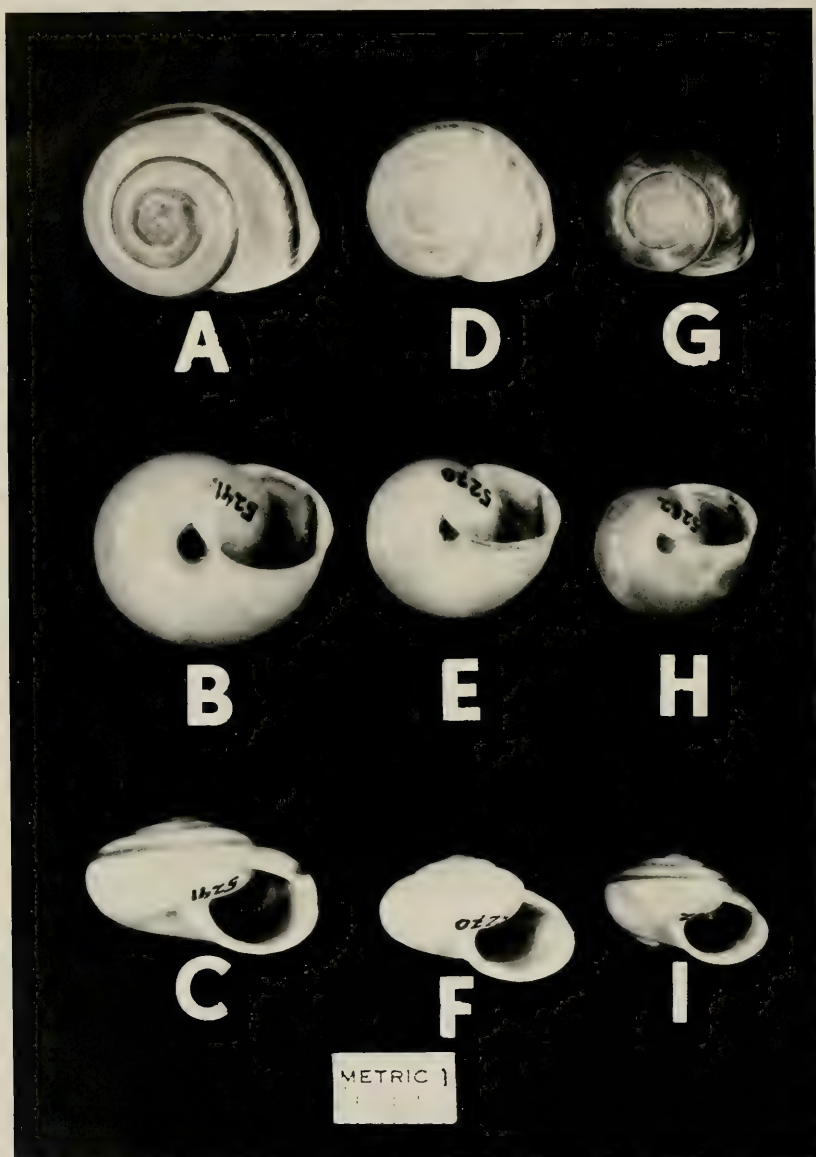


Fig. 1. A, B, C, Shell of a paratype of *Sonorella reederi*; D, E, F, Shell of a paratype of *Sonorella russelli*; G, H, I, Shell of a paratype of *Sonorella bradshaveana*.

and color. Five live adults were dissected. All show a short spermathecal diverticulum, varying from 1.0 to 2.3 mm in length.

*Disposition of types*.—Holotype: USNM 792406. Paratypes: ANSP 356004; CAS 033405; FMNH 206235; UTEP 9051; RLR 298; WBM 5241 & 6307.

*Type-locality*.—Mohave Co., Arizona. Lower Granite Gorge of the Colorado River, in limestone rockslide just west and below Rampart Cave; elevation ca. 1700 ft., 36°06'N, 113°56'W.

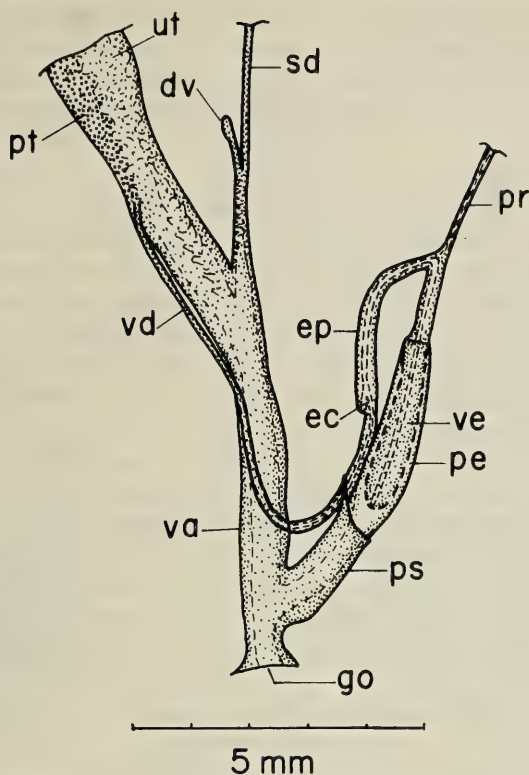


Fig. 2. Lower accessory structures of reproductive system of *Sonorella reederi*; drawing prepared from projection of stained whole mount WBM 6307. dv, spermathecal diverticulum; ec, epiphallic caecum; ep, epiphallus; go, genital orifice; pe, penis; pr, penial retractor muscle; ps, penial sheath; pt, prostate; sd, spermathecal duct; ut, uterus; va, vagina; vd, vas deferens; ve, verge.

*Remarks.*—The most outstanding distinguishing characteristic of this species is the presence of a spermathecal diverticulum, which is a structure not normally found in any other species of *Sonorella*. It is probably vestigial and too short to function in storing exogenous sperm. Its presence nevertheless may be of significance to students of evolutionary processes, in that the gene, or genes, for this structure have apparently not been eliminated from the ancestral helminthoglyptid genome but rather they have only been masked, or prevented from being expressed, by whatever mutations or chromosomal re-arrangements occurred when the founder *Sonorella* was formed.

This species appears to be genetically most closely related to its two geographical neighbors, *S. coloradoensis* (Stearns, 1890) to the east and *S. mohaveana* (W. B. Miller, 1968), to the southwest, as revealed by the similar type of short, cylindrical verge. In *S. coloradoensis*, however, the verge is widely corrugated instead of smooth-sided; furthermore, as stated above, only *S. reederi* is equipped with a distinct, short, spermathecal diverticulum. In shell characters, *S. coloradoensis* is a much smaller shell, whose average diameter is approximately half the size of *S. reederi* and *S. mohaveana*. *Sonorella mohaveana* is more narrowly umbilicate

than *S. reederi*, with the reflected columellar lip covering almost half of the umbilicus. *Sonorella mohaveana* is here raised to specific status because its differences from *S. coloradoensis* in both shell and reproductive anatomy are considered to be the expression of a genome sufficiently distinct to establish effectively reproductive isolation.

The first lot of *S. reederi* was obtained on 25 March 1970, by the author and his son, W. B. Miller III, with only two live adults available for dissection. The presence of a spermathecal diverticulum in each was astonishing, but the sample size was too small to allow a firm determination that it was characteristic of the population. On 23 November 1973, a second expedition was made to the type-locality, and with the help of Richard L. Reeder and Noorullah Babrakzai, four more live adults were obtained; all showed the presence of a spermathecal diverticulum. Vegetation at the type locality was typically Lower Sonoran, with *Acacia greggi* the predominant shrub.

*Etymology*.—When first discovered, this species was tentatively given the manuscript name of *Sonorella boreoccidentis*. Unfortunately, it was inadvertently listed in Bequaert and Miller, 1973, in a caption under Fig. 2 showing the distribution limits of the genus. Accordingly, it became a nomen nudum. I now take great pleasure in naming this species for Richard L. Reeder, friend and colleague, who, together with Noorullah Babrakzai, assisted me in the 1973 backpacking expedition to Rampart Cave to obtain additional live specimens.

*Sonorella russelli*, new species

Figs. 1D–F, 3A

*Description of holotype*.—Shell depressed-globose, heliciform, very light tan, with pale-chestnut, spiral band on well-rounded shoulder; umbilicate, umbilicus contained 9 times in diameter and slightly covered by reflected columellar lip. Embryonic shell of  $1\frac{1}{2}$  whorls, dull, with surface microscopically roughened by radial ripples and papillae. Post-embryonic whorls marked with light growth-wrinkles. Body whorl glossy underneath, descending only slightly to peristome. Aperture oblique, rounded, with margins converging; parietal callus thin. Shell measurements in mm: diameter 15.8, height 10.2, umbilicus 1.8;  $4\frac{1}{2}$  whorls.

*Reproductive anatomy*.—Ovotestis and distal accessory structures as in other *Sonorella*. Proximal structures show diagnostic characters. Penis short, containing short, stout, rhomboid, obtusely pointed verge about  $\frac{1}{3}$  length of penis; penial sheath embraces proximal  $\frac{1}{2}$  of penis. Epiphallus about equal in length to penis, proximally stout as far as attachment of penial retractor muscle, then thin; epiphallic caecum miniscule and buried in connective tissue of epiphallus. Vagina short, about  $\frac{2}{3}$  length of penis. Lengths in mm: penis 4.5, penial sheath 2.5, verge 1.5, epiphallus 5.0, epiphallic caecum 0.3, vagina 3.0.

*Variations in paratypes*.—Approximately 30 dead, adult shells were collected during five separate expeditions over a period of four years, from 6 September 1966 to 6 September 1970. The largest shell measures 18.1 mm in diameter and the smallest measures 14.7 mm. All show similar sculpture and shape; many are all glossy white with no trace of the chestnut spiral band.

*Disposition of types*.—Holotype: USNM 792407. Paratypes: ANSP 356002; CAS 033406; FMNH 206236; UTEP 9050; WBM 4916, 4967, 5200, 5230, 5270.



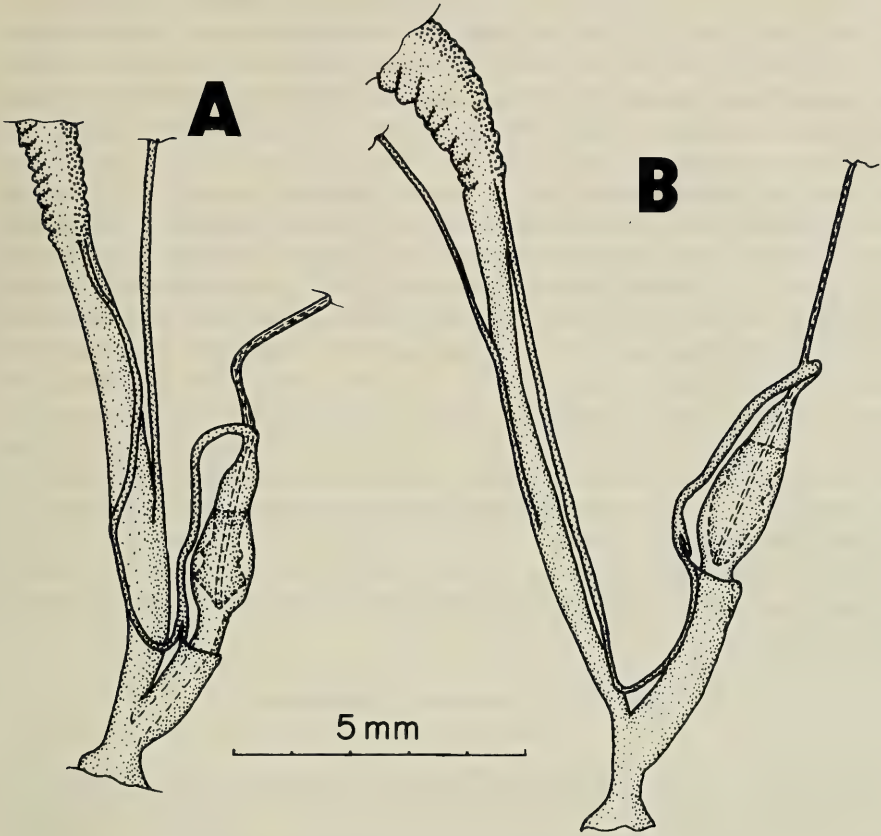


Fig. 3. A, Lower accessory structures of reproductive system of *Sonorella russelli*; drawing prepared from projection of stained whole mount, WBM 5200; B, Lower accessory structures of reproductive system of *Sonorella bradshaveana*; drawing prepared from projection of stained whole mount, WBM 5282. Both drawings to same scale.

*Type-locality.*—Black Canyon, Yavapai County, Arizona, on west flank of Black Mesa, east of Arrastre Creek (a tributary to Black Canyon Creek), in Sec. 10, T9N, R2E, at 34°08'05" N, 112°08'42" W; elevation ca. 2850 ft. This locality is presently about 0.1 mile east of Interstate highway 17, northbound lane, at a point 6.3 road miles north of the town of Rock Springs.

*Remarks.*—*Sonorella russelli* is known only from the type-locality. The locality is a very arid lava rockslide in the Lower Sonoran Zone. It is probable that the type population speciated by rapid genetic drift after ecological isolation in post-pluvial times within the past ten thousand years. The scarcity of live animals, as well as of dead shells, indicates that the population may be on the verge of extinction. In spite of repeated, diligent efforts to find live animals, only 1 live immature specimen was ever obtained. Although this immature specimen was reared carefully for a period of two years, its shell was deformed and could not be used as a holotype; accordingly, a more typical holotype was selected from other shells. The live animal not only yielded a good anatomy, but also laid two

eggs, obviously through self-fertilization. The eggs hatched but the young snails lived only a short while. Their embryonic shells showed details not otherwise discernible on the holotype or other older shells, as follows: embryonic shell of  $1\frac{1}{2}$  whorls, minutely wrinkled by radial striae and densely covered by periostracal hairs, the hairs arranged in spiral rows above the suture but the basal papillae not fused into long threads.

The proximal genitalia show that *S. russelli* belongs to the group of *S. sitiens* Pilsbry & Ferriss, 1915, and probably evolved from an ancestral *S. sitiens* population. It differs from *S. sitiens* in that the proximal genitalia (penis, verge, vagina, etc.) are about half the size of similar structures in *S. sitiens* for shells of approximately equal diameter. The verge of *S. russelli* is particularly distinctive in shape, with a sharply rhomboid outline and a short, obtuse, conical tip. The shells of *S. russelli* are generally paler than those of *S. sitiens*; many show no trace of the peripheral chestnut band although the shells are relatively fresh, lustrous, and not bleached.

The locality for *S. russelli* is far to the north of the nearest known locality for *S. sitiens* which is in the Papago Indian Reservation at Ventana Cave, some 120 miles due south of Black Canyon.

*Etymology.*—I take great pleasure in naming this species for Richard H. Russell, former graduate student and colleague, who collected the one and only live specimen ever found.

*Sonorella bradshaveana*, new species

Figs. 1G–I, 3B

*Description of holotype.*—Shell depressed-globose, heliciform, thin, glossy, light tan, with narrow, chestnut spiral band on well-rounded shoulder; umbilicate, umbilicus contained  $8\frac{1}{2}$  times in diameter and about  $\frac{1}{4}$  covered by reflected columellar lip. Embryonic shell of  $1\frac{1}{4}$  whorls, with surface microscopically roughened by radial wrinkles and minute papillae. Post-embryonic whorls marked with light growth wrinkles and pits of worn-off periostracal hairs, pits fewer on later whorls. Last whorl descends abruptly to slightly expanded peristome. Aperture oblique, rounded, slightly wider than high, with margins converging; parietal callus thin. Shell measurements, in mm: diameter 14.7, height 9.3, umbilicus 1.7;  $4\frac{1}{4}$  whorls.

*Reproductive anatomy.*—Ovotestis and distal accessory structures as in other *Sonorella*. Proximal structures show diagnostic characters. The penis contains a short, stout, acutely pointed verge which is about  $\frac{1}{3}$  the length of the penis; a penial sheath embraces the proximal  $\frac{2}{3}$  of the penis. Epiphallus about as long as the penis, proximally thick as far as attachment of penial retractor muscle, then thin; epiphallic caecum miniscule, buried in connective tissue of epiphallus. The vagina is short, about  $\frac{4}{5}$  the length of the penis. Lengths, in mm: penis 6.0, penial sheath 4.0, verge 2.0, epiphallus 6.0, epiphallic caecum 0.2, vagina 4.7.

*Variations in paratypes.*—A total of 18 adult shells was collected from the type-locality. The largest measures 14.8 mm and the smallest 13.5 mm. All have similar sculpture, shape, and color.

*Disposition of types.*—Holotype: USNM 792408. Paratypes: ANSP 356003; CAS 033404; FMNH 206237; UTEP 9052; WBM 5282.

*Type-locality*.—Bradshaw Mountains, Yavapai County, Arizona, on northeast slope of Horse Mt., in small rockpile along a tributary to Pine Creek, at a point 1.2 road miles south of ford of “Senator highway” across Pine Creek, at 34°14'40" N, 112°23'04" W; elevation ca. 5800 ft. At the type-locality, the “Senator highway,” a dirt road, roughly follows Pine Creek on its left bank; 1.2 road miles to the north of the type-locality, the road fords the creek and climbs out of the valley.

*Remarks*.—The proximal genitalia show *S. bradshaveana* to belong to the group of *S. sitiens*. It is closely related to *S. russelli* and probably evolved from the same ancestral *S. sitiens* population. Unlike *S. russelli* which evolved in the arid Lower Sonoran Zone of Black Canyon, *S. bradshaveana* radiated to the Transition Zone of the Bradshaw Mountains. The vegetation at the type-locality consists predominantly of *Pinus ponderosa*, *Quercus gambeli*, *Garrya wrighti*, and *Cercocarpus montanus*.

The shell of *S. bradshaveana* is smaller and thinner than those of *S. russelli* and *S. sitiens*; its color, like *S. sitiens*, is darker than *S. russelli*.

The lower genitalia separate it from the other species. The shape of the verge alone can be used to separate the three species. In *S. sitiens*, it is short, stout, gradually increasing to a maximum diameter, then tapering to an obtuse rounded tip. In *S. russelli*, it is about half the length and diameter of that of *S. sitiens*, sharply rhomboid, with an obtuse, pointed tip. In *S. bradshaveana*, it is about equal in length but only half the diameter of that of *S. sitiens*, and the tip cone is less obtuse, than in either *russelli* or *sitiens*, being longer than in those species. Lengths of penis and penial sheath are also different for the three species.

Besides the type-population, another population of *S. bradshaveana* was found along the Senator highway about 16 road miles north of the type-locality, at a point 0.5 miles south of Venezia (about 15 road miles south of Prescott) at an elevation of 6100 feet, in a small rockslide of lichen-covered granite. Dissection revealed the anatomy to be similar to that of the type specimens.

*Etymology*.—The species is named for the Bradshaw Mountains which it inhabits.

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Department of General Biology, University of Arizona, Tucson, Arizona 85721.



## THE SYSTEMATIC POSITION OF THE NERITID PROSOBRANCH GASTROPOD *NERITA POLITA* AND RELATED SPECIES

Geerat J. Vermeij

**Abstract.**—*Nerita polita* Linnaeus, 1758, is the type of the new subgenus *Linnerita* of the genus *Nerita* Linnaeus, 1758. This species, like the three other members of the subgenus, is a common intertidal gastropod in the Indo-West-Pacific region.

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*Nerita polita* Linnaeus, 1758, is an abundant intertidal gastropod which is widely distributed in the Indo-West-Pacific region from the mainland coast of East Africa to the Hawaiian Islands. It is the best known of a small group of distinctive Indo-West-Pacific species whose taxonomic unity has never been questioned but whose nomenclature and relationships to other members of the genus *Nerita* have remained unresolved. Baker (1923) exacerbated an already confusing situation when he synonymized several subgenerically distinct species under the single name *Nerita polita*. In this paper I review the relationships of *N. polita* and its relatives to superficially similar species of the genus, and I formally erect a taxon for this group.

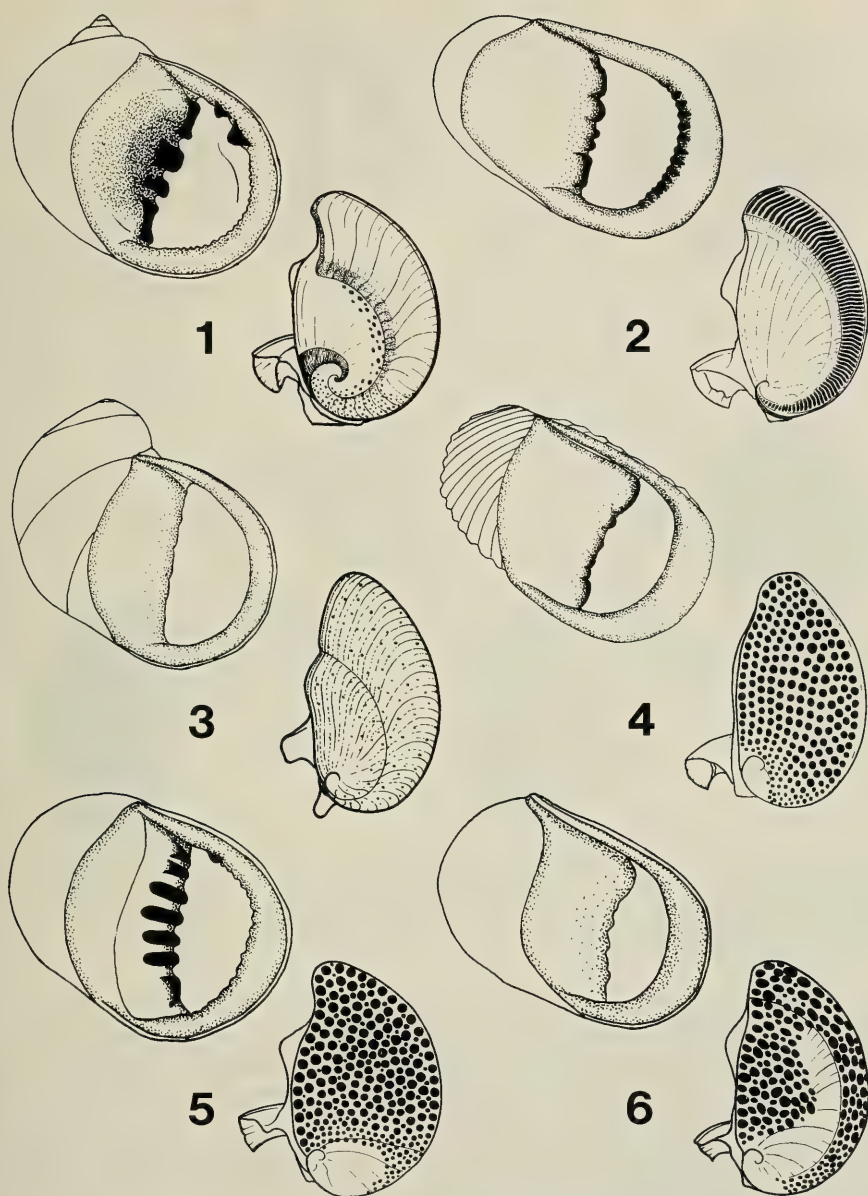
### Nomenclatorial Background

Von Martens (1887-89) believed that *N. polita* was the type of the genus *Nerita* Linnaeus, 1758, and therefore saw no need to coin a name for the group containing this and related species. Abbott (1958), however, confirmed the suspicion of other workers that the distinctive West Indian *N. peloronta* Linnaeus, 1758, was the type of the genus. In his classification based on radular characters, Baker (1923) considered *N. polita* to be a senior synonym of *N. umlaasiana* Krauss, 1848, which von Martens (1887-89) established as the type of his subgenus *Amphinerita*. *Nerita umlaasiana* and its relatives are morphologically and ecologically distinct from *N. polita* and its relatives, so that the name *Amphinerita* cannot be applied to the latter group. The only other name which has been proposed for the *N. polita* group is *Odontostoma* Mörch, 1852, but this name is preoccupied by *Odontostoma* Turton, 1829 (see Baker 1923). Accordingly, no valid name exists for the *N. polita* group, even though most students of *Nerita* have recognized the distinctiveness of this group.

### *Linnerita*, new subgenus

*Type-species.*—*Nerita polita* Linnaeus, 1758.

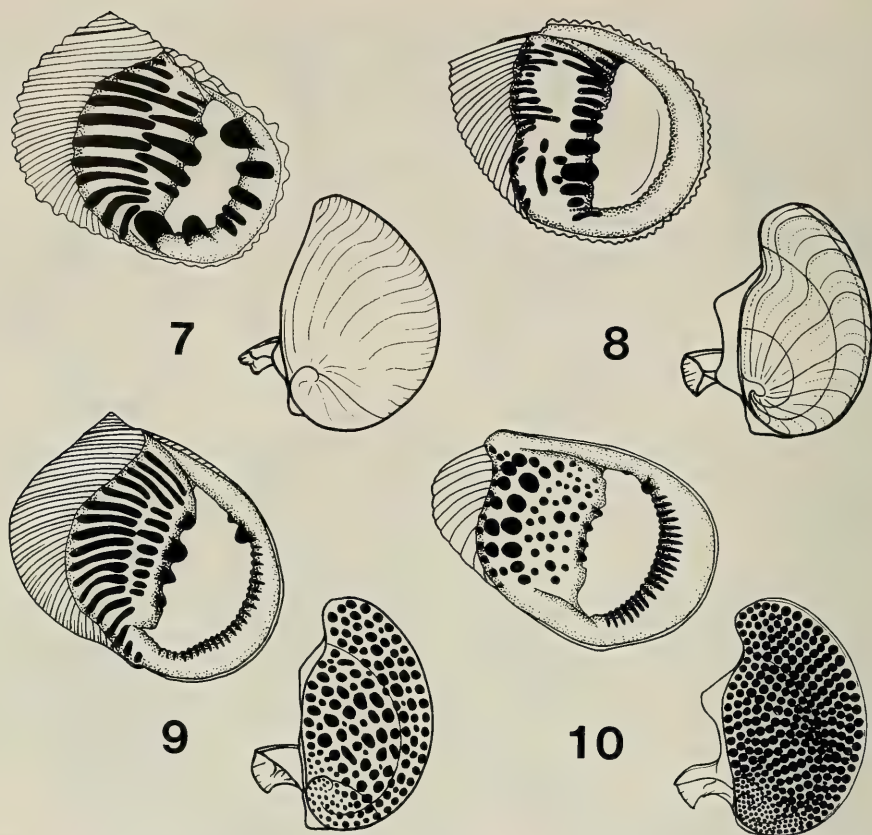
*Diagnosis.*—Shell neritiform; spiral sculpture very weakly developed or absent; collabral sculpture consists of closely spaced wrinkles slightly reflected away from outer lip; apex hardly protruding above rest of shell; outer lip with numerous weakly developed denticles; columellar edge with 3 to 5 teeth; parietal callus



Figs. 1–6. Views of ventral shell surface and outer opercular surface of the type-species of Recent subgenera of *Nerita*: 1, *N. (Nerita) peloronta* Linnaeus, 1758; 2, *N. (Linnerita) polita* Linnaeus, 1758; 3, *N. (Heminerita) japonica* Dunker, 1859; 4, *N. (Lepidonerita) insculpta* Recluz, 1841; 5, *N. (Melanerita) atramentosa* Reeve, 1855; 6, *N. (Amphinerita) umlaasiana* Krauss, 1848. Drawings by E. J. Petuch; plate preparation by M. G. Harasewych.

smooth or transversely wrinkled. Operculum mostly smooth on outer face, flat to convex outward, with granulated raised rim.

*Etymology.*—This taxon is named in honor of Carolus Linnaeus, who in 1758 described its type-species, *N. polita*.



Figs. 7-10. Views of ventral shell surface and outer opercular surface of the type-species of Recent subgenera of *Nerita*: 7, *N. (Ritena) plicata* Linnaeus, 1758; 8, *N. (Ilynerita) planospira* Anton, 1839; 9, *N. (Cymostyla) undata* Linnaeus, 1758; 10, *N. (Theliostyla) albicilla* Linnaeus, 1758. Drawings by E. J. Petuch; plate preparation by M. G. Harasewych.

*Remarks.*—*Linnerita* contains at least four species: *N. polita* Linnaeus, 1758, *N. antiquata* Recluz, 1853, *N. doreyana* Quoy and Gaimard, 1834, and *N. orbignyana* Recluz, 1841. All these species are from the Indo-West-Pacific region. Ecologically, the group is diverse. *Nerita polita* and *N. orbignyana* (the latter being a species or subspecies from the Red Sea) bury themselves in shallow sand by day and come out on middle to high intertidal rocks at night (Taylor 1968, Safriel 1969). *Nerita doreyana* from the Indian and Western Pacific Oceans is found on rocks in the middle and upper intertidal zones and does not burrow in sand (Vermeij 1973). No published information exists on the habits of *N. antiquata*, a species which is apparently limited to the Philippines.

In sculpture, species of *Linnerita* are superficially similar to members of the subgenera *Amphinerita* von Martens, 1887 (type-species: *N. umlaasiana* Krauss, 1848) and *Melanerita* von Martens, 1887 (type-species: *N. nigra* "Gray" von Martens, 1889 = *N. atramentosa* Reeve, 1855). The collabral wrinkles of *Linnerita*, which are best developed in *N. antiquata*, do not appear in the other two subgenera.



Table 1.—Distribution of characters in the subgenera of *Nerita*.

Character	A	C	H	I	L	M	N	R	T
Operculum									
Outer surface granulate throughout	+	+	—	—	—	+	—	+	+
Granulate on rim	—	—	—	—	+	—	—	—	—
Outer surface smooth throughout	—	—	+	+	—	—	—	—	—
Shell sculpture									
Spiral cords present	+	+	+	+	—	+	+	+	+
Axial wrinkles present	—	—	—	—	+	—	—	—	—
Sculpture lacking	+	—	—	—	—	+	—	—	—
Callus									
Granulate or pustulose	—	—	—	+	—	+	±	—	+
Transversely wrinkled	—	+	—	—	+	—	—	+	—
Smooth	+	—	+	—	+	—	—	—	—
Teeth on outer lip									
Strong, fewer than 15 in number	—	—	—	—	—	—	—	+	—
Numerous and weak	+	+	+	+	+	+	+	—	+
Apex									
Raised on tall spire	—	+	+	—	—	+	+	+	—
Barely raised above rest of shell	+	—	—	+	+	—	—	—	+

- + Present, at least in some species.
- Absent in all species.
- A *Amphinerita*.
- C *Cymostyla*.
- H *Heminerita*.
- I *Ilynerita*.
- L *Linnerita*.
- M *Melanerita*.
- N *Nerita* s.s.
- R *Ritena*.
- T *Theliostyla*.

One feature which distinguishes *Linnerita* from all other members of the genus *Nerita* is the operculum, whose smooth outer surface is bordered by a raised granulated rim. The operculum of *Amphinerita*, *Melanerita*, and *Theliostyla* Mörch, 1852 (type-species: *N. albicilla* Linnaeus, 1758) has the convex or flat outer face granulated throughout (Fig. 1). The operculum of *Ilynerita* von Martens, 1887 (type-and only species: *N. planospira* Anton, 1839) is entirely smooth on its outer face. Mienis (1970) described the operculum of *N. olivaria* Le Guillou, 1841 as having two granulated regions separated by a longitudinal line on the outer surface. This species, whose shell is very much like that of *N. umlaasiana*, may belong to *Amphinerita*. Species of *Cymostyla* von Martens, 1887 (type-species: *N. undata* Linnaeus, 1758), *Ritena* Gray, 1858 (type-species: *N. plicata* Linnaeus, 1758), and *Heminerita* von Martens, 1887 (type-species: *N. pica* Gould, 1850 = *N. japonica* Dunker, 1859), and *Nerita* s.s. (type- and only species: *N. peloronta* Linnaeus, 1758) have opercula whose outer face is flat to concave and granulated throughout or in the central area (see Fig. 1). *Nerita insculpta* Recluz, 1841 is a distinctive species with a fully granulated operculum. The nerites with a smooth or nearly smooth operculum are very different in shell characters from *Linnerita*.

*Ilynerita* has a strongly pustulose rather than a smooth or transversely wrinkled parietal callus, and strong spiral cords on the outer surface of the shell. *Heminerita*, some of whose species have a nearly smooth flat operculum (example: *N. guamensis* Quoy and Gaimard, 1834), has a spirally corded shell with a high spire. *Nerita plicata*, the type-species of *Ritena*, has a nearly smooth operculum, but the operculum is strongly concave outward and the shell has strong spiral cords and a strongly toothed aperture.

#### Relationships in *Nerita*

A summary of the distribution of shell and opercular characters of the subgenera of *Nerita* is outlined in Table 1. This compilation suggests that *Linnerita* is closely allied with *Amphinerita* and furthest removed from *Ritena*. It is possible that the clade containing *Linnerita* and *Amphinerita* is of relatively recent origin, because these subgenera are confined in the modern fauna to the Indo-West-Pacific, and have no known fossil species outside that region. *Cymostyla*, *Ritena*, and *Theliostyla*, on the other hand, have Tethyan distributions, which may imply a more ancient origin for these usually strongly sculptured nerites. *Melanerita* shares many features in common with *Theliostyla*, and may represent a group of cool-water species of *Theliostyla* in which the external sculpture, callus sculpture, and lip dentition have become reduced. *Heminerita* is a group of small species which resemble *Cymostyla* save for the smooth callus and greatly reduced lip dentition. Members of *Heminerita* may be progenetic derivatives of the *Cymostyla* stock which are now found chiefly on islands in the Indo-West-Pacific region. *Ilynerita* and *Nerita* are monospecific taxa confined respectively to the Indo-West-Pacific and Caribbean regions. Their origins and relationships with other members of the genus *Nerita* remain unclear.

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SYSTEMATICS, STATUS, AND LIFE HISTORY  
ASPECTS OF THE ASHY DARTER,  
*ETHEOSTOMA CINEREUM* (PISCES: PERCIDAE)

Thomas E. Shepard and Brooks M. Burr

*Abstract.*—*Etheostoma cinereum*, an endemic of the Cumberland and Tennessee River drainages, is redescribed and diagnosed. Although the species has historically been collected in 15 tributary systems, it has been taken from only 7 in the past 20 years. Sexual dimorphism exists in breeding coloration, size and shape of the genital papilla, tuberculation, and several body proportions. Geographic trends in meristic and morphometric characters indicate that somewhat distinct populations exist in the Cumberland, Duck, and upper Tennessee drainages; no subspecies are recognized. *Etheostoma cinereum* is a pool-inhabiting species often associated with cover in the form of boulders, snags, and stands of *Justicia*. The maximum life-span is 52 months, maximum size is 100 mm SL. A sex ratio of 1.5 females to 1 male was found. Spawning apparently occurs from late January to mid-April. Females at the peak of the spawning season contain an average of 53 mature ova per gram adjusted body weight. The diet consists primarily of chironomids, *Ephemera* larvae, and oligochaetes. Individuals are parasitized by fluke metacercariae, encysted nematodes, and acanthocephalan worms.

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The ashy darter, *Etheostoma cinereum* Storer, is one of the largest, most spectacular, and poorly known members of the genus *Etheostoma*. Since its description in 1845 by D. H. Storer from specimens collected near Florence, Alabama, this uncommon fish has been taken in fewer than 80 collections for a total of less than 250 specimens. It is sporadically distributed in medium-size to large streams of the Cumberland and Tennessee River drainages in Alabama, Georgia, Kentucky, Tennessee, and Virginia. Historically, *E. cinereum* has been recorded from 15 tributary systems; recently, however, it has been taken with regularity in only four: Rockcastle River, Big South Fork of the Cumberland River, Buffalo River, and Little River.

*Etheostoma cinereum* is considered extirpated in Alabama (Smith-Vaniz 1968, Ramsey 1976), and was last collected in Georgia in 1955 (Dahlberg and Scott 1971) and in Virginia in 1964 (Jenkins and Musick 1980). It is on the endangered list in Kentucky (Branson *et al.* 1981) and of special concern in Tennessee (Starnes and Etnier 1980). Nationally, the Endangered Species Committee of the American Fisheries Society (Deacon *et al.* 1979, Williams 1981) recognized *E. cinereum* as a species of special concern because it is presently threatened by destruction, modification, or curtailment of its habitat and range.

Nearly 50 years after its original description, Kirsch (1893) rediscovered and described additional specimens of *E. cinereum* from the Obey River, Tennessee. Bailey, in Bailey and Gosline (1955), placed *E. cinereum* in the monotypic subgenus *Allohistium* based on several unusual morphological features and noted



that the species appeared to be most closely related to the subgenera *Nothonotus* and *Oligocephalus*. Collette (1965) did not find breeding tubercles on a male with well developed testes from the Cumberland River drainage. Page and Whitt (1973) discovered that *E. cinereum* was the only *Etheostoma* species with electrophoretic mobility of the LDH B<sub>4</sub> isozyme (apparently present in all *Percina*). Based on aspects of the lateralis system, Page (1977) considered *Allohistium* to be a primitive subgenus, as did Collette and Bănărescu (1977). Recently, Page (1981) amplified and augmented Bailey's original description of *Allohistium*. Other than these brief accounts and its inclusion in checklists and state fish-books, very little has been published on the systematics or life history of *E. cinereum*.

The paucity of information about all aspects of this unusual darter prompted this study. Its goals were to: 1) document the historical and present geographic range of the species based on museum specimens and additional collecting; 2) redescribe the species and discuss its geographic variation; and 3) provide information on the life history of the species.

*Methods.*—Counts and measurements followed the methods of Hubbs and Lagler (1964) except as follows. Squamation on the breast, nape, belly, cheek, and opercle were estimated to the nearest 10%. Postdorsal length was the distance from the posterior margin of the second dorsal fin base to the end of the hypural plate. Terminology and counting procedures of the cephalic lateralis system followed Hubbs and Cannon (1935) and Page (1977).

Methods of studying aspects of the life history were those employed by Page (1974) except as follows. Aging to month was done by using March, the month with the ripest females, as month zero; thus a specimen collected in October and having no annuli on its scales was considered to be 6 months of age. Eighty-three specimens were dissected to obtain information on diet, internal parasites, and reproduction.

In the statistical analysis of data, regression coefficients were calculated by the method of least squares using the General Linear Models procedure of SAS. F tests were used to test the significance of group differences in regression coefficients and in homogeneity of regression. Correlation coefficients were all Pearson product-moment correlations (*r*). Morphometric characters were tested for significant differences between populations at the 0.05 level by regression analysis of the characters on standard length (SL). The effect of sexual dimorphism on differences in regression between drainage populations was reduced by testing the semipartial contribution of drainage to the correlation after partialing out the effects of sex. Determinations as to which populations differed significantly from others were accomplished using a priori orthogonal comparisons. Sexual dimorphism in morphometric characters was analyzed by testing the semipartial contribution of sex to correlations between the characters and SL. For tabular presentation, measurements were expressed as thousandths of SL for specimens greater than 40 mm SL.

Means of meristic characters were tested for significant differences between drainages at the 0.05 level using Duncan's multiple range test. Raw meristic and morphometric data were transformed to natural logarithms and subjected to SPSS discriminant analyses using the WILKS stepwise method (Nie *et al.* 1975). A priori groupings of specimens were by tributary system. Because small sample sizes can artificially inflate group separations due to random effects (Shaklee and

Tamaru 1981), only those tributary systems with more than 5 specimens were included in the analyses. Meristic and morphometric data were analyzed both together and separately.

For the analysis of variation in some morphological characters and life history aspects, tributary populations were combined into 3 or more inclusive drainage units: Cumberland, Duck, and upper Tennessee. Throughout this paper, "upper Tennessee drainage" refers to the Tennessee River drainage exclusive of the Duck River drainage.

*Material Examined.*—The following material was examined. The number of specimens in each series is in parentheses. Abbreviations for institutions are identified in Acknowledgments. Complete collection data are on deposit at the Department of Zoology, SIUC.

*CUMBERLAND DRAINAGE.* ROCKCASTLE RIVER. Kentucky, Rockcastle-Laurel Co.: INHS 87452 (1), 28 May 1981; SIUC 6612 (2), 23 Oct 1979; 2108 (2), 28 Oct 1980; 2131 (2), 27 Oct 1980; 3863 (1), 25 Sep 1981; 3923 (2), 25 Sep 1981; 3989 (4), 12 Apr 1981; 3993 (1), 12 Apr 1981; 4048 (5), 26 Sep 1981; 7456 (9), 5 Mar 1983. BIG SOUTH FORK RIVER. Kentucky, McCreary Co.: SIUC 6633 (1), 24 Oct 1979. Wayne Co.: ECU 1130 (1), 31 Oct 1980; REJ 555 (2), 18–19 May 1972; USNM 25106 (7), 7 Sep 1891; 46212 (1), 7 Sep 1891. Tennessee, Scott Co.: INHS 83895 (1), 30 Sep 1978; SIUC 4128 (1), 30 Sep 1978; UF 17509 (1), 16 Sep 1968; UT 91.175 (2), 26 May 1968; 91.402 (1), 8 Sep 1969; 91.430 (5), 30 Aug 1968; 91.431 (5), 16 Sep 1968; 91.658 (1), May 1972; 91.1463 (5), 1 Nov 1977; 91.2174 (5), 22 Sep 1968; WCS 015-02 (1), 7 Aug 1969; 455-13 (1), 4 Oct 1975. BUCK CREEK. Kentucky, Pulaski Co.: UMMZ 171557 (5), 14 Sep 1955; 171590 (2), 14 Sep 1955. OBEY RIVER. Tennessee, Overton Co.: ECU 655 (1), 6 Jul 1970; INHS 75541 (1), 6 Jul 1970; USNM 70674 (9), 28 Aug 1891. Pickett Co.: USNM 70675 (6), 28 Aug 1891. ROARING RIVER. Tennessee, Jackson Co.: UT 91.266 (1), 30 Aug 1968. RED RIVER. Tennessee, Robertson Co.: UMMZ 175061 (3), 21 Jun 1957.

*DUCK DRAINAGE.* UPPER DUCK RIVER. Tennessee, Bedford Co.: AU 4375 (1), 7 Oct 1971; 4408 (4), 7 Oct 1971; UT 91.229 (1), 20 Oct 1968; 91.736 (1), 4 Oct 1972. BUFFALO RIVER. Tennessee, Lewis Co.: INHS 79389 (2), 14 Apr 1978; NLU 29692 (5), 10 Apr 1974; 39945 (6), 8–9 Apr 1978; SIUC 4127 (1), 22 Mar 1978.

*UPPER TENNESSEE DRAINAGE.* CLINCH RIVER. Virginia, Russell or Scott Co.: VPI 2153 (1), 1964. EMORY RIVER. Tennessee, Morgan Co.: UT 91.224 (1), 5 Aug 1969; 91.690 (1), 1 Jul 1972. LITTLE RIVER. Tennessee, Blount Co.: CU 65136 (1), 31 Jul 1980; ECU 717 (2), 18 Oct 1975; NLU 47492 (6), 8 Apr 1981; OAM 6279 (1), summer 1966; SIUC 3517 (1), 10 Aug 1979; 4141 (5), 13–14 Mar 1982; 7466 (1), 5 Mar 1983; UAIC 4148.15 (2), 5 Jun 1975; 5742.01 (1), 1 Nov 1977; 5743.01 (1), 23 May 1979; 5818.16 (7), 13 Oct 1979; 5953.08 (1), 13 Mar 1980; 6334.16 (4), 25 Jan 1981; UF 19172, 17 Aug 1972; 30676 (1), 10 Apr 1981; UT 91.273 (1), 26 Oct 1968; 91.376 (1), 23 Oct 1969; 91.418 (2), 28 Dec 1969; 91.445 (2), 15 May 1970; 91.499 (4), 21 Jul 1970; 91.512 (1), 20 Oct 1970; 91.593 (10), 5–7 Oct 1971; 91.732 (1), 26 Oct 1972; 91.1205 (4), 17 Apr 1976; 91.1206 (1), 6 Nov 1975; WCS 572-02 (1), 18 Apr 1976; 1071-01 (4), 16 Jun 1979; 1132-02 (4), 25 Aug 1979; 1422-01 (1), 1 Aug 1979. ELK RIVER. Tennessee, Lincoln Co.: TVA uncat. (1), 28 Apr 1981.



## Systematics

*Etheostoma cinereum* Storer, 1845

## Fig. 1

*Types*.—The type(s) of *Etheostoma cinereum* were “caught in deep still water” (Storer 1845) by Charles A. Hentz from Florence, Alabama, some time prior to 1845. It is unclear from the wording just prior (p. 48) to the original description (p. 49) whether Storer based the description on actual specimens, on drawings and a description sent to him by Hentz, or both. Careful reading of the minutes of the Boston Society of Natural History meeting where Storer presented the original description, and a personal letter from Hentz to Storer accompanying some drawings, indicates that no specimens were sent to Storer and none were saved by Hentz. Hentz’s original fish drawings are not at the Boston Museum of Science (K. E. Hartel, pers. comm.). This may explain why Collette and Knapp (1966) were unable to find any types of *Etheostoma cinerea*, or of *E. tessellata* described from the same set of drawings and descriptions sent to Storer by Hentz.

The following counts for the missing type(s) or original drawings are from the original description: 11 dorsal spines, 13 dorsal rays, 15 pectoral rays, 6 pelvic rays, 10 anal-fin elements, 17 caudal rays.

*Diagnosis*.—A species of *Etheostoma* and only member of subgenus *Allohistium* as diagnosed by Page (1981). A large darter reaching a maximum SL of 100 mm characterized by thick, papillose lips; snout long in relation to head length ( $\bar{x}$  = 32% of head length); greatly reduced gill rakers on arches 1–3, occurring in 7–9 discrete clusters per arch; breast and nape unscaled (or few scales posteriorly on nape); absence of palatine teeth; usually 6 branchiostegal rays; separate or narrowly joined branchiostegal membranes across isthmus; mid-lateral row of 10–13 small black rectangles expanding into grayish-brown diagonal bands, darkest just below lateral line and forming interrupted lateral stripe extending through eye to tip of snout; usually 4 irregular rows of orange dots forming thin horizontal stripes on upper sides.

The most distinctive features of *Etheostoma cinereum* are those characteristic of mature males including a greatly elongate and distally rounded second dorsal fin reaching nearly to caudal base when depressed (mean second dorsal fin length 32% of SL); rust or blood red on lips (in Cumberland River populations), margin of first dorsal fin, and interradi al membranes of both dorsal fins; brilliant, iridescent blue on rays of anal and pelvic fins, that is less intense on interradi al membranes of anal and pelvic fins, chin, branchiostegals, lower opercle, breast, belly, and lower caudal peduncle and as a median band in first dorsal fin.

*Description*.—Certain counts and measurements are presented in Table 1. General body shape is illustrated in Fig. 1.

Dorsal spines 10(6 specimens), 11(78), 12(83), 13(15), 14(1); dorsal rays 11(5), 12(89), 13(78), 14(11); total dorsal fin elements 22(7), 23(59), 24(44), 25(54), 26(16), 27(3); anal spines 1(1), 2(182); anal rays 7(6), 8(142), 9(34); left pectoral rays 14(35), 15(135), 16(12). Pelvic fins with 1 spine and 5(183) rays. Principal caudal rays 15(3), 16(163), 17(2). Lateral line on body complete, rarely a few pores lacking posteriorly. Lateral-line scales 50(1), 51(5), 52(3), 53(14), 54(21), 55(27), 56(25), 57(24), 58(27), 59(14), 60(14), 61(7), 63(1); scale rows above lateral line 6(14), 7(109), 8(50), 9(5), 10(1); scale rows below lateral line 9(7), 10(37),



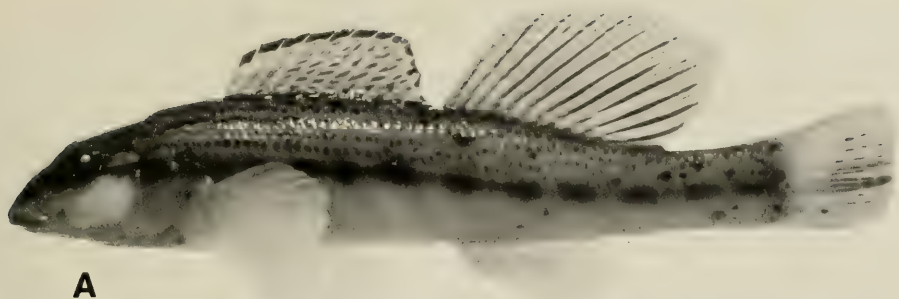


Fig. 1. *Etheostoma cinereum*: A, Male, 77 mm SL, Rockcastle R., Rockcastle-Laurel Co. line; KY, 28 May 1981 (INHS 87452); B, Female, 66 mm SL, as above, 5 Mar 1983 (SIUC 7456). Photos by L. M. Page and B. M. Burr.

11(80), 12(38), 13(14), 14(3); transverse scale rows to first dorsal fin 18(7), 19(27), 20(42), 21(40), 22(34), 23(18), 24(14), 25(1); caudal-peduncle scale rows 20(1), 21(1), 22(12), 23(59), 24(72), 25(32), 26(5). Cheek scales small, slightly ctenoid, moderately to deeply imbedded; cheek, belly, and opercle always fully scaled; nape usually naked, rarely as much as 20% scaled; breast and prepectoral area naked. Modified midventral scales absent. Branchiostegal rays 5:6(1), 6:6(177), 7:6(2), 6:7(1), 6:5(4). Gill rakers greatly reduced and arranged in 7–9 discrete clusters, those on first arch more reduced than on subsequent arches. Vertebrae 39(1), 40(2), 41(48), 42(75), 43(40), 44(1). Prevomerine teeth present; palatine teeth absent. Canals of cephalic lateralis system complete. Infraorbital pores 7(2), 8(174), 9(3); preoperculo-mandibular pores 9(1), 10(175), 11(3); supratemporal pores 3; supraorbital pores 4; lateral pores 5.

Body elongate, moderately deep (mean body depth 17% of SL), and somewhat compressed (mean body width 93% of body depth), and deepest at nape. Caudal peduncle shallow (mean caudal peduncle depth 10% of SL). Snout long and pointed

Table 1. — Comparisons of means and ranges of selected meristic and morphometric (in thousandths of SL) characters among populations of *Etheostoma cinereum* from three drainages. M is the modal count for each meristic character.

Character	Cumberland drainage			Duck drainage			Upper Tennessee drainage				
	M	$\bar{x}$	n	M	$\bar{x}$	Range	n	M	$\bar{x}$	Range	n
Dorsal spines	11	11.16	87	12	11.86	11-12	21	12	12.04	10-14	75
Dorsal rays	12	12.15	87	13	12.57	12-13	21	13	12.93	11-14	75
Dorsal spines and rays	23	23.31	79	25	24.43	23-25	21	25	24.97	23-27	75
Anal spines	2	2.30	87	2	2.00	2	21	2	1.99	1-2	75
Anal rays	8	8.14	87	9	8.57	8-9	21	8	8.08	7-10	75
Lateral-line scales	57	57.18	87	58	58.33	55-61	21	55	54.97	51-60	75
Scales above lateral line	7	7.44	85	7	7.33	6-8	21	7	7.07	6-8	73
Scales below lateral line	11	11.21	85	12	11.86	10-14	21	11	10.84	9-13	73
Transverse scale rows	20	21.13	87	22	22.33	20-24	21	21	20.47	18-24	75
Caudal peduncle scales	23	23.52	87	24	24.15	23-26	21	24	23.88	22-26	75
Vertebrae	41	41.29	75	43	43.00	42-44	21	42	42.27	41-43	71
Body depth		164	76		172	159-184	21		182	161-201	75
Body width		114	66		123	113-134	21		125	86-204	67
Predorsal length		330	76		331	307-398	21		331	200-360	67
Postdorsal length		223	66		214	188-237	21		206	171-311	67
Caudal peduncle depth		96	76		99	93-108	21		101	78-114	67
Caudal peduncle length		270	66		266	244-292	21		262	189-324	67
Head depth		155	66		161	151-175	21		175	122-195	67
Head width		137	76		137	123-159	21		152	109-183	67
Snout length		97	76		99	88-111	21		95	81-112	67
Eye length		65	66		68	61-76	21		66	57-77	67
D <sub>1</sub> base length		212	76		226	158-268	21		233	184-270	67
D <sub>2</sub> base length		199	76		206	178-254	21		214	159-252	67
Longest dorsal spine length		101	66		90	75-107	21		103	64-136	67
Longest anal spine length		51	66		49	30-60	21		57	36-81	67
Pectoral fin length		219	75		209	170-239	21		235	187-283	67
Upper jaw length		84	66		86	77-95	21		87	72-100	67
Gape width		67	76		70	54-86	21		77	59-90	67
Cheek length		115	66		110	96-120	21		110	88-136	67
Suborbital width		26	66		29	19-36	21		29	16-43	67
Interorbital width		33	76		40	29-44	21		39	26-53	67

(mean snout length 32% of head length). Lips thick and fleshy with flattened papillae on inner surfaces. Premaxillary connected to snout by broad frenum. Lower jaw included in upper jaw. Gill membranes separate to narrowly connected. Pectoral fins short (mean pectoral fin length 22% of SL). Posterior margin of caudal fin straight-edged or slightly emarginate.

*Coloration.*—The description is based on fresh and preserved material including specimens in breeding condition collected in Little River, Tennessee, 13–14 March 1982, in Rockcastle River, Kentucky, 5 March 1983, and on color notes provided by Noel M. Burkhead on specimens collected 11 February 1978 in Little River. A color photograph of a breeding male from Little River is shown in Deacon *et al.* (1979).

Ground color of nonbreeding specimens straw-yellow dorsally, white or cream ventrally. Midlateral row of 10–13 small black rectangles, darkest for about 4 scale rows below lateral line, expanding into fainter grayish-brown diagonal bands forming an interrupted lateral stripe which adjoins a dark stripe on head extending through eye to margins of frenum. Usually 4 irregular rows of orange dots on upper sides of body forming thin horizontal stripes. Dorsum crossed by 7 or 8 faint blotches extending ventrally only as far as uppermost horizontal stripe. Subocular bar absent. First dorsal fin with rust-orange blotches on interradial membranes, and blood-red marginal band. Second dorsal fin with several orange blotches on interradial membranes proximally, melding into blood red vertical bars distally. Caudal fin with brown pigment over rays in blotches, sometimes forming 2 or 3 distinct bands, more prominent proximally; blood red blotches present on interradial membranes distally. Pectoral, pelvic, and anal fins usually clear.

Breeding males with intense iridescent blue over rays of pelvic and anal fins, interradial membranes with less intense blue or blackish pigment. Chin, lower opercle, breast, belly, branchiostegals, and lower caudal peduncle, iridescent blue. First dorsal fin with a distal blood red band and a median iridescent blue band, most intense over first 2 or 3 interradial membranes, becoming fainter posteriorly. Second dorsal fin with faint blue-black band over basal one-third of first 7–9 interradial membranes; distal two-thirds of fin with blood red on rays and red spots on interradial membranes. Pectoral fins darkly pigmented on rays, less so on interradial membranes. Caudal fin with red spots on interradial membranes and a dark distal edge. Males more darkly pigmented than females and nonbreeding males, taking on a bronze iridescent appearance. Anus and genital papilla white, contrasting sharply with darkly pigmented venter. Intense blood red on lips in Cumberland River populations only. Breeding females do not develop intense blue body and fin colors, but have red on margin of first dorsal fin and on interradial membranes of both dorsal fins and caudal fin and some blue on ventral edge of caudal fin base. Females and immature males from Cumberland drainage also develop red on lips, but not as intensely as breeding males.

*Tuberculation.*—Collette (1965) did not find tubercles on specimens of *Etheostoma cinereum* he examined. Since then, a 77 mm SL nuptial male (SIUC 7456) with tubercles on the pelvic and anal fins was collected on 5 March 1983 from Rockcastle River. On the anal fin the tubercles are small, white, and rounded and most abundant on the distal portions of rays 3–8, sparsely developed on rays 1–2. The tubercles on the pelvic fins are similar to those on the anal fin and are



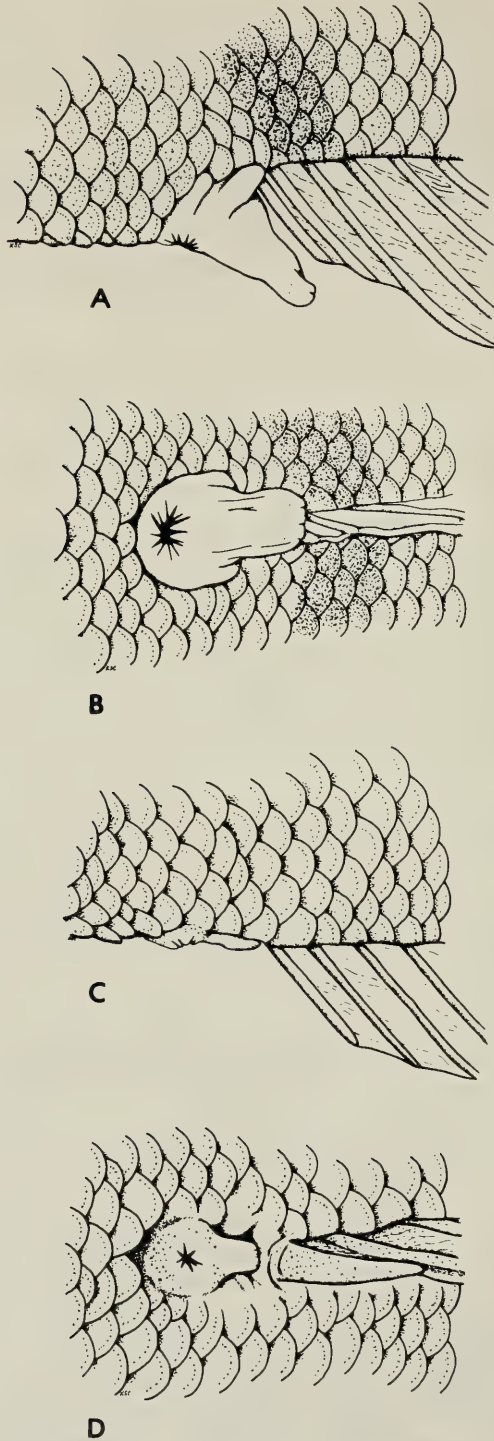


Fig. 2. Genital papillae of *Etheostoma cinereum*. A, Lateral view and B, ventral view of papilla of gravid female collected 13 Mar 1982 (SIUC 4141); C, Lateral view and D, ventral view of papilla of nuptial male collected 10 Apr 1974 (NLU 29692).

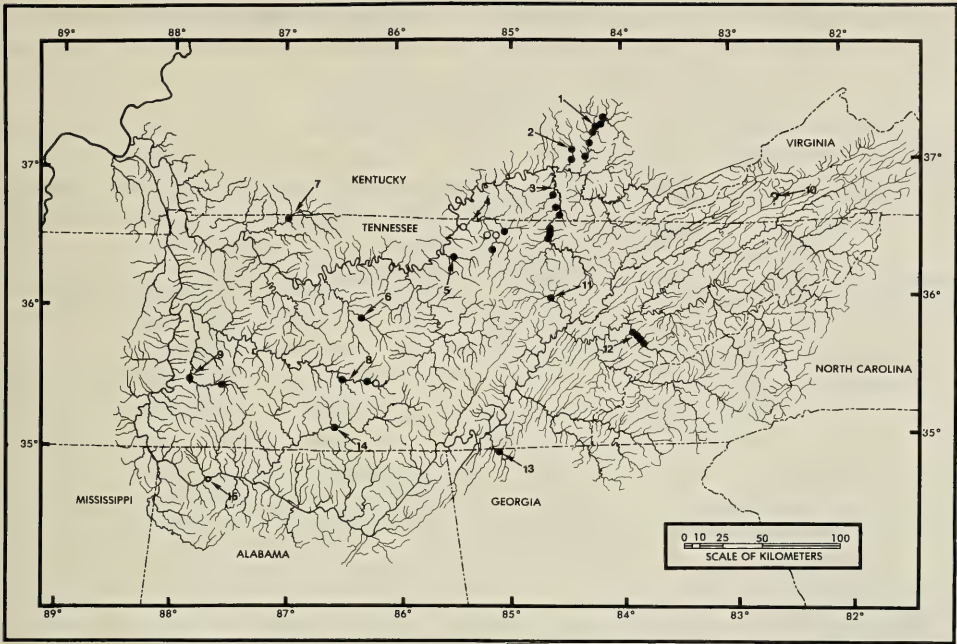


Fig. 3. Distribution of localities where *Etheostoma cinereum* has been collected. Open symbols represent localities presently impounded; the star represents the approximate type locality; the question mark represents an uncertain locality in the Clinch River. 1. Rockcastle R. 2. Buck Cr. 3. Big South Fork of the Cumberland R. 4. Obey R. system. 5. Roaring R. 6. Stones R. 7. Red R. 8. upper Duck R. 9. Buffalo R. 10. Clinch R. 11. Emory R. 12. Little R. 13. Chickamauga Cr. 14. Elk R. 15. Approximate type locality near Florence, Alabama.

located on the ventral sides of rays 2–3. Tubercles were not found on any other specimen examined.

**Sexual dimorphism.**—Sexual dimorphism in breeding coloration, tuberculation, and growth rate are discussed elsewhere in this paper. No sexual dimorphism in meristic characters was found. Of 30 morphometric characters tested (F-test) for sexual dimorphism, 3 displayed highly significant differences ( $P < 0.005$ ), and 5 displayed less significant differences ( $0.005 < P < 0.05$ ). The most significant characters were longer first dorsal, second dorsal, and anal fin lengths in males. Greater dorsal and/or anal fin lengths in males is a common sexually dimorphic trait in darters, e.g., *Etheostoma variatum*, *E. blennioides*, and *E. zonale* (Lachner *et al.* 1950); *E. moorei* (Raney and Suttkus 1964); *E. kennicotti* (Page 1975); *E. smithi* (Page and Burr 1976); *E. fonticola*, *E. microperca*, and *E. proeliare* (Burr 1978); and *E. blennioides* (Burr 1979). The longer pectoral, pelvic, and caudal fins reported for males of several darter species were not found in *E. cinereum*. Measurements significantly greater in males at the  $0.005 < P < 0.05$  level were caudal peduncle length, snout length, second dorsal fin base length, cheek height, and gape width.

The development of the second dorsal fin of mature males of *E. cinereum* is the greatest of any darter. The second dorsal fins of both sexes develop at the same rate until about 50 mm SL. After this size the male's fin begins to lengthen

Table 2.—Status of selected populations of *Etheostoma cinereum* with a list of habitat modifications that may have adversely affected them. Numbers refer to localities as identified in Fig. 3.

Locality, date of last collection and no. of specimens taken on that date	Habitat modifications that may have adversely affected population	Present status and source
<b>Cumberland R. drainage</b>		
2. Buck Cr., Pulaski Co., KY, 1955:7	Acid wastes; pesticide and chemical pollutants from farming and coal mining	Extirpated; pers. observ., R. R. Cicerello, pers. comm.
4. Obey R. system, Overton Co., TN, 1973:3	Inundation of some localities by Dale Hollow Lake; coal mining pollution	Unknown, additional collecting needed; Carrithers (1971)
5. Roaring R., Jackson Co., TN, 1968:1	Unknown	Unknown, additional collecting needed; this study
6. Stones R., Rutherford Co., TN, 1961:1	Inundation of potential habitat downstream by Percy Priest Lake	Extirpated; this study
7. East Fork Red R., Robertson Co., TN, 1957:3	Heavy siltation; pesticide pollution	Extirpated; pers. observ., Warren and Cicerello (1984)
<b>Tennessee R. drainage</b>		
8. Upper Duck R., Bedford Co., TN, 1972:1	Inundation of some localities by Normandy and Columbia lakes	Unknown, additional collecting needed; Starnes and Etnier (1980)
10. Clinch R., Scott or Russell Co., VA, 1964:1	Alkaline spill in 1967; acid spill in 1970; inundation of potential habitat downstream by Norris Lake	Extirpated; Jenkins and Musick (1980)
11. Emory R., Morgan Co., TN, 1972:6	Coal mining pollution; acidic water; inundation of potential habitat downstream by Watts Bar Lake	Unknown, additional collecting needed; Tackett (1963)
13. Chickamauga Cr., Catoosa Co., GA, 1955:1	Siltation; domestic and industrial pollution	Extirpated; Etnier et al. (1981)
15. Florence, AL (type locality), 1845:?	Siltation; insolation; inundation by Pickwick, Wilson and Wheeler lakes	Extirpated; Ramsey (1976)

at a rate of about 1.5 times that of the female's, which grows at the same rate throughout life. The relationship between second dorsal fin length (Y) and SL (X) for males was  $Y = -10.81 + 0.50X$ , with  $r = 0.94$ , and for females was  $Y = -3.55 + 0.34X$ , with  $r = 0.94$ .

There is a marked difference between the genital papilla of the female and that of the male. In nonbreeding females the genital papilla is a short thickened tube. During the breeding season, it becomes enlarged to form a conical tube, with a crenate flap of flesh on the distal anterior margin which overhangs the gonopore (Fig. 2). Papilla length (measured from anal orifice to tip of papilla) ranged from 3.7 to 4.7 mm,  $\bar{x} = 4.2$  mm, in 6 ripe females 62 to 88 mm SL ( $\bar{x} = 73$  mm).



The genital papilla of both nonbreeding and breeding males is a short flattened tube (Fig. 2) which does not noticeably enlarge during the breeding season.

### Distribution and Status

*Etheostoma cinereum* has been collected from 15 tributary systems in the Cumberland and Tennessee River drainages (Fig. 3). It has not been collected in seven of these since 1969, and in the past five years has been collected only from Big South Fork of the Cumberland, Rockcastle, Buffalo, Little, and Elk River systems. The fact that this fish has not been recently collected from a given tributary system is not necessarily an indication of its absence there. Even at localities where reproducing populations are known to exist, *E. cinereum* is often not taken unless special effort is made thoroughly to collect its habitat. The apparent elimination of *E. cinereum* from some tributary systems is perhaps an artifact of inadequate sampling in recent years.

Some populations of *E. cinereum* have apparently been extirpated and the species has not been collected from several localities in the last 11 years (Table 2). The status of *E. cinereum* in four localities is unknown (Table 2). The factors most seriously affecting the species are impoundments, siltation, coal mining, and domestic and industrial pollution (Table 2). Because *E. cinereum* is primarily a pool inhabitant, siltation may have a greater detrimental effect on its habitat than on that of riffle-dwelling darters where the current helps keep the riffles swept clean of silt deposits.

Reproducing populations showing some recruitment include Rockcastle River, Kentucky, Big South Fork Cumberland system, Kentucky and Tennessee, Buffalo River, Tennessee, and Little River, Tennessee. In the Cumberland drainage, *E. cinereum* has been collected from seven localities in Rockcastle River, Rockcastle-Laurel counties, in the past 10 years, and more than 50 specimens have been collected there in the past five years. The Rockcastle River watershed is partially protected in the Daniel Boone National Forest and water quality and species diversity remain high there. However, Branson (1977) has cited strip mining as a potential threat to fishes in this river. Comiskey and Etnier (1972) reported substantial numbers of *E. cinereum* in the Big South Fork of the Cumberland River and its larger tributaries. More recent collections reveal that the population is still substantial. The lower portion of the system in Kentucky is protected in the Daniel Boone National Forest, but there is considerable coal mining pollution in the upper watershed and the silt load is heavy there at times. Two streams, New River and lower Rock Creek, are badly polluted by strip mining (Comiskey and Etnier 1972).

In the Tennessee drainage, *E. cinereum* has been regularly collected in the Buffalo River in recent years, but only at the mouth of Grinders Creek, Lewis County, Tennessee. Specimens were also taken once in 1971 in Perry County at the Highway 13 bridge. The Buffalo River, one of the most unspoiled southeastern rivers (Anonymous 1973) contains apparently suitable habitat for *E. cinereum* throughout much of its length. It is thus expected that the species is more widespread in the Buffalo River. More specimens (>100) have been collected from Little River, Blount County, Tennessee, than any other system, with the largest single series (11) collected there in 1971. The headwaters of Little River are

Table 3.—Counts of total dorsal fin elements in *Etheostoma cinereum*.

Population	22	23	24	25	26	27	n	$\bar{x}$	SD	CV
Rockcastle R.	2	14	3	1			20	23.15	0.67	2.90
Buck Cr.	2	3	2				7	23.00	0.82	3.55
Big South Fork	1	29	7	2			39	23.26	0.59	2.56
Obey R.	1	6	6	4			17	23.76	0.90	3.80
Roaring R.				1			1	25.00	...	...
Red R.	1	2					3	22.67	0.58	2.55
Upper Duck R.			4	3			7	24.43	0.53	2.19
Buffalo R.		1	6	7			14	24.43	0.65	2.65
Clinch R.				1			1	25.00	...	...
Emory R.			1	1			2	24.50	0.71	2.87
Little R.		3	15	34	16	3	71	25.01	0.89	3.57
Elk R.		1					1	23.00	...	...

protected in the Great Smoky Mountains National Park, and *E. cinereum* faces no immediate threat from habitat modification in that area, although a substantial reach of lower Little River has been subject to recent development.

The only record of the species in the Elk River, Lincoln County, Tennessee, is a specimen collected by C. F. Saylor of the TVA near Fayetteville in 1981. The presence of this species in the Elk is surprising in light of water levels that vary more than 1 m daily due to power generation at Tims Ford Dam. Because this dam had been in operation for more than five years when the specimen was collected, there must have been recruitment in the population.

### Geographic Variation

While considerable overlap among major drainage populations existed in the ranges of nearly all characters examined, univariate analyses revealed some significant differences and distinctive geographic trends. The limited range of *E. cinereum* and similarity of the streams it inhabits, particularly in regard to temperature regimes, suggest that genetic rather than environmental factors are responsible for most geographic variation found. Results of discriminant analyses

Table 4.—Counts of total vertebrae in *Etheostoma cinereum*. Counts of two specimens from the Obey River are taken from Bailey and Gosline (1955).

Population	39	40	41	42	43	44	n	$\bar{x}$	SD	CV
Rockcastle R.			4	16			20	41.80	0.41	0.98
Big South Fork	1	2	32	3			38	40.97	0.49	1.20
Obey R.			9	9			18	41.50	0.51	1.24
Roaring R.			1				1	41.00	...	...
Upper Duck R.					6	1	7	43.14	0.38	0.88
Buffalo R.				1	13		14	42.93	0.27	0.62
Clinch R.					1		1	43.00	...	...
Emory R.					1	1	2	42.50	0.71	1.66
Little R.			2	47	18		67	42.24	0.50	1.18
Elk R.					1		1	43.00	...	...

Table 5.—Counts of anal rays in *Etheostoma cinereum*.

Population	7	8	9	n	$\bar{x}$	SD	CV
Rockcastle R.	1	16	3	20	8.10	0.45	5.52
Buck Cr.		5	2	7	8.29	0.49	5.89
Big South Fork		31	8	39	8.21	0.41	4.99
Obey R.		16	1	17	8.06	0.24	3.01
Roaring R.		1		1	8.00	...	...
Red R.	1	2		3	7.67	0.58	7.53
Upper Duck R.		6	1	7	8.14	0.38	4.64
Buffalo R.		3	11	14	8.79	0.43	4.85
Clinch R.		1		1	8.00	...	...
Emory R.		2		2	8.00	...	...
Little R.	4	59	8	71	8.10	0.47	5.86
Elk R.		1		1	8.00	...	...

provided further evidence of isolation and divergence of some drainage populations, and gave an indication of multivariate similarity among them.

Counts of dorsal spines, dorsal rays, total dorsal fin elements, and vertebrae were all correlated and displayed similar geographic trends (Tables 1, 3, and 4). Counts of vertebrae and dorsal spines were also highly correlated in a population of *Etheostoma exile* (Gosline 1947) and in *E. zonale* (Tsai and Raney 1974), suggesting that these characters may be linked in development, possibly involving the differentiation of somites (Gosline 1947). Specimens from the Cumberland drainage, with the exception of Rockcastle River, typically had 41 vertebrae, 11 dorsal spines, and 12 dorsal rays. Most specimens from the Rockcastle River had 42 vertebrae, but displayed the same modal dorsal spine and ray counts as other Cumberland drainage populations. Duck and upper Tennessee drainage specimens typically had 42 or 43 vertebrae, 12 dorsal spines, and 12 or 13 dorsal rays. Only 27% of specimens from the upper Tennessee drainage had 43 or more vertebrae, compared to 95% in the Duck drainage. The Buffalo River population was unique in having a modal anal ray count of 9 compared to 8 in all others (Table 5). Scale counts were generally correlated with each other, and to a lesser degree, with

Table 6.—Counts of lateral-line scales in *Etheostoma cinereum*.

Population	51	52	53	54	55	56	57	58	59	60	61	62	63	n	$\bar{x}$	SD	CV
Rockcastle R.					1	2	4	2	5	3	2	—	1	20	58.55	1.99	3.39
Buck Cr.					1	1	3	2						7	56.86	1.07	1.88
Big South Fork	2		3	5	7	9	5	3	2	2	1			39	55.85	2.27	4.06
Obey R.					1	1	2	5	3	3	2			17	58.47	1.66	2.84
Roaring R.										1				1	60.00	...	...
Red R.							1	1	1					3	58.00	1.00	1.72
Upper Duck R.						1	1	1	1	2	1			7	58.71	1.80	3.07
Buffalo R.					1	1	2	6	1	1	2			14	58.14	1.70	2.93
Clinch R.											1			1	60.00	...	...
Emory R.							1	1						2	57.50	0.17	1.23
Little R.	3	2	12	16	16	10	6	5	—	1				71	54.73	1.78	3.26
Elk R.										1				1	59.00	...	...



counts of dorsal fin elements. Tsai and Raney (1974) found similar results for *E. zonale*. Little River specimens had significantly fewer lateral-line scales (modally 54, 55) than other tributary systems (Table 6). Most specimens from the Cumberland drainage, as well as the other Tennessee drainage tributaries, had 56 or more, while those from the Duck River drainage usually had 58 to 60. Other scale counts displayed the same trends (Table 1). No other significant variation in meristic characters was found.

As judged by mean values of body depth and body width (Table 1), specimens from the Cumberland drainage were typically less robust than those from the Duck and upper Tennessee drainages. These differences may reflect the condition of individual specimens at the time of capture more than genetically determined factors. Many Cumberland drainage specimens (particularly those collected in fall and winter) often appeared slightly emaciated. As noted in the section on diet, *Ephemera* larvae, a major food item for Cumberland drainage specimens only, were eaten only from late spring until early fall, possibly contributing to the emaciated appearance. Cumberland drainage specimens also differed from others in having significantly longer cheeks, caudal peduncles, and postdorsal lengths and in having shorter first and second dorsal fin bases, upper jaw lengths, sub-orbital widths, and interorbital widths (Table 1). Specimens from the upper Tennessee drainage differed from others in having significantly greater head depths, head widths, gape widths, pectoral fin lengths, and longest dorsal spine lengths (Table 1). Duck drainage specimens had no unique morphometric features and were more similar to specimens from the upper Tennessee drainage than to those from the Cumberland drainage in most body proportions.

A trenchant color difference may exist between breeding males in the Cumberland and upper Tennessee drainages. Based on examination of a small number of fresh specimens, color transparencies, and Noel M. Burkhead's color notes on a breeding male from Little River, mature males from the Cumberland drainage have blood red lips at least from early fall until late spring (possibly year-round). Males from Little River apparently develop no red on the lips even in peak spawning condition. Examination of more fresh material is needed to determine the distribution and consistency of this character from throughout the range of the species.

In the discriminant analysis with both morphometric and meristic characters included, five significant ( $P < 0.001$ ) functions were derived, with the first two accounting for 70% of the variance between groups. While the variables with the highest value on the WILKS selection criterion were meristic, all of the discriminant functions were most heavily loaded for morphometric characters, e.g., body depth, postdorsal length, and predorsal length. The analysis correctly classified 97.2% of specimens, with all misclassified specimens being assigned to another tributary system in the same major drainage unit. The first two functions were sufficient to classify 97.9% of specimens into their correct major drainage, but only 78.2% into their proper tributary system. In a plot of individual scores on the first two functions (Fig. 4), the clusters formed by specimens from the three Cumberland drainage tributary systems widely overlap each other, as do the two Duck drainage clusters, while the Little River specimens formed a discrete cluster. The only overlap between major drainage units was between the Rockcastle River cluster and those formed by individuals from the two Duck drainage tributaries.

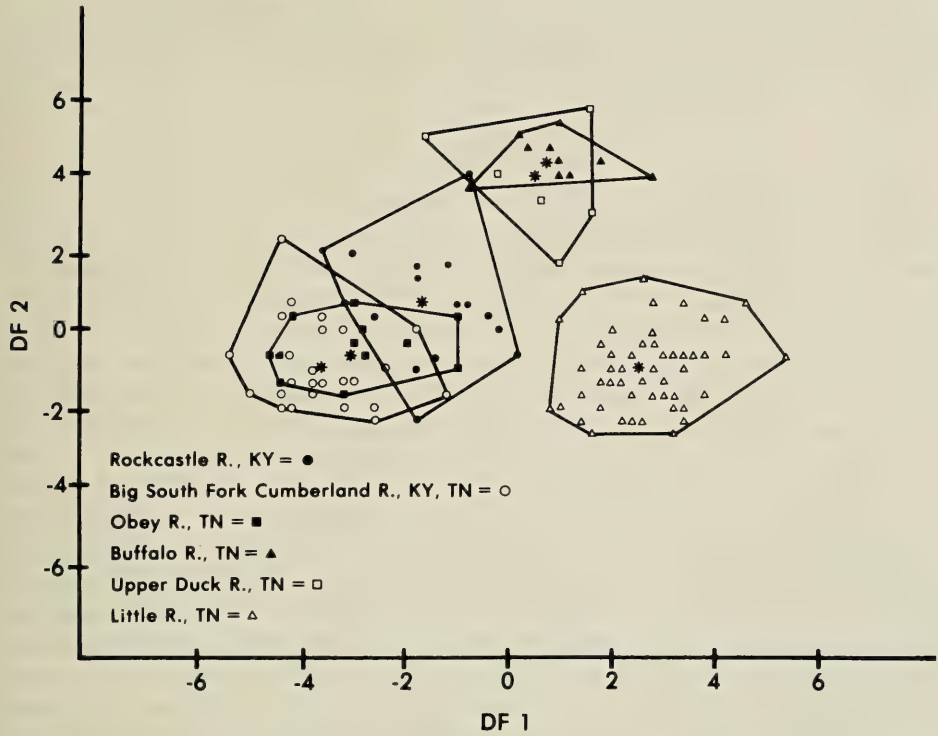


Fig. 4. Projection of 141 specimens of *Etheostoma cinereum* from 6 tributary systems on the first 2 discriminant functions in an analysis using 8 meristic and 26 morphometric characters. Asterisks represent group centroids. Solid lines connect outermost specimens of each tributary system cluster. Where 2 specimens overlap, only 1 is shown.

A discriminant analysis using only meristic characters classified 85.6% of specimens correctly, with 94% being placed in their proper major drainage. All five functions were significant ( $P < 0.001$ ), with the first two accounting for 82% of the separation between groups. The first function was most heavily loaded for vertebrae, dorsal rays, and lateral-line scales. Those characters along with dorsal spines and transverse scale rows were also heavily loaded on the second function.

The analysis using only morphometric characters correctly classified 87.9% of specimens, assigning 93% to their correct major drainage. Of five significant ( $P < 0.001$ ) functions derived, the first two accounted for 74% of the variance between groups. The first two functions were most heavily loaded for postdorsal length, pectoral fin length, caudal peduncle length, body depth, and head width.

Based on the results of the univariate and discriminant analyses, *E. cinereum* can most equitably be divided into three somewhat distinct populations: Cumberland drainage, Duck drainage, and upper Tennessee drainage. In most meristic and morphometric characters, the Duck drainage population is more similar to the upper Tennessee population than the Cumberland population, suggesting that it has experienced either more gene exchange with the former or that the populations in the two drainages have experienced similar selection pressures (Ehrlich and Raven 1969). Although no population is distinct enough in any character to

warrant separate taxonomic status, examination of more fresh breeding material may eventually reveal color differences which might justify the naming of subspecies.

### Aspects of Life History

*Habitat.*—*Etheostoma cinereum* has been most consistently collected from clear pools or eddies with sluggish current in water 0.50–1.75 m deep over silt-free sand or gravel substrates in medium-size to large upland streams. The species is often taken close to shore and is usually associated with cover such as boulders, snags, and stands of water willow (*Justicia*) above and below riffles. The close association with cover makes conventional seining techniques inefficient, and may partially explain why *E. cinereum* has usually been collected in low numbers ( $\bar{x}$  number specimens per collection = 2.6). On several occasions more than one individual has been collected from the same restricted area of habitat; in one instance (SIUC 4048, 26 Sep 1981) four individuals were collected from the same pool area of approximately 10 m<sup>2</sup>, in another, (SIUC 7456, 5 Mar 1983) nine individuals were collected from a pool about 30 m in length in one hour. This suggests that the species may not be as uncommon and solitary in its principal habitat as the low collection numbers indicate. However, the areas meeting the habitat requirements of *E. cinereum* in the streams it inhabits are often rare and localized, contributing to the low population numbers of this fish.

*Age and growth.*—The oldest specimen examined (EKU 655) was a 100 mm SL, 52-month-old male collected in the Obey River. The oldest female (NLU 29692) was 49 months old, measured 89 mm SL, and was collected in the Buffalo River. Most males (68.2%) and females (79.7%) were less than two years old, with only 20.5% of males and 18.8% of females being in their third year of life (Table 7). Of six specimens more than three years old, five were males. Males also dominated older year classes in other large darters including *Percina sciera* (Page and Smith 1970), *Etheostoma squamiceps* (Page 1974), and *E. kennicotti* (Page 1975). The few species of darters in which females have been found to be more long-lived than males are small species in which very few individuals of either sex live more than 18–20 months, e.g., *E. proeliare* (Burr and Page 1978) and *E. microperca* (Burr and Page 1979).

Within the size range examined (29–89 mm), *E. cinereum* grows at a decreasing rate throughout life. The relationship between SL (Y) and age in months (X) was  $Y = 1.52 + 20.18 \text{ Log}_e X$ , with  $r = 0.88$ . One-half of the first year's length (26 mm) was reached in approximately 13 weeks. There may be an indirect relationship between growth rate and maximum adult size among darters. The smallest species, e.g., *E. microperca*, and *E. proeliare*, reach one-half of the first year's mean SL in eight weeks or less (Burr and Page 1978, 1979). Larger species, e.g., *E. squamiceps* (Page 1974) and *E. kennicotti* (Page 1975), typically reach one-half of the first year's mean growth in 12 weeks or more.

Significant differences were found between growth rates of specimens from the Duck, upper Tennessee, and Cumberland River drainages. Those from the Duck drainage grew fastest ( $Y = -3.68 + 23.08 \text{ Log}_e X$ ,  $r = 0.83$ ), followed by those from the upper Tennessee drainage ( $Y = 1.33 + 20.45 \text{ Log}_e X$ ,  $r = 0.82$ ), and Cumberland drainage ( $Y = 7.87 + 19.05 \text{ Log}_e X$ ,  $r = 0.73$ ). These differences in



Table 7.—Distribution of sexes among year classes in *Etheostoma cinereum*, with corresponding ranges and means of standard length. Only 108 individuals were sexed.

Year class	Sex	n	Percent	Range SL	Mean SL	SD
0	M	4	9.1	39.0–49.5	43.7	4.92
	F	5	7.8	32.6–47.2	38.6	5.79
1	M	26	59.1	39.2–66.6	57.6	6.03
	F	46	71.9	39.7–66.2	56.8	6.47
2	M	9	20.5	62.4–79.1	73.9	5.76
	F	12	18.8	60.5–82.1	70.6	5.17
3	M	4	9.1	79.9–88.6	84.8	3.62
	F	...	...	...	...	...
4	M	1	2.2	100.0	100.0	...
	F	1	1.6	89.4	89.4	...

growth rate are reflected in the mean and range values of SL of each year class for the major drainages compared (Table 8). Differences in the diets of the Cumberland and Tennessee drainage populations, which may be partially responsible for the differences in growth, are described elsewhere in this paper. Other factors known to effect the growth rates of fish and which may play some role in effecting the growth of *E. cinereum* include temperature, competition, and genetically determined growth potential (Weatherley 1976).

Although males of each year class measured larger than females (Table 7), regression analysis of 104 specimens from several localities failed to reveal significant differences between the growth rates of males and females. Since specimens used in the regression analysis were lumped from widely separated localities, variation between localities may have obscured differences between the sexes.

*Reproductive biology, males.*—No male less than 50 mm SL had well developed testes or enlarged second dorsal and anal fins associated with maturity. All males greater than 50 mm SL and collected during the breeding season had white spongy testes and secondary sexual characteristics suggesting maturity. All 2-year-old males, but only 88% of 1-year-old males, were mature. In most small species of darters (e.g., *E. microperca*, Burr and Page 1979; *E. striatulum*, Page 1980; *E. simoterum*, Page and Mayden 1981) all males, regardless of size, are capable of spawning at one year of age. Among several larger, more long-lived species of darters only males above some minimum size are capable of spawning, including: *E. olmstedii* and *E. longimanum* (Raney and Lachner 1943); *E. variatum*, *E. zonale*, and *E. blennioides* (Lachner *et al.* 1950); *E. squamiceps* (Page 1974); and *E. olivaceum* (Page 1980).

Males collected in February, March, and April had the most darkly pigmented fins and bodies, and the proportionally largest testes. Males collected from May until October had small, thin, clear testes, and nearly clear anal and pelvic fins. Large males collected in late October had slightly enlarged whitish testes and had developed some dark pigmentation on the fins.

*Reproductive biology, females.*—No female less than 55 mm SL had ovaries containing mature ova. All 2-year or older individuals and 65% of 1-year-olds

Table 8.—Distribution of year classes in *Etheostoma cinereum* from three drainages, with corresponding ranges and means of standard length.

Year class	n	Percent of individuals	Range SL	Mean SL	SD
Cumberland Drainage					
0	15	19.5	29.6–47.3	39.8	5.00
1	36	46.8	39.2–67.1	56.1	7.15
2	25	32.5	58.5–78.9	67.7	5.50
3	...	...	...	...	...
4	1	1.3	100.0	100.0	...
Duck Drainage					
1	12	57.1	49.8–64.2	57.1	4.00
2	6	28.6	67.8–82.1	72.1	5.45
3	2	9.5	79.9–88.5	84.2	6.12
4	1	4.8	89.4	89.4	...
Upper Tennessee Drainage					
0	23	30.7	32.6–49.5	42.7	4.56
1	42	56.0	42.9–66.2	56.6	6.59
2	8	10.7	60.5–79.1	70.6	6.16
3	2	2.7	85.1–85.9	85.5	0.57

collected during the breeding season had ovaries containing mature ova. The highest gonadosomatic indices were found in two females collected in March ( $\bar{x}$  GSI = 225). Mature ova in these specimens were orange or translucent, averaged 2.0 mm in diameter (range = 1.7–2.4 mm,  $N = 20$ ) and lacked the indentation on one side described for *E. fonticola*, *E. microperca*, and *E. proeliare* (Burr and Page 1978, 1979), and *E. olivaceum* and *E. striatulum* (Page 1980). The two ripest females contained 150 and 249 mature ova (Table 9), with an average of 53 mature ova per gram adjusted body weight (ABW). Small, short-lived species of darters, which spawn only once, typically have higher numbers of ova per gram ABW, e.g., 209 ova per gram ABW calculated for *E. proeliare* from data in Burr and Page (1978), and 114 eggs per gram ABW calculated for *E. simoterum* from data in Page and Mayden (1981). Larger species which spawn in more than one breeding season have values closer to that calculated for *E. cinereum*, e.g., 66 eggs per gram ABW calculated for both *E. squamiceps* from data in Page (1974) and *E. kennicotti* from data in Page (1975).

Females collected in May had the lowest gonadosomatic indices ( $\bar{x}$  GSI for May = 2.4). Ovaries grew at an increasing rate from May until the peak breeding season in March and April. The relationship between GSI (Y) and month (X) with May taken as month 1, for females greater than 55 mm SL, was  $\text{Log}_e Y = 0.30 + 0.15X$ , with  $r = 0.93$ .

*Sex ratio.*—Of 104 individuals sexed, 62 were females and 42 were males, giving an overall ratio of 1.5 females to 1 male ( $X^2 = 3.85$ ,  $P < 0.10$ ). This skewed sex ratio, however, may be a manifestation of small sample size and/or sampling bias. Females outnumbered males in collections from the upper Tennessee drainage (34 to 15) and Duck drainage (13 to 2). However, more males than females (25 to 15) were collected in the Cumberland drainage. Most species of darters do not deviate significantly from a 1:1 sex ratio, except for the territorial and po-

Table 9.—Relationship between size, age, and ovary weight of *Etheostoma cinereum* females and the number of mature ova. An age of 1 year = 11–13 months, 2 years = 23–25 months.

Standard length (mm)	Adjusted body weight (g) <sup>a</sup>	Month of collection	Age in years	Weight of ovaries (g)	Number of mature ova	GSI <sup>b</sup>
58	2.15	January	2	0.16	149	74
63	2.94	March	1	0.35	150	119
70	4.38	March	2	0.98	249	224
64	2.83	March	2	0.64	106	225
58	1.47	April	1	0.08	43	54
					(partly spent)	
60	1.62	April	1	0.08	51	49
					(partly spent)	

<sup>a</sup> Adjusted weight is the specimen's weight after removal of the ovaries, stomach, intestine, and liver.

<sup>b</sup> Equals weight of ovaries × 1000/adjusted body weight.

lygamous species of the subgenus *Catonotus*, in which females outnumber males (Lake 1936; Page 1974, 1975; Page and Burr 1976; Page 1980).

*Spawning*.—As judged by size, weight, and color of gonads, and period of breeding coloration, the spawning season of *E. cinereum* probably extends from late January to mid-April, with peak spawning probably in mid-March. Spawning habitat and spawning behavior are unknown, but the conical-shaped genital papilla of ripe females (Fig. 2) indicates that the species may be an egg burier or egg attacher (following the classification of Page, 1983).

*Diet*.—Of the 83 stomachs examined, only 72% contained at least 1 food item. The most common food items were chironomid larvae, larvae of the burrowing mayfly *Ephemera*, and oligochaetes. The abundance of *Ephemera* larvae and oligochaetes in the diet correlates the observation that the principal habitat of *E. cinereum* is sandy-bottomed pools where these organisms most frequently occur (Needham *et al.* 1935; Pennak 1978). Although the feeding behavior of *E. cinereum* was not observed, the elongate snout and papillose lips may be specializations for feeding on burrowing organisms. Less common items in the diet were, for the most part, either terrestrial organisms which had fallen into the water (e.g., formicids and cercopids), or aquatic organisms which are uncommon in the principal habitat of *E. cinereum* (e.g., *Ferrisia* and *Stenonema*).

Substantial differences were found among food items of specimens from the Cumberland (N = 39) and upper Tennessee (N = 35) drainages. Chironomids accounted for a larger proportion of the diet of upper Tennessee drainage specimens (84%) than of Cumberland drainage specimens (52%). *Ephemera* accounted for 25% of the diet and occurred in 46% of the stomachs examined in Cumberland drainage specimens but were only 3.3% of the diet of upper Tennessee drainage specimens. Oligochaetes also comprised a larger proportion of the diet of Cumberland drainage specimens (15.3%) than of upper Tennessee drainage specimens (2.2%). Too few specimens (2) from the Duck drainage were examined for stomach contents to make comparisons with other populations.

Food habits varied among size classes. Specimens less than 40 mm SL fed almost exclusively on chironomid larvae. Chironomids were less important in the diets of 41 to 60 mm SL specimens, with larger food items such as ephem-



cropterans and oligochaetes accounting for 30% of the diet. Only 50% of stomachs of specimens larger than 60 mm SL contained chironomids, with 40% of the diet being ephemeropterans, plecopterans, trichopterans, and other large food items. Microcrustaceans, important in the diets of smaller size classes of many species of darters, were not found in the stomachs of any specimens of *E. cinereum*, possibly because few specimens smaller than 40 mm SL were examined.

Seasonal variation in the importance of several food items in the diet was apparent. While chironomid larvae were eaten every season, *Ephemera* larvae were a major food item only from late spring through early fall, and plecopteran larvae were present in the diet only from April until June.

*Parasites.*—The only external parasites found on *E. cinereum* were fluke metacercariae; 76% of individuals examined had at least 1 metacercarial cyst, and 27% had 10 or more. The most heavily infested individual had 75 cysts. Cysts were present on individuals from all months in which the species has been collected.

Of the 83 specimens dissected, encysted nematodes were found on the livers and intestines of nine, with the most heavily infested individual containing five cysts. The intestines of three specimens each contained one acanthocephalan worm.

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## SYSTEMATIC IMPLICATIONS OF CHROMOSOMAL BANDING ANALYSES OF POPULATIONS OF *PEROMYSCUS TRUEI* (RODENTIA: MURIDAE)

William S. Modi and M. Raymond Lee

**Abstract.**—C-band, G-band, and Ag-NOR analyses were carried out on the southern (AN = 54) and northern (AN = 62) cytotypes of *Peromyscus truei* from New Mexico, Texas, and Oregon. Results support the retention of *comanche* as a subspecies of *P. truei*, but populations possessing the southern cytotype are regarded as specifically distinct and referable to *Peromyscus gratus*.

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*Peromyscus truei*, as currently recognized, contains 15 subspecies including *Peromyscus truei comanche* (Hall 1981; Schmidly 1973). This arrangement differs somewhat from the latest taxonomic revision of the species (Hoffmeister 1951), which recognized 12 subspecies and regarded *comanche* as a subspecies of *Peromyscus nasutus* (= *P. difficilis*).

Several karyological studies have addressed the systematics and evolution of *P. truei*. These analyses indicate that two distinct chromosomal forms exist: a northern,  $2n = 48$ , AN = 62 cytotype (AN = number of autosomal arms, see Lee and Elder 1977) from the western and southwestern United States, and a southern,  $2n = 48$ , AN = 54 cytotype from New Mexico and Mexico (Hsu and Arrighi 1968; Lee *et al.* 1972; Zimmerman *et al.* 1975). Further, the standard karyotype of *P. t. comanche* was shown to be identical to that of *P. truei* and quite different from that of *P. difficilis* (Lee *et al.* 1972).

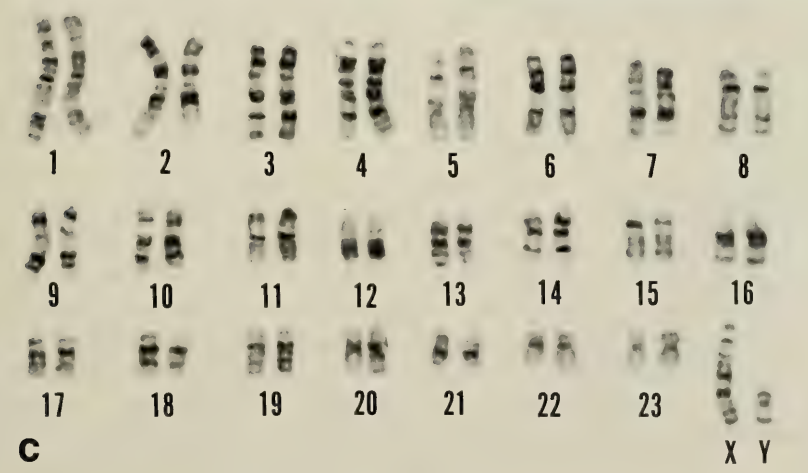
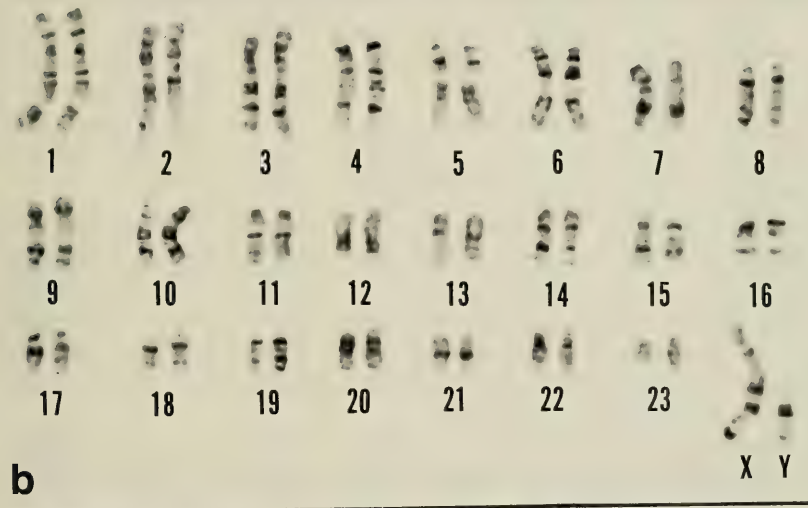
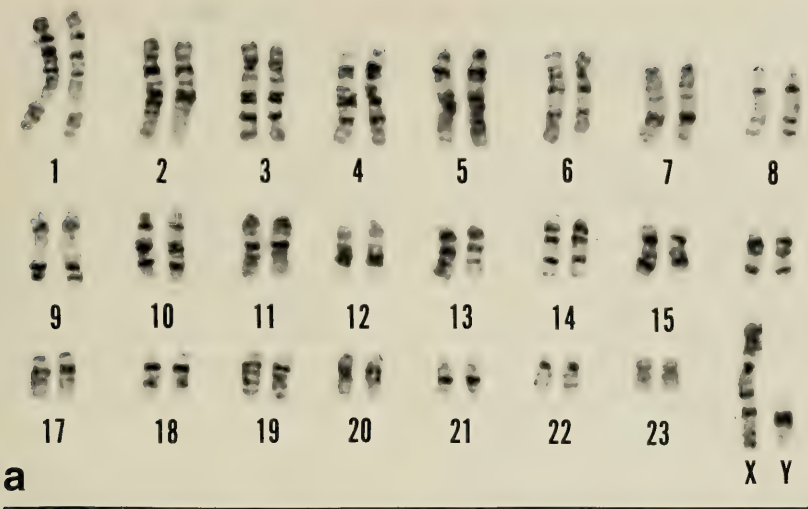
We present chromosomal banding comparisons of *P. t. comanche* and of the two *P. truei* cytotypes. We think the evidence derived both from our work and from previous studies most appropriately maintains *P. t. comanche* as a subspecies of *P. truei*, while we recognize populations having the southern, AN = 54 cytotype as a distinct species referable to *P. gratus* Merriam, 1898.

**Methods.**—Mice were live-trapped and shipped to the laboratory for processing. All chromosomal preparations were derived from bone marrow following Lee and Elder (1980). The differential staining procedures we utilized are also cited therein. Voucher specimens are deposited in the Museum of Natural History, University of Illinois, Urbana-Champaign.

Specimens examined: *P. t. truei* (12), New Mexico: 2 mi NE Hanover, Grant Co., 1 female; 2 mi N Hanover, Grant Co., 2 males, 1 female; 8 mi S Magdalena, Socorro Co., 2 males, 1 female; 1 mi N Magdalena, 2 males; 2 mi up from Monica Canyon Ranger Station, San Mateo Mts., Socorro Co., 2 males, 1 female. *P. t. comanche* (4), Texas: 15 mi E Canyon, Randall Co., 3 males, 1 female. *P. t. preblei*

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Fig. 1. a, G-banded karyotype of *P. t. truei*. Autosomes and X chromosome are from a female, the Y chromosome is from a male; b, G-banded karyotype of a male *P. t. comanche*; c, G-banded karyotype of a male *P. gratus*.





(3), Oregon, 10 mi NW Terrebonne, Jefferson Co., 3 females. *P. gratus* (4), New Mexico: 2 mi NE Hanover, Grant Co., 1 female; 1 mi N Luna, Catron Co., 1 male; 3 mi up from Monica Canyon Ranger Station, San Mateo Mts., Socorro Co., 2 males.

**Results.**—*Peromyscus truei truei* ( $2n = 48$ ,  $AN = 62$ ). All autosomes are acrocentric except 1, 2, 3, 6, 9, 15, 22, and 23. The X is a large submetacentric; the Y is a small acrocentric. The short arm of chromosome 1 is longer than that found thus far in other *Peromyscus* and appears to be the result of a pericentric inversion not involving the telomere (Figs. 1a, 3d). Autosomal heterochromatin is restricted to centromeric regions. The centromeric area and short arms of the X and the proximal one-third to one-half of the Y are heterochromatic (Fig. 2a). Our G- and C-band results appear to agree with those of Robbins and Baker (1981) for this species, although they apparently misidentified pairs 16, 17, 18, and 20 (see Committee 1977, Fig. 1a). Nucleolus organizer regions (NORs) are located telometrically on the short arms of pairs 1 and 22 (Fig. 3c).

*Peromyscus truei comanche* ( $2n = 48$ ,  $AN = 62$ ). The karyotype is similar to that of *P. t. truei*. The elements within the G-banded karyotype of *P. t. comanche* and *P. t. truei* are homologous with the exception of the short arms of chromosome 6 and the X (Figs. 1b, 3d). These differences were not observed by Robbins and Baker (1981) in their examination of *P. t. comanche*. The chromosomal locations of C-bands are the same as in *P. t. truei*; however, the amount of heterochromatin in the karyotype of *P. t. comanche* is somewhat less (Fig. 2b). The silver-stained karyotype is indistinguishable from that of *P. t. truei* (Fig. 3a).

*Peromyscus truei preblei* ( $2n = 48$ ,  $AN = 62$ ). The elements within the G-banded karyotype are homologous with those of *P. t. truei* and *P. t. comanche*, again with the exception of the short arms of chromosome 6 and the X (Fig. 3d). Each of the three populations of *P. truei* thus possesses different G-banding patterns for these two elements. The C-banded karyotype (not shown) is similar to that of *P. t. comanche*, and the silver-stained karyotype (also not shown) is identical to those of *P. t. truei* and *P. t. comanche*.

*Peromyscus gratus* ( $2n = 48$ ,  $AN = 54$ ). All autosomes are acrocentric except pairs 1, 2, 22, and 23. The X is a large submetacentric; the Y is a small metacentric. The Y chromosome and the short arm of the X have unique G-band patterns compared with other species of *Peromyscus* (Figs. 1c, 3d). (See Greenbaum *et al.* 1978; Robbins and Baker 1981; Yates *et al.* 1980). Heterochromatin is located centromerically on all autosomes and the sex chromosomes, and on the short arms of the Y (Fig. 2c). Three pairs of Ag-NORs are located telomerically on pairs 3, 7 or 8 or 9, and 22 (Fig. 3b).

**Discussion.**—*Peromyscus truei truei*, *P. t. comanche*, and *P. t. preblei*, differ karyotypically in the inversion patterns found in chromosome 6, in the G-banding patterns of the heterochromatic short arm of the X, and in the presence of slightly more heterochromatin in the karyotype of *P. t. truei*. These findings indicate that *P. t. comanche* has undergone only a slight amount of chromosomal change in the 10,000-year period that it has been geographically isolated from the main population of *P. truei* (Blair 1950), and is no more differentiated than are either of the other two populations that were examined. We think that *P. t. comanche* should be retained as a subspecies of *P. truei*. This same conclusion was reached by Schmidly (1973) using morphological criteria. Electrophoretic comparisons of

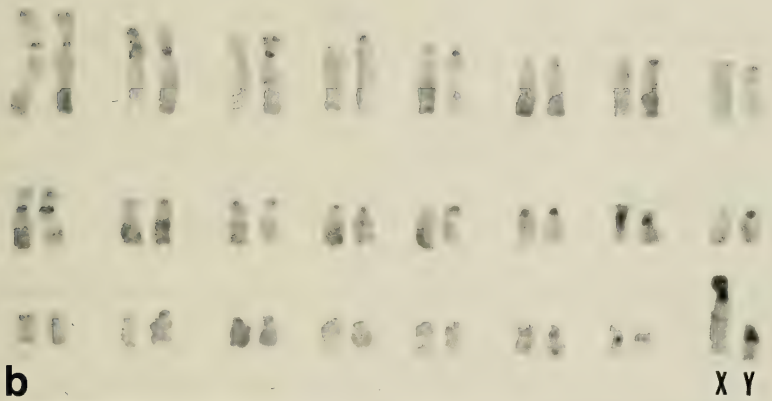
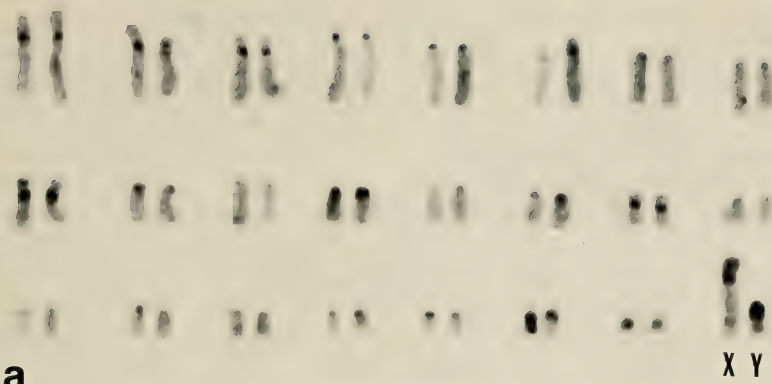


Fig. 2. a, C-banded karyotype of a male *P. t. truei*; b, C-banded karyotype of a male *P. t. comanche*; c, C-banded karyotype of a male *P. gratus*.

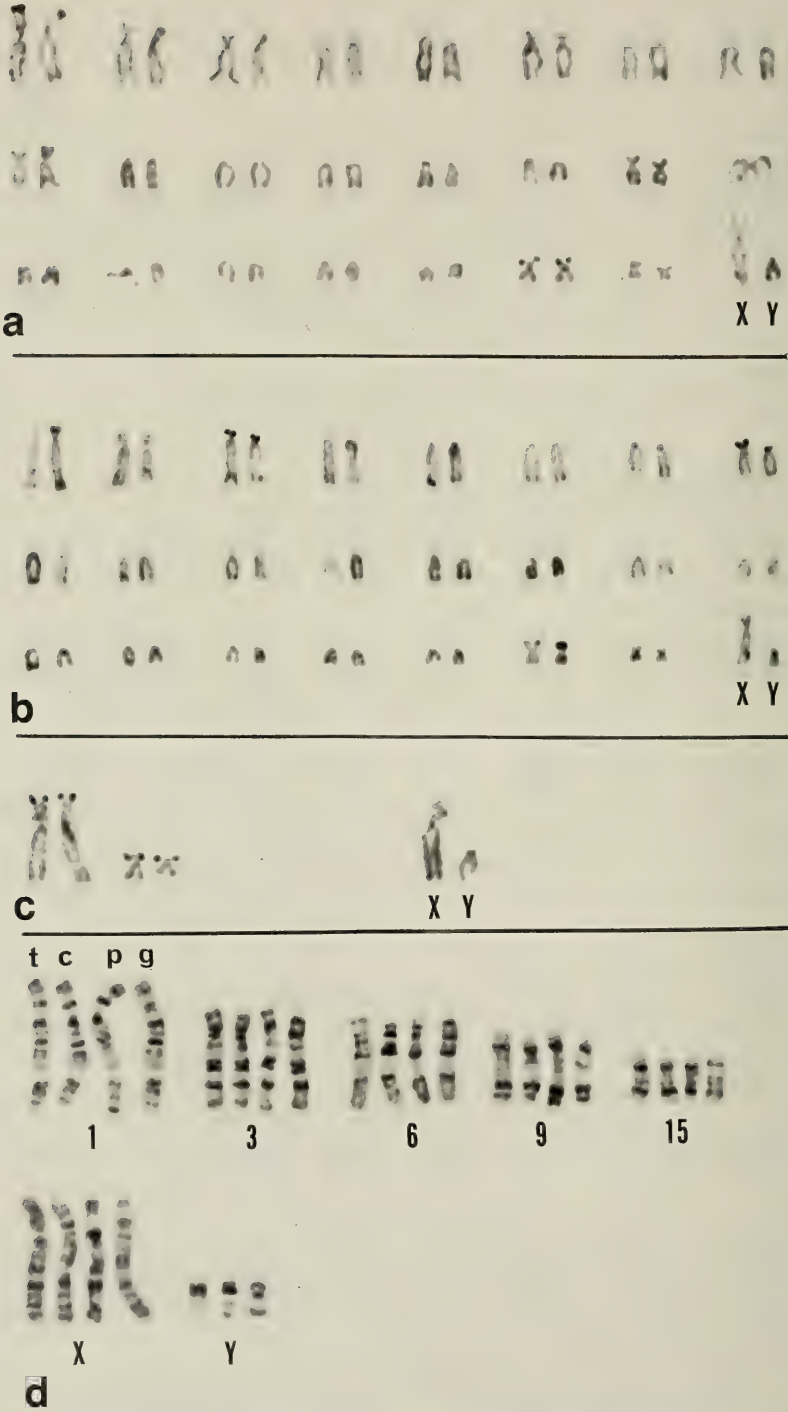


Fig. 3. a, Silver-stained karyotype of a male *P. t. comanche*; b, Silver-stained karyotype of a male *P. gratus*; c, Partial silver-stained karyotype of a male *P. t. truei* showing two pairs of autosomes with Ag-NORs and the sex chromosomes; d, Partial, composite, G-banded karyotype (*P. t. truei* (t), *P. t. comanche* (c), *P. t. prelei* (p), *P. gratus* (g), from left to right in each set) showing elements for which G-band differences exist among the four taxa. The Y was not examined in *P. t. prelei*.



*P. truei truei* and *P. t. comanche* (Rogers' similarity = 0.96, Johnson and Packard 1974) also suggest to us no more than subspecific differentiation of *commanche*; Johnson and Packard (1974), however, recommended specific status for *comanche*. Unpublished data from breeding experiments in our laboratory also show that *P. truei truei* (New Mexico) and *P. t. comanche* are completely interfertile.

The problem regarding *P. truei* and *P. gratus* is more complex. Karyotypic data from conventional and banded preparations are available for 122 specimens belonging to these two taxa. Seventy-five individuals (AN = 62) have been examined from Utah and California (Hsu and Arrighi 1968); Arizona, Colorado, Utah, and Texas (Lee *et al.* 1972); New Mexico and Texas (Robbins and Baker 1981; present study); Oregon (present study); and Arizona, Utah, and New Mexico (Zimmerman *et al.* 1975). Forty-seven specimens (AN = 54) have been reported from New Mexico (Hsu and Arrighi 1968; present study), Coahuila (Lee *et al.* 1972), Chihuahua and Durango (Zimmerman *et al.* 1975), and Michoacan and Mexico (Schmidly and Kilpatrick, pers. comm.).

No karyotypic variation has yet been reported within either cytotype with the exception of the differences reported here between *P. t. truei*, *P. t. comanche* and *P. t. preblei*. Most importantly, near and at the contact zone of the AN = 62 and the AN = 54 cytotypes in New Mexico, 24 specimens have been collected which range from being fully sympatric to occurring within 20 miles of one another in Grant and Socorro Counties, and none was karyotypically intermediate (Hsu and Arrighi 1968; Robbins and Baker 1981; Zimmerman and Kilpatrick 1972; present study).

When the cytotypes of *P. truei* and *P. gratus* are compared at least five major chromosomal differences can be demonstrated: (1) based on the primitive *Peromyscus* karyotype proposed by Robbins and Baker (1981) *P. truei* has undergone pericentric inversions in chromosomes 1, 2, 3, 6, 9, and 15, whereas *P. gratus* has experienced an inversion only in chromosome 2 (although we tentatively follow Robbins and Baker, 1981, who designated euchromatic differences of this type as pericentric inversions, we think that latent centromeric activity rather than inversions may account for at least some of these differences in euchromatic arm morphology, e.g., chromosome 3); (2) significant differences are seen in the G-banded and C-banded patterns of the short arms of the X chromosomes; (3) major differences exist in the morphology and in the G- and C-band patterns found in the Y chromosomes; (4) a difference occurs in the number and location of Ag-NORs; and, (5) there is a difference in the total amount of autosomal heterochromatin; more C-band positive material is found in *P. gratus*. Since both of the cytotypes are distinctive, wide-ranging, relatively homogeneous, and occur sympatrically, in our opinion each warrants recognition as a distinct species. Electrophoretic comparisons of *P. truei* and *P. gratus* yielded values ( $S = 0.866$ ,  $0.872$ , Avise *et al.* 1979;  $S = 0.863$ , Zimmerman *et al.* 1975) that are representative of those found between some species or semispecies of *Peromyscus* (Avise 1975; Zimmerman *et al.* 1978).

The northern limits of the geographic distribution of *P. gratus* are not precisely known. In his revision of *P. truei*, Hoffmeister (1951:29) recognized a subspecific boundary between *P. t. truei* and *P. t. gentilis* that closely coincided with the United States-Mexican border. However, the presence of *P. gratus* in New Mexico, as well as in Mexico, indicates that the limits of *P. gratus* should be extended northward at least to central and southern New Mexico. The distribution of *P.*

*gratus* thus includes the present ranges of *P. t. gratus*, *P. t. gentilis*, *P. t. erasmus*, *P. t. zapotecae*, and part of *P. t. truei*. The remaining northern populations and subspecies represent *P. truei* (see Hall 1981:702).

### Systematics and Synonymy

*Peromyscus gratus* Merriam

*Peromyscus gratus erasmus* Finley

*Peromyscus truei erasmus* Finley, 1952, University, Kansas Publications, Museum Natural History, 5:625. Type from 8 mi NE Durango, 6200 ft., Durango.

*Peromyscus gratus gentilis* Osgood

*Peromyscus gratus gentilis* Osgood, 1904, Proceedings Biological Society Washington, 17:61. Type from Lagos, Jalisco.

*Peromyscus truei gentilis*, Osgood, 1909, North American Fauna, 28:175.

*Peromyscus truei truei*, Hoffmeister, 1951, Illinois Biological Monographs, 21:30 (part).

*Peromyscus gratus gratus* Merriam

*Peromyscus gratus* Merriam, 1898, Proceedings Biological Society Washington, 12:123. Type from Tlalpan, Distrito Federal, Mexico.

*Peromyscus truei gratus*, Osgood, 1909, North American Fauna, 28:173.

*Peromyscus sagax* Elliot, 1903, Field Columbian Museum Publications 71, Zoological Series 3(8):142. Type from La Palma, Michoacan.

*Peromyscus pavidus* Elliot, 1903, Field Columbian Museum Publications 71, Zoological Series 3(8):142. Type from Patzcuaro, Michoacan.

*Peromyscus zelotes* Osgood, 1904, Proceedings Biological Society Washington, 17:67. Type from Querendero, Michoacan.

*Peromyscus gratus zapotecae* Hooper

*Peromyscus truei zapotecae* Hooper, 1957, Occasional Papers Museum Zoology, University Michigan, 586:6. Type from 1 mi E Tlacolula, 5700 ft., Oaxaca.

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A NEW SPECIES OF SKATE,  
*NEORAJA CAROLINENSIS*, FROM OFF  
THE SOUTHEASTERN UNITED STATES  
(ELASMOBRANCHII: RAJOIDEI)

John D. McEachran and M. Stehmann

*Abstract.*—*Neoraja carolinensis*, n. sp. is described from the continental slope of the southeastern United States. *Neoraja carolinensis* is very similar to its congeners, *N. caerulea* and *N. stehmanni*, and *Breviraja africana* recently described from off West Africa, but can be distinguished from them mainly by the extreme length of its anterior pelvic lobe and coloration. *Neoraja carolinensis* lacks cross-bars on the dorsal surface of the tail and possesses a uniformly dark abdominal region which is sharply marked off from the light colored interbranchial and cloacal regions. A key is given to the three congeners and *B. africana*, and their distribution is discussed.

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In their revision of *Breviraja* and descriptions of *Neoraja*, n. gen., *N. (Neoraja)*, n. subgen. and *N. (Fenestraja)*, n. subgen., McEachran and Compagno (1982) briefly described and illustrated the skeletal anatomy of a new species of *Neoraja* (*Neoraja*) from off the coast of North Carolina. This species was not formally described, however, because of lack of adequate material. McEachran (1984) removed *N. (Fenestraja)* from *Neoraja* and placed it in *Gurgesiella* as a subgenus, thus restricting *Neoraja* to the two described species in the subgenus *Neoraja*. Since publication of the generic revision, four more specimens of the undescribed species were captured off the coast of the southeastern United States by the FRV *Anton Dohrn* which conducted a bottom trawl survey from George's Bank to Florida during October and November 1979 (Stehmann 1980). Herein the species is described and compared with its two congeners, and the eastern central Atlantic *Breviraja africana* Stehmann and Seret, 1983. The latter species appears closely related to those of *Neoraja* in several aspects, and one of us (JDM) feels it should be assigned to this genus.

Specimens of the new species were obtained from the National Marine Fisheries Service Systematics Laboratory, Smithsonian Institution, and the Aussenstelle Ichthyologie des Instituts für Seefischerei, Hamburg, (ISH). The former two specimens were donated to the National Museum of Natural History, Smithsonian Institution (USNM). External measurements were made according to Bigelow and Schroeder (1953) with the exception of the pelvic lobe measurements. The anterior lobe was measured from the proximolateral margin of the left prepelvic process (which can be felt externally) to the tip of the lobe. The posterior lobe was measured from the proximolateral margin of the left prepelvic process to the tip of the lobe. Two specimens were dissected to reveal the structure of the neurocranium and scapulocoracoids. The neurocranium of one specimen was stained with alcian blue to distinguish the distal section of the rostral shaft. Unfortunately, none of the specimens were mature males so clasper structure could not be determined.

All specimens were radiographed to verify the anatomical observations based on dissections and to count vertebrae and pectoral radials. Methods for making skeletal measurements followed Hubbs and Ishiyama (1968) and McEachran and Compagno (1979, 1982).

*Neoraja carolinensis*, new species

Figs. 1–6, Tables 1, 2

*Neoraja*, sp., McEachran and Compagno, 1982.

*Holotype*.—ISH 3650/79, 285 mm TL, adolescent male, collected off Cape Fear, North Carolina, 33°38'N, 76°04'W, 796 to 800 m, 4.56°C, 34.958‰, 8 Nov 1979, FRV *Anton Dohrn* station 6410/79, by M. Stehmann.

*Paratypes*.—ISH 3559/79, 280 mm TL, adolescent male, collected off the east coast of Florida, 29°11'N, 77°07'W, 1000 to 1008 m, 6.09°C, 35.035‰, 3 Nov 1979, FRV *Anton Dohrn* station 6385/79, by M. Stehmann.—ISH 3640/79 a+b, 143 mm TL, juvenile male, 232 mm TL, adolescent female, off Cape Fear, North Carolina, 33°27.5'N, 76°07'W, 990 to 1010 m, 4.18°C, 34.929‰, 8 Nov 1979, FRV *Anton Dohrn* station 6408/79, by M. Stehmann.—USNM 265013 (formerly Texas Cooperative Wildlife Collection, TCWC 2725.1), 247 mm TL, adolescent male, collected off Cape Fear, North Carolina, 33°56'N, 75°54'W, 695 m, 31 Jan 1972, RV *Oregon II* station 11757.—USNM 265014 (formerly TCWC 2740.1), 225 mm TL, juvenile female, collected off Cape Lookout, North Carolina, 34°22'N, 75°43'W, 805 m, 1 Feb 1972, RV *Oregon II* station 11765.

*Diagnosis*.—Anterior lobe of pelvic fin nearly as long or longer than posterior lobe of fin; dorsal surface of tail without distinct cross-bars; abdominal area uniformly dark colored and sharply marked off from light interbranchial and cloacal regions.

*Description*.—Individual morphometrics and meristics given in Tables 1 and 2. Values of paratypes follow in parentheses those of holotype. Disc heart-shaped (Figs. 1, 2) 1.2 times (1.1–1.2 in paratypes) as broad as long; snout short, maximum angle in front of spiracles 120° (125°–136°); tip of snout with a small, flat, triangular process; anterior margin concave on either side of process, convex to level of orbits and concave from level of orbits to level of first gill slits (paratypes with less undulated anterior margin and smallest juvenile with almost convex margin); outer corners of disc broadly rounded; posterior margins and especially inner margins strongly convex. Axis of greatest disc width 0.76 (0.70–0.77) of distance from tip of snout to axil of pectoral fins. Pelvic fins deeply incised; anterior lobe long, narrow and tapering to acute tip; posterior lobe relatively short with convex lateral margin. Tail slender, little depressed, its width at mid-length about three-fourths eye diameter. Tail with lateral fold along each ventrolateral surface, extending from about mid-length of tail to near tip (originating from mid-length to posterior third of tail); lateral folds broaden posteriorly to width equal to one-half height of epichordal caudal lobe at level of dorsal fins. Length of tail from center of cloaca to tip 1.4 (1.3–1.5) times distance from tip of snout to center of cloaca.

Preorbital length 2.7 (2.4–2.7) times as long as orbit, 3.1 (2.9–3.2) times interorbital width; preoral length 1.7 (1.6–2.0) times internarial distance. Interorbital distance 0.9 (0.8–1.0) times length of orbit, orbit length 2.1 (1.9–2.4) times as

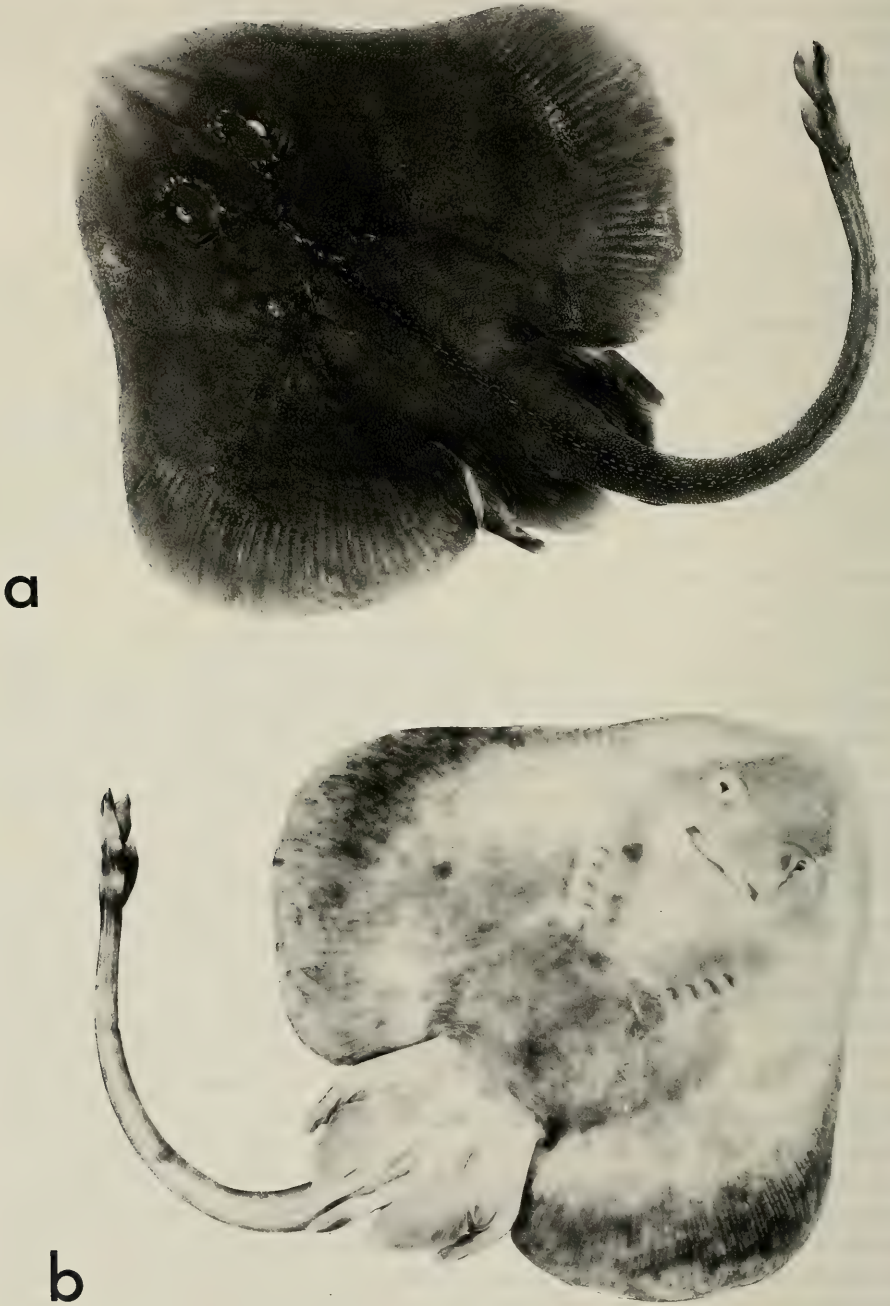


Fig. 1. *Neoraja carolinensis* ISH 3650/79, 285 mm TL (Holotype) adolescent male: a, Dorsal view; b, Ventral view.



Table 1.—Proportional measurements and meristic values for *Neoraja carolinensis*. Proportions expressed as percentage of total length. Measurements made to nearest 1 mm are given to nearest 1 mm and those made to nearest 0.1 mm are given to nearest 0.1 mm.

	Holotype		Paratypes				
	ISH 3650/79	ISH 3559/79	ISH 3640/79	wSH 3640/79	USNM 265013	USNM 265014	$\bar{x}$
Sex	♂	♂	♀	♂	♂	♀	
Total length (mm)	285	280	232	143	247	225	
Disc width	55.0	56.0	57.0	52.0	55.0	52.0	55.0
Disc length	47.0	47.0	48.0	43.0	47.0	48.0	47.0
Snout length (preorbital)	11.5	10.0 <sup>1</sup>	11.3	9.7	10.4	11.4	10.8
Snout length (preoral)	12.9	11.9 <sup>1</sup>	12.7	12.9	11.6	13.0	12.4
Snout to maximum width	30.0	29.0	31.0	27.0	27.0	29.0	29.0
Prenasal length	9.4	7.6 <sup>1</sup>	9.1	9.6	9.0	9.0	8.9
Orbit diameter	4.2	4.3	4.5	3.8	4.9	4.2	4.3
Distance between orbits	3.7	3.5	3.8	3.7	3.4	3.6	3.6
Orbit and spiracle length	4.9	4.9	5.4	4.9	6.0	5.0	5.2
Spiracle length	2.0	2.0	1.9	2.0	2.7	1.9	2.1
Distance between spiracles	7.0	7.3	7.3	7.0	6.6	6.7	7.0
Mouth width	7.3	7.9	7.0	6.2	7.4	6.7	7.2
Nare to mouth	4.1	3.7	4.1	3.6	—	3.9	3.9
Distance between nostrils	7.6	7.5	7.9	6.9	7.2	6.5	7.3
Width of first gill opening	1.3	1.2	1.3	0.7	1.5	0.9	1.2
Width of third gill opening	1.4	1.2	1.4	1.0	1.6	1.0	1.3
Width of fifth gill opening	1.0	0.9	1.0	0.6	1.3	0.8	0.9
Distance between first gill openings	12.6	13.5	12.8	12.1	13.2	12.8	12.9
Distance between fifth gill openings	7.2	7.6	7.8	7.4	8.2	7.1	7.5
Length of anterior pelvic lobe	13.8	15.1	14.7	12.8	15.8	14.5	14.6
Length of posterior pelvic lobe	15.0	15.2	15.0	13.2	16.0	14.9	15.0
Tail width of axil of pelvic fins	4.2	3.0	4.4	3.4	3.7	3.8	3.8
Distance-snout to cloaca	42	41	43	40	42	41	42
Distance-cloaca to first dorsal fin origin	47	47	44	47	48	47	47
Distance cloaca to 2nd dorsal origin	50	53	49	53	52	51	51
Distance-cloaca to caudal fin origin	55	56	54	57	53	56	55
Distance-cloaca to caudal fin tip	58	59	57	60	59	59	58
First dorsal fin, height	2.6	3.4	2.8	1.9	2.8	3.3	2.8
First dorsal fin, base length	5.7	6.0	5.8	6.6	5.8	5.6	5.9
Second dorsal fin, height	2.0	2.5	3.1	1.7	2.6	2.7	2.4
Second dorsal fin, base length	4.2	5.0	5.5	5.2	3.7	4.7	4.7
Tail at pelvic tips, height	2.6	2.5	2.7	2.5	2.6	2.6	2.6
Tail at pelvic tips, width	3.5	3.3	3.8	3.5	3.0	3.4	3.4
Tail at first dorsal origin, height	1.1	0.9	1.1	1.0	0.9	0.9	1.0
Tail at first dorsal origin, width	1.9	1.4	1.9	1.6	1.5	1.4	1.6
Head length, to 5th gill slits	25.4	24.3	25.4	24.7	—	24.9	24.9 (5)
Nasal curtain, length	5.1	4.6	4.8	4.3	—	4.6	4.7 (5)
Nasal curtain, width each lobe	3.2	2.6	3.0	2.8	2.8	2.7	2.9
Nasal curtain, distance between lobes	3.0	3.6	3.0	3.0	2.4	2.5	2.9
Clasper, postcloacal length	13.4	7.0	—	6.3	9.5	—	9.1 (4)
Angle of snout	120°	136°	136°	127°	125°	125°	128°
Pseudobranchial folds	8	10	9	9	8	10	9
Number of tooth rows (upper jaw)	44	45	46	40	42	42	43
Number of trunk vertebrae	24	24	25	24	26	26	25
Number of predorsal caudal vertebrae	73	70	65	70	72	70	70
Number of pectoral fin radials	64	64	62	63	65	66	64

<sup>1</sup> Snout slightly deformed.

Table 2.—Neurocranial and scapulocoracoid proportional measurements of *Neoraja carolinensis* expressed in percent of nasobasal length and greatest length respectively.

	ISH 3640/79 <sup>b</sup> 232 mm TL ♀	USNM 265013 247 mm TL ♂
Nasobasal length (mm)	25.1	24.6
Cranial length	178	183
Rostral cartilage length	77	80
Prefontanelle length	61	58
Cranial width	117	117
Interorbital width	34	33
Rostral base	17	15
Anterior fontanelle length	49	47
Anterior fontanelle width	14	12
Posterior fontanelle length	42	41
Posterior fontanelle width	12	10
Rostral appendix length	60	48
Rostral appendix width	20	20
Rostral cleft length	53	41
Cranial height	24	23
Width across otic capsules	58	60
Least width of basal plate	30	30
Greatest width of nasal capsules	49	49
Internarial width	15	15
Greatest length (mm)	11.7	11.4
Greatest height	84	77
Premesocondyle	44	43
Postmesocondyle	56	56
Postdorsal fenestra length	16	13
Postdorsal fenestra height	10	10
Anterior fenestra length	21	14
Anterior fenestra height	26	26
Height of rear corner	62	66

long as spiracle. Spiracle with 8 (8–10) pseudobranchial folds. Anterior nasal flap (nasal curtain) strongly undulated laterally, with distinct, short triangular loblet at mid-length and finely fringed posterior margin, posterior nasal flap poorly developed and very weakly fringed (smooth to weakly fringed) (Fig. 3). Mouth nearly straight, upper and lower jaws slightly arched on either side of symphysis (nearly straight in juveniles) and upper jaw slightly indented at symphysis. Teeth with very short pointed cusps near symphysis but with rounded cusps towards corners of jaws (juveniles with rounded cusps throughout); teeth in quincunx arrangement.

Distance between first gill slits 1.6 (1.6–1.8) times as great as distance between nares; distance between fifth gill slits 0.9 (1.0–1.1) times as great as between nares; length of first gill slits 1.3 (1.1–1.4) times length of fifth gill slits and 0.2 (0.1–0.2) times mouth width. First dorsal fin about equal in size and shape to second, their bases confluent and second dorsal confluent with short and low epichordal caudal lobe; hypochordal caudal lobe poorly developed. Not fully formed claspers extending distal to posterior pelvic lobe (not exceeding pelvic lobe in paratype males), inner dorsal lobe of glans with two proximal clefts or slits, ventral lobe with elongate shield.

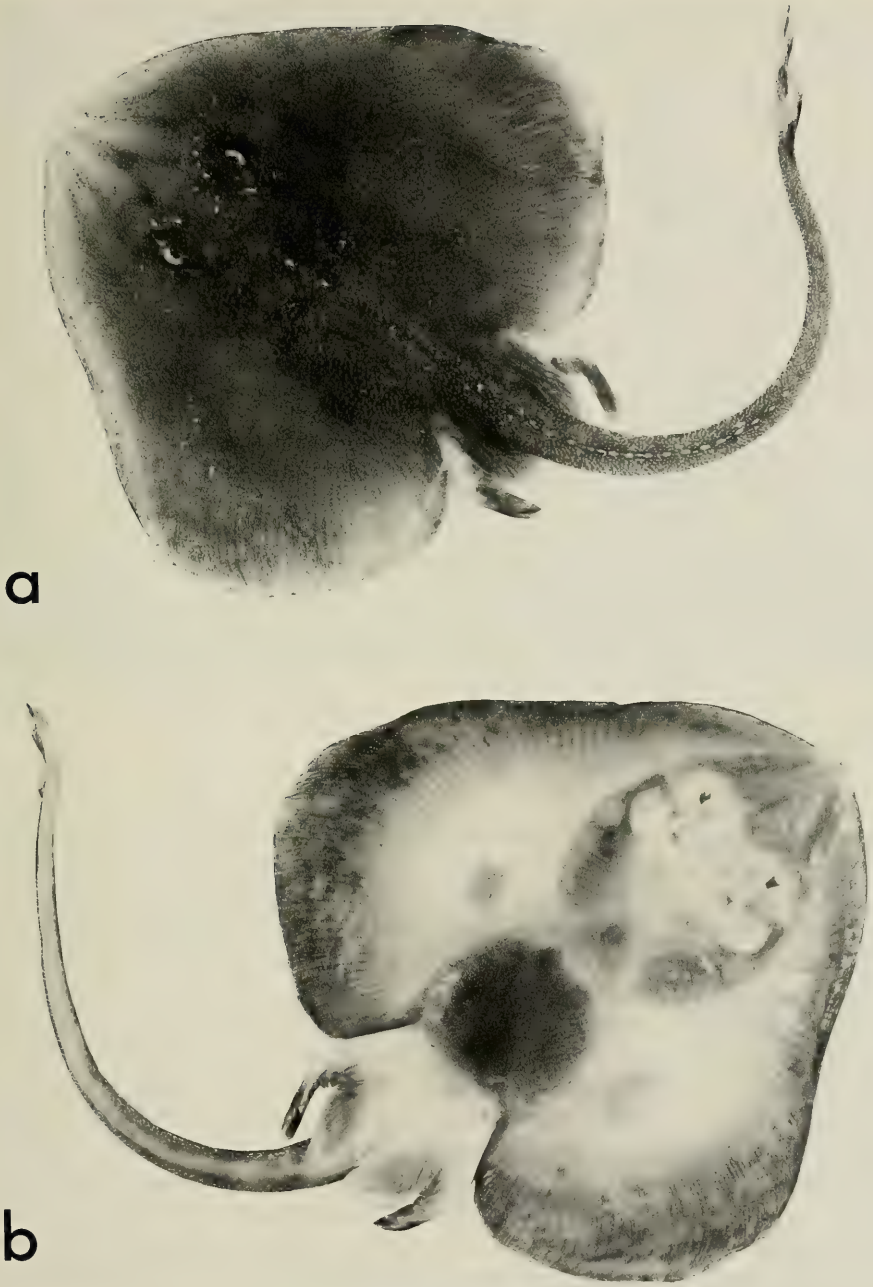


Fig. 2. *Neoraja carolinensis* ISH 3640/79<sub>a</sub>, 143 mm TL (Paratype) juvenile male: a, Dorsal view; b, Ventral view.

Upper surface of disc except narrow posterior margins densely and uniformly covered with denticles bearing slender spines with recurved tip; anterior pelvic lobes naked; posterior pelvic lobes sparsely covered with denticles from origin to center with broadly smooth outer margins; distomedial aspect of claspers sparsely



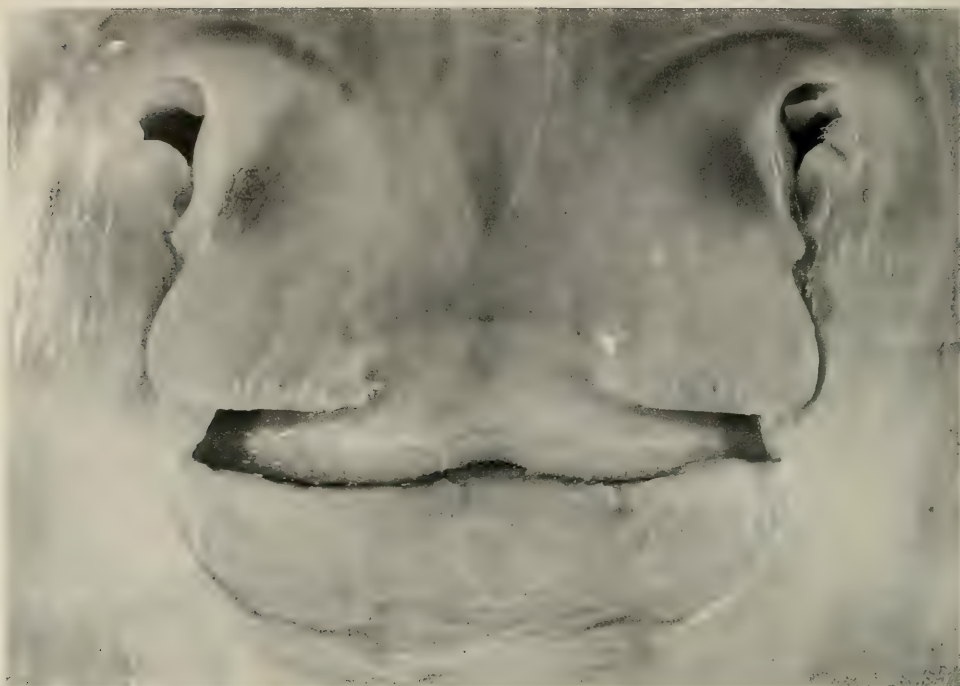


Fig. 3. *Neoraja carolinensis*, ISH 3650/79 285 mm TL (Holotype) adolescent male, mouth and nasal region.

covered with denticles (naked in male paratypes). Ventral surface naked except for denticles along lateral aspects of tail to level of first dorsal fin (some paratypes with lateral denticles only on posterior half of tail). Orbital thorns small, set in an almost continuous inner half-ring consisting of: 5 preorbital, innermost two being largest, and 3 postorbital, plus 2 supraorbital, of which 1 on left and both on right side broken off; 1 supra- and 1 interspiracular thorn on each side, right interspiracular broken off (paratypes with 3–5 pre-, 0–2 supra-, and 1–4 postorbital, 0–1 supra- and 0–1 interspiracular thorns). An irregular median row of 6 thorns over nape/shoulder area, smaller posterior two in suprascapular position; 2 thorns on each shoulder, left outer one broken off (paratypes with 2–5 median nuchal, 1–2 suprascapular, and 1–2 scapular thorns). About 75–80 small thorns from about level of maximum disc width along midline onto mid-length of tail in irregular row, on origin of tail in narrow band of two or three irregular rows; remaining tail section to origin of first dorsal fin without median thorns, but with longitudinal groove also lacking denticles (paratypes with 40–50 thorns in irregular midrow originating at posterior third of body, or at level of pectoral or pelvic axils; smallest paratype with 40 thorns in almost regular midrow along body and tail to origin of first dorsal and lacking smooth longitudinal groove on tail (Fig. 2a). Thorns with roundish bases and recurved tips bearing small lateral keels. Dorsal and upper caudal fins sparsely covered with denticles.

*Color*.—After preservation in formalin and storage in alcohol, dorsal surface (Figs. 1a, 2a) uniformly grayish-brown, except area on either side of rostrum,

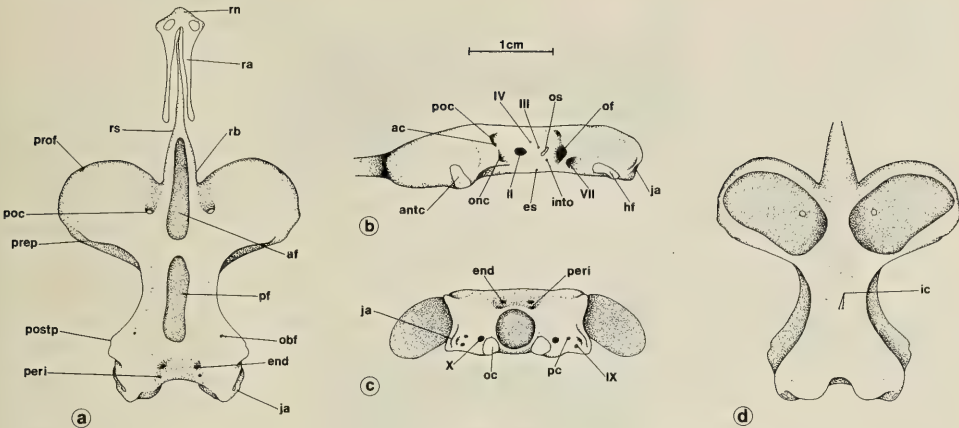


Fig. 4. Neurocranium of *N. carolinensis*, ISH 3640/79b, 232 mm TL (Paratype) adolescent female: a, Dorsal view; b, Lateral view; c, Posterior view; d, Ventral view. ac—anterior cerebral vein foramen, af—anterior fontanelle, antc—antorbital condyle, end—endolymphatic foramen, es—efferent spiracular artery foramen, hf—hyomandibular facet, ic—internal carotid artery foramen, into—interorbital vein foramen, ja—jugal arch, obf—otic branch of facial nerve foramen, oc—occipital condyle, of—orbital fissure, onc—orbitonasal nasal canal foramen, os—optic stalk, pc—posterior cerebral vein foramen, peri—perilymphatic foramen, pf—posterior fontanelle, poc—preorbital canal foramen, postp—postorbital process, prep—preorbital process, prof—profundus nerve foramen, ra—rostral appendix, rb—rostral base, rn—rostral node, rs—rostral shaft, II—optic nerve foramen, III—oculomotor nerve foramen, IV—trochlear nerve foramen, VII—hyomandibular branch of facial nerve foramen, IX—glossopharyngeal nerve foramen, X—vagus nerve foramen.

posterior pectoral and outer margins of posterior pelvic lobes and apices of dorsal fins semitransparent and lighter; anterolateral margin of anterior pelvic lobes and claspers yellowish-white, but distolateral margin of left ventral clasper lobe brown; lateral tail folds marbled brown and white, almost yellowish-white in distal section; tail colored like remainder of disc with several light spots on left side in its posterior third. Ventral surface yellowish-white, except for margins of disc posterior to first gill slits, area lateral to gill slits, transverse axis of disc, abdomen, area lateral to cloaca, and margin of posterior pelvic lobes, all of which more or less spotted, blotched, or clouded grayish-brown; abdomen uniformly grayish-brown and sharply marked off from predominantly whitish interbranchial and cloacal areas; claspers yellowish-white, except for brown distolateral margin and pale brown cross-bar distally on left; origin of tail whitish, remaining section pale brown with scattered darker spots, and tip of tail whitish except for two grayish-brown cross-bars at level of dorsal fins. Paratypes similarly colored, except that tail may have vague dark cross-bars in anterior third and at dorsal fins (ISH 3559/79, 3640/79b, USNM 265013) and some variation in extension of brownish spots and blotches ventrally; ventral surface varying from predominantly whitish in smallest paratype (Fig. 2b), with abdomen thus appearing distinctly darker than remainder of ventrum, or predominantly dark with only few pale areas as in USNM 265014; ventral side of tail varying from entirely whitish with few dark spots, to brown on anterior and white on posterior half, or to completely light brown with white tip, with cross-bars at dorsal fins less evident. Freshly caught four ISH specimens showed brown color more intensively on both surfaces.

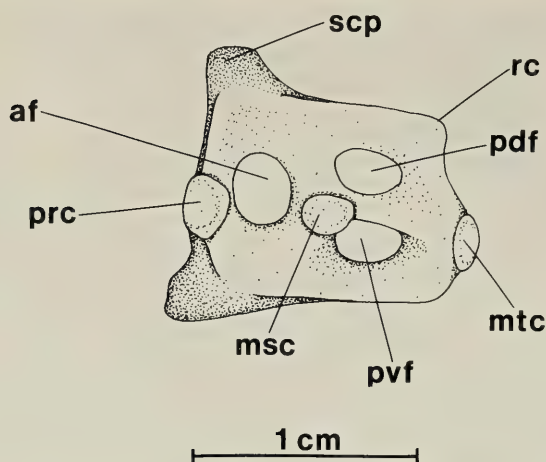


Fig. 5. Lateral view of left scapulocoracoid of *N. carolinensis*, ISH 3640/79<sub>b</sub>, 232 mm TL (Paratype) adolescent female: af—anterior fenestra, msc—mesocondyle, mtc—metacondyle, pdf—postdorsal fenestra, prc—procondyle, pvf—postventral fenestra, rc—rear corner, scp—scapular process.

Neurocranium (mainly based on paratypes ISH 3640/79b and USNM 265013) with very slender, unsegmented rostral shaft tapering to filament abutting against but free of rostral node and appendices (Fig. 4a); rostral node consisting of narrow bridge joining rostral appendices at tip of snout; rostral appendices plate-like anteriorly with large elliptical foramina, posteriorly extending nearly to anterior fontanelle and conical in cross section, 60–80% of rostral length; propterygia of pectoral girdle terminating lateral to anterior margin of appendices; rostral base narrow, 18–23% of cranial width; nasal capsules ovoid-shaped, greatly laterally expanded and set at about 33° angle to transverse axis and at 67°–75° angle to longitudinal axis of neurocranium; profundus nerve with two foramina on leading edge of each nasal capsule; interorbital region moderately narrow 26–31% of cranial width (Table 2); preorbital processes poorly developed, separated from incised supraorbital crests by narrow groove; anterior fontanelle narrow, tapering anteriorly, with rounded anterior and posterior margins; posterior fontanelle narrow and constricted at about mid-length; foramen for anterior cerebral vein on vertical with dorsal rim of optic nerve foramen and on line with foramina for preorbital and orbitonasal canals (Fig. 4b); jugal arches very slender (Fig. 4c); basal and nasal plates moderately narrow (Fig. 4d).

Scapulocoracoids moderately expanded (Fig. 5; and Fig. 13c McEachran and Compagno 1982), with postdorsal and anterior fontanelles little expanded, those of female more expanded than those of male (Table 2); scapular process directed dorsomedially; anterodorsal margin (anterior to rear corner) straight to slightly concave, rear corner little elevated, if at all; posterodorsal margin concave and steeply sloping to metacondyle.

Pelvic girdle with relatively slender puboischiadic bar, nearly straight anteriorly; strongly concave posteriorly, more deeply concave in males than in females (Fig. 6a, b); prepelvic processes short and oriented laterally; iliac processes long, strongly curved and directed anteromedially; two obturator foramina.



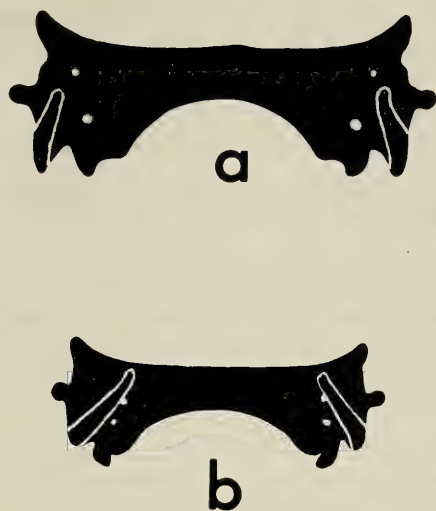


Fig. 6. *Neoraja carolinensis* pelvic girdles: a, ISH 3650/79, 285 mm TL (Holotype) adolescent male; b, USNM 265014, 225 mm (Paratype) juvenile female. Drawn from radiographs.

*Etymology*.—Named after the type-locality, the Carolinian Province of the western North Atlantic.

*Remarks*.—*Neoraja carolinensis* is very similar to its two congeners, *N. caerulea* and *N. stehmanni*, and to *Breviraja africana* in external morphology, squamation, coloration, and skeletal structure but differs from them in the several characters. In *N. caerulea*, *N. stehmanni* and *B. africana* the anterior lobe of the pelvic fin is about 70 to 80% of the length of the posterior lobe (lobes are about equal in length in *N. carolinensis*). *Neoraja caerulea* has 47 to 55 ( $\bar{x} = 50$ ) and *B. africana* 45 to 49 ( $\bar{x} = 47$ ) tooth rows in the upper jaw (*N. carolinensis* has 40 to 46 ( $\bar{x} = 43$ )). Both *N. caerulea* and *N. stehmanni* have 6 to 9 distinct cross-bars on dorsal surface of tail (*N. carolinensis* either lacks or has indistinct cross-bars on tail). Abdominal region of *N. caerulea*, *N. stehmanni* and *B. africana* is light colored or light with dark blotches (*N. carolinensis* has a uniformly dark abdominal region). *Neoraja carolinensis* also differs from its two congeners in several aspects of its neurocranial and scapulocoracoid structure (McEachran and Compagno 1982). *Neoraja caerulea* and *N. stehmanni* neurocrania possess shorter rostral shafts, shorter rostral appendices and less laterally expanded nasal capsules. The scapulocoracoids of *N. caerulea* and *N. stehmanni* possess an elevated rear corner and a more concave dorsal margin than that of *N. carolinensis*.

Material examined in the course of this study necessitates several changes in McEachran and Compagno's description of *N. (Neoraja)*. McEachran and Compagno (1982) stated, that species of *N. (Neoraja)* possess a single row of thorns along the proximal midline of the tail, that the rostral shaft of *N. sp. nov.* (= *N. carolinensis*) is distally segmented and that the anterodorsal margin of the scapulocoracoids is concave with the rear corner elevated. However, the holotype and larger paratypes of *N. carolinensis* possess a narrow band of two or three irregular rows of thorns on the proximal aspect of the tail unlike the smaller specimens or

the three other species. Staining one of the dissected neurocrania of *N. carolinensis* revealed that the rostral shaft is not distally segmented. Apparent segmentation of the rostral shaft in the previous study is an artifact of dissection. The rostral shafts of *N. caerulea* and *N. stehmanni* are probably also unsegmented. While the scapulocoracoids of *N. caerulea* and *N. stehmanni* possess a concave anterodorsal margin and an elevated rear corner, those of *N. carolinensis* and *B. africana* are straight to slightly concave, without or at most with a slightly elevated rear corner.

#### Key to Species of *Neoraja* and *Breviraja africana*

1. Anterior and posterior pelvic lobes of about equal length, dark cross-bars on dorsal surface of tail indistinct to absent, abdomen uniformly grayish-brown and marked off from light interbranchial and cloacal regions . . . . . *N. carolinensis*
- Anterior pelvic lobe at most 70 to 80% of posterior pelvic lobe length, dark cross-bars on dorsal surface of tail usually distinct, abdomen uniformly light colored to light with dark blotches but not uniformly dark colored nor marked off from interbranchial and cloacal regions . . . . . 2
2. Dorsal surface of disc and pelvic fins grayish with irregular pattern of dark blotches and light spots, 38 to 44 tooth rows in upper jaw . . . *N. stehmanni*
- Dorsal surface of disc and pelvic fins plain brown to bluish-violet, without blotches, 45 to 55 tooth rows in upper jaw . . . . . 3
3. Dorsal surface of disc and pelvic fins bluish-violet, dorsal side of tail light colored, dark cross-bars on dorsal surface of tail distinct . . . . . *N. caerulea*
- Dorsal surface of disc, pelvic fins and tail uniformly brown (faint bluish shade centrally when newly dead), dark cross-bars on dorsal surface of tail indistinct . . . . . *B. africana*

*Distribution.*—The three species of *Neoraja* and *Breviraja africana* are allopatrically distributed but occur in similar habitats. *Neoraja carolinensis* was captured along the continental slope off the southeastern United States, 34° 22'N to 29° 11'N, at 695 to 1010 m, at temperatures of 4.18° to 6.09°C. *Neoraja caerulea* was captured on the slopes of the Rockall Basin, west of Scotland and Ireland, 61°06'N to 55°44'N, at 600 to 1262 m, at temperatures of 6.41° to 9.10°C (Stehmann 1976). *Neoraja stehmanni* was captured along the continental slope off the west coast of South Africa, 33°53.7'S to ca. 34°S, at 292 to 640 m, at temperatures of 5.55° to 5.70°C (Hulley 1972). Another very small specimen of *N. stehmanni* reported from off northern Mauritania, 22°50'N, at 1490 to 1620 m, by Golovan (1978) probably represents another species (Stehmann, in press). *Breviraja africana* was captured on the continental slope off Gabon, 2°41'S to 3°25'S, at 900 to 1030 m, at temperatures of 4.35° to 4.66°C (Stehmann and Seret 1983).

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Fechhelm prepared Figs. 4 and 5. This study was supported in part by grants to JDM from the National Science Foundation, Grant nos. DEB 78-11217 and DEB 82-04661.

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## A HAMERKOP FROM THE EARLY PLIOCENE OF SOUTH AFRICA (AVES: SCOPIDAE)

Storrs L. Olson

*Abstract.*—Two bones from early Pliocene deposits at Langebaanweg, southwestern Cape Province, South Africa, constitute the first fossil record of the family Scopidae. These are described as a new species, *Scopus xenopus*, that was larger than the living Hamerkop, *S. umbretta*, and that had a foot structure possibly indicating that the fossil species was better adapted for swimming.

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The Hamerkop, or Hammerheaded Stork, *Scopus umbretta*, is the sole living member of the family Scopidae. The exact systematic position of this family has long been disputed (Kahl 1967), although it is generally conceded that *Scopus* is probably related to storks (Ciconiidae) and the Shoebill (Balaenicipitidae), with which it is associated in all modern classifications. *Scopus umbretta* is widely distributed through sub-Saharan Africa and also occurs in Madagascar and southwestern Arabia (Snow 1978). Up to the present, there has been no fossil record for the Scopidae (Brodkorb 1963). This has now changed with my discovery at the South African Museum of two bones of a new species from the early Pliocene at Langebaanweg, in southwestern Cape Province, South Africa.

The deposits at Langebaanweg are renowned for the number of vertebrate remains they have yielded, including a great diversity of birds (Rich 1980). A variety of ecological conditions existed in the vicinity of Langebaanweg in the Pliocene (Hendey 1981a, b; 1982), resulting in remains of freshwater, marine, and terrestrial organisms being deposited. The geology and chronology of the Langebaanweg succession have been detailed by Hendey (1981b).

### Order Ciconiiformes Bonaparte, 1854

The content and relationships of this polyphyletic order are still being actively debated. One of the families traditionally included here, the flamingos (Phoenicopteridae), has been shown conclusively to belong in the Charadriiformes near the Recurvirostridae (Olson and Feduccia 1980). The ibises and spoonbills (Plataleidae) seem to be more closely related to the Charadriiformes and Gruiformes than to storks (Olson 1979), a conclusion that has received strong support from the fossil record (Peters 1983). On the other hand, the vultures of the families Vulturidae (=Cathartidae) and Teratornithidae, currently placed with the hawks in the Accipitriformes, are probably best included in or near the Ciconiiformes (Ligon 1967; Olson, in press). Thus, at this point it is neither possible nor prudent to provide a diagnosis of the order Ciconiiformes. Nevertheless, *Scopus* would surely be included in the same ordinal level taxon as *Ciconia*, and as the ordinal name Ciconiiformes has priority over that of any of the groups that might possibly be included with the storks and allies (e.g., Pelecaniformes), the Scopidae would belong in the Ciconiiformes regardless of its ultimate composition.

Table 1.—Measurements (mm) of fossil and living species of *Scopus*.

	<i>S. xenopus</i>	<i>S. umbretta</i>		
		n	Range	Mean
TARSOMETATARSUS				
Distal width through trochleae	9.2	6	8.2–8.7	8.4
Shaft width at proximal end of distal foramen	6.6	6	6.1–6.3	6.2
Width of middle trochlea	3.3	6	2.9–3.3	3.1
Shaft width 25 mm proximal to middle trochlea	3.6	6	3.0–3.4	3.3
CORACOID				
Distance from humeral edge of glenoid facet to sternal lip of scapular facet	8.8	7	7.2–8.7	8.1
Shaft width just sternal to procoracoid process	5.8	7	4.5–4.8	4.7

Family Scopidae Bonaparte, 1853

The fossil specimens can be referred to the Scopidae on the basis of the following characters: (1) distal end of tarsometatarsus essentially similar to that in the Ciconiidae but much smaller than in any known living or fossil stork; coracoid with (2) distinct ovoid furcular facet, (3) extensive pneumatization, (4) lack of excavation on the ventrolateral surface between the head and the glenoid facet, and (5) no procoracoid foramen. Character 2 separates the Scopidae from all avian taxa except the Balaenicipitidae and Pelecaniformes (within which the Phaethontidae are exceptional in lacking this character and the modern Fregatidae have it obliterated by fusion with the clavicle). Character 3 separates the Scopidae from the Phalacrocoracidae and Anhingidae, character 4 from the Pelecanidae and Sulidae, and character 5 from the Balaenicipitidae.

Genus *Scopus* Brisson 1760  
*Scopus xenopus*, new species  
Figs. 1–2

*Holotype*.—Distal end of left tarsometatarsus with posterior parts of inner and outer trochleae abraded, SAM-PQ-L43396.

*Paratype*.—Scapular half of right coracoid lacking part of the head and the tip of the procoracoid process, SAM-PQ-L28440S.

*Type-locality and horizon*.—"E" Quarry, Langebaanweg, southwestern Cape Province, South Africa. Varswater Formation (early Pliocene). The holotype is either from bed 3aS of the Pelletal Phosphate Member or from the Quartzose Sand Member, whereas the paratype is definitely from the latter (see Hendey 1981b).

*Measurements*.—See Table 1.

*Etymology*.—Greek, *xenos*, strange, and *pous*, foot; in reference both to the peculiarities of the tarsometatarsus and to the fact that frogs and tadpoles of the genus *Xenopus* Wagler are one of the principal food items of the living species *Scopus umbretta* (Kahl 1967).

*Diagnosis*.—Somewhat larger than *Scopus umbretta* (Table 1). Inner trochlea

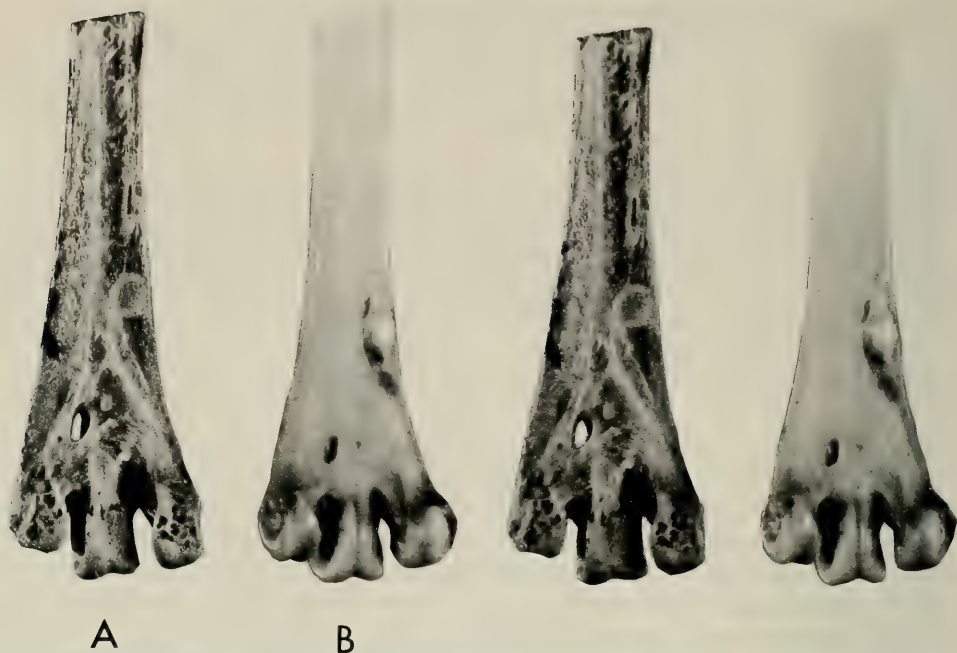


Fig. 1. Stereo pairs of distal end of left tarsometatarsus, plantar aspect. A, *Scopus xenopus* new species, holotype, SAM-PQ-L43396; B, *Scopus umbretta*, USNM 18898. Figures are 3 $\times$ .

(II) of tarsometatarsus more distally produced, almost level with the middle trochlea (III), and consequently with a noticeably longer shaft; scar for hallux larger, extending farther distally, with a more distinct, rounded proximal articular surface; middle trochlea angled more medially; distal foramen relatively larger. Furcular facet of coracoid narrower and more elongate.

*Discussion.*—In the preliminary sorting of avian remains from Langebaanweg (Rich 1980), the holotype of *Scopus xenopus* was identified as a pelecaniform of uncertain affinity; as such it was listed under the Pelecaniformes by Hende (1981b:48) as “Fam., gen. and sp. not det.” This determination was not unjustified and carries interesting functional and systematic implications. The tarsometatarsus of *Scopus xenopus* resembles that in the Pelecaniformes because of the more distally situated inner trochlea that is nearly even with the middle trochlea. Such a condition obtains in most of the Pelecaniformes, in some of which the inner trochlea extends farther distally than the middle one. This adaptation is associated with swimming behavior; increasing specialization for terrestrial locomotion involves elevation of the inner trochlea rather than distal displacement.

The living Hamerkop is an aquatic “wading” bird that typically walks in shallow water while foraging (Kahl 1967). The scant fossil evidence suggests the possibility that *Scopus xenopus* may have been better adapted for swimming locomotion and thus may have had different habits from *S. umbretta*. If so, *S. xenopus* and *S. umbretta* may not have had an ancestral-descendent relationship.

That the tarsometatarsus of *S. xenopus* bears a resemblance to that in the Pelecaniformes may have phylogenetic significance. Cottam (1957) noted many





Fig. 2. Fossil and recent species of *Scopus*: right coracoid, ventral aspect (A, B); distal end of left tarsometatarsus, cranial aspect (C, D). A, *Scopus xenopus* new species, paratype SAM-PQ-L28440S; B, *Scopus umbretta*, TM 42863; C, *Scopus xenopus*, new species, holotype SAM-PQ-L43396; D, *Scopus umbretta*, USNM 18898. Figures are 2 $\times$ .

striking similarities between the Shoebill (*Balaeniceps rex*) and the Pelecaniformes; a number of these same characters are also present in *Scopus*. The highly derived order Pelecaniformes must have had its origins in some less specialized group. Such a group may have included the ancestors of *Scopus* and *Balaeniceps*, a possibility that merits detailed investigation.

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## EVIDENCE OF A LARGE ALBATROSS IN THE MIOCENE OF ARGENTINA (AVES: DIOMEDEIDAE)

Storrs L. Olson

*Abstract.*—A single pedal phalanx from early late Miocene marine deposits in Argentina provides the first Tertiary record of an albatross (Diomedidae, genus indet.) from South America. The specimen is from a species considerably larger than represented by the two Tertiary albatross fossils hitherto reported from the Southern Hemisphere.

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Although the modern forms of albatrosses (Diomedidae, Procellariiformes) are concentrated mainly in the Southern Hemisphere, there is a much better fossil record for the family in the Northern Hemisphere. Tertiary albatrosses have been reported from California, Florida, England, and France, with numerous unpublished specimens being known from Oregon, North Carolina, and South Carolina (Brodkorb 1963; Olson, in press, a). Only two albatross fossils have been reported from the Southern Hemisphere: an incomplete rostrum from the late Miocene of Victoria, Australia, the holotype of *Diomedea thyridata* Wilkinson (1969); and the proximal end of a tarsometatarsus from the early Pliocene at Langebaanweg, Cape Province, South Africa (Olson 1983; in press, b). Both of these specimens are from relatively small species, the size of *D. melanophris*.

A third fossil now documents the former existence of a larger species of albatross in the Tertiary of the southern oceans. The specimen consists of the left basal phalanx of the fourth pedal digit (vertebrate paleontological collections of the National Museum of Natural History, Smithsonian Institution, USNM 336381). It was obtained at Punta Ninfas, on the south side of the entrance of Golfo Nuevo, opposite Peninsula Valdéz, Chubut Province, Argentina. The fossil was derived from beds of so-called Rionegrense age at a level 50 m (165 feet) above the present base of the cliff. Various outcrops in northeastern Argentina attributed to the Rionegrense because of similarities in lithology may not actually be contemporaneous, however, due to their discontinuous nature and the frequency of Neogene marine transgressions in this area (Zinsmeister *et al.* 1981). Fortunately, a volcanic tuff near the top of the Rionegrense horizon at the site of collection of the fossil is the source of the only radioisotopic age determination yet obtained for any of the Rionegrense beds. The mean of three glass concentrates from this tuff dated by the  $^{40}\text{K}$ - $^{40}\text{Ar}$  method was  $9.41 \times 10^6$  years, which correlates "with the late Miocene Tortonian marine stage in Europe and the Chasicoan Land Mammal Age in South America" (Zinsmeister *et al.* 1981).

The large size, very elongate, slender proportions, and occurrence in a marine context, identify the fossil with the Diomedidae. The specimen (Fig. 1) measures 53 mm from the dorsal margin of the proximal articular surface to the distal end; the width and depth of the shaft at the midpoint are  $4.4 \times 5.7$  mm. Thus, in overall size the fossil is larger than any of the living albatrosses except *D. exulans* (56.0-62.0 mm,  $n = 4$ ) and *D. epomophora* (57.0 mm;  $n = 1$ ), with the closest





Fig. 1. Left pedal phalanx (p 1, d IV) of *Diomedidae* gen. et sp. indet. from the Miocene of Peninsula Valdéz, Argentina (a, c); compared with *Diomedea albatrus* USNM 567025 (b, d). A, B, lateral aspect; C, D, ventral aspect. All figures natural size.

approach among lesser species being *D. albatrus* (41.0–45.0 mm;  $n = 3$ ) and *D. cauta* (48.0 mm;  $n = 1$ ). Postcranial specimens of *D. leptorhyncha* (= *D. irrorata* auct.) were not available for comparison. Because the fossil is more laterally compressed, it appears much more slender than in any of the species of albatrosses examined, including the two species of *Phoebetria*. Thus the affinities of the specimen within the family cannot be refined. Nevertheless, it constitutes the first Tertiary record of an albatross from South America.

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*TANAOCHELES STENOCHILUS*, A NEW GENUS AND  
SPECIES OF CRAB FROM GUAM, MARIANA ISLANDS  
(BRACHYURA: XANTHIDAE)

Roy K. Kropp

*Abstract.*—A new xanthid crab, *Tanaocheles stenochilus*, described from Apra Harbor, Guam, Mariana Islands, is the type-species of a new genus of crab which lives in association with the scleractinian coral *Leptoseris gardineri*.

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Three specimens of the xanthid crab subfamily Trapeziinae were collected among colonies of the scleractinian coral *Leptoseris gardineri* van der Horst, 1921, at moderate depth (27 m) from Apra Harbor, Guam. These specimens are not referable to any of the known genera of the subfamily and are described herein as new.

Crabs were measured to the nearest 0.1 mm with dial calipers. Measurements are given as carapace length  $\times$  carapace width. Specimens are deposited in the National Museum of Natural History, Smithsonian Institution (USNM) and the Allan Hancock Foundation (AHF).

Family Xanthidae MacLeay, 1838

Subfamily Trapeziinae A. Milne Edwards, 1862

*Tanaocheles*, new genus

*Diagnosis.*—Carapace wider than long, convex in both directions; posterolateral border longer than anterolateral border, latter with spines. Eye large, not wholly contained within cuplike orbit. Front broad, sinuous, without teeth or spines; carapace sharply deflected near frontal margin. Chelipeds unequal, but morphologically similar, very long, relatively thin; fingers of chelae short, spoon-tipped. Walking legs long, thin; dactylus of each long, with many spiniform and stout setae, claw bladelike. Abdomen of male with 7 distinct segments.

*Etymology.*—From the Greek “tanao,” outstretched, in combination with the Greek “chele,” claw; in reference to the very long chelipeds characteristic of this genus. Gender feminine.

*Type-species.*—*Tanaocheles stenochilus*, new species, by monotypy.

*Remarks.*—The nine genera of the Trapeziinae can be separated into two groups on the basis of the number of distinct segments of the male abdomen. *Tanaocheles* is included among the genera in which the male abdomen has seven distinct segments. These genera are *Tetralia* Dana, 1851; *Ectaesthesius* Rathbun, 1898; *Calocarcinus* Calman, 1909; and *Philippicarcinus* Garth and Kim, 1983. *Tanaocheles* and *Philippicarcinus* both differ from the other three genera by having approximately hexagonal carapace outlines. *Tanaocheles* differs from all four genera by having long, very slender chelipeds, with meri much longer than broad, and spoon-tipped fingers.



*Tanaocheles stenochilus*, new species

Fig. 1

*Holotype*.—Male, 4.5 mm × 6.2 mm; Apra Harbor (Western Shoals), Guam, Mariana Islands; on *Leptoseris gardineri*; 27 m; 23 Jul 1981; Coll. V. Tyndzik; USNM 210636.

*Paratypes*.—Female, 5.6 mm × 7.3 mm; USNM 210637. Male, 3.2 mm × 4.3 mm; AHF 819. Both same collection data as holotype.

*Description*.—Carapace wider than long; smooth, regions poorly marked, with a few scattered plumose setae. Lateral margins rounded; spineless posterolateral part about twice as long as anterolateral part; anterolateral part bearing two spines, posterior sharp, anterior blunt, rounded. Orbital margin raised. Front broad, slightly sinuous, without median notch; carapace sharply deflected at frontal margin then produced anteriorly forming narrow, flattened rim. Inner suborbital angle not meeting front, second antenna not excluded from orbit.

Chelipeds unequal, very long, thin; merus and carpus of both morphologically similar, major thicker. Merus long, smooth, rounded, with no distinct margins; with 3 sharp anterior spines, 2 at proximal end, one near distal end; no posterior spines. Carpus smooth, with a sharp or rounded anterior spine. Manus long, rounded, without spines. Major manus gradually thickening distally, much thicker than minor; fingers short, dark, spoon-tipped; outer edges of occlusal surfaces with 3 broad, sharply edged teeth, inner edges rounded, without teeth, leaving space when fingers close. Minor manus long, thin, of uniform thickness; fingers short, spoon-tipped, occlusal surfaces morphologically similar to those of major, but with 2 low teeth. Carpus and manus with interlocking knobs on upper and lower surfaces at joint.

Walking legs long, thin, with scattered long plumose and nonplumose setae. Merus of legs 1–3 with anterior margin minutely denticulate, sometimes with spines; merus of leg 4 smooth. Carpus of legs 1–4 with 2, 2, 1, 0 anterodistal spines respectively; anterodistal margin produced into knob fitting into socket on propodus. Propodus long, thickening slightly distally. Dactylus long, claw broad, bladellike; anterior margin with 2 rows of stout, spiniform setae, distal setae largest; posterior margin lined with many long, spiniform and short, stout setae. Propodus-dactylus joint with locking mechanism on posterior surface; distal margin of propodus produced into broad flange fitting into groove made by raised knob on proximal part of dactylus.

*Color notes*.—Carapace and chelipeds reddish blond, fingers of chelae dark brown. Walking legs white with scattered orange blotches and spots or broken orange lines.

*Remarks*.—The female paratype differs from the holotype by having a third small, sharp spine immediately posterior to the large spine on the anterolateral border of the carapace and by having 3 sharp proximal spines on the anterior surface of the merus of the cheliped. The male paratype has a sharp anterior spine on the anterolateral border of the carapace instead of a blunt spine, and a proximal spine on the posterior surface of the merus of the cheliped.

*Etymology*.—From the Greek “stenos,” narrow, in combination with the Greek “cheilos,” a lip or rim; in reference to the narrow rim at the frontal margin of the carapace.

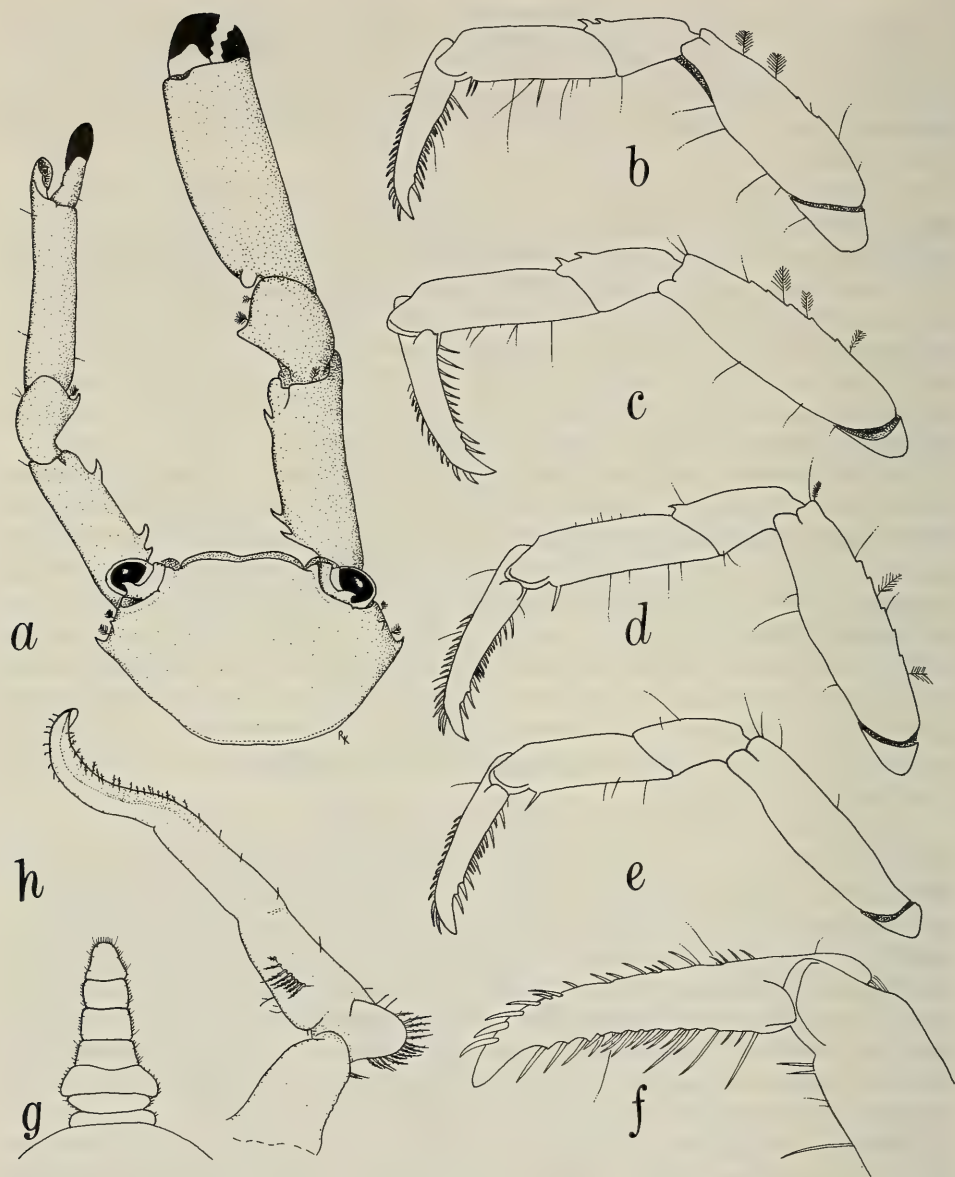


Fig. 1. *Tanaocheles stenochilus*, male holotype, carapace length 4.5 mm: a, Carapace and chelipeds; b-e, Walking legs 1-4; f, Dactylus of leg 1; g, Abdomen; h, Gonopod. b-e, g slightly enlarged; f, h enlarged.

*Habitat*.—Found free-living in association with the living coral *Leptoseris gardineri*.

*Distribution*.—At present known only from the type-locality.

#### Acknowledgments

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## PROTEOCEPHALIDEAN CESTODES FROM VENEZUELAN SILURIFORM FISHES, WITH A REVISED CLASSIFICATION OF THE MONTICELLIIDAE

Daniel R. Brooks and Graciela Rasmussen

*Abstract.*—Specimens of proteocephalidean cestodes collected in siluriform fishes from the delta of the Orinoco River represent five species: *Proteocephalus* cf. *kyukyu*, *Nomimoscolex kaparari*, *Goezeella siluri*, *Amphoteromorphus praeputialis*, and *Choanoscolex abscissus*. The last species is reported in new collections for the first time since its description in 1896; it possesses cortical gonads and is thus a monticelliid. The delta of the Orinoco is a new locality for all five species. *Megalodoras irwini* is a new host for *P. kyukyu*, *Brachyplatystoma vaillantii* is a new host for *N. kaparari*, *Pseudoplatystoma fasciatum* is a new host for *C. abscissus*, and *Pseudocetopsis othonops* is a new host for *G. siluri* and *A. praeputialis*. Examination of these specimens allowed character analysis for a suite of morphological characters leading to a phylogenetic hypothesis for the monticelliids which is superior to the one proposed earlier by the first author.

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Classification of the cestode order Proteocephalidea has been hampered by a lack of critical character analysis and by incomplete information regarding many taxa. Brooks (1978) summarized published data used to classify proteocephalideans based on a phylogenetic systematic analysis. In that study, the relationships of the genera comprising the family Monticelliidae LaRue, 1911, were marked by extensive parallel evolution. Postulates of parallel evolution stemming from phylogenetic analyses at the supra-specific level may be the result of (1) real parallel evolution, (2) para- and polyphyletic groupings or (3) inadequate character analysis.

Phylogenetic trees produced by cladistic analysis, and the classifications derived from them, are explicit hypotheses predicting certain distributions of characteristics among species. They can be tested by finding new characters and determining their distributions. If the new data are incongruent with previous observations, they may force a modification of the original phylogenetic hypothesis. This study represents the first test of Brooks' (1978) hypothesis of monticelliid relationships. Collection of proteocephalidean material from the delta of the Orinoco River during the winter of 1978 has permitted re-evaluation of some characters. This, coupled with extension of the analysis to the species level to test the monophyly of the generic groupings, has reduced the apparent parallel evolution shown by the monticelliids.

### Materials and Methods

Hosts were collected by hook and line or trawl and examined immediately for parasites. Cestodes were removed from hosts, studied alive, then relaxed in river water, fixed in steaming AFA and stored in 70% ethanol. Whole mounts were

prepared by hydrating specimens, staining them with Mayer's hematoxylin, dehydrating them, clearing them with methyl benzoate, and mounting them in Canada balsam. Some specimens were embedded in paraffin, serially cross sectioned at 8  $\mu$ m, and stained with hematoxylin-eosin for study. Figures were drawn with the aid of a drawing tube.

## Results

### *Proteocephalus* cf. *kyukyu* Woodland, 1935

*Host*.—*Megalodoras irwini* Eigenmann (Siluriformes: Doradidae), new host.

*Locality*.—Vicinity of Isla Tres Caños, delta of the Orinoco River, Venezuela, new locality.

*Site of Infection*.—Anterior third of intestine.

*Deposition of Specimens*.—University of Nebraska State Museum, No. 22455; James R. Adams Parasitology Collection, University of British Columbia.

Woodland (1935) described *Proteocephalus kyukyu* from immature specimens found in the gut of *Pseudodoras niger* and *P. brunnescens*. His specimens exhibited simple scolices, a very long unsegmented portion of strobila, and a few segments at the posterior end. Even the posteriormost segments lacked formed reproductive organs although anlagen of ovaries and cirrus sacs were present. Freze (1965) considered this a species inquirenda.

We found over 100 specimens in the intestine of one *Megalodoras irwini*, all of which agreed with Woodland's (1935) description. The immaturity of the strobilae in specimens collected from the Amazon (Woodland) and Orinoco (present study) suggests that this might be a normal aspect of the biology of this species. The implication of such a thought is that *P. kyukyu* might be hyperapolytic, with maturity and reproduction occurring after the proglottids have left the strobila. However, we found no such detached proglottids in the infected host. Until more is known we concur with Freze and consider this a species inquirenda.

### *Nomimoscolex kaparari* Woodland, 1935

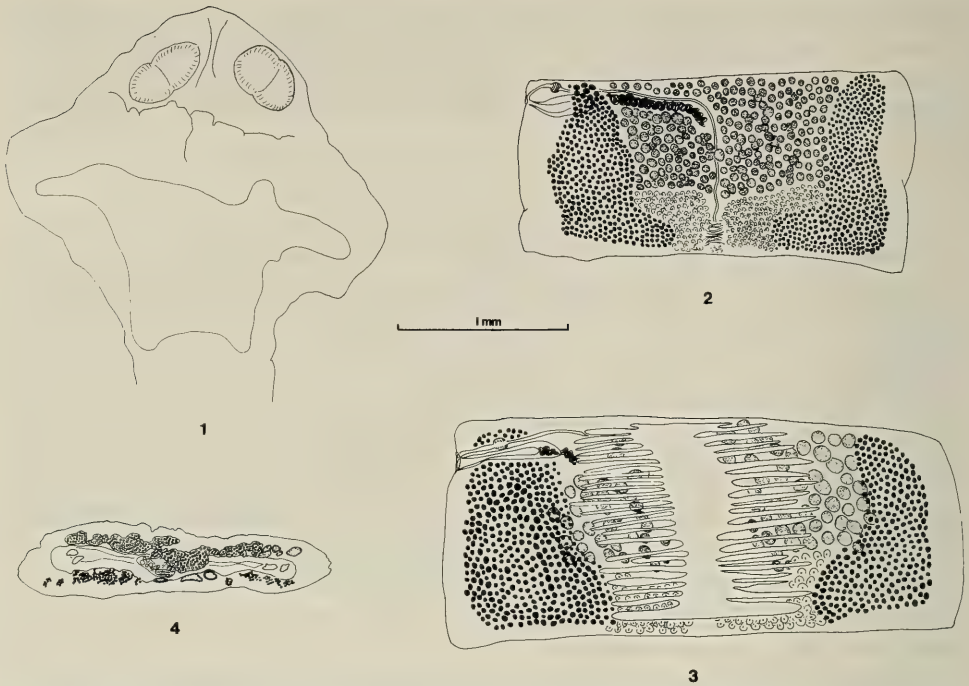
*Host*.—*Brachyplatystoma vaillanti* (Cuvier and Valenciennes) (Siluriformes: Pimelodidae), new host.

*Locality*.—Vicinity of Isla Tres Caños, delta of the Orinoco River, Venezuela, new locality.

*Site of Infection*.—Anterior third of intestine.

*Deposition of Specimens*.—University of Nebraska State Museum No. 22451.

We collected three immature proteocephalideans exhibiting scolices with four simple suckers with two muscular papillae, one on each side of the anterior margin. Woodland (1935) reported that *N. kaparari* possessed eight "unguiculate protrusions," two on each sucker. They appear to be the same as structures found on the suckers of *N. alovarius* Brooks and Deardorff, 1980, a parasite of *Pimelodus clarias* in the Magdalena River of Colombia (see Brooks and Deardorff 1980). The papillae of *N. alovarius* are positioned on the anterior portion of the suckers rather than on the margins of the anterior portions. *Nomimoscolex kaparari* has previously been reported in *Brachyplatystoma filamentosum* and *Pseudoplatystoma tigrinum* in the Amazon River.



Figs. 1-4. *Goezeella siluri*. 1, Scolex; 2, Mature proglottid; 3, Gravid proglottid; 4, Cross section of young gravid proglottid. Scale in millimeters.

*Goezeella siluri* Fuhrmann, 1916

Figs. 1-4

*Host*.—*Pseudocetopsis othonops* (Eigenmann) (Siluriformes: Cetopsidae), new host; immature specimens in *Brachyplatystoma vaillantii*.

*Locality*.—Vicinity of Los Castillos, of Isla Tres Caños, and of La Portuguesa, delta of the Orinoco River, Venezuela, new localities.

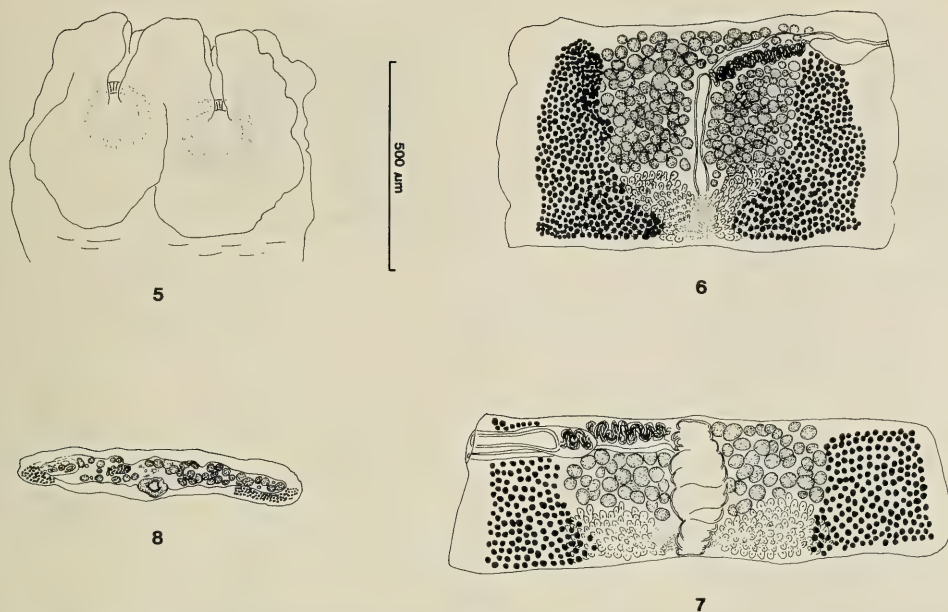
*Site of Infection*.—Posterior fifth of intestine.

*Deposition of Specimens*.—University of Nebraska State Museum, No. 22452, 22454; James R. Adams Parasitology Collection, University of British Columbia.

Collection of a number of *G. siluri* permitted examination of living worms and of sectioned material. By observing live specimens, we were able to confirm that the metascolex is formed by an expansion of the neck tissue posterior to the scolex. Contracted specimens do not show this clearly (e.g., see Brooks and Deardorff 1980). A vaginal sphincter was found in all proglottids, and the vagina was found to pass anterior or posterior to the cirrus sac. The single specimen reported by Brooks and Deardorff (1980) from *Ageneiosus caucanus* in Colombia had all vaginae passing anterior to the cirrus sac.

Cross sections of *G. siluri* show cortical testes, ovaries, vitellaria, and uteri. The vitelline follicles converge towards the ventral midline of the proglottid, and the uterine wall is very thin (Fig. 4).





Figs. 5–8. *Amphoteromorphus praeputialis*. 5, Scolex; 6, Mature proglottid; 7, Gravid proglottid; 8, Cross section of young gravid proglottid. Scale in micrometers.

*Amphoteromorphus praeputialis* Rego, Dos Santos and Silva, 1974

Figs. 5–8

*Host*.—*Pseudocetopsis othonops*, new host.

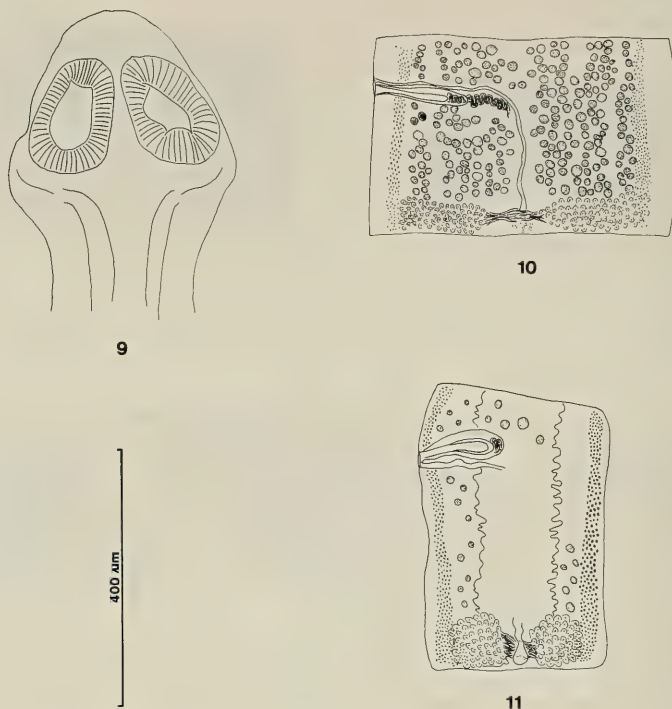
*Site of Infection*.—Anterior fifth of intestine.

*Locality*.—Vicinity of Los Castillos, of Isla Tres Caños, and of La Portuguesa, delta of the Orinoco River, Venezuela, new localities.

*Specimens Deposited*.—University of Nebraska State Museum, No. 22449, 22453, 22457, 22458; James R. Adams Parasitology Collection, University of British Columbia.

Our specimens agree well with the original description of this species in *Cetopsis caecutiens* (Licht.) from the Amazon River near Maicuru, Brazil. There appears to have been some confusion in labelling some of the diagrams in the original description (see Rego *et al.* 1974). Their figures 23–24, labelled as scolices of *Monticellia siluris* (= *G. siluri*), show contracted specimens with uniloculate suckers; *G. siluri* has biloculate suckers (see Fig. 1). Figure 25 by Rego *et al.* is an unclear photomicrograph of a specimen called *M. siluris*, but the nature of the sucker faces cannot be determined. Finally, their figures 26–27 are labelled photomicrographs of *M. siluris*, but judging from the shape of the uterus, they are specimens of *A. praeputialis* (see Figs. 6–7).

The metascolex of *A. praeputialis* is formed by a proliferation of tissue around each sucker rather than by the expansion of the neck seen in *G. siluri* (compare Figs. 1 and 5). In addition, all gonads except the vitellaria are medullary in *A. praeputialis*, and the uterus is very narrow (Figs. 6–7) and thick-walled (Fig. 6).



Figs. 9–11. *Choanoscolex abscissus*. 9, Scolex; 10, Mature proglottid; 11, Gravid proglottid. Scale in micrometers.

We examined 18 *Pseudoceptopsis othonops* from four different localities during this study. Both *A. praeputialis* and *G. siluri* were found in all four localities. Fifteen of the 18 fish (83%) were infected with at least one species of cestode. Nine of those 15 (60%) carried *A. praeputialis* and 12 of 15 (80%) carried *G. siluri*; 6 of 15 (40%) carried both species. *Amphoteromorphus praeputialis* always occurred in the anterior fifth of the intestine whereas *G. siluri* always occurred in the posterior fifth of the intestine, regardless of the presence of other species. We found no other helminths in *P. othonops*. Based on our phylogenetic analysis (presented later), *G. siluri* appears to be a colonizer of *P. othonops*, while *A. praeputialis* exhibits an apparent coevolutionary relationship with its cetopsid hosts. Thus, it is surprising that *G. siluri* occurred more often in *P. othonops* than did *A. praeputialis*. The small sample size precludes any stringent conclusions from being drawn, but this does illustrate the point that degree of coevolution cannot necessarily be drawn from host specificity or incidence data (see also Brooks 1979).

*Choanoscolex abscissus* (Riggenbach, 1896) LaRue, 1911

Figs. 9–11

*Host*.—*Pseudoplatystoma fasciatum* (Linnaeus) (Siluriformes: Pimelodidae), new host.

*Locality*.—Vicinity of Isla Tres Caños, delta of the Orinoco River, Venezuela, new locality.

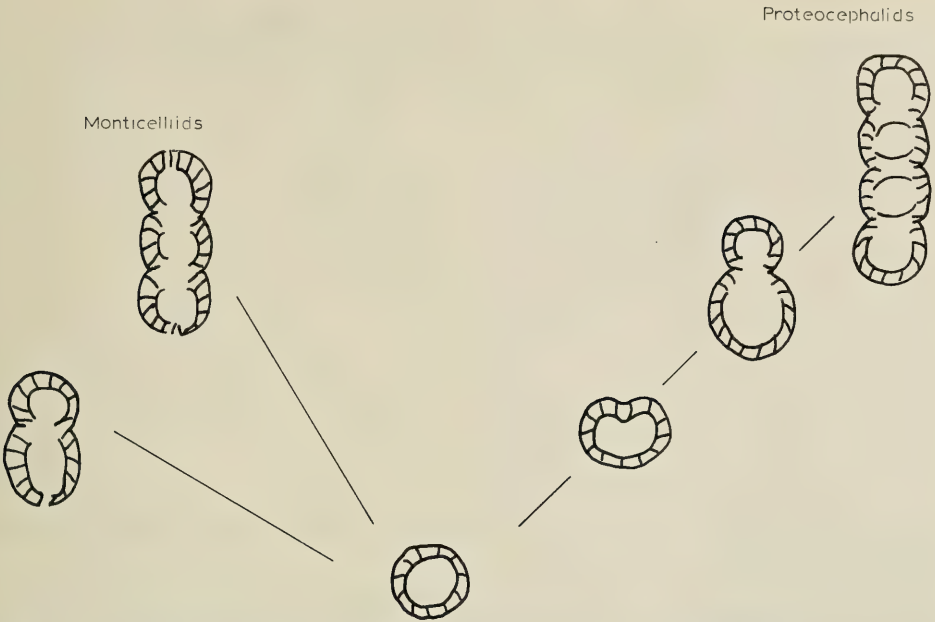


Fig. 12. Evolutionary transformations in scolex suckers among proteocephalideans.

*Site of Infection.*—Anterior third of intestine.

*Deposition of Specimens.*—University of Nebraska State Museum, No. 22456.

This species was described by Riggenbach (1896) from specimens collected in “*Silurus* sp.” (probably a pimelodid) from the Paraguay River. To our knowledge, it has never been reported in new collections until now. Unfortunately, our specimens are only of marginal quality, so we will not attempt a redescription at this time. However, we have been able to make a number of observations which help us place this species in a more suitable taxonomic context. Riggenbach reported (1) approximately 100 testes per proglottid, and our specimens have 130–173 testes, (2) a large number of uterine diverticula, and our specimens show 70–80 total diverticula, (3) a flat but folliculate ovary, which our material confirms, (4) a genital pore in the anterior fourth of the proglottid, in general agreement with our measurements, which show the genital pore in the anterior 16–25% of mature proglottids and 23–25% of gravid proglottids, and (5) a metascolex, which our observations of living and relaxed fixed material show to be formed by an expansion of the neck region, similar to that of *G. siluri*. In addition, we were able to provide a few cross sections which provided very little detail beyond the recognition that the gonads are cortical. This necessitates removal of *C. abscissus* from the Proteocephalidae and placement of it in the Monticelliidae.

Discussion

The new data supplied by study of the present specimens permit re-interpretation of some of the characters listed by Brooks (1978), and the use of some new characters.

1. Metascolex (Brooks’ character 5). This study demonstrates that the monticelliids exhibit at least two different types of metascolex. One type is exhibited



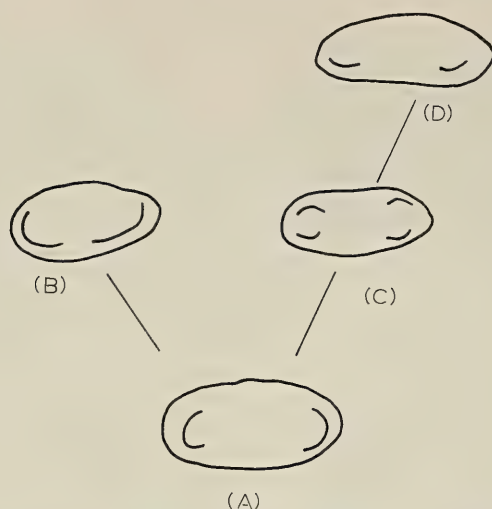


Fig. 13. Evolutionary transformations in vitelline configuration, viewed in cross section, among monticelliid cestodes.

by *Goezeella siluri* and *Choanoscolex abscissus*, in which the metascolex is formed by an expansion of the neck. The other type is exhibited by *Amphoteromorphus praeputialis* and its relatives. In the latter species, the metascolex is formed by proliferation of tissue around each sucker on the scolex. Within the Proteocephalidae, metascolices of the Corallobothriinae are formed by a general proliferation of scolex tissue around the base of the suckers. Thus, at least three different structures have all been called "the proteocephalidean metascolex." Re-coding of this character eliminates three cases of parallel evolution from the cladogram depicted by Brooks (1978).

2. Uterine structure. *Amphoteromorphus praeputialis* possesses thick-walled, narrow uteri, which differ from those of most other proteocephalideans. Illustrations of *Zygobothrium megacephalum* and the other species of *Amphoteromorphus* suggest that this structure is representative of this small group of monticelliids.

3. Scolex papillae. Three species, *Nomimoscolex kaparari*, *N. alovarius*, and *Myzophorus woodlandi*, are known to possess papillae on the suckers or sucker margins of the scolex. For *N. kaparari*, there are two papillae on the margins of each sucker; *N. alovarius* also has two papillae per sucker, but they are situated on the suckers themselves; and *M. woodlandi* has four papillae on the margin of each sucker.

4. Ovarian structure. Most monticelliids possess highly follicular ovaries (see Figs. 2, 6), which differ from those of other proteocephalideans. This includes those of the members of the Acanthotaeniinae, which have compact ovaries with digitiform lobes, and of the Corallobothriinae, whose compact ovaries may be lobulated.

5. Sucker structure. The primitive state for proteocephalidean scolex suckers is the uniloculate condition. In one proteocephalid lineage and in the monticelliids, bi-, tri- and tetraloculate suckers have arisen. The transformation series for these changes is shown in Fig. 12.



Fig. 14. Cladogram depicting phylogenetic hypothesis for 34 species of monticelliids. Abbreviations for generic names include: N = *Nomimoscolex*; My = *Myzophorus*; E = *Endorchis*; O = *Othinoscolex*; Ep = *Ephedrocephalus*; R = *Rudolphiella*; A = *Amphoteromorphus*; Z = *Zygobothrium*; M = *Monticellia*; S = *Spatulifer*; C = *Choanoscolex*; G = *Goezeella*. Numbers accompanying slash marks on branches refer to derived traits (synapomorphies) listed in Appendix.

6. Embryonation of eggs. None of the monticelliids which we examined have any evidence of embryonated eggs in utero. This is a condition found in at least some tetraphyllidean, trypanorhynch and lecanicephalan cestodes. The presence of embryonated eggs in utero may be of use in distinguishing some groups of cestodes. At present, not enough is known to draw conclusions, but we include the character for future reference.

7. Ovarian position in cross section (Brooks' character 2). Primitively, the ovary is medullary. In some monticelliids, the ovary is partially cortical, and in others it is almost entirely cortical.

8. Vitelline configuration in cross section. There are four different basic configurations found in monticelliids. The plesiomorphic condition is derived from outgroup comparisons. These are shown in Fig. 13.

9. Testes number. The primitive state for monticelliids appears to be between 100 and 150 testes per proglottid based on both outgroup comparisons with other proteocephalideans and on functional outgroup analysis. Other states include: (1) 80–120, with a mean of 100; (2) 40–60; (3) 150–200; and (4) 200–400.

10. Position of vaginal opening relative to cirrus sac. The primitive condition among proteocephalideans is the presence of vaginal openings irregularly alternating between anterior and posterior to the cirrus sac. In some monticelliids, the vagina is reported to pass either only anterior or only posterior to the cirrus sac.

The cladogram corresponding to the most parsimonious representation of the above data, and data previously recorded by Brooks (1978), for 34 species of monticelliids is shown in Fig. 14. The high rate of parallel evolution found by

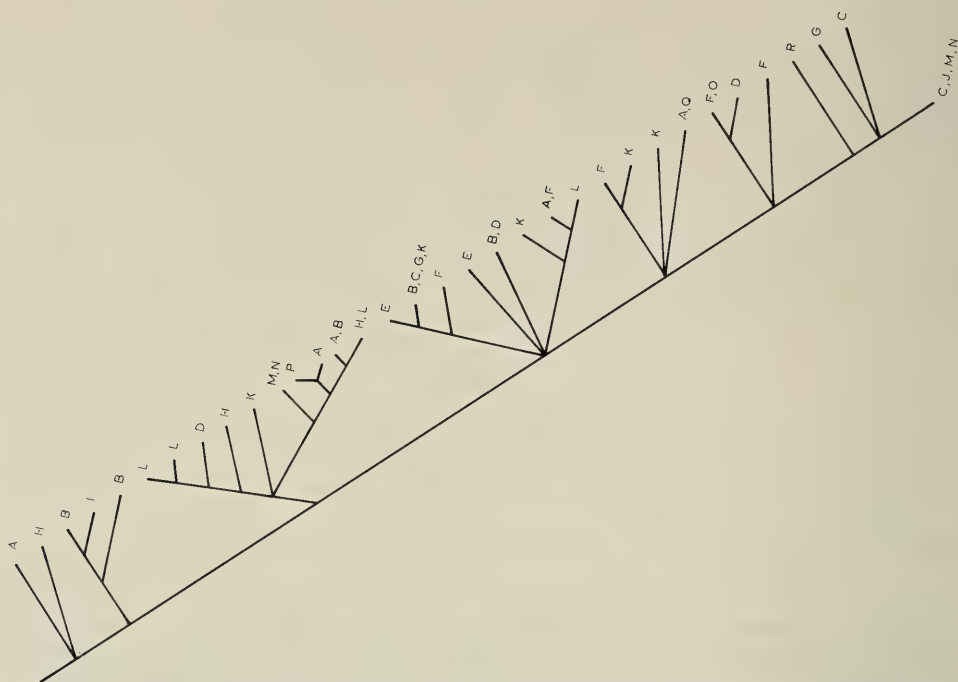


Fig. 15. Cladogram from Fig. 14 with letter codes indicating host identity superimposed. Refer to text for host names.

Brooks (1978) can be seen to have been due to the para- and polyphyletic nature of some of the generic groupings, in particular *Nomimoscolex*, *Myzophorus*, *Amphoteromorphus*, and *Monticellia*. An indicator of the degree to which characters showing parallel evolution have been used to construct a phylogeny is the consistency index (CI) (Kluge and Farris 1969; Farris 1970). The higher the CI (1.0 is maximal), the lower the parallel evolution. For Fig. 14, the CI is 0.57, which is average for phylogenetic analyses of various kinds of organisms (see Mickevich 1982). However, virtually all of the parallel evolution can be attributed to two characters, vaginal position and testes number. If we remove those characters, the CI for the tree is 0.83, indicating very little parallel evolution in the majority of other characters.

If the results of this study are corroborated by future work, it will be necessary to revise the taxonomy of the monticelliids considerably to make it consistent with their phylogeny. However, until we have made a thorough examination of available material, we refrain from making such nomenclatural changes.

#### Host-Parasite Relationships

The search for monticelliids in neotropical siluriforms cannot be termed extensive. On the other hand, recent collections in Brazil (Rego, Dos Santos, and Silva 1974), Colombia (Brooks and Deardorff 1980) and Venezuela (present report) have produced only two new species in *Nomimoscolex*, one of *Spatulifer* and one of *Amphoteromorphus*. This suggests that although monticelliids are



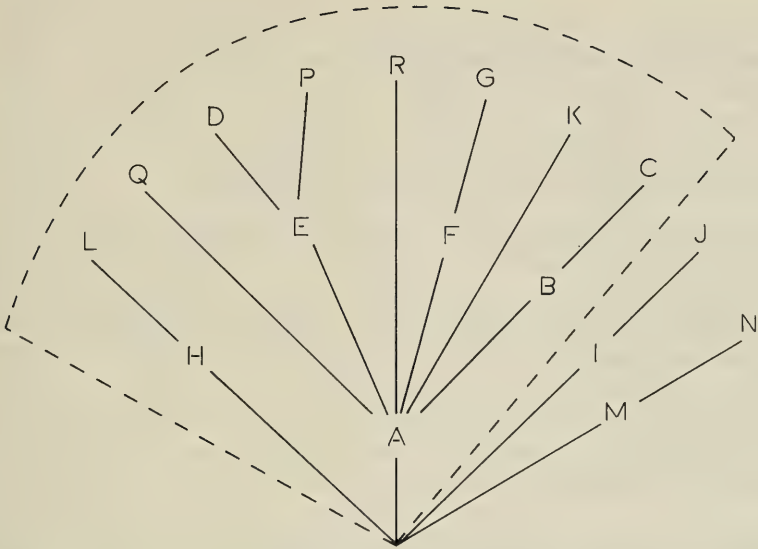


Fig. 16. Transformation series for best-fitting hypothesis of host-parasite relationships. Species enclosed in dotted circle belong in the family Pimelodidae.

highly divergent morphologically, they may not be particularly speciose. In addition to the monticelliids, only nine species of proteocephalids are known from South America, one of *Corallotaenia* (see Brooks and Deardorff 1980), one of *Megathylacus* and seven of *Proteocephalus*, including four in siluriform fishes (*P. fossatus*, *P. jandia*, *P. kyukyu*, *P. platystomi*). Thus, proteocephalidean diversity in South America may not be striking. The six species reported in this study appear to have relatively broad distributions in South America.

The cladogram in Fig. 15 represents the phylogenetic relationships of the monticelliids considered in this study with letters superimposed at the ends of branches indicating the identity of piscine hosts used by each cestode species. The letters refer to the following hosts (families listed in parentheses):

- A. *Brachyplatystoma flavicans* (Castelnau) (= *B. rousseauxii*) (Pimelodidae)
- B. *Brachyplatystoma filamentosum* (Lichtenstein) (Pimelodidae)
- C. *Brachyplatystoma vaillanti* (Cuvier and Valenciennes) (Pimelodidae)
- D. *Luciopimelodus pati* (Cuvier and Valenciennes) (= *Pimelodus pati*) (Pimelodidae)
- E. *Pimelodus clarias* (Bloch) (Pimelodidae)
- F. *Pseudoplatystoma fasciatum* (Linnaeus) (Pimelodidae)
- G. *Pseudoplatystoma tigrinum* (Cuvier and Valenciennes) (Pimelodidae)
- H. *Phractocephalus hemiliopterus* (Schneider) (Pimelodidae)
- I. *Ageneiosus brevifilis* Cuvier and Valenciennes (= *Pseudogeneiosus brevifilis*, *P. zungaro*) (Ageneiosidae)
- J. *Ageneiosus caucanus* Steindachner (Ageneiosidae)
- K. *Platystomatichthys sturio* (Kner) (Pimelodidae)
- L. *Pinirampus pirinambu* (Cuvier and Valenciennes) (= *Pirara bicolor*) (Pimelodidae)

- M. *Cetopsis caecutiens* (Lichtenstein) (Cetopsidae)
- N. *Pseudocetopsis othonops* (Eigenmann) (Cetopsidae)
- O. "*Silurus* sp." (prob. Pimelodidae)
- P. *Pseudopimelodus zungaro* (Humboldt) (Pimelodidae)
- Q. *Rhamdia* sp. (Pimelodidae)
- R. *Calophysus macropterus* (Lichtenstein) (Pimelodidae)

Note that the bulk of the hosts belong to the family Pimelodidae. Only six of the 47 (13%) of the host records for this group of cestodes are from other siluriforms. Figure 16 depicts a transformation series of hosts, derived using the "nearest-neighbor" method of Mickevich (1982), which provides the most parsimonious explanation of host-parasitic relationships. If those transformations are consistent with host phylogeny, only nine of the 47 (20%) host relationships postulated by the cladogram are attributable to host-switching; all the rest are due to coevolution. If this is the case, the monticelliids have coevolved with a fairly small number of siluriforms, and may well have speciated more often than their hosts.

One of the most interesting host switches is that for *Goezeella siluri* in *Cetopsis caecutiens* and *Pseudocetopsis othonops* (family Cetopsidae). When *G. siluri* is found in other hosts (pimelodids and ageneiosids), it occurs in the anterior third of the intestine. We found immature specimens of *G. siluri* in the anterior third of the intestine of *Brachyplatystoma vaillanti*. But when it inhabits cetopsids, it is found in the posterior third of the intestine. This does not appear to be a function of competitive exclusion by *Amphoteromorphus praeputialis*, which inhabits the anterior third of the intestine of cetopsids, because *G. siluri* lives in the posterior third of the gut even if *A. praeputialis* is absent. We suggest that the site selection by *G. siluri* in cetopsids is a function of the location in the gut of a host cue (either physical or physiological) to which *G. siluri* responds and is not a function of the presence of other helminths.

### Summary

The previous phylogenetic hypothesis for monticelliids (Brooks 1978) overestimated the amount of parallel evolution exhibited by the group. This was due to faulty character analysis and the use of non-monophyletic generic groupings. The present study, while far from a complete analysis, nonetheless presents a more stable phylogenetic hypothesis. At present, monticelliid cestodes appear to be a distinctive group of cestodes which has coevolved primarily with pimelodid catfish.

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Appendix 1.—Synapomorphy list for cladogram of monticelliid cestodes inhabiting neotropical siluriform fishes.

1. Uniloculate suckers
2. Thin-walled uterus
3. Weakly-developed internal muscle layer
4. Compact ovary
5. Vagina alternating between anterior and posterior to cirrus sac
6. Apical organ present
7. Vitellaria partially cortical
8. 100–150 testes per proglottid
9. Vitelline bands arranged like two parentheses on either side of the proglottid
10. Ovary medullary
11. Testes medullary
12. Uterus medullary
13. No metascolex
14. No papillae on suckers
15. Vagina posterior to cirrus sac only
16. 50–60 testes
17. Ovary follicular
18. Vitellaria totally cortical
19. Internal muscle layer strongly developed
20. Vagina anterior to cirrus sac only
21. Triloculate suckers
22. No apical organ
23. Vitellaria in four quadrants, two dorsal and two ventral, along lateral margins
24. Vagina posterior to cirrus sac only
25. No apical organ
26. Metascolex I (*Amphoteromorphus* type)
27. Vitellaria in four quadrants, two dorsal and two ventral, along lateral margins
28. Partly cortical ovary
29. Vitellaria in two ventral bands on either side of proglottid
30. 150–200 testes
31. Elongate eggs
32. 100 testes
33. Vagina anterior to cirrus sac only
34. Short, thin egg filaments
35. Long, thick egg filaments
36. Vagina posterior to cirrus sac only
37. Uterus thick-walled, tubular
38. Biloculate suckers
39. Spinose scolex
40. 40 testes
41. Vitelline bands arranged like two parentheses on either side of the proglottid



42. 150–200 testes
43. Tissue growth around suckers so pronounced that only an anterior and posterior opening remain
44. Ovary partially cortical
45. Two papillae on margin of each sucker
46. 40–60 testes per proglottid
47. Alate ovarian lobes
48. Two papillae on tops of each sucker
49. Vagina posterior to cirrus sac only
50. Vagina anterior to cirrus sac only
51. Four papillae on margins of each sucker
52. Vagina anterior to cirrus sac only
53. Vagina posterior to cirrus sac only
54. 200–250 testes per proglottid
55. Vagina posterior to cirrus sac only
56. Vagina anterior to cirrus sac only
57. Ovary cortical
58. Testes cortical
59. Uterus cortical
60. Vitelline bands converging towards midline ventrally
61. 200 testes per proglottid
62. Spinose suckers
63. 60 testes per proglottid
64. 200 testes per proglottid
65. *Metascolex* II (*Goezeella* type)
66. 100 testes per proglottid
67. 40–50 testes per proglottid
68. 150–200 testes per proglottid
69. 200–400 testes per proglottid
70. Biloculate suckers

## TWO NEW SPECIES OF *GIGANTIONE* KOSSMANN (ISOPODA: EPICARIDEA: BOPYRIDAE) FROM THE WESTERN NORTH ATLANTIC

Daniel L. Adkison

*Abstract.*—*Gigantione mortenseni* n. sp. is described from three dromiid crabs, *Dromidia antillensis* Stimpson, *Hypoconcha sabulosa* (Herbst), and *H. spinosissima* Rathbun. *Gigantione uberlackerae* is described from an undescribed axiid species, *Axiopsis* (*Paraxiopsis*) sp.

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*Gigantione* is a well defined taxon having several unusual characteristics reflecting the distinctiveness of *Gigantione* from other bopyrid genera. The unusual characteristics for the female of *Gigantione* are: (1) the oral cone is visible in dorsal view, (2) the maxilliped is edged with plumose setae, (3) the basal segment of the first antenna is enlarged and applied to the oral cone, (4) the coxal plates and lateral plates are pubescent, and (5) the uropods have a discrete peduncle. The male of most species has biramous pleopods and uropods. The following generic diagnosis is presented to include several of the above unusual characters.

### *Gigantione* Kossmann

*Generic diagnosis.*—Female: body nearly circular in outline; distortion slight to moderate; all regions and segments distinct. Head with oral cone visible in dorsal view; anterior lamina medially narrow, usually laterally developed into lobes; basal segments of first antenna greatly enlarged and applied to oral cone; maxilliped without palp, margin at least medially fringed with plumose setae; posterior lamina, one pair of lateral projections and median projection. Coxal plates present on at least anterior pereomeres, pubescent. Dorsal bosses on pereomeres 1-4. Pleomeres 1-5 with lateral plates, lateral plates pubescent; pleomere 6 set deeply in pleomere 5. Pleopods, 5 biramous pairs; first pair larger than others with rami leaf-shaped; other pleopods digitate, decreasing in size posteriorly. Uropods biramous.

Male: all regions and segments distinct. Pleomeres usually with lateral margin directed ventrally. Pleopods, 5 pairs. Pleopods and uropods present, generally biramous.

*Remarks.*—In the phylogeny of the Bopyridae, *Gigantione* represents a primitive branchial form (Shiino 1952, 1965; Markham 1974). In the Bopyridae, advanced forms are characterized by the reduction in some or all of the following characters: pleopod rami reduced, number of pleopod pairs reduced, oostegites reduced, fusion of pleomeres, fusion of pereomeres. For the male, advanced forms are characterized by some or all of the following: head fused to pereomere, pleopods reduced in number or rami, pleomeres fused. Both the female and male of *Gigantione* have all regions and segments distinct, five pairs of biramous pleopods (generally biramous for males), and uropods generally biramous.

*Gigantione mortenseni*, new species

Figs. 1-5

*Gigantione bouvieri* Nierstrasz and Brender à Brandis, 1931:152-153, figs. 7-12.

*Material examined*.—Infesting *Dromidia antillensis* Stimpson, 1859, Gulf of Mexico. Station SAM 475-10; 30°08'N, 87°07'W; 32 m; Apr 1975; R. L. Shipp collected; D. L. Adkison determined host; 1 ♀ (immature, no male) USNM 172464.—Station MAFLA III-D(37); 29°48'N, 86°03'W; capetown dredge; 43 m; Jun 1974; T. S. Hopkins collected; D. L. Adkison determined host; 2 ♀ (both immature, no males, both from right gill chamber of same host) USNM 172461.—Bellows station 39; 28°26'N, 84°21'W; capetown dredge; 43 m; 1 Jul 1977; S. B. Collard and D. L. Adkison collected; D. L. Adkison determined host; 1 ♀ (gravid), 1 ♂ USNM 172467.—Station MAFLA II-N(49); 28°24'N, 84°21'W; 46 m; Jun 1974; T. S. Hopkins collected; D. L. Adkison determined host; 2 ♀ (1 ovigerous, 1 immature), 2 ♂ (1 juvenile) RMNHL I-5911.—Station MAFLA I-B(62); 27°50'00"N, 83°31'00"W; diver collected; 28 m; 16 Aug 1976; T. S. Hopkins collected; D. L. Adkison determined host; 1 ♀ (gravid, no male) USNM 172463.—Station EJ-65-272; 27°37'N, 83°28'W; 37 m; 31 Aug 1965; B. Presley collected; N. Whiting determined host; 1 ♀ (immature), 1 ♂ FSBC I-22928.—Station BLM 3102014; 26°24'N, 83°49'W; capetown dredge; 98 m; 15 Jul 1976; T. S. Hopkins collected; D. L. Adkison determined host; 1 ♀ (gravid), 1 ♂ ZMC.—Hourglass station L, EJ-65-347; 26°24'N, 83°22'W; 55 m; 13 Nov 1965; B. Presley collected; W. G. Lyons determined host; 1 ♀ (gravid), 1 ♂ FSBC I-22929.—Hourglass station L, EJ-65-380; 13-14 Dec 1965; H. Wahlquist collected; W. G. Lyons determined host; 2 ♀ (1 gravid, 1 juvenile), 1 ♂ FSBC I-22927.—Station BLM 15-I-A(62); 26°21'N, 82°57'W; capetown dredge; 37 m; 28 Jul 1975; T. S. Hopkins collected; D. L. Adkison determined host; 1 ♀ (gravid), 1 ♂ DISL.—Station 65-188; 25°50'N, 82°44'W; 36 m; 30 Jun 1965; E. Joyce determined host; 1 ♀ (gravid, holotype) USNM 172456; 1 ♂ USNM 172457; 2 ♀ (juvenile), 1 ♂ USNM 172458.—Station EJ-65-209; 25°29'N, 82°17'W; 27 m; 10 Jul 1965; A. Provenzano determined host; 1 ♀ (non-gravid), 1 ♂ USNM 172466.—Oregon II station 21317, 21318; 24°51'N, 82°20'W; trawl; 28 m; 15 Dec 1976; D. L. Adkison collected and determined host; 1 ♀ (non-gravid, no male) USNM 172460.—Station EJ-67-147; 24°38'N, 82°59'W; 28-33 m; 27 Apr 1967; W. G. Lyons and M. Moe collected; W. G. Lyons determined host; 4 ♀ (juvenile), 1 ♂ USNM 172462. Atlantic Ocean off Florida.—Station EJ-73-63; 27°55'N, 80°03'W; 46 m; 14 May 1973; D. Barber collected; N. Whiting determined host; 2 ♀ (1 gravid, 1 immature), 2 ♂ (1 juvenile) USNM 172459.—Yucatan Peninsula, Mexico. Station EJ-68-64; 20°03'N, 87°04'W; box dredge; 37 m; 20 Jul 1968; D. K. Camp collected; D. L. Adkison determined host; 1 ♀ (gravid), 1 ♂ USNM 172465.—Haiti; 1974; Pr. A. Veillet collected; D. L. Adkison determined host; 1 ♀ (non-gravid), 1 ♂ MNHN Ep. 114.

Infesting *Hypoconcha sabulosa* (Herbst).—North from Thatch Cay, St. Thomas, Virgin Islands; approx. 18°21'N, 64°52'W; 15 Mar 1906; T. Mortensen collected; D. L. Adkison determined host; 1 ♀ (gravid), 1 ♂ ZMC.—Station EJ-74-191; 28°37'N, 80°11'W; 40 m; 14 Oct 1974; D. Barber collected; R. H. Gore determined host; 1 ♀ (immature), 1 ♂ USNM 172468.

Infesting *Hypoconcha spinosissima* Rathbun.—Station MAFLA III-D(37);



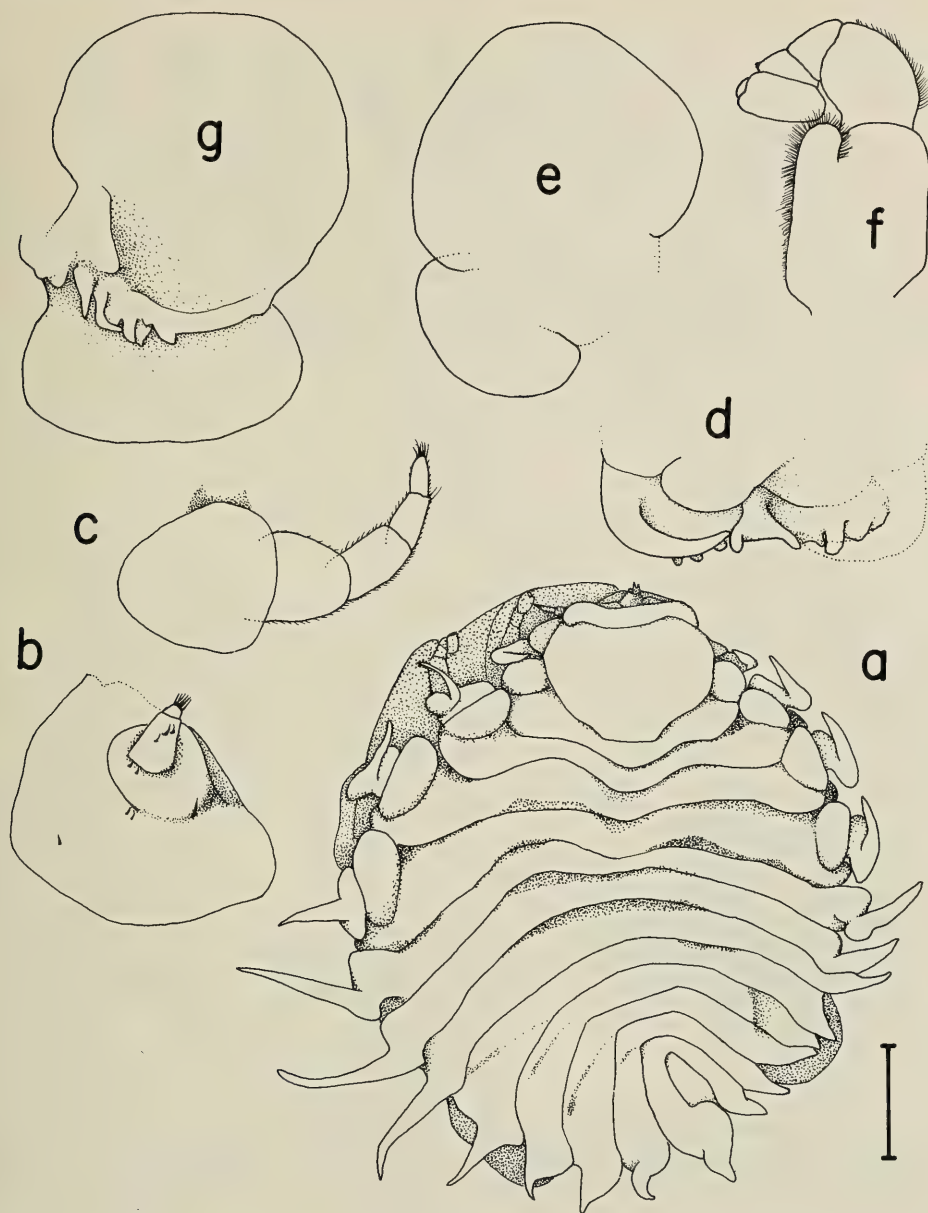


Fig. 1. *Gigantione mortenseni*, female: a, Dorsal view, holotype; b, First antenna (stippled area, point of attachment); c, Second antenna (stippled area, point of attachment); d, Posterior lamina, right maxilliped and spur removed (spur indicated with stippling); e, Maxilliped (setae omitted); f, Pereopod 6; g, Oostegite 1, internal view. Figures from holotype, a, d, g. Figures from USNM 172468, b, c, f. Figure from Nierstrasz and Brender à Brandis specimen ZMC, e. Scale = 2.0 mm.

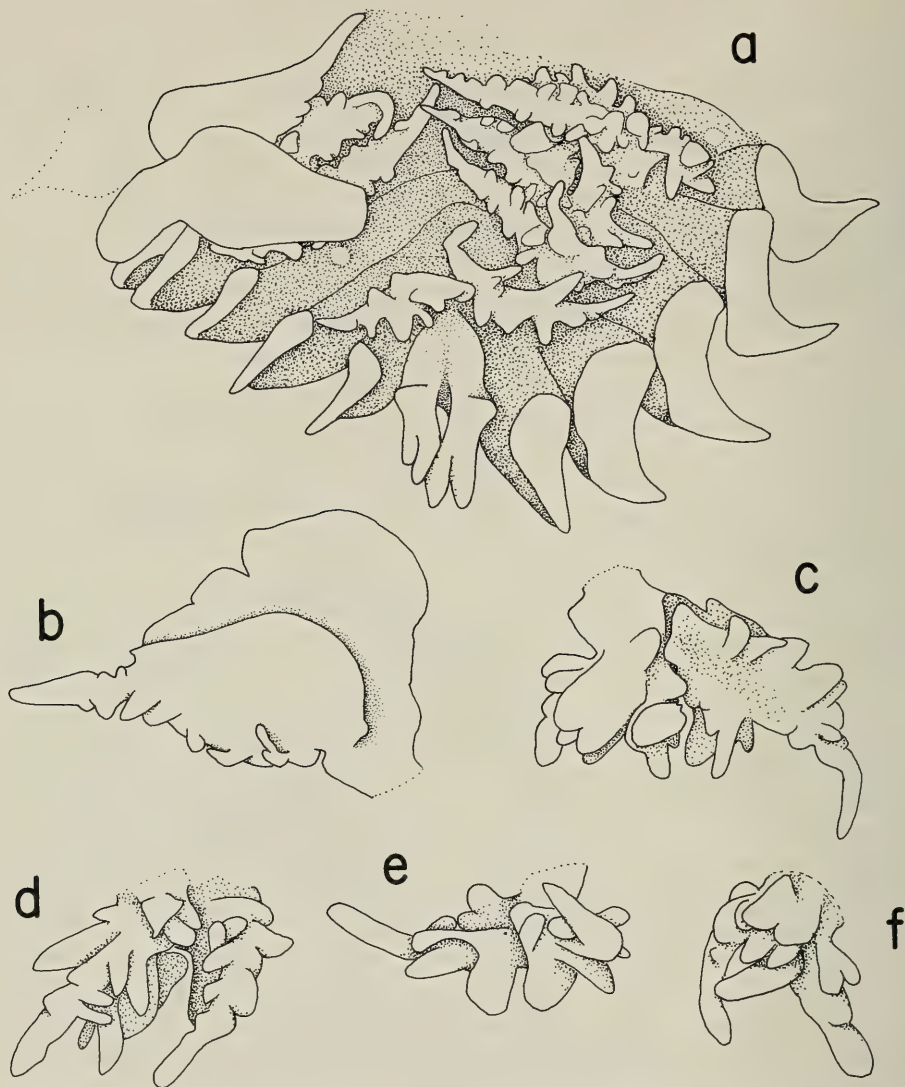


Fig. 2. *Gigantione mortenseni*, female: a, Pleon, ventral view (right pleopod 3 and left pleopod 1 missing); b-f, Pleopod, exopods on right; b, Pleopod 1; c, Pleopod 2; d, Pleopod 3; e, Pleopod 4; f, Pleopod 5. Figure from Nierstrasz and Brender à Brandis specimen ZMC, a. Figures from USNM 172468, b-f.

29°37'N, 80°03'W; capetown dredge; 43 m; Jul 1974; T. S. Hopkins collected; D. L. Adkison determined host; 1 ♀ (juvenile, no male) USNM 172470.—Station 2105; 26°24'N, 83°49'W; capetown dredge; 98 m; 2 Feb 1979; T. S. Hopkins collected; D. L. Adkison determined host; 1 ♀ (juvenile, no male) USNM 172467.

*Description.*—Female (Figs. 1–4): Mature specimens; length, 5 to 9.5 mm; width across pereomere 4, 5.7 to 8.8 mm; distortion angle 0–30°.

Head wider than long; anterior lamina narrow, laterally expanded into lobes. Eyes often present, visible in anterolateral view. First antenna, segmentation indistinct, 2 to 4 segments, usually 3 segments; basal segment greatly expanded.

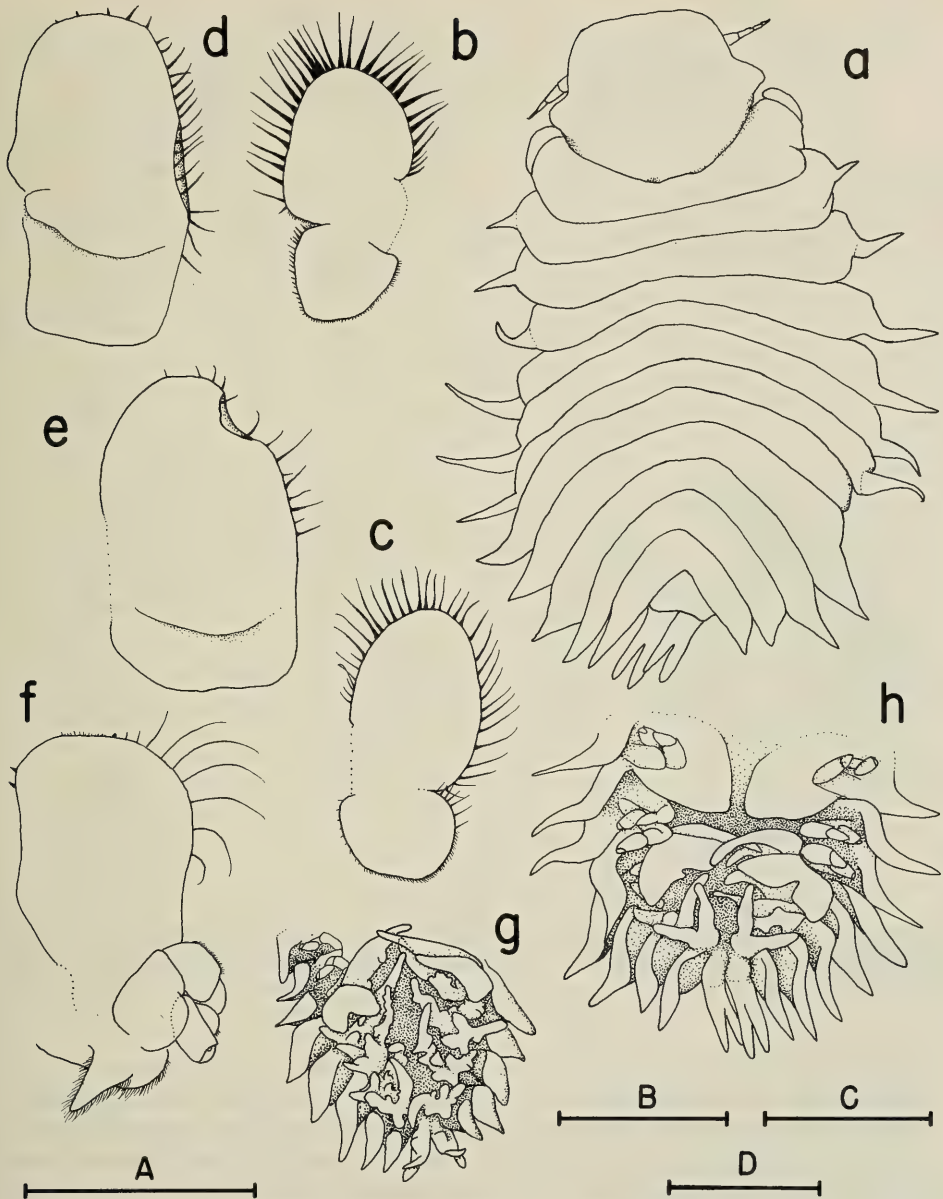


Fig. 3. *Gigantione mortenseni*, immature female: a, Dorsal view; b, Maxilliped; c, Maxilliped; d, Oostegite 1, external view; e, Oostegite 1, internal view; f, Second pereopod, coxal plate and oostegite; g, Pleon, ventral view; h, Pleon of a, ventral view. Figures from USNM 172470, b and g (specimen less mature than USNM 172467). Figures from USNM 172467, a, c–f, h. Scale A = 1.0 mm (Fig. a); B = 0.5 mm (Figs. b–f); C = 1.0 mm (Fig. h); D = 1.0 mm (Fig. g).

Second antenna, 5 or 6 segments; with numerous short setae. Second antenna about twice length of first. Maxilliped fringed with long plumose setae. Posterior lamina margin tuberculate, 1 pair of lateral projections and a median projection with 1 pair of tubercles.



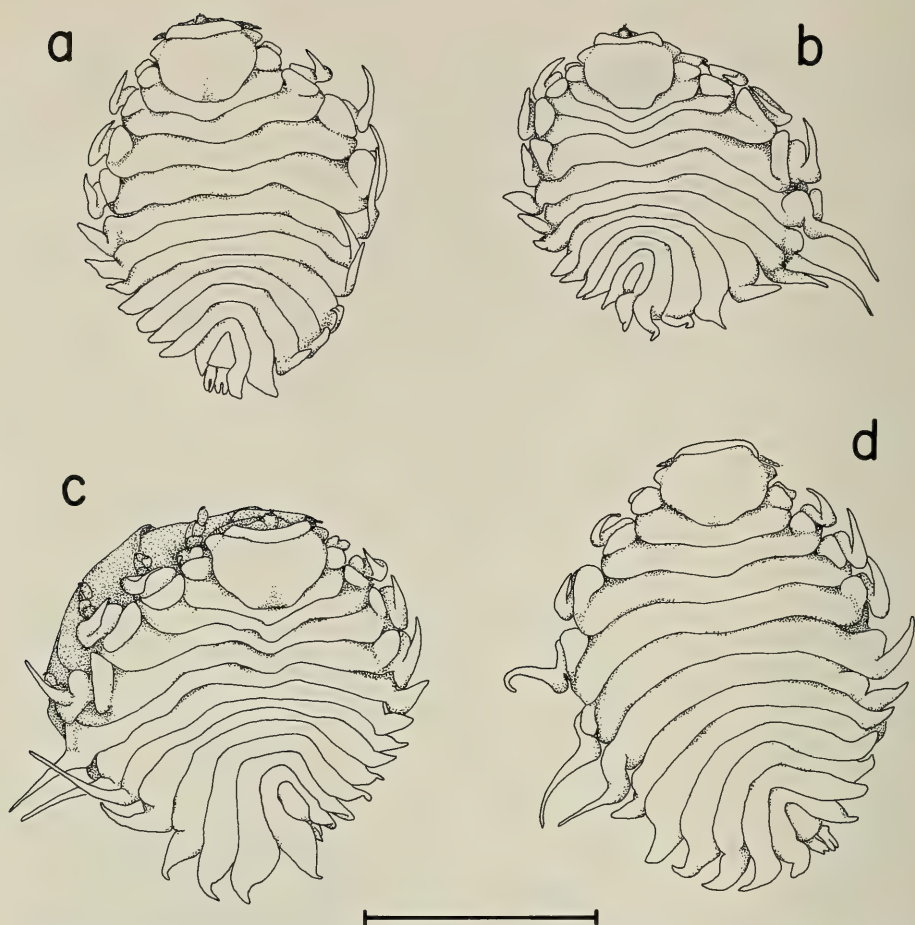


Fig. 4. *Gigantione mortenseni*, variation of female: a, From left gill chamber, USNM 172463; b, From left gill chamber, FSBC I-22929; c, From right gill chamber, USNM 172459; d, From right gill chamber, DISL. Scale = 5.0 mm.

Pereon with dorsal bosses present on pereomeres 1 to 4 and rarely pereomere 5. Coxal plates present on all pereomeres, pubescent; projection elongate, increasing in length posteriorly; on expanded side, coxal plates longer and narrower than on reduced side, coxal plate projection often reduced to small lobe on pereomere 1. First oostegite, posterior plate short, broader than anterior plate; anterior plate with anteromedian edge fringed with short plumose setae, internal ridge with projections on lateral half of ridge. Pereopods of similar size, increasing slightly in size posteriorly, with basal carina.

Pleon of 6 segments, lateral plates on all but pleomere 6; lateral plates pubescent; lateral plates on expanded side with narrow projection similar to that of coxal plates. Pleopods of 5 biramous pairs; first pair much the largest, leaf-shaped, with dorsal margin digitate, exopod wider than endopod. Other pleopods digitate to multilobed often appearing triramous; pleopods decreasing in size posteriorly, endopod longer than exopod. Uropods biramous, rami nearly equal in size, base

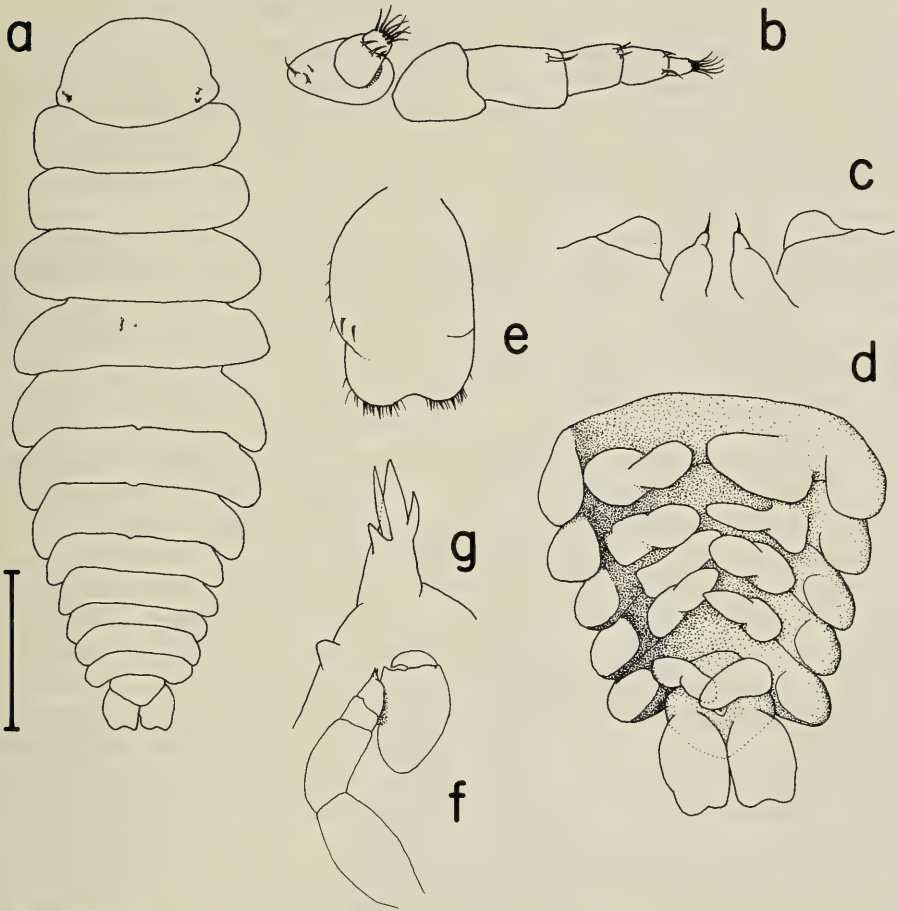


Fig. 5. *Gigantione mortenseni*, male: a, Dorsal view; b, Left antennae; c, Maxillipeds; d, Pleon, ventral view; e, Right uropod; f, Pereopod; g, Complex spine on carpus. Figure from FSBC I-22927, c. Figures from USNM 172468, a, b, d-g. Scale = 0.5 mm.

with prominent tubercle on ventral surface at about point where uropod becomes visible in dorsal view.

Male (Fig. 5): Based on mature specimens; length 2.1 to 2.7 mm, width across pereomere 4, 0.8 to 1.0 mm.

Head, approximately trapezoidal; expanded lobes present at posterolateral corner of head. Eyes present, generally pigmented. First antenna, 3 segments; second antenna, 5 segments; second segment 3 times length of first. Maxillipeds as figured.

Pereomere 1 anterior margin convex; pereomeres 2-4 nearly straight; pereomeres 5-7 progressively directed more posteriorly. Midventral tubercle absent. Pereopods, all of similar size, carpus with a complex spine.

Pleon of 6 segments; all but last with lateral area directed posterolaterally. Midventral tubercles absent. Pleopods, 5 biramous pairs, endopod usually elongate and larger than exopod. Uropods biramous.

*Etymology.*—This species is named for Dr. Th. Mortensen who collected the first known specimens of the new species.

*Distribution.*—*Gigantione mortenseni* is known from Haiti, the Virgin Islands, the Gulf of Mexico, and the Atlantic Ocean off Florida.

*Discussion.*—Nierstrasz and Brender à Brandis, 1931, described and illustrated a pair of bopyrids from *Hypoconcha sabulosa* as *Gigantione bouvieri* Bonnier, 1900, a species known from the xanthid crab, *Pilumnus hirtellus* (L.). Based on the phylogenetic distance between *Hypoconcha* and *Pilumnus*, the forms do not appear to be conspecific.

While Nierstrasz and Brender à Brandis (1931) thought the differences between their specimen and the description of *Gigantione bouvieri* were minor, I believe these differences are specific and differentiate the two species. The differences noted for the female *G. mortenseni* are: (1) the coxal plates are very slender, (2) coxal plates do not cover dorsal bosses, (3) the first pair of pleopods are smaller (though the relative development of the pleopods is age-related to some degree), and (4) the uropods have a basal projection. The differences for the male of *G. mortenseni* are the presence of biramous pleopods and uropods. The complex spine on the pereopods of the male of *G. mortenseni* is unusual and may be a specific character. The pleopods of the female may also be more digitate but this cannot be determined without examination of specimens of *G. bouvieri*. *Gigantione mortenseni* also has a distinct frontal lamina that was not mentioned by either Bonnier (1900) or Nierstrasz and Brender à Brandis (1931), or illustrated by Nierstrasz and Brender à Brandis (1931). Examination of the material of Nierstrasz and Brender à Brandis shows it to have a distinct frontal lamina.

During maturation of the female *G. mortenseni*, projections of coxal plates and lateral plates appear early in development, but the coxal plates and dorsal bosses do not become discrete units until the adult form is nearly attained. The uropods take on the adult form with the basal projection early in development but after the projections on the coxal and lateral plates are present. The relative length of the oostegites and the complexity of the pleopods are the best estimates of maturity. Pleopod 1 becomes larger and broader with age, with the tubercles on the dorsal edge becoming larger and more numerous. Pleopods 2 to 5 become more complex with maturity, being a simple V-shape in the juvenile to complexly tuberculate in the adult and appearing triramous. While the pleopods are becoming more complex, oostegites 2 to 5 are increasing in length. At the simple V-shape stage of the pleopods, the oostegites are small plates that do not reach the midline of the specimen. The oostegites continue to increase in length until in a mature nongravid female the oostegites nearly reach the pereopods of the opposite side. The maturation of the male is not known due to the lack of immature specimens.

The only important variation noted (Fig. 4) for the mature female is a variation in the outline, distortion angle, and development of posterior coxal plates and pleon lateral plates. This variation in gross form does not affect the specific characteristics listed above.

*Gigantione uberlackerae*, new species

Figs. 6–8

*Material examined.*—Infesting *Axiopsis* (*Paraxiopsis*) n. sp. Florida Middle-grounds, eastern Gulf of Mexico; Bellows station 21; 28°34'N, 84°17'W; capetown dredge; 30 m; 10 Jul 1977; S. B. Collard and D. L. Adkison collected; B. F.



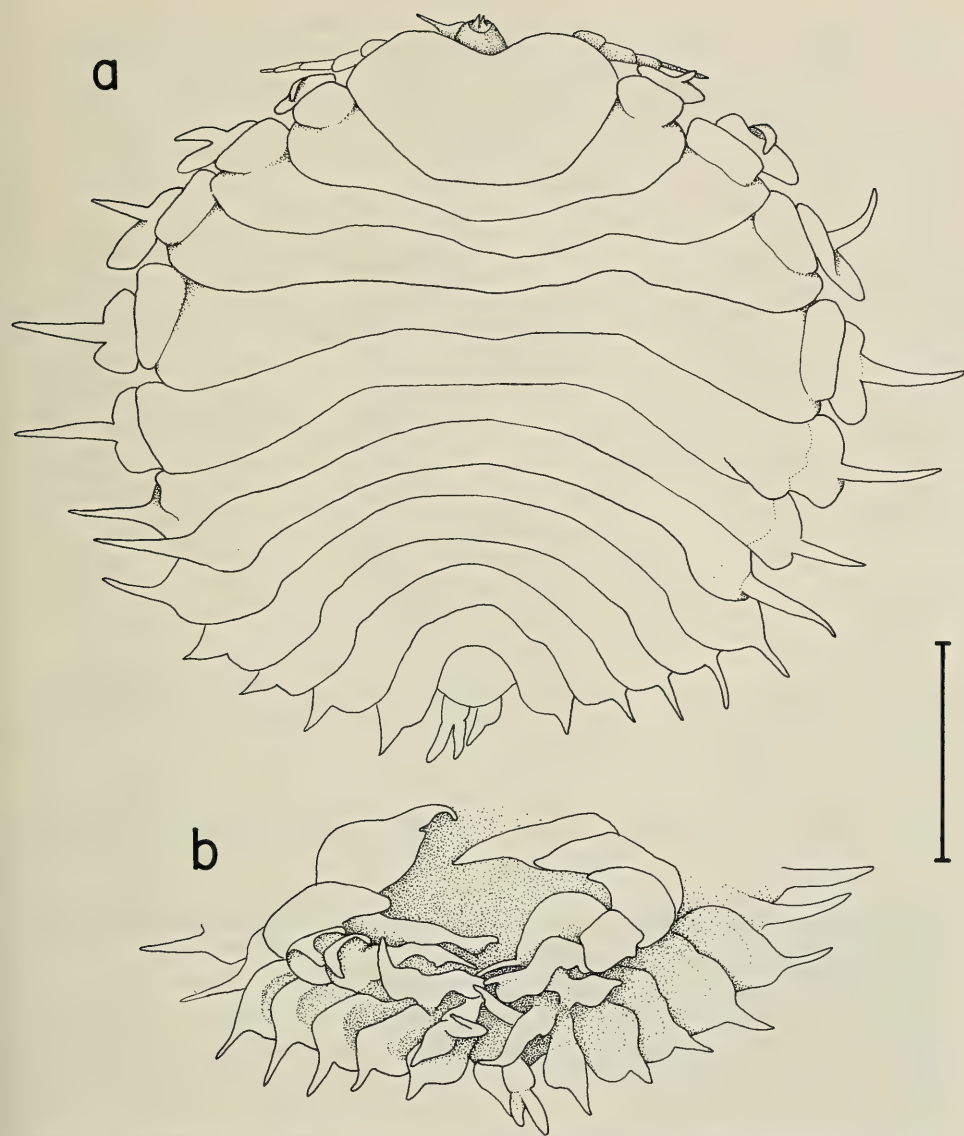


Fig. 6. *Gigantione uberlackerae*, female, holotype: a, Dorsal view; b, Pleon, ventral view. Scale = 2.0 mm.

Kensley determined host; 1 ♀ (non-gravid, holotype) USNM 172449, 1 ♂ USNM 172450 (host USNM 172451).

*Description.*—Female (Figs. 6 and 7). Length 2.9 mm; width across pereomere 4, 3.2 mm; distortion angle less than 5°; specimen nearly mature, oostegites nearly fully developed.

Head with distinct median notch; anterior lamina reduced; no lateral projections. Eyes absent. First antenna, segmentation indistinct apparently on 5 segments; second antenna, 8 segments; second antenna three times length of first. Maxilliped fringed with plumose setae.

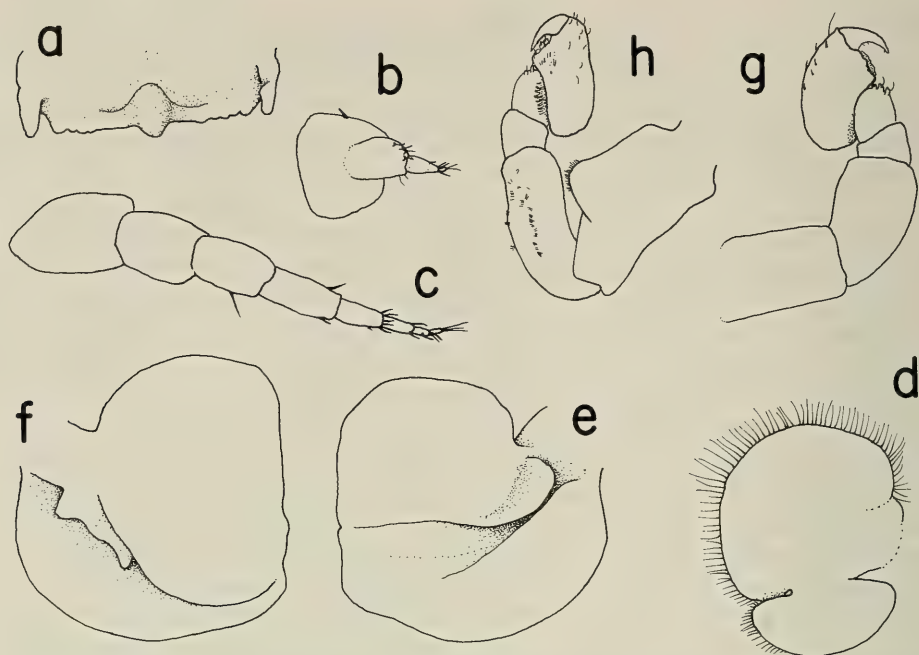


Fig. 7. *Gigantione uberlackerae*, female, holotype: a, Posterior lamina; b, First antenna; c, Second antenna; d, Maxilliped; e, Oostegite 1, external view; f, Oostegite 1, internal view; g, Pereopod 1; h, Pereopod 4.

Pereon with dorsal bosses on pereomeres 1 to 4; coxal plates on all pereomeres pubescent, increasing in length until pereomere 5, thereafter decreasing in length; tergally defined on pereomeres 1 to 5. Pereopods all of similar size, posterior pairs with small basal carinae. First oostegite, posterior plate wider than anterior plate; interior ridge with 2 lateral projections.

Pleomere 1 broader than pereomere 7; lateral plates on pleomeres 1 to 5; pubescent, lateral plates narrower on right side. Pleopods, 5 biramous pairs, first pleopods leaf-shaped, pleopod rami becoming more lanceolate on posterior pairs; margins with only scattered tubercles. Uropods biramous, right uropod without exopod.

Male (Fig. 8): Length 1.7 mm; width across pereomere 3, 0.7 mm.

Head, unpigmented eyes present. First antenna, 4 segments; second antenna, 8 segments; first antenna approximately  $\frac{1}{3}$  length of second antenna. Maxillipeds as figured (Fig. 8e).

Pereomeres 5 to 7 with lateral area progressively directed posteriorly. Midventral tubercles absent. Pereopod slightly larger anteriorly.

Pleon decreasing in width posteriorly; pleomere 6 without lateral development, deeply set in pleomere 5. Pleopods, 5 biramous pairs, decreasing in size posteriorly; exopod reduced to lobe. Uropods biramous.

*Etymology.*—This species is named for Joan Uberlackner, who has found several interesting bopyrids in her studies.

*Distribution.*—*Gigantione uberlackerae* is known from one pair collected on the Florida Middlegrounds.

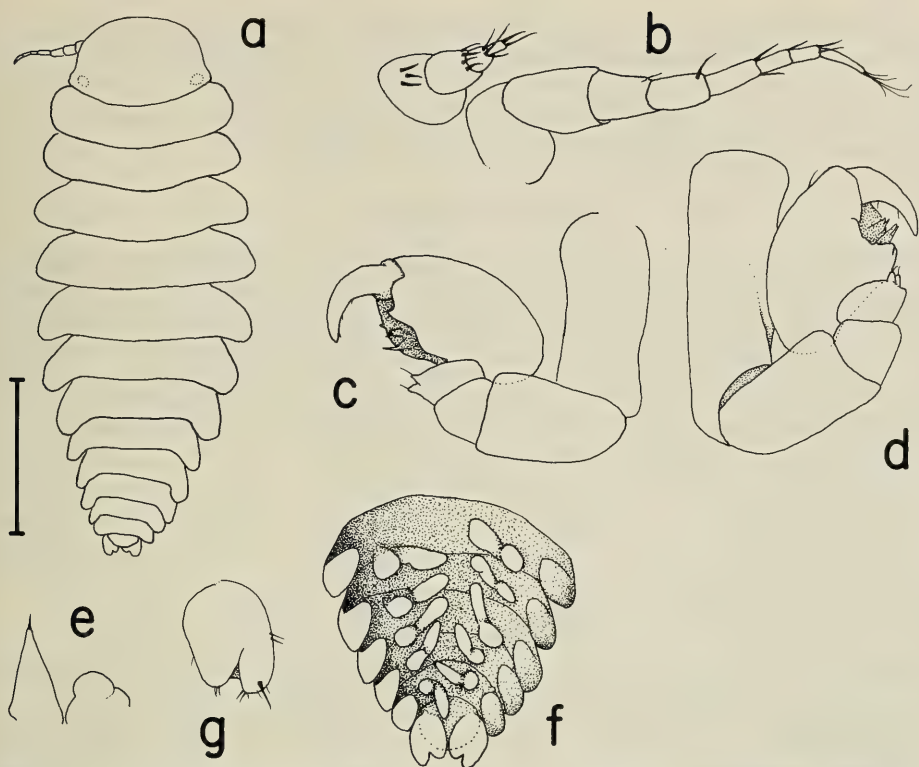


Fig. 8. *Gigantione uberlackerae*, male: a, Dorsal view; b, Antennae; c, Pereopod 1; d, Pereopod 7; e, Left maxillipeds; f, Pleon, ventral view; g, Left uropod. Scale = 0.5 mm.

**Discussion.**—The female of *Gigantione uberlackerae* n. sp. is distinguished from the nine other members of the genus by: (1) the presence of an anteromedial notch in the head, and (2) the pleopod having few tubercles. Only three species of *Gigantione*: *G. uberlackerae*, *G. rathbunae* Stebbing, 1910, and *G. sagamiensis* Shiino, 1958, do not have lateral projections on the head of the female. The female of *G. rathbunae* differs from the female of *G. uberlackerae* by at least pleopods 2 and 3 being tuberculate. The male of *G. rathbunae* also differs in having uniramous pleopods and uropods. The female of *C. sagamiensis* differs from *G. uberlackerae* by the presence of an enlarged first pleopod, pleopods 2 to 5 having a V-shape with some tubercles, short uropodal rami, and tuberculate lateral plates on the expanded side. The male of *G. sagamiensis* has uniramous uropods.

*Gigantione uberlackerae* is the first *Gigantione* reported from a non-brachyuran host. It is for this reason that I have decided to describe this species based on only one pair. The holotype is non-ovigerous and may be somewhat immature. Oostegites 2 to 5 overlap those on the opposite side. Based on study of the maturation of *Gigantione mortenseni*, pleopods of the holotype appear to be nearly mature. The first pleopod of *G. uberlackerae* is not enlarged as in the other members of the genus.

The lack of an exopod of the right uropod of the female is the only apparent abnormality noted for *Gigantione uberlackerae*.



The holotypes of both species and several paratypes are deposited in the collection of the Smithsonian Institution (USNM). Paratypes are deposited in collections of the following museums: Universitetets Zoologiske Museum, Copenhagen (ZMC); Rijksmuseum van Natuurlijke Historie, Leiden (RMNHL); and Muséum National d'Histoire Naturelle, Paris (MNHN).

#### Acknowledgments

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COMMENTS ON THE SKATES OF THE TROPICAL  
EASTERN PACIFIC: ONE NEW SPECIES  
AND THREE NEW RECORDS  
(ELASMOBRANCHII: RAJIFORMES)

John D. McEachran and Tsutomu Miyake

*Abstract.*—Recent collections of benthic fishes off the coasts of Ecuador, Peru, and the Galapagos Islands yielded a new species and three new records of skates from the eastern central Pacific. *Bathyraja peruana*, n. sp. is described from eight specimens, including the paratype of *B. aguja* Kendall and Radcliffe. This species is distinguished from other *Bathyraja* species of the eastern Pacific in morphometrics, meristics, spination, and pigmentation. A specimen resembling *B. richardsoni* but differing from it in a number of proportional measurements is discussed. *Bathyraja longicauda* and *Breviraja nigerrima* (= *Malacoraja nigerrima*) are recorded from Peru for the first time. A neotype for *M. nigerrima* is designated and described.

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As presently known, the skate fauna of the eastern central Pacific, southern Baja California to northern Peru, is species poor, consisting of *Psammobatis aguja*, (Kendall and Radcliffe), (= *Bathyraja aguja*), *B. spinosissima* (Beebe and Tee-Van), *Raja badia* Garman, *R. ecuadoriensis* Beebe and Tee-Van, *R. equatorialis* Jordan and Bollman, *R. velezi* Chirichigno, and *Sympterygia breviceaudata* (Cope). In the eastern central Atlantic, zoogeographically similar to the eastern central Pacific (Briggs 1974), there are 32 species of skates (Stehmann 1981).

Beebe and Tee-Van (1941) and Hildebrand (1946) suggested that the paratype of *B. aguja* represents an undescribed species of skate and recent collections mainly by the R/V *Anton Bruun* (cruises 16, 18A, and 18B) support their suggestion and indicate that the paucity of skates in the eastern central Pacific may, in part, be due to sampling error. Herein we describe the eight species of skate from this area and discuss three other species which are either new records for the area or new species.

Materials and Methods

Specimens examined were obtained from the Museum of Comparative Zoology, Harvard University (MCZ), the Smithsonian Oceanographic Sorting Center (SOSC), and the National Museum of Natural History, Smithsonian Institution (USNM). The SOSC specimens were deposited at the Museum of Comparative Zoology (MCZ), the Texas Cooperative Wildlife Collection (TCWC) and the USNM. One specimen of the new species was dissected to reveal the structure of the neurocranium, scapulocoracoids and claspers. Most specimens, including the holotype and paratype of *B. aguja*, were radiographed to verify anatomical observations based on dissections and to count vertebrae and pectoral radials. Methods for making measurements and counts follow McEachran and Compagno (1979, 1982).

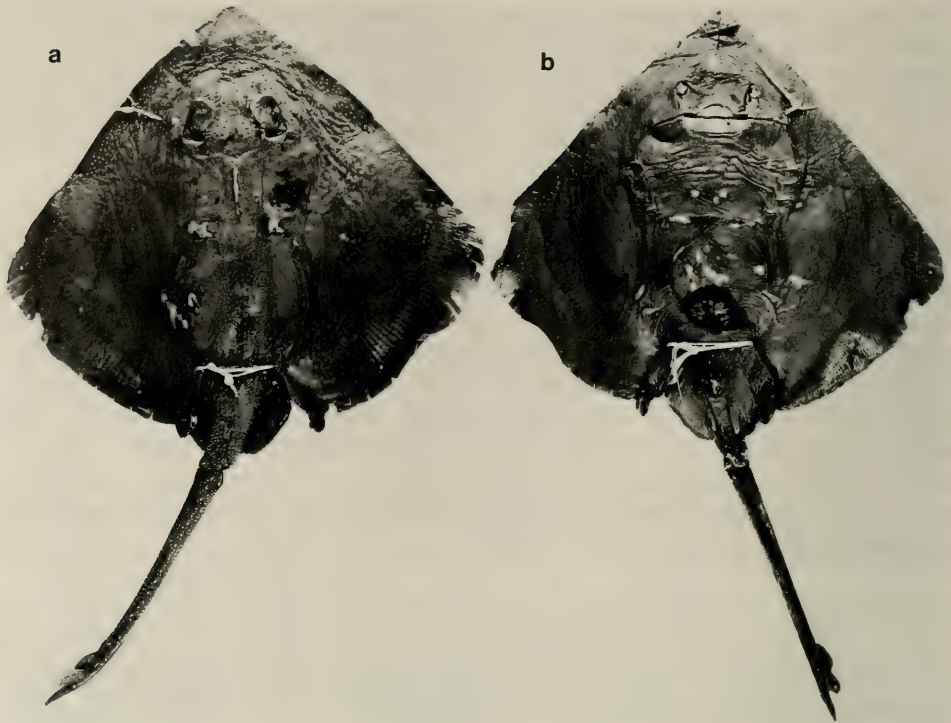


Fig. 1. *Bathyraja peruana* MCZ 1364 (Holotype, 283 mm TL, immature male), a, Dorsal view; b, Ventral view.

*Bathyraja peruana*, new species

Figs. 1–4; Tables 1, 2

*Raja aguja* Kendall and Radcliffe, 1912:78–79 (in part), Fig. 2.

*Holotype*.—MCZ 1364, 283 mm TL, juvenile male (paratype of *Raja aguja*, collected off Point Aguja, Peru, 5°47'S, 81°24'W, 980 m, 12 Nov 1904, R/V *Albatross*, Station 4653.

*Paratypes*.—MCZ 61113, 173 mm TL, juvenile male, 70°49'S, 80°38'W, 605–735 m, 5 Jan 1966, R/V *Anton Bruun*, Cruise 18B, Station 754.—TCWC 3515.1, 970 mm TL, 980 mm TL, mature females, 15°11.5'S, 75°43'W, 1010 m, 25–26 Aug 1966, R/V *Anton Bruun*, Cruise 18A, Station 739A.—TCWC 3516.1, 1053 mm TL, mature female, 15°11'S, 75°44'W, 1060 m, 25–26 Aug 1966, R/V *Anton Bruun*, Cruise 18A, Station 739.—USNM 267045, 203 mm TL, 469 mm TL, juvenile males, 610 mm TL, juvenile female, 3°15'S, 80°55'W, 945–960 m, 10 Sep 1966, R/V *Anton Bruun*, Cruise 18B, Station 770.

*Diagnosis*.—Disc lozenge-shaped, anterior margin more or less straight; preorbital length 2.41 to 3.40 times orbital length and 0.10 to 0.14 times total length; disc lacking thorns; tail with 18 to 26 midrow thorns, lacking thorns between dorsal fins; ventral surface of disc without dermal denticles.

*Description*.—Disc 1.15 times as broad as long (1.22 to 1.36 in paratypes);



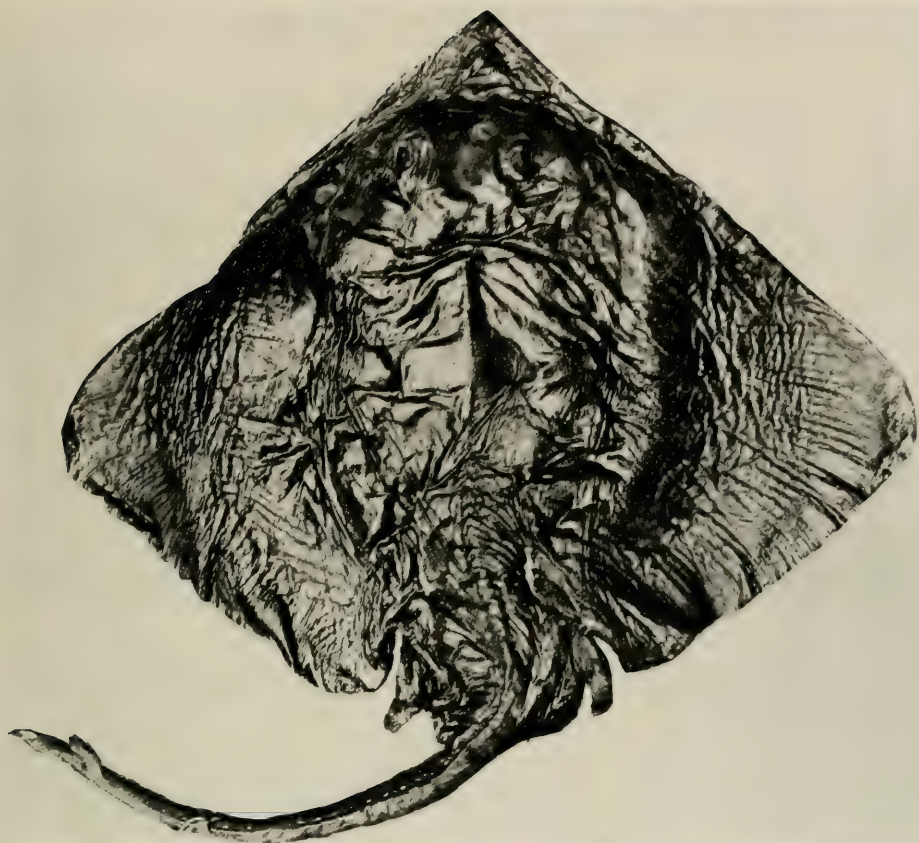


Fig. 2. *Bathyraja peruana* TCWC 3516.1 (Paratype, 1053 mm TL, mature female).

maximum angle in front of spiracles  $105^{\circ}$  ( $100^{\circ}$  to  $125^{\circ}$ ); margin of disc nearly straight from tip of snout to level of nares, slightly convex to level of first gill slits, nearly straight to outer corners which are abruptly rounded, posterior margin slightly convex. Axis of greatest width 0.80 (0.70 to 0.82) times distance from tip of snout to axil of pectoral fins. Pelvic fins deeply incised; anterior lobe narrow, tapering distally, length 0.88 times posterior lobe (0.64 to 0.95, with ratio greater in larger specimens). Tail slender, little depressed, with narrow lateral fold along ventrolateral surface originating at axil of pelvic fins, widening distally and extending to near tip. Length of tail from center of cloaca to tip 1.07 times distance from tip of snout to center of cloaca (0.88 to 1.40, with ratio smaller in larger specimens). Post dorsal fin tail length less than one-half length of base of second dorsal fin.

Preorbital length 3.13 (2.41 to 3.40) times orbit length; preoral length 1.69 times internarial distance (1.23 to 1.72, with ratio smaller in larger specimens). Interorbital distance 1.04 times orbit length (1.02 to 1.17); orbit length 1.62 times spiracle length (1.16 to 1.78, with ratio smaller in larger specimens). Anterior nasal flap (nasal curtain) coarsely fringed along distal margin; posterior nasal flap

Table 1.—Proportional measurements and meristic values of *Bathyraja peruana*. Proportions are expressed in percent total length.

Sex	MCZ 1364 <sup>1</sup>	MCZ 61113 <sup>2</sup>	USNM 267045 <sup>2</sup>	USNM 267045 <sup>2</sup>	USNM 267045 <sup>2</sup>	TCWC 3515.1 <sup>2</sup>	TCWC 3515.1 <sup>2</sup>	TCWC 3516.1 <sup>2</sup>	x
Total length (mm)	283	173	203	469	610	970	980	1053	
Disc width	64	63	63	70	69	71	70	70	69
Disc length	55	49	51	53	52	59	51	54	54
Snout length (preorbital)	13.3	9.8	12.5	13.3	13.4	10.9	10.9	10.5	11.4
Snout length (preoral)	14.1	10.8	13.2	14.5	13.9	11.1	10.9	10.1	11.6
Snout to maximum width	36	32	32	36	32	30	33	32	32
Prenasal length	11.0	8.9	10.8	11.2	10.4	8.7	9.3	8.9	9.5
Orbit diameter	4.2	3.8	4.3	3.9	3.9	4.3	4.0	4.3	4.1
Distance between orbits	4.4	4.3	4.4	4.1	4.9	4.8	4.4	5.1	4.7
Orbit and spiracle length	5.3	5.0	4.8	5.1	4.9	5.2	4.9	6.0	5.2
Spiracle length	2.6	2.3	2.4	2.2	2.5	3.7	3.3	3.5	3.1
Distance between spiracles	7.1	6.5	6.8	6.1	6.0	7.6	7.1	7.7	7.1
Mouth width	8.2	6.6	8.1	8.1	7.2	9.4	9.0	9.2	8.7
Nare to mouth	3.7	2.6	3.3	4.1	3.8	3.3	2.8	2.4	3.1
Distance between nostrils	8.3	6.9	7.9	8.4	8.0	8.3	8.8	8.0	8.2
Width of first gill openings	1.7	1.1	1.5	1.9	2.0	2.0	2.1	2.7	2.1
Width of third gill openings	2.0	1.1	1.7	1.9	2.3	2.6	2.4	3.1	2.5
Width of fifth gill openings	1.2	0.9	1.1	1.4	1.5	1.9	1.8	2.4	1.8
Distance between first gill openings	19.3	16.1	19.1	17.4	16.3	20.9	20.0	21.2	19.5
Distance between fifth gill openings	11.7	11.3	12.4	10.5	10.8	14.9	13.4	15.1	13.3
Length of anterior pelvic lobe	11.1	11.9	11.3	11.7	12.0	10.9	10.0	12.8	11.4
Length of posterior pelvic lobe	12.6	12.8	12.0	14.8	16.1	15.2	15.8	16.4	15.5
Distance—snout to cloaca	48	42	46	49	48	51	53	50	50
Distance—cloaca to 1st dorsal fin	40	40	43	42	39	40	37	44	40
Distance—cloaca to caudal origin	46	47	48	50	47	46	43	49	47
Distance—cloaca to caudal tip	52	58	53	51	52	47	47	50	50
Number of tooth rows (upper jaw)	33	35	34	35	36	34	36	35	34.8
Number of trunk vertebrae	34	33	35	32	33	34	35	34	33.8
Number of predorsal caudal vertebrae	69	69	69	64	65	69	68	71	68.0
Number of pectoral radials	77			72	70				73.0

<sup>1</sup> Holotype.<sup>2</sup> Paratype.

Table 2.—Neurocranial and scapulocoracoid measurements of *Bathyraja peruana* USNM 267045, 469 mm TL juvenile male. Measurements are expressed as percentage of nasobasal length or scapulocoracoid length.

Nasobasal length (mm)	51.7
Cranial length	187
Rostral cartilage length	87
Prefontanelle length	77
Cranial width	115
Interorbital width	34
Rostral base	30
Anterior fontanelle length	36
Anterior fontanelle width	19
Posterior fontanelle length	42
Posterior fontanelle width	4
Rostral appendix length	31
Rostral appendix width	16
Rostral cleft length	19
Cranial height	23
Width across otic capsules	49
Least width of basal plate	27
Greatest width of nasal capsule	42
Internasal width	21
Scapulocoracoid length (mm)	33.2
Scapulocoracoid height	69
Premesocondyle	29
Postmesocondyle	71
Postdorsal fenestra (largest) length	15
Postdorsal fenestra (largest) height	10
Predorsal fenestra length	10
Predorsal fenestra height	10
Rear corner	49

poorly developed and weakly fringed (smooth to weakly fringed). Upper and lower jaws slightly arched (moderately arched in larger specimens). Teeth with short pointed cusps (larger specimens with longer cusps) and quincunx arrangement.

Distance between first gill slits 2.32 (2.08 to 2.64) times internarial distance; distance between fifth gill slits 1.41 (1.25 to 1.89) times internarial distance; length of first gill slits 1.48 times length of fifth gill slits (1.05 to 1.32 with ratio smaller in larger specimens). First dorsal fin about equal in size and shape to second; distance between dorsal fins equal to about one-half of base of first; second dorsal fin separated by short distance from poorly developed epichordal caudal fin lobe.

Upper surface of disc and tail covered with dermal denticles, dense along anterolateral margin, over cranium and along midline to tip of tail but sparse over branchial region and on base of pectoral fins; denticles with four-pointed, star-shaped bases and posteriorly directed spine. Disc devoid of thorns (some specimens with several midrow thorns just anterior to axil of pectoral fins). Tail with 25 small midrow thorns (18 to 26) with oval bases.

*Color.*—After storage in alcohol, holotype is uniform brownish gray; paratypes are similarly colored, except areas around nares, mouth, base of pelvic fins and base of tail are lighter, ranging from brown to yellow.



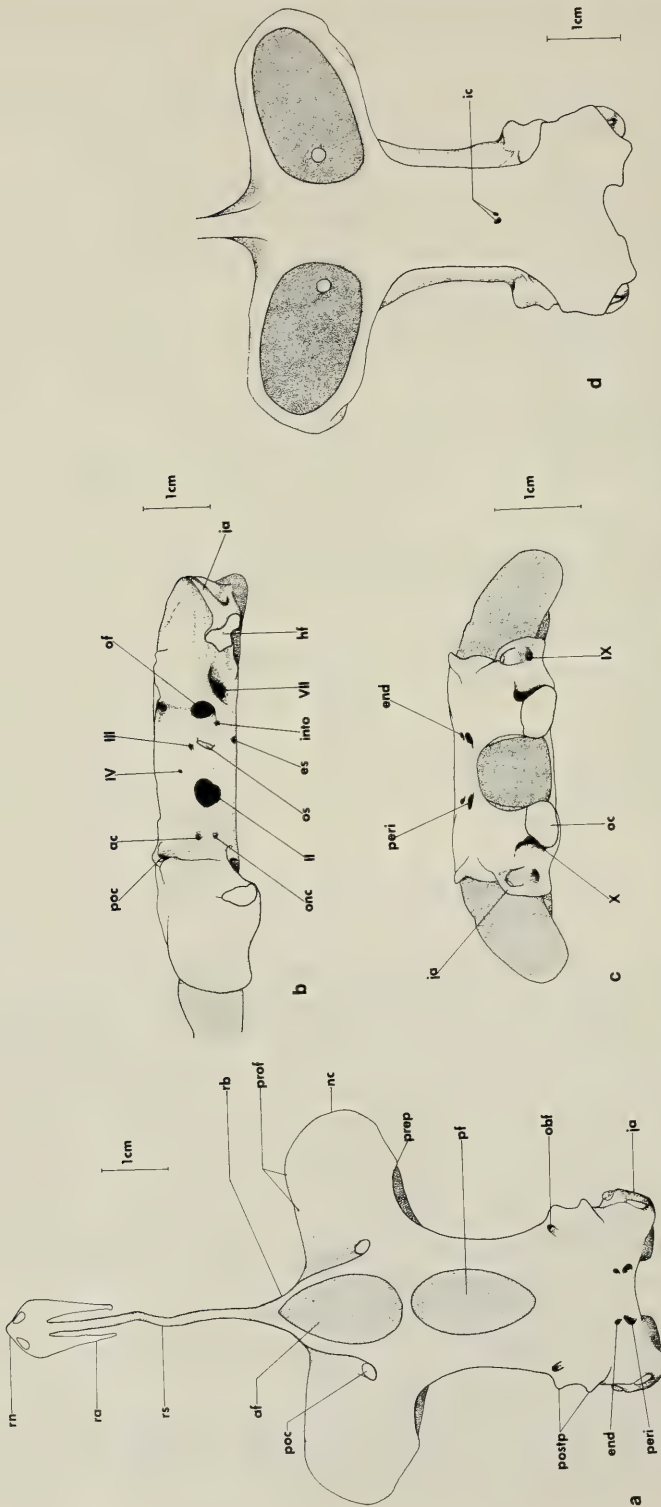


Fig. 3. Neurocranium of *Bathyrhaja peruana* USNM 267045 (Paratype, 469 mm TL, juvenile male), a, Dorsal view; b, Lateral view; c, Posterior view; d, Ventral view. ac—anterior cerebral vein foramen, af—anterior fontanelle, end—endolymphatic foramen, es—effluent spiracular artery foramen, hf—hyomandibular facet, ic—internal carotid artery foramen, into—interorbital vein foramen, ja—jugal arch, nc—nasal capsule, obf—otic branch of facial nerve foramen, oc—occipital condyle, of—orbital fissure, onc—orbitonasal canal foramen, os—optic stock, peri—perilymphatic foramen, pf—posterior fontanelle, poc—preorbital process, prep—preorbital canal foramen, postp—postorbital process, prof—profundus nerve foramen, ra—rostral appendix, rb—rostral base, rn—rostral node, rs—rostral shaft, II—optic nerve foramen, III—oculomotor nerve foramen, IV—trochlear nerve foramen, VII—hyomandibular branch of facial nerve foramen, IX—glossopharyngeal nerve foramen, X—vagus nerve foramen.

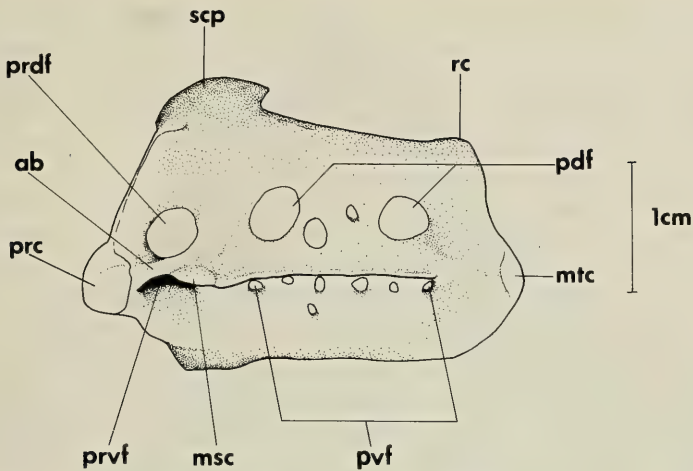


Fig. 4. Lateral view of left scapulocoracoid of *Bathyraja peruana* USNM 267045 (Paratype, 469 mm TL, juvenile male). ab—anterior bridge, msc—mesocondyle, mtc—metacondyle, pdf—postdorsal foramina, prc—procondyle, prdf—predorsal fenestra, prvf—preventral fenestra, pvf—postventral foramina, rc—rear corner, scp—scapular process.

*Neurocranium.*—Rostral shaft relatively long, slender and unsegmented (Fig. 3a, Table 2); rostral appendices relatively long, about one-third of rostral shaft, broadly joining rostral node posterior to rostral foramen, plate-like anteriorly but conical in cross-section posteriorly; rostral base moderately narrow; propterygia of pectoral girdle extending to lateral extreme of rostral appendices; nasal capsules rather small, rhomboid-shaped, with straight anterior margins, set at about  $16^\circ$  angle to transverse axis of neurocranium; foramen for profundus nerve on leading edge of nasal capsule; preorbital processes only moderately developed, continuous with incised supraorbital crests; anterior fontanelle teardrop-shaped, moderately broad, extending slightly anterior to leading edge of nasal capsules; posterior fontanelle narrow, with irregular lateral margins; foramen for anterior cerebral vein on a vertical with dorsal rim of optic nerve foramen, just posterior to line connecting foramina of preorbital and orbitonasal canals (Fig. 3b); foramen for trochlear nerve double, dorsal to optic nerve foramen, foramen for oculomotor nerve dorsal to optic stalk; foramen for intercerebral vein anterior to orbital fissure and posterior to efferent spiracular artery foramen; jugal arches moderately slender (Fig. 3c); basal and internasal plates relatively narrow (Fig. 3d).

*Scapulocoracoids.*—Lateral aspect low and greatly expanded between mesocondyle and metacondyle (Fig. 4, Table 2); four postdorsal foramina, first and fourth largest, third minute; seven postventral foramina; anterior corner slightly elevated.

*Etymology.*—Named after Peru, the type-locality. The name was proposed by Carl L. Hubbs and R. Ishiyama.

*Comments.*—*Bathyraja peruana* and *B. aguja* are transferred from *Psammobatis* to *Bathyraja* because they share the following synapomorphies with the latter genus: 1) scapulocoracoid greatly expanded between meso- and metacondyle and 2) scapulocoracoid with multiple postdorsal foramina (McEachran, unpublished

data). Also they lack the following synapomorphies possessed by *Psammobatis* (McEachran 1983): 1) tip of snout with small, slender, conical integumental process; 2) nasal flaps forming tube-like structures around nares; 3) rostral shaft of neurocranium very slender and separated from remainder of neurocranium; 4) rostral base lacking; 5) nasal capsules with basal fenestra; and 6) interorbital region moderately narrow to narrow (McEachran 1983).

*Bathyraja peruana* is distinguished from *B. aguja* by its nearly straight anterior disc margin (in *B. aguja* it is distinctly undulated) (Kendall and Radcliffe 1912); preorbital length 2.41 to 3.40 times orbital length (3.70 times); preoral snout length 1.23 to 1.72 times internarial distance (2.12); dorsal surface of disc covered with dermal denticles (dorsal surface sparsely covered with denticles); disc without thorns (several midrow thorns anterior to axil of pectoral fins); tail with 18 to 26 midrow thorns (33 midrow thorns); no thorns between dorsal fins (one thorn); nasal capsules set at about 16° angle to transverse axis of neurocranium (33° angle); pelvic girdle with rather short prepelvic processes (extremely long and slender prepelvic processes); dorsal surface of disc uniformly colored (with two large, light colored spots on base of pectoral fins and small, light colored spots along margin of disc and pelvic fins) (Kendall and Radcliffe 1912).

*Bathyraja peruana* is distinguished from the other eastern Pacific *Bathyraja* species as follows: *B. abyssicola* (Gilbert), *B. cf. richardsoni* (Garrick) and *B. spinosissima* (Beebe and Tee-Van) possess denticles on the ventral aspect of the disc (Miller and Lea 1972); *B. abyssicola*, *B. aleutica* (Gilbert), *B. kincaidi* (Garman), *B. interrupta* (Gill and Townsend), *B. parmitifera* (Bean) and *B. rosispinis* (Gill and Townsend) possess thorns on the dorsal surface of the disc (Eschmeyer and Herald 1983); *B. abyssicola* and *B. aleutica* have preorbital snout lengths exceeding 15% of total length (McEachran, unpublished data); in *B. cf. richardsoni* the anterior pelvic lobe is only one-half the length of the posterior lobe, and the upper jaw possesses 44 tooth rows; *B. spinosissima* has a short preorbital length, about equal to interspiracular distance (McEachran, unpublished data); in *B. trachura* (Gilbert) the anterior margin of disc is distinctly undulated, denticles on disc are coarser and more sparsely distributed, and the postdorsal tail nearly equals length of second dorsal fin (McEachran, unpublished data); *B. longicauda* (de Buen) lacks dermal denticles over most of disc and possesses thorns on disc from level of maximum width to origin of pelvic lobes.

#### New or Rarely Encountered Skates

Three species of skates were captured in the eastern tropical Pacific which are new records for that area or, in two cases, may represent undescribed species.

##### *Bathyraja cf. richardsoni* (Garrick)

Fig. 5, Table 3

TCWC 3514.1, ca. 1860 mm TL, mature female, collected off Galapagos Islands, 0°11.3'S, 97°27.2'W, 1710 m, 25 May 66, *Anton Bruun*, Cruise 16, Station 618 A.

*Description*.—Disc 1.16 times as broad as long; maximum angle in front of spiracles 91°, margin of disc lozenge-shaped, slightly concave from level of spiracles to level of first gill slits, outer corners abruptly rounded, posterior margin





Fig. 5. *Bathyraja* cf. *richardsoni* TCWC 3514.1 (ca. 1860 mm TL, mature female), dorsal view.

more or less straight. Axis of greatest width 0.67 times distance from tip of snout to axil of pectoral fins. Pelvic fins with narrow anterior lobes, length 0.47 times posterior lobes, posterior lobes with convex lateral margins. Tail broad, slightly depressed, poorly developed lateral fold originating as ridge near axil of pelvic fins, and extending to tip of tail; tail damaged, extending only to posterior margin of first dorsal fin.

Preorbital length 3.69 times orbit length; preoral length 1.14 times internarial distance. Interorbital distance 1.82 times orbit length; orbit length 1.49 times spiracle length. Anterior nasal flap with triangular process posterior to nare, coarsely fringed along distal margin; posterior nasal flap poorly developed. Upper and

Table 3.—Proportional measurements and meristic values of *B. aguja*, *B. cf. richardsoni* (compared with *B. richardsoni*), *B. longicauda* and *Malacoraja nigerrima*. Proportions are expressed in percent total length.

	<i>B. aguja</i>			<i>B. richardsoni</i>			<i>B. longicauda</i>				<i>Malacoraja nigerrima</i>	
	USNM 65641 <sup>1</sup>	TCWC <sup>2,3</sup> 3514.1	♀	Range <sup>3,4</sup>	♂ <sup>3,4</sup>	♀	TCWC 3597.1	♂	TCWC 3597.1	♀	USNM 267046 <sup>5</sup>	Range ♂
Sex												
Total length (mm)	481	1860		950-1722			110	156	167		374	139-374
Disc width	69	65		74-82	77		65	67	64	65	53	51-53
Disc length	57	56		60-65	62		45	51	46	48		46-49
Snout length (preorbital)	12.1	12.0		12.3-15.4	13.7		7.8	9.6	8.3	8.7	12.1	10.2-12.8
Snout length (preoral)	12.8	11.6		13.3-15.8	14.5		9.0	10.8	9.5	9.8	14.5	12.6-14.5
Snout to maximum width	36	35					33	35	31	33	35	31-35
Prenasal length	9.6	9.3					5.9	8.0	6.9	7.0	11.5	9.6-11.5
Orbit diameter	3.3	3.2					3.9	3.6	3.4	3.6	4.6	3.7-4.8
Distance between orbits	4.3	5.9		7.1-8.8	8.0		5.3	3.7	3.6	4.0	3.5	3.3-3.6
Orbit and spiracle length	4.9	4.8					5.5	4.7	4.7	4.9	4.8	3.4-5.2
Spiracle length	2.0	2.2					1.5	1.8	1.7	1.7	1.8	1.5-2.3
Distance between spiracles	6.0	11.3		11.8-13.6	12.7		8.1	7.1	6.4	7.1	6.1	6.1-6.8
Mouth width	7.7	10.9		11.4-13.2	12.5		7.6	6.7	6.5	6.8	7.2	6.2-7.2
Nare to mouth		2.1					2.3	3.0	2.8	2.7	3.5	2.6-3.5
Distance between nostrils	6.2	10.1		10.6-12.4	11.6		6.7	6.4	6.2	6.4	7.1	6.5-7.1
Width of first gill openings	2.0	2.2		1.6-1.9	1.7		0.9	1.1	1.2	1.1	1.3	1.0-1.5
Width of third gill openings	2.2	2.4		1.8-2.2	2.0		1.0	1.2	1.3	1.2	1.3	1.0-1.5
Width of fifth gill openings	1.1	1.6		1.3-1.9	1.6		0.7	0.6	0.7	0.6	1.1	0.6-1.1
Distance between first gill openings	16.1	20.2		21.0-22.9	22.3		19.1	16.7	16.3	17.2	13.9	13.0-14.5
Distance between fifth gill openings	12.0	15.9		17.0-18.9	17.9		12.2	10.1	10.5	10.8	8.8	8.1-8.8
Length of anterior pelvic lobe	10.5	7.4					9.9	10.1	9.4	9.8	12.5	10.4-14.7
Length of posterior pelvic lobe	14.0	15.6					9.4	9.9	9.7	9.7	15.7	11.8-16.0
Distance—snout to cloaca	49	58		64-68	66		43	44	43	43	44	40-44
Distance—cloaca to 1st dorsal fin	40	43		32-37	34		43	43	45	44	41	41-44
Distance—cloaca to caudal origin	48						52	53	54	53	47	47-57
Distance—cloaca to caudal tip	51			43-48	45		57	56	57	57	56	56-60
Number of tooth rows (upper jaw)	30	44		24-40	29.6		34	32	33	33	33	36-46
Number of trunk vertebrae	35	38					31	31		31	29	27-30
Number of predorsal caudal vertebrae	66	70					62	62		62	65	59-65
Number of pectoral radials	81						72	72		72	65	61-65

<sup>1</sup> Holotype.

<sup>2</sup> *B. cf. richardsoni*.

<sup>3</sup> Proportional measurements based on distance from tip of snout to origin of first dorsal fin.

<sup>4</sup> Data from Templeman (1973), females.

<sup>5</sup> Neotype.

lower jaws moderately arched. Teeth with sharp pointed cusps and arranged in rows.

Distance between first gill slits 1.99 times internarial distance; distance between fifth gill slits 1.57 times internarial distance; length of first gill slits 1.40 times length of fifth gill slits.

Upper and lower surfaces of disc and tail uniformly covered with denticles, dorsal surface of anterior pelvic lobes naked, remainder of fins with denticles. Disc devoid of thorns. Tail with 18 moderate sized thorns.

*Color*.—After storage in alcohol specimen is uniform chocolate-brown on both surfaces.

*Comments*.—This specimen agrees with *B. richardsoni* in disc shape, interorbital distance, denticle pattern and coloration. Most of its morphometric and meristic values, however, do not fall within the ranges given by Templeman (1973) for *B. richardsoni* (Table 3). Although this specimen most likely represents a new species, it is not named at this time because of its poor condition and the lack of other specimens. The tail posterior to the first dorsal fin is missing and the neurocranium is crushed. Proportional measurements of skates are usually based on total length, tip of the snout to tip of the tail, and this measurement can only be approximated for this specimen. Templeman (1973) based his proportional measurements on the distance from tip of the snout to origin of the first dorsal fin, and thus it was possible to compare the specimens of his study with the one from Galapagos Islands.

*Bathyraja richardsoni* was described from New Zealand and has since been reported from off southeastern England (Forester 1965), and from the northwestern Atlantic off Labrador to Georges Bank (Templeman 1973) and off the Virginia Capes (Musick, personal communication).

*Bathyraja longicauda* (de Buen)

Fig. 6, Table 3

TCWC 3597.1, 167 mm TL, 110 mm TL, juvenile males, 156 mm TL, juvenile female collected off Peru, 7°49'S, 80°38'W, 605 to 735 m, 5 Sep 1966 aboard R/V *Anton Bruun*, Cruise 18B, Station 754.

*Description*.—Disc 1.30 to 1.42 times as broad as long; maximum angle in front of spiracles 118° to 128°; anterior margin of disc convex except straight to slightly concave from level of orbits to level of second gill slits; outer corners sharply rounded; posterior margins convex. Axis of greatest width 0.84 to 0.88 times distance from tip to snout to axil of pectoral fins. Pelvic fins deeply incised, anterior lobes narrow and acutely tipped, length 0.97 to 1.06 times posterior lobes. Tail slender, with a narrow lateral fold extending to origin of hypochordal caudal lobe. Length of tail from center of cloaca to tip 1.26 to 1.34 times distance from tip of snout to center of cloaca.

Preorbital length 2.00 to 2.68 times orbital length; preoral length 1.30 to 1.69 times internarial distance. Interorbital distance 1.02 to 1.30 times orbit length; orbit length 2.00 to 2.53 times spiracle length. Anterior nasal flaps fringed along posterior margin; posterior nasal flaps poorly developed and weakly fringed. Upper and lower jaws more or less straight; teeth with short pointed cusps in quincunx arrangement.



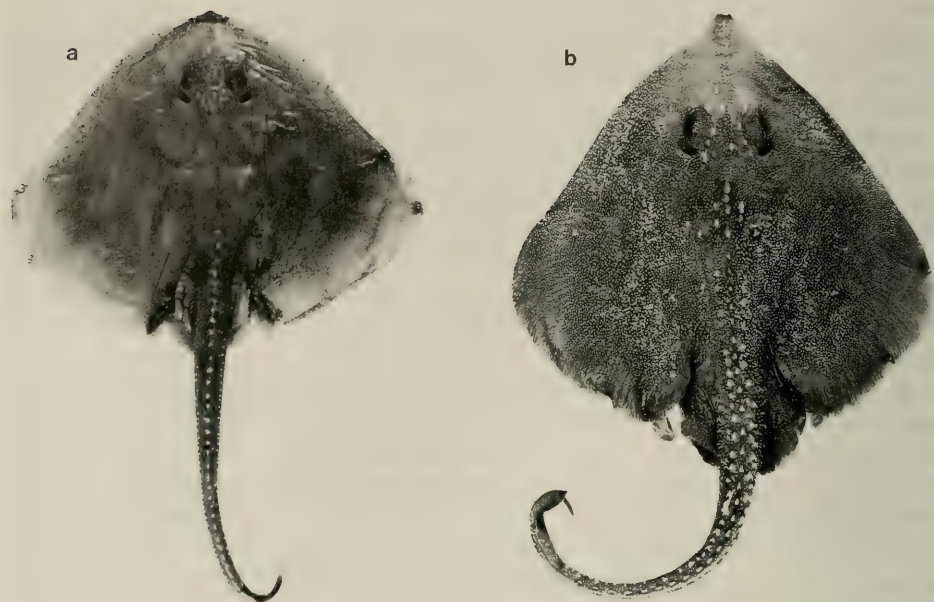


Fig. 6. a, *Bathyraja longicauda* TCWC 3597.1 (156 mm TL, juvenile female), dorsal view; b, *Malacoraja nigerrima* USNM 267046 (Neotype, 374 mm TL, juvenile male), dorsal view.

Distance between first gill slits 2.61 to 2.84 times internarial distance; distance between fifth gill slits 1.58 to 1.81 times internarial distance; length of first gill slits 1.25 to 1.89 times length of fifth gill slits. First dorsal fin slightly larger than second; interspace between dorsal fins about equal to one-half base of first dorsal fin; second dorsal fin separated by short distance from poorly developed epichordal caudal lobe formed by confluence of lateral folds; hypochordal lobe very short.

Dorsal surface of disc with denticles or thornlets along anterior margin to level of second gill slits, on snout and between orbits. Mid-row thorns number from 26 to 30 and run from just posterior to maximum width of disc to origin of first dorsal fin; one or two thorns between dorsal fins. Ventral surface naked. Tail with lateral row of denticles or thorns on each side.

*Color.*—Dorsal surface uniform tannish-brown, except tip of snout dark brown. Ampular pores on dorsal surface dark brown. Ventral surface of disc brown (slightly darker than dorsal surface) except for dark brown tip of snout and light tan blotches around mouth, on center of abdomen, on anterior pelvic lobes and on entire surface of tail.

*Comments.*—*Bathyraja longicauda* was previously known from a single specimen from off Valparaiso, Chile, ca. 33°S, which has subsequently been lost (R. I. Lavenberg, personal communication). The above three specimens agree with the description (de Buen 1959) and the figure (de Buen 1960) of *B. longicauda*, except that they have more mid-row thorns (26 to 30 vs. 19), and the thorns originate slightly anterior to the origin of the pelvic girdle rather than at the level

of the pelvic girdle as in the holotype. Also the tail length of these specimens is slightly shorter than that of the holotype (1.26 to 1.34 vs. 1.42 times the distance from the tip of the snout to the cloaca). Because of the small size of the specimens it was decided to wait for additional material to become available before selecting a neotype.

The range of *B. longicauda* is extended from Valparaiso, Chile to Peru (7°49'S, 80°38'W).

*Malacoraja nigerrima* (de Buen)

Fig. 6, Table 3

*Neotype*.—USNM 267046, 374 mm TL, juvenile male, collected off Chile, 34°53.5'S, 72°44'W, 780 to 925 m, 9–10 Aug 1966, R/V *Anton Bruun*, Cruise 18A, Station 40.

*Other material*.—TCWC 3881.1, 273 mm TL, juvenile female, same data as neotype.—TCWC 3882.1, 139 mm TL, 144 mm TL, 162 mm TL, 292 mm TL, juvenile males, 273 mm TL, 277 mm TL, juvenile females, collected off Chile, 34°06.5'S, 72°18.5'W, 750 m, 5 Aug 1966, R/V *Anton Bruun*, Cruise 18A, Station 25.—TCWC 3883.1, 114 mm TL, 135 mm TL, juvenile females, collected off Chile, 32°08.5'S, 71°43'W, 960 m, 12 Aug 1966, R/V *Anton Bruun*, Cruise 18A, Station 47.—TCWC 3884.1, 365 mm TL, juvenile female, collected off Chile, 24°29.5'S, 70°40'W, 950 m, 16 Dec 1966, R/V *Anton Bruun*, Cruise 18A, Station 60.—TCWC 3885.1, 239 mm TL, juvenile female, collected off Peru, 3°15'S, 80°55'W, 945–960 m, 10 Sep 1966, R/V *Anton Bruun*, Cruise 18A, Station 120.

*Description*.—Disc 1.07 times as broad as long in neotype (1.06 to 1.13 in other specimens); maximum angle in front of spiracles 101° (98° to 108°); anterior margin of disc slightly concave from tip to anterior extension of pectoral radials, slightly convex to level of mouth, slightly concave to level of second gill slits, outer corners broadly rounded, posterior margins convex. Axis of greatest width 0.89 (0.78 to 0.89) times distance from tip of snout to axil of pectoral fins. Pelvic fins deeply incised; anterior lobe narrow, tapering distally, length 0.80 (0.83 to 0.93) times posterior lobe. Tail moderately slender, depressed, with lateral folds originating just anterior to origin of first dorsal fin and extending to tip of tail. Length of tail from center of cloaca to tip 1.29 (1.28 to 1.48) times distance from tip of snout to center of cloaca.

Preorbital length 2.64 (2.38 to 2.99) times orbit length; preoral length 2.05 (1.92 to 2.10) times internarial distance. Interorbital distance 0.76 (0.72 to 0.92) times orbit length; orbit length 2.55 (1.70 to 2.90) times spiracle length. Anterior nasal flap laterally expanded but indented at mid-length; posterior margin coarsely fringed; posterior nasal flap with well developed, finely fringed lateral lobe. Upper and lower jaws slightly arched. Teeth with very short pointed cusps (rounded to slightly pointed) in quincunx arrangement.

Distance between first gill slits 1.96 (1.91 to 2.16) times distance between nares; distance between fifth gill slits 1.25 (1.15 to 1.32) times distance between nares; length of first gill slits 1.18 (1.38 to 1.89) times length of fifth gill slits. Dorsal fins similarly shaped and confluent at bases, first slightly larger than second; second dorsal confluent with poorly developed epichordal caudal lobe.

Dorsal surface of disc and tail densely covered with dermal denticles; anterior



lobe of pelvic fin naked; posterior lobe sparsely covered with denticles. Denticles with slender cusps and oval bases. Several thorns on rostral shaft, four along inner margin of orbits, one medial to each spiracle, triangular patch of 11 over nuchal and scapular regions, three rows on midline of disc posterior to suprascapula, and five rows on dorsal and lateral aspects of tail extending to origin of first dorsal fin. Thorns on oval bases and with posteriorly directed, claw-like cusps. Ventral surface naked except for tail which is densely covered with denticles, except for narrow midline which is naked.

*Color*.—After storage in alcohol dorsal surface is uniformly dark brown, except dorsal fins are blackish brown. Ventral surface is yellowish brown anteriorly grading to dark brown posteriorly.

*Comments*.—The 11 specimens described herein agree with de Buen's (1960) description and figure of *Breviraja nigerrima* in possessing a relatively long tail, narrow disc, long anterior pelvic lobes, confluent dorsal fins, and dense covering of dermal denticles on dorsal and ventral surface of tail.

The species is transferred from *Breviraja* to *Malacoraja* because it possesses the synapomorphy of the latter genus, i.e., dermal denticles along all but the narrow midline of the ventral surface of the tail, and lacks the synapomorphies of *Breviraja*, i.e., oronasal pits, rostral shaft distally very slender and shaft distally segmented.

The range of *M. nigerrima* is extended from its type-locality off Chile, 33°20'29"S, 71°59'0"W, to off Peru, 3°15'S, 80°55'W.

#### Acknowledgments

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## TWO NEW PHILIPPINE SUBSPECIES OF THE CRIMSON-BREASTED BARBET (AVES: CAPITONIDAE)

Victoria M. Dziadosz and Kenneth C. Parkes

*Abstract.*—The red-throated populations of the Crimson-breasted Barbet (*Megalaima haemacephala*) of the central islands of the Philippines are all currently assigned to the subspecies *intermedia* (Shelley, 1891). Geographic variation in these islands permits recognition of three subspecies: *M. h. intermedia* (Negros, Panay); *M. h. cebuensis*, n. subsp. (Cebu); and *M. h. homochroa* n. subsp. (Tablas and probably Romblon). A lectotype from Negros is designated for *M. h. intermedia*. Status of the populations on Guimaras and Masbate is uncertain.

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The Philippine populations of the polytypic Crimson-breasted or Coppersmith Barbet (*Megalaima haemacephala*) can be divided into two groups: those of the northern, eastern, and southern islands, in which the throat and stripes above and below the eye are yellow; and those of the central islands, in which the plumage of those areas is red. DuPont (1971) recognized three subspecies of the yellow-throated group, but no one has proposed the subdivision of the red-throated group. All barbets from the central islands of Cebu, Guimaras, Masbate, Negros, Panay, Romblon, and Tablas are currently assigned to the subspecies *M. h. intermedia* (Shelley, 1891).

In 1894, only three years after Shelley (1891) had described *intermedia*, Bourns and Worcester (1894:51) noted what appeared to be interisland variation in their series of specimens from Cebu, Negros, and Tablas. Part of Bourns and Worcester's series, now in the Carnegie Museum of Natural History, seemed to confirm their findings, so we borrowed further material, including most of the rest of the Bourns and Worcester specimens, to examine the alleged variation more closely.

We measured all specimens and found no differences between island populations in wing length, bill length, or bill width; so many specimens had badly worn or molting rectrices that tail measurements could not be fully evaluated; however, we believe that the populations probably do not differ significantly in tail length. We evaluated the following color characters: (1) color of the red of the throat; (2) extent of black on stripes along lateral borders of the red throat; (3) color of the wash on these lateral stripes; (4) size of yellow patches at sides of lower throat; (5) color and extent of yellow band across upper breast; (6) amount of yellow mixed with the red in the stripes above and below eye; (7) color of the red of the crown; (8) extent of black on occiput and nape; (9) color of wash on that black; (10) shade of green on back and wings; (11) presence or absence of orange tinge on tertials; (12) shade of green on tail.

Bourns and Worcester (1894) described their Cebu series as having "light edgings to feathers of the upper surface," lacking in their specimens from Negros and Tablas. This difference is indeed present, but is of seasonal rather than geographic significance, as it is due to feather wear. Cebu specimens taken in June and July show the light edgings, whereas three adult specimens taken in November (DMNH) do not have them. Furthermore, they are conspicuous in a worn May specimen from Negros (FMNH).

Evaluation of the other color characters listed above indicates that there is indeed geographically correlated variation within the central islands, such that three rather than only one subspecies can be defined in this area.

Shelley (1891) listed specimens from Negros and Cebu when he described *intermedia*, but did not designate a holotype. As Negros and Cebu populations differ (see beyond), we had to determine which population should bear Shelley's name. Hachisuka (1934:229) gave the type locality of *intermedia* as Negros, which can be accepted as a restriction (although Hachisuka erred in stating that the type was in the Rothschild collection in the American Museum of Natural History). Warren (1966), in accordance with her policy in her catalogue of bird type specimens in the British Museum (Natural History), listed only one of the syntypes (specimen 1888.11.24.337, an adult male from Negros), which has been placed in the segregated type series in the BM(NH). She specifically stated in her introduction that listing of a syntype in this catalogue did not constitute designation of a lectotype. As the syntypical series of *intermedia* is a composite, in order to stabilize the nomenclature of this species we formally designate BM(NH) 1888.11.25.337 as the lectotype of *Xantholaema intermedia* Shelley, 1891.

Two specimens from Panay (DMNH) are badly worn, but appear to agree well with Negros birds except that their crowns are of a slightly more orange red than most of the Negros series. On its museum label, FMNH 11099 from the Steere collection is attributed to "Siquijor"; however, this is based on a misreading of the scrawled locality "San Antonio" (a town in Negros) on the original label. No barbet has been collected on Siquijor (Rand and Rabor 1960).

Sexual dimorphism in these barbets is slight. Females tend to have the red of the crown and throat somewhat less intense, and to have more admixture of yellow feathers in the red of the mid- and lower throat and the facial stripes.

*Megalaima haemacephala cebuensis*, new subspecies

*Holotype*.—National Museum of Natural History 315155, adult male, collected 21 Jun 1892 at Toledo, Cebu Island, Philippines, by D. C. Worcester and F. S. Bourns (collectors' no. 984).

*Subspecific characters*.—Differs from *intermedia* of Negros in the greater extent of black (as opposed to green or bluish green) on the sides of the throat and on the occiput and nape. The red of the stripes above and below the eye is more mixed with yellow, sex for sex. There is a distinct yellow spot at the posterolateral corners of the red throat patch; in extreme female specimens (USNM 315156, DMNH 1814) this yellow spot is extended medially, forming a yellow band at the posterior edge of the throat. In *intermedia* there are no more than one to four yellow feathers, if any, in the corners of the throat patch.

*Range*.—Known only from Cebu Island, Philippines.

*Etymology*.—Named for the island it inhabits.

*Megalaima haemacephala homochroa*, new subspecies

*Holotype*.—Carnegie Museum of Natural History 137984, adult female, collected 23 Sep 1892 at Badajos, Tablas Island, Philippines, by D. C. Worcester and F. S. Bourns (collectors' no. 962).

*Subspecific characters*.—In general, duller and more uniform in color than *intermedia* and *cebuensis*. The red of the crown and throat is less brilliant, sex for



sex, in *homochroa*. In *intermedia* and *cebuensis* the black of the nape and occiput is washed with varying amounts of blue-green to blue-gray; in *homochroa* this wash is green, similar to (but slightly less yellowish than) the green of the back. The tertials scarcely contrast with the back color, whereas in *intermedia* and *cebuensis* these feathers, in good light, have a tinge of dark orange and contrast with the green back. Similarly, the tail of *homochroa* is of the same dull green as the back, whereas in the other two races the tail is a richer, less yellowish green than the back. The black of the sides of the throat is washed with olive-green rather than with blue-green or blue-gray as in *intermedia* and (to a lesser extent) *cebuensis*. The yellow band across the upper breast tends to be more diffuse in *homochroa*, blending more gradually with the pale yellow or whitish ground color of the more posterior underparts, whereas the yellow of this area tends to be more sharply defined in *cebuensis* and *intermedia*. In the latter subspecies, the yellow area is richer, tending toward an orange color without counterpart in *homochroa*. The yellow spots at the posterior corners of the throat patch are reduced or absent, as in *intermedia*.

*Range*.—Known at present from Tablas Island, Philippines (see below).

*Etymology*.—The name, from the Greek *homos*, same or uniform, and *chroa*, surface of the body or skin color, refers to the relative uniformity of color of the upperparts of this subspecies.

*Remarks*.—We have examined two specimens from the island of Guimaras (AMNH, CM). The geographic position of Guimaras, between Negros and Panay, suggests that the barbets of this island should be *intermedia*, and the AMNH specimen does, indeed, match a Negros series. The CM specimen, however, resembles *homochroa* in all characters. A larger series from Guimaras must be examined before the true characteristics of the barbet population of this island can be determined. We have not seen specimens from the islands of Romblon and Masbate. Those of Romblon are almost certainly *homochroa*, as the avifauna of that island is virtually identical with that of Tablas. Masbate is closer to Panay than to any other island inhabited by the red-throated group of subspecies, but is even closer to islands occupied by yellow-throated populations, so the examination of specimens from Masbate would be highly desirable. The only specimens of this species known to us from Romblon and Masbate were those collected by McGregor. These were destroyed in the burning of the National Museum of the Philippines during the battle for Manila in World War II.

*Specimens examined*.—*M. h. intermedia*: Negros, 12 (AMNH), 9 (FMNH), 4 (DMNH); Panay, 2 (DMNH). *M. h. cebuensis*: Cebu, 5 (DMNH), 5 (USNM), 1 (CM), 1 (FMNH). *M. h. homochroa*: Tablas, 5 (USNM), 3 (CM), 2 (FMNH). *M. h. subsp.*: Guimaras, 1 (CM), 1 (AMNH).

#### Acknowledgments

Specimens to supplement the small series in the Carnegie Museum of Natural History (CM) were borrowed from the National Museum of Natural History (USNM), Field Museum of Natural History (FMNH), and Delaware Museum of Natural History (DMNH). Specimens at the American Museum of Natural History (AMNH) were examined in situ by Parkes. We are indebted to the curators of these museums for permission to study their specimens.

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# GENERIC REVISION OF *MASTOBRANCHUS* AND *PERESIELLA* (POLYCHAETA: CAPITELLIDAE) WITH DESCRIPTIONS OF TWO NEW SPECIES FROM THE GULF OF MEXICO AND ATLANTIC OCEAN

R. Michael Ewing

*Abstract.*—Two new species of capitellid polychaetes from the Gulf of Mexico and Atlantic Ocean are described: *Mastobranchnus variabilis* and *Peresiella spathulata*. Emended diagnoses for these genera are proposed. Two species currently assigned to *Mastobranchnus*, *M. dollfusi* Fauvel, 1936, and *M. indicus* Southern, 1921, are considered incertae sedis. Keys to the species of *Mastobranchnus* Eisig, 1887, and *Peresiella* Harmelin, 1968, are presented.

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From 1975 to 1981 the Bureau of Land Management (BLM; now Mineral Management Services) funded several large scale benthic studies of the Gulf of Mexico outer continental shelf. The polychaete fauna from these benthic collections was examined in great detail in a taxonomic standardization program conducted by Barry A. Vittor and Associates, Mobile, Alabama; an atlas of Gulf of Mexico polychaetes was published by this firm in mid-1984. The BLM-OCS samples yielded numerous undescribed taxa in several polychaete families. Two of the new species of Capitellidae encountered during the polychaete standardization program are described in this paper; these capitellids were collected from the MAFLA (Mississippi, Alabama and Florida) and SOFLA (Southwest Florida) study areas. In the course of examining the BLM material, additional specimens of these new taxa were found in benthic samples collected by Interstate Electronics Corporation (IEC) at dredged material disposal sites off Florida, North Carolina, and Puerto Rico. Several specimens of one of these species, collected near Hutchinson Island, Florida by the Florida Department of Natural Resources, were also examined.

Description of these species necessitated generic revisions of *Mastobranchnus* Eisig, 1887, and *Peresiella* Harmelin, 1968. The generic diagnoses and dichotomous keys provided in this paper reflect only adult characters.

Type-specimens are deposited in the National Museum of Natural History (USNM), Smithsonian Institution, Washington, D.C., and the Allan Hancock Foundation (AHF), University of Southern California, Los Angeles, California.

## Family Capitellidae Grube, 1862

### Genus *Mastobranchnus* Eisig, 1887, emended

*Type-species.*—*Mastobranchnus trinchessii* Eisig, 1887.

*Diagnosis.*—Thorax with achaetous peristomium and 11 setigerous segments. First setiger with or without neurosetae. Setigers 1-9 with capillary setae only; last 2 thoracic segments with capillary setae only or hooded hooks only. Two or



more abdominal notopodia with mixed fascicles of capillary setae and hooded hooks; abdominal neuropodia with hooks only.

*Remarks.*—Gallardo (1968) noted that the two species added to *Mastobranthus* after its original description, *M. dollfusi* Fauvel, 1936, and *M. indicus* Southern, 1921, have combinations of characters clearly not within this genus.

*Mastobranthus dollfusi* is described as having an achaetous peristomium, followed by an incomplete first setiger with capillary setae in notopodia only, 12 thoracic setigers with capillary setae only in both rami and a transitional segment (setiger 14) with capillary notosetae and neuropodial hooded hooks; however, there are no abdominal segments with mixed fascicles of capillary setae and hooks in the notopodia, an important diagnostic character of the genus *Mastobranthus*. The setal pattern of *M. dollfusi* fits that of the genus *Leiocapitella*; in fact, its specific setal formula is presently occupied by another species, *L. glabra* Hartman, 1947. However, the palmate branchiae characteristic of *M. dollfusi* (see Fauvel 1936, fig. 11) are not known in *Leiocapitella*. For these reasons, *M. dollfusi* is herein considered incertae sedis.

*Mastobranthus indicus* was described from a single incomplete specimen. This species has 11 biramous thoracic setigers with capillary setae only; setigers 12 and 13 are transitional with capillary notosetae and neuropodial hooded hooks; following segments have hooks only in both rami. The specific setal arrangement of *M. indicus* does not fit that of any presently recognized capitellid genus. In the author's opinion it would be inadvisable to erect a new genus for a species described from a single, incomplete specimen; *M. indicus* is therefore regarded as incertae sedis.

*Mastobranthus variabilis*, new species

Fig. 1 a–e

*Mastobranthus* sp. A.—Ewing, 1984: 14–35, figs. 14–30a–f.

*Material Examined.*—GULF OF MEXICO: off Alabama: MS 694, 30°04'14"N, 87°53'50"W, 13.4 m, sand, 11/80, 1 spec.; off Florida: IEC 713TB-003, 27°37.1'N, 82°54.0'W, 12 m, clean sand, 10/79, 1 spec.; IEC 713TB-004, 27°37.1'N, 82°55.1'W, 10 m, clean sand, 10/79, 5 spec.; IEC 713TB-005, 27°38.1'N, 82°55.1'W, 12 m, clean sand, 10/79, 2 spec.; IEC 713TB-006, 27°37.1'N, 82°58.0'W, 17 m, clean sand, 10/79, 5 spec.; IEC 723TB-003, 27°37.1'N, 82°54.0'W, 12 m, clean sand, 1/80, 3 spec.; IEC 723TB-004, 27°37.1'N, 82°55.1'W, 10 m, clean sand, 1/80, 3 spec. (Paratypes, AHF Poly 1369); IEC 723TB-006, 27°37.1'N, 82°58.0'W, 17 m, clean sand, 1/80, 1 spec.; IEC 723TB-007, 27°36.5'N, 82°55.8'W, 12 m, clean sand, 1/80 (Holotype, USNM 81993); SOFLA 2, 26°45.84'N, 82°45.18'W, 24 m, medium sand, 5/81, 2 spec. (USNM 75248); SOFLA 14, 25°46.01'N, 82°23.82'W, 26 m, fine sand, 7/81, 1 spec. (USNM 75244); SOFLA 28, 24°47.11'N, 83°13.08'W, 58 m, fine sand, 11/80, 1 spec. (USNM 75249); MAFLA 2318, 29°05'00.8"N, 83°45'00.0"W, 20 m, medium sand, 1/76, 1 spec.; MAFLA 2419, 29°46'59.8"N, 84°05'00.2"W, 10 m, fine sand, 8/77, 1 spec.; same location, 11/77, 1 spec. (USNM 75152); MAFLA 2528, 29°54'58.6"N, 86°04'58.5"W, 37 m, coarse sand, 9/75, 2 spec.; MAFLA 2531, 29°47'58.9"N, 86°09'28.9"W, 45 m, coarse sand, 2/76, 1 spec.; same location, 8/77, 2 spec.; MAFLA 2855, 30°08'02.1"N, 86°30'00.0"W,

40 m, medium sand, 8/77, 1 spec.; ATLANTIC OCEAN: off Florida: Hutchinson Island: HI-290, sta. 5, 27°22'22"08"N, 80°13'46"W, 10.3 m, coll. by D. Beaumariage, P. Camp and R. Gallagher, 5/10/72, 2 spec. (Paratypes, USNM 81994); HI-785, same coordinates, 9.7 m, coll. by C. Futch, W. Jaap and R. Gallagher, 7/9/73, 2 spec.; off North Carolina: IEC 733WL-010, 33°43.8'N, 78°01.0'W, 10 m, clean sand, 7/80, 1 spec.

*Description.*—Length of holotype approximately 47 mm, width 0.6 mm, 116 setigerous segments. Lengths of 8 additional complete specimens range from 16 to 73 mm, widths 0.4 to 1.3 mm, setigers 50 to 112.

Color light tan to reddish brown in alcohol; juveniles with dark brown pigment spots scattered over most of body. Thorax slightly inflated through setiger 4 (Fig. 1a). Thoracic epithelium smooth to faintly tessellate through setiger 4, thereafter smooth except for wrinkles of contraction. Abdominal segments smooth with glandular parapodial tori.

Prostomium long, broadly conical in dorsal view, binannulate; pair of nuchal slits at proximal margin; conspicuous elongate ocular patches on dorsal surface. Achaetous peristomium wider than long, approximately same length as following segment. Eversible pharynx bulbous, smooth on entire surface. Setigers 1–3 about 3 times wider than long, thereafter segments gradually increase in length to end of thorax (Fig. 1a). Anterior notopodia dorsolateral, well separated, but approach middorsally by setiger 10–11; neuropodia ventrolateral in position throughout thorax.

Number of setae per fascicle proportional to body size; setiger 1 with 4–6 capillary setae per fascicle, thereafter increasing to as many as 20 per fascicle in last thoracic segment. Nephridial apertures (1 pair on each segment) located in segmental groove following each of last 5 thoracic and first abdominal segments. Lateral organs present on all thoracic setigers as a minute ciliated pore between noto- and neuropodium, increasing in size toward abdomen; appearing as conspicuous ovoid tuft of cilia just beneath notopodial tori in abdominal segments. Transition from thorax to abdomen distinct, marked by change in notopodia from capillary setae to mixed fascicles and in neuropodia from capillary setae to hooded hooks (in adults), slight broadening of segments, and appearance of glandular neuropodial tori.

Anterior abdominal segments approximately same length as those of posterior thorax, gradually lengthening to midabdominal region where they are 2 to 3 times as long as wide; thereafter segments becoming increasingly shorter; far posterior segments usually strobiliform.

Branchiae from mid- to posterior abdominal region (about setiger 67 in holotype) as eversible palmate tufts of 5–8 digitate filaments emerging posterior to notopodial tori (Fig. 1b).

Abdominal notopodia with mixed fascicles of 10–20 capillary setae and 3–8 hooded hooks through all or most of abdomen; notopodia in posterior third of abdomen often with hooks only. Occasionally notosetae absent in last few segments. Abdominal neuropodia with hooks only on slightly elevated glandular tori; hook rows separated by shallow midventral groove; first abdominal segment with 6–10 hooks per fascicle, increasing in number to as many as 35 hooks per fascicle and then decreasing to 1–2 hooks in far posterior setigers. Hooded hooks mul-

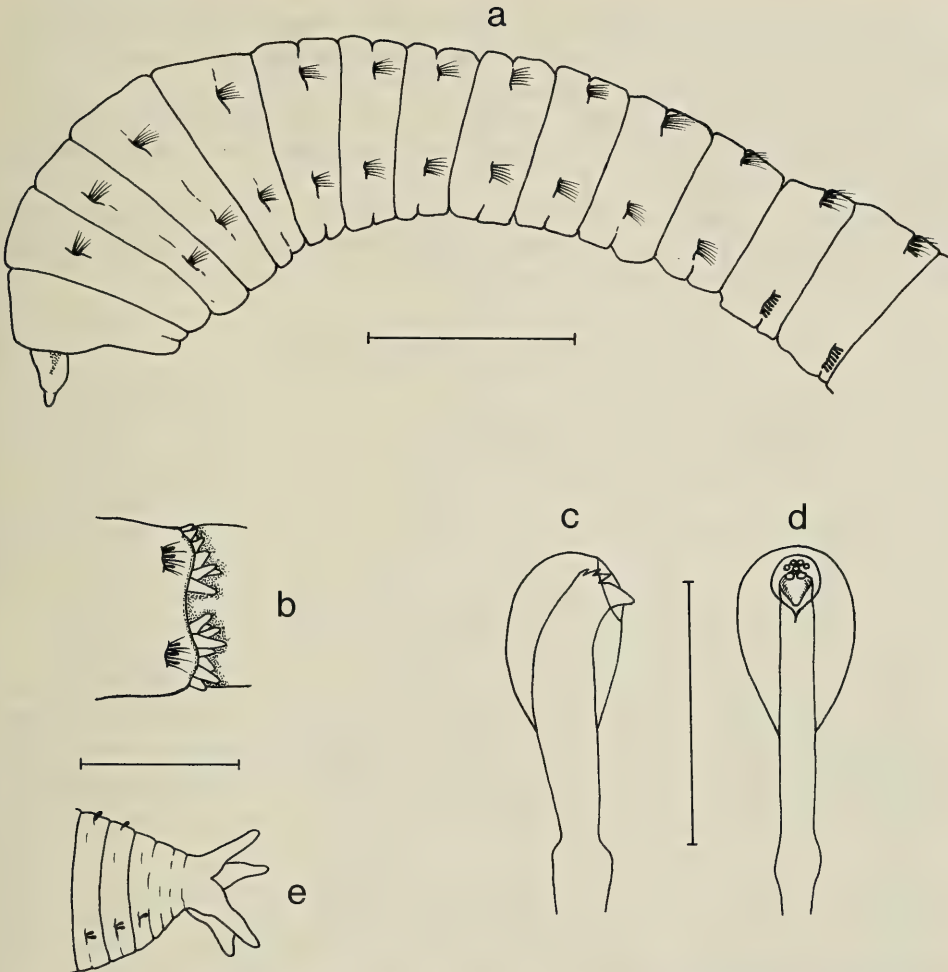


Fig. 1. *Mastobranthus variabilis*: a, Lateral view of anterior end showing thorax and first 2 abdominal segments; b, Dorsal view of midabdominal segment showing everted branchiae; c-d, Lateral and frontal views of neuropodial hooded hook from abdomen; e, Lateral view of pygidium. Scales = 0.5 mm for a, b, e; 0.035 mm for c, d.

tidentate, consisting of main fang surmounted by 7-8 teeth arranged in 3 rows (Fig. 1c, d); hooks in notopodia and neuropodia similar in crown structure and total length although shafts of notopodial hooks frequently extend further out of body, giving appearance that these setae are longer. Subtle variations in structure of these hooks were observed (i.e., relative sizes and location of denticles).

Pygidium conical with 3-4 digitiform caudal cirri (Fig. 1e).

*Remarks.*—Considerable variations from the thoracic setal arrangement of adults were observed in small specimens of *Mastobranthus variabilis*. Mixed setal fascicles or hooded hooks only rarely appeared in the last 1-2 notopodia. Neuropodia of the last 4 thoracic segments were found with capillary setae only, hooks only, or mixed setal fascicles.



*Mastobranthus variabilis* has a first setiger without neuropodia. The other two species of *Mastobranthus*, *M. trinchessii* Eisig, 1887, and *M. loi* Gallardo, 1968, have both noto- and neuropodia on setiger 1.

*Etymology*.—The specific name refers to the size-related differences in the thoracic setal arrangement of *Mastobranthus variabilis* (Latin “variabilis” meaning variable or changeable).

*Distribution*.—*Mastobranthus variabilis* was collected from sandy sediments in the northeast Gulf of Mexico off Alabama and Florida and in the Atlantic Ocean off Florida and North Carolina; known depth range 9.7 to 58 m.

#### Key to the Species of *Mastobranthus*

1. Setiger 1 with notopodia only ..... *M. variabilis*
- Setiger 1 with both noto- and neuropodia ..... 2
2. Last 2 thoracic setigers with hooded hooks only in noto- and neuropodia  
..... *M. loi*
- Thorax with capillary setae only ..... *M. trinchessii*

#### Genus *Peresiella* Harmelin, 1968, emended

*Type-species*.—*Peresiella clymenoides* Harmelin, 1968.

*Diagnosis*.—Thorax with an achaetous peristomium and 11 setigerous segments. First 3 setigers with capillary setae only; setiger 1 without neurosetae; following 2 setigers biramous; remaining thoracic segments (setigers 4–11) biramous with modified spatulate setae, capillary setae or hooded hooks. Abdominal parapodia with hooded hooks only in both rami.

#### *Peresiella spathulata*, new species

Fig. 2a–e

*Peresiella* sp. A—Ewing, 1984:14–13, figs. 14–8a–e.

*Material Examined*.—ATLANTIC OCEAN: off Puerto Rico: IEC 724SJ-001, 18°30.7'N, 66°09.0'W, 257 m, sandy mud, 1/80 (Holotype, USNM 81995); IEC 724SJ-002, 18°30.7'N, 66°08.5'W, 261 m, mud, 1/80, 1 spec.; IEC 724SJ-003, 18°30.2'N, 66°09.0'W, 220 m, sandy mud, 1/80 (Paratype, USNM 81996); IEC 724SJ-005, 18°31.2'N, 66°09.0'W, 279 m, mud, 1/80, 2 spec.; IEC 724SJ-010, 18°30.7'N, 66°11.6'W, 210 m, mud, 1/80, 1 spec.; IEC 731SJ-003, 18°30.2'N, 66°09.0'W, 220 m, sandy mud, 6/80, 1 spec.; IEC 731SJ-005, 18°31.2'N, 66°09.0'W, 279 m, mud, 6/80, 1 spec. GULF OF MEXICO: off Florida: SOFLA 18, 25°45.37'N, 83°42.22'W, 87 m, medium sand, 4/81, 1 spec. (USNM 75252); MAFLA 2105, 26°24'59.5"N, 83°49'57.6"W, 90 m, coarse sand, 6/75, 1 spec.; MAFLA 2106, 26°24'56.8"N, 84°15'00.0"W, 168 m, silty very fine sand, 5/75, 1 spec.; MAFLA 2212, 27°57'00.0"N, 84°47'59.6"W, 189 m, silty very fine sand, 8/77, 1 spec.; same location, 11/77, 1 spec.; MALFA 2426, 28°57'59.4"N, 85°23'00.2"W, 82 m, fine sand, 6/75, 2 spec.; MAFLA 2645, 29°35'00.5"N, 27°20'02.2"W, 106 m, coarse sand, 6/75, 1 spec. (USNM 75158).

*Description*.—Holotype an incomplete gravid female (18  $\mu$ m ova), length approximately 19 mm, width 0.5 mm, 40 setigerous segments. Lengths of 15 ad-

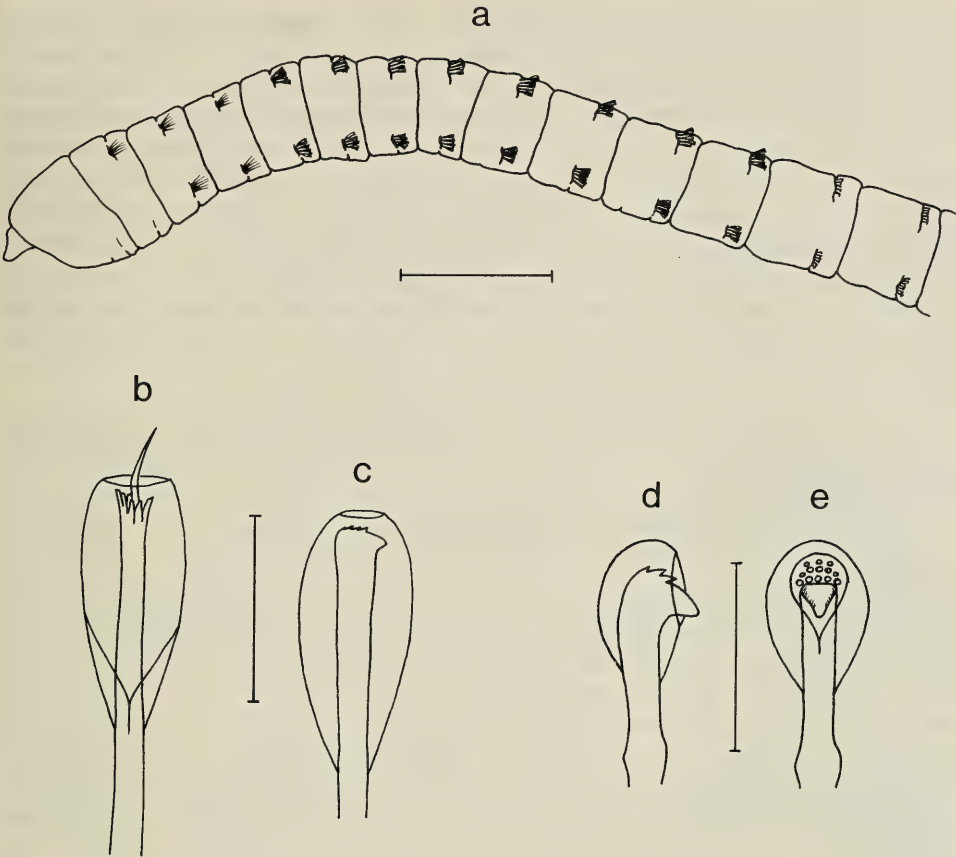


Fig. 2. *Peresiella spathulata*: a, Lateral view of anterior end showing thorax and first 2 abdominal segments; b, Frontal view of spatulate seta; c, Lateral view of thoracic hooded hook; d-e, Lateral and frontal views of neuropodial hooded hook from abdomen. Scales = 0.5 mm for a; 0.025 mm for b-e.

ditional incomplete specimens ranged from 4 to 8 mm, widths 0.3 to 0.5 mm, with up to 36 setigers.

Color light tan in alcohol. Thorax slightly inflated through setiger 2 (Fig. 2a). Thoracic epithelium smooth to faintly tessellate with glandular ring around posterior half of setiger 11. Entire surface of first 2-3 abdominal segments glandular in appearance (on unstained specimens), thereafter segments smooth anterior to setal fascicles and glandular on posterior margin.

Prostomium conical in dorsal view, tapering to bluntly rounded tip, often partly withdrawn under peristomium; paired nuchal slits at posterolateral margin; eyes absent. Achaetous peristomium slightly longer than wide, approximately twice as long as first setigerous segment. Eversible pharynx bulbous, sparsely papillate on distal half, smooth proximally. Setigers 2-3 approximately 3 times as wide as long, thereafter segments increase in length with last thoracic setiger about as wide as long (Fig. 2a).

Anterior 3 setigers with 4-6 capillary setae per fascicle. Remaining thoracic setigers (of holotype) with 6-8 modified setae per fascicle in both rami; modified

setae elongate, spatula-shaped with truncate hood and short arista (often broken off) extending from end of shaft through hood aperture (Fig. 2b). In smaller individuals last thoracic segment (setiger 11) may have mixed noto- and neuropodial fascicles of 4–6 spatulate setae and hooded hooks or hooks only. These thoracic hooks (Fig. 2c) transitional in structure between spatulate setae of preceding segments and typical capitellid-like hooks on following abdominal segments: hood usually slightly truncate rather than rounded; hood aperture distal to, rather than at right angle to shaft; crown not well developed, with reduced main fang and minute, barely discernible denticles; length of shaft intermediate between that of elongate spatulate setae and shorter abdominal hooks. Nephridial apertures and lateral organs not observed. Transition from thorax to abdomen marked by noticeable change in setal type (or structure of hooded hooks) and slight increase in number of neurosetae per fascicle.

First 1–2 abdominal segments approximately same length as last thoracic segment, thereafter segments gradually increasing in length. Branchial structures presumably absent. Pygidium not observed.

Abdominal parapodia with multidentate hooded hooks only in both rami, emerging from slightly elevated glandular ridges; notopodia dorsal in position with 6–8 notosetae per fascicle on narrowly separated tori; neuropodia ventrolateral with 7–11 hooks per fascicle. Under ordinary light microscopy hooded hooks appear to consist of large main fang surmounted by 10–13 teeth arranged in 3–4 rows (Fig. 2d, e). SEM reveals microstructure of these hooks more complex, with at least 20 teeth in numerous rows above main fang; in posterior view these hooks have many additional, irregularly arranged minute denticles (micrographs not shown). With the exception of minor differences in the number of teeth in the crown area of the hook, these setae do not vary in structure throughout the abdomen.

*Remarks.*—In an earlier study the author noted that this species (reported as *Peresiella*, sp. A; Ewing, 1984) had hooded hooks only in the last thoracic setiger. Later examination of additional material revealed that the largest specimen, an ovigerous female, had spatulate setae only on this segment and that smaller individuals had mixed setal fascicles or “transitional” hooks only on the last thoracic segment. The suggestion is, of course, that these hooks (on setiger 11) are present only in juveniles and are then replaced by modified spatulate setae during growth of the individual.

*Peresiella spathulata* differs considerably from the other two known species of *Peresiella*, *P. clymenoides* Harmelin, 1968, and *P. acuminatobranchiata* Thomassin, 1970. The type-species, *P. clymenoides*, has a thorax with capillary setae on setigers 1–3 and spatulate setae on the following 8 segments (setigers 4–11); this thoracic setal arrangement is identical to that of *P. spathulata*. However, the anterior end of *P. clymenoides* differs sharply from the usual pattern of the Capitellidae, i.e., the first and second segments are obliquely flattened, resembling the cephalic plate of many maldanids (see Harmelin 1968: pl. II). *Peresiella spathulata* is further distinguished from *P. clymenoides* in that the latter has neuropodial hooks on setigers 12–13 with a slender, extremely curved main fang, noticeably different from other abdominal hooks; noto- and neuropodial hooks are similar in structure throughout the abdomen of *P. spathulata*.

*Peresiella acuminatobranchiata* has two thoracic segments with modified setae,



which according to original illustrations (Thomassin 1970: fig. 3) resemble blunt-tipped, slightly curved acicular spines enveloped by a hood; *P. acuminatobranchiata* also has nonretractile, acuminate branchial processes beginning on anterior abdominal segments. *Peresiella spathulata* has 7–8 setigers with modified, spatula-shaped setae and no apparent parapodial (branchial) extensions.

*Etymology*.—The specific name refers to the shape of the modified thoracic setae (Latin “*spathulata*” meaning spatulate).

*Distribution*.—*Peresiella spathulata* was collected in the Gulf of Mexico off Florida and in the Atlantic Ocean off Puerto Rico at depths of 87–279 m. The species is known to inhabit a wide range of sediment types from mud to coarse sand.

### Key to the species of *Peresiella*

1. Two thoracic segments with modified setae; branchial structures present ..... *P. acuminatobranchiata*
- At least 7 thoracic segments with modified setae; branchiae absent .... 2
2. Anterior end modified like an oblique cephalic plate; abdominal hooks of 2 distinct types ..... *P. clymenoides*
- Anterior end capitellid-like, not modified; all abdominal hooks similar in structure ..... *P. spathulata*

### Acknowledgments

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## SYNONYMY OF *TENONIA PRIOPS* (HARTMAN) (POLYCHAETA: POLYNOIDAE)

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*Abstract.*—The polynoid worms, *Harmothoe priops* Hartman, 1961, and *Tenonia kitsapensis* Nichols, 1969, are the same species. *Tenonia priops* is found in soft sediments from northern Washington to southern California.

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Scaleworms from two sites off Whidbey Island in Puget Sound, Washington (Benedict, in preparation) were identified as *Tenonia kitsapensis* Nichols, but also fit the description for *Harmothoe priops* Hartman. After comparing the holotype and other specimens of *Harmothoe priops* from southern California with paratypes of *Tenonia kitsapensis* from Puget Sound, I have concluded that the two species are synonymous.

*Tenonia priops* (Hartman, 1961), new combination

*Harmothoe priops* Hartman, 1961:50-51; 1963:3; 1966:193-194, 215, 267, 320, 402, pl. 1, figs. 4-6.

*Tenonia kitsapensis* Nichols, 1969:205-208.—(Polynoidae sp. I) Lie 1968:272, 286, 295, 317.

*Material examined.*—WASHINGTON: Pratt's Bluff, Puget Sound, 10 m in sandy mud, 22 Aug 1980, A. Benedict, collector, 2 specimens, Huxley College 152.1.288.—Port Madison, Puget Sound, 28 m in fine sand, 22 Oct 1965, F. H. Nichols, collector, 4 paratypes (*Tenonia kitsapensis*), USNM 38264. CALIFORNIA: San Francisco Bay, 38-39 m in silty fine sand, 6 Jun 1973 and 3 Oct 1973, F. H. Nichols, collector, 10 specimens, FN 44.—Santa Barbara Point, 25.6 m in silt, 21 Nov 1957, R/V *Velero IV*, holotype (*Harmothoe priops*), AHF, sta 5402-57.—Point Dume, 50 m in silty clay, 14 Dec 1975, R/V *Velero IV*, 2 specimens, AHF, sta 23981.—Long Beach, 33 m in silty mud, 3 Feb 1977, R/V *Thomas G. Thompson*, 1 specimen, AHF, sta 81902.

*Remarks.*—*Tenonia priops* is a member of the subfamily Harmothoinae with 15 pairs of elytrae and less than 40 segments. All setae are slender and similar in thickness; superior neurosetae are unidentate, inferior neurosetae are bidentate. Members of *Harmothoe* Kinberg, in contrast, have thick notosetae, bidentate superior neurosetae, and usually some unidentate inferior neurosetae (Fauchald 1977).

The setal illustrations attributed to *Harmothoe priops* in Hartman's (1968) monograph are actually those of *Gattyana brunnea* Hartman. Illustrations of both species had previously appeared together in plate 1 of Hartman 1966.

Hartman (1961) describes this species' bidentate, subacicular neurosetae as "slightly thicker" than the capillary-tipped supra-acicular neurosetae, while Nichols (1969:208) states that "all setae are of approximately the same thickness (5-10  $\mu$ m)." Notosetae from most specimens I examined are approximately 6  $\mu$ m



wide at their thickest points (up to 7  $\mu\text{m}$  in the largest specimen). Capillary-tipped neurosetae vary from 5–9  $\mu\text{m}$ , but are usually 6–7  $\mu\text{m}$  wide. Mid-parapodial bifid neurosetae are slightly thicker than the capillary-tipped neurosetae in all specimens, varying in width from 6–11  $\mu\text{m}$ , usually 8–9  $\mu\text{m}$ . Within the bifid neurosetae series, the inferiormost setae are shorter and slimmer than those surrounding the acicula.

Because *Tenonia priops* fragments easily, the maximum length and number of segments are undetermined. Worm lengths of 7–8 mm were reported in both original descriptions of *T. priops*. One 23-setiger specimen I examined is 10.5 mm long; it is estimated that if entire, the specimen would be at least 12 mm long. Hartman (1961:50) states that “segments may not number more than 39.” Nichols (1969) and I have not seen a specimen with more than 33 setigers.

*Tenonia priops* is widest anteriorly, tapering posteriorly. Hartman (1961) did not include the worm's long neuropodial lobes in width measurements of 0.7 mm, while Nichols (1969) must have included them to record widths of up to 3.2 mm. The holotype (*Harmothoe priops*) is 0.9 mm wide without parapodia, and 1.9 mm wide with parapodia at setiger 4. The greatest widths measured in this study are 1.3 mm excluding parapodia, and 3.4 mm including parapodia.

Dorsal pigment patterns of the Whidbey Island specimens are very similar to those of the California specimens. Wide, dark bars stretch across the middle of segments, and narrower bars cross intersegmentally. The ventral cirri of the first setiger (which are inserted at the base of the parapodia, unlike those of the remaining setigers) resemble the tentacular cirri and are likewise pigmented. The prostomium bears speckles posteriorly, and scars on the elytra are pigmented. Specimens from Port Madison, which had been stored for years in formalin (Nichols, personal communication), lack pigment.

*Distribution.*—*Tenonia priops* is found in soft sediments in Puget Sound and vicinity from 2–70 m, at 40 m in San Francisco Bay, and in southern California from 8–170 m.

### Acknowledgments

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## SPECIES-DISTINCTIVENESS OF LONG-BILLED DOWITCHER SONG (AVES: SCOLOPACIDAE)

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*Abstract.*—A prominent type of breeding vocalization (“song”) of the Long-billed Dowitcher (*Limnodromus scolopaceus*) is described and compared with song of the Short-billed Dowitcher (*L. griseus*). In *L. scolopaceus*, the song consists of an introductory series of elements followed by several identical components (“song units”), each consisting of two element types in series. The first type is a doublet, and the second is a buzz. Song of *L. griseus* is organized similarly, but each song unit has three element types in series and no doublets. The species differ strongly in quantitative features of buzzy elements. Analyses of vocalizations of the Asiatic Dowitcher (*L. semipalmatus*), and of other groups within the Scolopacidae (especially godwits, woodcock, and snipe) are needed to evaluate the systematic significance of these observations.

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Acoustic signals provide useful characters for systematic studies on birds, particularly closely related species (e.g., Stein 1963; Lanyon 1978; Munding 1979; Johnson 1980). This is likely to apply to sandpipers and their allies (Scolopacidae, 86 species), though little research on acoustic communication in the group has been carried out. Sounds of many species are quite distinctive and vary relatively little intraspecifically (Miller 1984). Such sounds may provide insight into affinities of several problematic taxa, including dowitchers (*Limnodromus*). This genus consists of three species whose affinities with calidridine sandpipers, godwits, snipe, and woodcock remain unclear (Pitelka 1950; Strauch 1976, 1978; our nomenclature and classification follow Gochfeld *et al.* 1984). The purpose of this paper is to describe one prominent type of vocalization (“song”) used by the Long-billed Dowitcher (*L. scolopaceus*) during breeding, and compare it with the homologous call type of the Short-billed Dowitcher (*L. griseus*). These two species are much more closely related to one another than either is to the Asiatic Dowitcher (*L. semipalmatus*), whose vocalizations have not been analyzed; song of *L. griseus* is described elsewhere (Miller *et al.* 1983), as are other calls of *L. scolopaceus* (Tikhonov and Fokin 1979, 1980, 1981). For general accounts of the species, see Johnsgard (1981) and Cramp (1983).

*Methods and Materials.*—Records were obtained near Barrow and Atkasuk, Alaska in June 1977, and at Berelyakh, near the mouth of the Indigirka River, Yakutiya, U.S.S.R., in June 1976. Analyses were made with a Kay Elemetrics Sona-Graph 7029A, and a Honeywell Visicorder System 1858. Variables were measured on wide-band (300 Hz) sound spectrograms; even the frequency measure used (terminal frequency of certain elements) was more easily and repeatably measured on wide- than on narrow-band (45 Hz) spectrograms. Variables used for each song unit were (see below and Figs. 1 and 3 for terminology): (i) interval preceding song unit (this was the interval between one unit's type *c* element and the next unit's type *a* element, or the interval between a song's introduction and

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\* Deceased.



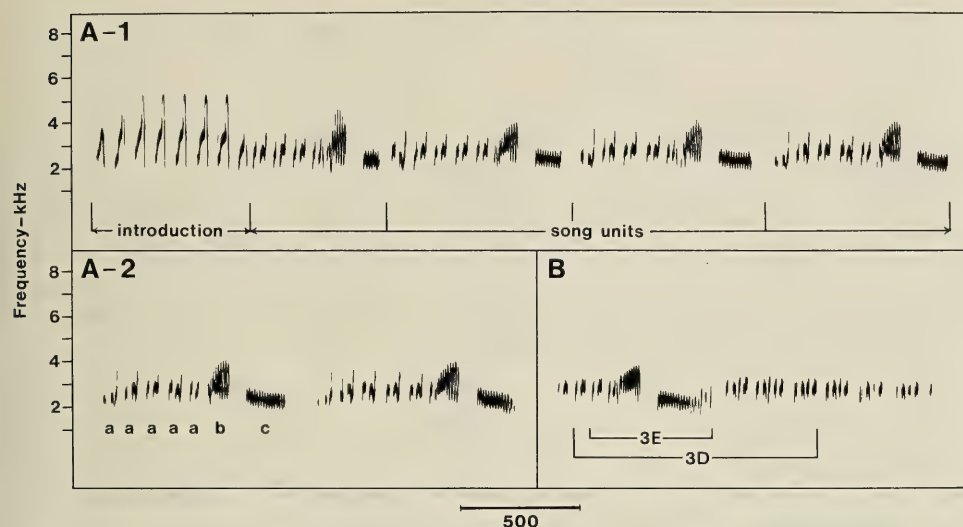


Fig. 1. Sound spectrograms of song of *L. scolopaceus*. A (two parts), Song from Alaska, consisting of an introduction and six song units (A-2 shows the continuation of A-1). Element types are indicated for the first song unit in A-2; B, Terminal song unit in song from the U.S.S.R., with following compound elements. Segments marked as 3D, 3E are shown as oscillograms in Fig. 4D, E, resp. Analyzing filter bandwidth, 300 Hz; time marker in msec.

the first type *a* element); (ii) total duration of song unit; (iii) duration of the series of type *a* elements; (iv) duration of type *b* and *c* elements; (v) rate of frequency modulation of type *b* and *c* elements (estimated using up to the first 10 cycles in the elements); and (vi) terminal frequency of type *b* and *c* elements.

**Results.**—Song of *L. scolopaceus* consists of an introduction, followed by several repetitions of a complex sequence (“song unit”). The introductory portion is a sequentially graded series of brief elements, each with a broad frequency range, and each typically increasing then decreasing quickly in frequency (Fig. 1A). Two element types occur in fixed sequence in each song unit: (*a*) doublets, occurring as a sequentially graded series of variable length; and buzzes, the first (*b*) being brief, and the second (*c*) longer and lower in frequency (Figs. 1, 3). The sequence and general characteristics of element types in *L. scolopaceus* song were present in all song units examined, from Alaska ( $n = 10$ ) and the U.S.S.R. ( $n = 12$ ). Song of *L. griseus* also consists of an introductory series, followed by several song units, but three distinct element types occur in each song unit (Fig. 2). In addition, the number of buzzy elements is variable, ranging from one to five (Fig. 2; Miller *et al.* 1983).

The parts of each doublet in *L. scolopaceus* song have a simple structure which changes gradually over a sequence: the first part rapidly increases in frequency then levels off; the second may show a similar pattern, or a more complex one of rises then falls in frequency (Fig. 3C). The amplitude envelopes of type *a* elements are simple and consistent, and the parts are roughly equal in peak amplitude (Fig. 4). Type *b* elements begin with one or more modified type *a* elements (e.g., Figs. 3, 4), but are dominated by a rapid frequency modulation of

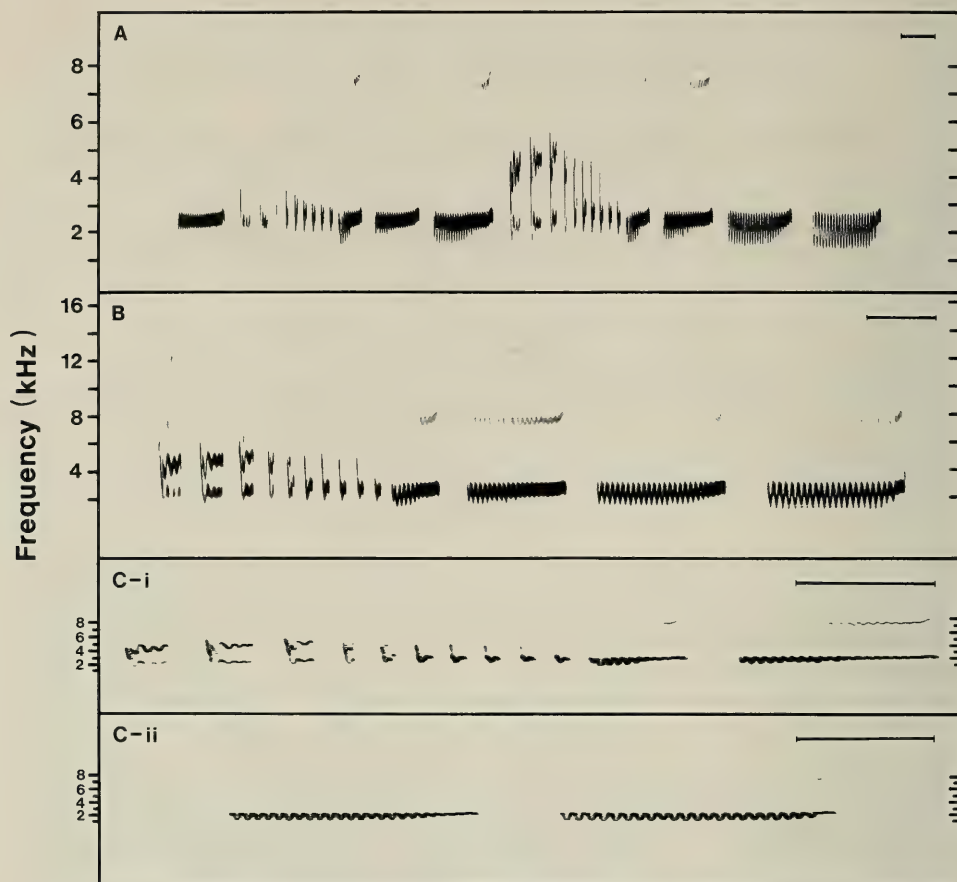


Fig. 2. Sound spectrograms of song of *L. griseus* from Labrador. A, Terminal buzzy element and two complete song units. Analyzing filter bandwidth, 300 Hz; B, Second song unit from panel A, shown on a different time scale. Analyzing filter bandwidth, 300 Hz; C (two parts), Same song unit as B, shown on different frequency and time scales. Analyzing filter bandwidth, 45 Hz. Time markers, 125 msec.

a gradually increasing carrier frequency (Figs. 1, 3). The modulated part of *b* elements averages about 80 msec long, with a modulation rate of about 100 Hz and a terminal frequency of about 3 kHz; they are significantly briefer, more slowly modulated, and higher in frequency than in *L. griseus* (Table 1). Type *b* elements have the highest amplitude in a song unit, and show pronounced modulation of amplitude coupled to that of frequency, as in *L. griseus* (Fig. 4; Miller *et al.* 1983). Type *c* elements are simply buzzes with a slowly descending carrier frequency (Figs. 1, 3). They average about 145 msec long, have a modulation rate of about 94 Hz, and a terminal frequency of about 2 kHz; thus they are briefer, more slowly modulated, and slightly lower in frequency than comparable elements of *L. griseus* (Table 1). Unlike type *b* elements, rhythmic amplitude modulation of *c* elements is not pronounced (Fig. 4). Type *c* elements are both absolutely and relatively briefer and lower in frequency (compared to type *b* elements) in *L. scolopaceus* than in *L. griseus* (Table 1).

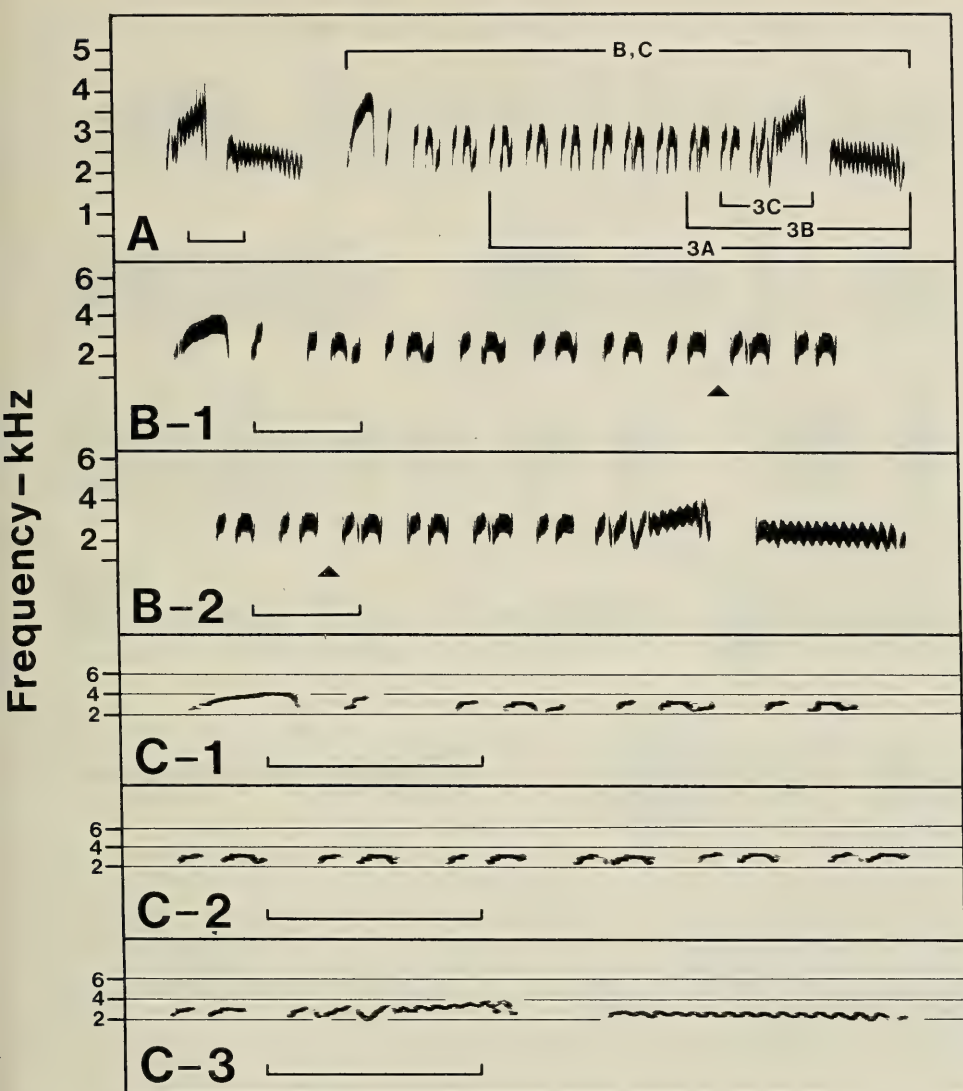


Fig. 3. Sound spectrograms of song of *L. scolopaceus*, A, Terminal elements (types *b*, *c*) of one song unit, followed by an entire song unit, from an Alaskan song. The song unit marked "B, C" is also shown in parts B and C of this figure. Other segments marked are shown as oscillograms in Fig. 4A, B, C. Analyzing filter bandwidth, 300 Hz; B (two parts), Same song unit as in A, shown on a different time scale. There is some overlap between parts 1 and 2; the triangles mark the same point in the series of *a* elements. Analyzing filter bandwidth, 300 Hz; C (three parts), Song unit as in A and B, shown on a different time scale and with different analyzing filter bandwidth (45 Hz). The last element in each part is followed by the first element in the part immediately below; there is no overlap. Time markers, 125 msec.

A call type often associated with song consists of rhythmically repeated groups of brief simple elements (Figs. 1B, 4D); these are very similar in structure to a call type of several calidridine species (Miller 1983a, b).

Major differences between song of *L. scolopaceus* and *L. griseus* include: the



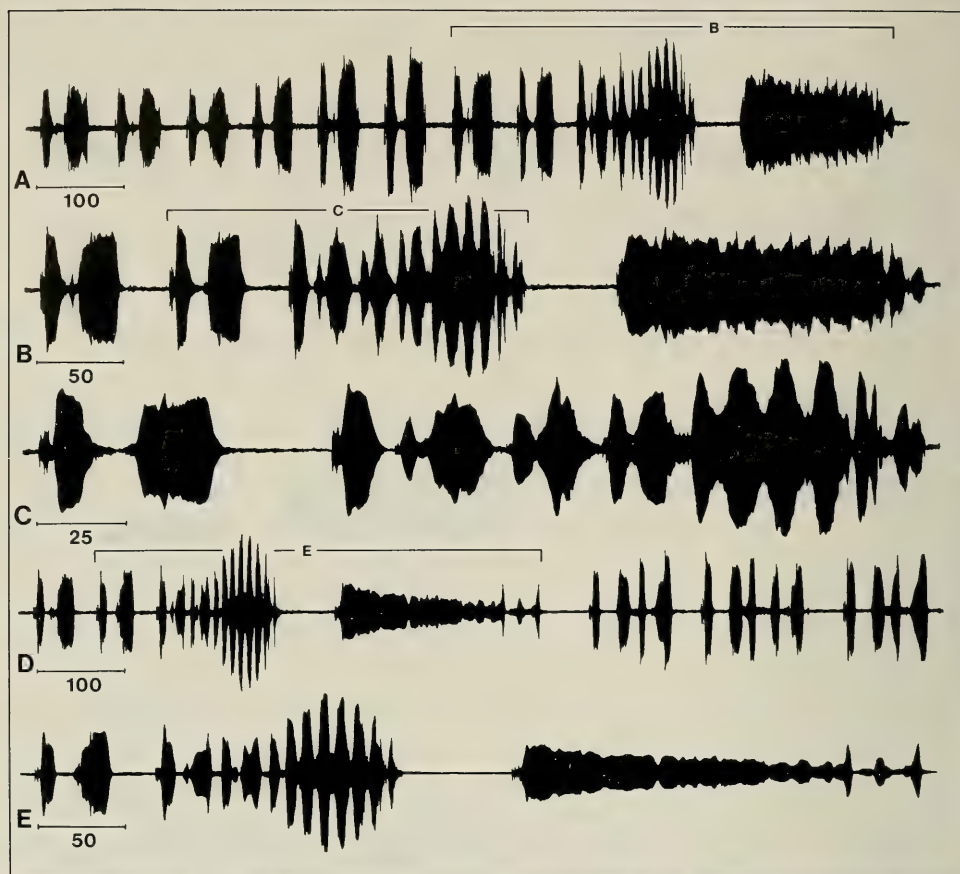


Fig. 4. Oscillograms of song of *L. scolopaceus*. A, B, C, Segments of a song unit from an Alaskan song, shown at different time scales (refer to Fig. 3A). The portions marked "B" in part A, and "C" in part B, represent parts B and C of this figure; D, E, Segments of a song unit with following elements, in song from the U.S.S.R., shown at different time scale (refer to Fig. 1B). The portion marked "E" in part D represents part E of this figure. Scale for amplitude varies across traces, but is constant within single groups; time markers are in msec.

presence of doublets in the former, whereas the latter has series of two kinds of elements at a comparable position in each song unit; temporal and frequency characteristics of buzzy elements; low number of buzzy elements in *L. scolopaceus*; and weakly developed amplitude modulation in type *c* elements of *L. scolopaceus*.

### Discussion

Songs of *L. scolopaceus* and *L. griseus* show many quantitative and some qualitative differences, but are very similar in hierarchical organization and in characteristics of buzzy elements. Both species differ strongly from *L. semipalmatus*, which utters repeated low-frequency, buzzy elements during aerial song (Veprintsev 1982). The buzzy elements in song of *L. griseus* and *L. scolopaceus* are strikingly similar to those in song of a calidridine, the Least Sandpiper (*Calidris*

Table 1.—Summary of descriptive statistics for variables on song units of *Limnodromus scolopaceus* and *L. griseus*.<sup>a</sup>

Variable	<i>L. scolopaceus</i> <sup>b</sup>	<i>L. griseus</i> <sup>c</sup>	<i>P</i> <sup>d</sup>
Interval preceding song unit (msec)	*68.7 ± 5.37 (18)	69.5 ± 1.79 (63)	NS
Duration of song unit (msec)	824 ± 53.6 (15)	986 ± 32.8 (69)	*
Duration of buzzy elements (msec)			
a. First element	78.8 ± 2.33 (19)	112 ± 4.2 (83)	***
b. Second element	**145 ± 10.2 (18)	240 ± 6.1 (83)	***
c. [(b - a)/a]%	84.8 ± 12.29 (18)	139 ± 9.4 (82)	*
Initial cycle rate of buzzy elements (Hz)			
a. First element	101 ± 1.1 (19)	140 ± 1.1 (82)	***
b. Second element	94.3 ± 1.94 (18)	114 ± 1.1 (85)	***
c. [(b - a)/a]%	-6.77 ± 2.205 (18)	-18.7 ± 0.82 (80)	***
Terminal frequency of buzzy elements (Hz)			
a. First element	2977 ± 24.2 (19)	2424 ± 10.3 (86)	***
b. Second element	***2207 ± 36.1 (18)	2342 ± 18.2 (85)	**
c. [(b - a)/a]%	***-25.7 ± 1.47 (18)	-3.50 ± 0.732 (81)	***
Interval between first two buzzy elements (msec)	*66.6 ± 2.26 (18)	56.5 ± 1.24 (84)	***

<sup>a</sup> Each cell entry is listed as  $\bar{Y} \pm SE(n)$ .  
<sup>b</sup> Variables which differ significantly between samples from Alaska and the U.S.S.R. are indicated by asterisks (\*  $P < 0.05$ , \*\*  $P < 0.01$ , \*\*\*  $P < 0.001$ ; by one-way analyses of variance).  
<sup>c</sup> Data are from Table II of Miller *et al.* (1983), or from raw data used in that study.  
<sup>d</sup> Probability of difference between means (two-tailed), based on *t*-tests (symbolism as for footnote b; NS = not significant ( $P > 0.05$ )).

*minutilla*; Miller 1983a), notably in their sequential increase in duration and decrease in frequency and modulation rate within song units, and their rhythmic amplitude and frequency modulation (which are coupled). Other features of song structure in these three species are similar, but none so strikingly. Information about songs of other calidridines is too scanty to permit comprehensive comparisons, though song in several species is very different (Miller 1983b).  
Vocalizations of only two species each of snipe, woodcock, and godwits have been analyzed, and these differ strongly from song structure described here (Glutz von Blotzheim *et al.* 1977; Mal'chevskii 1980; Warham and Bell 1980; Cramp 1983; Miller 1984). However, buzzy elements occur in several of the taxa mentioned, and also characterize nuptial displays in several species of Calidridini

(Miller 1983b). Quantitative analysis of buzzy elements which occur within song, or independently of it, could therefore provide insight into adaptive radiation and affinities of this group of Scolopacidae. Available evidence is clearly too limited to judge which features of *L. scolopaceus* song are ancestral and which are derived. Detailed descriptions of vocalizations in the taxa mentioned are badly needed.

### Acknowledgments

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TAXONOMY OF SOME SPECIES OF *PHALLODRILUS*  
(OLIGOCHAETA: TUBIFICIDAE) FROM THE  
NORTHWEST ATLANTIC, WITH DESCRIPTION  
OF FOUR NEW SPECIES

Christer Erséus

*Abstract.*—New material of species of *Phallodrilus* Pierantoni from Georges Bank (SE of Massachusetts), the continental shelf off New Jersey, Maryland, and Virginia, and littoral sediments in Barbados is described. Four of the species, *P. boeschi*, *P. flabellifer*, *P. caviatriatus*, and *P. davis*i, are new to science. New taxonomic information is also provided for *P. sabulosus* Erséus, *P. coeloprostatus* Cook, and *P. biprostatus* (Baker and Erséus) n. comb. *Peosidrilus* Baker and Erséus is considered a junior synonym of *Phallodrilus*, as the definition of the latter is modified to include a few species possessing true penes. The relationships between *Phallodrilus* and some other genera within the subfamily Phallodrilinae are discussed.

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In 1979 the marine tubificid genus *Phallodrilus* Pierantoni, 1902, was revised by the present author (Erséus 1979a) to include 23 species. Subsequently, several species have been added (Giere 1979; Erséus 1980a, b, 1981a, 1983a, 1984a; Baker 1981; Giani and Martinez-Ansemil 1981), whereas two species have been transferred to other genera (Erséus 1981b, 1982). Thus the genus has comprised no less than 39 species to date. This makes *Phallodrilus* by far the largest genus within the subfamily Phallodrilinae, and yet many species are still undescribed (present paper; Erséus, unpublished). However, *Phallodrilus* is a heterogeneous taxon; for instance, it has hitherto been defined (Erséus 1979a, with slight emendation by Baker 1981) to include both species with and without an alimentary canal. In addition, although the general configuration of the male efferent duct is the same in all the species (vas deferens entering atrium apically or sub-apically, and prostate glands always two per atrium), the terminal part of the duct exhibits considerable variation throughout the genus. In some species the atrium opens directly on the body surface, whereas in others, there are various kinds of pseudopenes developed (with or without copulatory sacs). In some, the "pseudopenial" structure has evolved so far as to approach the situation of a true penis. One such species is *P. minutus* Hrabě, 1973 (see Erséus and Kossmagk-Stephan 1983), another one *P. vanus*, recently described and discussed by Erséus (1984a).

One phallodriline species with a conspicuous (true) penis was regarded as a member of a separate, monotypic genus by Baker and Erséus (1979: *Peosidrilus biprostatus*), despite the fact that the rest of the male duct and the penial setae of that species clearly are *Phallodrilus*-like.

The present paper treats some additional material of *Phallodrilus* from the east coast of the U.S. and from Barbados. Some of the worms represents new species, all exhibiting various degrees of elaboration of the male terminalia in a way which bridges the gap between *Phallodrilus* and *Peosidrilus*. It is therefore proposed here

that *Peosidrilus* becomes a junior synonym of *Phallodrilus*. The paper should, however, be regarded only as a partial revision of the genus; in a forthcoming paper (Erséus, in press), the gutless species of *Phallodrilus* will be scrutinized and taxonomically revised.

### Material and Methods

Most of the material used in this study was collected during benthic surveys on the continental shelf off the east coast of the U.S. These projects are (1) the Georges Bank Infauna Monitoring Program, (2) a Bureau of Land Management baseline marine study, and (3) the "Philadelphia Dump Site" study, the latter two made by Virginia Institute of Marine Science off the coasts of New Jersey through Virginia. The specimens were stained with haematoxylin or paracarmine and mounted whole in Canada balsam.

The material of *P. caviatriatus* n. sp. was collected by the author during a stay at the Bellairs Research Institute of McGill University, St. James, Barbados. The worms were fixed in Bouin's fluid; the anterior end of one specimen was subsequently sectioned and stained in Heidenhain's haematoxylin and eosin, whereas the remaining individuals were stained in paracarmine and mounted whole in Canada balsam.

The type-material of the new species has been deposited in the United States National Museum of Natural History (USNM), Washington, D.C.

### *Phallodrilus sabulosus* Erséus, 1979

*Phallodrilus sabulosus* Erséus, 1979a:188–189, figs. 1–2.—Erséus and Loden 1981: 820–821, fig. 1A.

*New material examined.*—Two specimens from W of New Jersey, U.S.A., 39°22.1'N, 74°15.6'W, 15.5 m, medium to coarse sand, Aug 1976.

*Remarks.*—Only one of the new specimens is complete. It is 5.5 mm long and consists of about 45 segments, but its posterior end is not fully developed. Both worms are mature, but pre-copulatory. The penial setae (see Erséus 1979a: figs. 1–2) are one at each side, ventrally in XI; the spermathecal setae (Erséus 1979a: fig. 1) also one at each side, ventrally in X.

This species was previously known only from Florida (Erséus 1979a; Erséus and Loden 1981). Thus the present record considerably extends its known distribution to the north.

*Habitat.*—Sublittoral, largely coarse sands, known from 3–15.5 m depth.

*Distribution.*—East coast of the U.S.A., from New Jersey to Florida.

### *Phallodrilus coeloprostatatus* Cook, 1969

Fig. 1

*Phallodrilus coeloprostatatus* Cook, 1969:16–17, fig. 5.—Brinkhurst and Jamieson 1971:565, fig. 8.38D–F.—Erséus 1979a:189–190, fig. 4.

*New material examined.*—Four specimens from Georges Bank, SE of Massachusetts, U.S.A., May 1983: two from 40°39.6'N, 67°45.8'W, 78 m; one from 40°39.8'N, 67°46.1'W, 78 m; and one from 40°39.5'N, 67°45.4'W, 78 m; all sites



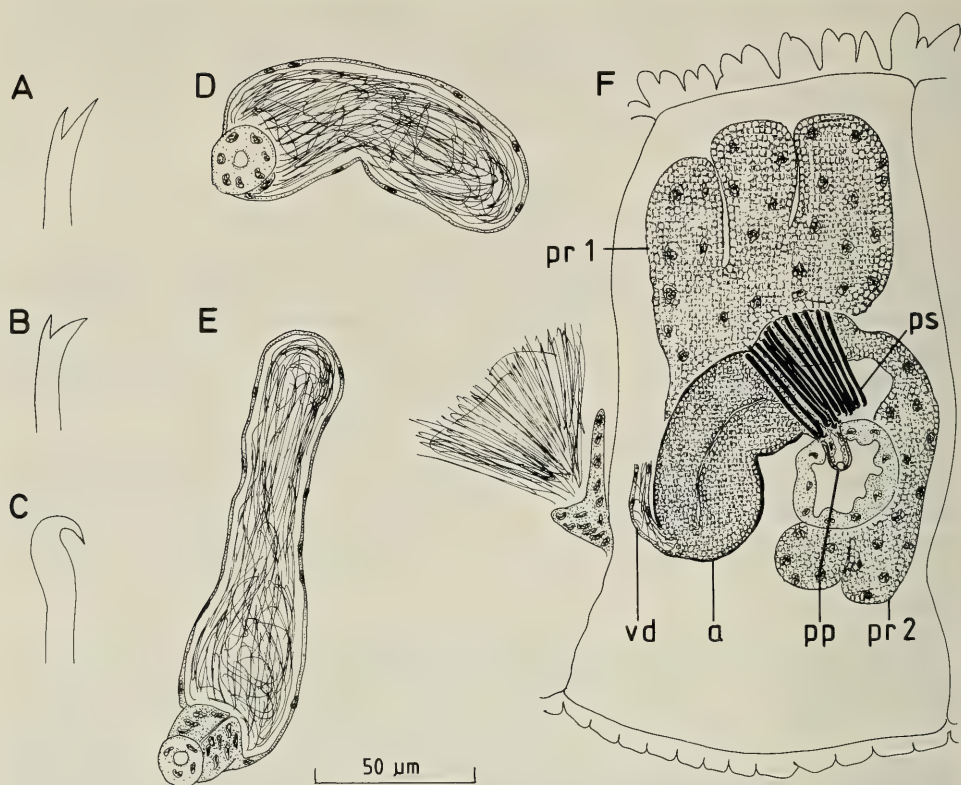


Fig. 1. *Phallopsyllus coeloprostatatus*: A, Free-hand drawing of anterior seta; B, Free-hand drawing of posterior seta; C, Free-hand drawing of penial seta; D-E, Spermathecae; F, Lateral view of male duct. a, atrium; pp, pseudopenis; pr 1, anterior prostate gland; pr 2, posterior prostate gland; ps, penial seta; vd, vas deferens.

coarse sand. Four specimens from off Maryland, U.S.A., 38°16'56"N, 74°15'41"W, 28 m, sediment unknown, Apr 1979.

*Description of material from Georges Bank.*—Length (fixed specimens) 3.6–4.2 mm, 48–54 segments. Diameter at XI, 0.17–0.23 mm. Clitellum extending over X–XI in two of the specimens (see below; location of genital pores), poorly developed in the others. Somatic setae (Fig. 1A–B) bifid, with upper tooth shorter and thinner than lower; teeth slightly more diverging in post-clitellar setae than in anterior setae. Bifids 35–45 µm long, 1.5–2 µm thick, 3–4 per bundle anteriorly, (2)3 per bundle in post-clitellar segments. Ventral setae of X (2 specimens), or IX (1 specimen), or VIII (1 specimen) modified into penial bundles (Fig. 1F, ps), each of which contains 9–13 straight, ectally hooked (Fig. 1C) penial setae, 35–40 µm long, about 1.5 µm thick. Male pores as small bursae in line with ventral somatic setae, posteriorly in VIII, IX or X. Spermathecal pores in lateral lines in most anterior part of VII, VIII or IX.

Pharyngeal glands poorly visible, but present in V–VI of at least one of the specimens. Male genitalia (Fig. 1F) paired. Vas deferens not observed in full length in available material, but enters atrium more or less apically. Atrium comma-

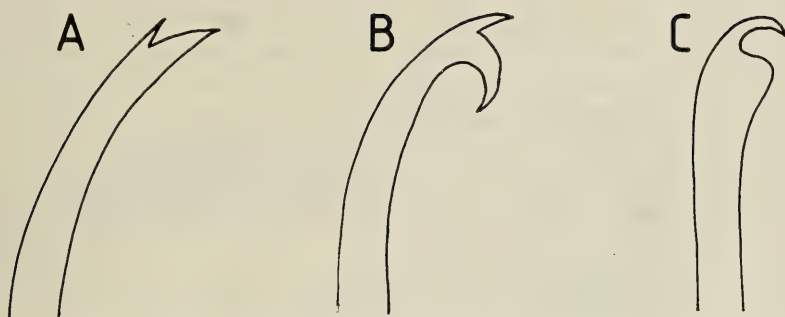


Fig. 2. *Phalloedrillus boeschi*, free-hand drawings of setae: A, Anterior seta; B, Posterior, dorsal seta; C, Penial seta.

shaped to almost horseshoe-shaped, about  $85\ \mu\text{m}$  long,  $25\text{--}35\ \mu\text{m}$  wide, with very thin outer lining, and thick, granulated inner epithelium. Anterior prostate gland very large, lobed, attached to ental end of atrium near entrance of vas deferens. Posterior prostate smaller, stalked, attached to ectal part of atrium. Ectal part of atrium abruptly tapering and terminating in small styliform pseudopenial papilla, which protrudes from wall of male bursa. Spermatheca (Fig. 1D–E)  $100\text{--}150\ \mu\text{m}$  long,  $12\text{--}37\ \mu\text{m}$  wide, consisting of short ducts and slender, thin-walled ampullae, latter with random masses of sperm.

*Remarks.*—Morphologically the new specimens from Georges Bank basically conform to the original description of *P. coeloprostatatus* from Cape Cod Bay by Cook (1969), and they are very similar to the specimens of that species reported from off New Jersey by Erséus (1979a). However, the position of the genital organ in the new material is remarkable. In none of the Georges Bank specimens are the spermathecae and male ducts located in segments X–XI as is normal for a tubificid, and as was known for all previously reported individuals of *P. coeloprostatatus*, but they are found in VII–VIII, VIII–IX, or IX–X. This forward shift is even more strongly expressed by the position of the testes (not mentioned in description above): in only one of the four specimens, the testes are located in the spermathecal segment (which is the normal tubificid situation); in all the other worms the testes are located more anteriorly, in the segment next or second next to that bearing the spermathecae.

The four worms from off Maryland exhibit a more moderate tendency towards forward shift of the genitalia; in two individuals the genitalia are in IX–X (with testes in IX), whereas the other two are “normal,” with genitalia in X–XI (testes in X).

It must be concluded here that the specimens with an aberrant location of the genitalia should not be regarded as a separate species, but as variant of *P. coeloprostatatus*. For some reason not yet understood, the otherwise so firmly fixed position of the tubificid genitalia has loosened in some populations of this species. In all other morphological respects, the specimens are identical.

Forward shift of genital organs has been reported for individuals of marine Tubificidae before (e.g., Erséus 1981b, *Giereidrillus inermis*; 1983a, *Bathydrillus sandersi* and *B. argentinae*; Erséus and Davis, 1984, a new species of *Adelodrillus*).

In brief, *P. coeloprostatatus* (sensu lato) can be described as follows: Length 3.6–10 mm, 38–60 segments. Somatic setae, with upper tooth shorter and thinner than lower, 3–5 per bundle anteriorly, (2)3–4 per bundle posteriorly. Penial setae 8–13 per bundle, in fan-shaped formations, and with ectal ends clubbed and hooked (Fig. 1C). Spermathecal pores in lateral lines. Pharyngeal glands extending into VI. Atria more or less horseshoe-shaped, 85–130  $\mu$ m long, ending in small, protruding pseudopenial papillae within a pair of shallow male bursae. Prostates very large, lobed.

*Habitat*.—Sublittoral, largely coarse sands, known from 3.4–78 m depth.

*Distribution*.—East coast of the U.S.A., from Massachusetts (Cape Cod Bay and Georges Bank) to Maryland.

*Phallodrilus boeschi*, new species

Figs. 2–3

*Holotype*.—USNM 96042.

*Type-locality*.—Off Virginia, U.S.A., 37°06.1'N, 74°33.4'W, 180–200 m, mixed sand, Mar 1976.

*Paratypes*.—USNM 96043–96046. Four specimens from off Maryland, U.S.A., 38°17.5'N, 74°41.0'W, 29 m, medium to coarse sand, Mar 1976.

*Other material examined*.—Author's collection: three specimens from the same site as the paratypes; one specimen from off New Jersey, U.S.A., 39°43.6'N, 73°34.8'W, 37 m, medium sand, Mar 1976; and one specimen from Georges Bank, SE of Massachusetts, U.S.A., 40°39.5'N, 67°43.3'W, 72 m, medium to coarse sand, Jul 1982.

*Etymology*.—The species is named for Dr. D. F. Boesch (now at Lumcon, Chauvin, Louisiana), principal investigator of the Bureau of Land Management baseline study from which most of the material of this species originates, and who first drew my attention to the large collection of marine oligochaetes in the Virginia Institute of Marine Science.

*Description*.—Length (fixed specimens) 2.8–4.2 mm, 28–39 segments. Diameter at XI, 0.11–0.15 mm. Clitellum extending over  $\frac{1}{2}$  X–XIII. Somatic setae (Figs. 2A–B) bifid, 25–45  $\mu$ m long, 1–2  $\mu$ m thick, 3–5 per bundle anteriorly, 2–3(4) per bundle posteriorly. Bifids with upper tooth much shorter and thinner than lower. Anterior setae (Fig. 2A) with lower tooth straight, almost parallel to upper tooth. Posterior dorsal setae (Fig. 2B) with lower tooth characteristically curved downwards, somewhat prolonged. Setae of mid-body and posterior ventral bundles intermediate. Ventral setae of XI modified into penial bundles (Figs. 3A–B, ps), each of which contains about 10–15 (exact number very difficult to establish) small, straight setae, 20–26  $\mu$ m long, maximally 1  $\mu$ m thick. Penial setae ectally clubbed, with a strongly bent apical tooth (Fig. 2C). Male pores in line with ventral somatic setae, posterior to middle of XI. Spermathecal pores near lateral lines, in most anterior part of X.

Pharyngeal glands inconspicuous, but extending as far back as into VII or VIII(IX?). Male genitalia (Fig. 3) paired. Vas deferens coiled, 7–9  $\mu$ m wide, much longer than atrium. Atrium small, more or less comma-shaped, about 35  $\mu$ m long, 12–20  $\mu$ m wide, with very thin (up to 1  $\mu$ m) muscular lining; ectal part of inner epithelium of atrium granulated, cilia not seen. Prostate glands compact and stalked. Anterior prostate attached with broad stalk to middle of atrium. Posterior



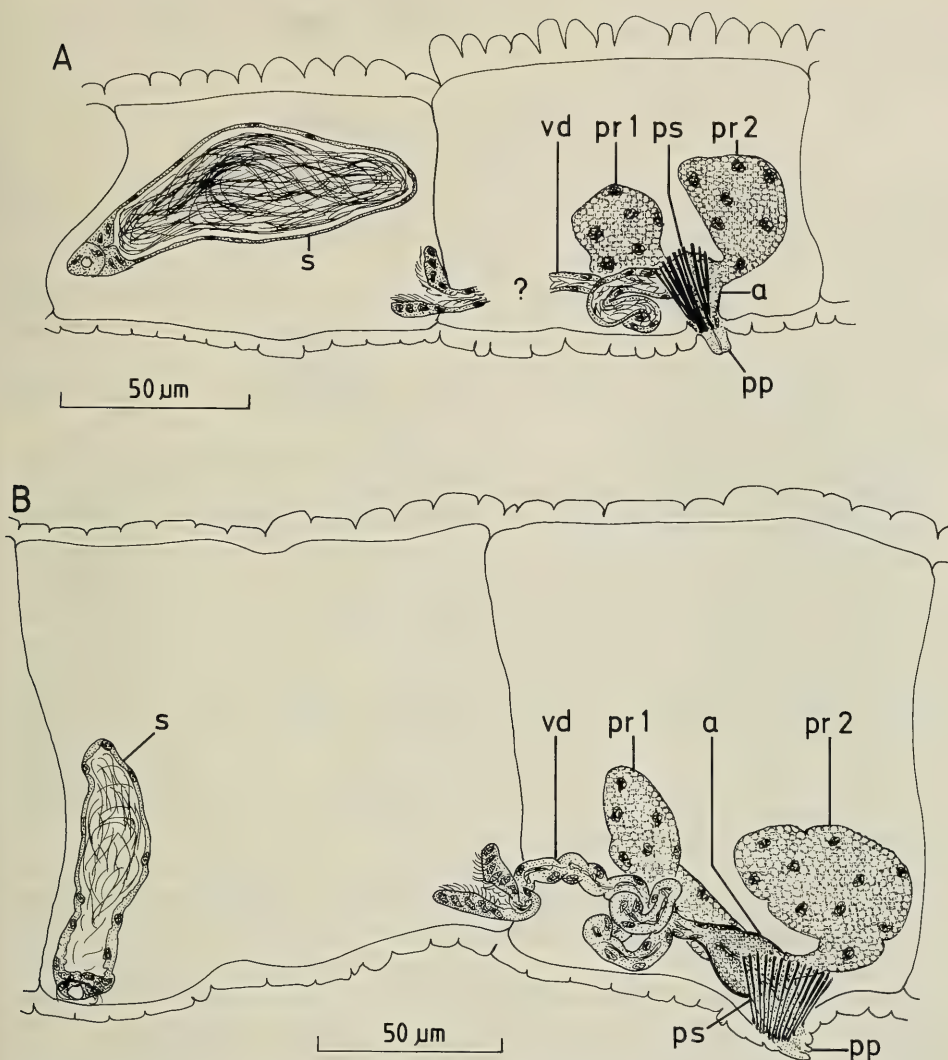


Fig. 3. *Phallodrilus boeschi*, lateral view of spermathecae and male ducts in segments X-XI: A, Specimen from Georges Bank; B, Specimen from off Virginia (holotype). s, spermatheca; other abbreviations as for Fig. 1.

prostate more ectally attached to (posterior face of) atrium. Atrial opening a simple pore lateral to penial setae, but in some specimens ectal end of atrium somewhat protruded to form small pseudopenis (Figs. 3A-B, pp). Spermathecae (Figs. 3A-B, s) 50–65 µm long, maximally 20–30 µm wide, with indistinct and very short ducts, and thin-walled ampullae; latter with random masses of sperm.

**Remarks.**—This species is closely related and superficially very similar to *P. coeloprostatatus*. However, it is easily distinguished from the latter by the shape of its posterior, dorsal setae (Fig. 2B), and by the small size of its atria; length only about 35 µm as opposed to 85–130 µm for *P. coeloprostatatus*.

**Habitat.**—Sublittoral, medium to coarse sand, known from 29–200 m depth.

*Distribution.*—East coast of the U.S.A., from Massachusetts (Georges Bank) to Virginia.

*Phallodrilus flabellifer*, new species

Fig. 4

*Holotype.*—USNM 96047.

*Type-locality.*—Georges Bank, SE of Massachusetts, U.S.A., 40°39.6'N, 67°45.8'W, 78 m, coarse sand, May 1983.

*Paratypes.*—USNM 96048–96049. Two specimens from Georges Bank: one from 40°39.5'N, 67°46.2'W, 79 m, medium to coarse sand, May 1983; and one from 40°39.5'N, 67°45.4'W, 78 m, coarse sand, May 1983.

*Other material examined.*—Author's collection: one specimen from the type-locality.

*Etymology.*—The name *flabellifer* (Latin for “fan-bearing”) alludes to the fan-shaped arrangement of the penial setae of this species.

*Description.*—Length (fixed, complete specimens) 3.0–3.3 mm, 29–34 segments; one specimen, which is not complete but very stretched, is 4.5 mm long, but still only consisting of first 28 segments. Diameter at XI, 0.11–0.16 mm. Clitellum extending over XI and at least anterior half of XII, but poorly developed in available specimens. Somatic setae (Fig. 4A) bifid, with upper tooth thinner and slightly shorter than lower. Bifids 35–45  $\mu$ m long, 1–1.5  $\mu$ m thick, 2 per bundle throughout body. Ventral setae of XI modified into penial bundles (Fig. 4C, ps), each of which containing 13–15 straight, ectally hooked (Fig. 4B) setae, arranged in fan-shaped formation. Penials 30–37  $\mu$ m long, about 1.5  $\mu$ m thick. Male pores in line with ventral setae posteriorly in XI. Spermathecal pores in line with ventral setae in most anterior part of X.

Pharyngeal glands in III–IV(V), poorly developed. Male genitalia (Fig. 4C) paired. Vas deferens about 5  $\mu$ m wide, thin-walled and very long, entering apical end of atrium. Atrium somewhat spindle-shaped, only slightly curved, 60–80  $\mu$ m long, 17–25  $\mu$ m wide, with 1–2  $\mu$ m thick outer lining of muscles, and inner granulated and ciliated epithelium. Lumen of atrium wide. Prostate glands moderately large, anterior one attached to apical end of atrium, near entrance of vas deferens, posterior one to ectal end of atrium. Atrium opening directly on body surface immediately anterior to ectal ends of penial setae. Spermathecae with distinct ducts, 35–50  $\mu$ m long, 11–14  $\mu$ m wide, and thin-walled ampullae, 70–120  $\mu$ m long, 23–35  $\mu$ m wide; latter with loose and random sperm.

*Remarks.*—The fan-shaped penial bundles of *P. flabellifer* are reminiscent of those of *P. coeloprostatatus* and *P. boeschi*, but the new species differs from the others in two important respects: (1) its somatic setae are arranged in bisetal bundles throughout the body, whereas most bundles of *P. coeloprostatatus* and *P. boeschi* each contain 3, 4 or 5 setae; and (2) its atria are spindle-shaped and hollow (lumen and ciliation easily seen), whereas the atria are of other shapes and with very narrow lumens in the other two species.

*Phallodrilus obscurus* Cook, 1969, which was redescribed on the basis of fully mature specimens by Erséus (1980a), is possibly also a close relative of *P. flabellifer*. That species, however, has a very high number of somatic setae (up to 7

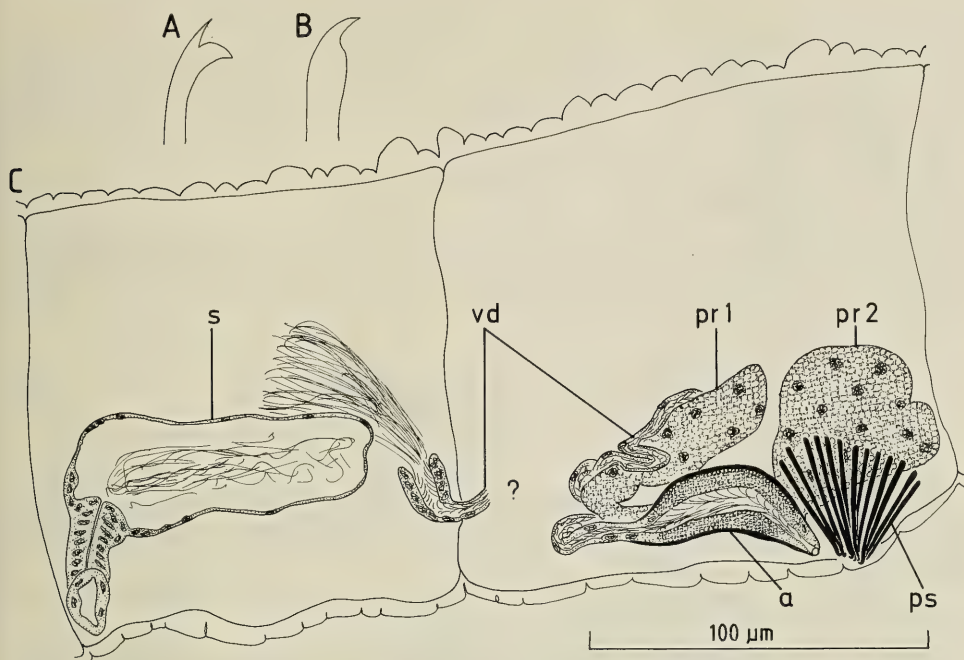


Fig. 4. *Phallodrilus flabellifer*. A, Free-hand drawing of somatic seta; B, Free-hand drawing of penial seta; C, Lateral view of spermatheca and male duct in segments X–XI. Abbreviations as for Fig. 3.

per bundle anteriorly) and its penial setae are more or less parallel within the bundles, not arranged in a fan as in *P. flabellifer*.

*Habitat*.—Sublittoral, largely coarse sand, known from 78–79 m depth.

*Distribution*.—Known only from Georges Bank, SE of Massachusetts.

*Phallodrilus biprostatatus* (Baker and Erséus, 1979), new combination

*Peosidrilus biprostatatus* Baker and Erséus, 1979:506–508, figs. 1–2 [Note that due to a typographical error the legend of fig. 2 was deleted from a part of the circulation of this publication. It should read: “Fig. 2. *Peosidrilus biprostatatus*: Lateral view of spermatheca and male genitalia in segments X and XI. Abbreviations: a, atrium; p, penis; pr 1 and pr 2, prostate glands; psa, penial sac; pse, penial setae; s, spermatheca; vd, vas deferens.”].—Erséus and Loden 1981: 819–820.

*Remarks*.—This species was described from sublittoral sediments off New Jersey and North Carolina (Erséus and Baker 1979), and subsequently reported from a similar habitat off the E coast of Florida (Erséus and Loden 1981).

The species is characterized by a pair of large penes with bulbous bases, separated from the atria proper by constrictions, and *P. biprostatatus* was, because of this striking feature, assigned to a monotypic genus, *Peosidrilus* Baker and Erséus, 1979. However, in other important characters, such as the penial setae (apically



clubbed and hooked), atria and prostate glands, the species is very similar to most of the *Phallodrilus* species treated in the present paper. It is now concluded that the penis of *Peosidrilus biprostatus* is just an elaboration of the pseudopenial structure found in several *Phallodrilus* forms, and consequently, the species is here transferred to the latter genus.

*Habitat*.—Sublittoral, medium to very coarse sands, known from 5.5–73 m depth

*Distribution*.—East coast of the U.S.A., so far recorded from New Jersey to Florida, but the species has recently been found on Georges Bank, SE of Massachusetts (Mr. D. Davis, pers. comm.).

*Phallodrilus caviatriatus*, new species

Fig. 5

*Holotype*.—USNM 96050.

*Type-locality*.—River Bay, NE Barbados, West Indies, inner end of bay at mouth of a stream, low water mark, coarse sand, probably often subject to brackish-water conditions; 27 Oct 1979.

*Paratypes*.—USNM 96051–96052. One sectioned and one whole-mounted specimen from the type-locality.

*Other material examined*.—Author's collection: one specimen from the type-locality.

*Etymology*.—The name *caviatriatus* refers to the hollow (=Latin “cavus”) nature of the atrium of this species.

*Description*.—Length (fixed specimens) 3.9–4.6 mm, 40–45 segments. Diameter at XI, 0.23–0.29 mm. Clitellum extending over  $\frac{1}{2}$  X– $\frac{3}{4}$  XII in whole-mounted paratype, poorly developed in other specimens. Somatic setae (Fig. 5A) bifid, with upper tooth thinner and slightly shorter than lower, and often with thin ligament connecting tip of lower tooth with setae shaft. Bifids 35–50  $\mu$ m long, 1.5–2.5  $\mu$ m thick, 2–3 per bundle anteriorly, 2 per bundle in postclitellar segments (occasionally “bundles” unisetal, or missing). Ventral setae of XI modified into penial bundles (Fig. 5D, ps), each of which containing about 13–18 (exact number often difficult to establish) straight, ectally clubbed setae, 40–55  $\mu$ m long, about 2  $\mu$ m thick. Ectal “clubs” of penials bearing a strongly curved apical tooth, but only seen in side view (see Fig. 5B). Penial setae located immediately ventral to male openings, at bases of penes. Male pores in line with ventral setae, posteriorly in XI. Spermathecal pores slightly dorsal to line of ventral setae, in most anterior part of X.

Pharyngeal glands extending into V, and most anterior part of VI. Male genitalia (Fig. 5C–D) paired. Vas deferens 9–12  $\mu$ m wide, slightly shorter than atrium, entering apical, ental end of atrium. Atrium cylindrical, hollow, characteristically bent at middle, with conspicuous circular muscles, 5–9  $\mu$ m thick, and ciliated inner epithelium; epithelium much thinner in ental part than in ectal part of atrium; atrium about 150–200  $\mu$ m long (exact length difficult to establish), ental part 45–60  $\mu$ m wide, ectal part 30–35  $\mu$ m wide; ectal part tapering into slender duct leading to wedge-shaped, rounded penis (cf. Fig. 5C). Two compact, small prostate glands present, one at entrance of vas deferens, another located posterior to, and attached to, atrial duct; stalks of prostates not well developed. Sperma-

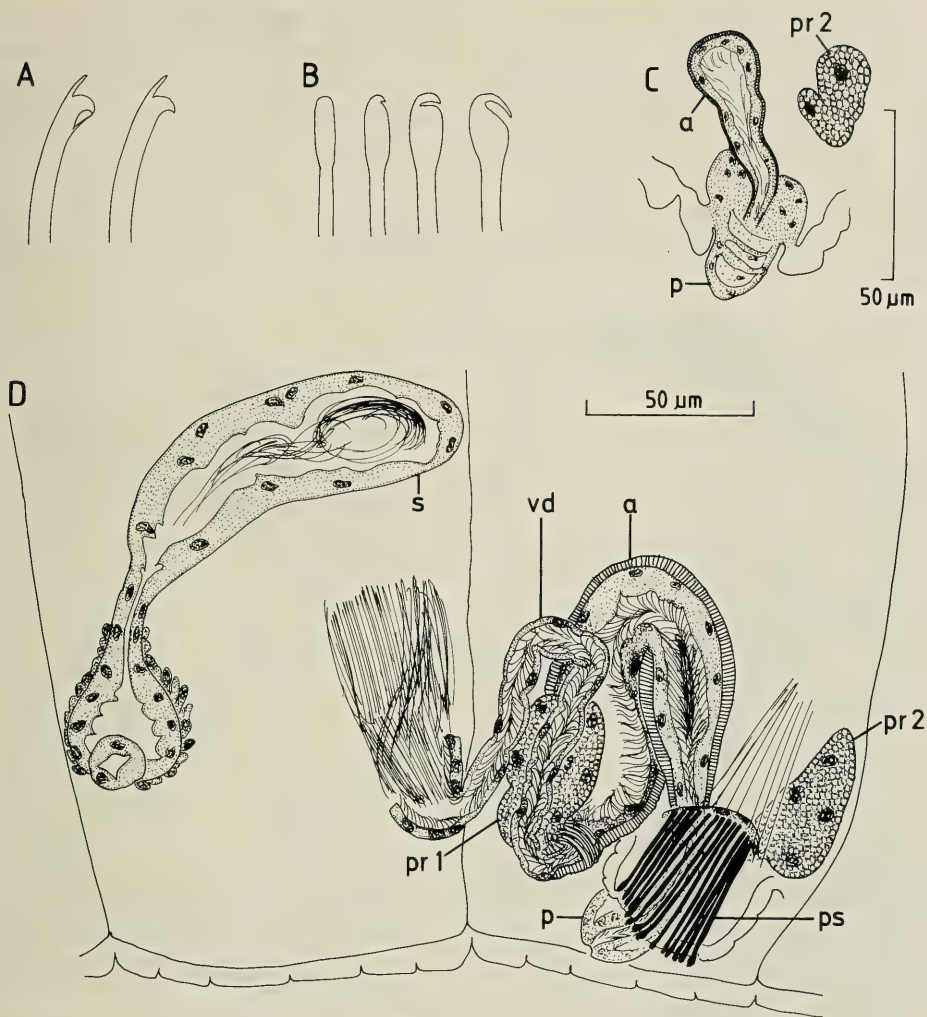


Fig. 5. *Phallodrilus caviatriatus*: A, Free-hand drawings of somatic setae; B, Free-hand drawings of penial setae, as seen from different angles; C, Section through terminal part of atrium and penis; D, Lateral view of spermatheca and male duct in segments X-XI. p, penis; other abbreviations as for Fig. 3.

thecae (Fig. 5D, s) slender, consisting of 80–90  $\mu\text{m}$  long ducts, and 70–115  $\mu\text{m}$  long, 40–45  $\mu\text{m}$  wide ampullae; ducts with bulbous outer portion, 30–45  $\mu\text{m}$  wide, and narrow inner portion, only about 10–12  $\mu\text{m}$  wide; ducts gradually widening into ampulla, having thick walls and containing random sperm.

**Remarks.**—The hollow ental half of the atrium is the most striking feature of *P. caviatriatus*, and it clearly distinguishes the species from other *Phallodrilus*. The penes are similar to, but not quite as pendant and deeply located within the penial sacs as, those of *P. biprostatus*.

**Habitat.**—Intertidal coarse sand.  
**Distribution.**—Known only from the type-locality in Barbados.

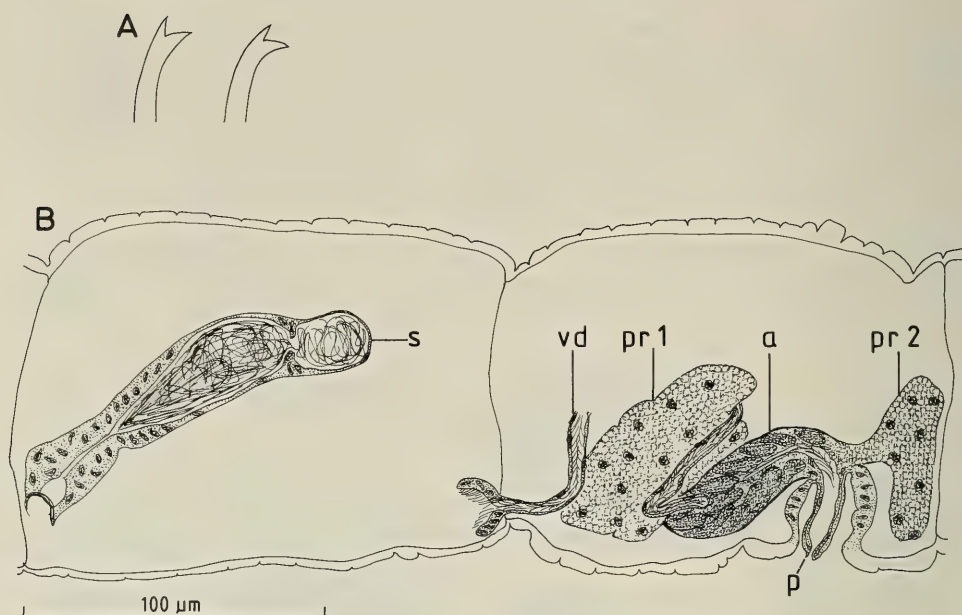


Fig. 6. *Phallodrilus davis*: A, Free-hand drawings of setae; B, Lateral view of spermatheca and male duct in segments X–XI. Abbreviations as for Fig. 5.

*Phallodrilus davis*, new species

Fig. 6

*Holotype*.—USNM 96053.

*Type-locality*.—Georges Bank, SE of Massachusetts, U.S.A., 40°39.6'N, 67°45.8'W, 78 m, coarse sand, May 1983.

*Paratypes*.—USNM 96054–96055. Two specimens from Georges Bank: one from 40°39.5'N, 67°46.5'W, 79 m, coarse sand, May 1983; and one from 40°39.4'N, 67°46.9'W, 80 m, medium to coarse sand, May 1983.

*Other material examined*.—Author's collection: one specimen from 40°39.3'W, 67°46.2'W, 79 m, medium to coarse sand, May 1983.

*Etymology*.—This species is named for Mr. Dale Davis (Battelle New England Marine Research Laboratory), who very kindly provided the material of *Phallodrilus* from Georges Bank.

*Description*.—Length (fixed specimens) 3.4–4.4 mm, 36–41 segments. Diameter at XI, 0.12–0.18 mm. Clitellum extending over at least XI– $\frac{1}{2}$  XII (not fully developed in some specimens). Setae (Fig. 6A) bifid, with upper tooth thinner and shorter than lower. Setae 40–70 μm long, 1.5–2.5 μm thick, (2)3–4 per bundle throughout body except for ventral bundles of XI, which are absent. Male pores in line with ventral setae in posterior part of XI. Spermathecal pores in line with ventral setae in most anterior part of X.

Pharyngeal glands in III–IV, but poorly developed. Male genitalia (Fig. 6B) paired. Vas deferens about 4–5 μm wide, long and thin-walled, entering atrium subapically. Atrium sigmoid- to comma-shaped, 65–85 μm long, 21–32 μm wide, with very thin outer lining of muscles and thick inner granulated and (at least



partly) ciliated epithelium; granulation of atrium confined to drop-shaped aggregations (each one an epithelial cell?). Anterior prostate gland large, attached to apical end of atrium. Posterior prostate smaller than anterior one, stalked and attached to most ectal end of atrium. Atrium terminating in cylindrical, ectally somewhat pointed penis, latter pendant within penial sac. Penis 25–30  $\mu\text{m}$  long, 6–12  $\mu\text{m}$  wide at middle, hollow, and appearing stiff, but cuticular lining not thickened into sheath. Spermathecae (Fig. 6B, s) slender, about 125  $\mu\text{m}$  long, maximally 25–40  $\mu\text{m}$  wide, consisting of ectal ducts, gradually widening into thin-walled ampullae; lumen of latter often incised at one or more places; sperm as random masses.

*Remarks.*—*Phallodrilus davis*i is the only known species of *Phallodrilus* which combines the possession of true, pendant penes with the lack of penial setae.

*Habitat.*—Sublittoral, largely coarse sands, known from 78–80 m depth.

*Distribution.*—Known only from Georges Bank, SE of Massachusetts.

### Modified Definition of the Genus *Phallodrilus* Pierantoni, 1902

Diverse group of predominantly marine tubificids. Hair setae absent. Penial setae generally present. Spermathecal setae occasionally present. Male and spermathecal pores paired, generally in segment XI and X, respectively (exceptions, see *P. coeloprostatus* above, and *P. postspermathecatus* Erséus, 1980b). Coelomocytes, if present, small and sparse, not of the “rhyacodriline-type.”

Male efferent ducts paired. Vasa deferentia ciliated, not dilated and storing sperm, but (generally) narrow and clearly set off from atria. Vasa deferentia join apical or subapical, ental ends, but never ectal halves of atria. In some species copulatory structures present, as protrusible pseudopenes or non-cuticularized true penes. Two pairs of prostate glands present; the anterior pair always attached to atria near entrances of vasa deferentia, posterior pair generally attached to ectal ends of atria; prostates often stalked. Spermathecae paired, generally longer than wide. Sperm in loose masses or bundles in spermathecae; spermatozeugmata and external spermatophores absent.

*Type-species.*—*Phallodrilus parthenopa*eus Pierantoni, 1902.

### Discussion

The definition of the genus *Phallodrilus* provided above has been modified to include some species with true penes (*biprostatus*, *caviatriatus* and *davis*i; all treated in the present paper). It excludes, however, some other phallodriline species with penes, such as the members of the genera *Aktedrilus* Knöllner, 1935, and *Bacescuella* Hrabě, 1973 (see Baker and Erséus 1982; Erséus 1978, 1980c, 1984a–c; Erséus and Kossmagk-Stephan 1982; Finogenova and Shurova 1980; Hrabě 1973; Strehlow 1982). In these genera the spermathecae, when present, are unpaired, middorsal, and the penes are certainly not homologous to those of the three *Phallodrilus* species mentioned above. In addition, in *Bacescuella* sperm are transferred by means of external spermatophores, a mode not known for any other genus within the Phallodrilinae.

In the previous definition (Erséus 1979a), it was stated: “alimentary canal absent in some species.” This sentence is now deleted, as the gutless species of *Phallodrilus* will be removed from that genus in a separate revision (Erséus, in press).

A great taxonomic problem with *Phallodrilus* is that the male efferent ducts of most of its species conform to a basic phallodriline plan, from which the male ducts of most other genera within the subfamily can be derived. This means that *Phallodrilus*, as defined here and previously, is a paraphyletic rather than a strictly monophyletic taxon (a "paraphyletic" group does have and includes a common ancestor, but it does not include all the descendants of that ancestor). Unfortunately, there does not seem to be any way out of this dilemma. A widening of *Phallodrilus* to a level where one would be confident that it was a strictly monophyletic group would imply that virtually all of the 15 phallodriline genera were united to form one large genus, which would hardly be beneficial for the classification of the very diverse subfamily Phallodrilinae. On the other hand, a splitting of today's *Phallodrilus* into smaller, monophyletic genera is, at present at least, impossible. One can of course recognize several species groups within *Phallodrilus*, which within themselves are monophyletic and can be defined on the basis of their synapomorphies, but if all these groups were raised to the level of genera, the remaining species would just become a large, most probably polyphyletic group, defined only by its plesiomorphic characters.

It is, therefore, considered appropriate to accept that *Phallodrilus* remains paraphyletic, but to define it in a way which allows for some short lineages of derived species; *P. biprostatus*, *P. caviatriatus* and *P. davis*i are examples of such derived species. It is a much different situation with large, coherent groups, such as *Aktedrilus* (references given above) and *Adelodrilus* Cook, 1969 (see Erséus 1983b; Erséus and Davis, 1984). *Aktedrilus* now contains 16 species, *Adelodrilus* 14, and they are both easily recognized and classified as genera on the basis of their shared derived characters (synapomorphies) (*Aktedrilus*: unpaired dorsal spermatheca, well developed penes, lack of penial setae, and littoral habitat; *Adelodrilus*: dilated vasa deferentia storing sperm, and highly modified penial setae).

Most of the *Phallodrilus* species treated in the present account, viz. *P. coeloprostat*us, *P. boeschi*, *P. flabellifer*, *P. biprostatus*, and *P. caviatriatus*, share the feature of small, multiple penial setae with characteristically clubbed and apically hooked tips (Figs. 1C, 2C, 4B, 5B; Baker and Erséus 1979, fig. 1C). It is noteworthy that these are all northwest Atlantic species and that there are no other known *Phallodrilus* with this kind of penial setae in other areas of the world. It seems feasible to regard these species as a monophyletic group within the genus and that it has evolved and radiated in the northwest Atlantic.

This group, however, is not the only one within the Phallodrilinae with the "clubbed and hooked" penial setae. Such setae are characteristic also for most species within *Adelodrilus* (see Erséus 1983b) and the monotypic *Bermudrilus* Erséus, 1979 (see Erséus 1979b). The geographical records of the latter genera are largely confined to the East coast of the U.S.; one species is known also from Bermuda and a few species are described from Europe (Erséus 1983b). It should be noted that the knowledge of marine Tubificiade from the northwest Atlantic is perhaps better than that from any other part of the world, but if *Adelodrilus* and *Bermudrilus* were present in, for instance, the Pacific Ocean, one would have expected these genera to turn up in the fairly extensive collections that now have been made there (the work by H. R. Baker in British Columbia; Erséus 1981a, 1984a, and unpublished). It therefore appears likely that the *Adelodrilus-Bermudrilus* lineage originated in the first area, or at least within a fauna the de-



scendants of which today inhabit this region. This would imply that the *Adelodrilus-Bermudrilus* assemblage split off relatively late from their ancestral stock within (most probably) *Phallodrilus*, a stock probably closely related to the Recent group of *Phallodrilus* treated in the present paper. The high number of closely related species of *Adelodrilus* within one restricted area (the U.S. east coast continental shelf; Erséus 1983b, Erséus and Davis, 1984) demonstrates how successful and radiative speciation has been within this particular group.

### Acknowledgments

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## AN EXTINCT SPECIES OF *LEIOCEPHALUS* FROM HAITI (SAURIA: IGUANIDAE)

Gregory Pregill

*Abstract.*—At least five species of the endemic West Indian lizard genus *Leiocephalus* are known only by fossils excavated from cave deposits in the Greater and Lesser Antilles. Fossils of yet another extinct species were recently found in a crate of matrix that was collected over 50 years ago from caves near St. Michel de l'Atalye, Haiti. This new form, *L. anonymus*, has a partially closed Meckelian groove, a condition structurally intermediate between the fully open groove of the extinct species *L. apertosulcus*, and the completely closed and fused groove characteristic of all other living and fossil species of *Leiocephalus*.

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One of the first assemblages of fossil vertebrates reported from the West Indies came from cave deposits in north central Haiti, northeast of the town of St. Michel de l'Atalye in the Département L'Artibonite. Descriptions of these caves and the bones of mammals found therein were published in a series of papers by Gerrit S. Miller (1922, 1926, 1929). Alexander Wetmore (1922) described some of the fossil birds, and Arthur J. Poole (1929) wrote additional descriptions of several more sites in the vicinity. Yet except for a comment on lizards by Hecht (1951) and Rímoli's (1976) review of the fossil rodents of Hispaniola, almost nothing has been written on the fossil material since its initial discovery.

All of the fossils and unsorted matrix from the St. Michel caves that were collected in the 1920s had been deposited with the Division of Vertebrate Paleontology, National Museum of Natural History, Smithsonian Institution. Some of the matrix remained in two shipping crates, each bearing a hand-written label identifying the contents as "small material from caves of Haiti, contains small shells, lizard jaws, etc. Has been sorted for small mammal remains." Each label had been initialed "P," presumably for Arthur J. Poole. Inside one crate was a note stating "Cave 1. Discarded material carefully worked over—Poole." "Cave 1" possibly refers to the first of three caves that Poole (1929:59) called the "San Francisco group . . . situated about three miles to the west of L'Atalaye and about one mile east of the village of St. Michel." While casually picking through this matrix recently I found that most of the fossils of mammals and birds had indeed been removed, yet abundant remains of lizards were still present. Among them were bones of the iguanid lizard *Leiocephalus*, a genus endemic to the West Indies and presently confined to the Greater Antillean Islands of Cuba, Hispaniola, and the Bahamas. Elsewhere in the West Indies at least five extinct species are known: Jamaica (Etheridge 1966a), the Dominican Republic (Etheridge 1964), Puerto Rico (Pregill 1981), and the Leeward Islands of Barbuda, Antigua and Anguilla (Etheridge 1964; Pregill, in prep.).

The fossils from St. Michel share certain similarities with the extinct species *Leiocephalus apertosulcus* that was described by Etheridge (1965), based on material collected from cave deposits in the Cerro de San Francisco, La Estrellata

Province, Dominican Republic. Yet consistent differences are apparent, especially in the partially closed Meckel's groove in the St. Michel lizards. The dentary is structurally intermediate between the completely open groove of *L. apertosulcus* and the closed and fused condition obtained in all other species of the genus. These and other features of this new *Leiocephalus* are described below.

Measurements were made with an eyepiece reticle on a Wild M8 stereomicroscope and read to the nearest 0.1 mm. Comparative skeletal material of *Leiocephalus* included representatives of 20 of 22 living species in the collections of the National Museum of Natural History, Smithsonian Institution (USNM), Museum of Comparative Zoology (MCZ), and Richard Etheridge (REE—San Diego State University). Notes and measurements on all fossil species of *Leiocephalus* were available from a previous study (Pregill 1981); the type material of *L. apertosulcus* was in hand. Estimates of snout to vent length of fossil individuals, hereafter referred to as SVL, are derived from the simple procedure of comparing ratios of measurements with modern individuals of known size (Pregill 1981).

*Leiocephalus anonymus*, new species

Fig. 1

*Holotype*.—USNM 340182, a right dentary in the collection of the Division of Vertebrate Paleontology.

*Locality and horizon*.—An unspecified cave(s) near St. Michel de l'Atalye, Département L'Artibonite, Haiti. Probably collected by Arthur J. Poole in December, 1927, in cave sediment of undetermined age, certainly no older than latest Pleistocene.

*Etymology*.—Greek, *anonymus*, nameless; in reference to the fact that fossils of this species lay buried in a crate for over fifty years, unnamed and unknown.

*Referred material*.—Dentaries: the type plus 18 left, 8 right nearly complete, and 30 fragments (USNM 340183–340185); Maxillae: 7 left, 7 right plus 17 fragments (USNM 340186–340188); Premaxilla: 1 (USNM 349192); Frontals: 5 complete and 3 partial (USNM 340189); Parietal: 1 (USNM 340190); Pterygoid: 1 partial right (USNM 34191).

*Diagnosis*.—A large species of *Leiocephalus* having Meckel's groove open except for a short distance in the middle of the dentary, usually between the twelfth and fifteenth teeth where the upper and lower borders converge and touch. The open portions of Meckel's canal expose a well-developed intramandibular septum. The pineal foramen is located wholly within the frontal bone.

*Description of Holotype*.—Tooth row 15.2 mm; length overall 18.6 mm, and height posterior to last tooth 3.4 mm; 24 pleurodont teeth of which numbers 5, 7, 8, 10 and 18 missing, front to back; estimated snout to vent length of individual in life 120 mm.

Teeth 1 through 4 plus number 6 simple, recurved and pointed; each slightly larger than tooth preceding; ninth tooth with small central cusp distinct from tooth shaft, and incipient lateral cusp on posterior side; tenth tooth and all those posteriad except for number 11 (missing crown) and number 24 (replacement tooth) with tricuspid crowns in fleur-de-lis shape typical of *Leiocephalus*. Anterior cusp of each tooth generally overlapping slightly posterior cusp of preceding tooth; shafts parallel-sided; approximately 35% of each tooth protruding above parapet



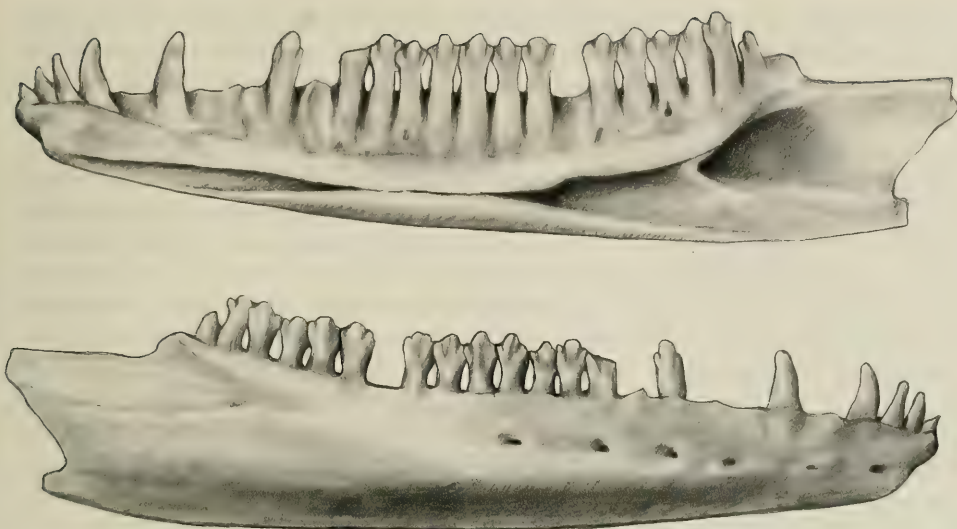


Fig. 1. Holotype of *Leiocephalus anonymus*, new species, a right dentary (USNM 340182) in lingual (above) and labial (below) view.

of jaw; teeth on holotype more abraded than those of some referred dentaries but their tricuspid condition clearly evident; on mesial side of dentary below dental shelf, Meckel's groove exposed anterior to twelfth tooth and posterior to fifteenth; between twelfth and fifteenth teeth, upper and lower borders of Meckel's groove converge and make contact, but do not fuse; within Meckel's canal well-developed intramandibular septum extending from symphysis posterior to level of last tooth; septum deeply emarginate at its posterior border.

Labial face of dentary convex throughout most of its length except for antero-ventral surface, where it is moderately flattened; horizontal row of six mental foramina perforating upper half of labial face between second and fourteenth teeth; in front of surangular process on dorsolabial surface, a deep wedge-shaped scar extending forward to level of twenty-second tooth, marking former position of anterolabial arm of coronoid.

*Other dentaries.*—Twenty-six other dentaries referred to this species are similar to the holotype in most respects. Some of these are nearly complete, others are badly worn, missing teeth or various processes and borders. Teeth missing from the holotype are present collectively on the referred specimens. The transition from simple to tricuspid teeth takes place rather abruptly between teeth 9 and 11. The number of teeth increases ontogenetically from 19 in the smallest dentary (tooth row of 9.2 mm) to 25 in the largest (tooth row 16.4 mm). These dentaries came from individuals estimated at 73 mm and 130 mm SVL, respectively. The average tooth row length for the 26 dentaries is 13.9 mm, an individual of approximately 110 mm SVL. The scar of the coronoid overlap on the dorsolabial surface spans a distance equivalent to 1 to 4 posteriormost teeth ( $\bar{x} = 2.1$ ), and the number of mental foramina ranges from 4 to 8 ( $\bar{x} = 5.5$ ) placed between the second and fourteenth teeth.

The most important diagnostic feature is the persistence of a partially closed

Meckelian groove near the middle of the dentary. In most cases contact is made between the upper and lower borders of Meckel's groove; in three specimens the borders actually fuse, and in two specimens Meckel's groove is continuously open.

*Maxillae*.—Fourteen nearly complete maxillae have tooth rows ranging from 11.3 mm (93 mm estimated SVL) to 15.4 mm (126 mm estimated SVL). The average tooth row length is 13.4 mm (110 mm estimated SVL). Tooth counts vary from 18 to 22, the number increasing with the size of the jaw. In all specimens the transition from simple to tricuspid teeth takes place at the eighth or ninth tooth. The teeth are otherwise similar to those on the dentary.

The supradental shelf is curved medially at the anterior end where it forms the premaxillary process. A prominent palatine process protrudes medially just posterior to the middle of the shelf. On the labial side of the maxilla a tall nasal process rises almost vertically above the dental row. Anterodorsally, the nasal process turns sharply mediad above the fenestra exonarina. On the nasal process immediately above the tooth row is a horizontal series of from 6 to 9 maxillary foramina placed between the third and thirteenth teeth. In one specimen the foramina are placed between the second and eleventh teeth. An additional 1 to 3 foramina penetrate the nasal process above the first 2 to 6 maxillary foramina.

*Premaxilla*.—A single premaxilla is referred to this species by its large size, and similarity to the premaxilla of other *Leiocephalus*. The rectangular incisive process is 3.6 mm wide, and bears seven simple, pointed teeth, as in all species of the genus. There is minimal inflection between the incisive process and the posteriorly directed nasal process, which is 1.4 mm wide at its base and 3.9 mm in length. The nasal process is thus relatively narrow and long in comparison to that of other species such as *L. carinatus*.

*Frontal*.—Five of the frontal bones are nearly complete; three others are missing portions of the postfrontal or nasal processes. The largest has a midsagittal length of 12.1 mm, an interorbital width of 4.2 mm, and measures 12.2 mm across the parietal border. These same measurements on the smallest complete specimen are 9.9 mm, 3.3 mm, and 9.5 mm, respectively. Overall, the frontal bone of *L. anonymus* has a gentle dorsal curvature with a rugose surface. In all specimens the pineal foramen lies wholly within the frontal bone, near the middle of the parietal border. Two deep semicircular excavations anteriorly indicate the former overlap of the nasal bones.

Ventrally, the olfactory canal is a smooth, deep fossa occupying the anterior third of the bone and bordered on either side by sharply descending subolfactory processes.

*Parietal*.—The single parietal referred to this species is missing only the distal half of the left supratemporal process. Its width at the frontal border is 10.2 mm. The width across the ends of the supratemporal processes is approximately 12.7 mm, accounting for the broken left tip. The midsagittal length is 4.7 mm. The bone probably came from a subadult individual estimated at 97 mm SVL.

The parietal table is rugose, like the frontals, and the sides converge postero-medially above the parietal fossa. On each of the anterolateral processes there is a distinct notch that in life articulates with the postorbital.

*Pterygoid*.—A single right pterygoid is missing the distal half of the quadrate process but otherwise is complete. There are no pterygoid teeth. The bone measures 5.9 mm across the tips of the palatine and ectopterygoid processes. A deep



basipterygoid notch is present for articulation with the basipterygoid process of the basisphenoid. In *Leiocephalus* the basipterygoid notch is accentuated by a pronounced ventral shelf and the ectopterygoid process is excavated on the dorsomedial surface.

*Remarks.*—Because of the unusual form of the dentary, *Leiocephalus anonymus* need only be distinguished from the extinct species *L. apertosulcus*. Indeed, one might argue that *L. anonymus* is simply a population of *L. apertosulcus* in which Meckel's groove has become partially closed. But the two differ in other respects, and some features stand apart as much or more than those of other *Leiocephalus*. Unfortunately, only a few comparably diagnostic bones are known for both taxa. For example, the premaxilla is unknown in *L. apertosulcus* but most other major skull elements have been identified (Etheridge 1965). In *L. anonymus* the premaxilla is known, but the species is otherwise represented by comparatively few cranial bones. For now, whether or not these two species are each other's closest relatives is an interpretation that depends largely on whether the open condition of Meckel's groove is primitive or derived.

In all species of *Leiocephalus* Meckel's groove is closed and fused except for a small opening anteriorly. In two fossil species, *L. etheridgei* and *L. partius* (both from Puerto Rico), Meckel's groove is open anteriorly as a narrow sulcus extending back a distance of 5 to 6 teeth (Pregill 1981). Of fifty dentaries referred to *L. apertosulcus* by Etheridge (1965) a continuously open groove was present in all but two specimens, wherein the upper and lower borders of the groove made contact below the twelfth to fourteenth teeth. Both species have a well-developed intramandibular septum (IMS), a structure found in other *Leiocephalus* only in the extinct species *L. partitus*, and the Antigua Bank form *L. cuneus*. Loss of the IMS in *Leiocephalus* and other tropidurines is thought to be a derived state correlated with closure and fusion of Meckel's groove (Pregill 1981). However, the septum is present in *L. partitus* and *L. cuneus*, two species having the Meckelian groove closed. In these, the persistence of the IMS may be the result of a reversal secondarily derived, or simply a retention of the primitive condition. I prefer the former interpretation because the complex dentary/postdentary articulation is constructed about a closed septumless Meckel's groove in most tropidurines and all extant *Leiocephalus*, clearly a monophyletic genus (Etheridge 1966b; Pregill, in prep.). By this same reasoning, the open and nearly open groove of *L. apertosulcus* and *L. anonymus* may also be a reversal and thus a shared derived character. However, Etheridge and de Queiroz (in prep.) suggest that an open Meckel's groove is plesiomorphic for iguanids. Hence, the character polarity of an open Meckel's groove and the presence of an intramandibular septum in *Leiocephalus* is still conjectural. (A review of the various tropidurine genera under way by Richard Etheridge, Darrel Frost, and myself may cast light on this interesting character complex.)

Another feature in which *L. anonymus* differs from *L. apertosulcus* is that the pineal foramen is located completely within the frontal bone. In *L. apertosulcus* and all other species except *L. semilineatus* and *L. raviceps*, the foramen is located at the frontoparietal suture, the primitive condition for iguanids (Etheridge and de Queiroz, in prep.) By comparison to *L. apertosulcus*, the frontal of *L. anonymus* is also proportionately wider between the orbits. This can be confirmed by visual inspection, and verified by comparing their ratios of interorbital width to mid-



sagittal length. The ratio averages 0.350 (0.339–0.377) in the five complete frontals of *L. anonymus*, and 0.315 (0.300–0.329) in frontals of *L. apertosulcus*. In fact, the difference in these ratios increases ontogenetically in this sample of individuals, estimated at from 85 mm to 130 mm SVL.

Differences also exist in the shape of the supratemporal processes of the parietal. In *Leiocephalus* the sides of the parietal table converge posteromedially with increased body size (Etheridge 1966b), whereas the shape of the supratemporal processes remains more or less unchanged during growth. Those of *L. apertosulcus* are flared dorsoventrally and are deeply emarginate; in *L. anonymus* the processes are narrower and not as excavated.

Differences in the maxilla and pterygoid bones between these two species are subtle; in fact, neither bone varies significantly among *Leiocephalus*. Pterygoid teeth are absent from both, but they have also been lost in most other species of the genus. The maxillae differ principally in that the transition to tricuspid teeth takes place variably between teeth 5 and 8 in *L. apertosulcus*, and rather abruptly at tooth 8 or 9 in *L. anonymus*. The transition to tricuspid teeth in *Leiocephalus* is subject to some ontogenetic increase (i.e., more posteriad), but there is an observable pattern throughout the genus. In some species the transition is consistently anterior at about the fourth or fifth tooth, as in *L. cuneus*. In other species such as *L. cubensis* the transition is as far posteriad as the tenth or eleventh tooth. The latter is probably the more derived condition (Pregill, in prep.).

*Leiocephalus apertosulcus* may have obtained a larger maximum adult size than *L. anonymus*. My calculations concur with Etheridge's estimates that *L. apertosulcus* was at least 150 mm snout–vent length, and possibly as much as 200 mm. *Leiocephalus anonymus*, on the other hand, probably obtained an average maximum size between 120 and 130 mm SVL. These figures may be influenced by sampling bias in the fossil record. It is curious, however, that both these species plus the other extinct forms *L. jamaicensis* and *L. cuneus* achieved a snout–vent length greater than any living species. Among living members only *L. carinatus* and *L. melanochloris* approach 120–130 mm.

Characters in which the two species are similar include the transition to tricuspid teeth on the dentary, the length of the coronoid overlap on the dentary's dorsolabial surface, and the number of mental and maxillary foramina. Of these, only the transition to tricuspid teeth has any phylogenetic utility. The other features vary individually and ontogenetically within *Leiocephalus* and are of little or no use as systematic characters. As with maxillary teeth, the transition to tricuspid teeth on the dentary occurs as far anteriorly as the third or fourth tooth in some species, and posteriorly at the eleventh or twelfth tooth in others.

The distribution of *Leiocephalus* in the West Indies today is obviously relictual, yet the causes of extinction within the group are unclear. Some extinctions may be related to changes in climate and sea level at the end of the Pleistocene 10–12,000 years ago (Pregill and Olson 1981), whereas others are probably much more recent and due to environmental disturbances wrought by early human colonization in the Antilles (Steadman *et al.*, 1984). Neither Miller (1922, 1926, 1929) nor Poole (1929) speculated much about the ages of the bone-bearing sediments from St. Michel, but like all other cave deposits thus far known from the West Indies, they are certainly no older than Late Pleistocene. Supposedly, some of the St. Michel sites were at least pre-Amerindian, others apparently were

contemporaneous with early human occupation of the region. I did find bones of *Rattus* in the crates of matrix from which the fossils of *L. anonymus* were removed. Unfortunately, collecting techniques were often haphazard in earlier days and surface sediments could have been mixed with several deeper layers, or contaminated in other ways. Hence, we cannot be totally confident that *L. anonymus* actually survived into post-Columbian time, that is, after *Rattus* had been introduced. A recent extirpation is not unlikely in view of the compelling evidence for human-caused extinction of small vertebrates in the West Indies (Steadman *et al.*, 1984).

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## THREE NEW SPECIES OF *ADELODRILUS* (OLIGOCHAETA: TUBIFICIDAE) FROM GEORGES BANK (NW ATLANTIC)

Christer Erséus and Dale Davis

*Abstract.*—Species of *Adelodrilus* Cook (subfamily Phallodrilinae) are reported from Georges Bank, SE of Massachusetts (U.S.A.). *Adelodrilus inopinatus*, n. sp., *A. correptus*, n. sp. and *A. pilatus*, n. sp. are described, and taxonomic notes are given for *A. anisosectus* Cook, *A. multispinosus* Erséus, and *A. cristatus* Erséus. All six species are interstitial forms inhabiting sublittoral, coarse sands.

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In the course of the "Georges Bank Benthic Infauna Monitoring Program," performed by Battelle New England Marine Research Laboratory for the Minerals Management Service, U.S. Department of the Interior, six species of the marine, meiofaunal tubificid genus *Adelodrilus* Cook, 1969 (subfamily Phallodrilinae) were encountered. Three of these are new to science and they are described in the present paper, which also provides taxonomic notes on the other three species found.

*Adelodrilus* was taxonomically revised by Erséus (1978), and subsequently treated in supplementary works by Erséus (1979, 1983), and Erséus and Loden (1981). With the new forms described here, the list of Northwest Atlantic *Adelodrilus* species is increased to ten (Erséus 1983, fig. 5A).

### Material and Methods

The material used in this study was sorted from grab samples collected on Georges Bank, SE of Massachusetts (U.S.A.). The worms were fixed in formalin, subsequently stored in 70% isopropanol, finally stained with paracarmine or haematoxylin and mounted whole in Canada balsam.

A few specimens of *A. inopinatus*, n. sp. were also found in material originating from a Bureau of Land Management baseline marine study undertaken by Virginia Institute of Marine Sciences.

The type-series of the new species are deposited at the U.S. National Museum of Natural History (USNM), Washington, D.C.

### *Adelodrilus anisosectus* Cook, 1969

*Adelodrilus anisosectus* Cook, 1969:13-15, fig. 3.—Erséus 1978:138-139, fig. 3; 1979, figs. 3F-J.

*New material examined.*—Authors' collections: two specimens from off Massachusetts (Georges Bank), 40°39.5'N, 67°41.9'W, 75 m, medium to coarse sand (Feb 1983).

*Remarks.*—*Adelodrilus anisosectus*, which is the type-species of the genus, was previously known only from Cape Cod Bay (Massachusetts) (Cook 1969, 1971).

The new material conforms with the original description with one exception:



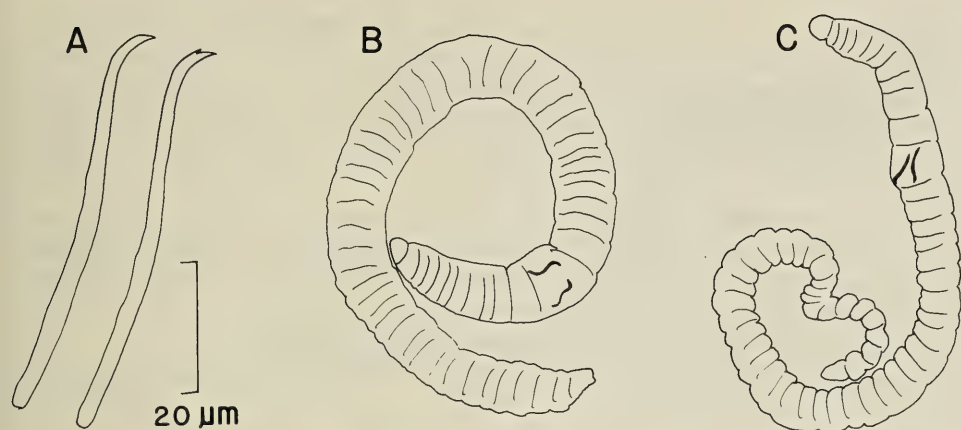


Fig. 1. A–B, *Adelodrilus multispinosus*: A, Dorsal, posterior somatic setae; B, Outline of whole worm (whole-mounted), 4.1 mm long; C, *Adelodrilus inopinatus*, outline of whole worm (whole-mounted), 4.3 mm long.

in the new worms the spermathecal pores are located between the lines of the ventral setae and the lateral lines, not in line with the ventral setae as stated by Cook (1969).

The species shares the feature of sharply single-pointed, somewhat enlarged setae in posterior dorsal bundles with *A. multispinosus* and *A. inopinatus*, n. sp. (both treated below). *Adelodrilus anisosetosus* is distinguished from these two species by the more or less equal size of the smaller penial setae within the bundle (Erséus 1978:fig. 3), as opposed to those of *multispinosus* and *inopinatus*, which are about twice as many (from 15 to about 28 per bundle) and of much varying size within the bundle (Erséus 1979:fig. 2; fig. 3).

*Habitat*.—Sublittoral, largely coarse sand, 10–79 m.

*Distribution*.—East coast of the U.S.: Cape Cod Bay and Georges Bank.

*Adelodrilus multispinosus* Erséus, 1979

Fig. 1A–B

*Adelodrilus multispinosus* Erséus, 1979:421–423, figs. 2, 3B–E.

*New material examined*.—Authors' collections: seven specimens from off Massachusetts (Georges Bank): one from 40°35.0'N, 67°11.7'W, 140 m, medium to coarse sand (Jul 1982); one from 40°39.5'N, 67°44.7'W, 72 m, medium to coarse sand (Jul 1982); one from 40°39.6'N, 67°45.8'W, 78 m, coarse sand (May 1983); and four from 40°39.5'N, 67°41.9'W, 75 m, medium to coarse sand (Feb 1983). The junior author checked a large number of additional specimens for consistency regarding body shape and setal characters.

*Remarks*.—This species was originally described from off New Jersey (Erséus 1979); the new material thus extends the known range northward to off Massachusetts.

The new worms are variable in size (2.5–8.2 mm long, 36–67 segments), but all are uniformly wide throughout their body length (Fig. 1B). The latter feature distinguishes it from the closely related *A. inopinatus*, n. sp. (see below).

It was noted in the original description that setae in the dorsal bundles of the posterior end of the body are sharply single-pointed. However, some of the setae in these bundles do have a reduced, very thin upper tooth, and it is possible that the single-pointed versus bifid nature of the setae simply is a matter of angle from which they are viewed (Fig. 1A); i.e., all somatic setae of *A. multispinosus* may actually be bifid.

Up to about 28 smaller penial setae per bundle were counted in the new individuals. In some worms the lengths of the penial setae slightly exceed the values given originally (giant penial seta up to about 175  $\mu\text{m}$  long, anteriormost smaller penial seta up to about 108  $\mu\text{m}$  long).

*Habitat*.—Sublittoral, medium to coarse sands, 25–140 m.

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

*Adelodrilus inopinatus*, new species

Figs. 1C, 2–3

*Holotype*.—USNM 96056.

*Type-locality*.—Georges Bank, SE of Massachusetts, U.S.A., 40°39.5'N, 67°46.2'W, 79 m, medium to coarse sand (Feb 1983).

*Paratypes*.—USNM 96057–96058. Two specimens from type-locality.

*Other material examined*.—Authors' collections: seven specimens from off Massachusetts (Georges Bank): four from type-locality; one from 40°39.5'N, 67°46.5'W, 72 m, coarse sand (Nov 1981); one from 40°39.0'N, 67°46.1'W, 72 m, medium to coarse sand (Feb 1982); and one from 40°34.2'N, 67°12.3'W, 140 m, coarse sand (May 1982). The junior author checked a large number of additional specimens from Georges Bank for consistency regarding body shape and setal characters. Senior author's collection: seven specimens from off Maryland: five from 38°17.5'N, 74°41.0'W, 29 m, medium to coarse sand (Mar 1976); and two from 38°08.0'N, 74°13.0'W, 53 m, medium to coarse sand (Mar 1976).

*Etymology*.—The name *inopinatus* (Latin "unexpected") alludes to the fact that this species was long regarded as a variety of *A. multispinosus* by the senior author.

*Description* (based on material from Georges Bank).—Length (fixed specimens) 3.4–5.1 mm, 45–56 segments; diameter at XI in whole-mounted, slightly compressed specimens, 0.19–0.24 mm. Posterior end of body distinctly narrower than anterior (Fig. 1C). Clitellum extending over  $\frac{1}{2}$  X–XII; tall epidermal cells present ventrally and partially extending up lateral sides, anteriorly in X (Fig. 2F). Somatic setae bifid, with upper tooth shorter and thinner than lower tooth (Fig. 2A); in all ventral bundles, and in anterior and mid-body dorsal bundles. Posterior, dorsal setae (Fig. 2B) sharply single-pointed; ectally strongly curved; distinctly larger than bifid setae. Somatic setae 45–75  $\mu\text{m}$  long, 1.5–3.5  $\mu\text{m}$  thick; (2)3–4 per bundle anteriorly, (2)3(4) per bundle posteriorly. Ventral setae of XI highly modified into penial bundles, each containing: (1) one giant, slightly sigmoid seta (Figs. 2E; 3:gs), 130–168  $\mu\text{m}$  long, 8–14  $\mu\text{m}$  wide at middle, with broad inner end and ectal "spoon" ending with single-pointed, but rounded tip; (2) about 5 intermediate, smaller setae (Figs. 2D; 3:ss, Part), largest (anteriormost) about 85–115  $\mu\text{m}$  long (inner end difficult to see), 4–6  $\mu\text{m}$  thick at middle, these setae ectally provided with slightly hooked tips followed by many tiny spines; (3) high number (at least

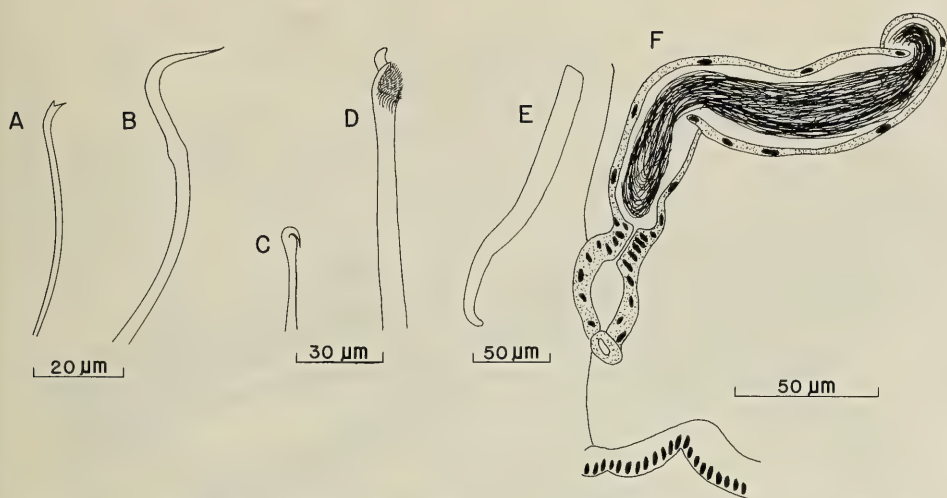


Fig. 2. *Adelodrilus inopinatus*: A, Bifid anterior somatic seta; B, Dorsal, posterior somatic seta; C, Smaller penial seta; D, Intermediate penial seta; E, Giant penial seta (different view than in Fig. 3); F, Spermatheca.

20 in many specimens) of small, ectally hooked setae (Figs. 2C; 3:ss, Part), 30–45  $\mu\text{m}$  long, 1–1.5  $\mu\text{m}$  thick. Small penial setae generally erect; giant and intermediate penial setae more or less parallel to long axis of worm. Ectal ends of penial setae located within deeply folded and complex copulatory sacs. Male pores paired, in line with ventral somatic setae posteriorly in XI. Spermathecal pores paired, in line with ventral setae in X near intersegmental furrow IX/X.

Pharyngeal glands in (IV)V–VII. Male genitalia (Fig. 3) paired. Vas deferens thin-walled and broadly dilated; longer than atrium, up to about 20  $\mu\text{m}$  wide; filled with spermatozoa; entering atrium subapically. Atrium oval; 45–70  $\mu\text{m}$  long, 27–32  $\mu\text{m}$  wide; with thin outer lining and thick, granulated inner epithelium; cilia not observed; opening into inner end of copulatory sac. Anterior prostate gland large, consisting of many lobes; attached to ental end of atrium, near junction with vas deferens. Posterior prostate smaller, attached by long stalk to ectal end of atrium. Spermathecae (Fig. 2F) with ducts 45–60  $\mu\text{m}$  long, 12–25  $\mu\text{m}$  wide, ectally dilated and entally narrow lumen; ampullae up to about 200  $\mu\text{m}$  long, 12–30  $\mu\text{m}$  wide, slender and thin-walled, sperm as random masses.

*Remarks.*—*Adelodrilus inopinatus* is similar and very closely related to *A. multispinosus*; the penial bundles of both species each contain one giant, somewhat spoon-shaped seta, and a row of about 20–25, gradually smaller setae. However, there are morphological differences between the two, differences which proved to be consistent when the junior author checked hundreds of specimens for body shape, spined versus non-spined intermediate penial setae, and shape of posterior dorsal somatic setae. *Adelodrilus inopinatus* is always tapered toward its posterior end, not as stout as *A. multispinosus* (Fig. 1B–C); its intermediate penial setae have spines ectally; and its posterior, dorsal setae are ectally much more curved and pointed than those of *A. multispinosus* (Figs. 1A, 2B).

It should be noted that the genitalia of one of the worms from Georges Bank



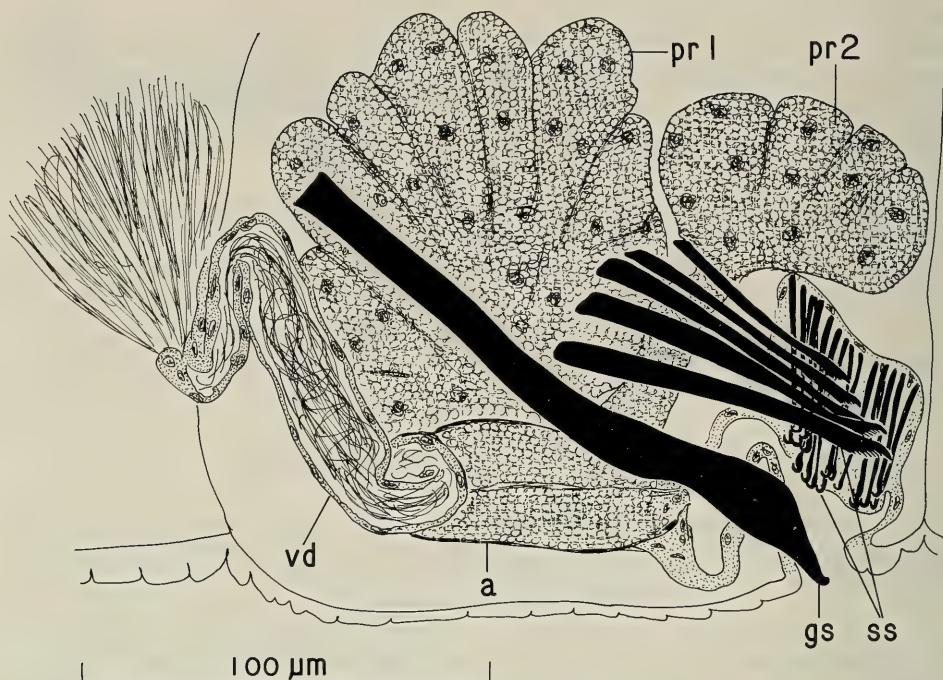


Fig. 3. *Adelodrilus inopinatus*, lateral view of male genitalia in segment XI. a, atrium; gs, giant penial seta; pr 1, anterior prostate gland; pr 2, posterior prostate gland; ss, smaller penial seta; vd, vas deferens.

area shifted forwards to segments VI–VII. This is a very unusual position for the genital organs of a tubificid, and it must be considered an intra-specific anomaly without taxonomic implications.

The material of *A. inopinatus* from off Maryland differs from the above description only in some dimensional features.

*Habitat*.—Sublittoral, largely coarse sands, 29–140 m.

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

*Adelodrilus correptus*, new species

Fig. 4

*Holotype*.—USNM 96059.

*Type-locality*.—Georges Bank, SE of Massachusetts, U.S.A., 40°39.6'N, 67°45.8'W, 78 m, coarse sand (May 1983).

*Paratypes*.—USNM 96060–96061. Two specimens from off Massachusetts (Georges Bank), 40°39.5'N, 67°45.4'W, 78 m, coarse sand (May 1983).

*Other material examined*.—Authors' collections: three specimens from off Massachusetts (Georges Bank): one from type-locality, and two from 40°39.8'N, 67°46.1'W, 78 m, coarse sand (May 1983).

*Etymology*.—The name *correptus* is Latin for “pronounced short”; this is a very small species of *Adelodrilus*.

*Description*.—Length (fixed specimens) 2.2–2.9 mm, 25–32 segments; diameter

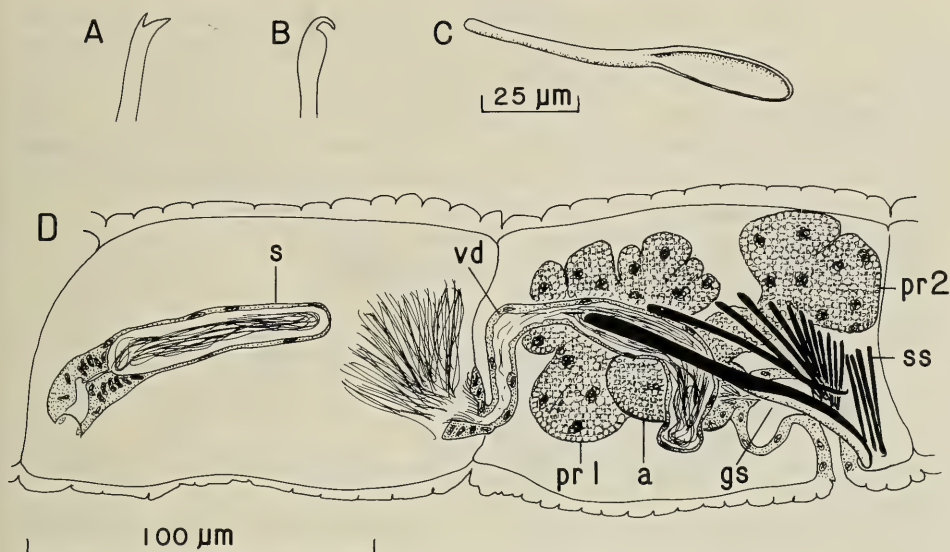


Fig. 4. *Adelodrilus correptus*: A, Free-hand drawing of somatic seta; B, Free-hand drawing of tip of smaller penial seta; C, Giant penial seta; D, Lateral view of spermatheca and male genitalia in segments X–XI. s, spermatheca; other abbreviations as for Fig. 3.

at XI in whole-mounted, slightly compressed specimens, 0.11–0.16 mm. Clitellum extending over  $\frac{1}{2}$  X–XII. Somatic setae bifid, with upper tooth thinner and shorter than lower tooth (Fig. 4A); 35–50  $\mu$ m long, 1–1.5  $\mu$ m thick; (2)3–4(5) per bundle anteriorly, (2)3–4 per bundle in post-clitellar segments. Ventral setae of XI modified into penial bundles, each containing: (1) one giant, slender, spoon-shaped seta (Figs. 4C; D:gs), with single-pointed, somewhat hooked tip, with ectal blade comprising slightly more than  $\frac{1}{3}$  of seta; (2) a row of about 15–20 smaller setae (Fig. 4D:ss), single-pointed and slightly hooked (anteriormost and larger ones), or somewhat clubbed with an apical tooth (posterior, smallest ones; Fig. 4B). Giant seta 65–85  $\mu$ m long, 3.5–4.5  $\mu$ m wide at middle (blade wider). Largest of smaller penial setae 45–60  $\mu$ m long, about 2  $\mu$ m thick; smallest penial setae about 25–30  $\mu$ m long, about 1  $\mu$ m thick. Ectal ends of penial setae located within thin-walled, folded copulatory sacs. Male pores paired, in line with ventral somatic setae, posteriorly in XI. Spermathecal pores paired, in line with ventral setae in X near intersegmental furrow IX/X.

Pharyngeal glands in IV–VI. Male genitalia (Fig. 4D) paired. Vas deferens thin-walled and broadly dilated; longer than atrium, 15–20  $\mu$ m wide; filled with spermatozoa or at least in middle and ectally; entering atrium sub-apically. Atrium oval or ovoid; 28–35  $\mu$ m long, 21–28  $\mu$ m wide; with thin outer lining and thick, granulated and ciliated inner epithelium; opening into inner end of copulatory sac. Anterior prostate gland large, attached to apical end of atrium. Posterior prostate smaller, attached by long stalk to middle-to-ectal part of atrium, somewhat opposite to entrance of vas deferens. Spermathecae small and slender (but not always as narrow as the one depicted in Fig. 4D); ducts 18–23  $\mu$ m long, 14–19  $\mu$ m wide; ampullae thin-walled, 44–57  $\mu$ m long, 10–25  $\mu$ m wide; sperm as random masses or compact bundle.



*Remarks.*—*Adelodrilus correptus* is similar to the European species *A. pusillus* Erséus, 1978 and *A. kiselevi* (Finogenova, 1972), in terms of penial setae and (small, slender) spermathecae. *Adelodrilus correptus*, however, has a higher number of smaller penial setae per bundle (*correptus*: about 15–20; *pusillus*: 5–10; *kiselevi*: 3–7), and the posteriormost setae within these bundles of smaller penial setae in *correptus* are ectally clubbed and hooked (Fig. 4B), a feature not observed in *pusillus* and *kiselevi* (Erséus 1983:table 1).

*Habitat.*—Sublittoral, coarse sand, 71–80 m.

*Distribution.*—East coast of the U.S.: Georges Bank.

*Adelodrilus pilatus*, new species

Fig. 5

*Holotype.*—USNM 96062.

*Type-locality.*—Georges Bank, SE of Massachusetts, U.S.A., 40°39.5'N, 67°45.4'W, 72 m, coarse sand (Nov 1982).

*Paratypes.*—USNM 96063–96064. Two specimens from Georges Bank: one from 40°39.0'N, 67°46.1'W, 80 m, medium to coarse sand (Nov 1982); and one from 40°38.5'N, 67°46.1'W, 78 m, heterogeneous coarse sand (Nov 1982).

*Other material examined.*—Authors' collections: seven specimens from Georges Bank: three from type-locality; two from 40°39.6'N, 67°47.6'W, 72 m, medium to coarse sand (Nov 1981); one from 40°39.5'N, 67°46.2'W, 78 m, medium to coarse sand (Feb 1983); and one from 40°40.6'N, 67°46.1'W, 77 m, medium to coarse sand (Nov 1982).

*Etymology.*—The name *pilatus* is Latin for “armed with a heavy javelin,” and refers here to the much enlarged, sharply single-pointed seta in the ventral bundles of segment X in this species.

*Description.*—Length (fixed specimens) 2.4–3.7 mm, 26–35 segments; diameter at XI in whole-mounted, slightly compressed specimens, 0.10–0.17 mm. Clitellum extending over  $\frac{1}{2}$  X–XII. Most somatic setae bifid, with upper tooth thinner and shorter than lower tooth (Fig. 5A); 30–50  $\mu$ m long, 1–1.5  $\mu$ m thick; 3–4 per bundle anteriorly, 2–3 per bundle posteriorly. Ventral setae of IX and X sharply single-pointed and enlarged, those of X (Fig. 5B:se) larger than those of IX; 2–3 per bundle in IX, 2 per bundle in X. One of two setae in each ventral bundle of X larger, 65–80  $\mu$ m long, 3.5–7  $\mu$ m thick at node; smaller seta in each ventral bundle of X and ventral setae of IX 50–65  $\mu$ m long, 2.5–3  $\mu$ m thick at node. Ventral setae of XI highly modified into penial bundles, each containing: (1) one giant, slightly sigmoid, ectally flattened and widened seta (Fig. 5B:gs), 115–140  $\mu$ m long, 7–9  $\mu$ m thick at middle (much wider ectally); (2) two or three intermediate setae, largest 40–65  $\mu$ m long, 3–4  $\mu$ m thick, more or less single-pointed and slightly curved ectally; (3) about 5 to 9 (exact number difficult to establish) thin, small setae (Fig. 5B:ss), ectally clubbed and with small apical hooks; 20  $\mu$ m long, about 1  $\mu$ m thick. Giant seta and intermediate setae parallel or somewhat oblique to long axis of worm; smaller penial setae generally erect. Ectal ends of penial setae located within thin-walled, folded copulatory sacs. Male pores paired, located close to each other, posteriorly and ventrally in XI. Spermathecal pores paired, in line with ventral setae in X near intersegmental furrow IX/X.

Pharyngeal glands in IV–VI. Male genitalia (Fig. 5B) paired. Vas deferens thin-



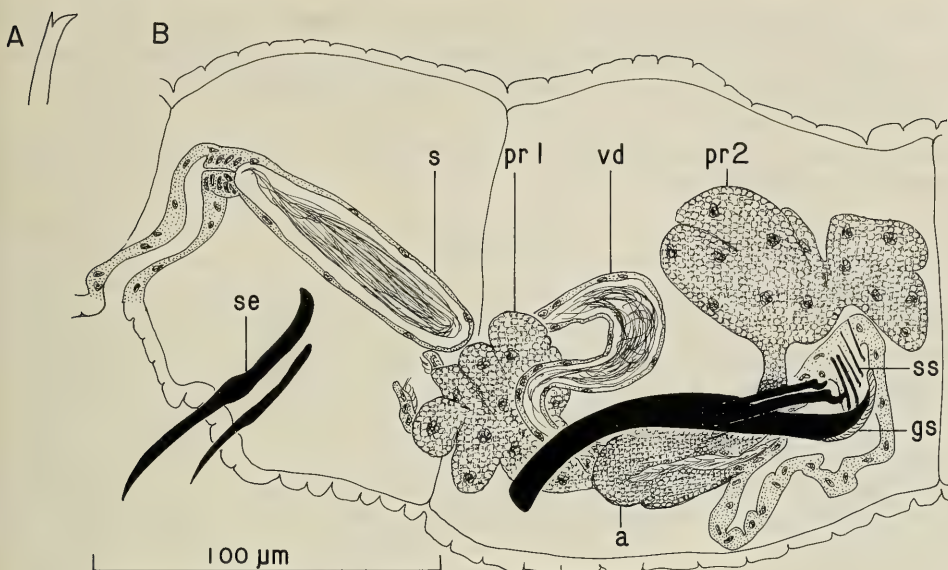


Fig. 5. *Adelodrilus pilatus*. A, Free-hand drawing of somatic seta; B, Lateral view of spermathecae and male genitalia in segments X-XI. se, ventral seta of X; other abbreviations as for Fig. 4.

walled and broadly dilated; about  $15\ \mu\text{m}$  wide; containing sperm in large bundle; entering close to apex of atrium. Atrium ovoid;  $40\text{--}55\ \mu\text{m}$  long,  $20\text{--}30\ \mu\text{m}$  wide; with thin outer lining and thick, granulated and ciliated inner epithelium; opening into inner end of copulatory sac. Anterior prostate gland attached by stalk to apex of atrium, at entrance of vas deferens. Posterior prostate attached by long stalk to ectal part of atrium. Spermathecae (Fig. 5B:s) slender; ducts long and hollow, about  $50\text{--}60\ \mu\text{m}$  long,  $15\text{--}20\ \mu\text{m}$  wide; ampullae thin-walled and elongate,  $75\text{--}100\ \mu\text{m}$  long,  $25\text{--}35\ \mu\text{m}$  wide, sperm as random masses or compact bundle.

**Remarks.**—This species is closely related to the European *A. cooki* Erséus, 1978, in having single-pointed setae in the ventral bundles of segments X and XI. However, in *A. cooki* these setae are far less enlarged than those of *A. pilatus* and they are not appreciably thicker than the normal, bifid setae. In addition, the anteriormost of the intermediate penial setae is *A. pilatus* is much stouter than the corresponding seta in the penial bundles of *A. cooki* (Fig. 5B; Erséus 1978: fig. 2D).

**Habitat.**—Sublittoral, largely coarse sand, 71–80 m.

**Distribution.**—East coast of the U.S.: Georges Bank.

#### *Adelodrilus cristatus* Erséus, 1983

*Adelodrilus cristatus* Erséus, 1983:78–79, fig. 4.

**New material examined.**—Authors' collections: two specimens from Georges Bank,  $40^{\circ}39.8'\text{N}$ ,  $67^{\circ}46.1'\text{W}$ , 78 m, coarse sand (May 1983).

**Remarks.**—This species was recently described from off Maryland and New Jersey (Erséus 1983); the new material thus extends the known range northward to off Massachusetts.

The two specimens conform fully to the original description, even in dimensional respects. Pharyngeal glands which were originally not observed, are poorly developed, but present in segments (III)IV–V of the present material.

*Habitat*.—Sublittoral, largely coarse sand, 21–78 m.

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

### Discussion

All the six species of *Adelodrilus* reported here were found in an area of Georges Bank characterized by bottoms of coarse sands. This underlines the view that *Adelodrilus* is largely a genus of interstitial tubificids. Only the species described from the Black Sea, *A. kiselevi* and *A. borceai* (Hrabě, 1973), and the deep-sea *A. voraginus* (Cook, 1970) and *A. fimbriatus* Erséus, 1983 are known from finer sediments.

As has been discussed elsewhere (Erséus 1978, 1984), *Adelodrilus* is closely related to *Phallodrilus* Pierantoni, and it is likely that the genus has evolved from *Phallodrilus*-like ancestors similar to species today found along the east coast of North America (*P. coeloprostat*, *P. boeschi*, *P. biprostat* and *P. flabellifer*; see Erséus 1984). The very high species diversity of *Adelodrilus* along this coast, including complexes of very closely related forms (*anisosetosus-multispinosus-inopinatus* and *voraginus-fimbriatus*) is noteworthy, and it can be expected that additional species are yet to be encountered in the area.

### Acknowledgments

We are indebted to Dr. R. J. Diaz (Virginia Institute of Marine Sciences), for providing the supplementary material of *A. inopinatus*; to Dr. James Blake (Battelle N.E. Marine Research Laboratory), for valuable criticism of the manuscript; and Battelle New England Marine Research Laboratory, for financial support. The work was also supported by the Swedish Natural Research Council. Specimens from Georges Bank were collected as part of the Georges Bank Benthic Infauna Monitoring Program, supported by Contract No. 14-12-0001-2912 from the U.S. Department of the Interior Minerals Management Service to Battelle New England Marine Research Laboratory.

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THE DEEP-SEA AMPHIPOD *PARACYPHOCARIS*  
*PRAEDATOR* (GAMMARIDEA: LYSIANASSIDAE)  
ASSOCIATED WITH THE PELAGIC SHRIMP  
*OPLOPHORUS NOVAEZEELANDIAE* AS AN EGG-MIMIC

Thomas E. Bowman and Robert A. Wasmer

*Abstract.*—Three specimens of the amphipod *Paracyphocaris praedator* were found among the attached eggs of the shrimp *Oplophorus novaezeelandiae*. The posterior pereon of the amphipod was greatly distended and filled with oily globules, causing it to resemble in form and color the eggs of the shrimp. It is suggested that *P. praedator* is an egg-mimic that feeds upon the *Oplophorus* eggs. The prehensile pereopods of *Paracyphocaris*, and perhaps those of other cyphocarid genera, prevent it from being dislodged by the host's grooming.

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*Paracyphocaris* is one of a group of genera of Lysianassidae designated by Barnard (1969) as "cyphocarids." The genus comprises three species: the type-species *P. praedator* Chevreux, 1905, *P. brevicornis* Birstein and Vinogradov, 1955, and *P. distincta* Birstein and Vinogradov, 1963. All captures of the three species have been made in the deep-sea pelagial. *Paracyphocaris distincta* is known only from the Philippine Trench, and *P. brevicornis* has been found at two localities, the Kurile-Kamchatka Trench (Birstein and Vinogradov 1955) and near the Solomon Islands (Birstein and Vinogradov 1960). *Paracyphocaris praedator* has a wide known distribution, having been recorded from seven localities in the North Atlantic (summarized by Shoemaker 1945) and two localities in the Indian Ocean, NW of Rodriguez Island and NE of the Chagos Archipelago (Birstein and Vinogradov 1964). Its known range is extended herein to include the South Pacific off southern Chile, where three specimens have been found among the eggs attached to the pleopods of the pelagic shrimp *Oplophorus novaezeelandiae*.

*Paracyphocaris praedator* Chevreux

Fig. 1

*Paracyphocaris praedator* Chevreux, 1905:1, figs. 1-3; 1935:25-27, pl. 10, fig. 3, pl. 11, figs. 2-3.—Stephensen, 1923:54; 1933:10.—Schellenberg, 1926:216; 1927:667-668, fig. 61.—Birstein and Vinogradov, 1960:170-171, fig. 1; 1964:156.—Shoemaker, 1945:189, text-fig. 2.—Gurjanova, 1962:71-73, figs. 11A, 11B.

*Material.*—Complete specimen about 8.7 mm in length and specimen lacking pleonite 3 and urosome judged to be about same length (USNM 211073), from among ova of 2 different specimens of *Oplophorus novaezeelandiae* De Man (USNM 211072), *Eltanin* cruise 25, sta 303, off Santiago, Chile, 33°11'–33°14'S, 72°40'–72°38'W, 400–475 m, 25 Sep 1966. Complete specimen about 9.5 mm in length (USNM 213334) from among ova of *Oplophorus novaezeelandiae* (USNM 213333), *Eltanin* cruise 25, sta 322, off Osorno, Chile, 41°01'–41°08'S, 78°59'–78°56'W, 380–475 m, 7 Oct 1966.

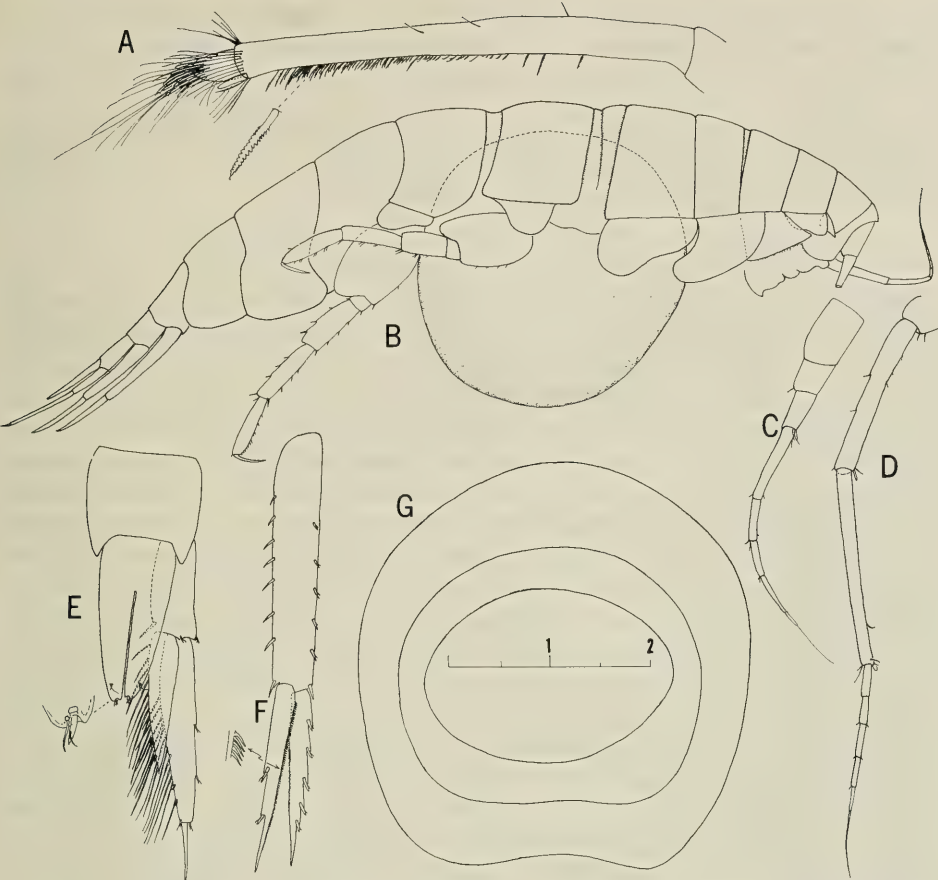


Fig. 1. A, *Oplophorus novaezeelandiae*, ovigerous ♀, pereopod 5 propus and dactyl. B–F, *Paracyphocaris praedator* from *Oplophorus marsupium*: B, Habitus, lateral, most appendages omitted; C, Antenna 1; D, Antenna 2, segments 1 and 2 of peduncle omitted; E, Telson and uropod 1; F, Uropod 3; G, Outer and middle circles, outlines of distended area of pereon of *P. praedator* viewed ventrally; middle circle is specimen in B; inner circle, outline of egg of *O. novaezeelandiae*. Scale in mm applies to B and G.

*Diagnostic characters.*—The Chilean specimens match the illustrations of Chevreux (1905) and Shoemaker (1945), as far as could be seen without dissection. The characters that distinguish *P. praedator* from its congeners are given in the key that follows.

Key to the Species of *Paracyphocaris*

- 1. Antenna 2 shorter than antenna 1. Pereopod basis wider than long . . . . . *P. brevicornis*
- Antenna 2 longer than antenna 1. Pereopod 4 basis longer than wide . . . . . 2
- 2. Antenna 1 flagellum 5-segmented. Pereopod 1 propus 2.3× as long as wide. Epimeron of pleonite 3 rounded posteriorly. Telson 2.3× as long as wide . . . . . *P. praedator*

- Antenna 1 flagellum 4-segmented. Pereopod 1 propus  $1.7\times$  as long as wide. Epimeron of pleonite 3 pointed posteriorly. Telson  $1.5\times$  as long as wide ..... *P. distincta*

Chevreaux's illustrations do not show the pectinate inner margins of the rami of uropod 1 (Fig. 1F). Shoemaker did not illustrate the uropods, but his Bermuda specimens have pectinate margins on the rami of uropod 1.

#### Nature of the *Paracyphocaris*-*Oplophorus* Relationship

Both Chilean specimens have the body greatly distended ventrally in the region of pereonites 5–7. The distension amounts to more than the normal depth and width of the body (Fig. 1B, G). The distended part is filled with oily globules and is dull orange after 18 years in alcohol. The eggs of the *Oplophorus* are similar in appearance, being filled with oily globules of yolk, and the color in alcohol is a paler yellowish orange. The eggs are oval and somewhat smaller than the distended part of the amphipod (Fig. 1G), but the long diameter of the egg is about equal to the length of the distended part in the complete specimens of *Paracyphocaris*.

Thus the swollen region of the *Paracyphocaris* matches the *Oplophorus* egg in texture, color, and size, and we suggest that *P. praedator* may be an egg-mimic, the first example among the Amphipoda. Elsewhere among the Crustacea egg-mimicry is found in copepods of the family Choniostomatidae (Hansen 1897) and perhaps some cryptoniscid isopods (Nielson and Stromberg 1965). In the choniostomatid *Sphaeronella monothrix* (Bowman and Kornicker, 1967) not only does the female mimic the eggs of its ostracode host, *Parasterope pollex*, but it lays its eggs in groups of about 15, enclosed by a membrane. Each group, or ovisac, is about the size of an egg of *Parasterope*. The presence of *Sphaeronella* in the *Parasterope* marsupium appears to inhibit egg-laying by the host.

In the Caspian Sea the amphipod *Cardiophilus baeri*, which usually occurs in the mantle cavity of the cockle *Cerastoderma lamarcki*, has been found in the marsupium of the amphipods *Corophium curvispinum* and *C. spinulosum* by Osadchikh (1977), who believes that early development of *C. baeri* takes place there. Osadchikh did not suggest that *Cardiophilus* either mimics or feeds on the *Corophium* eggs or young.

*Paracyphocaris* does not inhibit egg-laying by *Oplophorus*. The two Chilean shrimps from station 25 carried six and ten eggs respectively, rather loosely packed. In comparison, a South Atlantic *O. novaezeelandiae* of about the same length in the Division of Crustacea collections has 20 closely clustered eggs. This difference, together with the distended condition and appearance of the amphipod guts, suggests that the amphipods feed on the eggs of the shrimp. Thus the *Paracyphocaris* gains from its association a protected and concealed habitat where energy requirements are minimal and also a readily available source of rich food.

Seven of the 12 genera grouped as "cyphocarids" by Barnard (1969:300) are characterized by the prehensile nature of from 2–4 of the pereopods posterior to pereopod 2. In a recent discussion of Gammaridea having prehensile pereopods, Vader (1983) divided them into two groups: (1) abyssopelagic or bathypelagic species, which he considered to be probably all predators; (2) those living in direct contact with the mouthparts or appendages of large Crustacea. Vader placed the cyphocarids in the first group. *Paracyphocaris* is not necessarily predaceous, how-



ever; the prehensile pereopods may be adapted for resisting dislodgment by the grooming activities of the host rather than for seizing prey. Nothing is known about grooming in the Ophrophoridae, but the armament of the last pereopod of *O. novaezeelandiae* (Fig. 1A) suggests that it may be used in grooming. The posterior margin of the carpus bears two rows of setae with scalloped margins directed toward the medial axis of the shrimp. Similar setae on the thoracic appendages of *Pandalus danae* have been demonstrated by Bauer (1975) to function in grooming, although this shrimp does not brush its eggs with the 5th pereopods or with the chelate legs as in palaeomonids, hippolytids, and alpheidids (Bauer 1975, 1979). If *Ophrophorus* grooms its eggs, as we suspect, the *Paracyphocaris* must be able to resist dislodgment, and its prehensile pereopods 3–6 seem ideally suited for preventing it from being ejected.

The majority of the known specimens of *P. praedator* did not have a distended gut when collected and were probably free-living rather than inhabitants of marsupia. No ovigerous females have been collected, and details of the life history are unknown, but in general storage of large amounts of food is more likely to precede than to follow breeding. We suggest that after gorging itself, *Paracyphocaris* leaves the shrimp marsupium and takes up a pelagic life, during which it lives on the stored food and perhaps does not feed. Mating could take place during the pelagic phase or in the shrimp's marsupium. For the latter a second amphipod would have to enter the marsupium. We could speculate at length on further aspects of the life history, but this would contribute little in the absence of factual evidence.

Finally, we suspect that the other cyphocarid genera that have prehensile pereopods may prove to be associated with the marsupia of deep-sea pelagic shrimps. These genera are *Cebocaris*, *Crybelocephalus*, *Crybelocyphocaris*, *Mesocyclocaris*, *Metacyclocaris*, and *Metacyphocaris*. Diagnoses and references for these genera are given by Barnard (1969). There is some evidence for this suspicion. K. H. Barnard (1932) reported that the ventral surface of smaller specimens of *Metacyphocaris helgae* was bulging, and Shoemaker (1945) found this condition in an immature female of the same species.

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TWO NEW SPECIES OF *LEPIDONOTOPODIUM*  
(POLYCHAETA: POLYNOIDAE: LEPIDONOTOPODINAE)  
FROM HYDROTHERMAL VENTS OFF THE GALAPAGOS  
AND EAST PACIFIC RISE AT 21°N

Marian H. Pettibone

*Abstract.*—New collections from the hydrothermal vent areas at 21°N off Western Mexico and the Galapagos Rift included specimens of *Lepidonotopodium fimbriatum* Pettibone, 1983, and two new species: *L. riftense* and *L. williamsae*. The species are described and compared, including observations on their early stages. The species of *Lepidonotopodium* are unique among the Polynoidae in having well-developed bracts encircling the notopodia.

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Among the unusual fauna clustered around the hydrothermal vents in the Galapagos region and the 21°N site on the East Pacific Rise, scale-worms of the family Polynoidae are well-represented. The abundant available material was collected by the Galapagos Rift Biology Expedition in 1979 and the OASIS group of Scripps Institution of Oceanography in 1982. Two reports on the polynoids from these areas have appeared: *Lepidonotopodium fimbriatum* in the new subfamily Lepidonotopodinae by Pettibone (1983) and *Branchipolynoe symmytilida*, commensal in the mantle cavities of the deep-sea vent mussels, in the new subfamily Branchipolynoinae by Pettibone (1984). Based on additional material received from J. F. Grassle and I. Williams of the Woods Hole Oceanographic Institution (WHOI), with preliminary sorting by I. Williams, the present study supplements the first of the reports above. In addition to more specimens of *L. fimbriatum*, numerous others are referred to two new species of *Lepidonotopodium*.

The various methods of collecting and sorting of the material have produced many adults, as well as many minute young specimens of polynoids, as noted by accompanying collecting labels: clam bucket wash, clam bucket with mussels, crab trap wash, bottom of Instant Ocean aquarium, washes of, and rubble samples with, *Alvinella*, clams or *Calyptogena*, vestimentiferans or *Riftia*, and mussels. As is well known, many species of polynoids are noted for their close associations with other invertebrates. The closeness of the association of the species of *Lepidonotopodium* with the invertebrates referred to above cannot be determined. However, possible hosts are the ampharetid polychaetes *Alvinella pompejana*, described by Desbruyères and Laubier (1980), the giant clams *Calyptogena magnifica*, by Boss and Turner (1980), the giant vestimentiferans *Riftia pachyptila*, by Jones (1981), and the deep-sea vent mussels, as yet unnamed, but to be described by Kenk and Wilson (in press). The latter definitely serves as the host for *Branchipolynoe symmytilida*, since the polynoids have been found in the mantle cavities of the mussels, as noted above.

Many of the specimens have foreign material attached to the parapodia, setae, and elytral surfaces, including epibiotic bacterial masses of different morphological



types—coccoid, filamentous, terminal filaments, apical tufts or “hairs,” as observed also for *Alvinella pompejana* by Desbruyères *et al.* (1983).

Types and additional specimens are deposited in collections of the Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution (USNM).

### Family Polynoidae

#### Subfamily Lepidonotopodinae Pettibone, 1983

The genus *Lepidonotopodium* Pettibone, 1983, with *L. fimbriatum* Pettibone, 1983, as the type-species, is emended to include two additional new species from the hydrothermal vents in the Galapagos area and the East Pacific Rise at 21°N.

#### *Lepidonotopodium* Pettibone, 1983, emended

*Diagnosis.*—Body short, flattened, up to 30 segments (first achaetous). Elytra and prominent elythrophones 11 pairs, on segments 2, 4, 5, 7, 9, 11, 13, 15, 17, 19, and 21, with dorsal cirri on posterior segments. Prostomium deeply bilobed; median antenna with ceratophore inserted in anterior notch, with short style; without lateral antennae but with small frontal filaments on anterior lobes of prostomium; paired palps cylindrical, smooth, with filamentous tips; without eyes. First or tentacular segment fused to prostomium, not visible dorsally; tentaculophores lateral to prostomium, each with pair of tentacular cirri, single aciculum, without setae; without facial tubercle. Second segment with first pair of elytra, biramous parapodia and ventral or buccal cirri attached to basal parts of parapodia lateral to mouth; styles longer than following ventral cirri. Parapodia biramous, with notopodia shorter than neuropodia. Notopodia subconical, with well-developed bracts encircling notopodia anteriorly and dorsally. Neuropodia diagonally truncate, deeply notched dorsally. Distal tips of notopodia, notopodial bracts and neuropodia fimbriated with slender papillae. Notosetae and neurosetae numerous, spinous. Dorsal cirri on segments lacking elytra with cylindrical cirrophones attached on posterodorsal sides of notopodia, with tapered styles; ventral cirri short, tapered, attached near middle of neuropodia. Dorsal tubercles on cirriferous segments large, inflated. Elythrophones, dorsal tubercles and their bases with numerous ciliated ridges. Ventral segmental papillae lacking or with 2 to 4 pairs of long papillae on some middle segments (11–14). Pygidium dorsal, bulbous, wedged between parapodia of posterior small segments, with or without pair of anal cirri. Pharynx with 7 or 9 pairs of papillae, 2 pairs of jaws with few (5–9) or numerous basal teeth.

#### *Lepidonotopodium fimbriatum* Pettibone

Fig. 1

*Lepidonotopodium fimbriatum* Pettibone, 1983:393, figs. 1–5.

*Additional records.*—Pacific Ocean off western Mexico, 20°50'N, 109°06'W, OASIS Alvin dives in 1982:—Dive 1213, 2617 m, 19 Apr, *Alvinella* wash, 1 young specimen (USNM 81998).—Dive 1214, 2633 m, 20 Apr, vestimentiferan wash, 2 young specimens (USNM 81999).—Dive 1223-11, 2616 m, 7 May, coarse



Fig. 1. *Lepidonotopodium fimbriatum*, A, B, elytra from young specimen of 9 mm long and 25 segments, USNM 81998; C–E, border papillae and jaw of extended pharynx from young specimen of 7 mm long and 24 segments, USNM 82000: A, Left first elytron from segment 2, with detail of few microtubercles and micropapillae; B, Left elytron 10 from segment 19, with same; C, Dorsal border papillae; D, Ventral border papillae; E, Jaw. Scales = 0.5 mm for A, B; 0.2 mm for C–E.

fraction, 15 adults and 12 young specimens (USNM 96482).—Dive 1226-7, 2616 m, 10 May, *Riftia*, *Calyptogena* and *Alvinella* wash, 4 adults and 14 young specimens (USNM 82000), and fine fraction, 2 young specimens (USNM 96483).

**Supplementary description.**—The 19 adult specimens agree with the previously described types except for the larger size of some of them: the largest specimen, 37 mm in length and 16 mm in width with 30 segments, the last 2 of which are minute, compared with the adult types, 23–24 mm in length, 12–13 mm in width, with 28 segments, the last segment small. Nine of the adults have similar ventral segmental papillae on segments 11 and 12 (fig. 3A, in Pettibone 1983) and 10 lack them.

Some of the young specimens have the usual 11 pairs of elytra with 22–26 segments, the last segment small, 5–9 mm in length and 3.5–5 mm in width. When present, the elytra show some signs of the characteristic raised macro-tubercles but lack the full number of 2 macro-tubercles per elytron (Fig. 1A, B; figs. 1, 2E–G, in Pettibone 1983). The elytra are thinner and more delicate, with scattered microtubercles and slightly larger round micropapillae; some fine “hairs” or “bacteria” are attached to the microtubercles (Fig. 1A, B). The pharynx was extended on a young specimen, 7 mm in length, 4 mm in width, with 24 segments; it is slightly different from that of the figured paratype: 7 dorsal papillae with the median one extra large and 6 ventral papillae, with 2 middle ones small and adjacent lateral ones large, and jaw with 9 basal teeth (Fig. 1C–E; 7 pairs of papillae, jaws with 5–7 basal teeth on paratype, fig. 3B, C, in Pettibone 1983).

The remaining young specimens have 6–10 pairs of elytra, with 12–21 segments,

the last 1 or 2 segments very small, 1.5–5 mm in length and 1.2–3 mm in width. The elytra are rather thin and lack the raised macrotubercles.

*Distribution.*—East Pacific Rise at 21°N, in 2616–2633 meters, appear to be associated with ampharetid polychaetes, *Alvinella pompejana*, giant clams, *Calyptogena magnifica*, and vestimentiferans, *Riftia pachyptila*.

*Lepidonotopodium riftense*, new species

Figs. 2–4

*Material.*—East Central Pacific, from dives of the *Alvin* on 3 vent areas along the Galapagos Rift in 1979:

MUSSEL BED, 00°47.89'N, 86°09.21'W:—Dive 880, 21 Jan, 2493 m, 8 paratypes (USNM 96008).—Dive 887, 12 Feb, 2488 m, 27 paratypes (USNM 96009).—Dive 888, 13 Feb, 2483 m, 8 paratypes (USNM 96010).—Dive 991-1, 8 Dec, 2490 m, clam bucket wash, 13 paratypes (USNM 96011).

GARDEN OF EDEN, 00°47.69'N, 86°07.74'W:—Dive 884, 25 Jan, 2482 m, clam bucket with mussels, 5 paratypes (USNM 96016).—Dive 993-7, 10 Dec, 2518 m, crab trap wash, 30 paratypes (26 young, USNM 96017).

ROSE GARDEN, 00°48.25'N, 86°13.48'W:—Dive 890, 15 Feb, 2447 m, bottom of Instant Ocean washings, 11 paratypes (USNM 96013).—Dive 894, 19 Feb, 2457 m, amphipod trap, holotype (USNM 80635) and 3 paratypes (USNM 80636, 80637).—Dive 896-22, 21 Feb, 2460 m, Instant Ocean washings, 3 paratypes (USNM 96014).—Dive 984-32, 1 Dec, 2451 m, mussel washings, 2 young paratypes (USNM 96012).—Dive 990-41, 7 Dec, 2451 m, vestimentiferan wash, young paratype (USNM 96015).

Pacific Ocean off Western Mexico, 20°50'N, 109°06'W, OASIS *Alvin* dives in 1982:—Dive 1214, 20 Apr, 2633 m, vestimentiferan wash, 90 paratypes, including many young (USNM 96021).—Dive 1215-5B, 21 Apr, 2616 m, slurp sample, young paratype (USNM 96485).—Dive 1218-15, 24 Apr, 2618 m, clam and crab trap wash, adult and 15 young paratypes (USNM 96486).—Dive 1219-1B, 1219-10, 25 Apr, 2612 m, *Riftia* and clam wash, coarse and fine fractions and slurp sample, 19 paratypes, including young (USNM 96018).—Dive 1221-15, 4 May, 2618 m, *Riftia* and *Calyptogena* wash, coarse and fine fractions, 117 paratypes, including many young (USNM 96022).—Dive 1222-5b, 6 May, 2614 m, rubble sample from *Calyptogena* residue, 4 paratypes (USNM 96019).—Dive 1223-11, 7 May, 2616 m, coarse and fine fractions, 2 adults and 35 young paratypes (USNM 96487).—Dive 1225-6A, 9 May, 2618 m, rubble, coarse fraction, 2 young paratypes (USNM 96488).—Dive 1225-7, coarse and fine fractions, 4 adults and 9 young paratypes (USNM 96489, 96490).—Dive 1226-7, 10 May, 2616 m, *Riftia*, *Calyptogena* and *Alvinella* wash, coarse fraction, 8 young paratypes (USNM 96020) and fine fraction, 6 young paratypes (USNM 96491).

*Description.*—The holotype, from the Galapagos Rift (USNM 80635), has a length of 6 mm, a width of 4.5 mm, including the setae, with 23 segments. A slightly smaller paratype (USNM 80636) has a length of 5 mm, a width of 4 mm, with 22 segments. The largest paratype from the Galapagos Rift (USNM 96010) has a length of 10 mm, a width of 5 mm, with 24 segments. The largest paratype from the East Pacific Rise (USNM 96018) has a length of 13 mm, a width of 7 mm, with 25 segments. No color remains. The body is short, suboval in outline, flattened dorsoventrally, slightly tapered and rounded anteriorly and posteriorly.



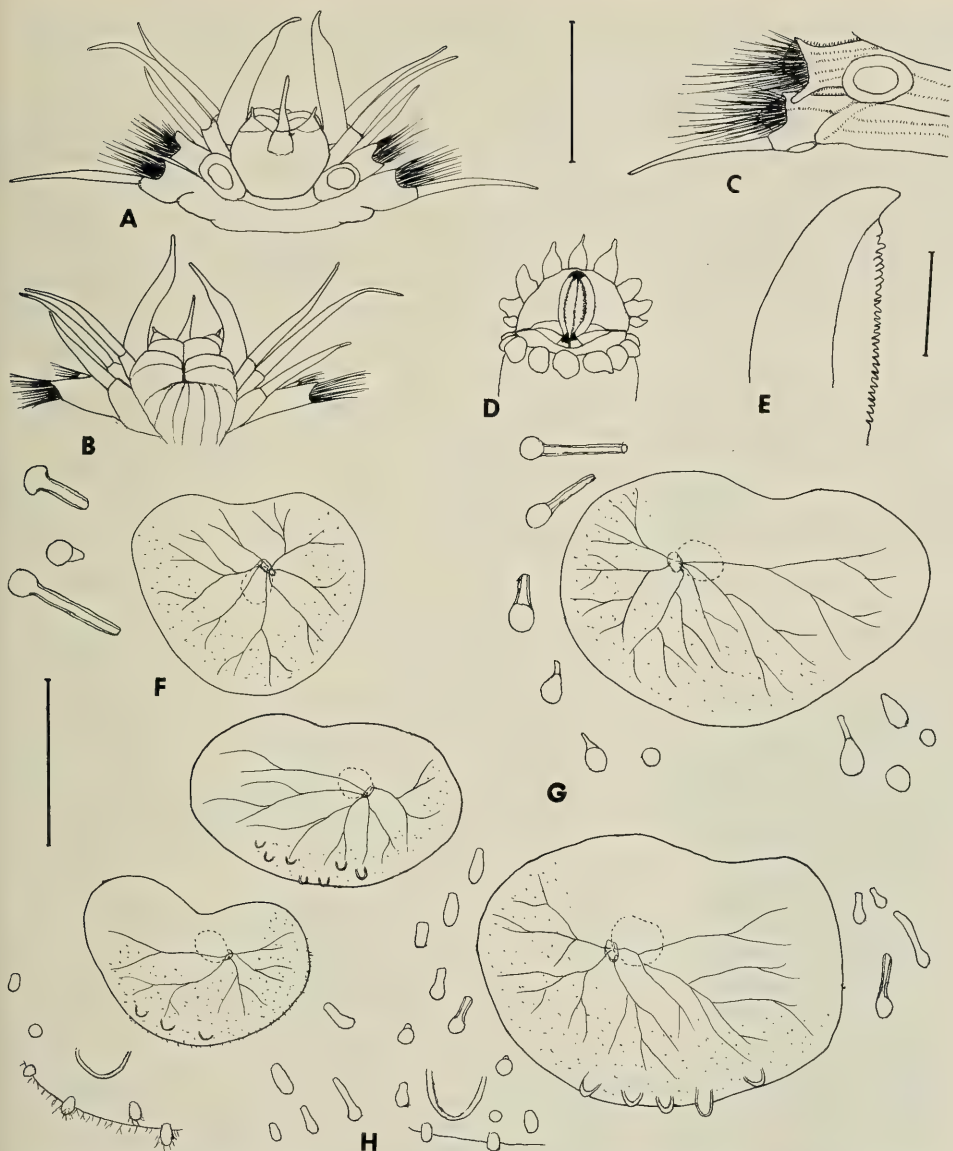


Fig. 2. *Lepidonotopodium riftense*, A–C, E–G, holotype, USNM 80635; D, paratype, USNM 96009; H, paratype, USNM 96021: A, Anterior end, dorsal view; B, Same, ventral view; C, Dorsal view of left segments 9 and 10; D, Ventral view of extended pharynx; E, Isolated jaw from pharynx; F, First right elytron, with detail of micropapillae; G, Left middle elytron, with same; H, Three elytra showing variable numbers of oval projections, with detail of micropapillae and projections. Scales = 1 mm for A–D; 0.1 mm for E; 1 mm for F–H.

The 11 pairs of elytra are attached eccentrically on prominent elytraphores, with dorsal cirri on the posterior segments (10 pairs of elytra on smaller juveniles with 19 segments). The elytra are oval to subreniform, imbricated, and cover the dorsum. They are opaque, smooth, with branching “veins” emanating from the place of attachment to the elytraphores. Near the posterior and lateral borders of

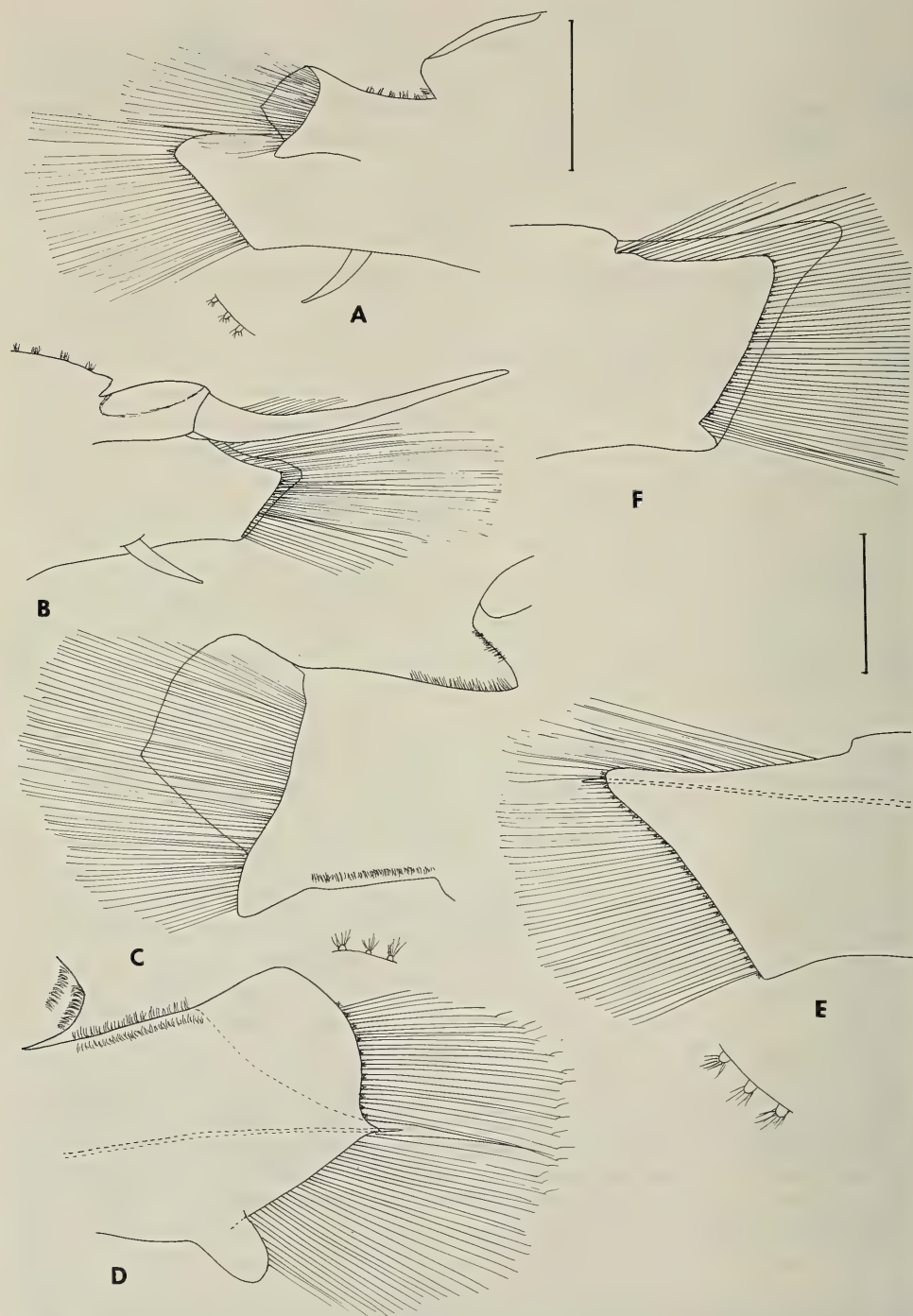


Fig. 3. *Lepidonotopodium riftense*, holotype, USNM 80635: A, Right elytrigerous parapodium from segment 9, anterior view, with detail of distal papillae; B, Right cirriferous parapodium from segment 10, posterior view; C, Enlarged view of right notopodium of elytrigerous parapodium, anterior

the elytra, scattered globular micropapillae with short to longer tapered or cylindrical bases are found on the surface (Fig. 2F, G). Numerous fine branched "hairs" or "bacteria" are found on the borders and surfaces of the elytra. On some specimens from the East Pacific Rise, the elytra have a variable number of oval projections near the posterior border, similar to the well-developed macrotubercles of *L. fimbriatum* (Fig. 2H). The dorsal cirri are attached dorsoposteriorly on the notopodia; they have cylindrical cirrophores with a blister-like lobe on the posterior side; the styles are tapering and extend to about the tips of the neurosetae (Figs. 2A, C; 3B). The dorsal tubercles on the cirriferous segments are large and inflated. The surfaces of both the elytraphores and dorsal tubercles have bands or tufts of cilia (Figs. 2C; 3A–D).

The prostomium is bilobed, the anterior lobes subtriangular, each with a small frontal filament; lateral antennae are absent (Fig. 2A, B). The median antenna is inserted in the anterior notch, having a short cylindrical ceratophore and short tapering style. The palps are cylindrical, with tapered tips, about one and a half times the length of the prostomium. Eyes are lacking. The tentaculophores of the tentacular segment are lateral to the prostomium and lack setae; the styles of the 2 pairs of dorsal and ventral tentacular cirri are similar in length, smooth, tapered, and subequal in length to the palps.

The second or buccal segment bears the first pair of large elytraphores, biramous parapodia, and ventral or buccal cirri attached basally on prominent cirrophores lateral to the ventral mouth; their styles are similar to the tentacular cirri and longer than the following ventral cirri (Fig. 2A, B). The mouth is enclosed in upper, lateral and posterior lips between segments 1 to 3 (Fig. 2B). The opening of the extended pharynx is encircled by 9 pairs of bulbous papillae, with the lateral one small or with only 7 pairs of subequal papillae (Fig. 2D). The 2 pairs of dorsal and ventral hooked jaws are minutely serrated with numerous teeth (about 26; Fig. 2D, E).

The biramous parapodia have shorter notopodia located on the anterodorsal sides of the longer neuropodia (Fig. 3A). The notopodium is subconical, with a projecting acicular lobe hidden anteriorly by the very numerous notosetae and enclosed by well-developed flaring anteroventral and posterodorsal bracts attached basally to the acicular lobe (Fig. 3A, C, D). The neuropodium is diagonally truncate and deeply cleft on the upper part. The presetal acicular lobe projects dorsally beyond the shorter rounded postsetal lobe (Fig. 3E, F). The distal margins of the notopodial bracts and neuropodial lobes are fimbriated with short papillae, with "hairs" or "bacteria" attached. The notosetae are very numerous, forming thick radiating bundles. They vary in length, are mostly slightly stouter than the neurosetae and have relatively few (7–8), widely-spaced spines along one side and blunt rounded tips; many of them had long strands of foreign material attached subdistally ("bacteria"?; Fig. 4A). The neurosetae are numerous, forming fan-shaped bundles. They are all similar, with slightly hooked bare tips and 2 rows

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view; D, Same, posterior view, with detail of distal papillae, notoaciculum dotted; E, Enlarged view of right neuropodium, anterior view, with detail of distal papillae, neuroaciculum dotted; F, Same, posterior view. Scales = 0.5 mm for A, B; 0.2 mm for C–F.



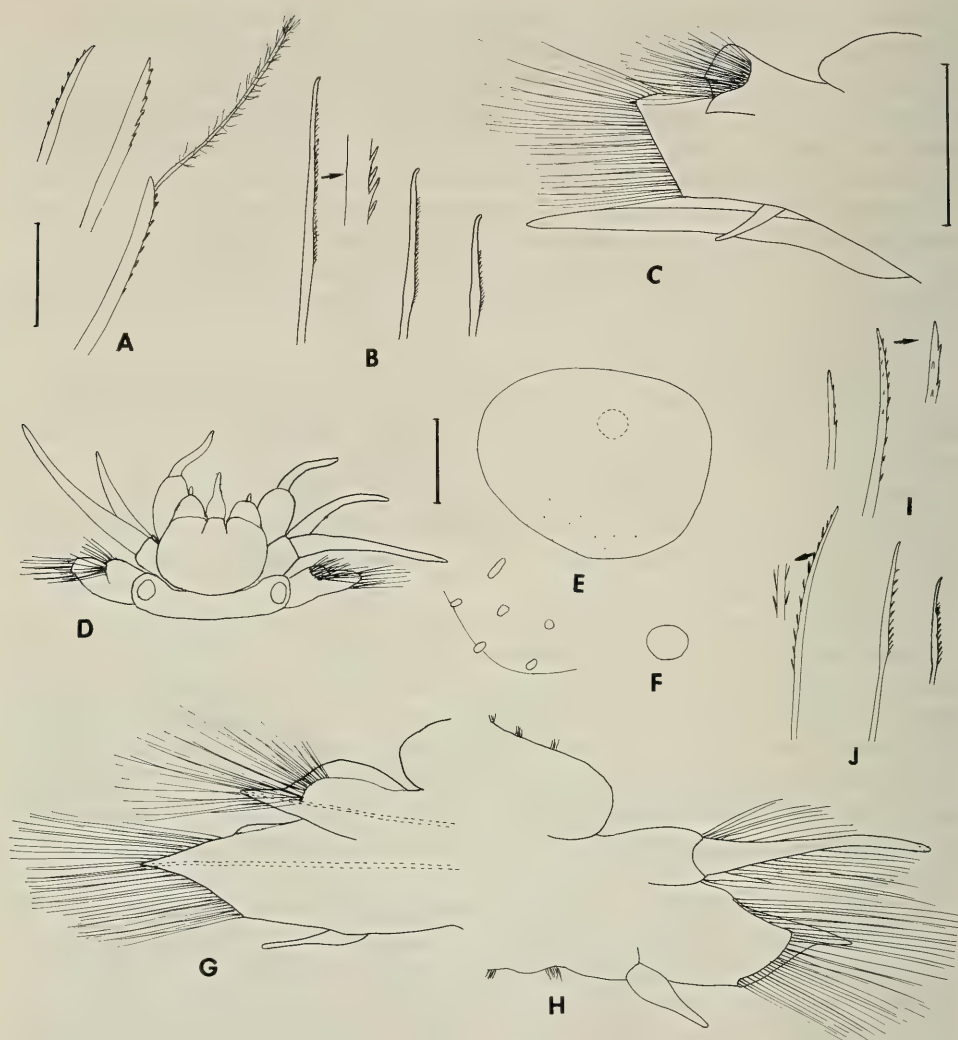


Fig. 4. *Lepidonotopodium riftense*. A, B, holotype, USNM 80635; C, paratype, USNM 80636; D–J, young paratype of 13 segments, 1.5 mm long, 1.5 mm wide, USNM 96008: A, Three notosetae, one with strand of attached “bacteria”; B, upper, middle and lower neurosetae, with detail of middle part; C, Right parapodium from segment 11, anterior view, showing elongated segmental papilla; D, Anterior end, dorsal view; E, Right middle elytron, with detail of some micropapillae; F, Right posterior elytron from segment 13 (incompletely developed); G, Right elytrigerous parapodium, anterior view, acicula dotted; H, Right cirriferous parapodium, posterior view; I, Short and longer notosetae, with detail of tip; J, Upper, middle and lower neurosetae, with detail of middle part. Scales = 0.1 mm for A, B, G–J; 0.5 mm for C; 0.2 mm for D–F.

of numerous spines along one side; the upper neurosetae are longer, with longer spinous regions (Fig. 4B). The ventral cirri are short, tapered, smooth and attached on the middle of the posterior face of the neuropodia (Fig. 3A, B).

Segmental or nephridial papillae are not obvious. On about half of the adult specimens there are 2 pairs of elongate papillae on segments 11 and 12, attached

basally on the ventroposterior sides of the neuropodia and extending to the tips of the lower neurosetae (Fig. 4C). Such papillae are lacking on the holotype. On some of the juveniles the papillae are present but shorter and incompletely developed. The pygidium is visible dorsally as a bulbous lobe wedged between the parapodia of the 2 posterior smaller segments, with a pair of long ventral anal cirri, similar to the posterior dorsal cirri.

Numerous young specimens were collected at the Galapagos Rift from washings of mussels and in crab and amphipod traps and from the East Pacific Rise from washings of *Riftia*, *Calyptogena* and *Alvinella*, coarse and fine fractions, rubble, clam and crab trap wash, and slurp sample. Juveniles with 17 to 20 segments, with less than 11 pairs of elytra, have lengths of 2.5 to 4 mm and widths of 2 to 3 mm. Young specimens with 10 to 15 segments have lengths of 1 to 2 mm and widths of 1 to 1.5 mm. A young specimen of 13 segments, 1.5 mm long and 1.5 mm wide, has 7 pairs of elytra (USNM 96008; Fig. 4D–J). Compared with the adult specimens, the anterior end is similar except that the palps are bulbous on the proximal half and filiform distally (Fig. 4D). The elytra are oval, delicate, with few scattered oval micropapillae; the posterior elytra on segment 13 are very small and incompletely developed (Fig. 4E, F). The bracts on the notopodia are not as well developed and the neuropodia have more prominent subtriangular presetal lobes (Fig. 4G, H). The notosetae and neurosetae are fewer in number and more slender (Fig. 4I, J).

*Etymology*.—The species is named *riftense* for its association with the rifts in the region of the hydrothermal vent areas of the Galapagos and 21°N.

*Distribution*.—East Central Pacific in Galapagos Rift, in 2447–2518 meters, associated with the unnamed deep-sea mussels and vestimentiferans, *Riftia pachyptila*. Also in East Pacific Rise at 21°N, in 2612–2633 meters, associated with ampharetid polychaetes, *Alvinella pompejana*, giant clams, *Calyptogena magnifica*, and vestimentiferans, *Riftia pachyptila*.

*Comparisons*.—*Lepidonotopodium riftense* is close to *L. fimbriatum* (see Key to the species of *Lepidonotopodium*). It differs in its smaller size (up to 13 mm in length, 7 mm in width, up to 25 segments, compared to up to 37 mm in length, 16 mm in width and up to 30 segments). The elytra are more delicate, with only scattered micropapillae, compared with the thick, leathery elytra with the characteristic raised macrotubercles and numerous microtubercles of *L. fimbriatum*. The jaws of *L. riftense* have numerous minute basal teeth, compared with the relatively few and larger basal teeth of *L. fimbriatum*.

*Lepidonotopodium williamsae*, new species

Figs. 5–7

*Material*.—East Central Pacific, from dives of the *Alvin* on 3 vent areas along the Galapagos Rift in 1979:

MUSSEL BED, 00°47.89'N, 86°09.21'W:—Dive 880, 21 Jan, 2493 m, mussel washings, paratype (USNM 96026).

GARDEN OF EDEN, 00°47.69'N, 86°07.74'W:—Dive 884, 25 Jan, 2482 m, clam bucket from mussels, paratype (USNM 96027).

ROSE GARDEN, 00°48.25'N, 86°13.48'W:—Dive 984-32, 1 Dec, 2451 m, mussel washings, holotype (USNM 96023), paratype (USNM 96024), 2 paratypes (USNM 96025).

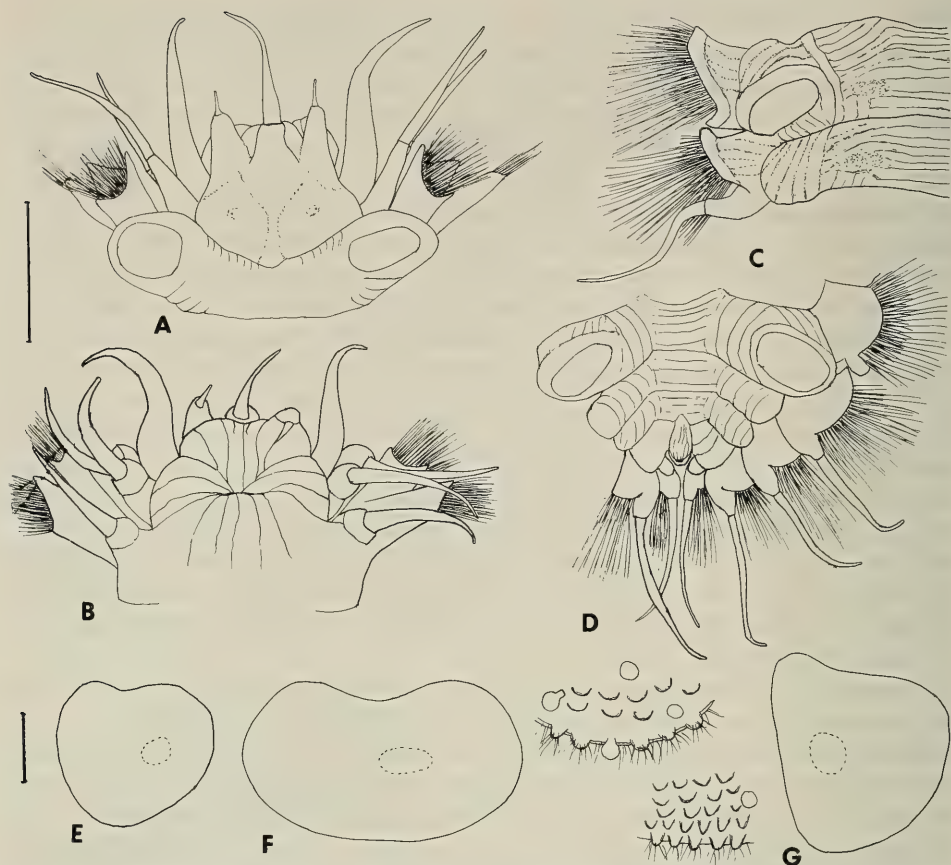


Fig. 5. *Lepidonotopodium williamsae*, holotype, USNM 96023: A, Anterior end, dorsal view; B, Anterior end, ventral view; C, Dorsal view of left segments 13 (elytrigerous) and 14 (cirriferous); D, Dorsal view of posterior end showing right parapodia of segments 21 to 25 and left parapodia of segments 24 and 25; E, Right first elytron from segment 2; F, Right fifth elytron from segment 9, with detail of microtubercles and scattered micropapillae; G, Right eleventh elytron from segment 21, with detail of same. Scales = 2 mm for A-D; 2 mm for E-G.

Pacific Ocean off Western Mexico, 20°50'N, 109°06'W, OASIS *Alvin* dives in 1982:—Dive 1214, 20 Apr, 2633 m, vestimentiferan wash, 64 paratypes (USNM 96032).—Dive 1219-10A & B, 25 Apr, 2612 m, *Riftia* and clam wash, coarse fraction, 5 paratypes (USNM 96028).—Dive 1221-15, 4 May, 2618 m, *Riftia* and *Calyptogena* wash, coarse fraction, 5 paratypes (USNM 96033).—Dive 1223-17, 7 May, 2616 m, rubble, 3 small paratypes (USNM 96029).—Dive 1225-7, 9 May, 2618 m, fine fraction, paratype (USNM 96484).—Dive 1226-7, 10 May, 2616 m, *Riftia*, *Calyptogena* and *Alvinella* wash, coarse fraction, 2 paratypes (USNM 96030).—Dive 1227-3, 11 May, 2616 m, slurp sample, paratype (USNM 96031).

*Description*.—The holotype, from the Galapagos Rift area, has a length of 26 mm, a width of 13 mm, including setae, with 25 segments. The adult paratypes from this area range in size from 11 to 26 mm in length, 6 to 14 mm in width, with 25 segments. The largest paratype from 21°N has a length of 36 mm, a



width of 14 mm, with 26 segments. The adult paratypes from this area range in size from 10 to 36 mm in length, 5 to 14 mm in width, with 24 to 26 segments. They are brownish to tan in color, elongate-oval, flattened ventrally and arched dorsally, rounded anteriorly and posteriorly. The 11 pairs of elytra are attached eccentrically on prominent elytraphores, with dorsal cirri on the posterior segments (Fig. 5A, C, D). The elytra are large, imbricate, covering the dorsum, oval, subreniform to subtriangular in shape (Fig. 5E–G). They are thick, stiff, opaque, without raised macrotubercles. Their surface is nearly covered with rounded to conical microtubercles, along with scattered globular micropapillae; fine “hairs” or “bacteria” may be attached to the microtubercles (Fig. 5F). The dorsal cirri have cylindrical cirrophores, wider basally, attached dorsoposteriorly on the notopodia; the styles are tapering and extend slightly beyond the neurosetae (Figs. 5C, D; 6B). The dorsal tubercles on the cirriferous segments are elongated and inflated (Figs. 5C; 6B). The surfaces of both the elytraphores and dorsal tubercles have numerous ciliated ridges (Figs. 5C, D; 6A, B).

The prostomium is bilobed, the anterior lobes prominent, cylindrical, extending anteriorly, each with a small frontal filament; lateral antennae are absent (Fig. 5A, B). The median antenna is inserted in the anterior notch, having a short cylindrical ceratophore and subulate style extending to about the tips of the palps. The palps are cylindrical, smooth, tapering, about one and a half times the length of the prostomium. Eyes are lacking, although a pair of tannish spots on a whitish area on the posterior half of the prostomium, each with a darker spot, may suggest a pair of “eyes” (Fig. 5A). The tentaculophores of the tentacular segment are lateral to the prostomium, each with a single aciculum, without setae. The styles of the 2 pairs of tentacular cirri are subequal in length to the palps, the ventral tentacular cirri slightly shorter than the dorsal ones (Fig. 5A, B).

The second or buccal segment bears the first pair of large elytraphores, biramous parapodia and ventral or buccal cirri attached basally on prominent cirrophores lateral to the mouth; their styles are similar to the tentacular cirri and longer than the following ventral cirri (Fig. 5A, B). The ventral mouth is enclosed in upper, lateral and posterior lips between segments 1 and 2 (Fig. 5B). The opening of the large muscular pharynx is encircled by 7 pairs of bulbous papillae, subequal in size (Fig. 7B). The 2 pairs of dorsal and ventral jaws are fused medially and the basal parts are serrated with 5–7 teeth (Fig. 7B–D).

The biramous parapodia have shorter notopodia located on the anterodorsal sides of the longer neuropodia (Fig. 6A). The notopodia are subconical with projecting acicular lobes hidden by the numerous notosetae and enclosed anterodorsally by well-developed large flaring bracts (Fig. 6A–C). The neuropodia are diagonally truncate and deeply notched on the upper part. The presetal acicular lobes project dorsally beyond the rounded postsetal lobes (Fig. 6A, B, D). The distal margins of the notopodial acicular lobes, notopodial bracts and neuropodial lobes are fimbriated with slender papillae to which numerous “hairs” or “bacteria” are attached. The notosetae are very numerous, forming radiating bundles; they vary in length from short to longer, much stouter than the neurosetae, with spinous rows on the distal part and blunt tapered bare tips; most of the notosetae have numerous fine “hairs” or “bacteria” attached (Fig. 6E). The neurosetae are numerous, forming fan-shaped bundles. The few upper supracicular neurosetae have 2 rows of prominent spines and tapered bare tips (Fig. 6F). The very numerous

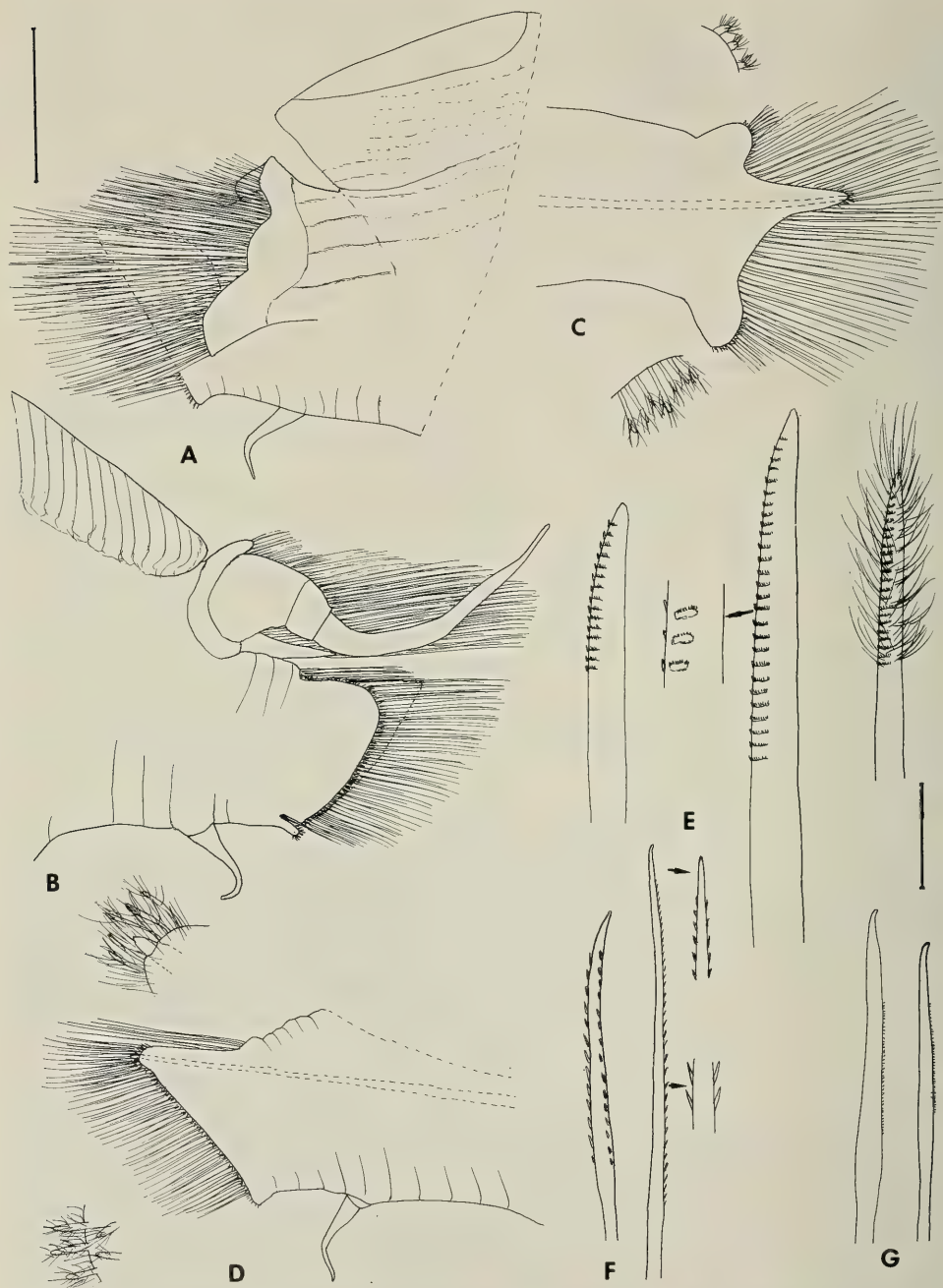


Fig. 6. *Lepidonotopodium williamsae*, holotype, USNM 96023: A, Right elytrigerous parapodium, anterior view; B, Right cirriferous parapodium, posterior view; C, Right notopodium, posterior view, with detail of distal papillae, notoaciculum dotted; D, Right neuropodium, anterior view, with detail of papillae, neuroaciculum dotted; E, Short and long notosetae and one thickly covered with "hairs" or "bacteria"; F, Two upper neurosetae, with detail of tip and middle part; G, Middle and lower neurosetae. Scales = 1 mm for A-D; 0.1 mm for E-G.

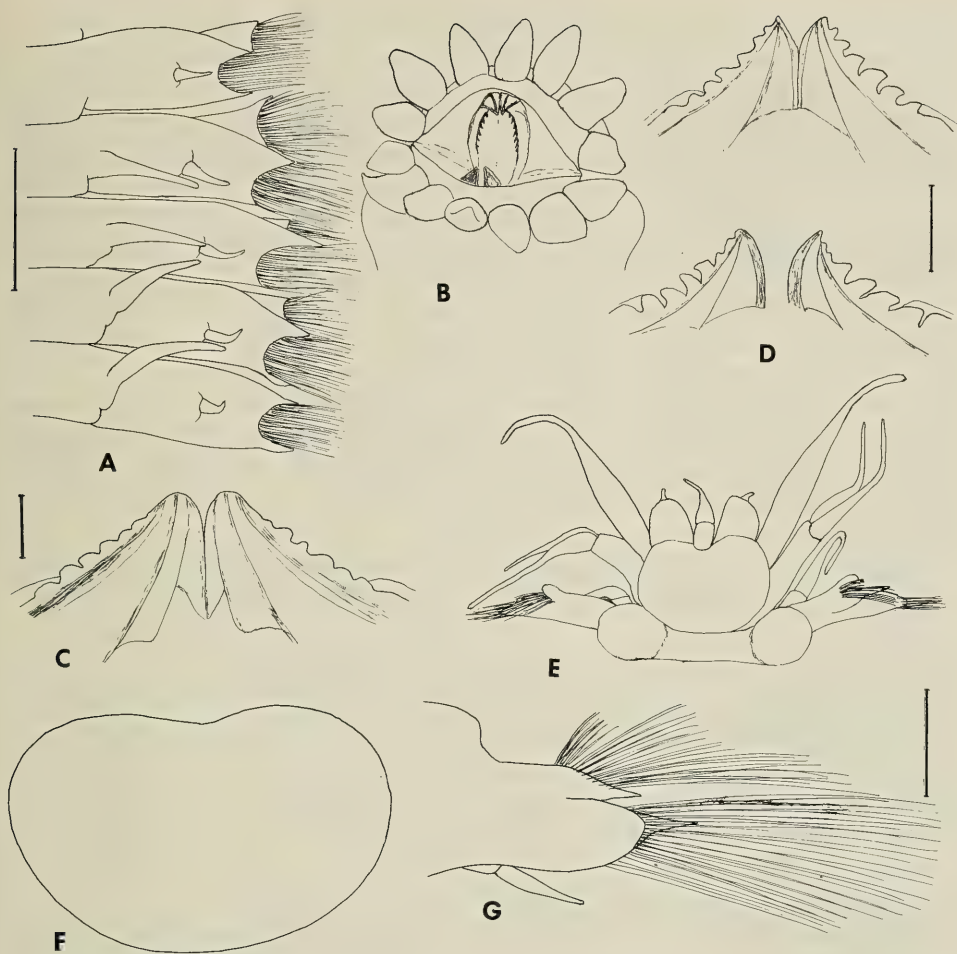


Fig. 7. *Lepidonotopodium williamsae*, A, paratype, USNM 96024; B, C, paratype, USNM 96032; D, small paratype, USNM 96028; E-G, young paratype of 13 segments, 1.5 mm long, 1.5 mm wide, USNM 96029: A, Ventral view of left segments 11-15; B, End view of distal end of extended pharynx; C, Dorsal jaws of same, spread apart; D, Dorsal and ventral jaws of smaller specimen, spread apart; E, Dorsal view of anterior end; F, Right middle elytron; G, Right elytrigerous parapodium, posterior view. Scales = 2 mm for A, B; 0.2 mm for C; 0.2 mm for D, E; 0.1 mm for F, G.

subacicular neurosetae have slightly hooked bare tips and small areas with finely spinous rows on the cutting edge (Fig. 6G). The ventral cirri are short, tapered, smooth, attached on the middle of the posterior face of the neuropodia (Fig. 6A, B).

Segmental or nephridial papillae are not obvious. On about half of the adult specimens, there are 4 pairs of elongate ventral papillae on segments 12, 13, 14, and 15, attached on the middle of the bases of the neuropodia and extending to near the bases of the ventral cirri (Fig. 7A). The pygidium is visible dorsally as a bulbous lobe wedged between the parapodia of the 3 posterior smaller segments (23-25); anal cirri are lacking (Fig. 5D).



Numerous young specimens were collected on the East Pacific Rise at 21°N, in vestimentiferan wash and in rubble. The smallest specimens have a length of 1.5 to 2 mm, a width of 1.5 mm, with 11 to 16 segments (Fig. 7E–G). The anterior end is similar to the adults in shape except that the palps, tentacular cirri and buccal cirri are wider basally, with longer distal filamentous regions (Fig. 7E). The notopodial bracts are not as well developed (Fig. 7E, G). The notosetae are similar to the adults except that the larger ones are more slender. The neurosetae are similar to the upper neurosetae of the adults, having 2 prominent spinous rows. The elytra are delicate, lacking microtubercles and micropapillae (Fig. 7F).

*Etymology.*—The species is named for Isabelle Williams of the Woods Hole Oceanographic Institution in recognition of her careful work in separating and retrieving the numerous polynoids on which this study is based.

*Distribution.*—East Central Pacific on the Galapagos Rift, in 2451–2493 meters, associated with the unnamed deep-sea mussels. Also on the East Pacific Rise at 21°N, in 2612–2633 meters, associated with ampharetid polychaetes, *Alvinella pompejana*, giant clams, *Calyptogenia magnifica*, and vestimentiferans, *Riftia pachyptila*.

*Comparison.*—*Lepidonotopodium williamsae* may be separated from the other two species of *Lepidonotopodium* by the following key to the species.

Key to the Species of *Lepidonotopodium*

- 1. Prostomium with prominent cylindrical anterior lobes (Fig. 5A). Elytral surface covered with numerous conical microtubercles and scattered micropapillae, without raised macrotubercles (Fig. 5E–G). Notosetae much stouter than neurosetae, with spinous rows on distal part (Fig. 6E). Upper neurosetae with 2 rows of prominent spines (Fig. 6F); lower neurosetae minutely spinous (Fig. 6G). Pharynx with 7 pairs of papillae, subequal in size; jaws with 5–7 basal teeth (Fig. 7B–D). Without anal cirri (Fig. 5D). Some specimens with 4 pairs of elongate ventral papillae on segments 12–15 (Fig. 7A) ..... *L. williamsae*, new species
- Prostomium with subtriangular anterior lobes (Fig. 2A; fig. 2A, in Pettibone, 1983). Notosetae similar in width to neurosetae, with relatively few (4–9) widely-spaced spines along one side (Fig. 4A; fig. 4E, in Pettibone, 1983). Upper neurosetae not markedly differing from lower ones (Fig. 4B; fig. 4F, in Pettibone, 1983). With pair of anal cirri (fig. 2D, in Pettibone, 1983). Some specimens with long ventral papillae on segments 11 and 12 (Fig. 4C; fig. 3A, in Pettibone, 1983) ..... 2
- 2. Elytra with 2 raised macrotubercles per elytron, numerous microtubercles and scattered globular micropapillae (figs. 1, 2E–G, in Pettibone, 1983). Pharynx with 7–9 pairs of papillae, unequal in size; jaws with few basal teeth (5–9; Fig. 1C–E; fig. 3B, C, in Pettibone, 1983) ..... *L. fimbriatum* Pettibone, 1983
- Elytra without raised macrotubercles, with scattered clavate micropapillae, with or without variable number of small projections (Fig. 2F–H). Pharynx with 7–9 pairs of papillae; jaws with numerous basal teeth (Fig. 2D, E) ..... *L. riftense*, new species

## Acknowledgments

I wish to thank J. F. Grassle and I. Williams of the Woods Hole Oceanographic Institution for the material on which this study is based, as well as the members of the Galapagos Rift Biology Expedition in 1979 and the OASIS group of Scripps Institution of Oceanography in 1982, including K. Smith. The manuscript benefited from the review of Meredith L. Jones.

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## TWO NEW SPECIES OF THE *SIPHONOECETES* COMPLEX FROM THE ARABIAN GULF AND BORNEO (CRUSTACEA: AMPHIPODA)

J. Laurens Barnard and James Darwin Thomas

*Abstract.*—A new species, *Siphonoecetes arabicus*, is described from the Arabian Gulf, and a new species *B. wongi* is described in the new genus *Borneoecetes* from Borneo. The former species does not fit recently described subgenera, thus indicating a necessary reassessment of those taxa.

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A new species of *Siphonoecetes* from the Arabian Gulf and a new species of *Borneoecetes*, new genus, from the shallow continental shelf off north Borneo are described.

The description of the Arabian species seems crucial at this time because of a massive oil spill in the Arabian Gulf in late 1982, a year after it was first collected by Dr. John C. McCain. Dr. McCain informed us that his survey of the benthos on the Arabian side of the Gulf near Dhahran showed this species to comprise nearly 30 percent of the total amphipod specimens in the sand biotope. This new species, *Siphonoecetes arabicus*, spins a tube from amphipod-silk, glues coarse grains, especially shell fragments, to the tube and simultaneously glues the tube to dead shells of bivalves or inside dead gastropod and bivalve mollusk shells, calcareous polychaete tubes, or into detached movable-finger crab claws, all of appropriate sizes. Owing to its small adult size, less than 3 mm in body length (smaller than 6 mm in body-antennae length), one assumes the competition for snail shells with hermit crabs is quite limited. Some of the variety of abodes selected by *S. arabicus* for gluing down its tubes are shown in Fig. 1. Although Harada (1971) found *S. tanabensis* able to drag its unfixed tubes around on the bottom by use of antenna 2, we initially judged that the heavy shells to which *S. arabicus* cements its tube would be too massive and too heavy to be moved by the very feeble appearing amphipod. However, Dr. J. Just of the Zoological Museum, University of Copenhagen, informs us that he has observed siphonoecetines able to drag very heavy loads and believes that most of the abodes we show in Fig. 1 could be moved by the amphipods.

Other species of *Siphonoecetes* are also known to inhabit shells of various sorts, for example, *Siphonoecetes pallidus* in *Dentalium* sp. (Sars 1895) in deep waters off Norway (100–300 m), *S. australis* also from *Dentalium* from Australia (Stebbing 1910), *S. conchicola* in *Olivella* sp. (Gurjanova 1951) from the Japan Sea, and *S. sabatieri* in snails of the genera *Bittium* and *Rissoa* (Chevreux and Fage 1925). But, apparently, some species always form simple silk tubes with agglutinated shell and mineral fragments, such as *S. colletti* (see Chevreux and Fage 1925). Several papers being published by Dr. Just give many more details of habitats of various species in the *Siphonoecetes* complex.

We follow the diagnostic method of Myers and McGrath (1979) who described *Siphonoecetes* from the British Isles and provided a key to the seven species of



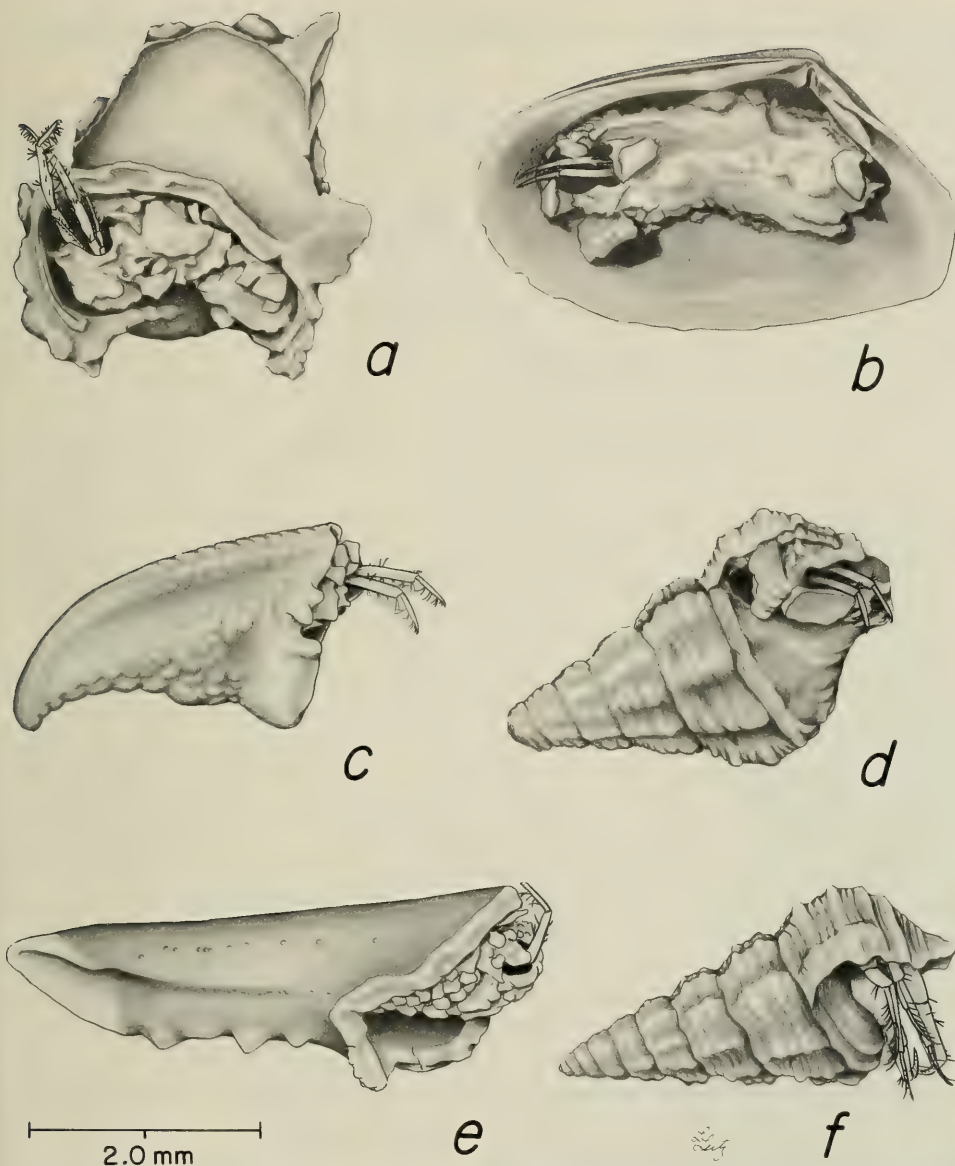


Fig. 1. Abodes of *Siphonoecetes arabicus*: a, Tube of amphipod silk and agglutinated shell fragments glued to bit of coral rubble; b, Same glued to bivalve; c, Same glued inside movable finger of crab claw; d, Same glued inside snail-shell; e, Same glued inside crab claw; f, Same glued inside similar snail-shell from different angle.

Europe. Because of the closeness of *Siphonoecetes* and *Borneoecetes* we use the same diagnostic method for *B. wongi*. Harada (1971) gave a key to all species of *Siphonoecetes* known at that time; we have therefore expanded the diagnoses from the Myers-McGrath format to include the characters used by Harada in his world treatment of the genus.

A paper by Just (1983) has been utilized in our work to classify these species

at generic level; his work may be consulted for extensive diagnoses and relationships of genera.

*Explanation of Figure Legends.*—Upper case letters in illustrations are explained in the following list; lower case letters to right of capital letters or in the body of an illustration are explained also in the following list; lower case letters to the left of capital letters are provided for subsidiary figures to note illustrated specimens listed in "Material." For each page of figures one main specimen is called "unattributed" and lacks letter designation. *A*, antenna; *B*, body; *C*, coxa; *F*, accessory flagellum; *G*, gnathopod; *H*, head; *J*, pleopod; *K*, spine or seta; *L*, labium; *M*, mandible; *O*, outer plate or ramus; *P*, pereopod; *R*, uropod; *S*, maxilliped; *T*, telson; *U*, labrum; *V*, palp; *W*, pleon; *X*, maxilla; *Y*, urosome; *Z*, oostegite. *d*, dorsal; *m*, medial; *r*, right; *s*, setae removed; *u*, unflattened.

*Siphonoecetes arabicus*, new species

Figs. 2-5

*Diagnosis.*—Size of adults about 2.25–2.80 mm. Body delicate, fragile, unpigmented in alcohol. Rostrum pointed, extending as far as ocular lobes, latter protuberant, quadrate. Eyes small. Antenna 1 barely exceeding apex of article 4 on antenna 2, flagellum with 5 well-developed articles tipped with tiny sixth. Articles 4 and 5 of peduncle on antenna 2 equal in length, flagellum with 4 articles, first two articles long and equal in juveniles, article 1 becoming slightly dominant in tropical adults, articles 3–4 vestigial, spines absent from article 1. Coxa 1 scarcely broader than long, anteroventral corner weakly and bluntly attenuate, all setae confined to small distance on margins. Gnathopod 1 with slender, unexpanded propodus (article 6) bearing 2–3 major posterior spines. Gnathopod 2 propodus ovate, palm sloping, equal to half of posterior margin, no extra spines present other than spine defining palm. Uropod 1 peduncle with about 4 dorsolateral setae evenly distributed, ventral apex extended as strongly serrate or fimbriate lamina. Uropod 1 rami unequal in length and thickness, inner shorter and thinner than outer, inner not swollen; outer ramus with dorsal spines, when present, evenly distributed, not mingling with apical spines. Uropod 2 peduncle apicoventral lamella strongly fimbriate; inner ramus more than 90 percent as long as outer ramus. Inner rami of uropods 1 and 2 each with 1 apical spine, apices of both rami with hollows bearing armaments. Uropod 3 peduncle with 2–3 apical spine-setae shorter than peduncle, ramus distinct, with 2–4 setae, middlemost (plumose) about twice as long as peduncle.

*Description and Notes on Illustrations.*—Most of morphology shown in illustrations; description largely based on holotype male. Eyes weak, formed of several irregular elements with scattered brownish pigment. Lateral and medial surfaces of peduncle on antenna 1 almost equally setose; accessory flagellum vestigial, composed of evanescent boss bearing 4 diverse setae. Lateral surfaces of peduncular articles on antenna 2 setose but lacking spines, medial surface of article 4 in both sexes with proximal to distal spine formula of 1-2, formula on article 3 in male = 1-2, in female = 0-1. Female antenna 2 relatively smaller than male but when adjusted to same magnification as in illustrations, articles 3–4 of peduncle of similar size, article 5 relatively longer in female, flagellum relatively

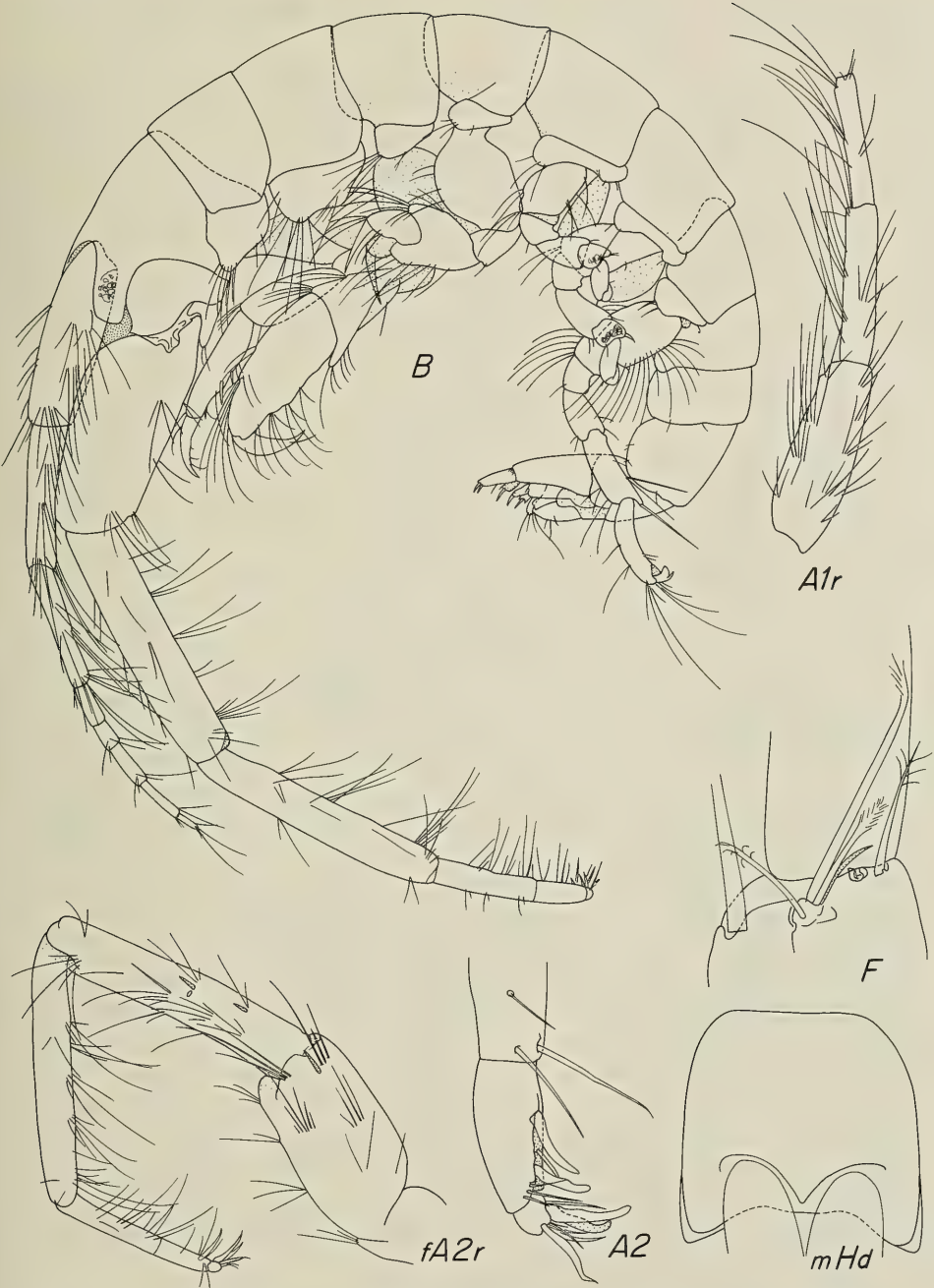


Fig. 2. *Siphonoecetes arabicus*, unattributed figures, holotype, male "a" 2.46 mm; f = female "f" 2.75 mm; m = male "m" 2.51 mm.



longer and thinner than in male; flagella with 4 articles; spinal differences slight (see illustrations).

Epistome unproduced; upper lip articulated to epistome, subcircular, weakly truncate or slightly excavate below. Mandibular incisors toothed, right and left laciniae mobiles with 2 and 3 teeth respectively, right and left rakers = 2 and 3, each molar with flake and seta, palp composed of one long article flared and bifid apically when properly flattened, notch bearing second tiny article tipped with seta. Labium as shown. Inner plate of maxilla 1 evanescent, outer plate with 7 spines (one hidden in illustration), medial pair bifid, palp ordinary. Inner plate of maxilla 2 with 3 medial setae, no facials. Inner plate of maxilliped with 2 main stubby apical spines, outer plate with sharp medial chisel-spines, palp article 4 small, stubby, bearing long nail and accessory nail.

Coxae all disjunct; coxa 1 of subadults generally with only 2 anterior setae and 6 on anteroventral corner (groups of 3-3 lateral and medial). Propodus (article 6) of gnathopod 1 in both sexes with tiny tooth apically representing palm, posterior margin with 2 spines, long in female, short in male. Gnathopod 2 without strong sexual distinction, lobe of carpus (article 5) with one stout spine, palm weak and defined by one stout spine, palm near hinge in female with cusp. Pereopods 3-4 alike, article 4 enveloping reduced article 5, article 6 attached to oblique apical margin of article 5, dactyl simple (bearing subapical meatus). Pereopods 5-6 subsimilar, small, article 5 with facial stridulating (or non-skid) surface, pereopod 7 elongate, lacking rough surfaces, dactyls of pereopods 5-7 with outer cusp. Large gills present on coxae 3-6 in male but in female gills 3-4 reduced greatly and gill 5 slightly reduced, thin oostegites present on coxae 2-5, formulae of anterior setae = 3-3-3-4, distal setae = 2-2-3-4, posterior setae = 2-2-2-3 (on female "f").

Epimera 1-3 each with midposterior seta in notch, epimeron 1 with 4 large ventral setae (one missing in illustration) and one posteroventral setule, epimeron 2 with 4 large ventral setae and 2 smaller posteroventral setae, epimeron 3 with 2 small ventral setae. Pleopods all subsimilar, each peduncle with medial lobe bearing 2 coupling hooks, formula of lateral peduncular setae on pleopods 1-3 = 3-2-2, outer rami all with 7 articles, formula of articles on inner rami = 7-7-6.

Urosomites 2 and 3 fused dorsally, urosome otherwise naked. Inner ramus of uropod 1 much smaller than outer ramus, dorsal minor spination of rami variable from side to side as shown. Uropod 2 as shown. Larger specimens and females generally with more setae on uropod 3 than male holotype, female "f" ramus with 5-6 setae, apex of peduncle with 5, medial peduncle with 1 seta; male "m" 2.51 mm with 4 apical setae on peduncle and 5 on ramus; female "k" 2.07 mm with 3 setae on peduncle apex and 3 on ramus. Plaques on telson with small corneal hooks (not well enough resolved in oil-immersion microscopy to illustrate). Female generally much more setose and spinose than male, especially on gnathopods.

*Holotype*.—USNM No. 195105, male "a," 2.46 mm.

*Type-locality*.—Arabian Gulf, off Manifa, 27°30'35"N, 49°00'15"E, Sta 1S1, 2-3 m, 21 Nov 1981, coll. Dr. J.C. McCain; fine medium grain sediments, near coral reef, 70°F, salinity 42‰.

*Material and Distribution*.—56 specimens from one station in the Gulf of Arabia, kindly supplied by Dr. John C. McCain of Tetra-Tech, Ltd., Dhahran, Saudi

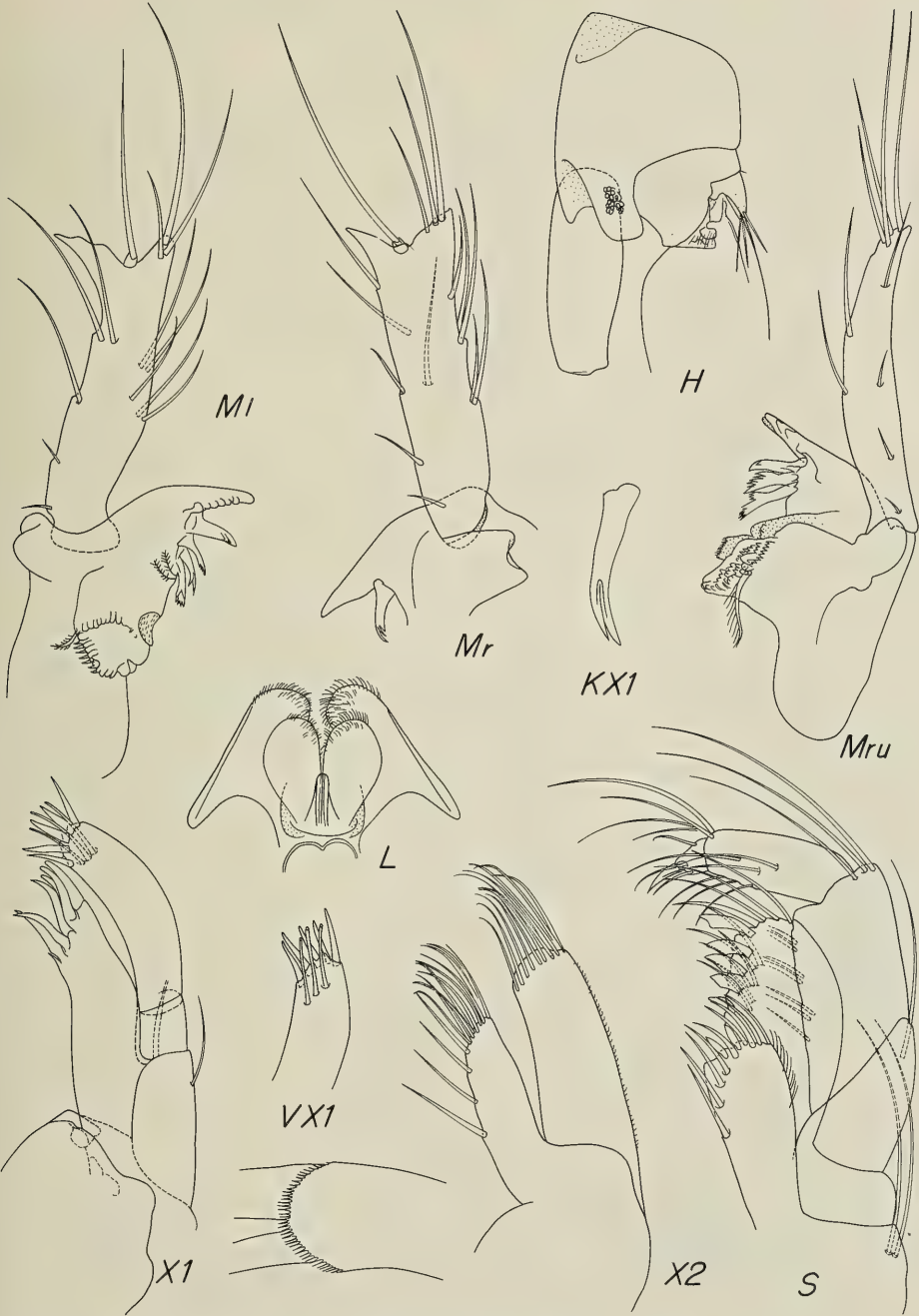


Fig. 3. *Siphonoecetes arabicus*, all figures, holotype, male "a" 2.46 mm.

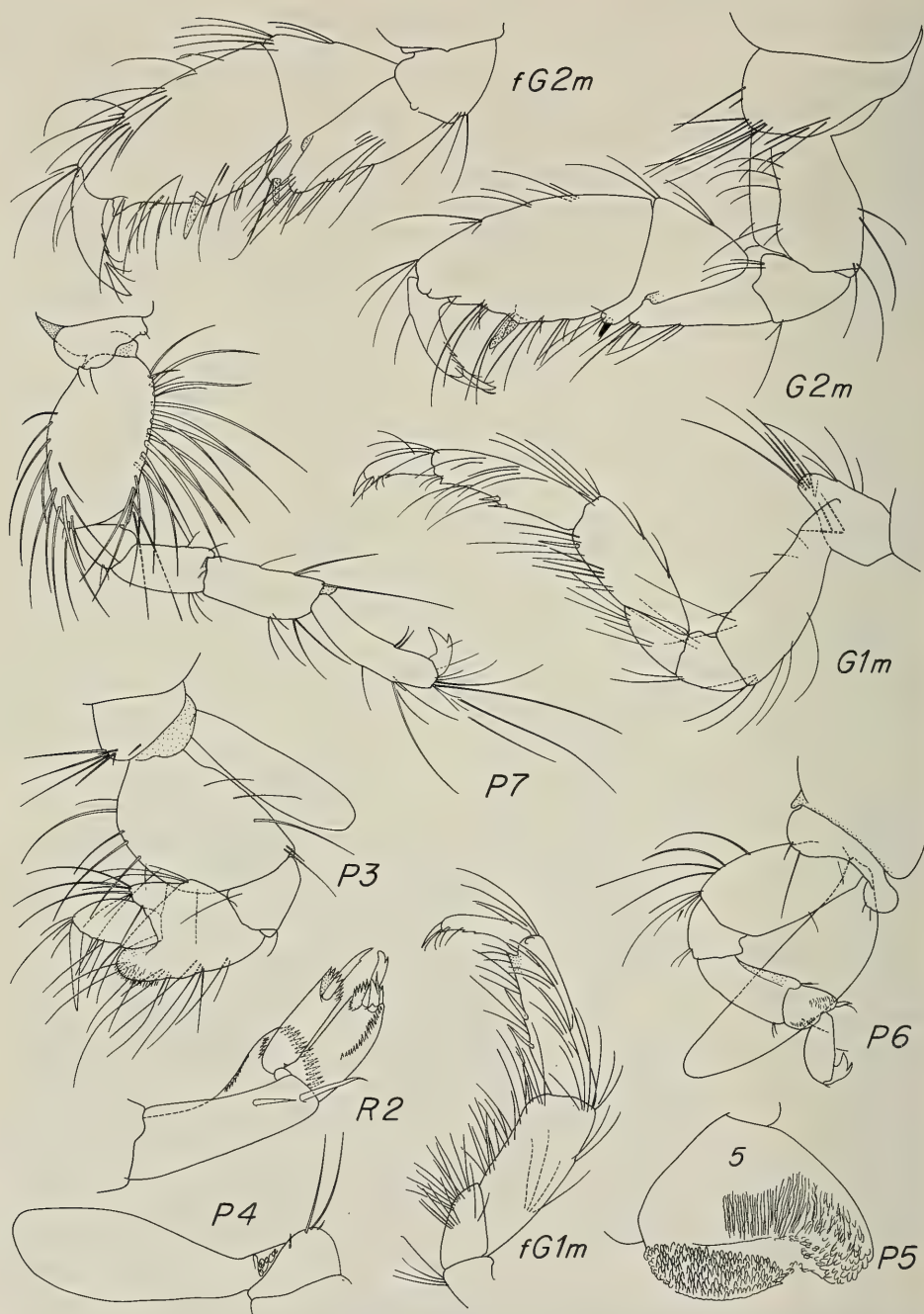


Fig. 4. *Siphonoecetes arabicus*, unattributed figures, holotype, male "a" 2.46 mm; f = female "f" 2.75 mm.



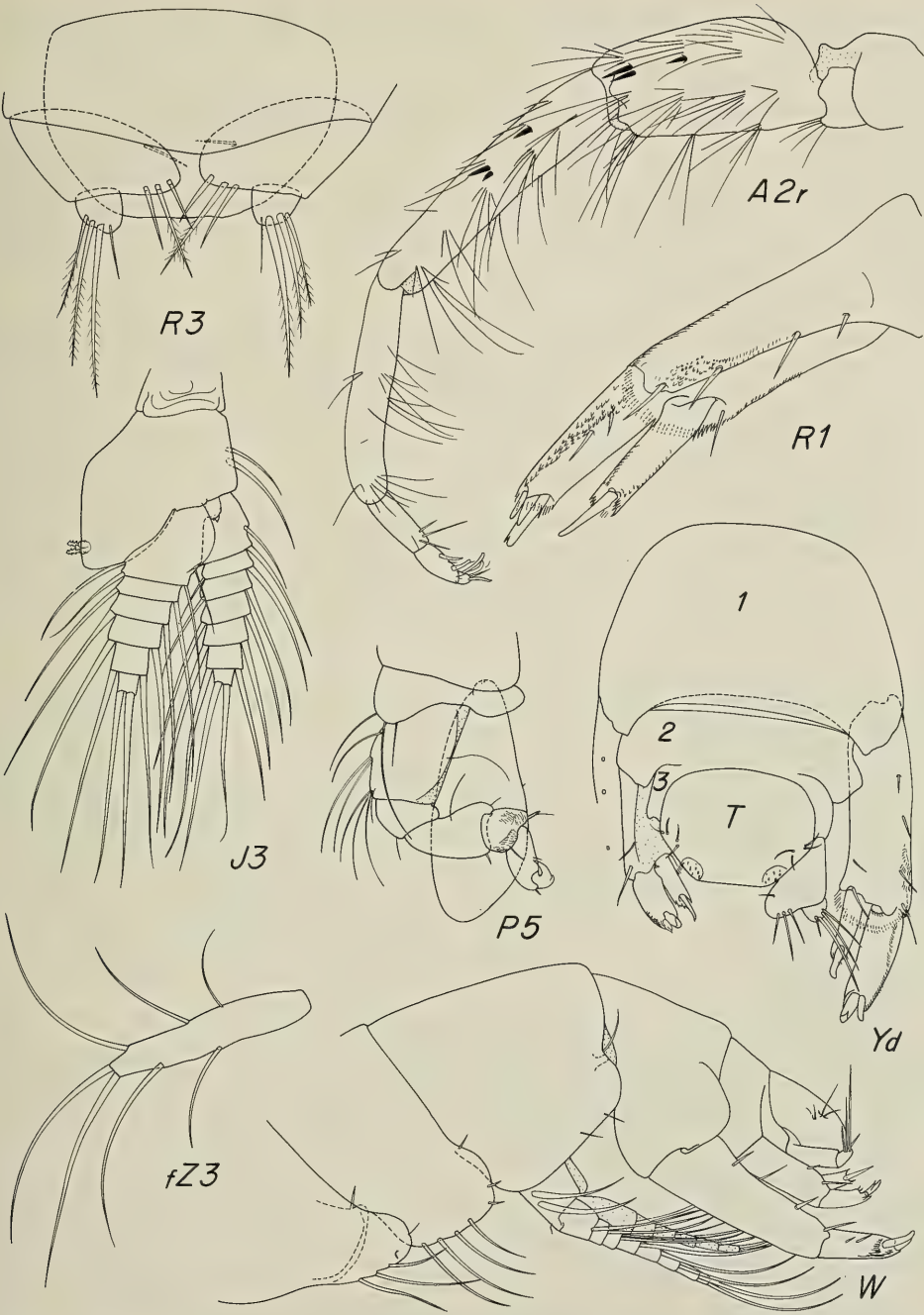


Fig. 5. *Siphonoecetes arabicus*, unattributed figures, holotype, male "a" 2.46 mm; f = female "f" 2.75 mm.

Arabia; male "d" 2.72 mm from crab claw; female "f" 2.75 mm (illustrated) from gastropod; female "k" 2.07 mm from crab claw; male "m" 2.51 mm (head illustrated) from gastropod.

*Ecology*.—Dr. McCain informs us that this species represents about 30 percent of the specimen count for amphipods in shallow waters along the shores of Saudi Arabia in the Arabian Gulf. The species builds a thin parchment tube of amphipod silk and attaches the tube inside the shells of *Dentalium* sp., *Caecum* sp., or other gastropods and often on the curved or flat surfaces of other shelled organisms such as pelecypods or the broken calcareous fragments of many other, unidentified shell-forming organisms.

*Relationship*.—This species does not fit precisely any of the subgenera described by Just (1983) as shown in the accompanying table. Four characters are used by Just to delineate those subgenera: (1) the presence or absence of spines on article 1 of the flagellum on antenna 2; (2) the normal ventral apex of uropod 1 bearing a straight comb as contrasted with a process; (3) the presence or absence of an apical hollow on the inner rami of uropods 1 and 2; (4) the presence of a strong row or essentially no row of apical setae on the peduncle of uropod 3.

*Siphonoecetes arabicus*: has only 1 spine on article 1 of the flagellum of antenna 2 and thus would barely be in the subgenus *Orientoecetes* but would remain very close to the other subgenera; has the normal uropod 1 and thus is not *Centraloecetes*; has the hollowed apex on the inner rami of uropods 1–2 and thus has affinities with the subgenus *Siphonoecetes* and not *Centraloecetes* nor *Orientoecetes*; has 3 apical setae on the peduncle of uropod 3 and thus lies in between any of the subgenera (Table 1).

By running this species through the key of Harada (1971) the similarities appear to be with *S. erythraeus* and *S. orientalis*, both of which belong to *Orientoecetes*. This species differs from *S. erythraeus* Ruffo (1959:20) from the Red Sea, in (1) the sharply bifid and splayed apex of the mandibular palp and the presence of a minute article 2 on the mandibular palp; (2) the denser setation of uropod 3 (7 setae versus 4); (3) the presence of only one (versus 2) apical spine on the inner ramus of uropod 2; (4) the much stouter and better developed hand of female gnathopod 2.

This species does not appear to be *S. orientalis* Walker (1904, pl. 7, fig. 49), from Ceylon, because gnathopod 2 of both sexes has a distinct palm and broader hand than illustrated by Walker. The flagellum of antenna 1 in *S. orientalis* has 14 articles. The spines on the flagellum of antenna 2 seem to be short, thick, evenly curved and regularly distributed.

*Siphonoecetes australis* Stebbing (1910), from Australia, has a broadened hand on gnathopod 1 and a strongly shortened and unornamented inner ramus on uropod 1. The rostrum is very blunt.

This species is very similar to *S. sabatieri* de Rouville (see Chevreux and Fage 1925:362) from the Mediterranean Sea, but differs in (1) the absence of thick spines mixed among the setae on the posterior margin of the hand on gnathopod 2; (2) the lack of one thick spine each on the peduncle and ramus of uropod 3; (3) the presence of only 1 (versus 2) apical spine on the inner ramus of uropod 1; (4) the different form of coxa 1 in which the plate is smaller, more quadrate, less attenuate and with the setae confined to less marginal length; many other characters of *S. sabatieri* are as yet poorly known.

All other species of *Siphonoecetes* have either a longer rostrum, no eyes, extra

Table 1.—Characters of subgenera in *Siphonoecetes*, compared to *Siphonoecetes arabicus*.

Character	<i>Siphono-</i> <i>ecetes</i>	<i>Centralo-</i> <i>ecetes</i>	<i>S. arabicus</i>	<i>Oriento-</i> <i>ecetes</i>
Antenna 2 flagellum spines on article 1 (male)	0	0	0	+
Uropod 1 normal	+	0	+	+
Uropod 2 inner ramus with hollowed apex	+	0	+	0
Uropod 3 apical setae on peduncle	0	5+	3	0

posterior spines on gnathopod 2 besides the spine defining the palm, more weakly fimbriate peduncles of uropods 1–2, more strongly shortened inner ramus of uropods 1 or 2, the presence of pigmentation, long setae on the peduncle of uropod 3 or distinct spines on uropod 3 (two kinds of spine-setae, thick and thin).

Now that our species has come to light, we detect that the following attributes and characters of several species of *Siphonoecetes* must be better described so that new distinctions can be attributed to those species: the flattened and bifid aspect of the mandibular palp; diversity in male and female gnathopods; and spine counts both on the apices and margins of uropods 1–2.

*Borneoecetes*, new genus

*Diagnosis*.—Rostrum normally pointed. Coxae 3–4 with simple distal margin. Large gills present on coxae 3–6; oostegites present on coxae 2–5 in female. Gnathopod 1 simple; gnathopod 2 subchelate. Dactyls of pereopods 3–7 with accessory tooth. Urosomite 2 free. Telson free, but proximal margin hidden by urosomite 2. Uropod 1 biramous, inner ramus reaching three-fourths along outer, both rami of similar structure, with strong apical spine(s); uropod 2 uniramous. Uropod 3 with distomedially expanded peduncle and setiferous ramus.

*Type-species*.—*Borneoecetes wongi*, new species.

*Etymology*.—Named for Borneo, the type-locality.

*Relationship*.—Dr. Jean Just has given us extensive help from his recent experience with undescribed species in the vicinity of this taxon. At first we considered this species to be *Bubocorophium tanabensis* (Harada, 1971), but Dr. Just assures us that the shape of the mandibular palp, the uniarticulate palp of maxilla 1 and unfused urosomites make such identification impossible. The latter character makes impossible the assignment of our species to *Bubocorophium* Karaman (1981). The only other available genus with uniramous uropod 2 is *Rhinoecetes* Just (1983) but our species differs from that genus in the ordinary head lacking anterodorsal depression. Our species “more or less” lacks spines on article 1 of the flagellum on antenna 2 (it often has one seta thickened sufficiently to be called a spine) but we have decided to ignore the spine problem for the moment as spines can only be evaluated synoptically by a single observer looking at all known species or by rendering unequivocal diagrams to define spines.

*Borneoecetes wongi*, new species

Figs. 6–9

*Diagnosis*.—Size of adults about 2.00–2.75 mm. Body delicate, fragile, unpigmented in alcohol. Rostrum pointed, extending as far as ocular lobes; latter round-



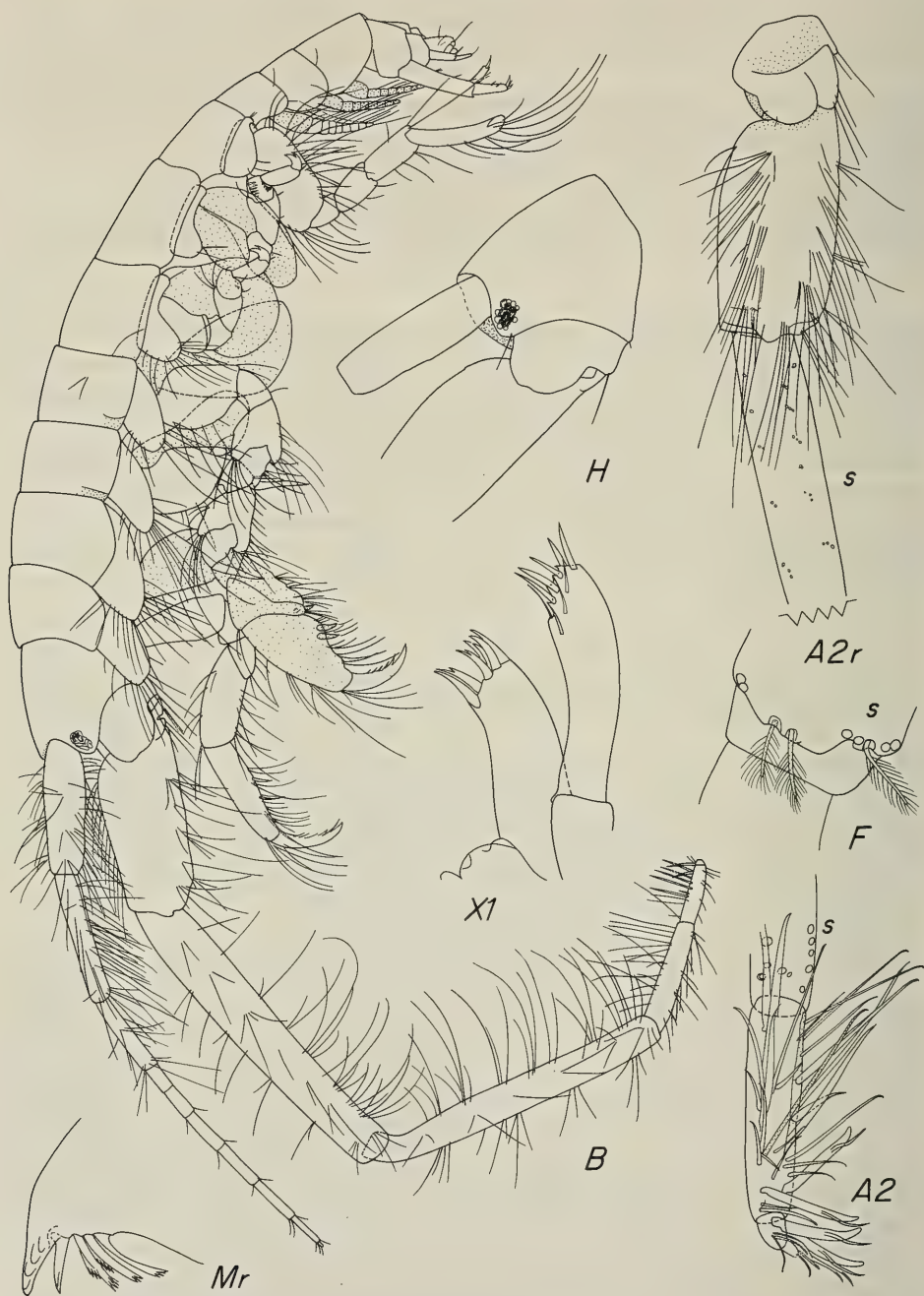


Fig. 6. *Borneoecetes wongi*, all figures holotype male "n."

ed. Eyes small. Antenna 1 barely exceeding apex of article 4 on antenna 2, flagellum with 6 well-developed articles tipped with tiny seventh. Article 5 of peduncle on antenna 2 about 90 percent as long as article 4, flagellum with 4 articles, article 1 lacking spines except for one apical element very slightly thickened and not

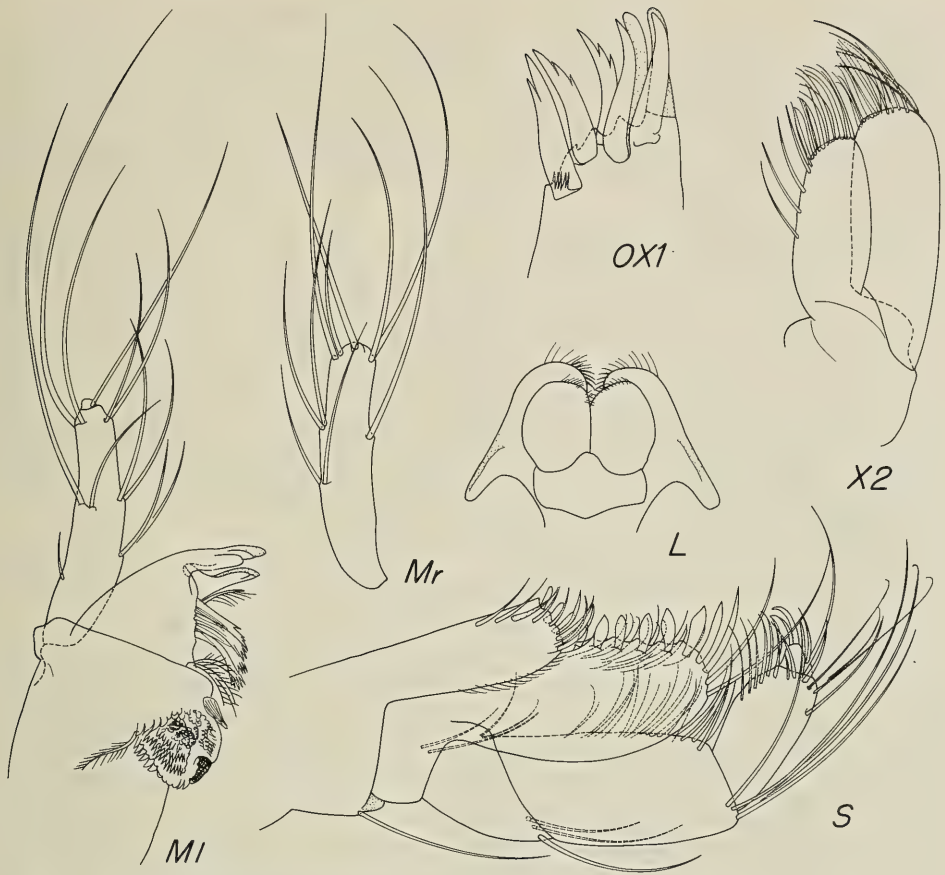


Fig. 7. *Borneoecetes wongi*, all figures holotype male "n."

capable of bending, article 2 of flagellum almost 60 percent as long as article 1, spinose, articles 3–4 vestigial. Coxa 1 scarcely broader than long, anteroventral corner blunt, all setae confined to moderate distance on margins. Gnathopod 1 with slender, unexpanded hand (article 6) bearing 2–3 posterior spines. Gnathopod 2 propodus (article 6) ovate, palm sloping, equal to half of posterior margin, no extra spines present other than 2 spines defining palm. Uropod 1 peduncle with 2+ dorsolateral setae and 4+ apicolateral setae, ventral lamella strongly serrate. Uropod 1 rami unequal in length and thickness, each with apical hollow, inner ramus shorter and thinner than outer, not swollen, bearing 1 apical spine; outer ramus with 2 apical spines, one subapical spine and 3 dorsolateral spines evenly distributed and not mingling with apical spines. Uropod 2 peduncle with 0–1 dorsal setae and 2–3 apicolateral setae, apicoventral lamella moderately fimbriate, inner ramus absent. Uropod 3 peduncle with 2–3 apical spine-setae shorter than peduncle, ramus with 3 long setae almost as long as peduncle; ramus tending to become fused to peduncle especially in adults.

*Description and Notes on Illustrations.*—Most of morphology shown in illustrations; description largely based on holotype male "n." Eyes weak, formed of several compacted elements with scattered brownish pigment. Lateral and medial

surfaces of peduncle on antenna 1 almost equally setose; accessory flagellum vestigial, composed of 2 penicillate setae attached side by side on apex of peduncular article 3. Lateral surfaces of peduncular articles on antenna 2 poorly setose but lacking spines, medial surface of article 4 in both sexes with proximal to distal spine formula of 0, formula on article 3 in both sexes = 0-1. Female antenna 2 similar to male, flagellum with 4 articles, first longest, each following article much shorter than previous.

Epistome unproduced; upper lip articulated to epistome, subcircular, weakly truncate or slightly excavate below. Mandibular incisors toothed, right and left laciniae mobiles with 2 and 3 teeth respectively, right and left rakers = 3 and 4, each molar with 2 flakes and seta, palp composed of one long article tapered apically when properly flattened, bearing second tiny article tipped with seta. Labium as shown. Inner plate of maxilla 1 evanescent, outer plate with 7 spines, medial triad bifid or trifid, palp ordinary in shape but 1-articulate. Inner plate of maxilla 2 with 4 medial setae, no facials. Inner plate of maxilliped with 3 main stubby apical spines, outer plate with sharp medial chisel spines, palp article 4 small, stubby, bearing long nail and accessory nail.

Coxae following coxa 2 all disjunct. Setae on coxae 1-2 in 2 tiers, in other words, anterior and ventral edges with lateral and medial rows. Propodus (article 6) of gnathopod 1 in both sexes with almost straight posterior margin bearing 2-3 (3 in female) spines. Gnathopod 2 without strong sexual distinction, lobe of carpus (article 5) with one stout spine, palm weak and defined by 2 stout spines, palm near hinge with rudimentary cusp. Pereopods 3-4 alike, article 4 enveloping reduced article 5, article 6 attached to oblique apical margin of article 5, dactyl simple (bearing subapical meatus). Pereopods 5-6 subsimilar, small, article 5 with facial stridulating (or non-skid) surface, pereopod 7 elongate, lacking rough surfaces, dactyls of pereopods 5-7 with outer cusp. Large gills present on coxae 3-6 in male, but in female 3-4 scarcely reduced and gill 5 not reduced, thin oostegites present on coxae 2-5, formula of anterior setae = 5-2-2-2, distal and posterior setae together = 7-5-3-3 (on female "p").

Epimera 1-3 each with midposterior seta in notch, epimeron 1 with 3 large ventral setae and one posteroventral setule, epimeron 2 with 5 large ventral setae and 1 smaller posteroventral seta, epimeron 3 with 2 small ventral setae. Pleopods all subsimilar, each peduncle with medial lobe bearing 2 coupling hooks, formulae of lateral peduncular setae on pleopods 1-3 = 3-2-3, ventral setae = 3-2-2, outer rami all with 7 articles, inner with 6, outer setae on outer rami = 8-9-8.

Urosomites 2 and 3 not fused together dorsally but urosomite 3 lacking dorsal representation, urosome otherwise naked except for dorsolateral seta on urosomite 2. Peduncle of uropod 1 with 3 dorsolateral setae and 3 apicolateral setae (female with 5 and 5). Outer ramus of uropod 1 with 2 dorsal and 2 apical spines (female with 3 and 3). Inner ramus of uropod 1 smaller than outer ramus, dorsal minor spination of rami variable from side to side. Uropod 2 of male with 2 apicolateral peduncular setae, female with 3 apicolateral and one middorsal setae as shown. Peduncle of uropod 3 with one apical seta (3 in female), ramus with 2 (3 in female). Ramus of uropod 3 frequently asymmetrical side to side, smaller or larger, on occasion partially fused to peduncle as shown. Plaques on telson with small corneal hooks (not well enough resolved in oil-immersion microscopy to illustrate).



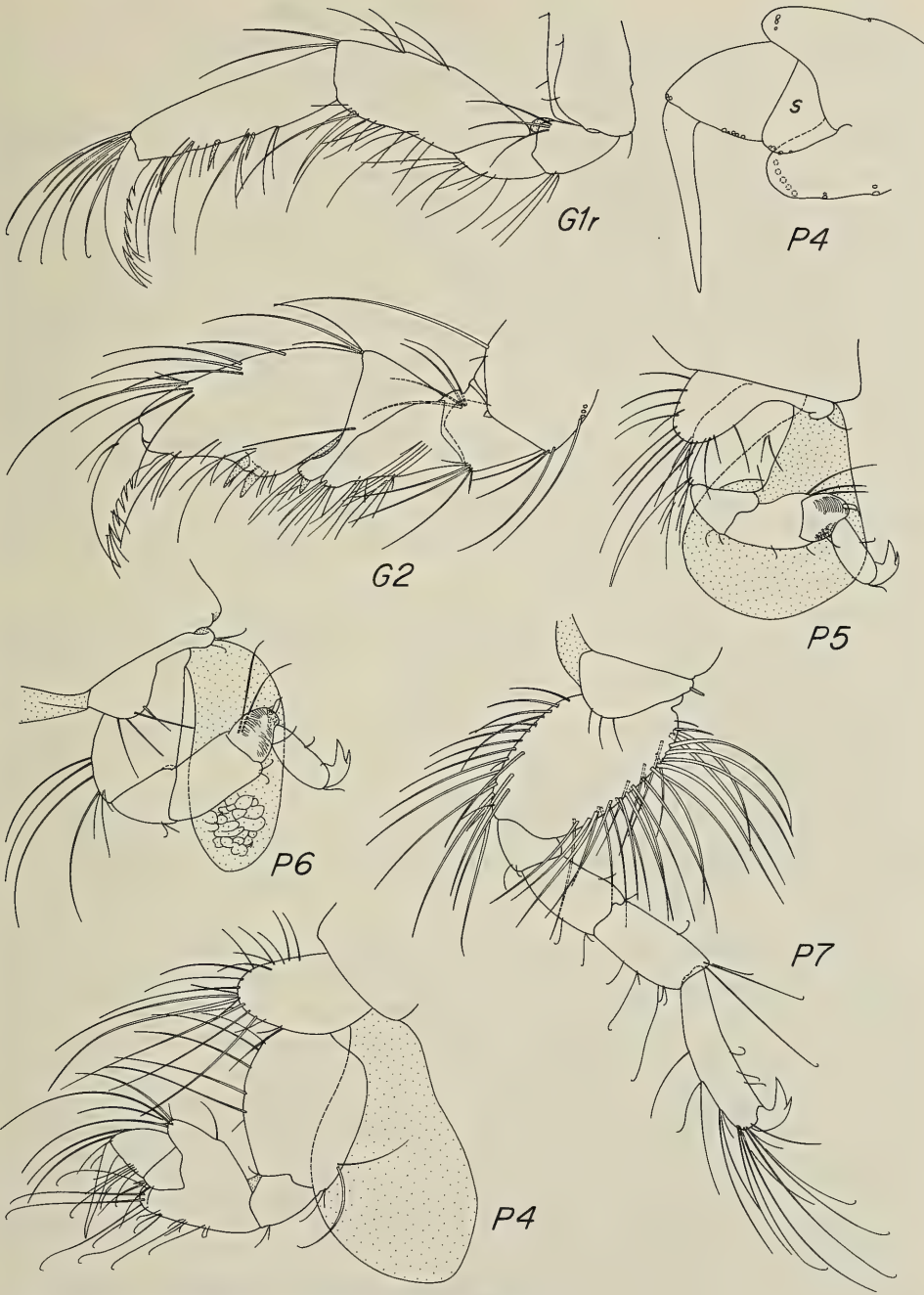


Fig. 8. *Borneoecetes wongi*, all figures holotype male "n."

Female "v."—Represents main described female referred to in male description above. Rostrum projecting slightly in front of eyes. Setae of coxae 1 = 33, of 2 = 33, of 3 = 29, of 4 = 17, of 5, 13 + 3 (anterior and posterior lobes), of 6 = 6 + 3, of 7 = 4 + 1. Main setae of epimeron 1 = 5, epimeron 2 = 7.

Female "p."—Main large setae on epimeron 1 = 3, epimeron 2 = 7. Setae of uropod 1 peduncle, dorsolateral = 6, apicolateral = 5; peduncle of uropod 2 = 3 and 1 proximal; peduncle of uropod 3 = 2, ramus = 2.

Juvenile "i," 0.98 mm.—Flagellum of antenna 1 with 3 large articles tipped with tiny fourth. Antenna 2 as stout as adult, first 2 articles equal in length as in Japanese adults of *B. tanabensis*. Example of weaker setation than in adults, coxae 1–7 = 6–9–4–3–2–1–0, with anterior and posterior divisions on coxae 5 and 6 being 1–1 and 0–1. Propodus (article 6) of gnathopod 1 with only 1 main posterior spine, gnathopod 2 with only 1 palmar defining spine. Epimera 1–3 all with large posterior crotch seta, main ventral setae = 1–2–0. Peduncle of uropod 1 with only 2 apicolateral setae, outer ramus with 3 apical spines, none dorsally. Only spine on uropod 2 on apex of ramus. See illustrations of uropod 3 and telson apex, peduncle of uropod 3 with one apicomedial seta, ramus with one long seta, vestige of inner ramus appearing through chitin of peduncle. Each apical plaque of telson with 3 weak hooks.

*Holotype*.—USNM No. 195136, male "n" 2.03 mm, illustrated.

*Type-locality*.—Borneo, north coast of Brunei, off Sungei Buloh, 4°N, 113°57'E, 2–3 m, 1983, temperature 31.5°C, salinity 32‰, Wong Tat Meng Sample MCF 40 (71 specimens).

*Material*.—Type-locality, male "n" 2.03 mm (main illustrations), female "p" 2.59 mm, ?male "q" 2.55 mm, male "r" 2.14 mm, male "s" 1.47 mm, ?sex "t" 1.61 mm, female "v" 2.71 mm (illustrated), juvenile "i" 0.98 mm (illustrated), juvenile "z" 0.90 mm. Also 15 specimens from MCD 53 and 9 specimens from MCD 47, both from same area in depths of 3–4 m and 2–3 m respectively.

*Etymology*.—The species is named for Dr. Wong Tat Meng of Universiti Sains Malaysia.

*Remarks*.—We immediately noticed the partially fused ramus of uropod 3 in our material and Harada (1971) shows the ramus completely fused to the peduncle in *Bubocorophium tanabensis*. Dr. Just informs us that this occurs infrequently in populations of the many species of the group he has examined. This fusion of uropod 3 to the peduncle was confusing to Harada who therefore identified the segment of urosomite 3 as the peduncle and the remainder of the appendage as the ramus, whereas one can distinguish in Harada's figures the fused ramus and the medial peduncular protrusion armed with 2 setae. Hence, one must correct Harada's key to the species of *Siphonocetes* so as to state that the medial protrusion on the peduncle of uropod 3 actually bears 2 setae; this is crucial to separating *B. tanabensis* from its neighbor, *S. conchicola* Gurjanova, from the Japan Sea, 5–12 m, associated with *Olivella* shells. That species is shown by Gurjanova to have about 5 peduncular setae and 7–8 ramal setae (one of which appears actually to be a stout spine). Harada's figures 8-5 and 8-6 show the peduncle with 1–3 medial and 1–4 ramal setae. Harada discusses the probability that Gurjanova's illustration of uropod 2 can be interpreted to show only one ramus, in which case *conchicola* indeed belongs to *Bubocorophium*.

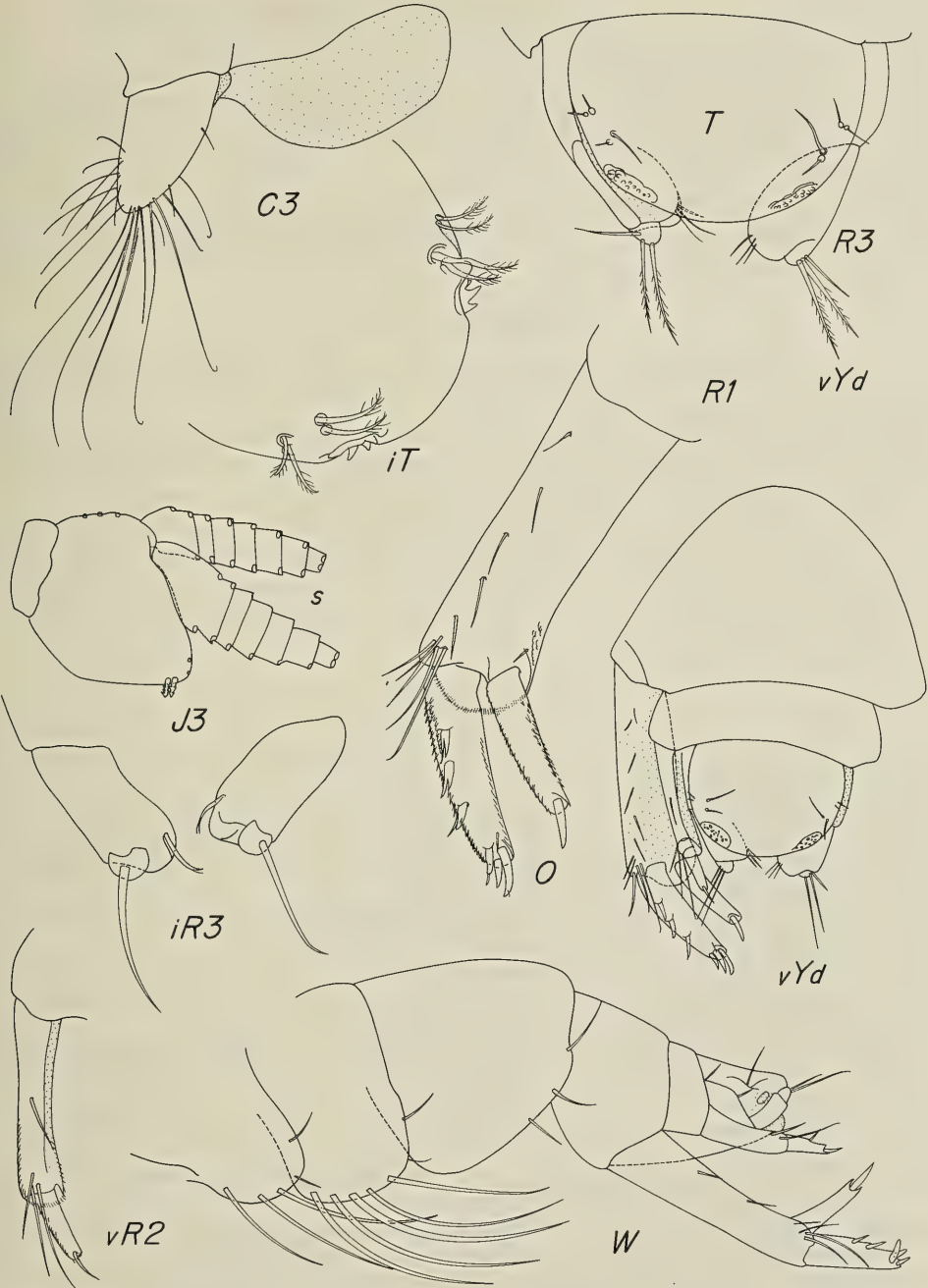


Fig. 9. *Borneoecetes wongi*, unattributed figures holotype male "n"; i = juvenile "i" 0.98 mm; v = female "v" 2.71 mm.



Harada noted that Barnard (1969) accepted *Siphonoecetes* as having one or two rami on uropod 2 (a condition Barnard had taken from his interpretation of *S. conchicola*). Karaman later established *Bubocorophium* to accommodate *tana-bensis* and "maybe" *conchicola*. Just (1983) has continued the division of siphonoecetines in greater detail and verifies the validity of the characters used in our diagnosis of *Borneoecetes* above.

We find the palp of maxilla 1 to be uniarticulate unlike any other siphonoecetine (Just has found a 2-articulate palp in 30 other species). Whether or not this has validity as a generic character must await Dr. Just's further studies.

### Acknowledgments

We thank the collectors of the material, Dr. Wong Tat Meng of Universiti Sains Malaysia, Penang; and Dr. John C. McCain of the University of Petroleum and Minerals, Dhahran, Saudi Arabia, who collected his material under auspices of Tetra-Tech, Ltd. We thank Linda B. Lutz of Mobile, Alabama for drawing Figure 1; and Janice Clark of the Smithsonian Institution for laboratory assistance. Carolyn Cox Lyons of New York City kindly inked our drawings. We thank Dr. Jean Just of the Zoological Museum, University of Copenhagen, who took much time from his sabbatical leave in Australia to help us, for his advice and for copies of his manuscripts in press. The second author was supported by NSF grant DEB 8121128.

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A REVIEW OF THE NEOTROPICAL PREDACEOUS  
MIDGE GENUS *PARYPHOCONUS*  
(DIPTERA: CERATOPOGONIDAE)

Gustavo R. Spinelli and Willis W. Wirth

*Abstract.*—A key is presented for identification of females of the 38 species of the Neotropical genus *Paryphoconus* Enderlein, including the following 11 species described as new: *apicalis*, *brunneipennis*, *ecuadorensis*, *fittkaui*, *flinti*, *fusciradi-  
alis*, *latipennis*, *leei*, *maya*, *paranaensis*, and *steineri*. *Ceratobezzia flavida* Johann-  
sen and *Bezzia telmatophilus* Macfie are transferred to *Paryphoconus* (New Com-  
binations). *Paryphoconus lanei* Wirth is a junior synonym of *P. flavidus* (Johannsen)  
and *P. travassosi* Lane a junior synonym of *P. subflavus* Macfie (New Synonymy).  
Previous erroneous identifications and synonymy are corrected and new distri-  
bution records are presented.

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Since the publication of Wirth and Ratanaworabhan's revision of the *Stenoxenini* in 1972 a large amount of new Neotropical material of the genus *Paryphoconus* Enderlein has accumulated in the U.S. National Museum of Natural History. In connection with concurrent studies of the Neotropical species of *Bezzia* Kieffer we have discovered several species that bridge the taxonomic gap between the two genera and necessitate a re-evaluation of the tribe *Stenoxenini*. At the same time we have separated a significant number of undescribed species of *Paryphoconus* and found a number of erroneous or new synonymies that are reported here. As a result of our studies we now recognize 38 species of *Paryphoconus*, of which 11 are described as new. Unfortunately we have been unable to find good characters for separation of species in the male sex, which shows considerable sexual dimorphism from the corresponding females. Our re-evaluation of the tribe *Stenoxenini* is still incomplete, pending completion of our studies on *Bezzia* and revision of generic concepts in the *Palpomyia-Bezzia* complex.

For explanation of our terminology see the papers by Wirth (1952) and Downes and Wirth (1981). All material examined is from the collection of the National Museum of Natural History in Washington, D.C., unless otherwise noted.

Genus *Paryphoconus* Enderlein

*Paryphoconus* Enderlein, 1912:57. Type-species, *Paryphoconus angustipennis* Enderlein, by original designation.

*References.*—Mayer, 1952:582 (egg; classification); Lane, 1956:299 (revision; key); Mayer, 1959:233 (pupa); Lane, 1961b:453 (key); Wirth and Ratanaworabhan, 1972:1369 (revision).

*Diagnosis.*—Moderate to large size species; body slender, dorsoventrally flattened. Eyes bare, widely separated. Female antenna much elongated, segments with dense setose hairs, these sometimes conspicuously flattened (hastate). Palpus 5-segmented; 3rd segment slender, without sensory pit. Mesonotum narrowed in



front, sometimes conically produced, usually with an erect anteromedian spine or tubercle. Legs long and slender; femora unarmed; femoral and tibial vestiture of very fine, erect hairs; last 3 tarsomeres relatively short; 4th tarsomere cordiform; 5th tarsomere without ventral batonnets. Female claws short and equal, each with small internal basal tooth. Wing long and narrow, often with color pattern; r-m crossvein distinct but short; costa long, extending nearly to wing tip; 1 very narrow radial cell, posterior branch of radius closely approaching costa; medial fork broadly sessile. Female abdomen slender, with paired gland rods and eversible glands. Male genitalia: 9th sternite short, 9th tergite tapering with well-developed apicolateral lobes; gonocoxite slender, gonostylus elongated; aedeagus with high, rounded basal arch and slender, pointed distomedian process projecting posteriorly from just behind tip; parameres separated, with contiguous clavate apices.

*Discussion.*—Females of *Stenoxenus* Coquillett can be distinguished readily from those of *Paryphoconus* by the following combination of characters: thorax broadly rounded in front, without anterior spine; palpus 4-segmented; and wing with vein M2 elbowed at the base. Males of *Stenoxenus* closely resemble those of *Paryphoconus* in wing venation, but lack the anterior mesonotal spine, have the palpus 4-segmented (only 1 segment distad of the one bearing the sensory organ), and the parameres are fused on the distal portion. In only a few species of *Paryphoconus* does the female costa extend to the wing tip as it does in all *Stenoxenus*; the non-elbowed media and 5-segmented palpus will readily distinguish these. Similarly, the females of some *Paryphoconus* species with the anterior mesonotal spine lacking can be distinguished by wing venation and their 5-segmented palpus. We have seen a few males with the parameres separate distally but with 4-segmented palpus, that we cannot associate with any known females of either genus; we are unable to interpret this combination of characters on the basis of the limited material available. Possibly they may represent species that may bridge the gap between the two genera, or one or the other of the characters may prove to be unreliable. Reared specimens in which the sexes can be definitely associated by pupal characters are badly needed for all species.

*Included Species.*—

*aemulus* Macfie, 1940b:180. Guyana.

*amapaensis* Land, 1961a:450. Brazil.

*angustipennis* Enderlein, 1912:57. Brazil.

*anomalicornis* Kieffer, 1917:333. Colombia and Paraguay.

*apicalis* n. sp. Ecuador.

*barrettoi* Lane, 1946:203. Brazil.

*batesi* Lane, 1961b:455. Brazil.

*brunneipennis* n. sp. Brazil.

*ecuadorensis* n. sp. Ecuador.

*enderleini* Lane, 1956:301. Brazil.

*fittkawi* n. sp. Brazil.

*flavidus* (Johannsen), 1943a:761 (*Ceratobezzia*). Guyana.

*flinti* n. sp. Mexico.

*fusciradialis* n. sp. Brazil.

*fuscus* Lane, 1946:206. Brazil.

*goianensis* Lane, 1961b:456. Brazil.

*grandis* Macfie, 1939:6. Brazil.  
*guianae* Macfie, 1940c:180. Guyana.  
*kiefferi* Lane, 1956:302. Brazil.  
*lanei* Wirth, 1959:236. Brazil. Syn. of *flavidus* (Johannsen).  
*latipennis* n. sp. Colombia.  
*leei* n. sp. Colombia.  
*macfie* Lane, 1946:203. Brazil.  
*maya* n. sp. Belize.  
*mayeri* Wirth, 1959:236. Brazil.  
*neotropicalis* (Lane), 1948:229 (*Macropeza*). Brazil.  
*nigripes* Macfie, 1939:8. Argentina.  
*nubifer* Macfie, 1939:5. Brazil.  
*oliveirai* Lane, 1956:303. Brazil.  
*paranaensis* n. sp. Argentina.  
*paulistensis* Lane, 1961b:457. Brazil.  
*sonorensis* Wirth and Ratanaworabhan, 1972:1374. Mexico.  
*steineri* n. sp. Peru.  
*subflavus* Macfie, 1940a:23. Guyana.  
*telmatophila* (Macfie), 1940b:77 (*Bezzia*). Brazil.  
*terminalis* (Coquillett), 1904:90 (*Ceratopogon*). Nicaragua.  
*travassosi* Lane, 1956:304. Brazil. Synonym of *subflavus* Macfie.  
*unimaculatus* Macfie, 1940c:179. Guyana.  
*wirthi* Lane, 1961b:458. Brazil.  
*wygodzinskyi* Lane, 1946:208. Brazil.

Key to the Species of *Paryphoconus* (Females)

- 1. Wing entirely hyaline, without dark markings (may become gradually and slightly unfuscated toward apex) ..... 2
- Wing entirely or partly infuscated, at least a distinct dark marking over r-m crossvein and/or at wing tip ..... 8

Wing Hyaline Without Markings

- 2. Legs entirely yellowish or whitish; mesonotum with yellowish ground color; small species, wing 2–3 mm long ..... 3
- Legs with at least hind tibia darkened at apex; mesonotum dark brown or blackish; larger species, wing 3–7 mm long ..... 4
- 3. Mesonotum completely yellow and with strong anterior spine ....  
..... *mayeri* Wirth
- Mesonotum yellow except for large blackish mark in front of wing root; anterior spine absent ..... *wygodzinskyi* Lane
- 4. Large species, wing 5–7 mm long; legs brown, fore femur yellow, hind femur blackish on distal ¼ ..... *batesi* Lane
- Smaller species, wing 3.2–4.0 mm long ..... 5
- 5. All femora and tibiae dark at apices ..... *neotropicalis* (Lane)
- Legs yellow, hind tibia partly dark ..... 6
- 6. Hind tibia brown at base and apex; hind tarsus pale at base; antenna slender, light brown ..... *paulistensis* Lane

- Hind tibia brown on distal ¼; hind tarsus brown to base; antennal segments short, all black ..... 7
- 7. Mesonotum without anterior spine; antenna longer, antennal ratio 1.18 ..... *sonorensis* Wirth and Ratanaworabhan
- Mesonotum with prominent anterior spine; antenna short, antennal ratio 0.71 ..... *paranaensis*, n. sp.
- 8(1). Wing infuscated over entire surface ..... 9
- Wing with dark spots or shading but not darkened over entire surface ..... 17

Wing Entirely Infuscated

- 9. Femora and tibiae brownish black ..... 10
- Femora and tibiae yellowish, at most with narrow apices dark .... 11
- 10. Hind femur with subapical pale band; tarsi brownish; wing 5 mm long (female)..... *fuscus* Lane
- Hind femur without subapical pale band; tarsomeres 1–3 pale yellow; wing 3.3 mm long ..... *aemulus* Macfie
- 11. Large species, wing 5–7 mm long ..... 12
- Smaller species, wing 1.5–3.0 mm long; (wing without well defined distal dark band) ..... 13
- 12. Wing with more intense dark band at apex: tibiae and hind femur with narrow apices dark; base of hind basitarsus pale .. *barrettoi* Lane
- Wing darker on anterior margin and along veins, without well-defined distal dark band; hind tibia dark on distal ¼; hind basitarsus all brown ..... *grandis* Macfie
- 13. Small species, wing 1.5 mm long; wing broad, uniformly infuscated; antenna entirely dark brown; legs with vestiture normal, the setae short ..... 14
- Larger species, wing 2–3 mm long; wing narrower; antenna with base paler; legs with longer, fuzzier, pilose vestiture ..... 15
- 14. Mid and hind femora with prominent broad brown bands; wing infuscation much darker in radial cell, paler posteriorly; spermatheca large, 0.130 mm in diameter ..... *fusciradialis*, n. sp.
- Femora unbanded; wing infuscation in radial cell scarcely darker than on posterior portion of wing; spermatheca smaller, 0.053 by 0.040 mm. .... *latipennis*, n. sp.
- 15. Fore tibia all brown; wing pale brownish, gradually darker toward costa ..... *leei*, n. sp.
- Fore tibia yellowish to pale brown; wing pale brown, veins darker ..... 16
- 16. Legs uniform yellowish to pale brown, apex of hind tibia darker, hind tarsus pale; antenna long and slender, antennal ratio 1.45, segments 3–10 white, 11–15 brown; anal angle of wing poorly developed ..... *brunneipennis*, n. sp.
- Legs dirty yellowish brown, hind femur, tibia, tarsus dark brown; antenna pale brown, segments 3–10 with pale bases, antennal ratio 2.38; wing with anal angle broad ..... *ecuadorensis*, n. sp.



- 17(8). Wing with a single dark spot or area over r-m crossvein ..... 18  
 - Wing with additional markings or without a spot at r-m crossvein 21

#### Dark Spot Over R-M Crossvein

18. Mesonotum yellow, or yellowish with dark markings ..... 19  
 - Mesonotum dark brown or blackish; (wing 2.5 mm long) . *wirthi* Lane  
 19. Large species, wing 6 mm long ..... *unimaculatus* Macfie  
 - Smaller species, wing 2.3–3.0 mm long ..... 20  
 20. Legs entirely yellowish; mesonotum without anterior spine; marking on r-m crossvein small and inconspicuous ..... *enderleini* Lane  
 - Hind tibia with dark apical band; mesonotum with strong anterior spine; marking on r-m crossvein prominent ..... *flavidus* (Johannsen)  
 21(17). Wing with dark mark at r-m crossvein and also dark on entire anterior margin, wing tip pale; (thorax blackish; large species, wing 6 mm long) ..... *goianensis* Lane (part)  
 - Wing with dark marking at apex ..... 22  
 22. Wing without dark mark over r-m crossvein; mesonotum blackish 23  
 - Wing with dark mark over r-m crossvein; mesonotum various ... 25

#### R-M Crossvein Pale: Dark Mark at Wing Tip

23. Wing with a single dark mark, at apex; legs yellowish except apex of hind tibia brown; small species, wing 2.0–2.9 mm long ..... 24  
 - Wing with dark apical shading and a mark on lower branch of cubital fork (vein Cul); legs blackish; larger species, wing 5.5 mm long ...  
 ..... *nigripes* Macfie  
 24. Antenna all black; wing 2.9 mm long ..... *guianae* Macfie  
 - Antenna with segments 3–10 white, 11–15 black; wing 2.0 mm long  
 ..... *terminalis* (Coquillett)  
 25(22). Wing infuscated at base, over r-m crossvein, and at broad distal portion, forming more or less 3 bands, these sometimes connected by infuscation along veins; mesonotum yellowish, usually with dark brown markings; large species, wing 4–7 mm long ..... 26  
 - Wing markings confined to r-m crossvein, wing tip, and rarely narrowly along veins; mesonotum various; size various, usually smaller 29

#### Angustipennis Group; Large Species With Banded Wing

26. Mesonotum entirely yellowish ..... *oliveirai* Lane  
 - Mesonotum with dark brown markings ..... 27  
 27. Antenna stout with prominent, dense, long, black, hastate setae ..  
 ..... *angustipennis* Enderlein  
 - Antenna long and slender with slender setae ..... 28  
 28. Antenna uniformly dark brown ..... *flinti*, n. sp.  
 - Antenna with segments 3–10 pale yellow; wing more or less infuscated between the 3 dark bands ..... *macfie* Lane (part)

29(25). Mesonotum yellowish or pale brown, with dark brown markings . . 30

– Mesonotum uniform dark brown or blackish . . . . . 31

Yellowish Species

30. Larger species, wing 5.5 mm long; mid and hind tibiae dark at apices; wing without infuscation on vein Cul . . . . . *kiefferi* Lane

– Smaller species, wing 2.2–3.0 mm long; only hind tibia with dark apex; wing with faint dark mark along vein Cul . . . . . *subflavus* Macfie

Mesonotum Blackish

31(29). Antenna with 5 distal segments contrasting white, proximal segments blackish with prominent hastate setae . . . . . *anomalicornis* Kieffer

– Antenna with segments uniformly colored or with distal 5 darker . . 32

Wing With Dark Marks Over R-M Crossvein and at Tip

32. Large species, wing 6–6.5 mm long . . . . . 33

– Small species, wing 2.5–3.0 mm long . . . . . 35

33. Legs completely dark brown; wing infuscated around entire margin . . . . . *goiaensis* Lane (part)

– Legs with tibiae yellowish at least in part . . . . . 34

34. All tibiae extensively marked with brown; wing very broad as in genus *Jenkinshelea* . . . . . *amapaensis* Lane

– Only hind tibia marked with brown; no dark mark on vein M1; small dark mark in base of anal cell . . . . . *macfie* Lane (part)

35(32). Antenna short, all black; wing veins all infuscated . . . . . *nubifer* Macfie

– Antenna long and slender, more or less pale at base; veins not infuscated except r-m and/or Cul . . . . . 36

36. Hind tibia dark brown; (legs dirty yellowish, fore and mid tibiae brownish, hind tarsus wholly brown; wing white, narrow apex infuscated, faint dark marks on r-m and Cul; antenna with segments 3–10 white, 11–15 brownish) . . . . . *maya*, n. sp.

– Hind tibia with only distal half or less brown . . . . . 37

37. Wing distally with broad brown band, radius and costa, r-m and Cul more or less infuscated; antenna with proximal segments brownish on apices, antennal ratio no more than 2.24 . . . . . 38

– Wing white with narrow tip infuscated, r-m infuscated, Cul very slightly infuscated; antenna white on 3–10, pale brown on 11–15, extremely long and slender with slender setae, antennal ratio 2.60; (legs pale yellow, narrow apex of hind tibia brown, basal ½ of hind basitarsus pale; halter dark brown) . . . . . *fittkau*i, n. sp.

38. Wing whitish with narrow tip infuscated; hind tarsus all brown; antennal ratio 2.24; 4 pairs of gland rods . . . . . *steineri*, n. sp.

– Wing gray overall with broad, ill-defined infuscation distally; legs pale yellow, narrow apex of hind tibia dark brown; hind basitarsus pale at base; antennal ratio 1.65; 1 pair of gland rods . . . . . *apicalis*, n. sp.

*Paryphoconus aemulus* Macfie

*Paryphoconus aemulus* Macfie, 1940c:180 (male; Guyana).—Lane, 1946:206 (female; Brazil).—Wirth and Ratanaworabhan, 1972:1371 (female notes; figs.; rec. Brazil).

*Distribution.*—Brazil, Guyana.

*Notes.*—The species is placed in the key on the basis of female characters given by Lane (1946) and Wirth and Ratanaworabhan (1972) from Brazilian specimens. The species resembles *P. fuscus* Lane and *barrettoii* Lane in its completely infuscated wing, but it is a smaller species (wing 3.3 mm long), has legs entirely dark except for the trochanters and extreme bases of the femora, and tarsomeres 1–3, which are pale yellowish. The antennae are unusually long, slender, and whitish in color. Spermatheca oval.

*Paryphoconus amapaensis* Lane

*Paryphoconus amapaensis* Lane, 1961a:450 (female; Brazil; fig. wing).—Wirth and Ratanaworabhan, 1972:1371 (notes).

*Distribution.*—Brazil.

*Notes.*—Wing length 6 mm. A large, shining dark brown species. Legs pale, fore and mid femora dark brown distally, tibiae brown except distally on mid leg; hind leg with only knee brownish; tarsi pale, distal tarsomeres brownish on fore and hind leg. Wing unusually broad, with expansion at margin of mediocubital fork; extensive infuscation narrowly around wing margin and across r-m crossvein to base of vein M3+4. Halter pale. No new data.

*Paryphoconus angustipennis* Enderlein

Fig. 13a

*Paryphoconus angustipennis* Enderlein, 1912:58 (female; Brazil; figs.).—Macfie, 1939:5 (Brazil; fig. wing).—Lane, 1946:202 (Brazil; figs.).—Lane, 1956:300 (Brazil, Argentina).—Wirth and Ratanaworabhan, 1972:1371 (redescription; figs.; distribution).

*Distribution.*—Argentina, Brazil, Colombia, Peru, Venezuela.

*New Record.*—ARGENTINA: Misiones, Arroyo Piray Guazu, San Pedro, 22 Nov 1973, O.S. Flint, Jr., 5 females.

*Notes.*—Wing length 5.8–6.5 mm; a large yellowish brown species with dark brown abdomen; legs yellow, distal tarsomeres and narrow tip of hind tibia dark brown; halter knob brownish. Antenna with torus yellowish, flagellum dark brown, the segments elongated, cylindrical, antennal ratio 1.35; last 5 segments with dense black hastate setae. Wing (Fig. 13a) with extensive dark brown pattern as figured; costal ratio 0.91. Spermatheca large, elongate oval, measuring 0.194 by 0.097 mm including the short neck. Male much smaller, wing length 2.1 mm; costal ratio 0.86. Genitalia figured by Wirth and Ratanaworabhan (1972). The female from Mexico reported by Wirth and Ratanaworabhan was misidentified, and is here described as *P. flinti* n. sp.



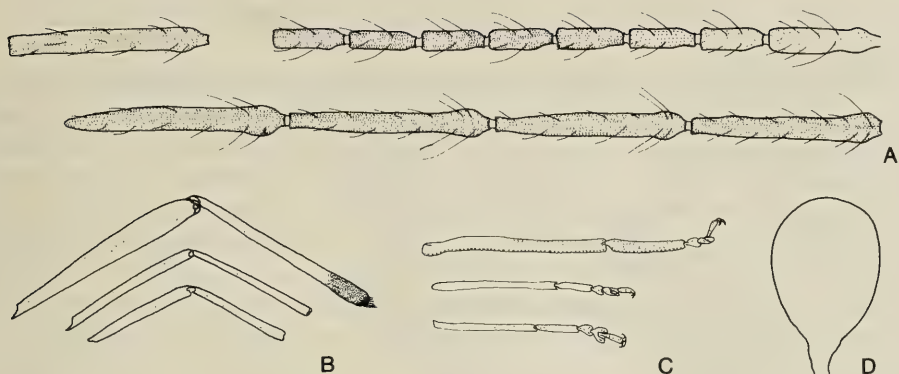


Fig. 1. *Paryphoconus apicalis*, female: a, Antenna; b, Femora and tibiae of (top to bottom), hind, mid, and fore legs; c, Tarsi of (top to bottom) hind, mid, and fore legs; d, Spermatheca.

*Paryphoconus anomalicornis* Kieffer

Fig. 13b

*Paryphoconus anomalicornis* Kieffer, 1917:333 (female; Colombia, Paraguay; figs.).—Wirth and Ratanaworabhan, 1972:1372 (redescribed; figs.; distribution).

*Distribution*.—Brazil, Colombia, Honduras, Mexico, Paraguay, Venezuela.

*New Records*.—BRAZIL: Amazonas, Rio Irapirapi, Cachoeira, 11 Jan 1963, E. J. Fittkau, at light, 1 female; Rio Solimões, 15 Sep 1961, Fittkau, at light, 3 females.

*Notes*.—Female wing length 3.1–4.2 mm. A shining black species with yellow legs, hind tarsus and extreme tip of hind femur dark brown. Wing (Fig. 13b) slightly infuscated along anterior margin; r-m crossvein and an apical area darker brown, slight infuscation narrowly along apices of veins M1, M2, M3+4, and Cul; costal ratio 0.88. Antenna with proximal flagellar segments black, bearing dense black hastate setae; distal 5 segments much elongated, contrasting whitish; antennal ratio 1.60. Spermatheca small and ovoid with long slender neck, measuring 0.097 by 0.072 mm, neck 0.011 mm.

The females from Rio Solimões are larger (wing 4.2 mm long) and darker than typical *P. anomalicornis*, with wing deeply infuscated along veins and around margins, the femora somewhat infuscated in midportions, and the hind tibia dark except at the base.

*Paryphoconus apicalis*, new species

Figs. 1, 13c

*Female*.—Wing length 2.36 (2.23–2.45,  $n = 5$ ) mm; breadth 0.62 (0.60–0.65,  $n = 5$ ) mm.

*Head*: Dark brown including scape and pedicel. Eyes separated for a distance equal to diameter of 5 ommatidial facets (0.092 mm). Antenna (Fig. 1a) dark brown, 2 or 3 basal segments slightly pale; lengths of flagellar segments in proportion of 38-26-24-26-24-24-25-27-77-72-72-74-80; antennal ratio 1.65 (1.53–1.75,  $n = 5$ ); verticils and setae sparse and fine, no black hastate setae. Palpus

short, yellow, with segments in proportion of 8-14-18-8-14; 3rd segment with scattered sensilla.

Thorax: Uniformly dark brown; mesonotum with a well-developed, erect, blunt, anterior spine. Legs (Fig. 1b, c) pale yellow, apex of hind tibia dark brown; tarsi brown except tarsomeres 1 and 2 of mid leg and basal  $\frac{1}{2}$  of hind basitarsus pale; hind tarsal ratio 2.00 ( $n = 5$ ). Wing (Fig. 13c) slender, anal angle poorly developed; membrane gray with broad, well-defined infuscation distally; veins more or less infuscated, especially costa, radius, and r-m crossvein; radial cell very narrow; costal ratio 0.91 (0.90–0.93,  $n = 5$ ). Halter dark.

Abdomen: Brown. One pair of well-sclerotized gland rods; spermatheca (Fig. 1d) pyriform, measuring about 0.060 by 0.046 mm, with 0.014 mm neck.

*Male*.—Unknown.

*Distribution*.—Ecuador, Panama.

*Types*.—Holotype female, Ecuador, Pastaza, Cononaco, 30 May 1976, J. Cohen, at light. Paratypes, 4 females, as follows: ECUADOR: same data as holotype, 2 females. PANAMA: Darien Prov., Santa Fe, 11 Sep 1967, A. Broce, 2 females.

*Discussion*.—This species is very similar to *P. fittkaui*, *maya*, and *steineri*; characters to separate all of them are found in the key.

#### *Paryphoconus barrettoi* Lane

*Paryphoconus barrettoi* Lane, 1946:203 (female; Brazil; fig. wing, spermatheca).

*Distribution*.—Brazil.

*Notes*.—No new records. The specimens from Mexico and Venezuela described as *P. barrettoi* by Wirth and Ratanaworabhan (1972:1373) were misidentified and are actually *P. grandis* Macfie (which see).

*Paryphoconus barrettoi* is a large species, wing 6.5 mm long; wing infuscated throughout, with distinct darker band on distal  $\frac{1}{5}$ ; base of wing very narrow, anal angle not developed; costal ratio 0.90. Antenna dark brown, with dense dark setae; antennal ratio 1.8. Thorax reddish brown, blackish at sides of mesonotum and in front of wing; mesonotum, scutellum, and postnotum densely covered with short pale pile; mesonotum with short anterior tubercle. Legs yellowish brown; narrow apices of femora and fore and mid tibiae, extreme base and distal  $\frac{1}{5}$  of hind tibia, apices of basitarsi, and all of tarsomeres 2–5, dark brown.

#### *Paryphoconus brunneipennis*, new species

Figs. 2, 13d

*Female*.—Wing length 2.23 mm; breadth 0.67 mm.

Head: Pale brown including scape, pedicel, and palpus. Eyes separated for a distance equal to diameter of 5 ommatidial facets (0.090 mm). Antenna (Fig. 2a) long and slender; brown, except antennal segments 3–10 and narrow bases of 11–15 pale; lengths of flagellar segments in proportion of 57-38-38-39-40-41-37-36-75-70-78-102-146; antennal ratio 1.45; verticils and setae sparse and fine, no black hastate setae. Palpus with lengths of segments in proportion of 8-14-20-13-19; 3rd segment with scattered sensilla.

Thorax: Brown with abundant small black mottlings; mesonotum with a well-developed, pale, pointed anterior spine. Legs (Fig. 2b, c) yellowish brown, narrow

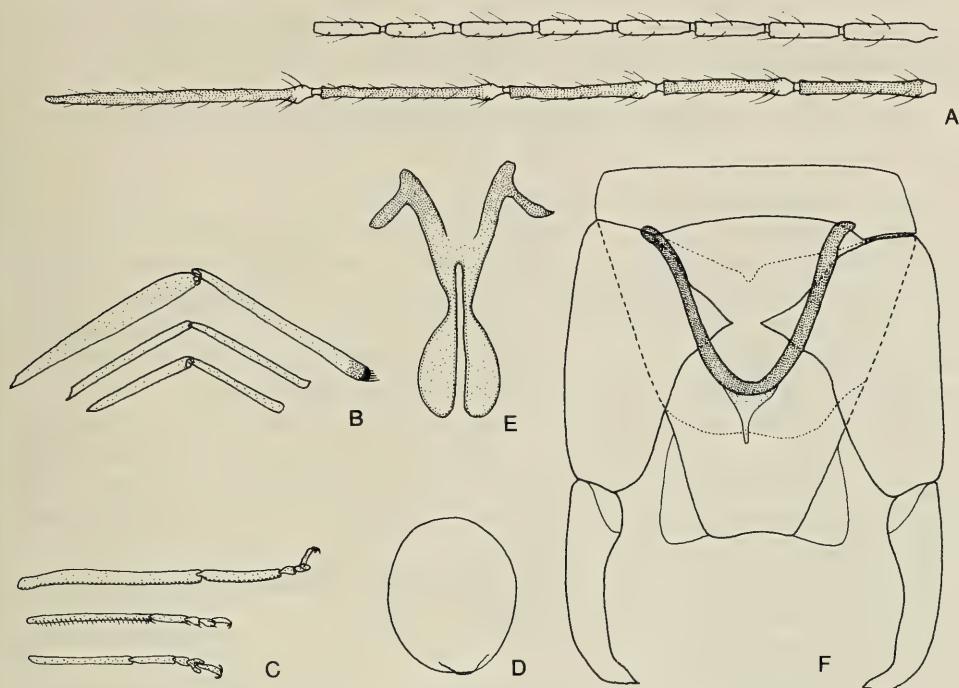


Fig. 2. *Paryphoconus brunneipennis*; a-d, female; e-f, male: a, Antenna; b, Femora and tibiae; c, Tarsi; d, Spermatheca; e, Parameres; f, Genitalia, parameres omitted.

apex of hind tibia infuscated; tarsi yellowish, basitarsus of mid leg with a single row of palisade setae; hind tarsal ratio 2.40. Wing (Fig. 13d) broad posteriorly, anal angle poorly developed; membrane infuscated over entire surface; veins darker, especially on r-m crossvein area; radial cell narrow to tip; costal ratio 0.90. Halter pale.

Abdomen: Brown. Apparently 4 pairs of sclerotized gland rods; spermatheca (Fig. 2d) subspherical with short neck, measuring 0.100 by 0.085 mm.

*Male*.—Wing length 1.77 mm.

Similar to female with usual sexual differences. Antenna with lengths of flagellar segments in proportion of 43-30-26-26-25-24-23-24-26-31-90-117-190. Wing with costal ratio 0.85. Genitalia (Fig. 2f): Ninth sternite narrow without caudomedian excavation; 9th tergite tapered distally, with 2 very well-developed apicolateral lobes. Gonocoxite with a triangular mesal protuberance; gonostylus shorter than gonocoxite, pointed. Aedeagus and parameres (Fig. 2e) typical of the genus.

*Distribution*.—Brazil (Amazonas), Colombia.

*Types*.—Holotype female, Brazil, Amazonas, Rio Solimões, 15 Sep 1961, E. J. Fittkau, at light. Allotype male, Colombia, Valle, Rio Raposo, May 1965, V. H. Lee, light trap.

*Discussion*.—This species is similar to *P. ecuadorensis*, n. sp. and *P. leei*, n. sp., but differs from these by the pale coloration of the proximal antennal segments; other differences are found in the key. This group of similar species, all with the general wing infuscation as in *P. fusciradialis* and *P. latipennis*, but with narrower



wings, also are distinguished by the long pilose vestiture of the legs giving them a fuzzy appearance. This fuzziness is most noticeable in *P. brunneipennis*.

*Paryphoconus ecuadorensis*, new species

Figs. 3, 13e

*Female*.—Wing length 2.20 mm; breadth 0.74 mm.

Head: Pale brown. Eyes separated for a distance equal to diameter of 4 ommatidial facets (0.060 mm). Antenna (Fig. 3a) entirely pale brown, bases of segments 3–10 very slightly paler; lengths of flagellar segments in proportion of 38–22–21–20–19–20–21–23–92–78–83–79–103, antennal ratio 2.38; verticils and setae sparse and fine, no black hastate setae. Palpus pale brown; lengths of segments in proportion of 8–13–20–11–14; 3rd segment with scattered sensilla.

Thorax: Pale brown; mesonotum with a very small, pale, anterior spine. Legs (Fig. 3b, c) dirty yellowish brown; hind leg darker; basitarsus of mid leg with a single row of palisade setae; hind tarsal ratio 2.60. Wing (Fig. 13e) broad, anal angle well developed; membrane infuscated over entire surface, veins dark brown; costal ratio 0.90. Halter pale brown.

Abdomen: Pale brown, gland rods not visible; spermatheca (Fig. 3d) oval, without sclerotized neck, measuring 0.074 by 0.053 mm.

*Male*.—Unknown.

*Distribution*.—Ecuador.

*Type*.—Holotype female, Ecuador, Pichincha, 113 km via Puerto Quito, 2700 ft, 30 Aug 1976, J. Cohen, CDC light trap.

*Discussion*.—*Paryphoconus ecuadorensis* can be distinguished from *P. brunneipennis* by the color of the antenna and legs, and by the well-developed anal angle of the wing.

*Paryphoconus fittkaui*, new species

Figs. 4, 13f

*Female*.—Wing length 2.90 (2.80–3.10,  $n = 3$ ) mm; breadth 0.72 (0.71–0.75,  $n = 3$ ) mm.

Head: Dark brown including scape and pedicel. Eyes separated for distance equal to diameter of 4.5 ommatidial facets (0.070 mm). Antenna (Fig. 4a) very long and slender and slender setae; pale brown except segments 3–10 and narrow bases of 11–15 paler; lengths of flagellar segments in proportion of 32–21–21–23–21–21–20–20–99–88–81–84–110, antennal ratio 2.60 (2.58–2.62,  $n = 3$ ). Palpus short, yellow, lengths of segments in proportion of 10–15–23–13–21; 3rd segment with scattered sensilla.

Thorax: Dark brown; mesonotum with a very small, blunt anterior spine. Legs (Fig. 4b, c) pale yellow, narrow apex of hind tibia brown; proximal  $\frac{1}{2}$  of hind basitarsus pale, the rest brown; tarsi of fore and mid leg pale except tarsomeres 3–5 of fore leg infuscated; hind tarsal ratio 1.82 (1.80–1.85,  $n = 3$ ). Wing (Fig. 13f) narrow; membrane white, narrow tip of wing infuscated; costa, radius, and r-m crossvein more or less infuscated, rest of veins when infuscated, only at tip and very slightly; radial cell very narrow; costal ratio 0.88 (0.87–0.89,  $n = 3$ ). Halter dark brown, apex of knob blackish.

Abdomen: Dark brown. Four pairs of slender gland rods; spermatheca (Fig. 4d)

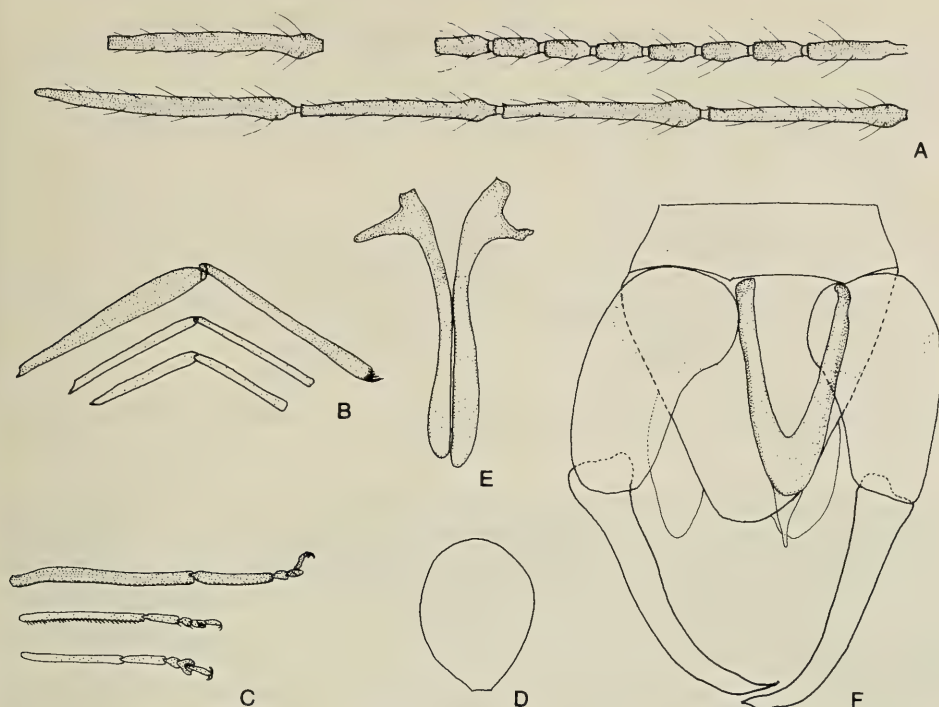


Fig. 3. *Paryphoconus ecuadorensis*; a-d, female; e-f, male: a, Antenna; b, Femora and Tibiae; c, Tarsi; d, Spermatheca; e, Parameres; f, Genitalia, parameres omitted.

oval with well-sclerotized neck, measuring 0.065 by 0.050 mm with neck 0.023 mm.

*Male*.—Unknown.

*Distribution*.—Brazil (Amazonas).

*Types*.—Holotype female, Brazil, Amazonas, Rio Marauia, Jan–Feb 1963, E. J. Fittkau, at light. Paratypes, 2 females, Amazonas, Rio Cueiras, Dec 1960, Fittkau, at light.

*Discussion*.—This species can be recognized by the peculiar, very long antenna with slender setae, and very high antennal ratio (2.60).

*Paryphoconus flavidus* (Johannsen), new combination

Fig. 13g

*Ceratobezzia flvida* Johannsen, 1943a:761 (female; Guyana).—Johannsen, 1940b: 767 (fig. antenna, thorax).

*Paryphoconus lanei* Wirth, 1959:236 (male, female; Brazil; fig. male genitalia).—Mayer, 1959:233 (pupae; fig. respiratory horn).—Wirth and Ratanaworabhan, 1972:1374 (redescribed; figs.; distribution).

*Distribution*.—Brazil.

*New Record*.—BRAZIL: Mato Grosso, Cuiaba, 2 Apr 1972, W. H. Whitcomb, 12 females.

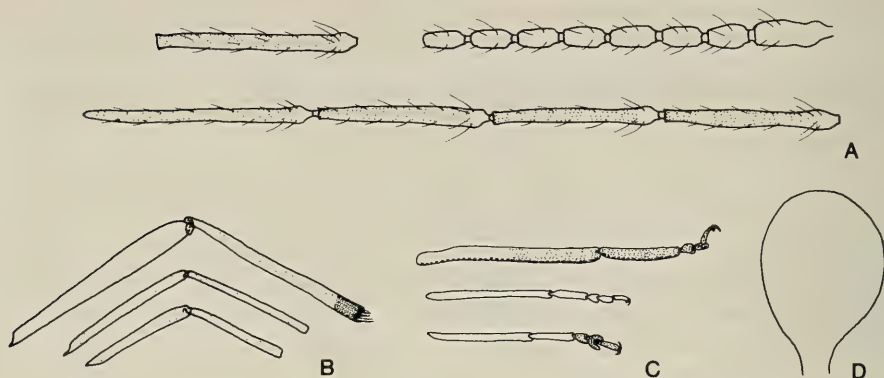


Fig. 4. *Paryphoconus fittkaui*, female: a, Antenna; b, Femora and tibiae; c, Tarsi; d, Spermatheca.

*Notes.*—A small yellowish species, hind tibia usually with a narrow dark brown apical band; wing (Fig. 13g) whitish hyaline with a prominent dark spot over r-m crossvein and a faint dark line along vein Cul. Antenna dark brown with numerous strong hastate setae on segments 3–10; antennal ratio 1.78. Wing length 2.3 mm; costal ratio 0.89. Spermatheca ovoid with short tapering neck, measuring 0.105 by 0.072 mm.

The synonymy of *P. lanei* and *P. flavidus* was established by direct comparison of the holotypes, that of *P. flavidus* by courtesy of Dr. Quentin D. Wheeler of Cornell University.

*Paryphoconus flinti*, new species

Figs. 5, 13h

*Female.*—Wing length 4.30 (4.10–4.50,  $n = 4$ ) mm; breadth 1.03 (0.99–1.05,  $n = 4$ ) mm.

Head: Yellowish, including scape, with numerous small dark mottlings. Eyes separated for a distance equal to diameter of 5 ommatidial facets (0.10 mm). Antenna (Fig. 5a) slender, pedicel brown, flagellum entirely dark brown; lengths of flagellar segments in proportion of 40-22-22-23-23-22-22-22-54-48-52-57-100; antennal ratio 1.50 (1.43–1.57,  $n = 2$ ); verticils and setae sparse and fine, no black hastate setae. Palpus moderately long, 3 proximal segments brown, last 2 dark brown; 3rd segment with scattered sensilla; lengths of segments in proportion of 10-25-30-23-30.

Thorax: Yellowish brown with numerous small dark mottlings; mesonotum with a small blunt, black anterior spine. Legs (Fig. 5b, c) dirty yellowish brown, tip of tibiae dark brown. Wing (Fig. 13h) brownish at base, at middle, and on broad apex, plus some infuscation along veins in between; costal ratio 0.91 ( $n = 4$ ). Halter yellowish.

Abdomen: Dark brown, terga shining black. Five pairs of well-sclerotized gland rods; spermatheca (Fig. 5c) elongate oval with short neck, measuring 0.138 by 0.088 mm.

*Male.*—Unknown.

*Distribution.*—Belize, Mexico.



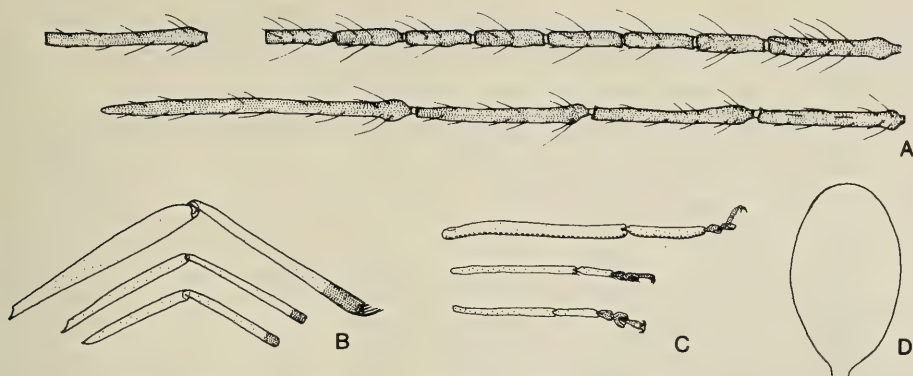


Fig. 5. *Paryphoconus flinti*, female: a, Antenna; b, Femora and tibiae; c, Tarsi; d, Spermatheca.

*Types*.—Holotype female, Mexico, Tabasco, Rio Puyacatengo, E. Teapa, 28 Jul 1966, Flint and Ortiz. Paratypes, 3 females, as follows: BELIZE: Cayo District, Western Hwy. MP 66, Jun 1969, W. and D. Hasse, light trap, 3 females. MEXICO: Chiapas, Rio Tuliya, 48 km S Palenque, 17 May 1981, C. M. and O. S. Flint, Jr. 1 female.

*Discussion*.—This species can be distinguished from related species by the dark brown tips of the tibiae; it also differs from *P. angustipennis* by the sparse, fine, antennal setae and verticils, and from *P. macfieii* by the antennal coloration (segments 3–10 white).

*Paryphoconus fusciradialis*, new species

Figs. 6, 13i

*Female*.—Wing length 1.55 ( $n = 3$ ) mm; breadth 0.60 ( $n = 3$ ) mm.

Head: Dark brown. Eyes broadly separated, for a distance equal to diameter of 7 ommatidial facets (0.110 mm). Antenna (Fig. 6a) entirely brown, bases of segments 3–10 very slightly paler; lengths of flagellar segments in proportion of 34-22-20-20-20-20-20-57-57-57-57-80; antennal ratio 1.74; verticils and setae sparse and fine, no black hastate setae. Palpus short, pale; lengths of segments in proportion of 5-10-20-12-14; 3rd segment broad, bearing a group of 5–6 sensilla on midportion.

Thorax: Dark brown; mesonotum without anterior spine. Legs (Fig. 6b, c) yellowish except mid  $\frac{1}{3}$  of mid and hind femora, and distal  $\frac{1}{3}$  of hind tibia dark brown; tarsi yellowish, last 3 segments slightly infuscated; hind tarsal ratio 2.23 (2.15–2.30,  $n = 3$ ). Wing (Fig. 13i) with membrane infuscated over entire surface, anterior veins and radial cell brown; venation as figured; costal ratio 0.88 ( $n = 3$ ). Halter pale brown.

Abdomen: Dark brown. One pair of very short gland rods present; spermatheca (Fig. 6d) exceptionally large, spherical with short neck, measuring 0.130 mm in diameter.

*Male*.—Unknown.

*Types*.—Holotype female and 2 female paratypes, Brazil, Para, Belem, Apr 1970, T.H.G. Aitken, light trap in APEG Forest.

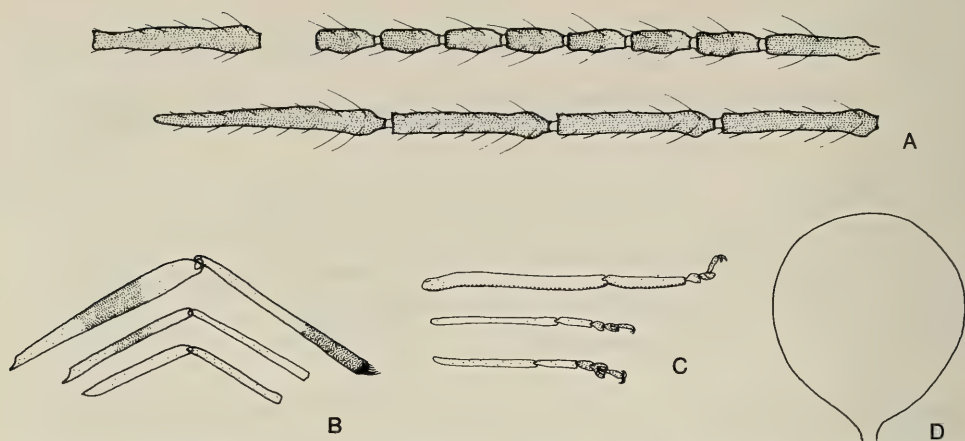


Fig. 6. *Paryphoconus fusciradialis*, female: a, Antenna; b, Femora and tibiae; c, Tarsi; d, Spermatheca.

*Discussion.*—This small species can be distinguished from the closely related *P. latipennis* n. sp. by the broad dark brown bands of the mid and hind femora, by the deep infuscation of the radial cell, by the extremely short gland rods, and by the voluminous spherical spermatheca. This species and *P. latipennis* have the general habitus of some species of the genus *Bezzia*, and may in fact be primitive members of the genus *Paryphoconus* indicating closer relationships of the two genera than previously thought.

*Paryphoconus grandis* Macfie

Fig. 13j

*Paryphoconus grandis* Macfie, 1939:6 (female; Brazil; fig. wing).

*Paryphoconus barrettoi* Lane of Wirth and Ratanaworabhan (misident.), 1972: 1373 (female; Mexico, Venezuela; figs.).

*Distribution.*—Belize, Brazil, Mexico, Venezuela.

*Specimens Examined.*—BELIZE: Cayo Dist., Western Hwy., 3 Jul 1969, W. Hasse, 1 female. MEXICO: On railway car from Mexico in quarantine at Nogales, Arizona, 24 Apr 1963, C. H. Spitzer, 2 females. VENEZUELA: Est. Portuguesa, Guanare, 10–13 Sep 1957, B. Malkin, 1 female (Calif. Acad. Sci.).

*Notes.*—Wirth and Ratanaworabhan (1972) misidentified their material which they described as *P. barrettoi* Lane. This description and figures should therefore be compared with Macfie's original description of *P. grandis*, which is in agreement. The large size (wing 5–7 mm long) and long costa (costal ratio 0.98) on the brownish wing with darker brown anterior margin and obscure dark lines along the tips of the medial and cubital veins are diagnostic (Fig. 13j). Halter with dark brown knob. Antenna short and uniformly black, without strong setae; antennal ratio 1.37. Legs yellowish brown, knees blackish; extreme tips of fore and mid tibiae, distal 2–3 tarsomeres on fore and mid legs, distal ¼ of hind tibia and all of hind tarsus blackish. Thorax dark brown, with dense pubescence and short hairs; anterior tubercle of mesonotum small. Spermatheca large, oval; measuring 0.173 by 0.122 mm with narrow neck 0.018 mm long.

Table 1.—Numerical values for species of *Paryphoconus*.

Species	Wing length (mm)	Costal ratio	Antennal ratio
<i>aemulus</i>	3.3	0.89	1.18
<i>amapaensis</i>	6.0	—	0.99
<i>angustipennis</i>	5.8–6.5	0.91	1.35
<i>anomalicornis</i>	3.1–4.2	0.88	1.60
<i>apicalis</i>	2.2–2.5	0.91	1.65
<i>barrettoi</i>	6.5	0.90	1.8
<i>batesi</i>	6.5	0.95	—
<i>brunneipennis</i>	2.2	0.90	1.45
<i>ecuadorensis</i>	2.2	0.90	2.38
<i>enderleini</i>	3.0	—	1.50
<i>fitkau</i>	2.9	0.88	2.60
<i>flavidus</i>	2.3	0.89	1.78
<i>flinti</i>	4.3	0.91	1.50
<i>fusciradialis</i>	1.5	0.88	1.74
<i>fuscus</i>	5.0	0.87	3.10
<i>goianensis</i>	6.0	0.93	—
<i>grandis</i>	5.0–7.0	0.98	—
<i>guianae</i>	2.9	0.87	2.00
<i>kiefferi</i>	5.5	—	1.42
<i>latipennis</i>	1.5	0.91	2.05
<i>leei</i>	2.4	0.90	2.00
<i>macfiei</i>	6.5	0.90	—
<i>maya</i>	2.5	0.88	1.95
<i>mayeri</i>	2.4	—	—
<i>neotropicalis</i>	3.2	—	1.10
<i>nigripes</i>	5.5	—	0.92
<i>nubifer</i>	3.0	0.87	1.20
<i>oliveirai</i>	4.0	—	1.55
<i>paranaensis</i>	4.6	0.99	0.71
<i>paulistensis</i>	4.0	—	—
<i>sonorensis</i>	3.8	0.98	1.18
<i>steineri</i>	2.8	0.90	2.24
<i>subflavus</i>	2.5	0.90	1.40
<i>terminalis</i>	2.0	0.87	1.70
<i>unimaculatus</i>	6.0	—	2.00
<i>wirthi</i>	2.5	—	—
<i>wygodzinskyi</i>	2.6	—	—

*Paryphoconus guianae* Macfie  
Fig. 13k

*Paryphoconus guianae* Macfie, 1940c:180 (female; Guyana).—Lane, 1956:302 (Brazil record).—Lane, 1961b:456 (Brazil records).—Wirth and Ratanaworabhan, 1972:1377 (erroneous synonym of *terminalis*).

*Distribution*.—Brazil, Ecuador, Guyana.  
*New Record*.—ECUADOR: Pastaza, Cononaco, 30 May 1976, J. Cohen, at light, 1 female.

*Notes*.—A small black species; wing hyaline with tip faintly infuscated (Fig. 13k). Wing length 2.9 mm; costal ratio 0.91. Antenna all dark brown; antennal ratio 2.00. The species is almost identical with the widespread species, *P. ter-*



*minalis* (Coquillett) and Wirth and Ratanaworabhan erroneously made *P. guianae* a junior synonym in 1972. *Paryphoconus terminalis* is a smaller species (wing 2.0 mm long), and segments 3–10 of the antennae are whitish.

*Paryphoconus latipennis*, new species

Figs. 7, 13l

*Female*.—Wing length 1.50 (1.30–1.60,  $n = 4$ ) mm; breadth 0.54 (0.48–0.58,  $n = 4$ ) mm.

Head: Dark brown, except frontoclypeus and palpus pale brown. Eyes broadly separated, for a distance equal to diameter of 8 ommatidial facets (0.140 mm). Antenna (Fig. 7a) entirely brown; lengths of flagellar segments in proportion of 35-23-20-19-21-23-22-24-70-70-70-72-102; antennal ratio 2.05 ( $n = 2$ ); verticils and setae sparse and fine, no black hastate setae. Palpus short, lengths of segments in proportion of 7-14-17-10-15.

Thorax: Dark brown; mesonotum with a small, erect, anterior spine. Legs (Fig. 7b, c) yellowish, apex of hind tibia and distal 3 tarsomeres brown; hind tarsal ratio 2.42 (2.30–2.50,  $n = 4$ ). Wing (Fig. 13l) infuscated over entire surface; broad posteriorly, anal angle poorly developed; radial cell broad, vein R4+5 more or less arcuate; costal ratio 0.91 (0.90–0.93,  $n = 4$ ). Halter pale.

Abdomen: Brown. One pair of slender, lightly sclerotized, gland rods; spermatheca (Fig. 7d) oval with short neck, measuring 0.053 by 0.046 mm, with neck 0.010 mm long.

*Male*.—Wing length 1.30 mm; breadth 0.40 mm. Similar to female with usual sexual differences. Antenna with lengths of flagellar segments in proportion of 38-24-22-21-20-20-20-20-20-25-75-100-135. Wing with costal ratio 0.88. Genitalia (Fig. 7f): Ninth sternite with very deep caudomedian excavation; 9th tergite with 2 rounded apicolateral lobes. Gonocoxite short, with pointed mesal protuberance and more or less developed ventromesal lobe; gonostylus elongated, slender. Aedeagus with very high basal arch and slender pointed tip. Parameres (Fig. 7e) separate, slender, each with distal portion slightly expanded in a bladelike process.

*Distribution*.—Colombia, Venezuela.

*Types*.—Holotype female, Colombia, Rio Raposo., Apr 1963, V. H. Lee, light trap. Allotype male, same data except May 1965. Paratypes, 3 females, as follows: COLOMBIA: same data as types except Oct 1964, 1 female, and Feb 1965, 1 female. VENEZUELA: Guarico, 12 km S Calabozo, 6 Feb 1969, P. and P. Spangler, light trap, 1 female.

*Discussion*.—The reduced size distinguishes *P. latipennis* from all other congeners with entirely infuscated wings except *P. fusciradialis*; characters to separate these two species are found in the key and the discussion of the latter species.

*Paryphoconus leei*, new species

Figs. 8, 14a

*Female*.—Wing length 2.37 (2.32–2.45,  $n = 3$ ) mm; breadth 0.66 (0.64–0.68,  $n = 3$ ) mm.

Head: Dark brown including scape and pedicel. Eyes separated for a distance equal to diameter of 3.5 ommatidial facets (0.060 mm). Antenna (Fig. 8a) brown,

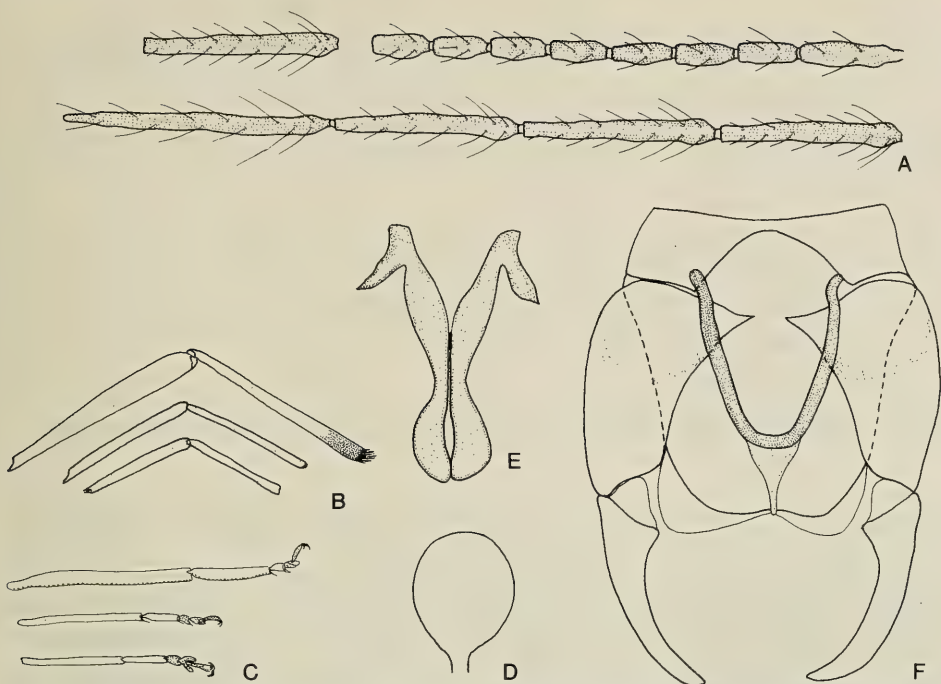


Fig. 7. *Paryphoconus latipennis*; a-d, female; e-f, male: a, Antenna; b, Femora and tibiae; c, Tarsi; d, Spermathecae; e, Parameres; f, Genitalia, parameres omitted.

bases of flagellar segments 4-10 pale; lengths of flagellar segments in proportion of 45-26-24-24-24-25-25-28-84-77-77-80-125; antennal ratio 2.00 ( $n = 2$ ); verticils and setae sparse and fine, no black hastate setae. Palpus short, last segment deeply infuscated; 3rd segment broad (palpal ratio 1.25) with scattered sensilla; lengths of palpal segments in proportion of 10-15-16-11-16.

Thorax: Uniformly blackish; mesonotum with very small anterior spine. Legs (Fig. 8b, c) yellowish, fore tibia all brown; basitarsus of mid leg with single row of palisade setae; hind tarsal ratio 2.38 (2.28-2.46,  $n = 3$ ). Wing (Fig. 14a) narrow, especially toward apex; membrane infuscated over entire surface, gradually darker toward costa; radial cell narrow; costal ratio 0.90 ( $n = 3$ ). Halter dark.

Abdomen: Very dark brown. Four pairs of well sclerotized gland rods; spermatheca (Fig. 8d) oval with very short neck, measuring 0.078 by 0.060 mm.

*Male*.—Unknown.

*Distribution*.—Colombia.

*Types*.—Holotype female, Colombia, Valle, Rio Raposo, Aug 1964, V. H. Lee, light trap. Paratypes, 2 females, same data except Mar 1964 and Jun 1965.

*Discussion*.—This species can be distinguished from other related species by the narrow distal portion of the wing, and by the entirely brown fore tibia.

### *Paryphoconus macfieii* Lane

Figs. 9, 14b

*Paryphoconus macfieii* Lane, 1946:203 (female; Brazil; fig. wing).—Wirth and Ratanaworabhan, 1972:1371 (in key).

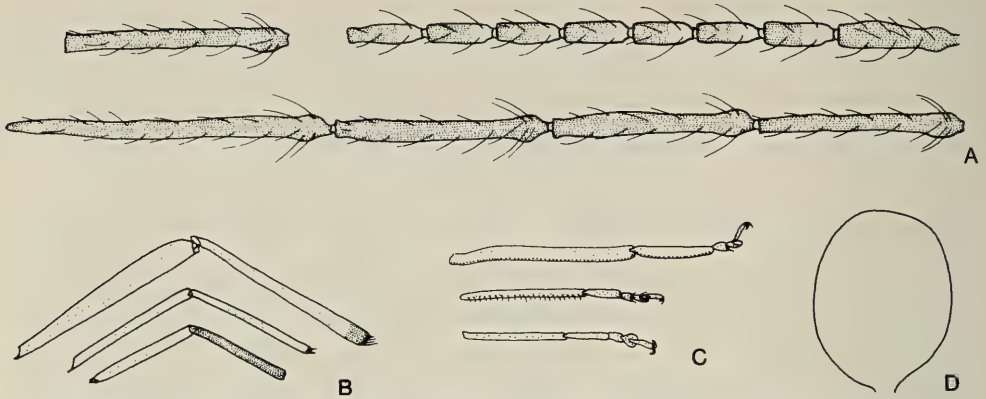


Fig. 8. *Paryphoconus leei*, female: a, Antenna; b, Femora and tibiae; c, Tarsi; d, Spermatheca.

*Female*.—Wing length 3.45 (3.35–3.55,  $n = 5$ ) mm; breadth 0.87 (0.84–0.90,  $n = 5$ ) mm.

Head: Yellowish brown including scape and pedicel, with numerous small dark mottlings. Antenna (Fig. 9a) with segments 3–10 pale yellow, 11–15 dark brown; lengths of flagellar segments in proportion of 35-20-21-22-23-23-23-23-41-41-47-50-80; antennal ratio 1.25 (1.12–1.37,  $n = 5$ ); verticils and setae sparse and fine, no black hastate setae. Palpus moderately long, 3 proximal segments brown, last 2 dark brown; 3rd segment with scattered sensilla; lengths of segments in proportion of 10-18-28-18-28.

Thorax: Yellowish to brown with small dark mottlings; mesonotum with very small, blunt, anterior spine. Legs (Fig. 9b, c) dirty yellowish brown; tibiae much infuscated, only tip of hind tibia dark brown; tarsi yellowish brown, last 2 tarsomeres infuscated; hind tarsal ratio 2.20 (2.15–2.30,  $n = 5$ ). Wing (Fig. 14b) as in *P. angustipennis*, but infuscation also lighter between the 3 bands; costal ratio 0.90 (0.90–0.91,  $n = 5$ ). Halter pale.

Abdomen: Brown, terga shining black. Five pairs of sclerotized gland rods; spermatheca (Fig. 9d) very elongate oval with short neck, measuring 0.156 by 0.060 mm.

*Male*.—Unknown.

*Distribution*.—Brazil, Ecuador, Venezuela.

*Specimens Examined*.—BRAZIL: Mato Grosso, Cuiaba, 4 Apr 1972, W. H. Whitcomb, 10 females. ECUADOR: Pastaza, Cononaco, 30 May 1976, J. Cohen, light trap, 3 females (wing bands more distinct in this series). VENEZUELA: Bolivar, Anacoco, Rio Cuyuni, 1–23 Aug 1979, Exp. Sta. La Salle, 1 female (wing bands distinct, only distal band prominent).

*Paryphoconus maya*, new species

Figs. 10, 14c

*Female*.—Wing length 2.45 (2.35–2.51,  $n = 5$ ) mm; breadth 0.64 (0.61–0.66,  $n = 5$ ) mm.

Head: Dark brown. Eyes separated for a distance equal to diameter of 4 ommatidial facets (0.060 mm). Antenna (Fig. 10a) with flagellar segments 3–10 white,



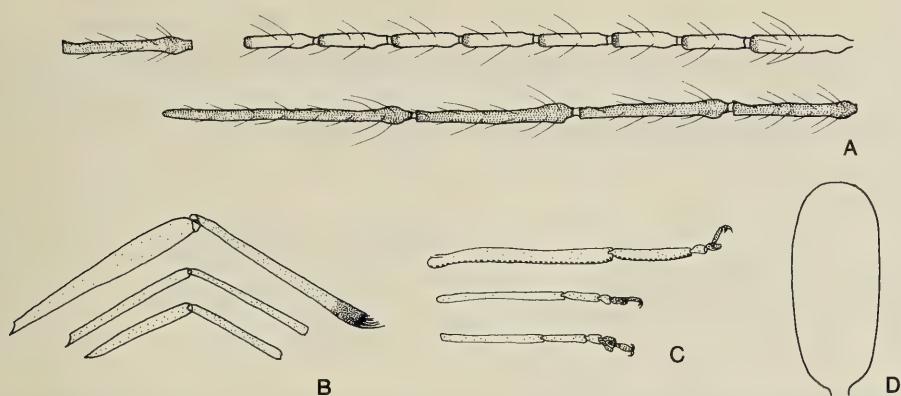


Fig. 9. *Paryphoconus macfie*, female: a, Antenna; b, Femora and tibiae; c, Tarsi; d, Spermatheca.

11–15 brownish; lengths of flagellar segments in proportion of 30-23-20-20-20-20-20-23-71-66-63-70-84; antennal ratio 1.95 (1.88–2.00,  $n = 5$ ); verticils and setae sparse and fine, no black hastate setae. Palpus short, pale yellow; lengths of segments in proportion of 7-13-16-14-16; 3rd segment with scattered sensilla.

Thorax: Dark brown, almost blackish; mesonotum with small, blunt, anterior spine. Legs (Fig. 10b, c) dirty yellowish, fore and mid tibiae brownish hind tibia dark brown (specimens from Mexico with only distal  $\frac{1}{2}$  of hind tibia dark brown); tarsi brownish, hind tarsus wholly brown (base of hind basitarsus slightly pale in some specimens); hind tarsal ratio 1.90 (1.83–2.00,  $n = 5$ ). Wing (Fig. 14c) narrow; membrane white, narrow apex infuscated; costa, radius, r-m, and Cul with faint dark mark; M1, M2, and M3+4, when infuscated, only at tips and then very slightly; costal ratio 0.88 (0.87–0.89,  $n = 5$ ). Halter dark brown, end of knob blackish.

Abdomen: Dark brown. Apparently with 3 pairs of sclerotized gland rods; spermatheca (Fig. 10d) oval with relatively long neck, measuring 0.058 by 0.049 mm with neck 0.018 mm long.

*Male*.—Unknown.

*Types*.—Holotype female, Belize, Cayo District, Western Hwy MP 66, Jun 1969, W. and D. Hasse, light trap. Paratypes, 8 females, as follow: BELIZE: same data as holotype, 6 females. MEXICO: San Luis Potosi, El Salto, 8 May 1964, F. S. Blanton, light trap, 2 females.

*Discussion*.—The species can be distinguished from related species by the coloration of the legs, especially the dark brown hind tibia. The antennal coloration is similar to that of *P. fittkaui* n. sp., but *P. fittkaui* is larger (wing length 2.9 mm) and the antennal ratio is much higher (2.60).

### *Paryphoconus nubifer* Macfie

Fig. 14f

*Paryphoconus nubifer* Macfie, 1939:5 (female; Brazil; fig. wing).—Lane, 1946:206 (Brazil record).—Lane, 1956:300 (in key).—Wirth and Ratanaworabhan, 1972: 1374 (female diagnosis; figs.; distribution).

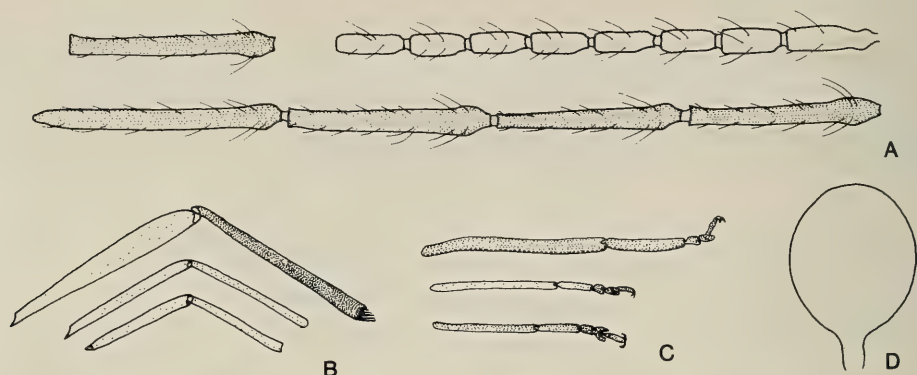


Fig. 10. *Paryphoconus maya*, female: a, Antenna; b, Femora and tibiae; c, Tarsi; d, Spermatheca.

*Distribution*.—Argentina, Bolivia, Brazil, Paraguay, Uruguay.

*New Records*.—ARGENTINA: Misiones, Arroyo Piray Guazu, N San Pedro, 22 Nov 1973, O. S. Flint, Jr., 4 females. PARAGUAY: Rio Aquidoban, Cerro Cora, 29 Nov 1973, O.S. Flint, Jr., 1 female.

*Notes*.—Wirth and Ratanaworabhan's (1972) record from Panama is erroneous, and this species does not occur north of Bolivia and Brazil. The species is readily distinguished by the extensive dark mark around the wing tip and the prominently infuscated veins (Fig. 14f). The antenna is unusually short and entirely black.

*Paryphoconus oliveirai* Lane

Fig. 14g

*Paryphoconus oliveirai* Lane, 1956:303 (female; Brazil).—Wirth and Ratanaworabhan, 1972:1374 (female redescribed; pupa; figs.; Brazil).

*Distribution*.—Brazil, Colombia.

*New Record*.—COLOMBIA: Amazonas, Leticia, 7 Sep 1969, D. H. Messersmith, at light, 1 female.

*Note*.—Wing as in Fig. 14g.

*Paryphoconus paranaensis*, new species

Figs. 11, 14h

*Female*.—Wing length 4.60 (4.45–4.70,  $n = 3$ ) mm; breadth 1.18 (1.15–1.20,  $n = 3$ ) mm.

*Head*: Dark brown. Eyes separated for a distance equal to diameter of 4 ommatidial facets (0.065 mm). Antenna (Fig. 11a) short, entirely dark brown; lengths of flagellar segments in proportion of 35-19-20-19-18-20-19-18-24-21-23-21-27; antennal ratio 0.71 (0.65–0.79,  $n = 3$ ); verticils and setae sparse and fine, no black hastate setae. Palpus short, pale brown; lengths of segments in proportion of 13-25-17-14-22; 3rd segment short and broad (palpal ratio 1.15), bearing scattered sensilla on midportion.

*Thorax*: Dark reddish brown; mesonotum with prominent, pale, pointed anterior spine (visible only on holotype). Legs (Fig. 11b, c) bright yellow, deep shade;

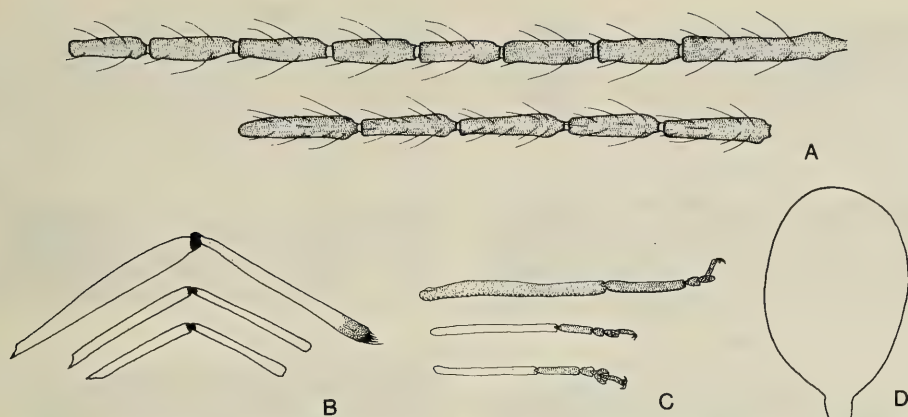


Fig. 11. *Paryphoconus paranaensis*, female: a, Antenna; b, Femora and tibiae; c, Tarsi; d, Spermatheca.

knees blackish, narrow apex of hind tibia dark brown; tarsi dark brown except fore and mid basitarsi pale brown; hind tarsal ratio 2.20 (2.15–2.25,  $n = 3$ ). Wing (Fig. 14h) pale, gradually darkening at distal  $\frac{1}{2}$  of costa to wing tip; costal ratio 0.99 ( $n = 3$ ). Halter stem pale brown, knob dark.

Abdomen: Dark brown, terga not shining. Spermatheca (Fig. 11d) elongate oval with moderately long neck; measuring 0.095 by 0.060 mm, neck 0.012 mm long.

*Male*.—Unknown.

*Distribution*.—Argentina.

*Types*.—Holotype female and 2 female paratypes, Argentina, Misiones Prov., Arroyo Piray Guazu, NE San Pedro, 22 Nov 1973, O. S. Flint, Jr.

*Discussion*.—This species is very similar to *Paryphoconus sonorensis* Wirth and Ratanaworabhan, from which it differs especially by the short antenna (antennal ratio 0.71 vs 1.18 in *P. sonorensis*). In addition, all the type material of *P. sonorensis* lacks the prominent anterior mesonotal spine found in the holotype of *P. paranaensis*.

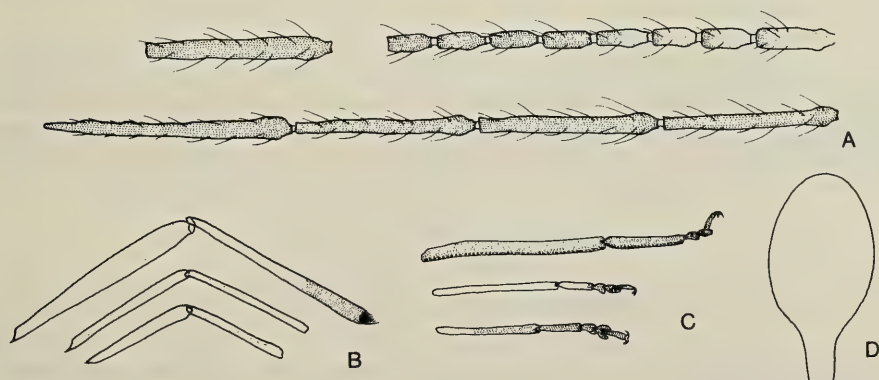


Fig. 12. *Paryphoconus steineri*, female: a, Antenna; b, Femora and tibiae; c, Tarsi; d, Spermatheca.



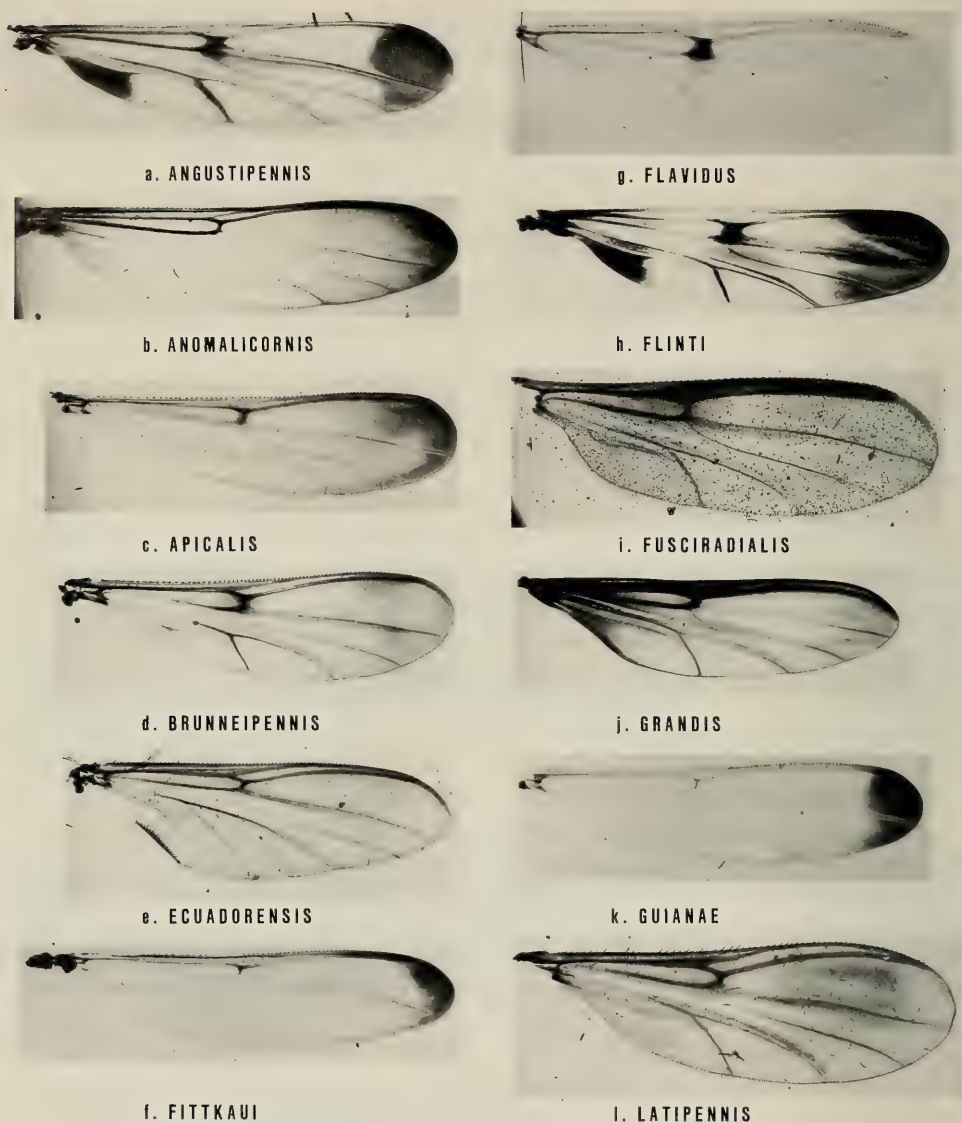


Fig. 13. Wings of *Paryphoconus* species, females: a, *angustipennis* from San Pedro, Argentina; b, *anomalicornis* from Comayagua, Honduras; c, *apicalis* from Cononaco, Ecuador (holotype); d, *brunneipennis* from Rio Solimões, Brazil (holotype); e, *ecuadorensis* from Pichincha, Ecuador (holotype); f, *fittkau* from Rio Marauia, Brazil (holotype); g, *flavidus* from Cuiaba, Brazil; h, *flinti* from Tabasco, Mexico (holotype); i, *fusciradialis* from Belem, Brazil (paratype); j, *grandis* from Cayo Dist., Belize; k, *guianae* from Conaco, Ecuador; l, *latipennis* from Rio Raposo, Colombia (paratype).

*Paryphoconus sonorensis* Wirth and Ratanaworabhan

Fig. 14i

*Paryphoconus sonorensis* Wirth and Ratanaworabhan, 1972:1374 (female; Mexico (Sonora), U.S.A. (Oklahoma); figs.).

*Distribution*.—Belize, Mexico, Panama, U.S.A.

*New Records*.—BELIZE: Cayo Dist., Western Hwy. MP 66, Jun 1969, W. and D. Hasse, light trap, 2 females. PANAMA: Dolega, 12 Dec 1952, F. S. Blanton, light trap, 2 female; Naranjal, 10 Oct 1952, Blanton, light trap, 1 female.

*Notes*.—Wing as in Fig. 14i. *Paryphoconus paranaensis* from Argentina is almost identical with *P. sonorensis* but that species has much shorter antenna (antennal ratio 0.71 in *P. paranaensis*, 1.18 in *P. sonorensis*), and there is a prominent pointed, pale, anterior spine on the mesonotum in *P. paranaensis*. The two species are widely separated in their distribution, *P. sonorensis* being essentially a Central American species, while *P. paranaensis* is restricted to Argentina.

*Paryphoconus steineri*, new species

Figs. 12, 14j

*Female*.—Wing length 2.80 (2.60–3.00,  $n = 2$ ) mm; breadth 0.71 (0.65–0.78,  $n = 2$ ) mm.

Head: Dark brown. Eye separation not visible on slide preparations available. Antenna (Fig. 12a) dark brown, 4 proximal segments slightly paler; lengths of flagellar segments in proportion of 40-26-24-26-26-25-25-25-96-88-88-92-122; antennal ratio 2.24; verticils and setae sparse and fine, no black hastate setae. Palpus short, yellow; lengths of segments in proportion of 9-15-20-14-18; 3rd segment with scattered sensilla.

Thorax: Uniformly blackish. Mesonotum apparently without anterior spine. Legs (Fig. 12b, c) pale yellow, distal  $\frac{1}{3}$  of hind tibia dark brown; tarsi dark brown except tarsomeres 1 and 2 of mid leg and proximal  $\frac{1}{3}$  of basitarsus of hind leg pale; hind tarsal ratio 1.85 (1.80–1.90,  $n = 2$ ). Wing (Fig. 14j) with anal angle poorly developed; membrane whitish with narrow tip infuscated; costa, radius and r-m crossvein all infuscated; M1, M2, M3+4 and Cul infuscated only distally; radial cell very narrow; costal ratio 0.90 ( $n = 2$ ). Halter yellowish, end of knob darkish.

Abdomen: Dark brown. Four pairs of sclerotized gland rods. Spermatheca (Fig. 12d) elongate oval, with long neck broad at base; measuring 0.070 by 0.045 mm, plus neck 0.025 mm long.

*Male*.—Unknown.

*Distribution*.—Panama, Peru.

*Types*.—Holotype female, Peru, Cuzco, Quince Mil, 26 Jan 1979, W. E. Steiner. Paratype, 1 female, Panama, Coclé Prov., Hermita, 18 Sep 1952, F. S. Blanton, light trap.

*Discussion*.—This species is named for Warren E. Steiner, in appreciation of his interest in collecting ceratopogonids for us. For separation from related species see the discussion under *P. apicalis* n. sp.

*Paryphoconus subflavus* Macfie

Fig. 14k

*Paryphoconus subflavus* Macfie, 1940a:23 (female; Guyana).—Wirth and Ratana-worabhan, 1972:1376 (female redescribed; figs.; distribution).

*Paryphoconus travassosi* Lane, 1956:304 (female; Brazil).—Wirth and Ratana-worabhan, 1972:1378 (female redescribed; figs.; Brazil). New Synonymy.

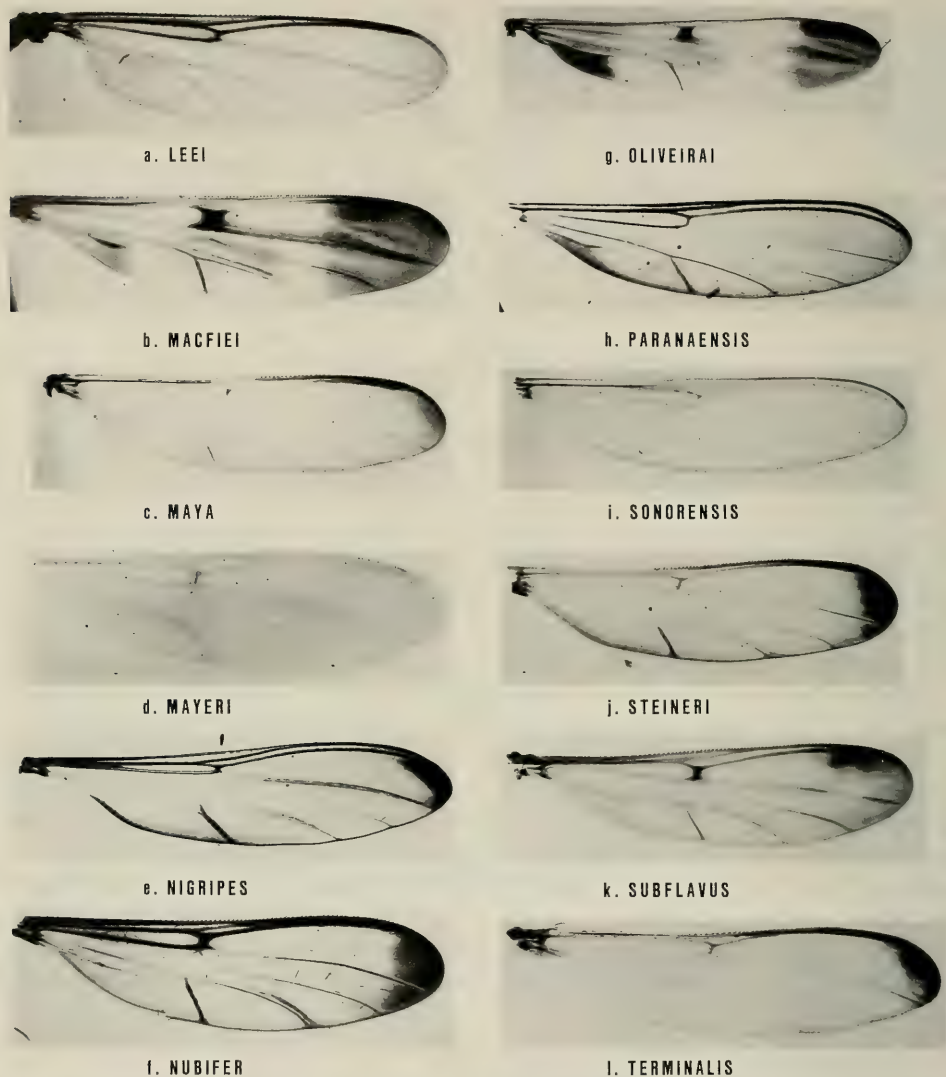


Fig. 14. Wings of *Paryphoconus* species, females: a, *leei* from Rio Raposo, Colombia (holotype); b, *macfiei* from Cuiaba, Brazil; c, *maya* from Cayo District, Belize (holotype); d, *mayeri* from Tabacorama, Brazil (holotype); e, *nigripes* from Cuiaba, Brazil; f, *nubifer* from San Pedro, Argentina; g, *oliveirai* from Leticia, Colombia; h, *paranaensis* from San Pedro, Argentina (paratype); i, *sonorensis* from Sonora, Mexico (paratype); j, *steineri* from Cuzco, Peru (holotype); k, *subflavus* from Rio Raposo, Colombia; l, *terminalis* from Tocumen, Panama.

*Distribution*.—Brazil, Colombia, Guyana.

*Note*.—Wing as in Fig. 14k. The characters which Wirth and Ratanaworabhan (1972) used to separate *P. subflavus* and *P. travassosi*, the dark line along vein Cul, and the infuscation on the fore and mid tibiae, are entirely unreliable, and in our opinion *P. travassosi* is a junior synonym.



*Paryphoconus telmatophilus* (Macfie), new combination

*Bezzia* (*Probezzia*) *telmatophila* Macfie, 1940b:77 (male; Brazil; figs.).

*Bezzia telmatophila* Macfie.—Lane, 1958:35 (male redescribed; fig. genitalia; Brazil).

*Distribution*.—Brazil.

*Notes on Types*.—Through the courtesy of Richard Lane and the Trustees of the British Museum (Nat. Hist.) Macfie's holotype of *Bezzia telmatophilus* was examined and found to belong to the genus *Paryphoconus*. The male that Lane (1958) described as the allotype of *P. telmatophilus* is not congeneric with Macfie's species and appears to represent the male (taken at the same time and place) of Lane's new species *Bezzia brasiliensis*, which is a junior synonym of *Nilobezzia schwarzii* (Coquillett).

Because of the difficulty of distinguishing species of *Paryphoconus* in the male we are treating this species as a species inquirenda in *Paryphoconus*.

*Paryphoconus terminalis* (Coquillett)

Fig. 141

*Ceratopogon terminalis* Coquillett, 1904:90 (female; Nicaragua).

*Paryphoconus terminalis* (Coquillett).—Wirth and Ratanaworabhan, 1972:1377 (combination; erroneous synonym *guianae*; redescribed female; figs.; distribution).

*Distribution*.—Belize, Brazil, Costa Rica, Ecuador, Honduras, Nicaragua, Panama, Peru.

*New Records*.—BELIZE: Cayo Dist., Western Hwy. MP 66, Jun 1969, W. and D. Hasse, light trap, 2 females. ECUADOR: Pastaza, Cononaco, 30 May 1976, J. Cohen, at light, 1 female.

*Notes*.—Wing as in Fig. 141. Wirth and Ratanaworabhan's synonymy of *P. guianae* Macfie under *P. terminalis* was erroneous. Characters for separating the two species are given in the key and in the discussion under *P. guianae*, *P. terminalis* appears to be one of the most widespread species of the genus, and is fairly common in collections.

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(GRS) Becario Externo, Consejo Nacional de Investigaciones Científicas y Técnicas de la República Argentina; Instituto de Limnología, Museo de la Plata, La Plata, Argentina; (WWW) Systematic Entomology Laboratory, IIBIII, Agricultural Research Services, USDA, % National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

*ACANTHOHAUSTORIUS PANSUS*, A NEW SPECIES  
OF SAND-BURROWING AMPHIPOD FROM  
LOOE KEY REEF, FLORIDA KEYS, WITH  
REDESCRIPTION AND DISTRIBUTION DATA OF  
*ACANTHOHAUSTORIUS BOUSFIELDI* FRAME, 1980  
(AMPHIPODA: HAUSTORIIDAE)

J. D. Thomas and J. L. Barnard

*Abstract.* — A new species of sand-burrowing amphipod, *Acanthohaustorius pansus*, is described from carbonate sands of the Florida Keys Reef Tract. This is the first time the predominantly cold-water genus *Acanthohaustorius* has been reported south of Virginia coastal waters. *Acanthohaustorius bousfieldi* Frame, 1980, originally described from Long Island Sound, is refigured and reported from shell-hash sediments off the central Atlantic coast of Florida. A revised key to the species of *Acanthohaustorius* is presented.

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Investigations by the authors have revealed a previously undescribed species of *Acanthohaustorius* from Looe Key Reef in the Florida Keys, and a range extension to Hutchinson Island, Florida, of *A. bousfieldi* Frame, 1980. To date, no species of *Acanthohaustorius* had been reported south of Virginia. This predominantly cold-water genus is found mostly in quartzose shallow water sediments and its occurrence in shell-hash sediments from central Florida and coralline sands of the Florida Reef Tract is significant.

The genus *Acanthohaustorius* was previously composed of six species: *A. spinosus* (Bousfield, 1962); *A. millsii* Bousfield, 1965; *A. intermedius* Bousfield, 1965; and *A. shoemakeri* Bousfield, 1965; all described from American North Atlantic waters. *Acanthohaustorius bousfieldi* Frame, 1980, and *A. similis* Frame, 1980, were described from offshore bottom sands of New York Bight and Long Island Sound. Reports of undescribed *Acanthohaustorius* species have been made by Camp *et al.* (1977) from Hutchinson Island, Florida (three species), and by Robertson and Shelton (1978) from the northwestern Gulf of Mexico. We believe that a number of undescribed haustoriids exist in the southern Atlantic and Gulf of Mexico waters, and that any major taxonomic treatment of the American Haustoriidae should be delayed until the southern Atlantic and Gulf of Mexico component species can be included.

Haustroriids are exceedingly spinose and setose and in the past the location and numbers of certain spines or spine groups have been used as species characters. However, the numbers of these spines and spine groups vary not only with size of the specimen (larger = more spinose) but with geographic distribution of a species (number of spines decreases with southerly distribution). One taxonomic difficulty is the determination of those characters or set of characters that will withstand the normal range of specific variation. Our studies show that spine morphology on pereopods 5-7, spination of uropod 1 (especially the peduncle), and the configuration of the telson are characters that vary little and thus offer



some help in sorting out the species. We examined a single character in selected haustoriids, the number of comb-setae on mandibular palp article 3, and found a direct correlation among genera and species between the number of comb-setae and specimen length, thus rendering this particular character of no use in separating species.

*Explanation of Figure Legend.*—Upper case letters refer to body parts as follows; lower case letters to left of capital letters refer to specimens mentioned in text; lower case letters to right of capital letters and in body of drawings are in following list: A, antenna; B, body; C, coxa; E, eye; G, gnathopod; H, head; I, inner plate or ramus; J, pleopod; K, seta or spine group; L, labium; M, mandible; N, palp; P, pereopod; R, uropod; S, maxilliped; T, telson; U, upper lip; W, pleon; X, maxilla; Y, epimeron; Z, molar; d, dorsal; f, flattened; l, left; o, other view; r, right.

*Acanthohaustorius pansus*, new species

Figs. 1–5

*Holotype.*—USNM 195103, female “a,” 4.82 mm, with 7 eggs.

*Type-locality.*—Looe Key Reef, Florida Keys, 24°32.5'N; 82°24.0'W, in coarse coralline sand in front of forereef, 8 m, 22 May 82, J. D. Thomas collector.

*Diagnosis.*—Posterior margin of coxa 3 deeply concave, posteroventral corner sharp and protuberant. Article 5 of pereopod 6 with horizontal ventral margin armed with about 4 spines evenly spaced, facial spines in 2 pairs forming square, posterior margin sparsely armed; posterior margin of article 6 with only one spine group proximal to group on apex. Coxa 7 blunt posteriorly. Peduncle of uropod 1 with 5 large dorsolateral spines, 2 ventral spines, 3 medial spines; inner ramus variable in size, short to subequally as long as outer ramus. Telson cleft to base, lobes separated by broad gape.

*Material.*—Female “a” 4.82 mm; female “b” 4.30 mm; male “g” 4.60 mm; juvenile “j” 2.11 mm.

*Description of female (ovigerous), 4.82 mm.*—Body broad, robust, barrel-shaped. Head 1.42 times wide as long, rostrum short. Eyes: in life white; in freshly preserved material (1–2 hours), clear with 4–5 pinkish-orange corneal inclusions; not discernible in preserved material.

Antenna 1: article 1 of peduncle as deep as wide, bearing 7 plumose setae on lateral margin; article 2 narrow, equal in length to article 1; flagellum 8-articulate; accessory flagellum with 2 long, subequal articles. Antenna 2: peduncular article 4 broad, with posterior lobe, posterolateral margin with 21 elongate glassy spines, medial margin with 7 elongate spines, entire posterior margin with long plumose setae, (not figured for clarity), 4 facial plumose setae near posterodistal margin; article 5 slightly expanded distally; flagellum composed of 6 articles, article 1 longest. Upper lip broad, apex smooth. Right mandible: incisor bifid, raker row with 6 elongate and 1 short spines; molar well developed, triturative, molar surface indented, bearing one jointed penicillate seta; palp article 2 with 3 setae; palp article 3 with 11 apical spines, and 11 marginal comb-spines. Left mandible: lacinia mobilis short; with 7 raker spines. Maxilla 1: inner plate with medial plumose setae, outer plate marginally pubescent, bearing 11 apical spines; palp slender, armed with spines and plumose setae. Maxilla 2: inner plate slender,

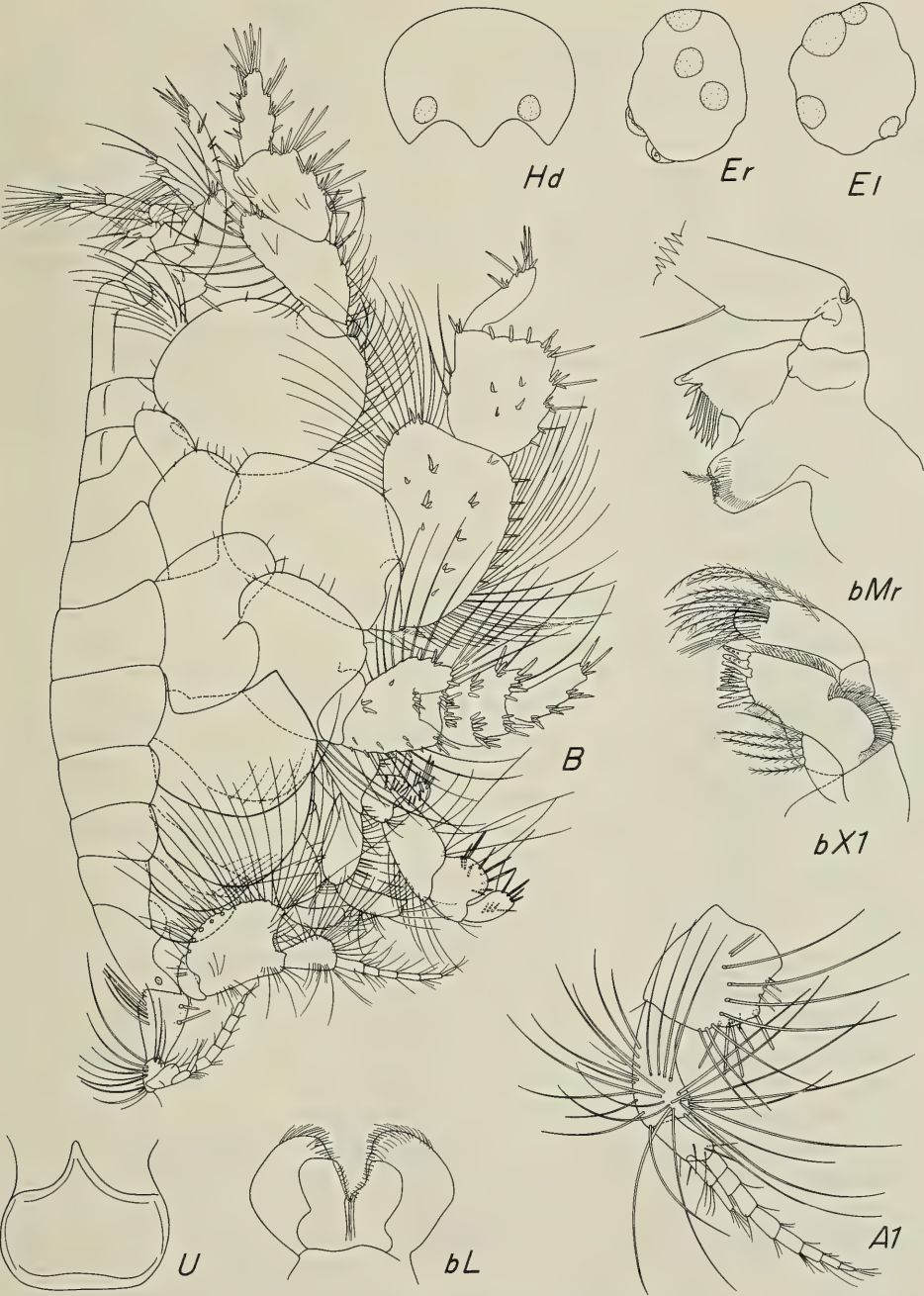


Fig. 1. *Acanthohaustorius pansus*, unattributed figures, female “a” holotype, 4.82 mm; b = female “b” 4.30 mm.

bearing medial row of marginal plumose setae, oral surface with oblique row of facial plumose setae; outer plate greatly expanded, lateral margin with fine pubescence, medial margin with numerous plumose setae, aboral side of medial margin with about 15 embedded thick spines. Maxilliped: inner plate with 7 medial plumose setae, apical margin with 2 blunt spines and one penicillate seta embedded in aboral surface, distal margin with double row of spines; outer plate much broader than inner, bearing recurved spines and numerous setae along medial margin; palp article 2, distal margin greatly expanded, dense setae along inner margin; palp article 3 geniculate, with long setae on distal margin, medial margin with 7 elongate spines.

Coxae 1–4 forming even ventral curve, no disjunctions, coxae progressively longer and broader. Gnathopod 1: coxa small, excavate, posterior margin with 5 plumose setae, posteroventral margin with 3 setae, anteroventral margin with 3 medial setae; article 2 elongate, with 12 elongate setae along posterior margin; article 5 with dense clusters of setae along posterior margin; article 6 with numerous hooked-tip setae along anterodistal margin; dactyl strong, nail prominent. Gnathopod 2: coxa subequal and similar in shape to coxa 1, posterodistal coxal margin with 8 plumose setae; article 2 elongate, setal formula of posterior margin = 1-1-1-2-2-2-3-2-5; article 5 with dense covering of setae along posteroventral margin, posterodistal margin with two groups of 5 and 6 spoon-shaped pectinate spines; article 6 elongate; dactyl short, stout. Pereopod 3: coxa scythe-shaped, posterior margin with 5 plumose setae, one long seta apically, posterodistal margin with single setule; article 2 elongate, posterior margin with elongate setae and plumose setae; article 4, anterior margin with 8 plumose setae, posterior margin with elongate setae, posterodistal corner with 3 elongate plumose setae; article 5 with 11 spines arranged around one circular cusp; article 6 with oblique row of 8 spines and one elongate plumose seta, dactyl indistinguishable. Pereopod 4: coxa broad, posterior margin slightly excavate, one setule present on ventral margin; article 2 elongate, 2 setae on posterodistal margin; article 4, anterior margin with 6 plumose setae, posterior margin with 8 plumose setae and 9 setules; article 5 expanded, with 6 spines and 3 plumose setae surrounding posterior cusp; article 6 with 9 oblique spines and 2 plumose setae, and setule representing dactyl.

Pereopod 5: coxa small, bilobed, posterior margin with 3 setae; article 2, posterior margin slightly expanded, hind margin with 6 setae, anterior margin with 2 setae and approximately 8 plumose setae; article 4 about as wide as deep, posterior margin expanded distally, anterior margin spine count = 1-1-1-1-1, posterior margin with single group of 2 spines, anterodistal margin with 5 spines, posterodistal margin with 6 spines, anterior facial margin with 2-2-2 spines, posterior facial margin with 2-1-1 spines, group of 4 facial spines located proximal to ventral margin, plumose setae located laterally along anterior, posterior, and posterodistal margins; and medially near anteroventral margin; article 5 slightly expanded posteroventrally, anterior margin spine count = 7-5, posterior margin spine count 3-5, 2 groups of facial spines = 7-4; article 6, anterior margin spine count = 3-3-3, apex with 4 spines and one embedded penicillate seta, representing dactyl. Pereopod 6: coxa small, rounded posteriorly, with 5 short setae along posterior margin and one seta near posteroventral margin (not shown in figure); article 2 quadrate, deeper than wide, posteroproximal margin with 5 short setae,



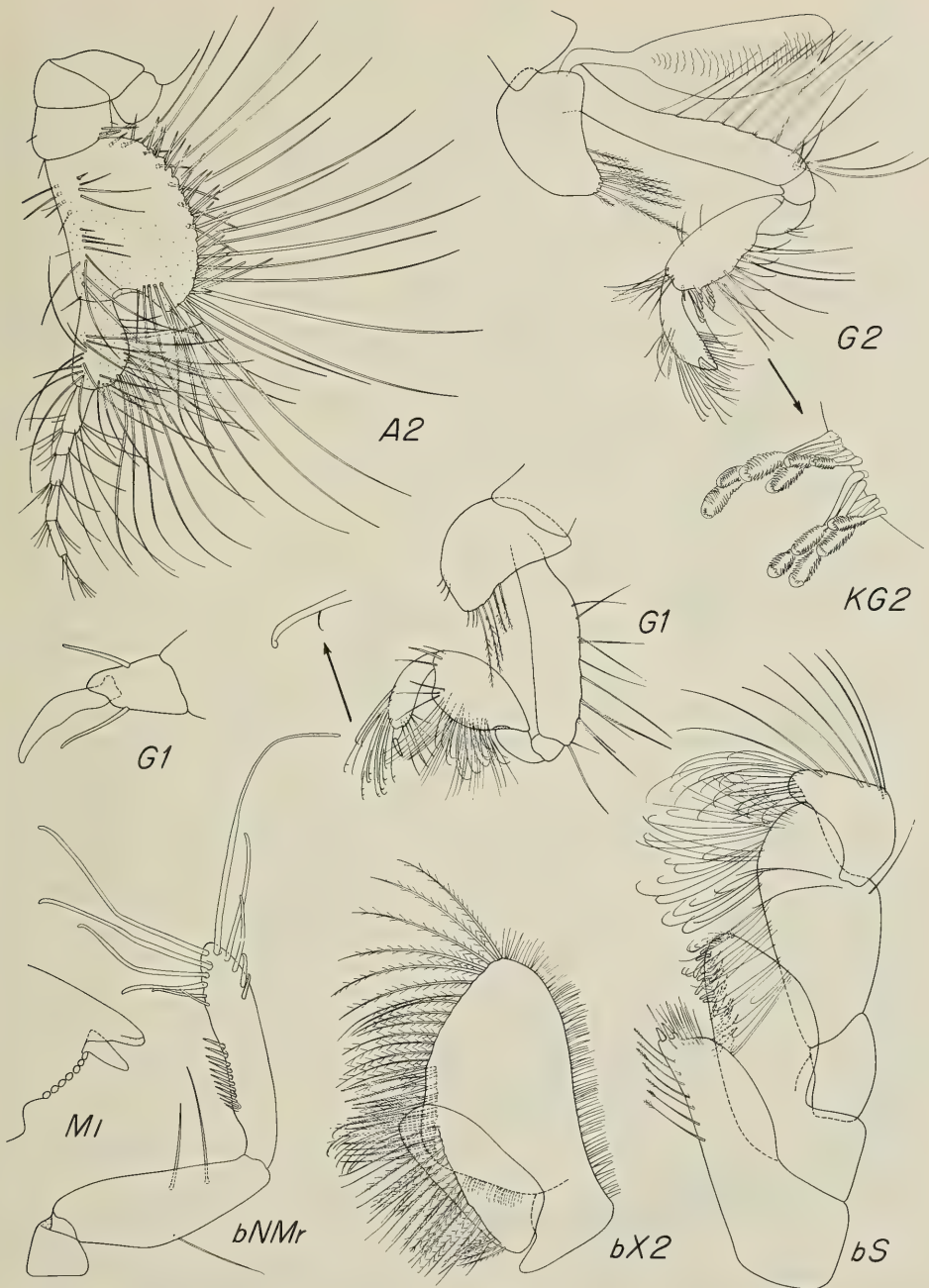


Fig. 2. *Acanthohaustorius pansus*, unattributed figures, female "a," holotype, 4.82 mm; b = female "b" 4.30 mm.

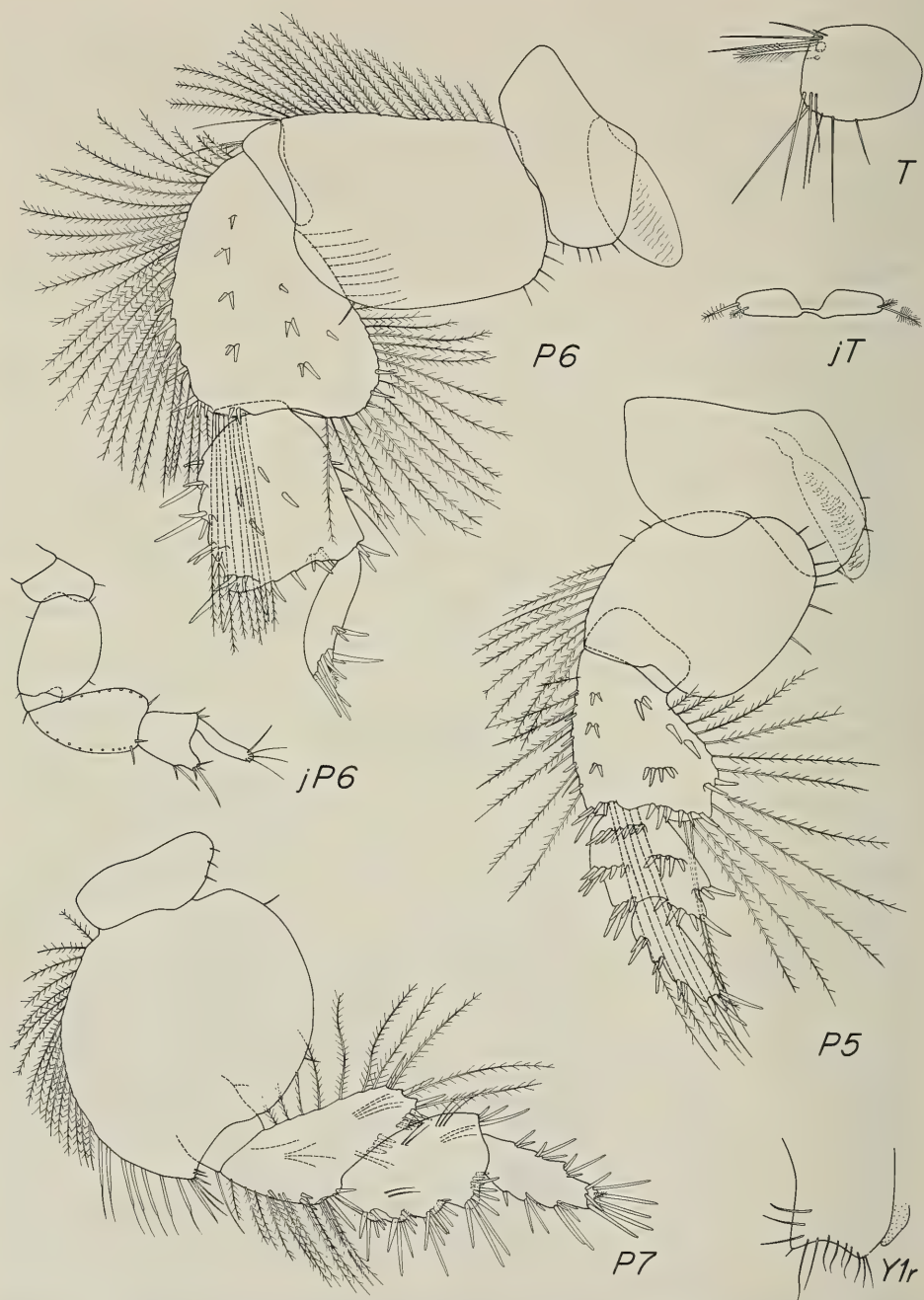


Fig. 3. *Acanthohaustorius pansus*, unattributed figures, female "a" holotype, 4.82 mm; j = juvenile "j" 2.11 mm.

anterior margin densely lined with plumose setae, anteroventral corner with several setae; article 4 with expanded posterodistal margin, anterior margin spine count = 1-1-1-1-2-2-4, ventral margin with cluster of 2 spines, posterior lobe with 4 single spines, facial setae in 3 clusters, anterior cluster = 1-2-2-2, middle cluster = 1-2-2, and one facial spine near posterior margin; anterior, posterior, and medioventral margins with numerous plumose setae; article 5 subquadrate, narrowing slightly at insertion with article 4, anterior margin spine formula = 1-3-4-4, anteroventral corner with group of 5 spines, ventral margin with 3 single spines, posterodistal margin with 3 spines, posterior margin with 2 single spines, each with one single long seta, 4 single facial spines on lateral surface, medial surface with pair of spines inserted near ventral margin; article 6, length  $4 \times$  width, posterior margin with group of 4 spines near apex, apex with 9 spines and one immersed penicillate seta representing dactyl. Pereopod 7: coxa small, rounded posteriorly, posterior margin with 3 short setae; article 2 large, circular, anterior margin with plumose setae and 7 elongate spines, anterodistal corner with 6 spines, posterior margin with 2 widely separated setules; article 4 produced posteroventrally, anterior margin with numerous plumose setae and 1-2-3 spines, posterior margin with moderately spaced plumose setae and 3 long spines at posterodistal margin, ventrolateral margin with 2 spines, medial surface with 4 setal clusters of 1-3-4-2, ventromedial margin with 3 spines, medial margin near posteroventral corner with 4 spines.

Pleosome: epimeron 1, ventral margin slightly excavate, 8 marginal setae, posterior margin with 3 setae, posteroventral margin with single setule; epimeron 2 ventral margin with 8 setae, 3 setae in oblique row near posterior margin; epimeron 3 largest, with moderate tooth, setal formula = 1-1-4-5-4-3-4; Pleopods: pleopods 1 and 2 similar, peduncles with slightly expanded medioventral lobes, outer rami with 15 articles, inner rami with 11 articles; pleopod 3 outer ramus with 15 articles, inner ramus with 12 articles. Uropod 1: peduncle  $3 \times$  long as wide, outer margin with 3 dorsolateral spines, ventral margin with 2-3 spines (variable L-R), apex with 1 large interramal spine surrounded on either side by one shorter spine; outer ramus longer than inner, with 1-2-2 dorsofacial spines and 5 apical and 2 mediomarginal spines; inner ramus 0.66 times outer, with 1 mediomarginal and 3 apical spines, and 4 mediomarginal and 3 apical setae. Uropod 2: peduncle and rami subequal, covered with numerous long setae. Uropod 3: peduncle shorter than rami; outer ramus longer than inner, 2 articulate, with 2 lateral setae on article 1, articles 1 and 2 with numerous apical setae; inner ramus slightly shorter than outer, with 3 mediomarginal setae, apical setae numerous. Telson cleft to base, consisting of two widely separated lobes joined by thin web, lateral margins of lobes with large penicillate seta and 2 long setae, posterior margin with 7-9 long setae.

Gills laminar, present on pereopods 2-6; brood plates setose, plate 2 smallest, plates 3-5 larger, subequal.

*Male "c," 4.30 mm.*—Similar to female in most respects but generally having more plumose setae, and clusters of facial spines on articles 4 and 5 of pereopods 5, 6, and 7. Pereopod 5: article 2 with 7 posterior setae; article 4 with 2-2-3 anterior facial spines, 2-4 middle facial spines, and 2-1 posterior facial spines; article 5 with 7-8-6 anterior facial/marginal spines, and 4-3-4 posterior facial/



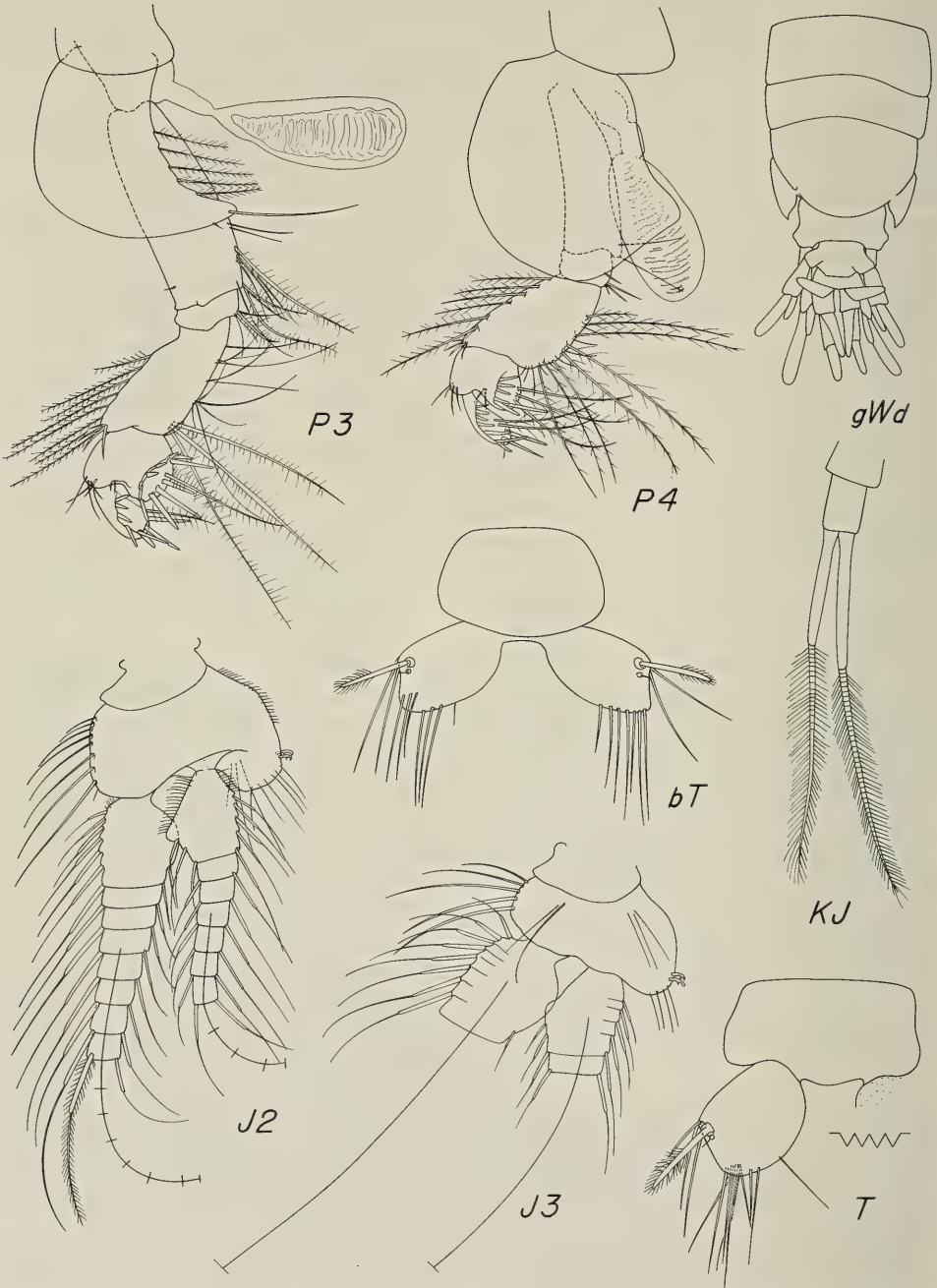


Fig. 4. *Acanthohaustorius pansus*, unattributed figures, female "a" holotype, 4.82 mm; b = female "b" 4.30 mm; g = male "g" 4.60 mm.

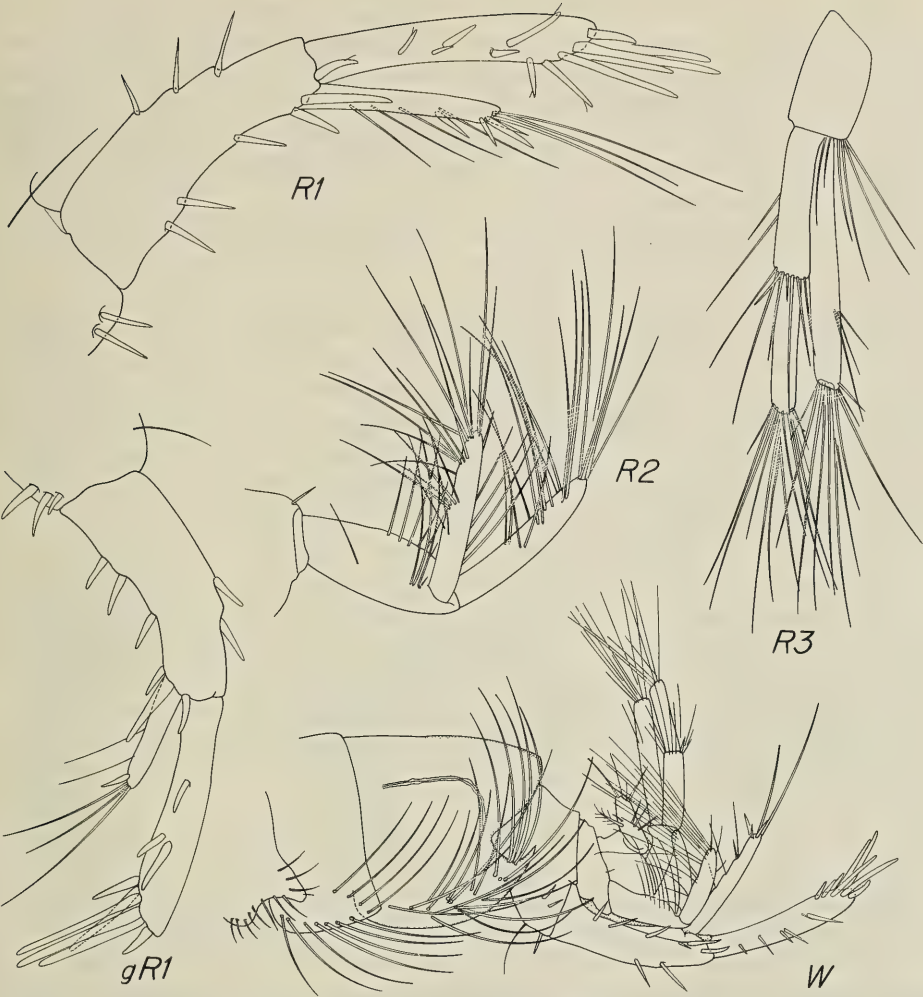


Fig. 5. *Acanthohaustorius pansus*, unattributed figures, female "a" holotype, 4.82 mm; g = male "g" 4.60 mm.

marginal spines. Pereopod 6: article 4 facial spines = 2-2-2, 3-3, and 1. Pereopod 7: article 4 with group of 3 facial setae on lateral margin.

Specimens under 3 mm in length have fewer spines and spine groups, and fewer clusters of spines in each group. Mandibular palp article 3 shows reductions in number of comb setae and apical spines.

*Juvenile "j," 2.11 mm.*—Left mandibular palp article 3 with 1 comb seta and 4 apical setae; pereopod 6 article 5 lacking facial spines; article 6 lacking posterior spines.

*Juvenile "k," 2.82 mm.*—Left mandibular palp article 3 with 3 comb setae and 7 apical setae; pereopod 6 article 5 lacking facial spines; article 6 with a single posterior marginal spine.

*Variations.*—All specimens exhibited some degree of variability. The ratio of the inner ramus to the outer in uropod 1 was especially variable. The percent length of the inner ramus to the outer was measured in the following specimens: male “g,” 25 percent; female “b,” 50 percent; male “c,” 58 percent; and the holotype, 70 percent. This wide variation sheds doubt on the validity of this particular meristic character which has been used to separate species within the genus *Acanthohaustorius*.

*Etymology.*—From the Latin “pansus,” meaning “spread out.” This is in reference to the completely separated lobes of the telson in which this species is unique.

*Relationships.*—*Acanthohaustorius pansus* appears closest to *A. millsi* but differs in: 1) widely separated lobes of the telson, 2) smaller inner ramus on uropod 1, 3) blunt posterior margin of coxa 7, 4) sparser facial or posterior armament of pereopod 6, either on articles 5 or 6, 5) presence of ventral spines on peduncle of uropod 1, 6) smaller number of comb setae on article 3 of the mandibular palp. *Acanthohaustorius pansus* differs from *A. shoemakeri* in 1, 3, 4 (article 6 only), and 6; from *A. intermedius* in 1 and 4; from *A. similis* in 1–4.

*Distribution.*—From Looe Key Reef, Florida Keys, to Eastern and Northern Gulf of Mexico, 8–40 m, in fine to medium fine sediments.

*Material examined.*—Bureau of Land Management MAFLA Stations: 2318, 29°05'00.8"N, 83°45'00.5"W, medium sand, 20 m.—2419, 29°46'59.8"N, 84°05'00.2"W, medium fine sand, 10 m.—2424, 29°13'00.7"N, 85°00'01.4"W, medium sand, 27 m.—2855, 30°08'02.1"N, 86°30'00.0"W, medium sand, 40 m.—2856, 29°54'01.3"N, 87°24'00.2"W, fine sand, 30 m.—2960, 25°40'N, 82°20'W, fine sand, 27 m.

*Acanthohaustorius bousfieldi* Frame

Figs. 6–9

*Material.*—Female “f,” 9.50 mm, with 8 eggs; male “m,” 6.62 mm Hutchinson Island, Florida, 27°21.6'N, 80°28'W, 12 m, coarse, poorly sorted shell hash.

*Diagnosis.*—Posterior margin of coxa 3 deeply concave, posteroventral corner sharp and protuberant. Article 5 of pereopod 6 with horizontal ventral margin armed with about 3 unevenly spaced spines, facial spines in rectangle of pairs; and singles, posterior margin well armed; posterior margin of article 6 with more than 2 spine groups other than proximal group. Coxa 7 blunt posteriorly. Peduncle of uropod 1 with short dorsolateral spines along middle two-thirds of peduncle, basal, and distal spines stout, no ventral or medial spines (one medial setule); inner ramus as long as outer, not variable. Telson cleft to base, lobes not separated.

*Description of Female, 9.50 mm.*—Body large, barrel shaped. Head  $0.71 \times$  long as wide, rostrum short, eyes not visible. Antenna 1 article 1 of peduncle with mid-ventral margin slightly produced, oblique row of plumose setae on dorso-lateral face; article 2 shorter than article 1, dense growths of plumose setae on anterior and posteroventral margins; flagellum 11-articulate; accessory flagellum with 2 long, subequal articles. Antenna 2: article 3 of peduncle with 3 plumose setae and 3 spines on posterior margin; article 4 large, posterior margin expanded, anterodistal quadrant with 9 plumose setae, posterior margin with 24 blunt spines on lateral surface and 7 elongate spines on medial surface, 4 facial setae located proximally, distal face with 4 long, plumose setae, medial surface with 6 enlarged



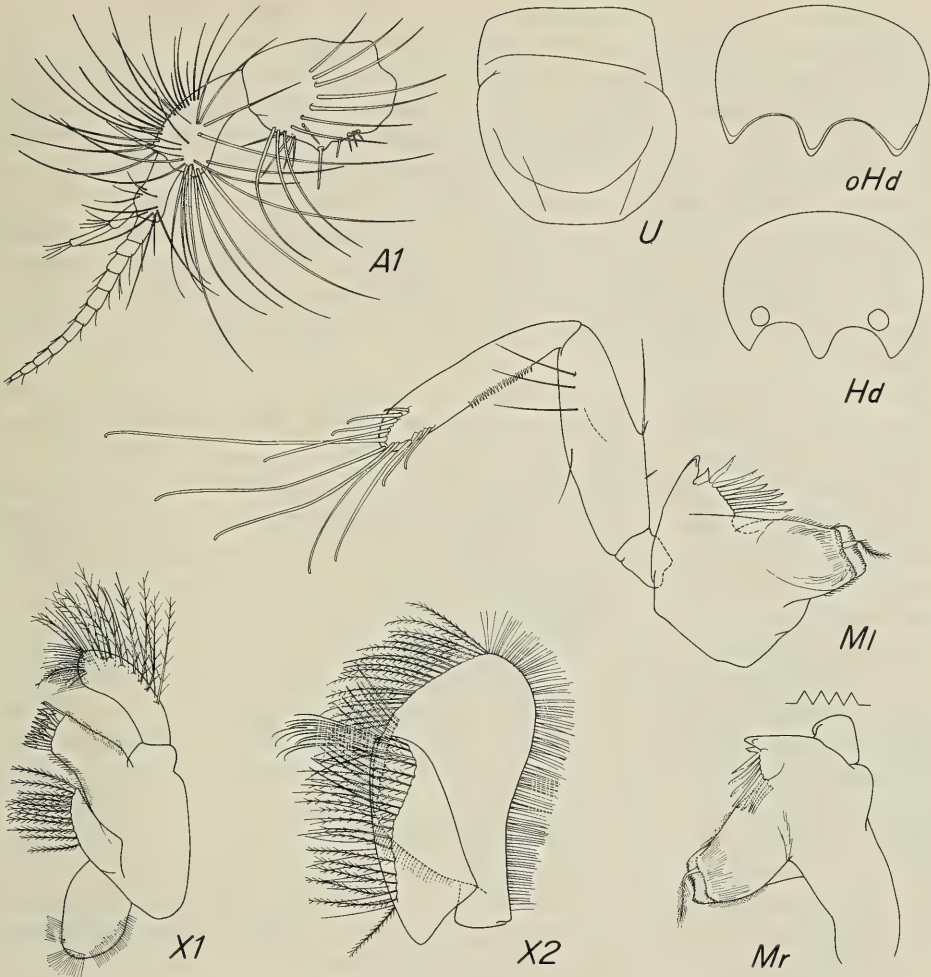


Fig. 6. *Acanthohaustorius bousfieldi* unattributed figures, female “f” 9.50 mm; m = male “m” 6.62 mm.

plumose spines embedded in sockets anteroproximally, posterior margin with numerous plumose setae; article 5 with 15 plumose setae near anterior margin, posteriorly lined abundantly with plumose setae, flagellum 8-articulate, article 1 longest.

Upper lip broad, apex smooth. Lower lip: inner lobes truncate, setose anteriorly, outer lobes anteromedial margins armed with short spines, pubescence well developed on anterior and lateral margins. Right mandible: incisor bifid, lacinia mobilis small, subacute and serrate; raker row with 1 short and 8 elongate spines; molar tritulative, with inserted penicillate seta; palp articles 1–3 with ratio 18: 65:72, article 3 with 21 comb-spines and 11 apical spines. Left mandible with 8 long raker spines. Maxilla 1: inner plate small, 11 plumose setae on medial margin; outer plate marginally setose, with 16 apical spines; palp with numerous plumose setae on lateral margin, apex with thin spines and one thick penicillate seta; coxal

baler lobe with 3 distinct lines of pubescence. Maxilla 2: inner plate slender, with plumose setae along medial margin, with row of oblique facial setae, apex with abundant long, hooked spines; outer plate enlarged aboral surface of medial margin with 15 thick, submarginal spines, medial margin bordered with numerous plumose setae, lateral surface with dense pubescence. Maxilliped: inner plate with 10 medial plumose setae, apex with 2 blunt spines and penicillate seta on aboral surface plus oblique row of 7 plumose setae on oral surface, lateral margin pubescent; outer plate much broader than inner, with curved spines and dense setae on distomedial margin; palp article 2 greatly expanded, reaching to end of article 3, medial margin densely setose; palp article 3 geniculate, arising from raised process on article 2, bearing facial row of 9 recurved setae, apex with 14–15 thick spines.

Coxae 1–4 forming even curve below, no disjunctions, coxae progressively longer and broader. Gnathopod 1: simple; coxa small, slightly excavate, ventral margin with 6 plumose setae, anterior margin with 9 medial setules; article 2 elongate, anterior margin bare, posterior margin with long setae; article 5 expanded distally, posterior margin densely setose; article 6 slender, with numerous hooked setae; dactyl simple, with long nail. Gnathopod 2: chelate; coxa small, 7 plumose setae on ventral margin, a single spine near apex; article 2 elongate, posterior margin distally setose; article 5 similar to gnathopod 1 except posterodistal surface with 3 groups (5), (7), (16–17), of spoon-shaped pectinate spines; article 6 with dense hooked setae. Pereopod 3: coxa scythe-shaped, posterior margin with 5 plumose setae, apex with slender spine, anteroventral margin with single setule; article 2 truncate, anterior margin with 4 setules, posterior margin with long setae and enlarged plumose setae at posteroventral margin; article 4 anterior margin with 8 plumose setae, posterior margin with 18 setae and 6 thick, elongate plumose setae, posterodistal apex with single long spine; article 5 with circle of 14 spines and 2 thick plumose setae; article 6 with circle of 8 spines and 3 plumose setae, 2 setae near apex. Pereopod 4: coxa enlarged, rounded anteriorly, posterior margin with 2 setae; article 2 anterior margin with 6 setules, posterior margin with sparse setae, single enlarged plumose seta on posterodistal margin; article 4 anterior margin with 5 plumose setae, posterior margin with 10 plumose setae interspersed with short spines, posterodistal surface with oblique row of 5 plumose setae; article 5 with circle of 6 spines and 3 plumose setae; article 6 with circle of 10 spines and 2 plumose setae, one setule near apex representing dactyl.

Pereopod 5: coxa bilobed, hind margin with 18 plumose setae; article 2 subcircular, anterior margin with plumose setae, 4 short setae on anteroproximal margin, posterior margin with 15 plumose setae and one setule; article 4 expanded posterodistally, posterodistal margin truncate, anterior margin with interspersed long and short plumose setae and single spines, ventral margin with 4 anterior and 7 posterior spines, posterior margin with plumose setae only, facial spine formulas = 1-3-3-4 anterior, and 2-6-3 posterior, mediofacial setae = 3-8-10 anterior and 2 posterior; article 5 similar in shape to 4, anterior margin lacking setae, facial spine formulas = 10-8-6 anterior and 6-3-6 posterior, 5 plumose setae embedded in posteroventral spine set; article 6 anterior spine formula = 2-4-3-3, posterior margin bare, apex with 5 spines and one penicillate seta. Pereopod 6: coxa small, bilobed, hind margin with 6 plumose setae; article 2 truncate, hind margin with 12 plumose setae and one setule, medial surface with 1-2-2-2 and 5

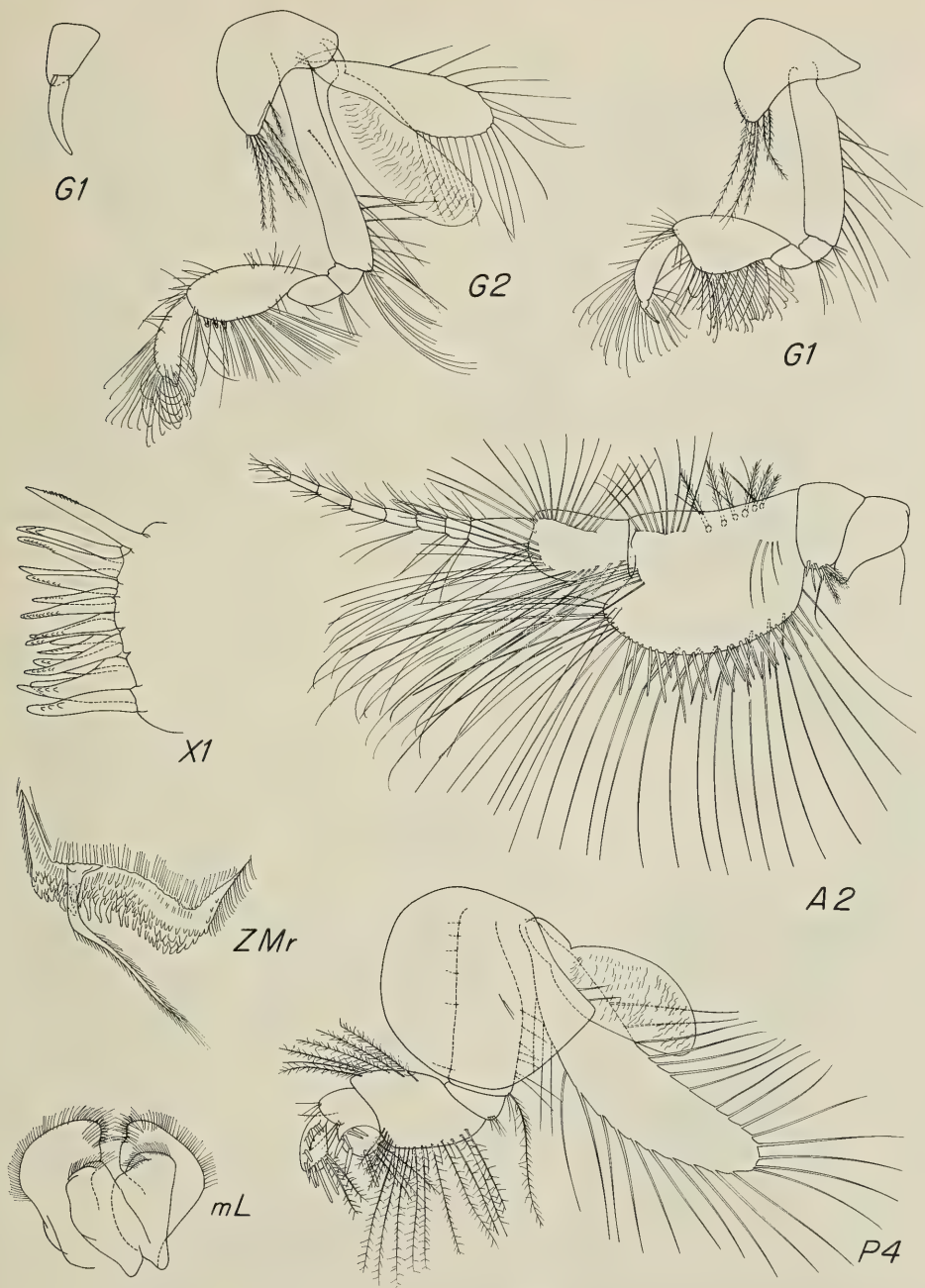


Fig. 7. *Acanthohaustorius bousfieldi*, unattributed figures, female "f" 9.50 mm; m = male "m" 6.62 mm.



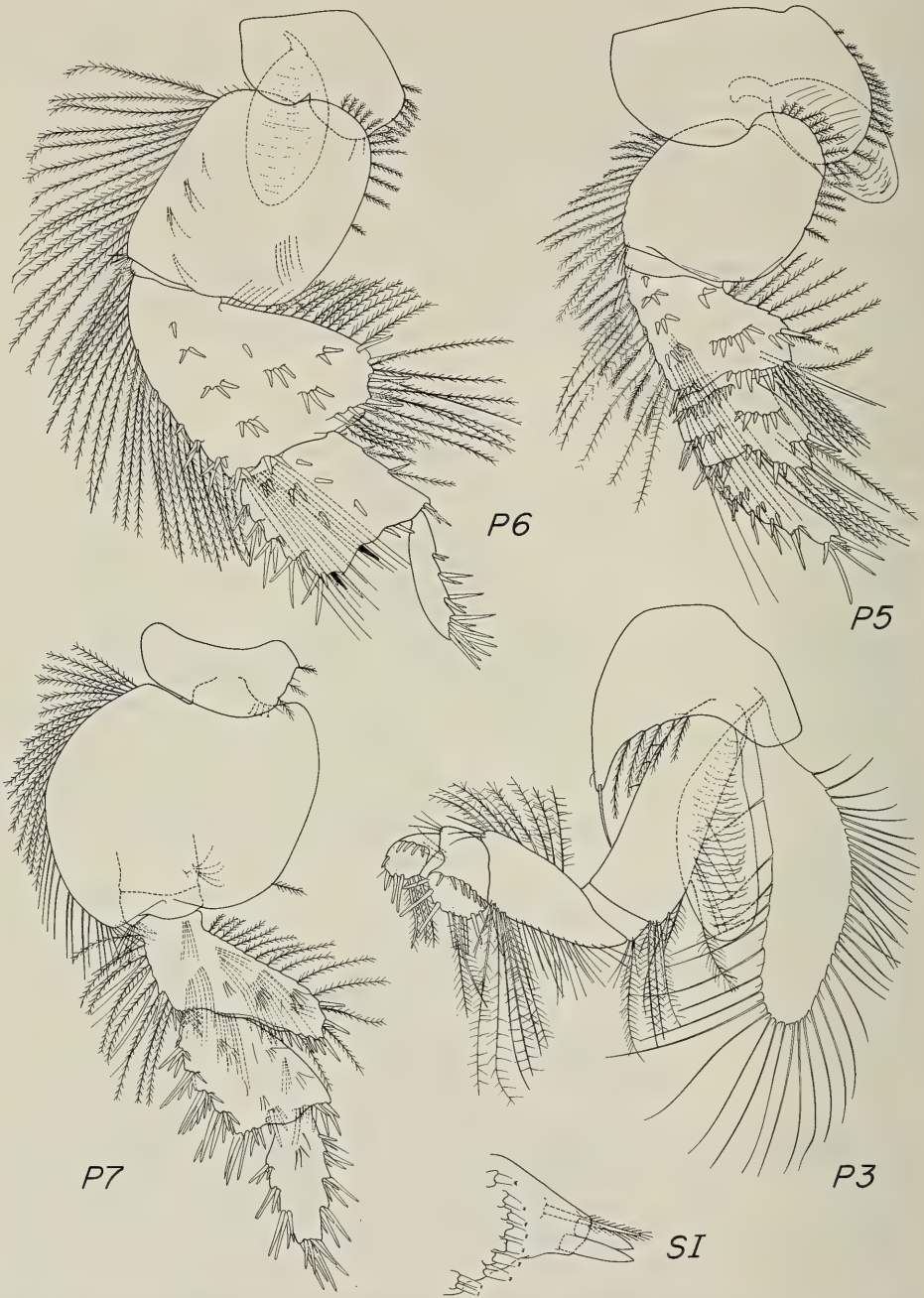


Fig. 8. *Acanthohaustorius bousfieldi*, unattributed figures, female "f" 9.50 mm.

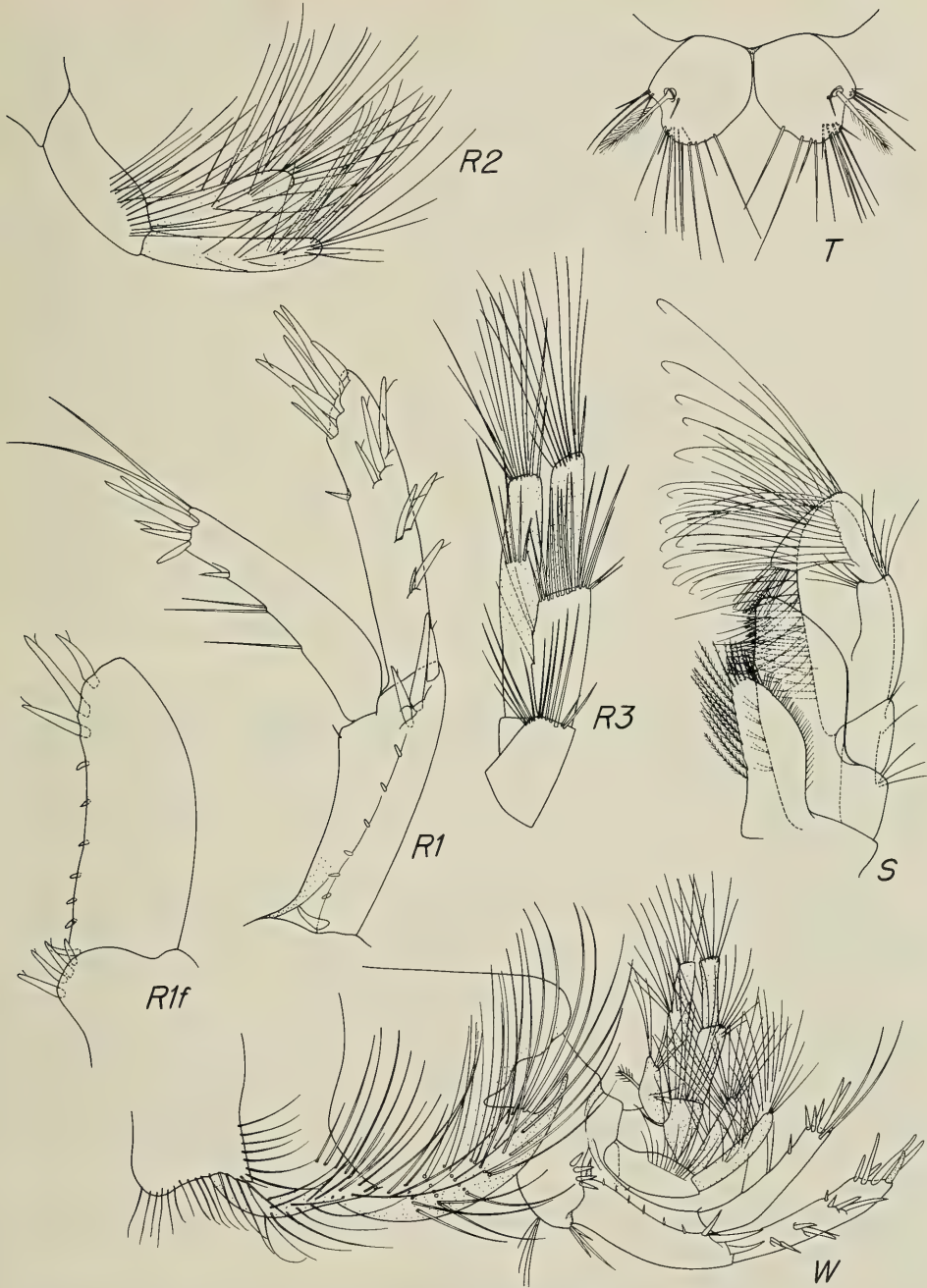


Fig. 9. *Acanthohaustorius bousfieldi*, unattributed figures, female “f” 9.50 mm.

facial setae; article 4 expanded posterodistally, anterior margin spine formula = 1-1-1-1-2-3-4-4, midventral margin with 2 spines, posterior margin with 1-1-2-4 spines, anterior and posterior margins with numerous plumose setae, 1-2-3-3 anterofacial, 1-3-3 midfacial, and 2 posterofacial spines, medial surface with about 13 long, plumose setae along anteroventral border; article 5 quadrate, anterior spine formula = 4-4-5-5-6, ventral margin with 1-1-1 spines, posterior margin with 1-1-2-3 spines plus 2 plumose setae, facial spines 2-2-1 anterior and 1-1, (1-1-1, on right pereopod) midfacials; article 6 elongate, narrow, anterior margin bare, posterior margin with 2-3-3, apex with 9 spines and one penicillate seta. Pereopod 7: coxa small, hind margin with 3 setae; article 2 large, subcircular, upper half of anterior margin with plumose setae, lower half with basally expanded, distally acute very thin spines, posterior margin with one seta; article 4 posteroventral lobe angular, extremely produced, anterior margin spines = 1-6, plumose setae and setae also present on anterior margin, posterior spine formula = 1-2, posterior margin bordered with plumose setae, ventral margin with 13 spines, lateral facial setae in 3 clusters 3-6-5, medial surface with 6 clusters 5-8-10-7-11-3; article 5 tapering somewhat at proximal margin, anterior spine formula 2-4-6-7-7-6, posterior margin lacking spines, posteroventral corner with 7 spines, facial setae abundant on lateral surface, medial surface with 5 spines near midventral margin and 1 cluster of facial setae; article 6 anterior spine formula = 4-4-5, posterior spine formula = 1-4-4-5, apex with 7 spines and penicillate seta, 3-1 facial setae present proximally.

Epimeron 1 smallest, excavate ventrally, with 16 setae, posterior margin with 7 setae. Epimeron 2 with slightly excavate posterior margin, ventral margin with 1-3-1-2-2-1-1-2-1 setae, posterior margin with 8 setae. Epimeron 3 rounded ventrally, hind margin with large spinous process, ventral margin with 2-5-7-7-5-5-4-4 setae. Pleopods 1-3, outer rami with 19-20-19 articles; inner rami with 13-14-14 articles.

Uropod 1: peduncle  $3\times$  long as wide, outer margin with 1 basofacial, 6 stubby, and 3 apicolateral spines; outer ramus subequal to peduncle, with 2-2-3 outer marginal spines, 7 apical spines, and 1 medial spine; inner ramus slightly shorter than outer, outer margin bare, inner margin setal formula = 1-2 and 1 spine, apex with 5 spines and 2 long setae. Uropod 2: peduncle  $2.5\times$  long as wide, with oblique row of facial setae; inner and outer rami subequal, slightly longer than peduncle, distally setose. Uropod 3: peduncle short,  $1.5\times$  long as wide, apically spinose; outer ramus 2-articulate,  $2.8\times$  peduncle, each article apically setose; inner ramus subequal to outer. Telson: cleft to base, lobes not separated, outer margin with concavity bearing 4 setae plus penicillate seta and setule, posterior margin with 7 dorsal and 4 ventral setae.

Gills laminar, present on pereopods 2-6; brood plates setose, plate 2 smallest, plates 3 and 4 larger, subequal.

*Male* "m," 6.62 mm.—Similar to female, tending to be more setose and spinose, especially articles 4 and 5 of pereopods 5-7.

*Ecology*.—Found in coarse, poorly sorted shell hash, 12 m.

*Remarks*.—We have compared our specimens with the type-material of *A. bousfieldi* in Smithsonian collections and answered our questions. Although our specimens seemed to have fewer short spines on the peduncle of uropod 1 than did the original illustrations, the allotype male of *A. bousfieldi* (USNM 172428)



also has the smaller number of short spines we noted. We depict the telsonic lobes as being appressed together, whereas Frame depicted them as being separated by a gape. On the type-specimens in undissected form the telsonic lobes are relatively closely appressed, perhaps less so than in our drawing but more than in Frame's drawing. The allotypic male also has the small number of ventral spines on article 5 of pereopod 6 seen in our material. The sharpness of coxa 7 matches closely in our respective specimens. We conclude that our southern specimens are identifiable with the northern *A. bousfieldi* but smaller and slightly less spinose and setose in all stages.

*Distribution.*—Hutchinson Island, Florida.

Key to the species of *Acanthohaustorius*

- 1. Telson U-cleft less than one-half to base, lobes truncate, posterior margins straight, outer margins with slight concavity; pereopod 6 article 5, distal margin oblique; setae on inner ramus of uropod 2 arranged in clusters. . . . . *A. spinosus*
- Telson cleft to base or nearly so; lobes of telson posteriorly rounded; pereopod 6 distal margin of article 5 horizontal; setae on inner ramus of uropod 2 inserted singly . . . . . 2
- 2. Telson of two widely separated and distinct lobes; pereopod 6 article 5 with 4 or fewer single facial spines, article 6 posterior margin with 1–2 clusters of spines . . . . . *A. pansus*
- Telson lobes not widely separated; pereopod 6 article 5 with more than 4 facial spines, posterior margin article 6 with 3–5 spine clusters . . . . . 3
- 3. Coxa 3, posteroventral lobe weak; epimeron 3 posterior margin lacking tooth, no concavity . . . . . *A. intermedius*
- Coxa 3, posteroventral lobe strong; epimeron 3 with large tooth, posterior margin with concavity . . . . . 4
- 4. Peduncle of uropod 1 with 5–9 short, stubby spines; coxa 7 posterior margin subacute . . . . . *A. bousfieldi*
- Peduncle of uropod 1 lacking short stubby spines; coxa 7 posterior margin acute . . . . . 5
- 5. Ventral margin of article 5 pereopod 6 with spines in 3–4 groups; uropod 1 inner ramus one-half outer . . . . . *A. shoemakeri*
- Ventral margin of article 5 pereopod 6 with continuous row of spines; uropod 1 rami subequal . . . . . 6
- 6. Peduncle of uropod 1 with 3–4 dorsolateral spines, ventral spines absent . . . . . *A. millsii*
- Peduncle of uropod 1 with 8–10 dorsolateral spines, 1–2 ventral spines usually present . . . . . *A. similis*

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REVISION OF *OPHIOPAEPAL* LJUNGMAN, 1872  
(ECHINODERMATA: OPHIUROIDEA), WITH A  
REDESCRIPTION OF *O. GOESIANA* LJUNGMAN,  
1872, AND NOTES ON *O. DIPLAX*  
(NIELSEN, 1932), NEW COMBINATION

Richard L. Turner

*Abstract.*—*Ophiopaepale* Ljungman, 1872, is revised. *Schizoderma* Nielsen, 1932, is a junior synonym. *Ophiopaepale* now includes two species, which form a geminate pair from tropical American waters: *O. goesiana* Ljungman, 1872, type-species, West Indies and Gulf of Mexico, redescribed herein; *O. diplax* (Nielsen, 1932), n. comb., type-species of *Schizoderma*, Gulf of Panama and other eastern tropical Pacific localities. Synonymy was required by the discovery of fragmented dorsal arm plates in *O. goesiana* and the presence of tables comprising the disc granulation of both species. *Ophiopaepale* is distinguished from other ophiuroid genera by the division of each ventral arm plate into proximal and distal halves.

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Nielsen (1932) erected *Schizoderma* as a new monotypic genus of ophiodermatid brittle star from the Gulf of Panama. He distinguished it from the closely related, monotypic, West Indian genus *Ophiopaepale* Ljungman, 1872,<sup>1</sup> by the presence in *Schizoderma* of fragmented dorsal arm plates and dorsally elongated genital slits. Nielsen was aware of the geologic history of the Isthmus of Panama and its role in formation of geminate species (1932:245); it is, therefore, surprising that he did not more closely examine the holotype of *O. goesiana* Ljungman, 1872, for comparison with his new material. Since Nielsen's (1932) original description, there has only been brief mention of *Schizoderma* by Clark (1940), Fell (1960), and Spencer and Wright (1966). Examination by the present author of recently collected *O. goesiana* from the southwest Florida shelf revealed the presence of fragmented dorsal arm plates along most of the arm length. This condition has been confirmed in the holotype. Based on this observation, an amended diagnosis of *Ophiopaepale* is given, *Schizoderma* is relegated to synonymy, and *O. goesiana* is redescribed.

Family Ophiodermatidae Ljungman, 1867

*Ophiopaepale* Ljungman, 1872

*Ophiopaepale* Ljungman, 1872:615-616 (diagnosed), 639 (key).—Lyman, 1882:17-18 (diagnosed).—Nutting, 1895:78 (listed).—Bather et al., 1900:278 (listed

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<sup>1</sup> This work is mistakenly dated 1871 by most authors who credit Ljungman with the several new genera, species, and varieties described therein. The error arises from the fact that the work was published (in 1872) in a volume which reported Proceedings of the Academy for 1871.



in systematic review as *Ophiopaepale* Lym.).—Meissner, 1901:906, 909, 912 (listed in systematic review), 919 (diagnosed).—Delage & Hérouard, 1903:150 (diagnosed).—Clark, 1915:346 (listed).—Matsumoto, 1915:83 (listed in systematic review).—Clark, 1921:34 (zoogeographic list).—Nielsen, 1932:338–339 (compared to *Schizoderma*).—Fell, 1960:27 (key).—Spencer & Wright, 1966:98 (listed in systematic review).—Madsen, 1983:30 (listed).

*Schizoderma* Nielsen, 1932:243 (listed), 327 (key), 335 (diagnosed), 338–339 (compared to *Ophiopaepale*) (type-species, *Schizoderma diplax* Nielsen, by monotypy).—Fell, 1960:27 (key).—Spencer & Wright, 1966:98 (listed in systematic review).

*Diagnosis*.—Disc arcuate pentagonal; abactinal surface flat or sunken; granulated with tables on both surfaces. Radial shields connected interradially by a few large marginal plates. In each interradius, 1 pair of long genital slits extending at least to edge of disc and visible when viewed from above. Arms long, slender, with 3–4 arm spines. Dorsal arm plates fragmented; ventral arm plates divided transversely into proximal and distal halves. 1 tentacle scale.

*Type-species*.—*Ophiopaepale goesiana* Ljungman, 1872, by monotypy.

*Remarks*.—*Ophiopaepale*, as redefined herein, includes two species. In addition to features described by Nielsen (1932), both species have fragmented dorsal arm plates, and the disc granulation consists of tables. Each table consists of a base and spire (Fig. 1A, B) but is larger and morphologically more complex than that of aspidochirote holothuroids. Species-specific differences in table morphology have not yet been found in *Ophiopaepale*, but they differ from the non-tabular granules of *Ophioderma* (Fig. 1C, D). The species differ in number of marginal disc plates, length of genital slits and arrangement of associated ossicles, granulation of the oral frame, relative length of arms and vertebrae (Fig. 2A, B; cf. *Ophioderma*, Fig. 2C), fragmentation pattern of dorsal arm plates, morphology of tentacle scales, and length of arm spines.

*Ophiopaepale goesiana* Ljungman, 1872

Figs. 1A, 2A, 3A–E, 4A–C, 5A–E

*Ophiopaepale goesiana* Ljungman, 1872:615–617 (diagnosed and described), 650 (zoogeographic list).—Lyman, 1875:3 (listed); 1878:228 (material); 1882:18, 313, 315 (listed), pl. 37, figs. 4–6; 1883:228 (listed), 233 (material, part).—Agassiz, 1888:111 (listed), fig. 393.—Nutting, 1895:81 (briefly described).—Verrill, 1899a:8 (material); 1899b:373 (listed).—Meissner, 1901:919 (listed).—Koehler, 1904:54 (listed), 57–59 (redescribed), figs. 1–4; 1907:287 (listed); 1914:48 (material).—Clark, 1915:346 (material).—Clark, 1921:44–50 (zoogeographic & station lists).—Nielsen, 1932:338–339 (compared to *Schizoderma diplax*).—Clark, 1941:106 (material), 139 (station list).—Clark, 1954:378 (zoogeographic list).—Fell, 1960:27 (listed).—Spencer & Wright, 1966:98 (listed).

Non *Ophiopaepale goesiana* Lyman, 1883:233 [part; (MCZ 797), 1 dry specimen, disc diameter 1.0 mm, Blake sta 127, is a young *Ophiomusium* or *Ophiophthalma*].

*Material*.—HOLOTYPE (Naturhistoriska Riksmuseet Stockholm 1447): alcoholic specimen, disc diameter (dd) 5.7 mm; Anguilla; 1870, 180 fm.

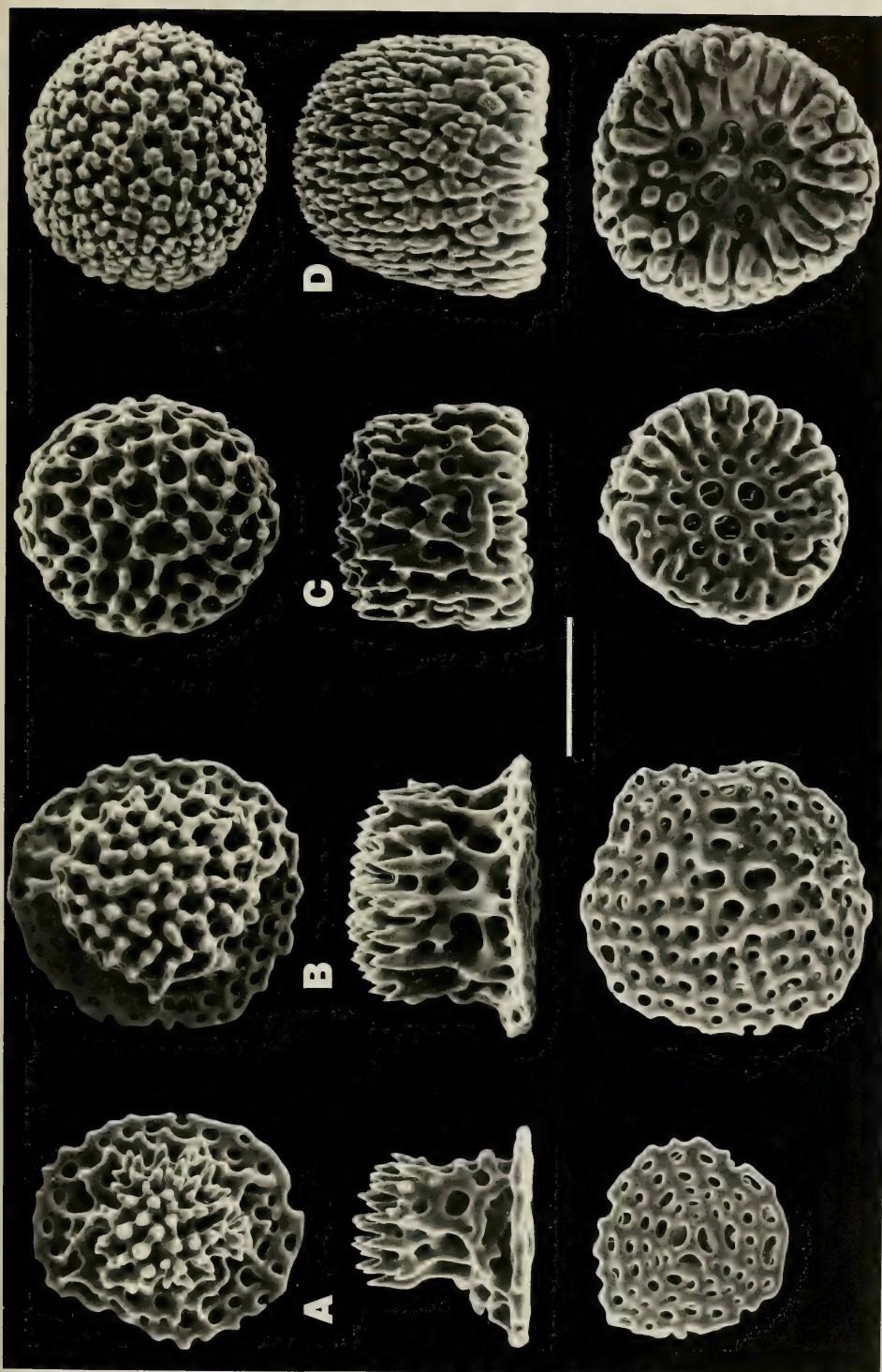


Fig. 1. Disc granules: apical (top row), side (middle row), and basal (bottom row) views. A, *Ophiopora goesiana*, USNM E30826; B, *Ophiopora goesiana*, MCZ 5459; C, *Ophiopora cinereum*, Carrie Bow Cay, Belize; D, *Ophiopora appressum*, Carrie Bow Cay, Belize. Scale bar, 0.05 mm.



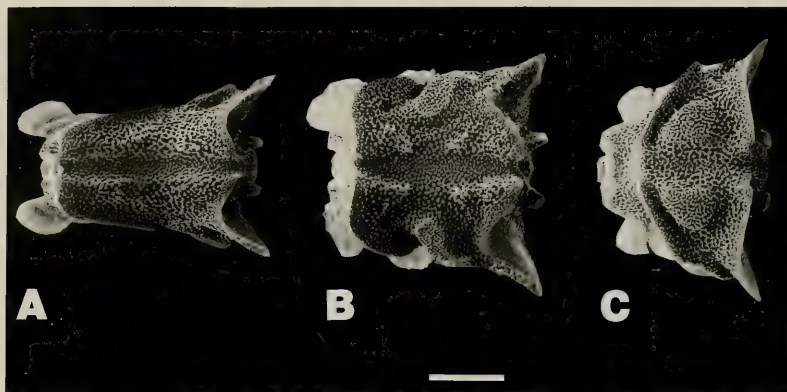


Fig. 2. Vertebrae from base of arm, near disc, abactinal views. A, *Ophiopaepale goesiana*, Holotype; B, *Ophiopaepale diplax*, MCZ 5459; C, *Ophioderma cinereum*, Carrie Bow Cay, Belize. Scale bar, 0.5 mm.

Non-type material: (MCZ 248), 1 dry spec., dd 10.4 mm; off Barbados; *Blake*, sta 272 and/or 297, 1878–1879, 76 fm and/or 123 fm.—(MCZ 249), 1 dry spec., dd 5.1 mm; Gulf of Mexico; *Blake*, sta 45, 1877–1878, 25°33'N, 84°21'W, 101 fm.—(MCZ 250), 1 dry spec., dd not measurable; off St. Vincent; *Blake*, sta 269, 1878–1879, 124 fm.—(MCZ 251), 1 dry spec., dd 5.8 mm; off Barbados; *Hassler Expedition*, 100 fm.—(MCZ 253), 2 dry spec., dd 6.5, 9.5 mm; off Grenada; *Blake*, sta 253, 1878–1879, 92 fm.—(MCZ 793), 2 alcoholic spec., dd 4.3, 5.4 mm; off Montserrat; *Blake*, sta 155, 1878–1879, 88 fm.—(MCZ 794), 3 alcoholic spec., dd 7.6–10.4 mm; off Havana; *Blake*, 1877–1878, 80–242 fm.—(MCZ 795), 3 alcoholic spec., dd 5.5–7.3 mm; same data as MCZ 250.—(MCZ 796), 1 alcoholic spec., dd 9.8 mm; St. Cruz, off Frederickstadt; *Blake*, sta 132, 1878–1879, 115 fm.—(MCZ 962), 1 dry spec., dd 7.7 mm; same data as MCZ 793.—(MCZ 6552), 1 dry spec., dd 8.1 mm; Old Bahama Channel, off Cayo Coco, Camaguey Province; Harvard-Havana Expedition, *Atlantis*, sta 3400, 28 Apr 1939, 180 fm.—(USNM 6491), 2 alcoholic spec., dd 5.7, 6.5 mm; off Barbados; *Blake*, sta 293, 1878–1879, 82 fm.—(USNM 7176), 3 alcoholic spec., dd 6.3–8.7 mm; *Albatross*, sta 2163, 30 Apr 1884, 23°10'31"N, 82°20'29"W, 133 fm.—(USNM 10184), 1 alcoholic spec., dd 6.9 mm; *Albatross*, sta 2319, 17 Jan 1885, 23°10'37"N, 82°20'06"W, 143 fm.—(USNM 10187), 1 dry spec., dd 5.2 mm; off Havana; *Albatross*, sta 2329, 17 Jan 1885, 23°11'03"N, 82°18'45"W, 118 fm.—(USNM 12396), 5 dry spec., dd 6.4–9.9 mm; *Albatross*, sta 2327, 17 Jan 1885, 23°11'45"N, 82°17'54"W, 182 fm.—(USNM 12411), 7 alcoholic spec., dd 6.2–9.8 mm; *Albatross*, sta 2159, 30 Apr 1884, 23°10'39"N, 82°20'08"W, 98 fm.—(USNM 12487), 1 dry spec., dd 6.7 mm; off Havana; *Albatross*, sta 2166, 1 May 1884, 23°10'36"N, 82°20'30"W, 196 fm.—(USNM 12506), 1 dry spec., dd 8.6 mm; off Havana; *Albatross*, sta 2160, 30 Apr 1884, 23°10'31"N, 82°20'37"W, 167 fm.—(USNM 12513), 1 dry spec., dd 9.9 mm; off Havana; *Albatross*, sta 2161, 30 Apr 1884, 23°10'36"N, 82°20'28"W, 146 fm.—(USNM 15286), 5 alcoholic spec., dd 7.7–10.1 mm; *Albatross*, sta 2322, 17 Jan 1885, 23°10'54"N, 82°17'45"W, 115 fm.—(USNM 15290), 3 alcoholic spec., dd 6.3–10.2 mm; *Albatross*, sta 2348, 20 Jan 1885, 23°10'39"N, 82°20'21"W, 211 fm.—(USNM 15306), 2 alcoholic spec., dd



6.7, 7.4 mm; *Albatross*, sta 2337, 19 Jan 1885, 23°10'39"N, 82°20'21"W, 199 fm.—(USNM 15312), 6 alcoholic spec., dd 9.0–10.2 mm; *Albatross*, sta 2336, 19 Jan 1885, 23°10'48"N, 82°18'52"W, 157 fm.—(USNM 15350), 3 dry spec., dd 7.6–9.4 mm; *Albatross*, sta 2320, 17 Jan 1885, 23°10'39"N, 82°18'48"W, 130 fm.—(USNM 15394), 1 dry spec., dd 10.2 mm; off Havana; *Albatross*, sta 2346, 20 Jan 1885, 23°10'39"N, 82°20'21"W, 200 fm.—(USNM E3663), 1 dry spec., dd 9.4 mm; off Puerto Rico; Johnson Smithsonian Expedition, sta 679, 1933.—(USNM E4294), 5 alcoholic spec., dd 7.8–10.4 mm (2 not measurable); off Havana, Morro Castle, bearing SW by W, about 2½ mi; Bahamas Expedition, sta 2, 24 May 1893, 110 fm.—(USNM E6302), 5 dry spec., dd 7.2–9.8 mm; Havana; State University of Iowa Biological Expedition to the Florida Keys and the West Indies, sta 2.—(USNM E11852), 1 dry spec., dd 7.7 mm; *Oregon*, sta 5624, 25 Sep 1965, 10°52'N, 66°08'W, 56 fm.—(USNM E28509), 3 alcoholic spec., dd 9.6–10.9 mm; Little Bahama Bank; *Gerda*, sta 251, 5 Feb 1964, 27°25'N, 78°41'00"W to 78°37'30"W, 293–311 m.—(USNM E30823), 1 alcoholic spec., dd 7.7 mm; Gulf of Mexico; U.S. Bureau of Land Management, Southwest Florida Shelf Ecosystems Study, Year 2, Cruise II (BLM 321-II), sta 35, 26 Jul 1981, 25°44.8'N, 84°21.0'W, 159 m, otter trawl.—(USNM E30824), 2 dry spec., dd 5.3, 6.6 mm; same data as USNM E30823, triangle dredge.—(USNM E30825), 2 dry spec., dd 10.4, 11.1 mm; Gulf of Mexico; BLM 321-II, sta 36, 2 Aug 1981, 25°16.8'N, 83°57.4'W, 127 m, otter trawl.—(USNM E30826), 1 alcoholic spec., dd 10.4 mm; same data as USNM E30825, triangle dredge.—(USNM E30827), 1 dry spec., dd 10.0 mm; Gulf of Mexico; BLM 321-III, sta 32, 6 Feb 1982, 26°16.7'N, 84°04.1'W, 137 m, otter trawl.—(USNM E30828), 1 alcoholic spec., dd 9.3 mm; same data as USNM E30827, triangle dredge.

*Diagnosis*.—3 plates at margin of disc in each interradius; middle plate wider than long. Genital slit extending to edge of disc; not bordered by specialized papillae and scales. Oral shields cordiform, naked centrally. Arm length 8–10 times disc diameter. Dorsal arm plates moderately fragmented; distal border composed of 2–4 subequal pieces. Distal tentacle scales spiniform.

*Morphology*.—The disc is arcuate pentagonal and firmly fused to the 5 arms. Strongly calcified margins of the disc support the thin integument of the central abactinal and interradiol actinal surfaces. Dense granulation covers all abactinal and most actinal disc plates. The sunken abactinal integument consists of crowded, imbricating, polygonal scales, which are smaller near the center of the disc and increase gradually in size toward the disc margin; the largest scales are between the paired radial shields (Fig. 3C). The diameter of the disc granules changes similarly. The radial shields are large, convex, smooth, broadly rounded and thick distally, becoming thin and more scale-like proximally; the adradial margins of members of a pair are divergent and extend proximally as inward processes as illustrated by Lyman (1882); a similar but shorter process occurs at the proximal end of the abradial margin of each radial shield. Interradiol, 3 large ossicles in series give a prominent margin to the disc (Fig. 3C). The middle ossicle is trapezoidal to rectangular, with its longer side parallel to the disc margin; it overlaps at each end another shorter ossicle which in turn overlaps the radial shield. Although the marginal ossicles and radial shields are obscured by granulation, the tumid condition of these plates gives the disc margin a lumpy appearance that reveals their location.

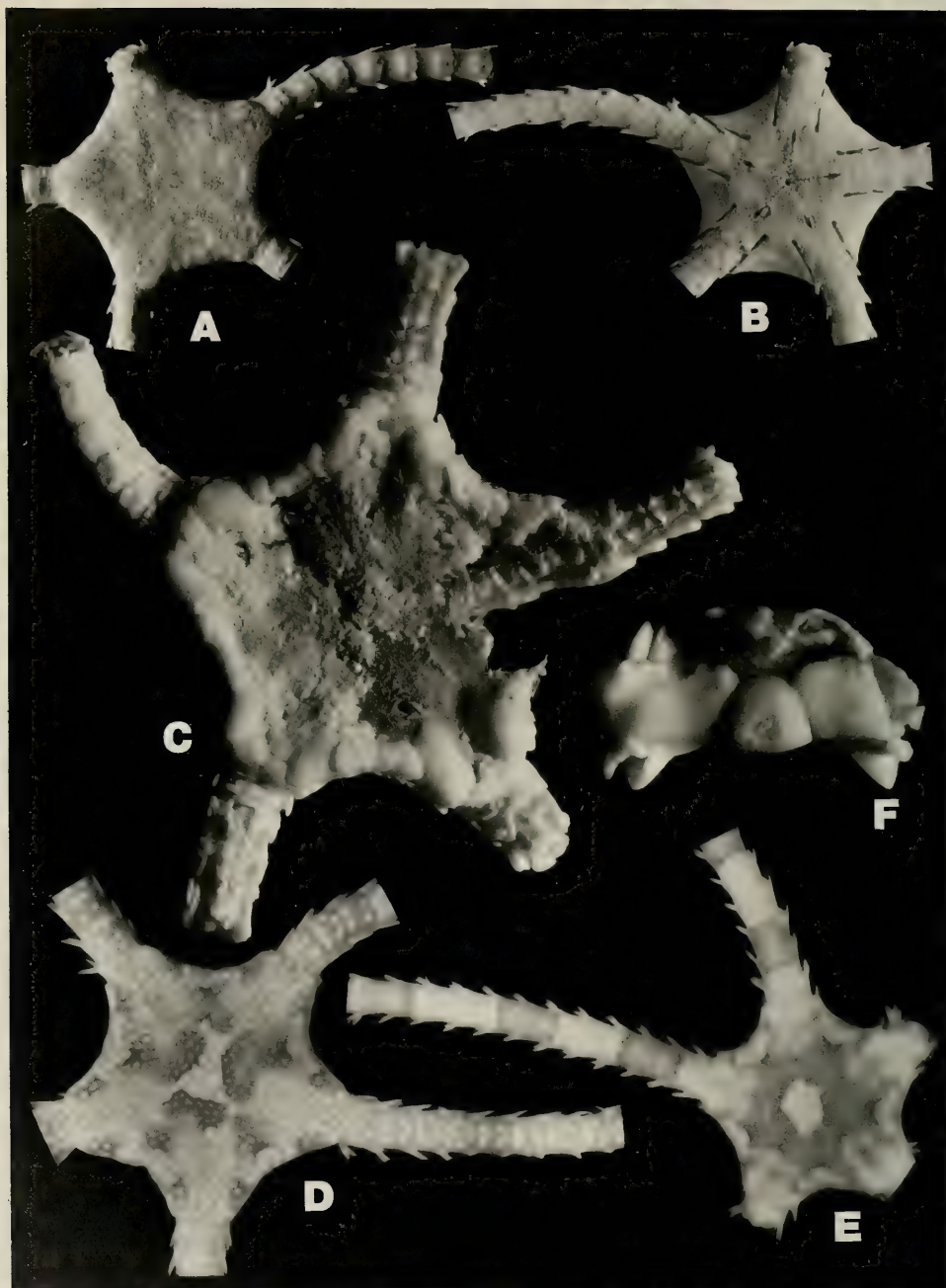


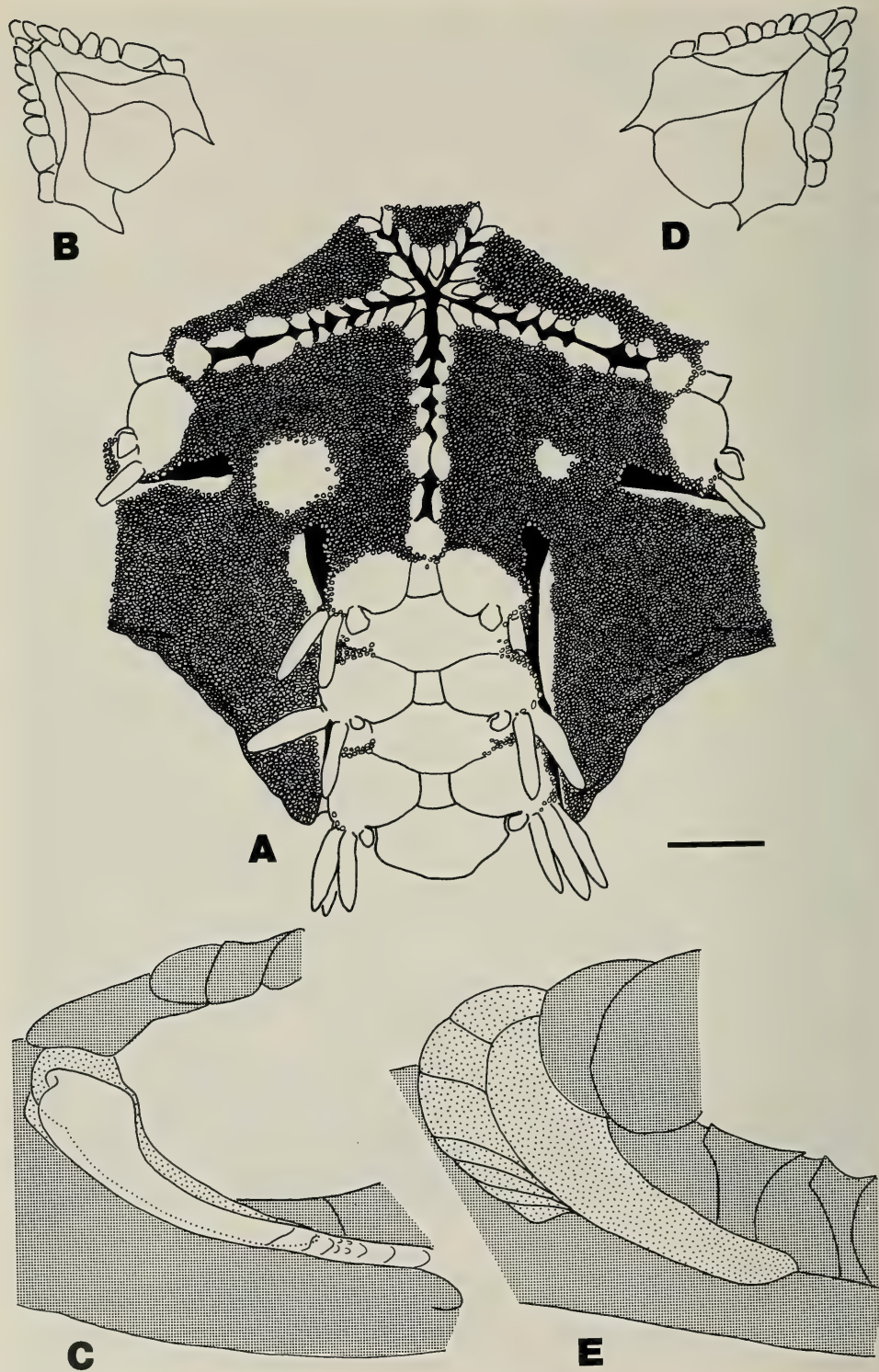
Fig. 3. General morphology and color patterns. *Ophiopaepale goesiana*: A, Abactinal view, Holotype, disc diameter 5.7 mm; B, Same, actinal view; C, Abactinal surface, partly digested with alkali, USNM E30825, disc diameter 11.1 mm; D, Abactinal view, USNM 12411; E, Same, USNM 6491, disc diameter 6.5 mm. *Ophiopaepale diplax*: F, Abactinal view of an interradius digested with alkali, showing interradiar plate, radial shields, and associated genital bar and scales, MCZ 5459, disc diameter 13.8 mm.



The central actinal surface is flat and sharply demarcated from the steeply sloping, triangular, concave interradiial surfaces. Most of the oral frame, including the bottom edge of the dental plate, is densely granulated, and the shapes and orientation of the major ossicles are not visible without removal of the granules. Only the central part of the oral shield is naked. There are 3–5 robust, symmetrical, lanceolate teeth borne in a vertical row, each tooth usually on a separate piece of the fragmented dental plate. In addition, the lowest piece bears a pair of smaller, asymmetrical, lanceolate teeth of equal or unequal size; if equal, they are aligned horizontally and are a pair of “infradental papillae”; if unequal, they are aligned vertically or obliquely, the smaller lying beneath the larger, giving the impression of an unpaired “infradental papilla”; in some cases, a third tooth is present on the lowest piece of the dental plate. Tooth papillae are absent. There are 6–8 oral papillae (5–7 on the holotype), the distalmost borne on the adoral shield and the others on the oral plate. The proximal oral papillae are asymmetrical, lanceolate, and point obliquely toward the center of the actinal surface; they are more spiniform and longer nearer the jaw apex and more lamelliform distally. The distalmost 2 oral papillae are rectangular, lamelliform; the next to last is the largest oral papilla, longer than wide (almost 3:1 in the holotype), and closing the oral gap; the distalmost is somewhat smaller, longer than wide, often with a concave adradial edge and not closing the oral gap. An additional oral papilla or enlarged granule sometimes lies between the 2 rectangular papillae. The oral plates are elongate triangles, with the shortest sides of a pair in contact abradially (Fig. 4B); the other 2 sides of each plate taper to an apex near the junction of the 2 distalmost oral papillae. The adoral shields join in front of the oral shield and extend to the first ventral and lateral arm plates of adjacent arms; the proximal and distal margins, formed by contact with the oral plate and oral shield, respectively, are somewhat parallel. The oral shield is cordiform. On the interradiial actinal surface, dense granulation covers small, thin, imbricating scales, through which the gonads can be seen when the granulation is removed from alcoholic specimens. The granulation extends onto the genital scales and ends at the edge of the genital slit. In each interradius there are 2 genital slits, each of which extends from the adoral shield to the edge of the disc, where the broadened, distalmost genital scale and the genital bar meet and form a specialized groove (Fig. 4C; see also Lyman 1882, pl. 37, fig. 4). The end of the groove can be seen in abactinal view, but it does not appear to curve upward onto the abactinal surface. No specialized granules, papillae, or scales occur along the genital slits.

The arms are long (8–10 times the disc diameter), slender, and taper uniformly to acute tips. The arms are usually widest at segment 3 (rarely segment 4; segment 2 on the holotype). Arm segments are wider than long (5:3 in larger specimens, 6:5 in smaller ones on the fourth free segment from the disc), but the vertebrae are longer than wide (Fig. 2A; see also Lyman 1882, pl. 37, figs. 5, 6). The segments are about as high as wide proximally, but distally the arms are flattened. Each segment is swollen distally because the lateral arm plates angle outward and the dorsal arm plate bulges upward just before the distal margin (Fig. 5A, C); this arrangement gives a beaded appearance to the arm, especially in smaller specimens and on the distal part of the arm. All dorsal arm plates are fragmented, strongly convex, and trapezoidal, with the distal margin wider. The distal margin is straight





or somewhat undulating and composed of 2–4 rectangular pieces, wider than long. The lateral margin is straight and composed of 2–3 additional rectangular pieces. Centrally there are a few pieces of variable shape. Typically, the dorsal arm plate consists of 9 pieces in 3 rows of 3 pieces each, all closely fitted as if made of fused porcelain tiles (Fig. 5C). The junctions of adjacent pieces are difficult to see without treatment with alkali and careful illumination. Each lateral arm plate bears rows and columns of many fine glassy tubercles on its surface. The first ventral arm plate is hexagonal, wider than long, and undivided. The remaining ventral arm plates are divided into two pieces: a short proximal piece lying between the lateral arm plates of a given segment; a wide distal piece lying between the paired lateral arm plates of two adjacent segments. The proximal piece is square or subrectangular on basal segments, with a convex distal margin and straight or slightly convex lateral margins; on distal segments, the proximal piece becomes very elongate with strongly convex lateral margins (Fig. 5E). The distal piece is somewhat octagonal; the distal margin is straight or slightly concave centrally, where it meets the proximal piece of the next segment, and enters a convex curve distolaterally, where it meets the lateral arm plates of the next segment; the distolateral margins curve sharply into the nearly parallel lateral margins, ending at the tentacle pores; the proximal margin is strongly concave at the lateral arm plates and less concave at its junction with the proximal piece. On distal segments, the distal piece becomes more semicircular or sometimes bilobed. Proximal ventral arm plates lack paired pores characteristic of some other ophiidermatid species. There are 3 arm spines, usually appressed and pointing slightly upward. Segment 1 usually bears 2 (rarely 1) spines on each side; segment 2 usually 2–3 spines; segment 3 almost always 3 spines. On the distal half of the arm, 4 arm spines are sometimes present. Arm spines are straight, subconical, subacute, becoming more flattened and acute on distal segments. The upper 2–3 arm spines of distal segments typically have dentate upper edges (Fig. 5B). The upper arm spine of basal segments is robust,  $\frac{1}{2}$  to 1 times the segment length; those on the rest of the arm are about  $\frac{1}{2}$  the segment length; the middle arm spine is smaller, and the lower arm spine is the smallest. Tentacle scales are single. Tentacle scales of the basal arm segments are lamelliform, oval, lanceolate, or trapezoidal, with the point of attachment to the lateral arm plate narrower than the maximal width. Scales of distal segments are progressively more spiniform and are morphologically similar to, but flatter than, the arm spines (cf., Figs. 4A and 5E). Tentacle scales are  $\frac{1}{3}$  to  $\frac{1}{2}$  the length of the lower arm spine. Granulation extends onto the base of the arm. Abactinially, the first free arm segment is heavily covered with granules, although most of the surface of the distal row of fragments is bare, as is occasionally the surface of more proximal fragments; the granulation extends onto the lateral arm plates.

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Fig. 4. *Ophiopaepale goesiana*: A, Actinal view of granulated specimen, USNM E30827; B, Oral frame, granules removed, MCZ 795; C, Side view of arm with interrarial integument removed to show orientation of genital ossicles; genital bar and an accessory scale (light stipple); genital scale (white); base of arm, radial shield, and interrarial plates (heavy stipple); USNM E30825. *Ophiopaepale diplox*: D, Oral frame, granules removed, MCZ 6173; E, Same view as C with genital scale removed, MCZ 5459. Scale bar, 1 mm.



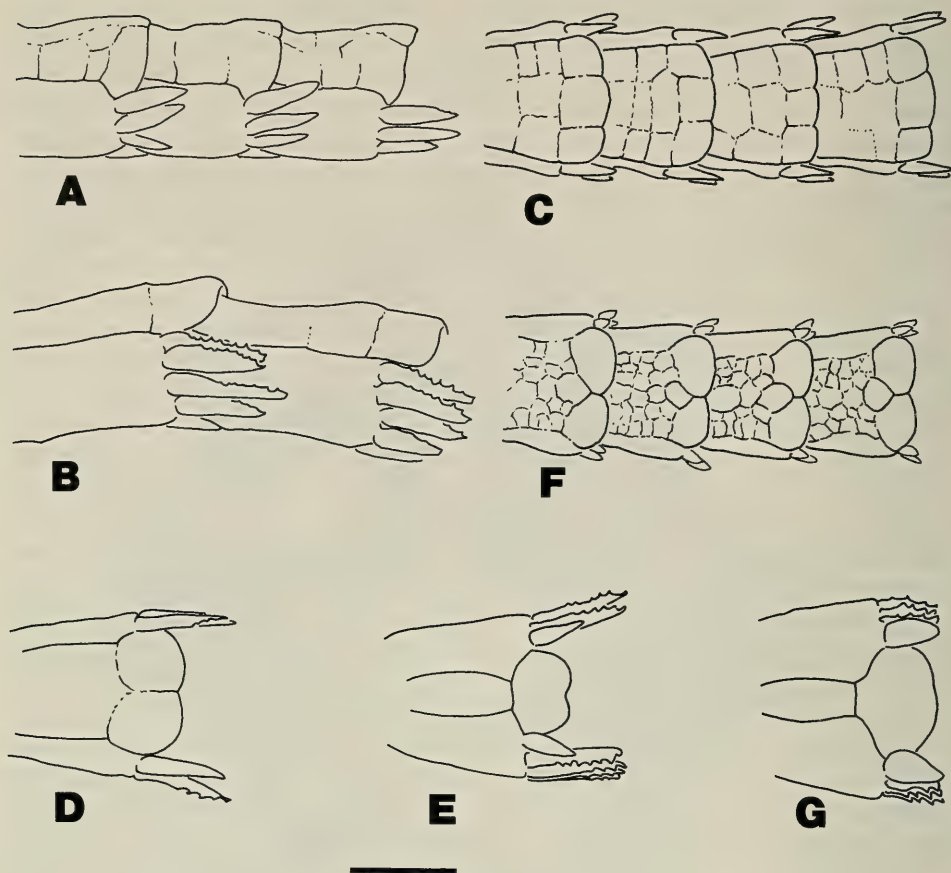


Fig. 5. *Ophiopaepale goesiana*: A, Side view of proximal arm segments, USNM E6302; B, Same, distal arm segments, USNM 15394; C, Abactinal view of proximal arm segments, USNM 6491; D, Same, distal arm segment, USNM E6302; E, Actinal view of distal arm segment, USNM E6302. *Ophiopaepale diplax*: F, Abactinal view of proximal arm segments, MCZ 5690; G, Actinal view of distal arm segment, MCZ 5458. Scale bar: A, C, F, 1 mm; B, D, E, G, 0.5 mm.

The next 2–3 segments rarely have more than a few scattered granules on the dorsal arm plate; granules often occur at the junction of the dorsal and lateral arm plates. Granulation does not extend farther on the arm. The first (undivided) ventral arm plate has a central naked region. The next 2–3 segments bear granules only at the junction of the distal piece of the ventral arm plate and the lateral arm plates; on the lateral and proximal regions of the lateral arm plates; and sometimes near the bases of the arm spines. The rest of the arm is naked actinally.

**Coloration.**—The color pattern of alcoholic and dried specimens is variable (Fig. 3D, E). Generally, the upper surface of the disc bears yellow-white spots on a darker, orange-yellow background. Large spots overlie the radial shields and marginal disc plates, and a dark crescent outlines the proximal edge of the unpaired interradial marginal plate. Other spots do not correspond to the locations of disc scales. The center of the disc frequently has a large irregular or subcircular spot. The spotted pattern continues onto the actinal interradial surface of the disc. The



oral frame and underside of the arm are uniformly pale yellow or yellow-white. The upper surface of the arm is banded. Band width is  $1\frac{1}{2}$ –2 segments. Banding results from alternating dark and light background colors coinciding with regions of small and large light spots, respectively. The 2–4 distal pieces of each dorsal arm plate bear larger light-colored spots than other pieces. In many specimens, the pieces of the dorsal arm plate are outlined by the dark underlying intervertebral muscles, which show through the thin edges where pieces abut. Verrill (1899a) reported that Nutting's (1895) description of white spots on a brown disc is the color in life.

*Type-locality*.—Anguilla, Lesser Antilles, 180 fm.

*Distribution*.—Eastern Gulf of Mexico and throughout the Greater and Lesser Antilles; 56–211 fm (or as deep as 242 fm) on coral (Koehler 1914), “pentacrinus grounds” (Nutting 1895), and other coarse and hard substrata (Pierce and Patterson 1879). The bathymetric range of 38–250 fm given by Lyman (1883), Verrill (1899a, b), Meissner (1901), and Clark (1915) apparently includes a misidentified juvenile of *Ophiomusium* or *Ophiosphalma* from Blake sta 127 (38 fm) (MCZ 797). In addition to material examined by me, Clark (1921) reported *O. goesiana* from Blake sta 298 at 120 fm. Lyman (1883) and others reported it from Blake sta 101 at 175–250 fm, but the material (MCZ 252) has been lost.

*Remarks*.—Although Koehler (1904) examined and illustrated Ljungman's holotype, his fig. 3 showed entire dorsal arm plates. An earlier figure (Agassiz 1888) of non-type material showed fragmentation only for the first segment free of the disc. It is difficult to interpret from Nielsen's (1932) discussion if he examined Ljungman's holotype or relied on the published figures mentioned above to conclude that dorsal arm plates of *O. goesiana* are entire.

*Ophiopaepale diplax* (Nielsen, 1932), new combination

Figs. 1B, 2B, 3F, 4D–E, 5F–G

*Schizoderma diplax* Nielsen, 1932:243 (listed), 335–339 (described), fig. 39.—Clark, 1940:343 (station data and material).—Fell, 1960:27 (listed).—Spencer & Wright, 1966:98 (listed).

*Material*.—PARATYPE (Universitetets Zoologiske Museum, Copenhagen): alcoholic specimen, dd 9.5 mm; Gulf of Panama, South of San José, Islas Perlas; Dr. Th. Mortensen's Pacific Expedition 1914–16, 27 Jan 1916, 25 fm.

Non-type material: (MCZ 5456), 5 dry spec., dd 8.1–15.9 mm; Gulf of California, Santa Inez Bay; Templeton Crocker Expedition, *Zaca*, sta 142-D-2/3/4, 11 Apr 1936, 30–50 fm.—(MCZ 5457), 3 dry spec., dd 7.8–15.6 mm; Gulf of California, Santa Inez Bay; Templeton Crocker Expedition, *Zaca*, sta 143-D-1, 13 Apr 1936, 20 (or 29?) fm.—(MCZ 5458), 3 dry spec., dd 7.6–11.0 mm; Gulf of California, Santa Inez Bay; Templeton Crocker Expedition, *Zaca*, sta 146-D-1, 17 Apr 1936, 35 fm.—(MCZ 5459), 3 dry spec., dd 5.8–13.8 mm; Gulf of California, Arena Bank; Templeton Crocker Expedition, *Zaca*, sta 136-D-1/14, Apr 1936, 45 fm.—(MCZ 5460), 5 dry spec., dd 6.6–9.7 mm; Lower California, Gorda Banks; Templeton Crocker Expedition, *Zaca*, sta 150-D-8/9, 22 Apr 1936, 40–60 fm.—(MCZ 5690), 1 dry spec., dd 6.0 mm; Colombia, Port Utria; University of Southern California, Hancock Pacific Expeditions, *Velero*, sta 856, 25 Feb 1938, 15–30 fm.—(MCZ 6172), 9 dry spec., dd 5.7–10.4 mm; Costa Rica,

14 mi SE of Judas Pt.; N.Y. Zoological Society, Department of Tropical Research, Eastern Pacific *Zaca* Expedition 1937–38, sta 214-D-1/2/3/4, 1 Mar 1938, 9°19'32"N, 84°29'30"W to 9°17'40"N, 84°27'30"W, 42–61 fm, 4-ft *Blake* dredge. — (MCZ 6173), 10 alcoholic spec., dd 6.9–10.6 mm; same data as MCZ 6172.

*Diagnosis.*—1 plate at margin of disc in each interradius; longer than wide. Genital slits extending onto abactinal surface of disc; bordered by flattened, square papillae on large accessory scales. Oral shields triangular, naked; adoral shields naked. Arm length 4–7 times disc diameter. Dorsal arm plates greatly fragmented; distal border composed of 2 large lateral and 1 small central pieces. Distal tentacle scales lamelliform.

*Remarks.*—The description of *O. goesiana* given above generally fits *O. diplax*. The notes given below emphasize major differences, and Nielsen's (1932) thorough description is modified based on examination of new material collected outside the type-locality.

In non-type material and one paratype, no distinct band of larger granules borders the disc; granules increase gradually in size from center to margin as in *O. goesiana* rather than abruptly as Nielsen (1932) described. Radial shields of adjacent radii extend well beneath a single interradiial plate and nearly meet at the midline (Fig. 3F); the interradiial plate is longer than wide (i.e., with a short side along the disc margin). On most specimens, granules cover the bottom edge of the dental plate and border the sutures of the oral frame; but the centers of the oral and adoral shields and, contrary to Nielsen (1932), oral plates are naked; the oral plates are granulated only in some larger specimens. Spination of the dental and oral plates and adoral shields is the same morphologically and meristically as in *O. goesiana* except that the 2 distalmost oral papillae of *O. diplax* are shorter (Fig. 4D). The paired oral plates are more extensively in contact; the adoral shields are wider and more tapering (i.e., proximal and distal margins divergent); oral shields are triangular, with proximal sides in some specimens concave. Genital slits appear to extend onto the abactinal surface of the disc because of the greater protrusion of the distal genital scale and of specialized scales on the genital bar at the distal end of the slit (Fig. 4E); flattened, square papillae border the distal  $\frac{1}{3}$ – $\frac{1}{2}$  of the margin of the slit (Nielsen 1932, fig. 39c). Arm length is 4–7 times the disc diameter. The arm is widest at segment 3–4, sometimes 5; this might reflect the relatively shorter arm length and shorter proximal vertebrae (Fig. 2B) compared to *O. goesiana*; i.e., a greater number of segments lie beneath the disc. Dorsal arm plates are more greatly fragmented (20–25 pieces; Nielsen 1932) and are bordered distally by 2 large lateral pieces and 1 small, keystone-like central piece (Fig. 5F; cf, Nielsen 1932, fig. 39c). The distal pieces of the ventral arm plates are proportionately wider than those of *O. goesiana*. The number of arm spines is more variable, generally 3–4 on proximal segments free of the disc (not regularly 4 as found by Nielsen 1932); distally, 4 arm spines are usually found. A fourth, uppermost arm spine, if present, is short; no arm spine exceeds  $\frac{1}{2}$  the length of a segment. Tentacle scales are proportionately larger than those of *O. goesiana*, and those on free segments of the arm do not become progressively spiniform (Fig. 5G). Coloration is similar to that of *O. goesiana*, but the banding extends onto the ventral arm plates in the distal half of the arm; a small central white spot occurs on the disc of many specimens, and a distinct white spot occurs abactinally on the arms every few segments. *Ophiopaepale diplax* ranges from



Santa Inez Bay, Gulf of California, to Port Utria, Colombia, in 25–61 fm and may occur as shallow as 15 fm. It was taken on mud, shell, and rock by the *Zaca* (Beebe 1938; Clark 1940).

*Discussion.*—*Ophiopaepale* was included in the same family or subfamily with *Ophioderma* and separated from *Ophiura* (= *Ophioglypha*) and *Ophiolepis* by early workers (Ljungman 1872; Verrill 1899a, b). It was later removed from association with *Ophioderma* and placed with *Ophiura* and *Ophiolepis* (Bather *et al.* 1900; Meissner 1901; Delage and Hérourard 1903; Koehler 1907), but Koehler (1914) returned it to the Ophiodermatidae. Matsumoto (1915) separated *Ophiopaepale* from the other three genera entirely, placing it in his new family Ophioleucidae; his treatment was accepted by H. L. Clark (1915, 1941) and A. H. Clark (1921, 1954). Nielsen (1932) assigned his new genus *Schizoderma* to the Ophiodermatidae but stated his willingness to assign it with *Ophiopaepale* to the Ophioleucidae. Most recently, Fell (1960) and Spencer and Wright (1966) treated *Ophiopaepale* and *Schizoderma* as ophiodermatids, not ophioleucids or ophiurids; and Madsen (1983) excluded *Ophiopaepale* from the Ophioleucinae, which he assigned to the Ophiuridae. Familial assignment of these genera was unspecified in other works cited in the synonymies given above for *Ophiopaepale* and *O. goesiana*.

The differences in systematic treatment have largely been due to the authors' interpretations of the morphology and spination of the arms, structural relationship of the arms to the disc, and spination of the oral frame. *Ophiopaepale* is retained in the Ophiodermatidae in the present work. Although the arms are long and slender, they are widest basally, at segments 3–5. Arm spines are few (3–4), but some other ophiodermatids also have relatively few arm spines (Fell 1960). The arms are inserted laterally into the disc, as in ophiodermatids; the appearance of a ventral, less firm insertion is only due to the elongated and upturned genital slits. The disc is almost fully granulated; the granules are tables (morphologically similar to those of some aspidochirote holothuroids) rather than rounded granules of some *Ophioderma* species, but no other comparative evidence of granule morphology is available on which to base a conclusion. Spination of the oral frame is identical to that of *Ophioderma*. Reliance on the number of infradental papillae alone is presently unwarranted for familial assignment because the nature of infradental papillae often has been misinterpreted; moreover, previous authors have not agreed on the number (indeed, the presence) of infradental papillae in ophiodermatid brittle stars. Madsen's (1983) inclusion of the closely related Ophioleucidae as a subfamily of Ophiuridae complicates assignment of *Ophiopaepale*. Re-examination of disc granulation, oral armature, and other features in families of the Chilophiurina would be well advised.

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A NEW SPECIES OF *CALLANTHIAS* (PISCES:  
PERCIFORMES: PERCOIDEI: CALLANTHIIDAE)  
FROM THE SOUTHEASTERN PACIFIC OCEAN

William D. Anderson, Jr. and G. David Johnson

*Abstract.*—*Callanthias parini*, a new species from the Nazca Ridge, is distinguished from all other species of *Callanthias* in having the following combination of characters: tubed lateral-line scales 25 to 30, unilaterally, 52 to 59, bilaterally; circum-caudal-peduncle scales 21 to 24; epipleural ribs 10 to 12; and segmented dorsal- and anal-fin rays—each 10. The new species is dimorphic in lengths of its dorsal-, anal-, and caudal-fin rays, and appears to be protogynous. *Callanthias* can be distinguished from the closely related *Grammatonotus* by the presence of two well-developed opercular spines and in having more segmented dorsal- and anal-fin rays, branched caudal-fin rays, and tubed lateral-line scales (segmented dorsal- and anal-fin rays almost always 10 or 11, branched caudal-fin rays 15 (8 + 7), and tubed lateral-line scales 21 to 42 in *Callanthias*).

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During the course of our revisionary studies of the percoid genera *Callanthias* and *Grammatonotus*, we have been fortunate to receive from N. V. Parin (via J. E. Randall) ten specimens of an undescribed species of *Callanthias* collected from the Nazca Ridge in the southeastern Pacific.

*Callanthias* Lowe, 1839, has been assigned by various authors to the Serranidae. Gilbert (1905) described *Grammatonotus*, assigned it to the Serranidae, and stated that he believed it to be closely allied to *Callanthias*. Our findings confirm the close relationship of these two genera, but we agree with Gosline (1966) that they should be removed from the Serranidae because they lack the innovative specialization, three spines on the opercle, that characterizes that family (Johnson, 1983). Böhlke (1960) placed *Grammatonotus* in the Grammidae (=Grammatidae). Springer (1982) considered both *Callanthias* and *Grammatonotus* to be representatives of the Grammatidae, but acknowledged that “there is little evidence to unite” the five genera he included in that family. Fourmanoir (1981) elevated the Callanthiinae, considered by Ogilby (1900), Katayama (1960), and Katayama *et al.* (1982) as a subfamily of the Serranidae, to the familial level; Johnson (in press) concurred with this and included both *Callanthias* and *Grammatonotus* in the Callanthiidae.

#### Methods and Abbreviations

Counts and measurements were made following Hubbs and Lagler (1958) except as noted. Lateral-line scales were counted on both sides of each specimen. Other scale counts, with exception of those around the caudal peduncle, were made on either side, depending on condition of the specimen. Mid-side lateral scales were counted along a horizontal line extending from middle of gill opening to middle of structural base of caudal fin. In making counts of rows of cheek scales, rows



of scales above the lateral line, and scales above and below the lateral line, small scales at orbit and at bases of dorsal and anal fins were excluded. Rows of cheek scales were difficult to count because of missing scales and the irregularity of the rows. The count of scales below lateral line was made along a posterodorsal series from the origin of the anal fin. Gillrakers on first gill arch and pseudobranchial filaments were counted on the right side. The first vertebra with a haemal spine was considered the first caudal vertebra; the urostylar vertebra, the last. On radiographs it is frequently difficult to determine which vertebra is the first bearing a haemal spine, but the first haemal spine in percoid fishes is almost always just posterior to the first pterygiophore of the anal fin.

Measurements were made with needlepoint dial calipers to nearest 0.1 mm. Measurements from anterior end of snout were taken from premaxillary symphysis; those involving orbit (snout length, orbit diameter, interorbital width, and postorbital length of head) were of bony orbit. Measurement of orbit was of horizontal diameter. Body depth was measured from dorsal-fin origin vertically to ventral midline of body. Pectoral- and pelvic-fin lengths were of longer (either left or right) fin. Lengths of caudal-fin lobes were taken from middle of fin base to distal tips of longest rays. The distance from the more posterior rib of last pair of pleural ribs to first haemal spine was measured on radiographs; this measurement was taken perpendicularly at the greatest point of separation between rib and haemal spine; damaged or grossly distorted specimens were not measured.

Abbreviations used include: ANSP (The Academy of Natural Sciences of Philadelphia), BPBM (Bernice P. Bishop Museum, Honolulu), CAS (California Academy of Sciences, San Francisco), GMBL (Grice Marine Biological Laboratory, College of Charleston), IOAN (Institute of Oceanology, Moscow), SL (standard length), USNM (National Museum of Natural History, Smithsonian Institution, Washington, D.C.), and ZMMU (Zoological Museum, Moscow State University).

*Callanthias parini*, new species

Figs. 1, 2

*Callanthias*, sp., Parin *et al.*, 1981:14 (brief description of material collected by R/V *Ikhtiandr* on the Nazca Ridge).

*Material examined*.—Ten specimens, 148 to 179 mm SL; all from the Nazca Ridge in the southeastern Pacific.

HOLOTYPE: USNM 265444, 175 mm SL; 21°25'S, 81°37'W; 325 m; *Akademik Knipovich* trawl 27; 4 Sep 1980.

PARATYPES: 4 specimens, 148 to 179 mm SL; same data as for holotype, BPBM 29399, 1 specimen, 148 mm SL; CAS 54643, 1 specimen, 179 mm SL; ZMMU P-15572, 2 specimens, 157 & 174 mm SL. ANSP 152995, 1 specimen, 153 mm SL; 21°27'S, 81°39'W; 335 m; *Ikhtiandr* trawl 43; 26 Sep 1979. IOAN uncat., 1 specimen, 177 mm SL; 21°27'S, 81°41'W; 330 m; *Ikhtiandr* trawl 15; 7 Sep 1979. IOAN uncat., 1 specimen, 164 mm SL; 21°25'S, 81°38'W; 320 to 330 m; *Ikhtiandr* trawl 24; 12 Sep 1979. IOAN uncat., 2 specimens, 163 & 168 mm SL; 21°29'S, 81°41'W; 335 m; *Ikhtiandr* trawl 83; 13 Nov 1979.

*Diagnosis*.—Dorsal-fin rays XI, 10. Anal-fin rays III, 10. Tubed lateral-line scales 25 to 30; sum of tubed lateral-line scales from left and right sides of each

Table 1.—Data on morphometric characters for *Callanthias parini*. Standard length is in mm; other measurements in percentage of standard length.

Character	n	Range	$\bar{x}$	Holotype
Standard length	10	148–179	166	175
Head, length	10	33.0–35.6	34.2	33.7
Snout, length	10	6.3–8.4	7.5	6.3
Orbit, diameter	10	11.3–13.2	12.3	11.3
Postorbital length of head	10	13.0–15.3	14.6	15.2
Upper jaw, length	10	13.3–15.4	14.2	13.7
Interorbital width	10	6.3–8.7	7.8	7.7
Body, depth	10	33.4–36.9	35.0	35.0
Predorsal length	10	29.1–33.1	31.1	30.3
Caudal peduncle, length	10	18.8–22.8	20.6	20.3
Caudal peduncle, depth	10	10.6–12.6	11.6	11.8
Pectoral fin, length	9	25.3–28.3	27.2	27.7
Pelvic fin, length	8	20.9–25.3	23.1	24.4
Anal fin, length of base	10	23.0–28.8	26.4	26.8
Distance from most posterior pleural rib to first haemal spine	10	2.4–3.9	3.2	3.4

specimen 52 to 59. Circum-caudal-peduncle scales 21 to 24. Dimorphism evident in lengths of dorsal-, anal-, and caudal-fin rays; these structures appreciably shorter (in most cases) in specimens less than 160 mm SL than in larger specimens.

*Description.*—Morphometric data appear in Tables 1 and 2. Meristic data are given below; counts for the holotype are followed by asterisks. Pectoral-fin rays 21 or 22, counts bilaterally symmetrical (21\* in 3 specimens, 22 in 7). Pelvic-fin rays I, 5\*. Branched caudal-fin rays 8 + 7\*. Dorsal procurent caudal rays 7 or 8 (7\* in 8, 8 in 2); ventral procurent caudal rays 7\*. (Most posterior dorsal procurent ray supported by most posterior epural and apparently also by the fifth hypural; most posterior ventral procurent ray articulating with haemal spine of penultimate vertebra.) Branchiostegal rays 6\*. Pseudobranch with 22 to 27 filaments (22 in 1, 23\* in 3, 24 in 4, 25 in 1, 27 in 1). Gillrakers, including rudiments, on first gill arch 8 to 10 + 22 to 24—total 30 to 34 (upper limb: 8 in 1, 9 in 8, 10\* in 1; lower limb: 22 in 3, 23 in 3, 24\* in 4; total: 30 in 1, 31 in 2, 32 in 3, 33 in 3, 34\* in 1).

Tubed lateral-line scales 25 to 30 (left: 26 in 3, 27 in 1, 28 in 4, 29\* in 1, 30 in 1; right: 25 in 1, 26 in 3, 27 in 3, 28 in 1, 29\* in 2); sum of tubed lateral-line scales from left and right sides of each specimen 52 to 59 (52 in 2, 53 in 2, 54 in 2, 55 in 1, 56 in 1, 58\* in 1, 59 in 1). (Range of differences between left and right counts of lateral-line scales for individual specimens 0 to 3.) Mid-body lateral scales 38 to 46 (38 in 1, 39 in 1, 42 in 1, 43 in 1, 44 in 2, 45 in 1, 46\* in 1). Rows of scales between lateral line and mid-base of spinous dorsal fin 1 or 2\*. Scales between dorsal-fin origin and lateral line 2 to 4\*. Scales between anal-fin origin and lateral line 15 to 19 (17\*). Rows of cheek scales 7 to 10\*. Circum-caudal-peduncle scales 21 to 24 (21 in 1, 23 in 4, 24\* in 2).

Vertebrae 24 (10 precaudal + 14 caudal)\*. Procurent spur (Johnson 1975) absent; parhypural and 5 hypurals present; hypural 1 fused with hypural 2 and hypural 3 fused with hypural 4; epurals 2 or 3 (2 in 1, 3\* in 9); uroneurals 1 pair.







Fig. 1. *Callanthias parini*, new species, holotype, USNM 265444, 175 mm SL.

Epipleural ribs on first 10 to 12 vertebrae (10 in 1, 11 in 1, 12\* in 7). Pleural ribs on vertebrae 3 through 10. Configuration of predorsal bones and anterior neural spines difficult to describe in conventional symbolization of Ahlstrom *et al.* (1976) because predorsal bones do not actually interdigitate with neural spines; the two predorsal bones oriented more or less obliquely with their proximal ends usually terminating anterior to distal end of anteriormost neural spine. Posteriorly, dorsal and anal fins each associated with single trisegmental pterygiophore.

Mouth terminal and oblique; jaws almost equal. Maxilla reaching posteriorly to near middle of eye. Premaxilla protrusible. No supramaxilla. Posterodorsal border of maxilla not covered by infraorbital bones. Interorbital slightly convex to flattened. Anterior nostril in short tube somewhat remote from eye; posterior nostril elliptical, near eye, much larger than anterior nostril, bordered by fleshy rim which is quite well developed anteriorly. Section A<sub>1</sub> of adductor mandibulae simple, without anterodorsal extension. Posteriormost point of head extending somewhat past vertical through anterior end of dorsal-fin base. Distal margins of preopercle, interopercle, and subopercle without serrations. Opercular spines two, ventral spine better developed. Lateral series of rakers on first gill arch long and slender, medial series of rakers on first gill arch and rakers on other arches short. Gillrakers on all arches with small teeth. Premaxilla with outer series consisting of conical teeth and a few small exerted canines at anterior end of jaw; inner band of villiform to conical teeth, band expanded near symphysis; no teeth at symphysis. Dentary with series of conical teeth, teeth larger anteriorly; patch of villiform to conical teeth next to symphysis; one to few exerted canines at anterior end of jaw; no teeth at symphysis. Vomer with small conical teeth in crescent-shaped or chevron-shaped patch. Palatine with series of small conical teeth; series of teeth may be expanded anteriorly into narrow band. No teeth on tongue or pterygoids. Body compressed, moderately deep. Scales ctenoid; posterior field of a scale with single row of primary and secondary scalelets. Secondary squamation essentially absent. Anterior end of lower jaw, gular region, branchiostegal membranes, and usually small section on lateral part of snout without scales; scales on maxilla largely restricted to distal end; remainder of head heavily scaled. Midlateral series of modified scales on body (Fig. 2). Lateral line ascending abruptly

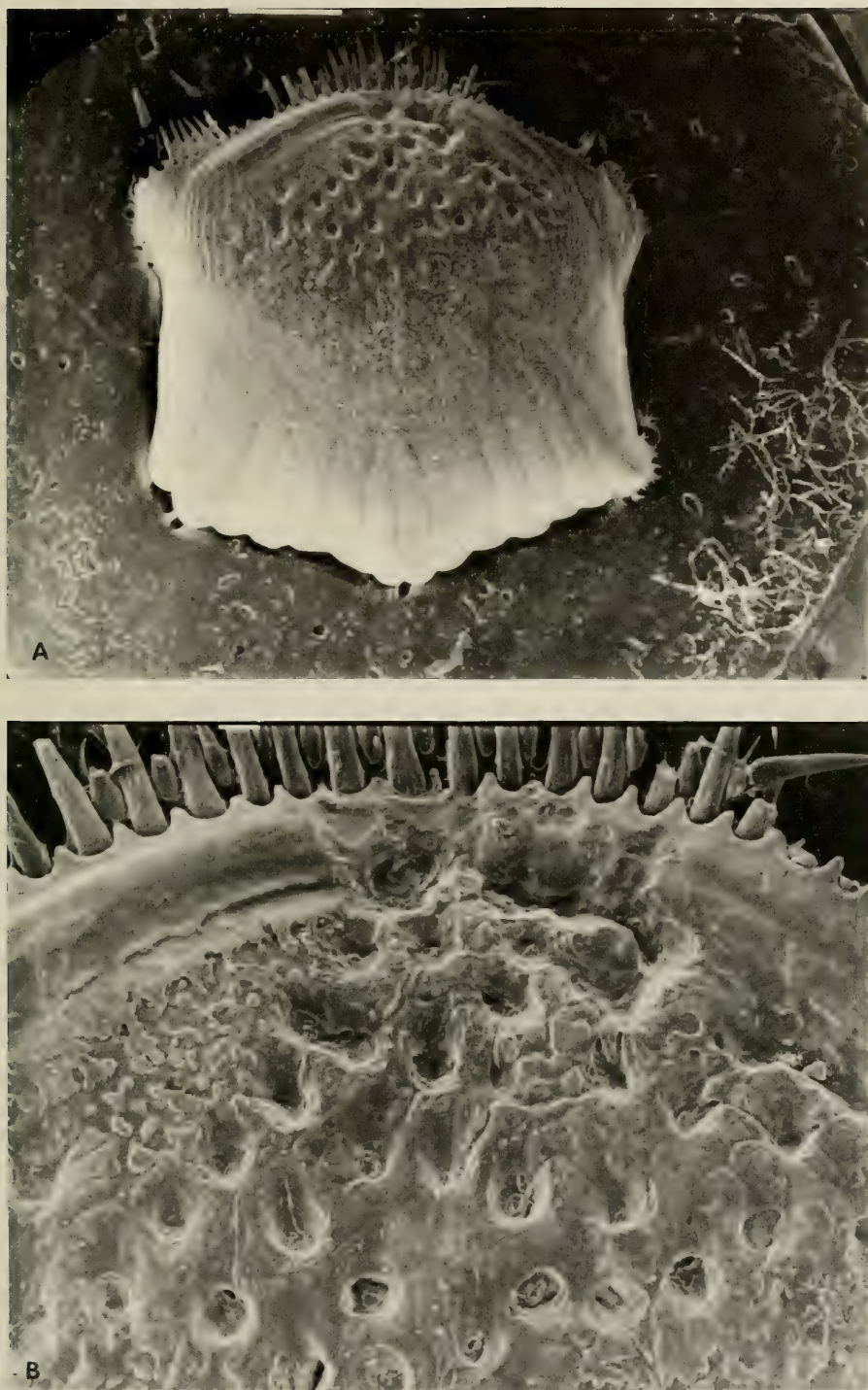


Fig. 2. *Callanthias parini*, new species; scanning electron photomicrographs of a modified mid-lateral scale from the caudal peduncle of CAS 54643, 179 mm SL; scale bar = 1000  $\mu\text{m}$  in A, 100  $\mu\text{m}$  in B.



ly from origin near opercle to within one or two scale rows of dorsal-fin base, continuing posteriorly to terminate at or near base of ultimate dorsal soft ray. Tubes in lateral line straight and simple, each extending for most of length of a scale. Lateral scale rows essentially parallel to horizontal part of lateral line. Membranes of dorsal and anal fins without scales. Pectoral-fin base with scales. Pelvic axillary scales present; pelvic-fin bases covered by mid-ventral triangular cluster of scales. Scales extending onto caudal fin. Dorsal and anal spines relatively slender. Dorsal fin not incised at junction between spinous and soft portions. Distal margin of anal fin rounded. Pectoral fin: distal margin rounded; longest rays in dorsal part of fin, reaching posteriorly to at least vertical from base of tenth dorsal spine to as far as vertical from base of second segmented dorsal ray; two dorsalmost and one to three ventralmost rays unbranched, others branched. Pelvic fin reaching posteriorly at least as far as between bases of first and second anal spines to as far as base of first segmented anal ray. Caudal-fin lunate with dorsal and ventral lobes produced in larger specimens.

*Coloration.*—In alcohol, body and head straw colored, fins pallid to straw colored; no distinctive patterns of pigmentation remaining. We received a color transparency of one of the specimens from N. V. Parin via J. E. Randall. In that photograph, head and body mostly orange; iris mostly pale anterodorsally and mostly melanistic elsewhere; dorsal and anal fins yellow-orange; pectoral and pelvic fins orange; caudal fin dull orange.

*Dimorphism.*—Our specimens are separable into two distinct morphs based on lengths of dorsal-, anal-, and caudal-fin rays (see Table 2). Individuals less than about 160 mm SL have short fin rays and larger specimens have long fin rays. Determinations of sex reported in Table 2 are based on examination of histological sections of the gonads by Mr. William A. Roumillat. Unfortunately, the viscera were not well preserved; consequently, sex could not be determined for each specimen unequivocally. Despite this, it seems likely that *Callanthias parini* is a protogynous hermaphrodite and that the two morphs represent different sexual stages.

*Comparisons.*—The other nominal species of *Callanthias* are: *C. allporti* Günther, 1876, and *C. australis* Ogilby, 1900, both from the Australian-New Zealand region; *C. japonicus* Franz, 1910, from Japanese waters; *C. legras* Smith, 1947, from off southern Africa; *C. platei* Steindachner, 1898, from the southeastern Pacific; and *C. ruber* (Rafinesque, 1810), from the eastern Atlantic and Mediterranean Sea. (*Callanthias crosnieri* Fourmanoir, 1981, is a *Grammatonotus*.) *Callanthias parini* may be distinguished by number of tubed lateral-line scales from *C. allporti*, *C. australis*, *C. japonicus*, and *C. platei* (25 to 30 in *C. parini* vs. 33 to 42 in the others); by sum of tubed lateral-line scales from left and right sides (from individual specimens) from *C. ruber* and the species previously listed (52 to 59 in *C. parini* vs. 43 to 50 in *C. ruber* and 68 to 83 in the others); and by numbers of circum-caudal-peduncle scales, epipleural ribs, and epural bones from *C. legras* (*C. parini* with 21 to 24 caudal-peduncle scales, 10 to 12 epipleural ribs, and 2 or 3 (almost always 3) epural bones; *C. legras* with 15 to 17 caudal-peduncle scales, 13 to 16 epipleural ribs, and 2 epural bones). Also useful in separating *C. parini* from *C. australis*, *C. japonicus*, and *C. platei* are numbers of dorsal- and anal-soft rays (*C. parini* with 10 in each fin, the other species almost always with 11 in each fin). In addition, dimorphism in length of some fin rays (see above and Table 2) has been demonstrated only in *C. parini*.



*Distribution.*—*Callanthias parini* is known only from the Nazca Ridge off the coast of Chile in depths of 320 to 335 meters.

*Etymology.*—It is a pleasure to name this species for N. V. Parin who provided the specimens of the new species.

*Remarks.*—*Callanthias* and *Grammatonotus* appear to be sister groups. They share three characters (Johnson, in press) that appear to be unique among percoid fishes: structure of the nasal organ (devoid of lamellae), presence of modified scales with unique ornamentation along the body mid-laterally, and lateral line running along base of dorsal fin and terminating near base of ultimate dorsal soft ray or continuing posteriorly on dorso-lateral surface of caudal peduncle. *Callanthias* can be distinguished easily from *Grammatonotus* in having more opercular spines, segmented dorsal- and anal-fin rays, branched caudal-fin rays, and tubed lateral-line scales (two well-developed opercular spines in *Callanthias*, one in *Grammatonotus*; segmented dorsal-fin rays 10 or 11—very rarely 12—in *Callanthias*, usually 9—rarely 8 or 10—in *Grammatonotus*; segmented anal-fin rays 10 or 11—very rarely 9 or 12 in *Callanthias*, 9 in *Grammatonotus*; branched caudal-fin rays 15 (8 + 7) in *Callanthias*, 13 (7 + 6) in *Grammatonotus*; tubed lateral-line scales 21 to 42 in *Callanthias*, 14 to 18 in *Grammatonotus*). Also, in *Callanthias* the most posterior dorsal procurent caudal-fin ray articulates with the most posterior epural and apparently in most cases also receives support from the fifth hypural; whereas, in *Grammatonotus* support for this element is almost always from the fifth hypural and only occasionally from both the most posterior epural and the fifth hypural. In *Callanthias* the most posterior ventral procurent caudal-fin ray always articulates with the haemal spine of the penultimate vertebra, but in *Grammatonotus* this fin ray is almost always supported by the haemal spine of the penultimate vertebra and by the parhypural. The distance from the most posterior pleural rib to the first haemal spine is usually appreciably greater in *Callanthias* than in *Grammatonotus* (*Callanthias*:  $N = 172$ , range in % SL = 1.05 – 4.79,  $\bar{x}$  in % SL = 3.20; *Grammatonotus*:  $N = 28$ , range in % SL = 0.68 – 2.14,  $\bar{x}$  in % SL = 1.63).

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John E. Randall (BPBM) forwarded the specimens described herein and a color transparency of one of them to us from N. V. Parin of the P. P. Shirshov Institute of Oceanology, Moscow, who very generously allowed us to deposit types in museums in the United States. William A. Roumillat, South Carolina Marine Resources Research Institute, Charleston, made and examined the histological sections of gonads. James F. McKinney (GMBL) provided the radiographs and the photograph for Fig. 1, and Robert Ashcraft (Medical University of South Carolina) made the scanning electron photomicrographs for Fig. 2. Carole C. Baldwin (GMBL) typed the manuscript and assisted in a number of other ways in its preparation. Carole C. Baldwin and John E. Randall reviewed the manuscript. This is GMBL contribution number 63.

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## NOTES ON THE FRESHWATER SHRIMPS OF ISLA DEL COCO WITH THE DESCRIPTION OF *MACROBRACHIUM COCOENSE*, NEW SPECIES

Lawrence G. Abele and Won Kim

*Abstract.*—Five species of freshwater shrimp are reported from Isla del Coco: *Macrobrachium hancocki*, *M. americanum*, *M. cocoense* n. sp., *M. sp.*, and *Archaeatya chacei*. Habitat notes are presented for each species, and chela dimorphism in *A. chacei* is noted.

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Isla del Coco is an isolated oceanic island located at 5°32'57" N and 86°59'17" W about 500 km southwest of Costa Rica. It is a small island about 23.3 km in circumference with abundant fresh water. The highest point is reported to be about 850 m, although at least one report states 518 m as the greatest elevation (see Hertlein 1963). Hertlein (1963) reviewed the biogeography of the island and presented a checklist of the fauna and a bibliography. In the list of 50 decapod crustaceans he included two freshwater species: *Macrobrachium americanum* Bate and *M. hancocki* Holthuis. A third freshwater decapod, *Archaeatya chacei*, was described by Villalobos (1959).

In 1973 one of us (LGA) had the opportunity, provided by the Smithsonian Tropical Research Institute, to visit Isla del Coco and to make some general collections there. In addition to the three previously reported freshwater shrimp species, a single male of an undescribed species of *Macrobrachium* was collected from a stream emptying into Wafer Bay. A male specimen of another *Macrobrachium* was collected from the same stream and is described but not named.

In the descriptions that follow, the abbreviation tl refers to total length including the rostrum, cl to carapace length from the posterior dorsal margin to the posterior orbital margin, and USNM to the National Museum of Natural History, Washington, D.C. Drawings were made with the aid of a Wild M-5 camera lucida by the second author.

### *Macrobrachium cocoense*, new species

Figs. 1-2

*Material.*—Isla del Coco, Costa Rica, stream on east side of Wafer Bay; 1 ♂; 14 Aug 1973; coll. L. G. Abele, J. Rodgers.

*Description of holotype.*—Rostrum convex posteriorly, very slightly upturned anteriorly, overreaching antennular peduncle but falling short of distal end of scaphocerite; armed dorsally with 11 teeth, including 2 postorbital; teeth about equally spaced from second to ninth tooth; distinct space between ninth and 2 anteriormost teeth; armed ventrally with 6 teeth, spaced more closely posteriorly; lateral ridge sloping slightly upward anteriorly, merging with orbital margin posteriorly.

Carapace covered with minute spinules (=very short setae) most distinct in anterior and anterolateral region; lower orbital angle rounded; hepatic spine dis-



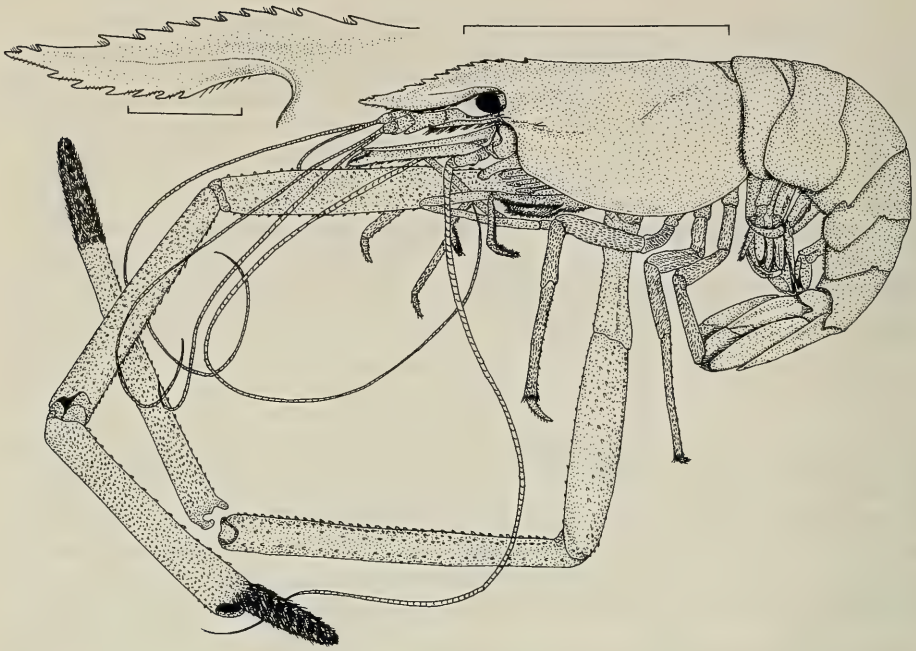


Fig. 1. *Macrobrachium cocoense*, male holotype, lateral view. Scale = 50 mm. Pleuron of third abdominal somite damaged. Rostrum scale = 10 mm.

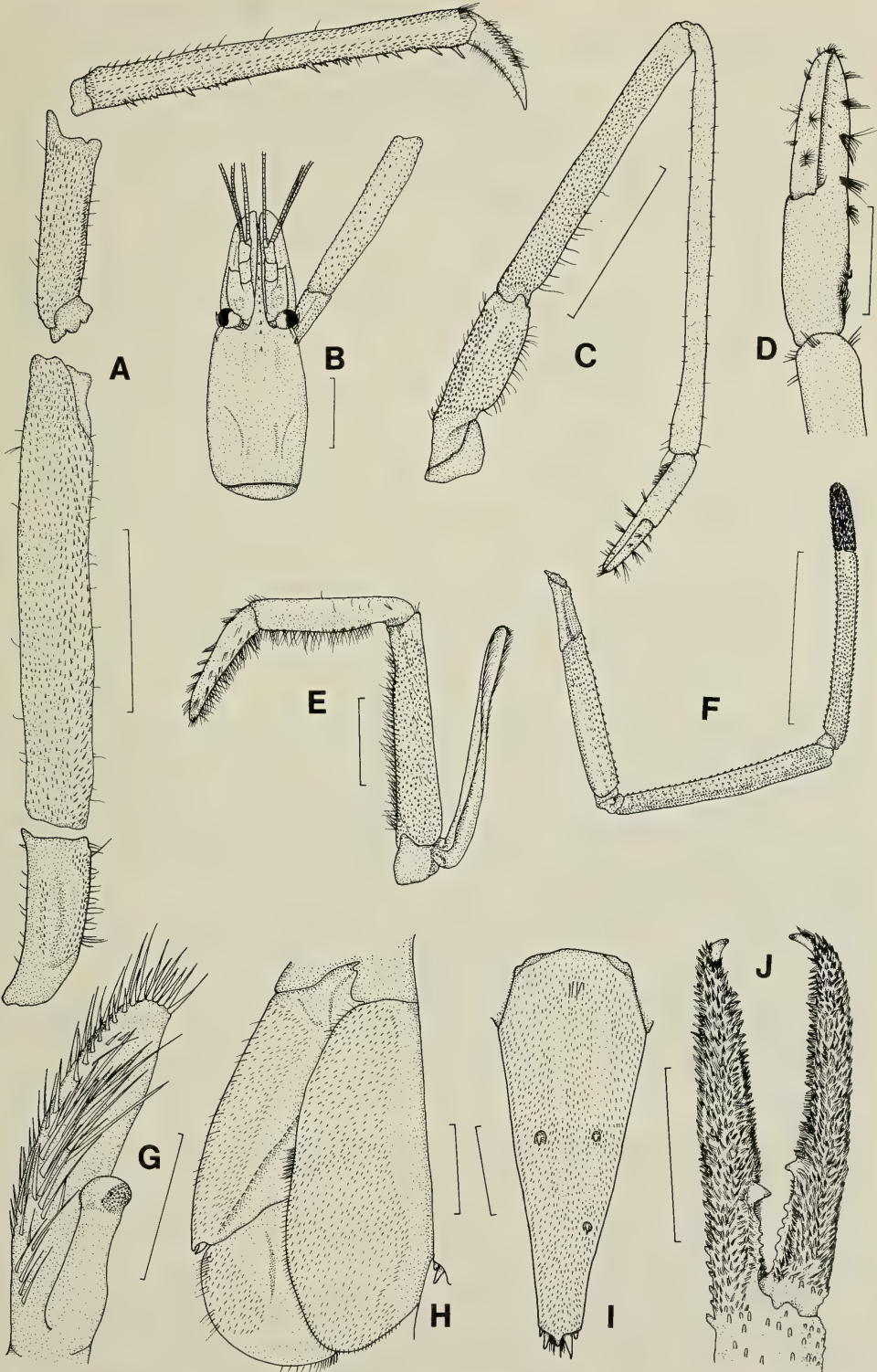
tinctly smaller than antennal spine; distinct hepatic and branchiocardiac grooves present; region behind orbital margin slightly depressed.

Abdomen covered with very small spinules except dorsal part of first 3 somites; pleura covered with very short setae similar to those on carapace; pleura of first 3 somites broadly rounded posteroventrally; pleuron of fourth somite angular; pleuron of fifth somite somewhat triangular; sixth somite with acute ventral and subdorsal posterior margins, about 1.4 times as long as fifth. Telson covered with minute spinules, about 1.5 times as long as sixth somite, with one pair of dorsal spines at midlength and only one (right) spine at  $\frac{2}{3}$  length of telson; posterior margin distinct, ending in median acute point; apex falling far short of tips of inner of 2 pairs of posterior spines; several feathered setae present between inner spines.

Cornea rounded and broader than eyestalk; ocellus distinct.

Antennule with stylocerite extending beyond midlength of penultimate segment of antennule; ultimate segment slightly longer than penultimate segment in dorsal view; antepenultimate segment lengthened laterally and ventrally.

Fig. 2. *Macrobrachium cocoense*, male holotype: A, Right third pereopod; B, Dorsal view of anterior region; C, Right first pereopod; D, Chela of right first pereopod; E, Left third maxilliped; F, Left second pereopod; G, Right appendix masculina; H, Left uropod; I, Telson; J, Fingers of left second pereopod. Scale: A, C, J = 10 mm, B = 20 mm, D = 3 mm, E, H, I = 5 mm, F = 50 mm, G = 2 mm.



Scaphocerite overreaching rostrum, almost 3 times as long as broad; outer margin almost straight, ending in short spine falling far short of distal margin of inner blade.

Third maxilliped falling slightly short of middle of scaphocerite; antepenultimate segment with many very small spinules laterally, about 1.4 times as long as penultimate; penultimate about 1.3 times as long as ultimate; penultimate and antepenultimate segments with many long setae; exopod extending to distal margin of antepenultimate segment.

First pereopods reaching with chela and part of carpus beyond scaphocerite; fingers slightly longer than palm; carpus 2.9 times as long as chela and 1.4 times as long as merus; merus and ischium with dense spinules ventrally, increasing in size proximally. Second pereopods similar in shape, unequal in size, overreaching scaphocerite by carpus and  $\frac{3}{5}$  length of merus. Left pereopod with fingers 0.36 times as long as palm, closing over their entire length; movable finger with large basal tooth about  $\frac{7}{10}$  of length from tip, 5 small denticles present between base of edge and large tooth, edge entire distal to large tooth; immovable finger with large tooth somewhat proximal to large one of movable finger, armed with 5 denticles between base and large tooth; both fingers covered with thick pubescence; palm elongate and cylindrical, about 11 times as long as high, with several longitudinal rows of spinules becoming larger lateroventrally; carpus longer than palm, though being shorter than entire chela, about 9.5 times as long as broad, narrowing slightly proximally; merus slightly swollen, broadest in middle, about 0.7 times as long as carpus, about 2 times as long as compressed ischium; carpus, merus, and ischium with several longitudinal rows of spinules being larger mid-ventrally. Third through fifth pereopods similar, covered with very short, dense spinules on all segments except dactylus. Third pereopod reaching with part of dactylus beyond scaphocerite; propodus 3.7 times as long as dactylus, 1.7 times as long as carpus and 0.8 times as long as merus. Fifth pereopod reaching somewhat beyond middle of scaphocerite; propodus almost 4.5 times as long as dactylus, 1.9 times as long as carpus and equal in length to merus; inferior margin of propodus with strong spines and rows of transverse, long setae.

First pleopods lacking appendix interna; endopod less than half as long as exopod. Appendix masculina present on second pleopod, about 2 times as long as appendix interna, with strong, stiff setae on superior surface and tip.

Uropods ovate, extending well beyond telson; lateral ramus slightly longer than mesial; diaeresis with one movable spine mesial to immovable spine at lateral angle; minute spinules on surface of uropods.

*Holotype*.—The male holotype (tl = 166.5 mm, cl 39.6 mm) is deposited in the USNM.

*Habitat*.—*Macrobrachium cocoense* was collected with a dip net in a slow-flowing, almost stagnant, freshwater stream. The depth was about 1 m, width 3–4 m and the bottom was mud and rotting vegetation. Visibility was virtually zero.

*Color*.—Carapace and abdomen predominately light brown mottled with black; abdomen bronze posteriorly; chelipeds black.

*Remarks*.—*Macrobrachium cocoense* is morphologically similar to two other eastern Pacific species in the genus, *M. tenellum* (Smith) and *M. rathbunae* Holthuis. We have examined specimens of both of these species, including the type-specimen of *M. rathbunae*. *Macrobrachium cocoense* can be easily distinguished





Fig. 3. *Macrobrachium* sp., lateral view. Scale = 50 mm. Abdomen disarticulated at third somite. Rostrum scale = 10 mm.

from *M. tenellum* by the following characters: in *M. cocoense* the fingers of the second pereopod are about 0.36 as long as the palm, while in *M. tenellum* they are about 0.8 as long; in *M. cocoense* the rostrum is almost straight, while in *M. tenellum* it is distinctly curved upward.

The present species can be distinguished from *M. rathbunae* by the following characters: in *M. cocoense* the carpus of the first pereopod is about 2.9 times the chela length, while in *M. rathbunae* it is about 2.0 times the chela length; in *M. cocoense* the second pereopods extend beyond the scaphocerite by the carpus and about 0.6 of the merus while in *M. rathbunae* they extend beyond the scaphocerite by the carpus only; in *M. cocoense* the fingers of the second pereopod are about 0.36 as long as the palm, while in *M. rathbunae* they are about 0.5–0.6 as long; in *M. cocoense* there are dense, strong spinules on pereopods 2–5, while in *M. rathbunae* they are fewer and weaker.

*Etymology*.—From the type-locality.

*Macrobrachium* sp.

Figs. 3–4

*Material*.—Isla del Coco, Costa Rica, stream on east side of Wafer Bay; 14 Aug 1973; coll. L. G. Abele.

*Description*.—Rostrum armed with 12 teeth dorsally, including one postorbital and one above orbital margin; armed ventrally with 5 teeth. Carapace smooth.

Abdomen smooth; pleura covered with indistinct short setae, sparse ventrally.

Telson sparsely covered with very small spinules.

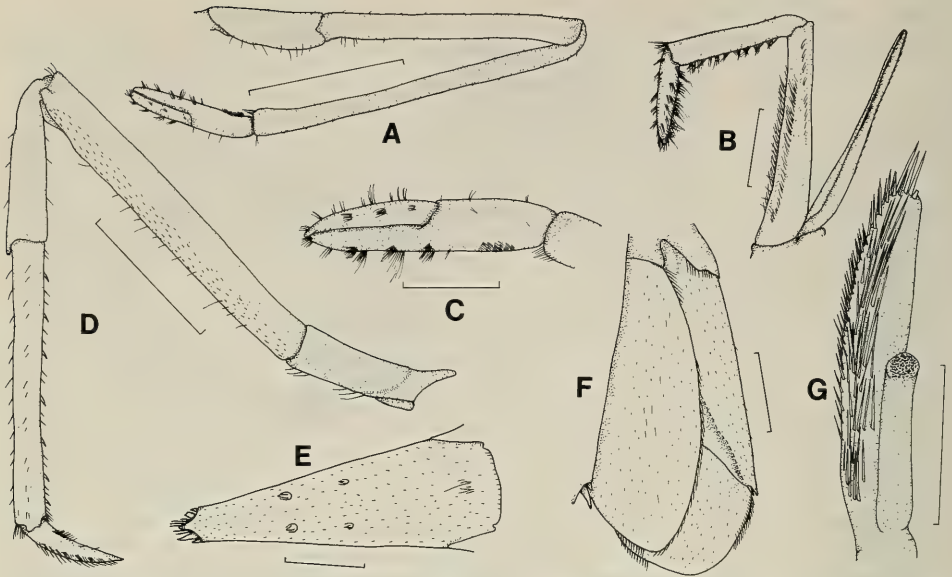


Fig. 4. *Macrobrachium* sp.: A, Right first pereopod; B, Left third maxilliped; C, Chela of left first pereopod; D, Left third pereopod; E, Telson; F, Right uropod; G, Left appendix masculina. Scale: A, D = 10 mm, C = 3 mm, B, E, F, G = 5 mm.

Right stylocerite damaged, with 2 lateral spines.

Third maxilliped having segments with long setae ventrally becoming dense proximally.

First pereopods overreaching scaphocerite by length of chela and having segments almost naked, ischium with sparse long setae ventrally. Left second pereopod overreaching scaphocerite by length of carpus and  $\frac{1}{5}$  length of merus; fingers about 0.6 times as long as palm, covered with pubescence; palm elongate, cylindrical, about 7 times as long as high, with several longitudinal rows of spinules larger and more distinct lateroventrally; carpus about 6.8 times as long as broad; merus 1.6 times as long as ischium; carpus, merus, and ischium with several longitudinal rows of spinules becoming larger lateroventrally. Right second pereopod regenerating. Third through fifth pereopods similar, covered with very short, sparse spinules on narrow area of ventral surface of merus, carpus and propodus. Third pereopod with propodus about 2.5 times as long as dactylus. Fifth pereopod with propodus 3.4 times as long as dactylus.

Uropods with sparse spinules on dorsal surface.

*Remarks.* The present specimen was collected in the same stream as *M. cocoense* and is virtually identical in size (tl 166 mm, cl 39.6 mm). We considered the possibility that this specimen is conspecific with *M. cocoense*, but without more material we hesitate to make a decision. We also compared it to type-material of *M. rathbunae*, but there are numerous differences in the form of the second pereopod and in the shape of the rostrum. The specimen is also damaged, with an aberrant right stylocerite and a regenerating right second pereopod. It seems best to describe the specimen, without naming it, until more material becomes available.

Table 1.—Comparison of size, sex, and chela type in *A. chacei* from Isla del Coco Island.

Gender	Chela type	CL (mm)								Total
		1.1–1.5	1.6–2.0	2.1–2.5	2.6–3.0	3.1–3.5	3.6–4.0	4.1–4.5	4.6–5.0	
Male	Ortmannioid			15	39	22	2			78
	Atyoid			3	3	1				7
										85
Female	Non-ovigerous	1	7	4	9	7	4	3		35
			10	31	11	3	5	1		61
	Ovigerous					3	6	6	2	17
							6	4		10
										27
Total individuals		1	17	53	62	36	23	14	2	208
% Female		100	100	66	32	36	91	100	100	

*Macrobrachium hancocki* Holthuis, 1950

*Macrobrachium hancocki*.—Holthuis, 1952:111, pl. 29, figs. a–e.

*Material examined*.—Isla del Coco, Wafer Bay, west side in swamp; 8 ♂♂, 13 ♀♀ (8 ovigerous); 15 Aug 1973; coll. L. G. Abele (LGA 73–63).—Wafer Bay, east side in stream; 4 ♂♂, 13 ♀♀ (5 ovigerous); 14 Aug 1973; coll. L. G. Abele (LGA 73–61).

*Measurements*.—Males cl 7.5–16.9 mm, females cl 7.1–13.8 mm, ovigerous females cl 7.2–11.5 mm.

*Type-locality*.—Esparta, Rio Barranca, Costa Rica.

*Distribution*.—This species has been reported from the Pacific drainage of Costa Rica, Panama, and Colombia as well as from Isla del Coco and the Galapagos Archipelago.

*Remarks*.—*Macrobrachium hancocki* is common on Isla del Coco. A few individuals were observed in a small stream emptying into Chatham Bay. Specimens were seen along the edges of the stream in slow-moving or still areas. This species was extremely common in a swamp on the eastern shore of Wafer Bay. The water was brown, almost stagnant with rotting vegetation on the bottom. Large males, but not small males or females, were a beautiful deep blue in color (see also Holthuis 1952:112). Additional collecting around Wafer Bay revealed that *M. hancocki* is most abundant in swamp waters 8–15 cm deep that are slow moving or stagnant.

Abele and Blum (1977) present data on the biology of this species from the Archipelago de las Perlas, Panama.

*Macrobrachium americanum* Bate, 1868

*Macrobrachium americanum*.—Holthuis, 1952:128, pl. 31, figs. d, e.

*Material examined*.—Isla del Coco, Wafer Bay, east side in stream; 1 ♀; 14 Aug 1973; coll. L. G. Abele (LGA 73–61).



*Measurements.*—Female cl 28.0 mm.

*Type-locality.*—Lake Amatitlan, Guatemala.

*Distribution.*—*Macrobrachium americanum* is widely distributed in Pacific drainages from Lower California to northern Peru, including Isla del Coco and the Galapagos Archipelago.

*Remarks.*—The single female was collected from the larger of two streams on the eastern side of Wafer Bay. Holthuis (1952) reported specimens from a stream entering Chatham Bay. Abele and Blum (1977) reported *M. americanum* from large pools in streams in the Archipelago de las Perlas, Panama.

*Archaeatya chacei* Villalobos, 1959

*Archaeatya chacei* Villalobos, 1959:331, figs. 1–25.

*Material examined.*—Isla del Coco, Chatham Bay, freshwater stream; 57 ♂♂, 97 ♀♀ (25 ovigerous); 13 Aug 1973; coll. L. G. Abele (LGA 73-59).—Wafer Bay, west side, swamp; 28 ♂♂, 20 ♀♀ (2 ovigerous); 14 Aug 1973 (LGA 73-63).—Wafer Bay, east side; 6 ♀♀; 14 Aug 1973 (LGA 73-61).

*Measurements.*—Males cl 2.1–3.1 mm, females cl 1.2–4.5 mm, ovigerous females cl 3.4–5.0 mm. Panamanian specimens: males cl 2.6–4.6 mm, females cl 2.4–5.6 mm, ovigerous females cl 4.2–5.4 mm.

*Type-locality.*—Isla del Coco.

*Distribution.*—Isla del Coco (Villalobos 1959); Costa Rican mainland (Smalley 1964); Archipelago de las Perlas, Panama (Abele and Blum 1977).

*Remarks.*—Individuals of *A. chacei* were collected from all freshwater streams sampled in Chatham and Wafer Bay watersheds from the sea-stream interface to the greatest altitude sampled (250 m). The species was found in virtually all microhabitats: side pools of streams, moving about on rocks, in fast-flowing riffle areas and among submerged parts of riparian vegetation at or near the shore. Individuals were relatively uncommon in a small stream flowing into Chatham Bay but were abundant in a larger stream flowing southwest in the same area. In the Wafer Bay area local variation in abundance was even more pronounced. A swamp on the east side had almost zero visibility, rotting debris, and flowing water. *Macrobrachium hancocki* was very abundant there, and *A. chacei* rare. On the west there was a swamp with clear, still water, where *A. chacei* was quite abundant and *M. hancocki* rare.

Chela heteromorphism has been described for some members of the Atyidae by Bouvier (1925), Edmondson (1929) and, most recently, by Chace (1983). Chela morphology basically has two forms: the ortmannioid form, in which a palm is present because the dactylus is shorter than the propodus, and the atyoid form, which lacks a palm because the dactylus and propodus are subequal in length. Generally the ortmannioid form has short setae on the chelae and the atyoid form long setae. The two forms can be quite distinct although the chelae of some individuals are difficult to classify.

We examined this phenomenon in *A. chacei* and its relationship to size and sex (Table 1). There are 208 complete specimens, 41% male and 59% female. Among the males 92% are ortmannioid and 8% atyoid, while among the females 42% are ortmannioid and 58% are atyoid. Among the 27 ovigerous females, which include the largest specimens, 63% are ortmannioid and 47% atyoid in form.

Table 2.—Comparison of size, sex, and chela type in *A. chacei* from Archipelago de las Perlas, Panama.

			CL (mm)								Total	
			2.1– 2.5	2.6– 3.0	3.1– 3.5	3.6– 4.0	4.1– 4.5	4.6– 5.0	5.1– 5.5	5.6– 6.0		
Gender	Chela type											
Male		Ortmannioid		12	91	128	74	1			306	
		Atyoid		1		1					<u>2</u>	
											308	
Female	Non-ovigerous	Ortmannioid	1	11	29	20	15	13	11	2	102	
		Atyoid	0	1	5		1	1	1		<u>9</u>	
												111
	Ovigerous	Ortmannioid						2	4		6	
		Atyoid					1				<u>1</u>	
Total individuals			1	25	125	149	91	17	16	2	426	
% Female			100	48	27	13	19	94	100	100		

The smallest animals appear to be females and no individuals with a cl less than 2.1 mm can be identified as males. Males account for 34–68% of the individuals from cl 2.1–3.5 mm. At cl 3.6–4.0 mm males are rare, accounting for 9% of the individuals. The 16 largest individuals cl 4.1–5.0 mm, are females. Although similar data have been used to suggest protandric hermaphroditism we hesitate to speculate without seasonal and histological data.

We compared the Isla del Coco specimens to individuals collected at Archipelago de las Perlas, Panama, and found no consistent differences except that the Panamanian specimens are larger as noted by Abele and Blum (1977). The sex ratio data may not be valid because these collections were used to measure egg numbers and stomach contents of females, and consequently females were removed from the vials. However, the data are valid to examine size, sex and chela type and to compare these data to those from Isla del Coco. There are 308 complete males, and of these 306 or 99% have ortmannioid chelae. Among the 118 females 108 or 92% have ortmannioid chelae, and 8% have atyoid chelae. The differences between the chela types are not as clear cut in the Panama material as in that from Isla del Coco. The size and sex data differ little from those of Isla del Coco. Other than the absence of animals with cl below 2.0 mm the general trend is the same. Males account for the majority of individuals in the middle size classes but are rare or absent in the larger size classes.

Nothing is known concerning the significance of the chela dimorphism.

Acknowledgments

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STUDIES IN THE HELIANTHEAE (ASTERACEAE).  
XXXIV. REDELIMITATION OF THE  
GENUS *ANGELPHYTUM*

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*Abstract.* — The genus *Angelphytum* Barroso of eastern South America, originally monotypic, is expanded to include a total of 14 species. The character of eradiate heads originally used to delimit the genus proved unreliable, occurring also in species of *Zexmenia*, *Wedelia*, and *Aspilia*. As redefined, *Angelphytum* includes species related to *Dimerostemma* but having fertile liguliform or disciform peripheral flowers in the heads. Three new species, *A. bahiense*, *A. hatschbachii*, and *A. reitzii* are described, ten new combinations are made, and a key is provided.

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The present effort continues a series of studies attempting to resolve and in some cases describe the numerous members of the *Wedelia* relationship of the subtribe Ecliptinae in Brazil. The related group includes many species, often xylopodial, in the open or crystalline habitats of eastern Brazil. It remains one of the most poorly resolved elements of the family Asteraceae in the area. The papers of the present series have sometimes retained the artificial traditional generic concepts such as *Wedelia* and *Aspilia* (Robinson 1984a, b), but in cases such as the recent treatment of *Dimerostemma* (Robinson 1984c), an apparently logical and natural generic limit has been attained. Again, in the present study of *Angelphytum*, logical and workable natural limits are established. The studies of both *Angelphytum* and *Dimerostemma* show the expected result of proving that many species of the Ecliptinae in Brazil previously assigned to widely distributed genera actually belong to local Brazilian genera.

*Angelphytum* was originally described by Barroso (1980) to honor the Argentine botanist Angel L. Cabrera. The genus included a single species from Mato Grosso, Brazil. It was compared with *Zexmenia* and *Dimerostemma* because of the winged margins of the achenes, but was separated by the lack of rays in the flowering heads. As indicated by Barroso, the heads had differentiated peripheral flowers with triquetrous achenes, but their corollas are disciform and bisexual rather than liguliform. In comparison, *Dimerostemma* has rays which are totally asexual, while *Zexmenia* has ray flowers with functional female structures. *Angelphytum* was not originally directly compared with either *Wedelia* or *Aspilia*, but the latter two differ traditionally from the genera mentioned by Barroso by having a strong constriction at the top of the achene below the pappus and by the essential lack of wings on the achene.

At the time of the original description of *Angelphytum*, there was no reason to doubt seriously the naturalness of the monotypic genus or the value of its distinguishing character. Only *Zexmenia foliosa* Rusby in Jones of Bolivia, a plant of very different habit, had at that time been described in the related group of genera with the same type of peripheral flowers in the head. Still, the form of the peripheral flowers of the head in the Heliantheae, and especially in the Ecliptinae, is evidently

of sporadic occurrence (Robinson 1981), and is beginning to come under suspicion as an a priori generic character. It seems rather fortuitous that in the last few years two additional previously undescribed South American members of the Ecliptinae that also lack radiate corollas have been sent for identification. As in the case of *Zexmenia foliosa*, these species are not congeneric with the type-species of *Angelphytum*. The first of the new species, from Mato Grosso, Brazil, has precisely the same floral arrangement as the type of *Angelphytum*, but the achenes, including the triquetrous peripheral achenes, lack wings and are constricted apically under the pappus. Also, the corollas, even though disciform, have funnellform throats rather than cylindrical throats with slightly campanulate bases as in *Angelphytum*. The new Mato Grosso species has shown additional characters relating it to members of the genus *Wedelia* that are common in the area, and the species has been named *Wedelia hatschbachii* (Robinson, 1984a). The second new eradiate Ecliptine species, collected in Ecuador, differs significantly from the first in the apparent lack of triquetrous peripheral achenes of the type found in *Angelphytum*. In this case the eradiate condition seems to derive from a complete lack of any flowers outside of the normal disk flowers. The Ecuadorian plant also differs in having black anther appendages and strong fiber sheaths along the veins of the corolla throats, characters that are very rare in *Wedelia* and quite common in *Aspilia*. This latter set of characters seems useful in spite of evidence of some artificiality in the separation of *Wedelia* and *Aspilia*. The combination of the characters in the Ecuadorian plant has been interpreted as evidence of relationship to *Aspilia*, a genus in which the rays are usually present but sterile, and the species has been named *Aspilia pastazensis* (Robinson, 1984b). The existence of *Zexmenia foliosa* of Bolivia, and the discovery of the two new species belonging to *Wedelia* and *Aspilia*, all lacking rays, in addition to the original doubts about the value of the character, furnish convincing evidence that the genus *Angelphytum* as originally described is untenable.

The discovery of the untenability of *Angelphytum* as originally described would be unwelcome except for the fact that the name thus becomes available for a much broader natural element that would otherwise be without a name. The additional species transferred here to *Angelphytum* have fertile rays and have previously been placed in *Zexmenia*. As in the case of *Wedelia hatschbachii*, the bisexual peripheral flowers with triquetrous achenes in the type-species of *Angelphytum* seem to relate to the fertile-rayed condition. The species transferred here to *Angelphytum* are not considered to have any direct relationship to *Zexmenia* which is typified by the Mexican and Central American *Z. serrata* Llave. As indicated in the unpublished thesis of Rindos (1980) on relationships within *Zexmenia*, some subgroups, including the type, have apically constricted achenes and are closely related to if not congeneric with *Wedelia*. Other comparatively distinct elements recognized in *Zexmenia* by Rindos prove to belong to *Lasianthaea* (Becker, 1979), *Lundellianthus* (Robinson, 1978), or in one case, immediately related to *Otopappus* from which it differs only by the lack of the primary technical character (Anderson *et al.* 1979). From all these latter elements the present concept of *Angelphytum* is distinct by being xylopodial herbs rather than shrubs, by having cylindrical rather than funnellform upper throats on the disk corollas, by having inflated collars on the anthers, and by having generally con-



torted or coiled abaxially glanduliferous rather than gradually curving non-glanduliferous branches on the disk styles. The species of *Angelphytum* do not have the strong fiber sheaths on the veins of the disk corolla throats seen in *Lasianthaea* DC., the intricately interconnected paleae seen in *Lundellianthus* H. Robinson, or a viny habit and wings of the mature achene extending without significant interruption to the tips of the pappus awns as seen in *Otopappus* Benth.

Most Brazilian species that have previously been placed in *Zexmenia* prove to belong to *Angelphytum* in a manner similar to the way Brazilian species once placed in the Andean genus *Oyedaea* DC. have proven to belong to *Dimerostemma*. Nevertheless, a few species in the area that have been placed in *Zexmenia*, such as *Z. foliosa* of Bolivia, *Z. rudis* Baker of Brazil, *Z. apensis* (Chod.) Hassl. of Paraguay and adjacent Brazil, and two species closely related to the latter, *Z. goyazensis* (Gardn.) Benth. and Hook. and *Wedelia goyazensis* Gardn. of Brazil, are shrubby species without xylopodia, with more funnellform throats on the disk corollas, mostly with partially to completely blackened appendages on the anthers, and with less curved branches on the disk styles. The members of the *Z. apensis* group show glands abaxially on the style branches and evenly distributed papillae on the inner surfaces of the corolla lobes as in *Angelphytum*, but they are further distinct in the more pilosulous outer surfaces of the disk corolla lobes. Evidence indicates that the above species are not particularly close to *Angelphytum*, and they are probably best retained under the somewhat narrowed umbrella concept of *Zexmenia*. One species from northern Argentina, *Wedelia brachylepis* Griseb., that has recently been transferred to *Zexmenia* seems best returned to *Wedelia* on the basis of habit and floret structure.

The actual closest relationship of *Angelphytum* seems to be with *Dimerostemma*. The latter has a similar herbaceous habit with a xylopodium in most species, has similarly shaped disk corollas with cylindrical upper throats, scarcely to non-setuliferous outer lobe surfaces, and evenly papillose inner lobe surfaces, has similarly enlarged anther collars, has similarly contorted usually abaxially glanduliferous branches of the disk styles, and has similar usually broadly winged disk achenes. In fact, the principal distinction of *Angelphytum*, the fertile rather than sterile peripheral or ray flowers, would not alone be evidence that the division between the genera was natural. The characteristic well differentiated outer series of involucre bracts in *Dimerostemma* compared to the undifferentiated or irregularly differentiated outer bracts in *Angelphytum*, however, seems to confirm the phyletic value of the distinction based in the fertile peripheral flowers.

One other group of species in the area of Brazil has some of the characters of *Angelphytum* and may prove related. These are the many xylopodial perennial *Wedelia* species of the planalto that are quite unlike the shrubby non-xylopodial typical members of that genus in the wetter parts of tropical America. Nevertheless, these Brazilian species have the achenes with constricted coroniform apices and have fertile ray flowers as in typical *Wedelia*, and for that reason they continue to be placed in that genus. In addition to having xylopodia, these species resemble *Angelphytum* in the shape of their disk corollas and in often having distinctly thickened anther collars. Still, none of the species have style branches of the disk flowers as curved as those of *Angelphytum*, and the branches are non-glanduliferous abaxially. Also, the corolla lobes often have prominent hairs on the outer



surface and vary in both overall shape and pattern of internal papillosity. The detailed floral characters seem to support fully the naturalness of the generic distinction from *Angelphytum* based on the form of the achenes. The planalto species do seem to be linked by intermediate forms with some of the typical types of *Wedelia* such as *W. hookeriana* Gardn. or *W. alagoensis* Baker that are found in eastern Brazil.

*Angelphytum* G. M. Barroso, Bolet. Soc. Argent. Bot. 19 (1-2):7-11. 1980.

Perennial herbs with few to many erect, scarcely to moderately branched stems from a xylopodium. Leaves alternate to opposite, linear and subsessile to ovate on distinct petioles, uni- to trinervate. Inflorescence with 1-many heads; peduncles elongate. Heads broadly campanulate with many flowers; involucre without or with an irregularly distinct outer series of bracts. Peripheral flowers of heads ca. 10-14, fertile, forming trigonous achenes, usually bearing rays, bearing bisexual disciform corollas in the type species. Disk corollas ca. 25-70, with a short glabrous basal tube weakly demarcated at the top from the slightly campanulate base of the throat; upper throat cylindrical and mostly glabrous, without obvious fiber sheaths on the veins; lobes ovate-triangular, with glands and few or no setulae externally, with low uniform papillae covering the entire inner surface; anther collars distinctly thickened and abruptly constricted at the top; anther appendages with glands on the outer surface; style branches strongly curved or contorted, with glands abaxially. Achenes not constricted above under the pappus, with broad wings or lobes on the margin not continuing uninterrupted to the tips of well developed awns; awns usually stout and tapering, triquetrous, sometimes lacking, squamellae variably present.

Type-species.—*Angelphytum matogrossense* G. M. Barroso.

Key to the species of *Angelphytum*

- 1. Leaves mostly or completely alternate, sometimes opposite near the base 2
- 2. Heads without rays, with peripheral flowers bearing bisexual disciform corollas ..... *A. matogrossense*
- 2. Heads with distinct rays ..... 3
- 3. Heads with herbaceous outer involucre bracts sometimes exceeding the height of the flowers; lower leaves often opposite ..... *A. arnottii*
- 3. Heads with firm involucre bracts of uniform or graduated lengths, not exceeding the height of flowers; leaves spirally inserted throughout ..... 4
- 4. Leaves elliptical ..... *A. myrtifolium*
- 4. Leaves linear ..... 5
- 5. Leaves with recurved margins; outer involucre bracts shorter than the inner and with more rounded tips; achenes without squamellae filling the gap between the awns; heads rounded on the lower surface ..... *A. reitzii*
- 5. Leaves with firm flattened margins; outer involucre bracts not shorter than the inner; achenes with squamellae filling the

- gap between the awns; heads with mostly tapering sides ... *A. hatschbachii*
1. Leaves mostly or completely opposite ..... 6
  6. Leaves sessile or tapering to the base; petiole indistinct, 1 mm or less long ..... 7
  7. Leaves linear; involucre bracts subequal in length . *A. oppositifolium*
  7. Leaves elliptical to oblong; outer involucre bracts foliose, often longer than the inner bracts ..... 8
  8. Leaf blades narrowly acute and attenuate at the base *A. hieronymi*
  8. Leaf blades broadly acute at the base ..... *A. paraquariense*
  6. Leaves with distinct petiole 4 mm or more long ..... 9
  9. Achenes with awns  $\frac{1}{3}$  or less the length of the body; wings interrupted or lobate ..... 10
  10. Leaf blades lanceolate, gradually narrowed at the base ..... *A. indutum*
  10. Blades of larger leaves ovate, rather abruptly narrowed at the base ..... 11
  11. Tips of involucre bracts reflexed; achenes with short but distinct awns ..... *A. bahiense*
  11. Tips of involucre bracts not reflexed, erect; achenes without distinct awns ..... *A. tenuifolium*
  9. Achenes with awns mostly  $\frac{1}{2}$  or more as long as the body; wings broad, uninterrupted ..... 12
  12. Leaves short-acute to obtuse; achenes incompletely squamellose between the awns; outer involucre bracts not longer than the inner ..... *A. grisebachii*
  12. Leaves narrowly acute; achenes completely squamellose between the awns; outer involucre bracts often longer than the inner ..... 13
  13. Leaves with numerous, smaller, more erect hairs on the lower surface between major veins, lower surface sparsely and minutely glanduliferous ..... *A. pseudosilphioides*
  13. Leaves without more numerous, smaller, more erect hairs on the lower surface, with numerous glandular punctations ..... *A. aspilioides*

The genus *Angelphytum* as presently recognized contains the following 14 species.

*Angelphytum arnottii* (Baker) H. Robinson, comb. nov.

*Verbesina arnottii* Baker in Martius, Fl. brasil. 6(3):215. 1884. *Zexmenia arnottii* (Baker) Hassler, Fedde Repert. 14:264. 1916. Northern Argentina, Brazil: Mato Grosso, Paraná, Paraguay.

*Angelphytum aspilioides* (Grisebach) H. Robinson, comb. nov.

*Verbesina aspilioides* Grisebach, Abh. Königl. Ges. Wiss. Göttingen 24:194. 1879. *Zexmenia aspilioides* (Griseb.) Hassler, Fedde Repert. 14:158. 1915. Argentina, Paraguay.

*Angelphytum bahiense* H. Robinson, sp. nov.

Plantae herbaceae perennes ad 1.5 m altae mediocriter ramosae; xylopodium non visum. Caules pallide rubescentes subteretes leniter striati minute strigulosi et sparse glandulo-punctati. Folia opposita, petiolis distinctis 4–15 mm longis; laminae ovatae plerumque 3.5–7.0 cm longae et 1.2–3.4 cm latae base late obtusae abrupte anguste decurrentiter acuminatae fere ad basem trinervatae margine multo serrulatae apice acutae supra dense minute scabridae sparse glandulo-punctatae subtus in nervis primariis et secundariis albidae et dense strigulosae cetera pallide virides dense subvelutine pilosulae et dense glandulo-punctatae. Inflorescentiae in ramis terminales 1–3-capitatae, pedunculis plerumque 2.5–8.0 cm longis. Capitula late campanulata ca. 7–9 mm alta; squamae involucri exteriores ca. 12–14 herbaceae vel distaliter herbaceae oblongae vel anguste ellipticae 7–17 mm longae et 2–5 mm latae apice recurvatae in partibus herbaceis foliiformes in partibus basilaribus pallide subscariosae dense scabridae et sparse glandulo-punctatae; bractae interiores et paleae pallide scariosae oblongo-lanceolatae ca. 7 mm longae et 2 mm latae margine puberulo-fimbriatae superne irregulariter paucè dentatae et minute serrulatae apice breviter acutae vel minute apiculatae extus superne ad medio multo glandulo-punctatae. Flores radii ca. 10 in capitulo; corollae flavae, tubis angustis ca. 1.5 mm longis pilosulis, limbis anguste oblongis ca. 10 mm longis et ca. 3 mm latis extus pilosulis et dense glandulo-punctatis. Flores disci ca. 30 in capitulo; corollae flavae tenues 4.0–4.5 mm longae, tubis ca. 1 mm longis glabris, faucibus cylindraceis base campanulatis ca. 2.7–3.0 mm longis inferne glabris superne paucè glanduliferis et in nervis setuliferis, lobis ovato-triangularibus ca. 0.7 mm longis et 0.6 mm latis extus glanduliferis intus praeter basem extremam dense breviter papillosis; filamenta in partibus superioribus ca. 0.45 mm longis valde inflata; thecae antherarum ca. 1.8 mm longae; appendices antherarum flavae ovatae ca. 0.35 mm longae et 0.3 mm latae extus glanduliferae; rami stylorum contorti vel spiraliter recurvati extus et in apicibus scaporum dense glanduliferi. Achaenia leniter complanata interdum triangularia vel subquadrangularia ca. 3.5 mm longae base angustiora superne pustulifera margine anguste lobato-alata; aristae pappi 2 breviter 0.5–1.0 mm longae; squamellae pappi in marginis lateralibus connatae irregulariter denticulatae. Grana pollinis in diametro ca. 26  $\mu$ m.

*Type*.—BRAZIL; Bahía: Espigão Mestre. Extensive limestone outcrop 6 km S of Cocos, and adjacent pastures; elev. 520 m. Perennial herb 1.5 m tall; flowers yellow. 16 Mar 1972. W. R. Anderson, M. Stieber, J. H. Kirkbride, Jr. 37028 (Holotype UB; isotype US).

*Angelphytum bahiense* occurs well to the northeast of other known members of the genus. The new species has opposite, petiolate, broadly bladed leaves, and lobate-margined achenes with reduced awns which indicates relationship to *A. tenuifolium* of northern Argentina and Paraguay. The present species is most easily distinguished by the recurved tips on the involucrel bracts and the presence of any pappus awns.

*Angelphytum grisebachii* (Baker) H. Robinson, comb. nov.

*Verbesina grisebachii* Baker in Martius, Fl. brasil. 6(3):214. 1884. *Zexmenia grisebachii* (Baker) Hassler, Fedde Repert. 14: 157. 1915. Argentina, Paraguay, Uruguay.



*Angelphytum hatschbachii* H. Robinson, sp. nov.

Plantae herbaceae perennes ad 50–75 cm altae non vel pauce ascendenter ramosae; xylopodium distinctum. Caules rubescentes teretes dense antrorse strigosi. Folia alterna aliquantum dense spiraliter inserta ascendenter sessilia linearia vel anguste elliptica plerumque 1.0–2.5 cm longa et 1–2 mm lata margine integra plana vel leniter inflexa apice breviter acuta supra et subtus dense breviter strigosa subtus distincte tricostata et interdum subtiliter ascendenter pinnato-nervata. Inflorescentiae in ramis solitariae terminales, pedunculis ca. 2–3 cm longis dense canescentiter antrorse strigosis. Capitula late infundibularia 9–11 mm alta; squamae involucri ca. 20 ca. 2-seriatae anguste oblongae 7–9 mm longae et 1.5–2.0 mm latae apice breviter acutae extus dense canescentiter strigosae interiores margine late glabrae scariosae; paleae fulvescentes ca. 8 mm longae distaliter oblongo-ovatae planae apice breviter pungentiter acutae extus subglabrae. Flores radii ca. 12 in capitulo; corollae flavae, tubis angustis ca. 1.3 mm longis glabris, limbis anguste oblongis ca. 8 mm longis et 2.7 mm latis extus setiferis et dense glandulopunctatis margine in sinibus minute puberulis. Flores disci ca. 25 in capitulo; corollae flavae 4.0–4.3 mm longae; tubis ca. 0.8 mm longis glabris; faucibus cylindraceis base campanulatis ca. 2.7 mm longis glabris, lobis ovato-triangularibus ca. 0.7 mm longis et 0.6 mm latis extus superne multo glandulopunctatis apice pauce spiculiformiter papillosis in sinibus pauce puberulis intus praeter basem extremam dense breviter papillosis; filamenta in partibus superioribus ca. 0.35 mm longa valde incrassata; thecae antherarum 1.8–2.0 mm longae; appendices antherarum flavae ovatae ca. 0.4 mm longae et 0.35 mm latae extus glanduliferae; rami stylorum longi-lineares valde recurvati extus supra mediam distincte glanduliferi. Achaenia complanata vel triquetra ca. 5 mm longa et 1.5 mm lata (ala exclusa) margine late alata in superficiis lateralibus superne sensim multo setulifera; aristae pappi 1–3 anguste subulatae triquetrae 2–3 mm longae in alis angustis interaristatis margine lateralibus breviter setulifera. Grana pollinis in diametro ca. 27  $\mu$ m.

*Type*.—BRAZIL: Mato Grosso do Sul: Ponta Porã, 30 km O. Campo limpo. Alt. 800 m. Ereta, capitulos amarelos. 11 Feb 1983. G. Hatschbach 46131 (Holotype MBM; isotype US).

*Angelphytum hatschbachii* is one of two species described here with spirally inserted linear leaves. From the other, *A. reitzii*, the present species differs by the subequal lengths of the involucre bracts, the more tapering rather than basally rounded shape of the head, the leaves without recurved margins, the achenes with a more continuous setuliferous wing between the awns, and the disk corolla lobes that have no setulae outside but have longer spiculiform papillae outside at the tip.

*Angelphytum hieronymi* (Hassler) H. Robinson, comb. nov.

*Zexmenia hieronymi* Hassler, Fedde Repert. 14:157. 1915. Argentina, Paraguay.

*Angelphytum indutum* (Chod.) H. Robinson, comb. nov.

*Aspilia induta* Chod. in Chod. & Hassler, Bull. Herb. Boiss., ser. 2, 3:720. 1903.

*Zexmenia induta* (Chod.) Hassler, Fedde Repert. 14:180. 1915. Paraguay.

*Angelphytum matogrossense* G. M. Barroso

*Angelphytum matogrossense* G. M. Barroso, Bol. Soc. Argent. Bot. 19(1–2):9. 1980. Brazil: Mato Grosso.

*Angelphytum myrtifolium* (Chod.) H. Robinson, comb. nov.

*Verbesina myrtifolia* Chod. in Chod. & Hassler, Bull. Herb. Boiss., ser. 2, 2:393. 1902. *Zexmenia myrtifolia* (Chod.) Hassler, Fedde Repert. 14:180. 1915. Brazil: Mato Grosso, Paraguay.

*Angelphytum oppositifolium* (Saenz) H. Robinson, comb. nov.

*Zexmenia oppositifolia* Saenz, Hickenia 1(54):285. 1982. Argentina: Misiones, Brazil: Santa Catarina.

*Angelphytum paraguariense* (Chod.) H. Robinson, comb. nov.

*Verbesina paraguariensis* Chod. in Chod. & Hassler, Bull. Herb. Boiss., ser. 2, 3: 722. 1903. *Zexmenia paraguariensis* (Chod.) Blake, Contrib. Gray Herb., n.s., 52:52. 1917. Paraguay.

*Angelphytum pseudosilphioides* (Hassler) H. Robinson, comb. nov.

*Zexmenia pseudosilphioides* Hassler, Fedde Repert. 14:263. 1916. Paraguay.

*Angelphytum reitzii* H. Robinson, sp. nov.

Plantae herbaceae perennes ad 50–60 cm altae non vel paucè ascendenter ramosae; xylopodium distinctum. Caules rubescentes teretes dense antrorse vel leniter subpatenter strigosi raro hispidi. Folia alterna aliquantum dense spiraliter inserta ascendenter sessilia linearia vel anguste elliptica plerumque 1–5 cm longa et 0.15–0.35 mm lata integra margine distincte leniter reflexa apice breviter acuta supra et subtus dense strigosa subtus solum in nervis primariis prominentia. Inflorescentiae in ramis terminales plerumque 1–2-capitatae, pedunculis 1–2 cm longis dense canescentiter antrorse strigosis. Capitula late campanulata 8–10 mm alta; squamae involucri exteriores 6–10 oblongae herbaceae 5–8 mm longae et 1.5–2.0 mm latae integrae apice obtusae extus dense canescentiter strigosae; bractae interiores 12–14 oblongo-lanceolatae ad 8–9 mm longae et 2 mm latae breviter acutae margine inferne scariosae superne leniter sinuatae dense hirtello-fimbriatae extus ad medio late dense canescentiter strigosae; paleae bracteis interioribus similes angustius acutae margine scabridulae extus sparsius strigosae. Flores radii 12–14 in capitulo; corollae flavae, tubis angustis ca. 2 mm longis subglabris, limbis anguste oblongis ca. 10 mm longis et 2.5 mm latis extus setuliferis minute puberulis et dense glandulo-punctatis. Flores disci ca. 50–70 in capitulo; corollae flavae 4.0–4.5 mm longae; tubis 1.0–1.5 mm longis glabris, faucibus cylindraceis base campanulatis ca. 2.5 mm longis glabris vel superne in nervis paucè setuliferis, lobis ovato-triangularibus ca. 0.8 mm longis et 0.6 mm latis extus sporadice setuliferis et minute multo glanduliferis intus praeter basem extremam dense breviter papillois; filamenta in partibus superioribus ca. 0.35 mm longa valde incrassata; thecae antherarum ca. 2 mm longae; appendices antherarum flavae ovatae ca. 0.35 mm longae et latae extus glanduliferae; rami stylorum longe lineares spiraliter contorti extus et in apicibus scaporum glanduliferi supra mediam distincte puberuli. Achnaenia complanata vel triquetra ca. 3.5–4.0 mm longa et 1.0–1.5 mm lata vix vel late alata in superficiis lateralibus minute setulifera; aristae

pappi 1–3 anguste subulatae triquetrae 1.5–2.0 mm longae, marginis interaristatis interrupte alatae et vix squamelliferae. Grana pollinis in diametro ca. 25–27  $\mu\text{m}$ .

*Type*.—BRAZIL: Paraná: Mun. Guarapuava. Fazenda 3 Capões, do campo sêco. Xilopodifera, 50 cm de altura, capitulos amarelos. 19/I/1968. G. Hatschbach 18327 (Holotype MBM; isotype US).

*PARATYPES*.—BRAZIL: Paraná: Guarapuava. Fazenda 3 Capões. Campo. Alt. 1000 m. Erva, flôr amarela. 16 Dec 1965.—Reitz & Klein 17756 (US); Santa Catarina: Mun. Xanxerê. 4 km north of Abelardo Luz, campo, alt. 500–600 m. 25 Dec 1956.—L. B. Smith & Pe. R. Reitz 9250 (US); 7 km north of Abelardo Luz, campo, alt. 500–600 m. 19 Feb 1957.—L. B. Smith & R. Klein 11481 (US); Mun. Chapecó, Fazenda Campo São Vicente 24 km west of Campo Erê, campo, by rancho, alt. 900–1000 m. 20–21 Feb 1957. L. B. Smith & R. Klein 11557 (US).

The distinctions of *Angelphytum reitzii* are discussed above under the closely related *A. hatschbachii*. One of the paratype specimens, Smith & Klein 11557, differs from the other specimens by having a more hispid or hirtellous rather than strigose pubescence.

*Angelphytum tenuifolium* (Hassler) H. Robinson, comb. nov.

*Zexmenia tenuifolia* Hassler, Fedde Repert. 14:178. 1915. Argentina, Paraguay.

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- . 1984b. Studies in the Heliantheae (Asteraceae). XXXIII. New species of *Aspilia* from South America.—Phytologia 55:415–423.
- . 1984c. Studies in the Heliantheae (Asteraceae). XXXI. Additions to the genus *Dimerostemma*.—Proceedings of the Biological Society of Washington 97(3):618–626.

Department of Botany, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.



## BIOLOGICAL SOCIETY OF WASHINGTON PROCEEDINGS

111th Annual Meeting, 4 May 1984

Dr. David Pawson called the meeting to order at 12:06 PM. Apologies were relayed for the Editor and Acting Editor, who could not attend the meeting. Results of the election for Society officers were announced: President, Dr. Donald Davis; Vice-President, Dr. Austin Williams; Secretary, Dr. Gordon Hendler; Treasurer, Dr. Leslie Knapp. The councillors elected were Dr. J. Laurens Barnard, Dr. Frederick M. Bayer, Dr. Isabelle Canet, Ms. Maureen Downey, Dr. Louis Kornicker, and Dr. Storrs Olsen.

Dr. Pawson summarized two major activities of the Society during the past year, the Symposium on Hydrothermal Vents at the Annual Meeting of the American Society of Zoologists, and passage of the Society's revised Constitution. Dr. Pawson noted that the vote in favor of the new Constitution had been overwhelming. He reviewed changes in editorial policy of the Proceedings regarding "free" pages.

The Treasurer's Report was tendered by Dr. Leslie Knapp. Dr. Knapp indicated that he would inform the IRS of the Constitutional changes. He reported on the Society's First Variable Rate Fund and on the Society's monies used for Hydrothermal Vent Symposium activities. Most important, he stated that the net worth of the Society, which had been declining, stabilized during the current year.

Speaking for the editors of the Proceedings, Dr. Pawson reported that Volume 96 had been published and that three numbers of Volume 97 were in press. Volume 97 will bear a new, two-tone cover designed by the editor, Dr. Brian Kensley. In his report, Dr. Kensley paid special thanks to Associate Editor, Mr. George Steyskal and to Dr. Stephen Cairns, the Acting Editor for 3 months during 1983-84. Dr. Bruce Collette suggested that an ISSN number be incorporated in the new cover for the benefit of abstracting services.

Dr. Meredith Jones reported that sources of funding for the Hydrothermal Vent Symposium include the Smithsonian Institution, NSF, the National Geographic Society, and NOAA. In addition, he presented an account of Symposium expenditures. The Symposium was held 27-28 December 1983, during the ASZ meeting in Philadelphia. Proceedings Bulletin #6 will include 37 papers presented at the Symposium, and 3 manuscripts reporting on post-Symposium developments in the field. The Bulletin is expected to number 350-375 pages, and should appear in November, 1984. Dr. Jones indicated that a number of pre-publication orders for the Bulletin have been received, and that arrangements are being made to advertise the Bulletin in appropriate newsletters and journals. As a result of the Symposium, the Society recruited several new members.

Minutes were read of the Biological Society of Washington meeting held in Philadelphia on 28 December 1983.

The invitation to the Society, to organize symposia at future ASZ meetings was discussed. The discussants favored the production of occasional symposia as special topics developed, rather than regular, annual paper sessions. Dr. Pawson presented a report on the attendance statistics at the Philadelphia meeting transmitted to the Society by Ms. Mary Wiley of the ASZ. ASZ also submitted an

advertisement for ASZ which the Council deemed should be considered for publication in the Proceedings on a space available basis.

A letter will be sent to ASZ, indicating that the Society looks forward to future collaboration, but that annual Society symposia are not planned.

A request was considered for financial support of the new American Association of Zoological Nomenclature. As explained in a brochure supplied by Dr. Ellis Yochelson, the purpose of the Association is to promote the correct use of zoological nomenclature and to support the International Trust for Zoological Nomenclature. Dr. Collette reviewed the current activities of the AAZN and reported that Secretary S. Dillon Ripley had promised continuing support of the Smithsonian Institution and that other agencies had also promised assistance. The level of support appropriate for the Biological Society was considered. In addition, Dr. Pawson suggested that the AAZN brochure be more widely advertised, and Dr. Robert Higgins noted that the Society dues slip could be modified so that tax exempt donations to the AAZN could be collected. A motion was unanimously carried that the Council favors support of the AAZN. Dr. Knapp suggested that, at this time, the Society treasury could provide an amount less than \$1000 to the AAZN.

The meeting was adjourned at 12:50 PM.

Respectfully submitted,  
Gordon Hendler  
Acting Secretary  
11 July 1984

## INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE

% British Museum (Natural History)  
Cromwell Road  
London W5 5BD

The Commission hereby gives six months notice of the possible use of its plenary powers in the following cases, published in the *Bulletin of Zoological Nomenclature*, volume 41, part 3, on 23 August, 1984 and would welcome comments and advice on them from interested zoologists.

Correspondence should be addressed to the Secretary at the above address, if possible within six months of the date of publication of this notice.

### Case No.

- 2474 International Code of Zoological Nomenclature: amendment proposed to third edition: proposal concerning Article 51c.
- 2475 International Code of Zoological Nomenclature: proposed amendment to third edition: Article 59b.
- 2476 Request for a declaration clarifying the meaning of the expressions 'Suppressed for nomenclatural purposes,' 'Rejected for nomenclatural purposes' and the status of information in works that are rejected under Articles 8 and 9 of the Code.
- 2477 A proposed amendment of Article 70b of the International Code of Zoological Nomenclature on misidentified type species.
- 2237 *Williamia* Monterosato, 1884 (Mollusca, Gastropoda): proposed conservation.
- 239 *Tibicina* Amyot, 1847 and *Lyristes* Horváth, 1926 (Insecta, Hemiptera, Homoptera): proposed conservation by the suppression of *Tibicen* Berthold, 1827. Also, arguments pour la suppression du nom de genre *Tibicen* et de ses dérivés dans la nomenclature de la superfamille CICADOIDEA.
- 1750 *Rana maculata* Brocchi, 1877 and *Eleutherodactylus richmondi* Stejneger, 1904 (Amphibia, Salientia): proposed conservation.
- 2142 *Hypocryphalus mangiferae* (Stebbing, 1914) (Insecta, Coleoptera): proposed conservation under the plenary powers.

R. V. MELVILLE  
Secretary



## INFORMATION FOR CONTRIBUTORS

*Content.*—The *Proceedings* of the Biological Society of Washington contains papers bearing on systematics in the biological sciences (botany, zoology, and paleontology), and notices of business transacted at meetings of the Society. Except at the direction of the Council, only manuscripts by Society members will be accepted. Papers will be published in English (except for Latin diagnosis/description of plant taxa which should not be duplicated by an English translation), with a summary in an alternate language when appropriate.

*Publication Charges.*—Authors will be asked to assume publication costs of page-charges, tabular material, and figures, at the lowest possible rates.

*Submission of manuscripts.*—Manuscripts should be sent to the Editor, *Proceedings* of the Biological Society of Washington, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

*Review.*—One of the Society's aims is to give its members an opportunity for prompt publication of their shorter contributions. Manuscripts will be reviewed in order of receipt by a board of associate editors and appropriate referees.

*Presentation.*—Clarity of presentation, and requirements of taxonomic and nomenclatural procedures necessitate reasonable consistency in the organization of papers. Telegraphic style is recommended for descriptions. Synonymy of abbreviated style (author, date, page) (except in botanical papers), with full citations of journals and books (no abbreviations) in the Literature Cited is required.

The establishment of new taxa must conform with the requirements of the appropriate international codes of nomenclature. Authors are expected to be familiar with these codes and to comply with them. New species-group accounts must designate a type-specimen deposited in an institutional collection.

The sequence of material should be: Title, Author(s), Abstract, Text, Acknowledgments, Literature Cited, Author's (s') Address(es), Appendix, List of Figures (entire figure legends), Figures (each numbered and identified), Tables (each table numbered with an Arabic numeral and heading provided).

Manuscripts should be typed, double-spaced throughout (including tables, legends, and footnotes) on one side of 8½ × 11 inch sheets, with at least one inch of margin all around. Submit a facsimile with the original, and retain an author's copy. Pages must be numbered on top. One manuscript page = approximately 0.5 printed page. Underline singly scientific names of genera and lower categories; leave other indications to the editor.

Figures and tables with their legends and headings should be self-explanatory, not requiring reference to the text. Indicate their approximate placement by a pencil mark in the margin of the manuscript.

Illustrations should be planned in proportions that will efficiently use space on the type bed of the *Proceedings* (12.5 × 20 cm) and should not exceed 24 × 15 inches. Figures requiring solid black backgrounds should be indicated as such, but not masked.

Art work will be returned only on request.

*Proofs.*—Galley proofs will be submitted to authors for correction and approval. Reprint orders will be taken with returned proof.

*Costs.*—Page charges @ \$60.00, figures @ \$10.00, tabular material \$3.00 per printed inch.

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