

# BOMOLOCHID COPEPODS PARASITIC ON THE EYES OF INDO-WEST PACIFIC CLUPEID FISHES

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## ABSTRACT

Three genera of bomolochid copepods (*Pumiliopes*, *Pumiliopsis*, *Pseudorbitacolax*) parasitic on the eyes of Indo-West Pacific clupeid fishes are redefined. *Pseudorbitacolax fimbriatus* new species is described, *Pseudorbitacolax varunae* (Bennet) is redescribed, *Orbitacolax nudus* Cressey and Boyle is transferred to the genus *Pseudorbitacolax*, *Pumiliopsis emarginatus* Cressey and Boyle is placed in synonymy with *Pumiliopsis sardinellae* (Bennet), and *Pumiliopes capitulatus* Cressey and Boyle is placed in synonymy with *Pumiliopes jonesi* (Bennet). Included also is a key to the genera of bomolochid copepods parasitic on the eyes of Indo-West Pacific clupeids and scanning electron micrographs of three species.

In 1973 we described five new bomolochid copepods collected from the eyes of Indo-West Pacific clupeid fishes housed in the Smithsonian (USNM) collections. Since then we have collected more copepods (including one new species) from clupeids in the collections of the Museum of Comparative Zoology at Harvard University (MCZ) and the British Museum (Natural History) (BM).

Examination of these additional collections (Table 1) enabled us to redescribe the three genera of bomolochids (*Pumiliopes*, *Pumiliopsis*, *Pseudorbitacolax*) parasitic on the eyes of Indo-West Pacific clupeid hosts, to transfer *Orbitacolax nudus* Cressey and Boyle to the genus *Pseudorbitacolax* Pillai, and to place *Pumiliopsis emarginatus* Cressey and Boyle in synonymy with *Pumiliopsis sardinellae* (Bennet), and to place *Pumiliopes capitulatus* Cressey and Boyle in

synonymy with *Pumiliopes jonesi* (Bennet). This paper also includes scanning electron micrographs of some species and a summary of the results of our later collections.

### Key to the Genera of Female Bomolochids Parasitic on the Eyes of Indo-West Pacific Clupeid Fishes

- 1a. Legs 2-4 exopods 2-segmented ..... 2
- 1b. Legs 2-4 exopods 3-segmented  
..... *Pseudorbitacolax*
- 2a. Legs 2-4 exopod last segment with  
barbed or serrate spine ..... *Pumiliopsis*
- 2b. Legs 2-4 exopod last segment with smooth,  
clawlike spine ..... *Pumiliopes*

### *Pseudorbitacolax* Pillai 1971

**Diagnosis.**—Bomolochidae. Female: Body dorsoventrally flattened. Rostrum rounded or bilobed. Abdomen 2- or indistinctly 3-segmented. Caudal rami each with one long, five short setae. First antenna with no modified setae. Last segment of second antenna with few to many hooklets, four hooked spines, and two setae terminally. Maxilliped claw with no outer accessory process. Legs 1-4 biramous. Leg 1 flattened, rami 2-segmented. Rami of legs 2-4 3-segmented, last segment of exopods each with apical barbed or serrate spine. Second endopod segment of leg 2 with two inner setae. Second endopod segment of legs 3 and 4 each with one inner seta.

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TABLE 1.—Indo-West Pacific clupeids and the copepods parasitic on their eyes.

Host	Parasite
<i>Anodontostoma chacunda</i>	<i>Pseudorbitacolax varunae</i>
<i>Clupanodon punctatus</i>	<i>Pumiliopes jonesi</i>
<i>Herklotsichthys dispilonotus</i>	<i>P. jonesi</i>
<i>H. punctatus</i>	<i>Pseudorbitacolax nudus</i>
<i>Sardinella albella</i>	<i>Pumiliopsis sardinellae</i>
<i>S. bulan</i>	<i>P. sardinellae</i>
<i>S. fimbriata</i>	<i>Pumiliopes squamosus</i>
	<i>Pumiliopsis sardinellae</i>
<i>S. jussieui</i>	<i>Pseudorbitacolax fimbriatus</i>
	<i>Pumiliopes squamosus</i>
<i>S. sirm</i>	<i>Pumiliopsis sardinellae</i>
<i>S. zunasi</i>	<i>P. plautus</i>
	<i>Pumiliopes squamosus</i>

*Male*.—Rostrum slightly produced, broader than long. Thoracic segments each slightly narrower than preceding segment. Genital segment longer than broad. Abdomen 2-segmented. Caudal rami each with one very long and five shorter setae. First antenna extending beyond margins of cephalothorax, with numerous long slender setae. Second segment of maxilliped ornamented on inner surface with numerous small, knoblike spinules, one long seta, and a row of short spinules; terminal segment in form of a claw armed with stout teeth along entire inner margin apposing second segment. Legs 1-4 biramous, rami 3-segmented except endopod of leg 4 2-segmented. Leg 1 endopod flattened. Second endopod segment of legs 2 and 3 each with two inner setae.

*Type-species*.—*Pseudorbitacolax varunae* (Bennet 1966).

*Remarks*.—In placing two more species in this genus we have been able to modify Pillai's (1971) original generic diagnosis, especially with regard to the size and shape of the rostrum and the first maxilla. As with *Pumiliopsis*, the structure of the rostrum is a specific rather than a generic character. The three setae of the first maxilla are of variable lengths rather than all small as stated by Pillai.

Our diagnosis of the male is based on a single, damaged specimen of *Pseudorbitacolax fimbriatus* and, as such, must be considered tentative until additional material is collected.

*Pseudorbitacolax fimbriatus*  
new species (Figures 1-17)

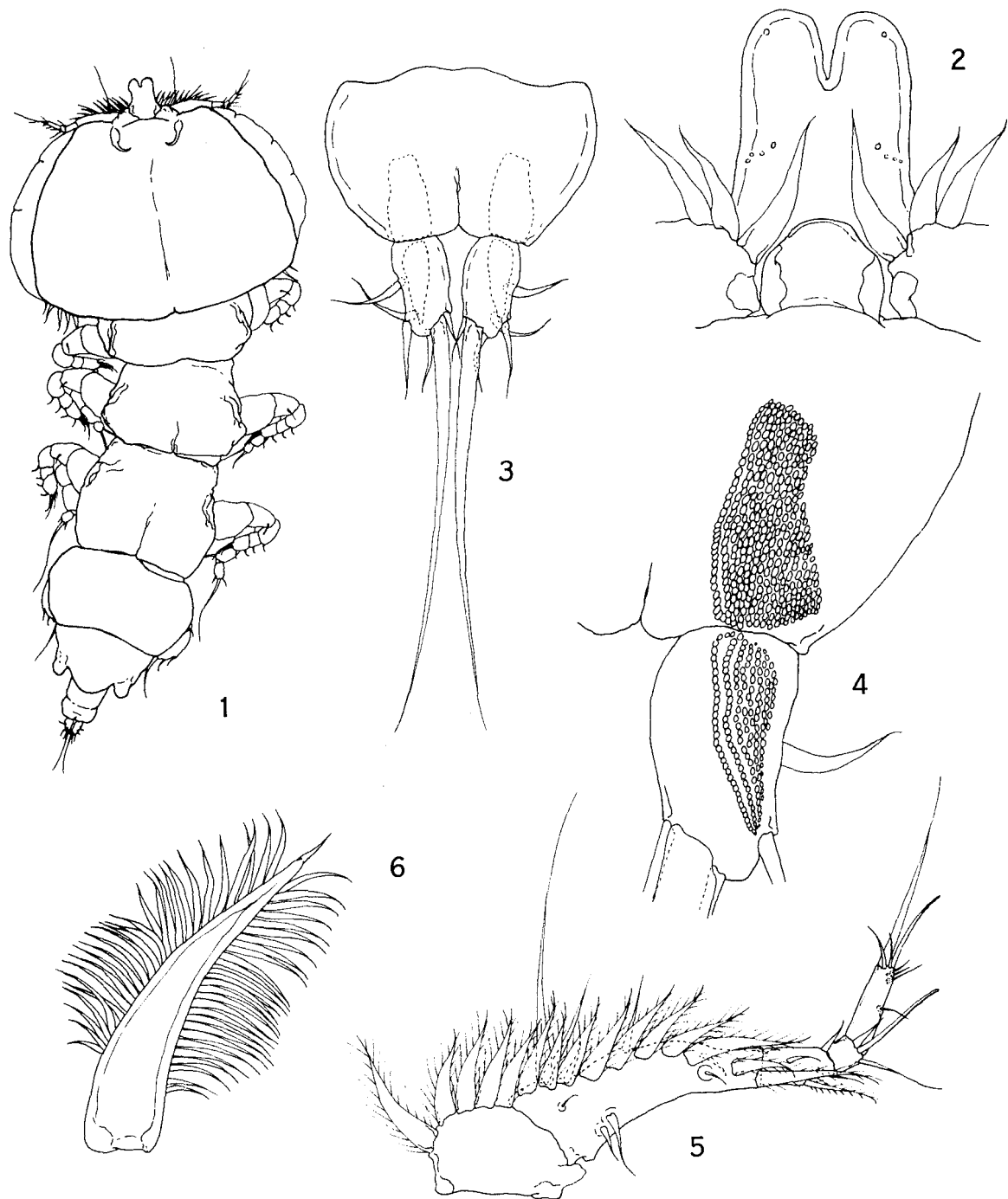
*Material examined*.—Two collections containing 3 ♀ 1 ♂ (holotype ♀ USNM 173021, allotype ♂ USNM 173022, two paratype ♀ USNM 173023) from the eyes of two *Sardinella fimbriata* (BM 1972.9.5.22, BM 1972.9.5.25) from New Guinea.

*Female*.—Body form as in Figure 1. Total length 3.66 mm; greatest width 1.60 mm (measured at widest part of cephalothorax). Cephalothorax length 1.42 mm and with lateral marginal membranes. Rostrum (Figure 2) with bilobed tip, each lobe gently rounded, with two dorsal hooks near base; rostrum length 236  $\mu\text{m}$ , width at base 206  $\mu\text{m}$ . Genital segment (see Figure 1) wider than long (389  $\times$  601  $\mu\text{m}$ ) with a greatly rounded process at each outer distal corner. Abdomen

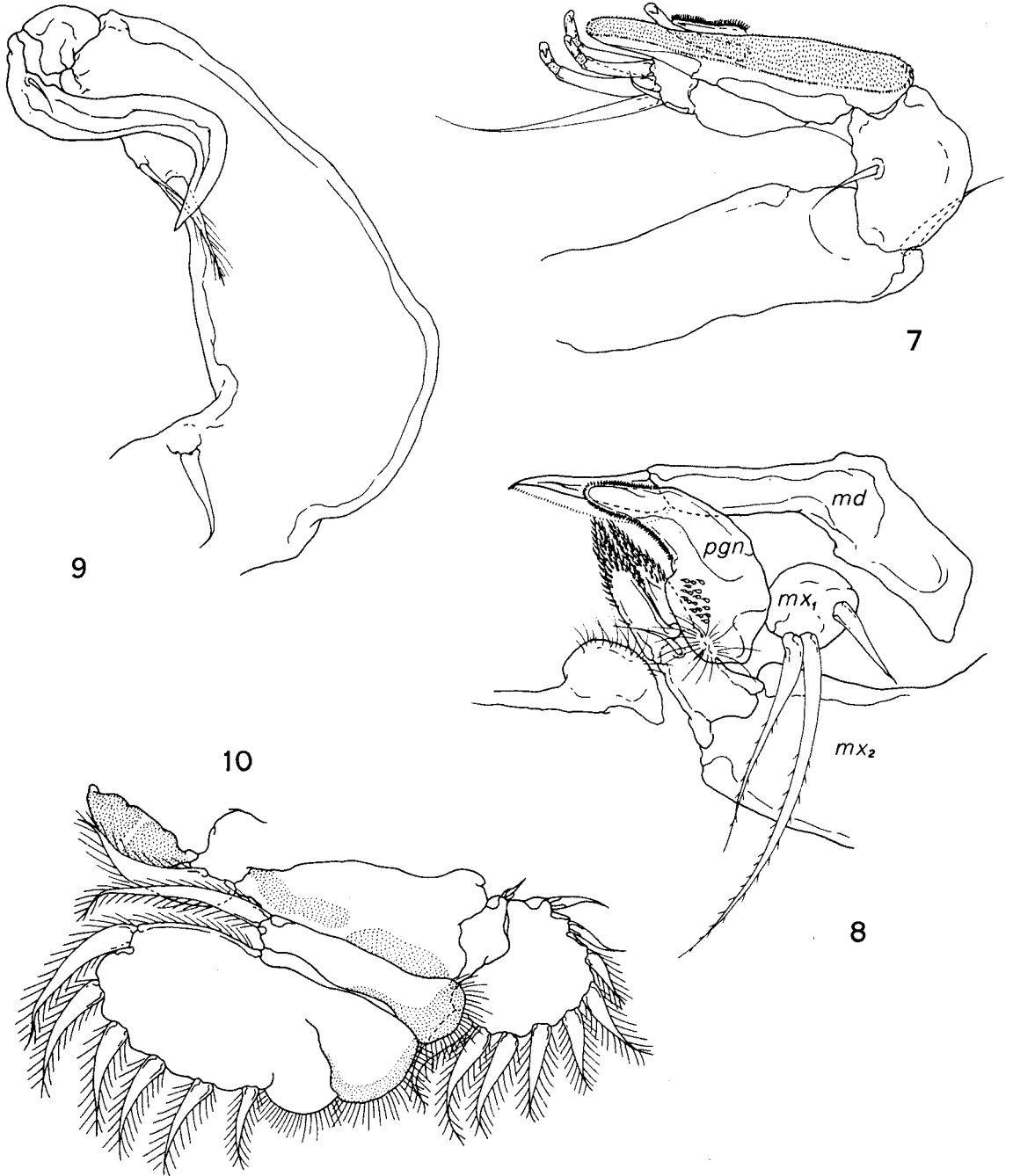
2-segmented: first segment wider than long (118  $\times$  224  $\mu\text{m}$ ) without ornamentation; second segment wider than long (94  $\times$  200  $\mu\text{m}$ ) with two ventral patches of scalelike spinules arranged in uneven longitudinal rows (see Figures 3 and 4). Caudal rami (Figure 3) longer than wide (82  $\times$  53  $\mu\text{m}$ ); each ramus with a patch of scalelike spinules in rows (Figure 4) and six setae (longest seta 289  $\mu\text{m}$ ).

First antenna (Figure 5) 5-segmented: basal two segments with 9 naked and 15 plumose setae; latter with broad, flattened plumosities (Figure 6); an aesthete present on each of last two segments. Second antenna (Figure 7) with several rows of minute spinules on third segment, four hooked spines, and two setae distally. Labrum with two large patches of scalelike spinules. Mandible, paragnath, first maxilla, and second maxilla as in Figure 8. Labium represented as a small, rounded, hairy lobe posterior to mouth. Base of maxilliped (Figure 9) posterior to oral area, armed with four setae and a strongly curved hook without an accessory process.

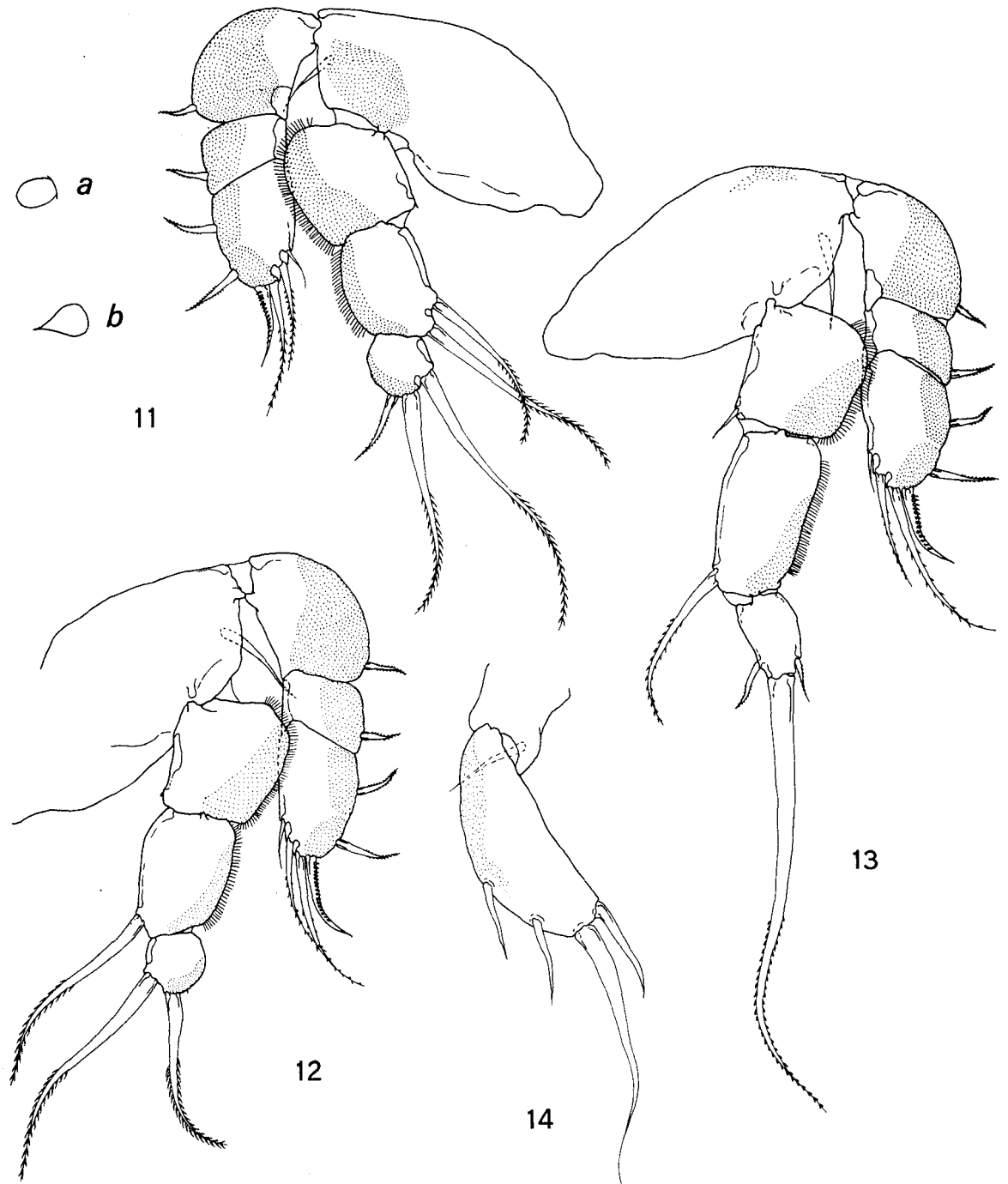
Legs 1-4 biramous, rami of legs 2-4 3-segmented. Leg 1 (Figure 10) interpodal plate with two patches of scalelike spinules; coxopod with broad inner seta; basipod with two patches of scalelike spinules; exopod first segment with outer spine, second segment with two naked and seven plumose setae; endopod first segment with outer patch of scalelike spinules and inner plumose seta, second segment with outer patch of scalelike spinules and six plumose setae; outer edges of endopod heavily hirsute. Basipod of leg 2 (Figure 11) with large ventral patch of scalelike spinules and a short dorsal seta; first segment of exopod with patch of scalelike spinules (Figure 11a) covering most of segment and one spine on outer distal corner, second segment with outer spine and outer patch of minute pointed spinules (Figure 11b), third segment with two outer spines, one barbed terminal spine and three inner setae, outer portion of segment with two distinct patches of spinules similar to those on second segment; first segment of endopod with minute, barely perceptible inner seta and a large patch of scalelike spinules, outer edge of segment fringed with short, blunt hairs, second segment with two inner setae and outer patch of scalelike spinules, outer edge of segment fringed with short hairs, third segment with two inner setae, one terminal spine and outer to terminal patch of scalelike spinules. Basipod of leg 3 (Figure 12) with dorsal seta, exopod and first



FIGURES 1-6.—*Pseudorbitacolax fimbriatus*, new species, female: 1, dorsal; 2, rostrum, ventral; 3, last abdominal segment and caudal rami, ventral; 4, same, enlarged; 5, first antenna; 6, first antenna seta.



FIGURES 7-10.—*Pseudorbitacolax fimbriatus*, new species, female (continued): 7, second antenna; 8, mandible, paragnath, first maxilla, second maxilla, labium; 9, maxilliped; 10, leg. 1.



FIGURES 11-14.—*Pseudorbitacolax fimbriatus*, new species, female (continued): 11, leg 2, a, scalelike spinules on endopod and first exopod segment, b, pointed spinules on exopod second and third segments; 12, leg 3; 13, leg 4; 14, leg 5.

segment of endopod similar to leg 2; second segment of endopod similar to leg 2 but with only one inner seta, third segment with two inner to terminal setae and one minute outer seta, outer portion of segment with scalelike spinules. Leg 4 (Figure 13) basipod, exopod, endopod first and second segments similar to leg 3 except first segment of endopod with short but well-developed inner seta; third segment of endopod with three setae (middle longest). Basal segment of leg 5 (Figure 14) with dorsal seta, terminal segment with minute spinules on outer proximal portion and four setae as indicated in the figure. Area of leg 6 obscured by egg sacs and not seen (usually present on bomolochids as three setae on genital segment).

*Male*.—Body form as in Figure 15. Total length 1.14 mm, greatest width 0.44 mm (measured at widest part of cephalothorax). Cephalothorax more or less rounded (length 0.41 mm) with broad rostrum. Genital segment longer than wide ( $247 \times 177 \mu\text{m}$ ) indistinctly separate from segment bearing leg 5. Abdomen 2-segmented: first segment slightly longer than wide ( $65 \times 59 \mu\text{m}$ ); second segment ( $59 \times 88 \mu\text{m}$ ) with two patches of scalelike spinules as in Figure 16. Caudal rami (Figure 16) longer than wide ( $50 \times 35 \mu\text{m}$ ), each with a single row of scalelike spinules and six setae (longest seta  $531 \mu\text{m}$ ).

Maxilliped (Figure 17) 4-segmented: second segment with several uneven rows of small knoblike processes, one seta, and an inner row of uniform spinules, proximal half of outer edge fringed with long hairs; last segment in form of claw with single small, toothlike process near proximal inner corner, inner edge serrate along entire length.

The single specimen examined was not dissected; therefore, detailed inspection of remaining appendages was not possible. The following description is based on gross examination of the specimen. First antenna 5-segmented with several long graceful setae and an aesthete on each of last two segments. Second antenna similar to female except spinules on third segment proportionately larger. Oral appendages similar to female. Legs 1-5 similar to *Pumiliopsis sardinellae* male with the following exceptions. Leg 2 endopod third segment with at least three setae. Leg 3 endopod third segment of *Pseudorbitacolax fimbriatus* damaged and examination not possible.

*Etymology*.—The specific name, *fimbriatus*, refers

to the specific name of the host fish (*Sardinella fimbriata*) from which this copepod was collected.

*Remarks*.—The female of this species can be separated from *P. varunae* and *P. nudus* on the basis of the size and shape of the rostrum; in *P. fimbriatus* it is slightly longer than broad, and in the other two species it is broader than long. The genital segment of *P. fimbriatus* has two prominent rounded processes that are lacking in *P. varunae* and *P. nudus*. Also, the maxilliped hook of *P. fimbriatus* is much more strongly curved than in either of the other two species.

*Pseudorbitacolax varunae*  
(Bennet 1966) (Figures 18-29)

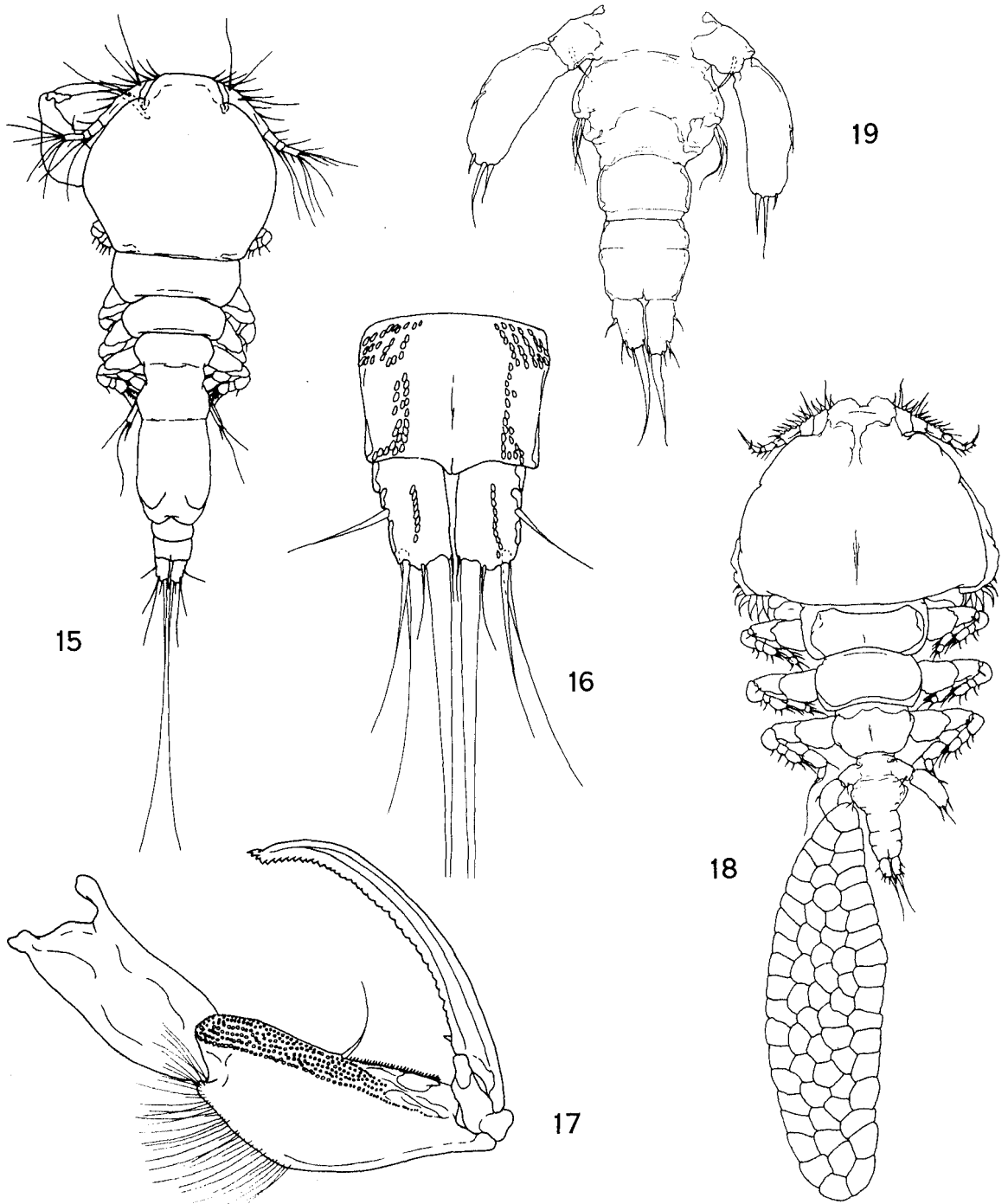
*Syn*: *Bomolochus varunae* Bennet 1966:295.

*Material examined*.—All copepods were collected from the orbit of the host fish, *Anodontostoma chacunda*: 8 ♀ from Manila, Philippine Islands; 4 ♀ from Kerala, India; 4 ♀ from Madras, India; 2 ♀ from Java; 8 ♀ from Sandakan Bay, Borneo.

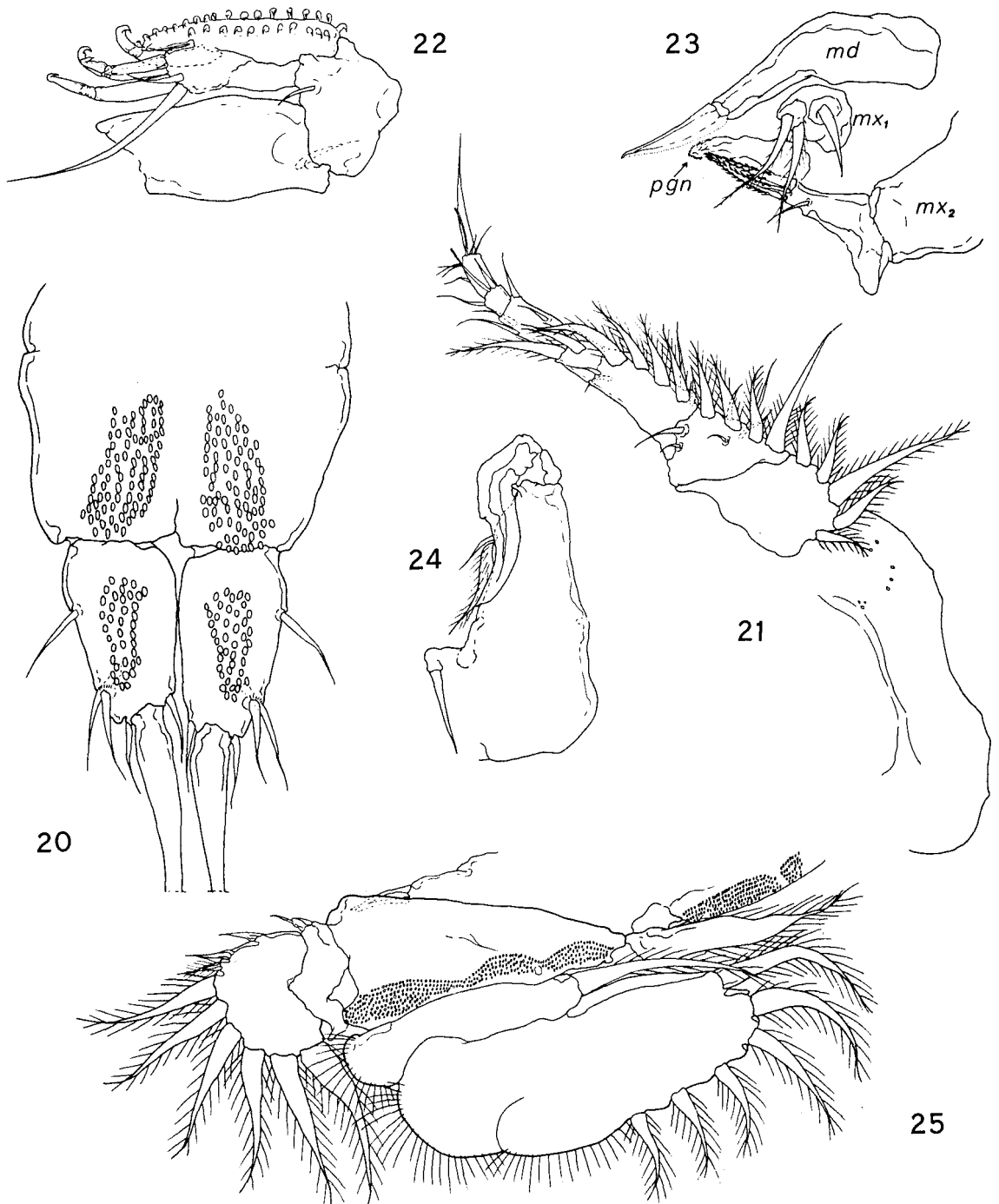
*Female*.—Body form as in Figure 18. Total length 2.01 mm, greatest width 1.07 mm (measured at widest part of cephalothorax); cephalothorax length 0.88 mm. Rostrum (see Figure 21) wider than long ( $106 \times 601 \mu\text{m}$ ) with no dorsal or ventral hooks. Genital segment (Figure 19) wider than long ( $147 \times 253 \mu\text{m}$ ). Abdomen (see Figure 19) 3-segmented, segmentation incomplete between second and third segments; segments measure (length  $\times$  width)  $88 \times 153 \mu\text{m}$ ,  $53 \times 153 \mu\text{m}$ , and  $76 \times 141 \mu\text{m}$ ; third segment (Figure 20) with two ventral patches of scalelike spinules. Caudal rami (Figure 20) longer than wide ( $118 \times 47 \mu\text{m}$ ), each ramus with ventral patch of scalelike spinules and six setae; longest seta  $165 \mu\text{m}$ .

First antenna (Figure 21) 7-segmented with an aesthete on each of the last two segments; plumose setae similar to those of *P. fimbriatus*. Second antenna (Figure 22) with 2 or 3 rows of conspicuous hooked spinules on third segment, four hooked spines and two setae distally. Mandible, paragnath, first maxilla, and second maxilla as in Figure 23; labrum with two large patches of scalelike spinules. Maxilliped (Figure 24) hook only slightly curved, with small, inner, toothlike projection.

Legs 1-4 biramous, rami of legs 2-4 3-segmented. Interpodal plate of leg 1 (Figure 25)

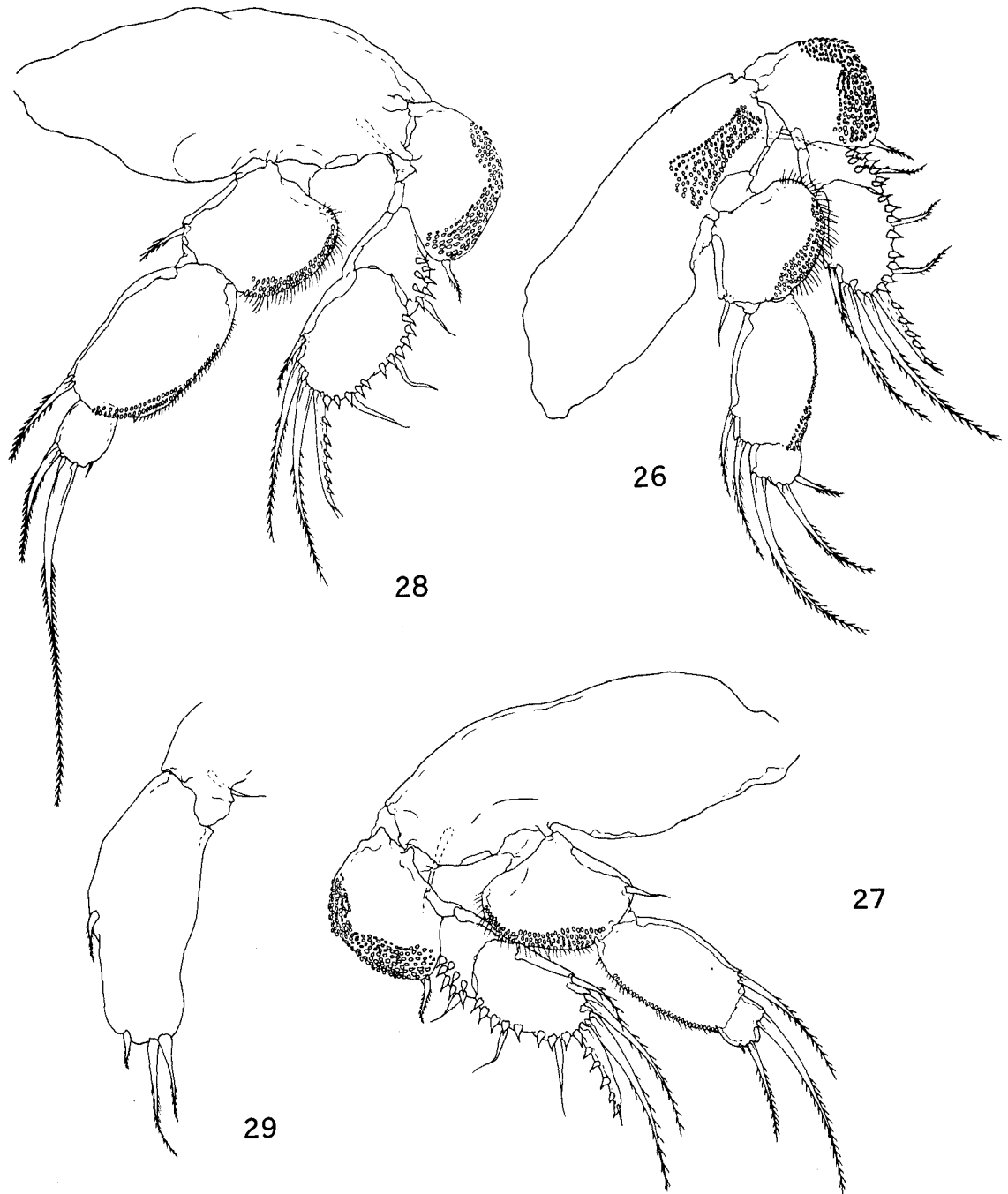


FIGURES 15-19.—*Pseudorbitacolax fimbriatus*, new species, male: 15, dorsal; 16, last abdominal segment and caudal rami, ventral; 17, maxilliped. *Pseudorbitacolax varunae* (Bennet), female: 18, dorsal; 19, genital segment and abdomen, dorsal.



FIGURES 20-25.—*Pseudorbitacolax varunae* (Bennet), female (continued): 20, last abdominal segment and caudal rami, ventral; 21, first antenna and rostrum, ventral; 22, second antenna; 23, mandible, paragnath, first maxilla, second maxilla; 24, maxilliped; 25, leg 1.





FIGURES 26-29.—*Pseudorbitacolax varunae* (Bennet), female (continued): 26, leg 2; 27, leg 3; 28, leg 4; 29, leg 5.

with two patches of scalelike spinules; coxopod with broad, inner plumose seta and outer sclerotized spine; basipod with several rows of small, scalelike spinules above insertion of endopod; exopod 2-segmented, first segment with outer, stout, flagellated spine, second segment with three outer setiform spines and six terminal to inner plumose setae; endopod 2-segmented, first segment with inner seta, second segment with six inner to terminal setae. Basipod of leg 2 (Figure 26) with ventral patch of scalelike spinules and dorsal seta; first segment of exopod with large patch of scalelike spinules along outer half of segment and setiform spine on outer distal corner; second segment with 1 or 2 rows of stout spinules along outer edge and one outer spine, third segment with row of stout spinules along outer edge, two outer spines, one barbed terminal spine, and three inner setae; first segment of endopod with scalelike spinules along outer edge and short inner seta, second segment with scalelike spinules along outer edge and two inner setae, third segment small, with three setae (innermost longest). Leg 3 (Figure 27) similar to leg 2 with following exceptions: basipod lacks ventral patch of scalelike spinules; second segment of endopod with only one seta; outermost seta on endopod third segment reduced to a setule. Leg 4 (Figure 28) similar to leg 3 except middle seta of endopod third segment longest (about three times longer than innermost). Leg 5 (Figure 29) basal segment with dorsal seta; free segment slightly inflated with one outer seta and three terminal setae (middle seta longest); no surface ornamentation visible. Leg 6 represented by three setae at area of egg sac attachment (see Figure 19); setae reach to about middle of first abdominal segment. Egg sacs flattened in most specimens. (The egg sacs of ovigerous females of bomolochids parasitic in the orbit of their hosts are typically flattened. The egg sacs of a few specimens of this new species were more rounded.)

*Male*.—Unknown.

*Remarks*.—Our description of this species is in general agreement with Pillai's (1971) redescription with the following exceptions on specific points. We found the segmentation between the second and third abdominal segments less distinct than did Pillai. Pillai failed to mention the ornamentation on the ventral surface of the last abdominal segment and caudal rami. We found the

first antenna to have one more segment than did Pillai. The last segment of the second antenna has four hooked spines and two setae rather than "5 claws and one stiff seta" as stated by Pillai. The maxilliped hook has a small but noticeable inner tooth. The basipod of leg 2 has a patch of scales not present on the basipods of legs 3 and 4. While these points are relatively minor, they aid in defining the species.

*Pseudorbitacolax nudus*

(Cressey and Boyle 1973) (Figures 30-35)

Syn: *Orbitacolax nudus* Cressey and Boyle 1973:6.

Originally reported from *Herklotsichthys punctatus* from the Philippines. Additional collections of 4 ♀ from the same host species and locality (BM 1933.3.11:15-16, BM 1933.3.11:17-18).

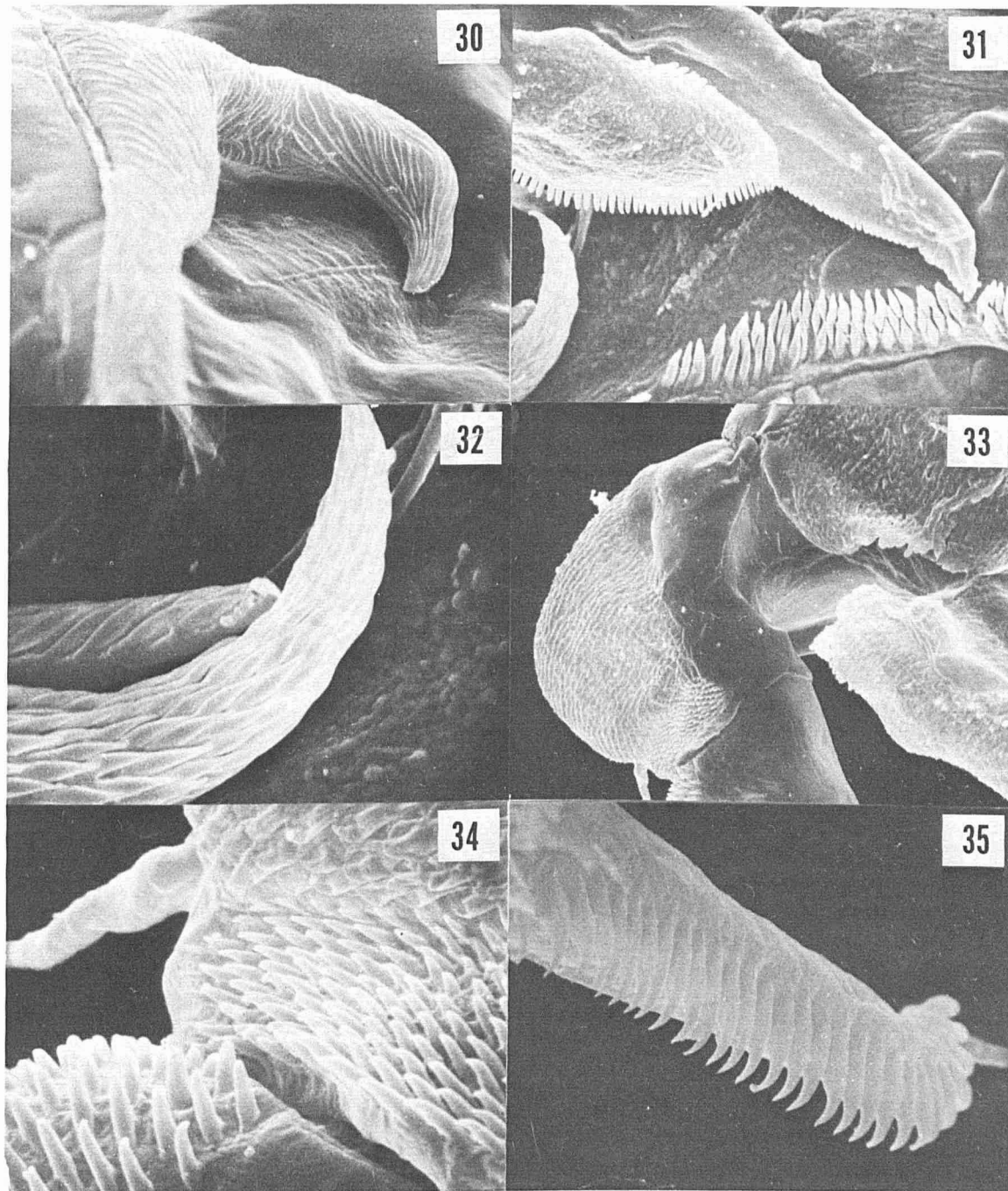
Our redescription of *Pseudorbitacolax* enabled us to reassign *Orbitacolax nudus* to this genus.

Figure 30 (SEM photo) reveals the presence of ridges on the surface of the dorsal cephalic hooks. Figure 32 shows the surface of the tip of the second maxilla to be covered with closely packed spinules. Figure 34 shows the spinules on the exopod of leg 2 to be somewhat blunted. The spinules on the terminal spines of legs 2-4 are hooklike (Figure 35) and similar to those commonly found on the second antenna.

*Pumiliopsis* Pillai 1967

*Diagnosis*.—Bomolochidae. Female: Body dorsoventrally flattened. Rostrum bilobed. Dorsal cephalic hooks present; ventral rostral hooks may or may not be present. Thoracic segments narrower than cephalothorax. Abdomen elongate, segmentation indistinct. Caudal rami each with one long, five short setae. First antenna with no modified setae. Second antenna typical of family, terminal segment with several rows of hooklets, four hooked spines, and two setae. First maxilla with three setae, middle seta more than twice the length of other two. Maxilliped hook with no outer accessory process, inner process may be present. Legs 1-4 biramous, rami 2-segmented, except endopod of leg 4 3-segmented. Leg 1 rami flattened. Last exopod segment of legs 2-4 with barbed spine.

*Male*.—Rostrum slightly produced. Thoracic segments each narrower than preceding segment.



FIGURES 30-35.—*Pseudorbitacolax nudus* (Cressey and Boyle), female: 30, dorsal cephalic hook ( $\times 1,475$ ); 31, tip of mandible, paragnath, labium ( $\times 2,150$ ); 32, tip of second maxilla ( $\times 5,000$ ); 33, leg 2 basipod, exopod first segment ( $\times 1,000$ ); 34, leg 2 exopod first segment, outer distal corner ( $\times 5,000$ ); 35, leg 3 exopod third segment spine ( $\times 5,000$ ).

Genital segment longer than broad. Abdomen 2-segmented. Caudal rami each with one very long and five short setae. First antenna extending beyond margin of cephalothorax, segments with numerous long, slender setae. Maxilliped second segment with numerous teethlike spines and large triangular process, last segment clawlike with very fine teeth at tip only. Legs 1-4 biramous, rami 3-segmented except endopod of leg 4 2-segmented. Leg 1 endopod flattened. Second endopod segment of legs 2 and 3 each with two inner setae.

*Type-species.*—*Pumiliopsis sardinellae* (Bennet 1964).

*Remarks.*—Pillai (1967) included in his generic diagnosis "rostrum triangular, longer than broad." While this is a prominent feature of the type-species, *P. sardinellae*, the shape of the rostrum of *P. plautus* is quite different. In other respects, however, *P. plautus* agrees with Pillai's description of *Pumiliopsis*. Furthermore, *Pseudorbitacolax fimbriatus* new species has a rostrum similar in shape to *Pumiliopsis sardinellae*; on the basis of several other characters, however, the two cannot be considered members of the same genus. We therefore consider the shape and relative size of the rostrum to be specific rather than generic characters.

*Pumiliopsis sardinellae*  
(Bennet 1964) (Figures 36-42)

Syn: *Pumiliopsis emarginatus* Cressey and Boyle 1973:4

Bennet originally described this copepod from the eye of *Sardinella albella* from Mandapam, South India. In 1973 we reported it from *S. perforata* (= *S. bulan*) from the Philippines. Since then we have collected the following: 12 ♀ from *S. albella* (BM 1962.3.26:96-98, BM 1963.5.6:6-7, BM 1966.11.16:28-33, BM 1966.11.16:52-54) from Mombasa, Aden, and Zanzibar; 17 ♀ 1 ♂ from *S. bulan* (BM 68.6.9:6, BM 1966.11.16:56-70, MCZ 17632, MCZ 30372, MCZ 30811, MCZ 32182) from Sarawak, Nosy Bé, Batavia, Penang, Java, and the Philippine Islands; 24 ♀ 2 ♂ from *S. fimbriata* (BM 84.5.15:27-28, BM 1965.7.5:11-13, BM 1965.7.5:15-16, BM 1966.1.28:20, BM 1966.2.28:10-11, BM 1966.11.20:2, BM 1970.4.24:1-20) from Sri Lanka, Thailand, Hong Kong, and Formosa; 4 ♀ from *S.*

*jussieui* (BM 1973.4.5:8-9) from Thailand. All additional collections were from the eye of the host.

Since our description of *P. emarginatus* in 1973 we collected additional material from *S. albella*, Bennet's type host for *P. sardinellae*. This, along with the minor differences noted between the two copepods (segmentation of abdomen, setation of leg 3 endopod of female, segmentation of legs 1-4 of male) have led us to conclude that *P. emarginatus* is synonymous with *P. sardinellae*. The differences noted could be due to the age or condition of the specimens examined.

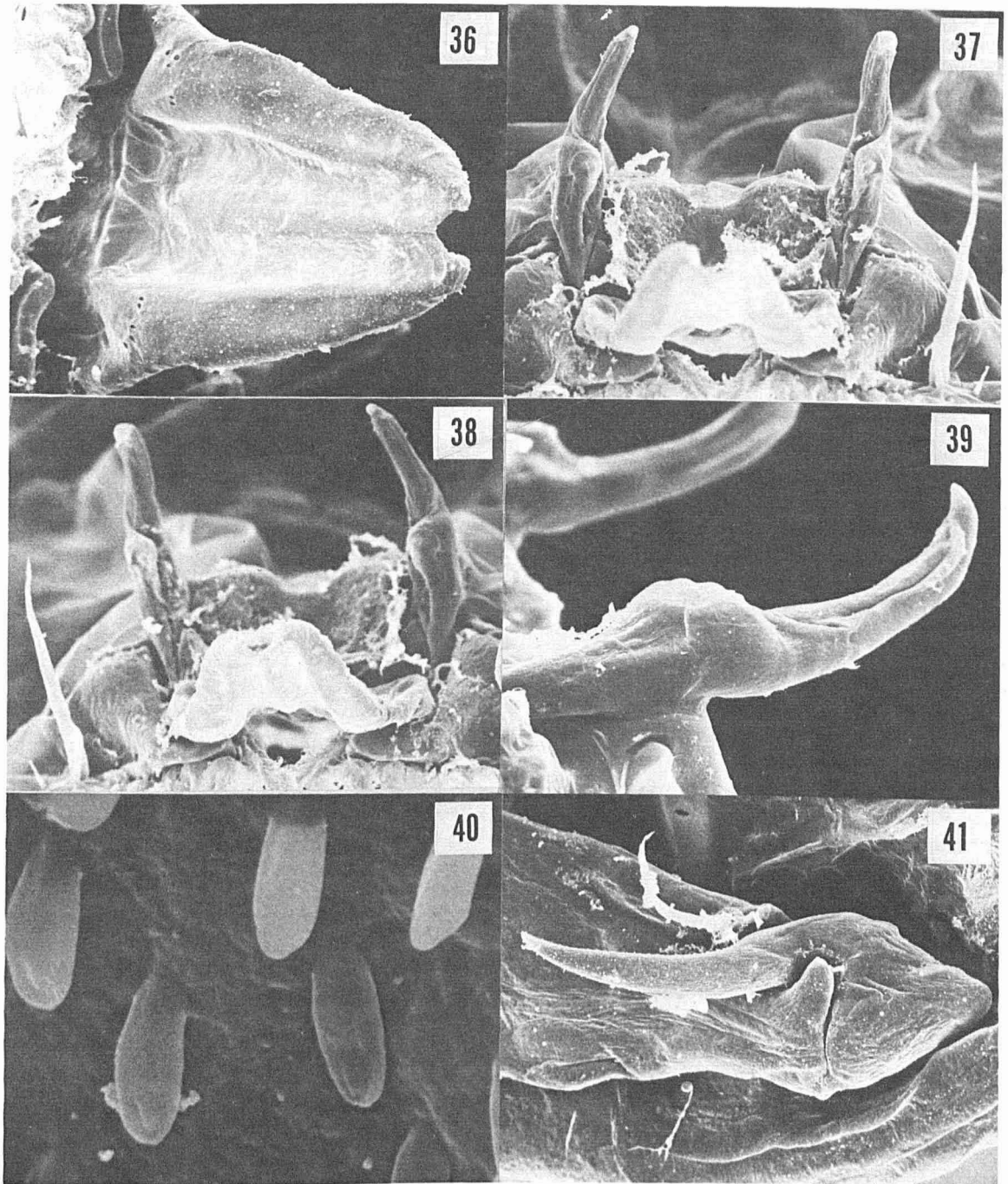
Scanning electron micrographs of the female of this species reveals features not easily seen with the light microscope. The rostrum (Figure 36) has a ventral groove with a cluster of pores near each outer basal margin. The cephalic "horns" (Figures 37-39) appear to be grooved ventrally. Figures 40 and 42 show the nature of the scales on the labrum and leg 1.

*Pumiliopsis plautus* Cressey and  
Boyle 1973 (Figures 43-46)

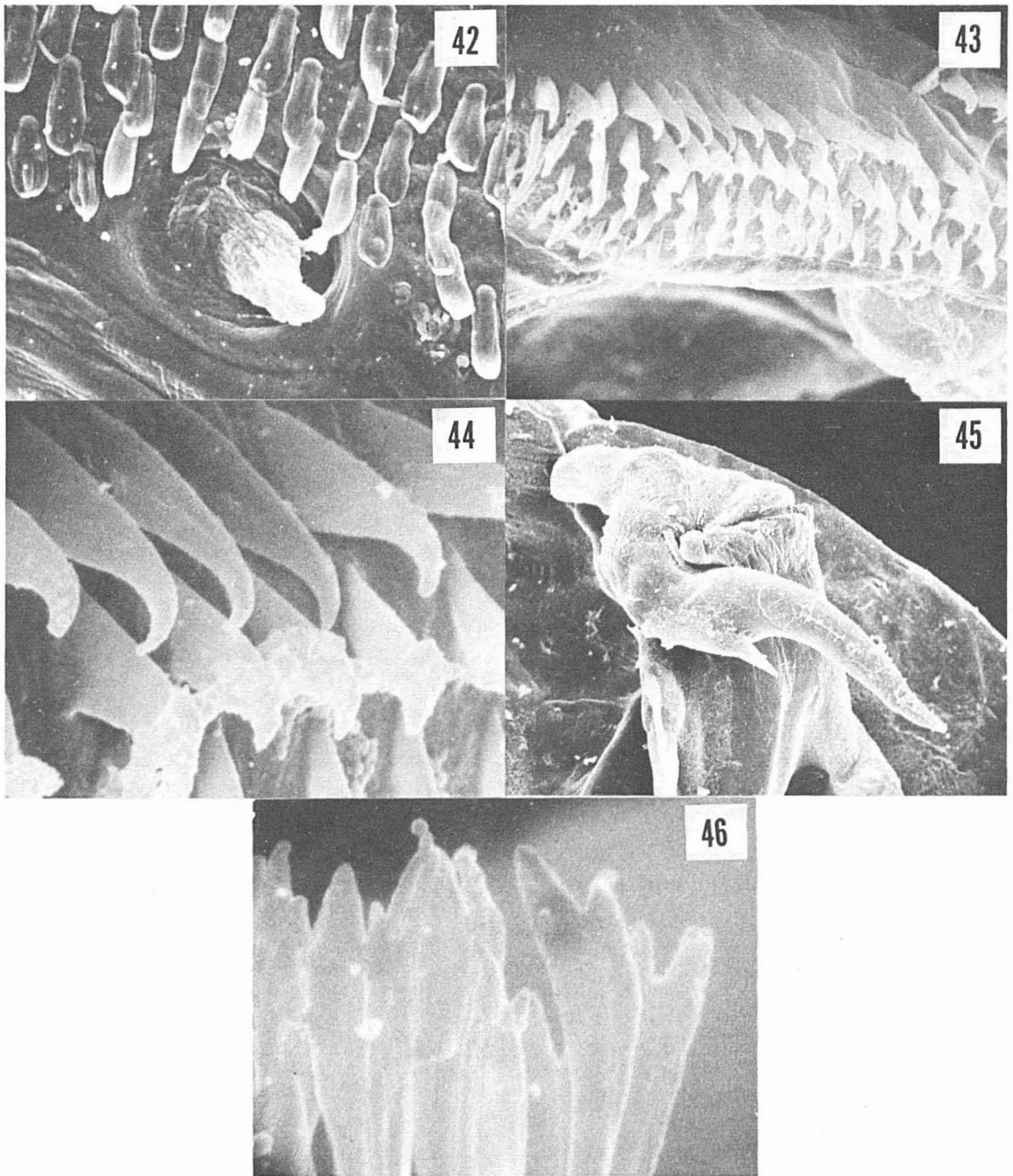
Syn: *Pumiliopsis spathepedes* Bennet 1975:156.

Originally described from *Sardinella sirm* and *S. leiogaster* (= *S. sirm*) from the Philippines. Bennet (1975) reported collecting 50 females from the eyes of *S. sirm* from Tuticorin, India. We collected an additional 6 ♀ from the same host (BM 1962.3.26:119-122, BM 1963.5.6:5, BM 1964.12.14:180-185) from Zanzibar and Aden.

Bennet's (1975) description of *P. spathepedes* is essentially in agreement with that of *P. plautus* (1973) with the following differences. Bennet did not observe a paragnath; however, one is present. He also failed to observe the tooth on the inner margin of the maxilliped hook (this process may be difficult to detect with the specimen lying flat). The rami of leg 1 are both 2-segmented rather than 3 as stated by Bennet, and he apparently mistook the coxopod with its seta for the first endopod segment; the terminal exopod segment has three spines and six setae rather than one spine and six setae. The basipods and exopods of legs 2-4 are all similar: the basipods each have one dorsal seta and two ventral patches of spinules; the second segment of the exopods each have three stout outer spines, one apical barbed spine, and two terminal setae. The second endopod segment of leg 2 has two small outer spinules and five terminal to inner setae rather than the armature reported by Ben-



FIGURES 36-41.—*Pumiliopsis sardinellae* (Bennet), female: 36, rostrum, ventral ( $\times 500$ ); 37, rostrum and dorsal cephalic hooks, head-on view ( $\times 260$ ); 38, rostrum and dorsal cephalic hooks, head-on view ( $\times 260$ ); 39, dorsal cephalic hook, lateral view ( $\times 500$ ); 40, scales on labrum ( $\times 10,000$ ); 41, maxilliped ( $\times 400$ ).



FIGURES 42-46.—*Pumiliopsis sardinellae* (Bennet), female (continued): 42, scales on basipod of leg 1 ( $\times 3,500$ ). *Pumiliopsis plautus* Cressey and Boyle, female: 43, second antenna ( $\times 1,900$ ); 44, hooklets on second antenna ( $\times 7,000$ ); 45, maxilliped ( $\times 500$ ); 46, leg 4 endopod hairs ( $\times 10,000$ ).

net. The first endopod segment of leg 3 does have a very short inner spinule. The last endopod segment of leg 4 has a small outer seta in addition to the two mentioned by Bennet. Leg 5 has a total of four setae on the terminal segment, one on the midouter margin and one subterminally in addition to the two terminal setae Bennet noted.

The scanning electron micrographs of the female indicate the hooklike nature of the ornamentation on the second antenna (Figures 43, 44) and the bifurcate tips on the lateral hairs on the endopod of leg 4 (Figure 46).

*Pumiliopes* Shen 1957

*Diagnosis*.—Bomolochidae. Female: Body dorsoventrally flattened. Rostrum only slightly produced, rounded, broader than long. Thoracic segments bearing legs 2-5 free, each segment slightly narrower than preceding one. Genital segment wider than last thoracic segment. Abdomen 3-segmented, segmentation may be indistinct. Caudal rami each with one long and five short setae. Neither dorsal cephalic nor ventral rostral hooks present. First antenna with no modified setae. Second antenna 3-segmented, last segment subdivided; subterminal portion with 1 or 2 rows of hooklets and one stout claw, terminal portion with three hooked spines and two setae. First maxilla with no or three short setae. Second segment of second maxilla produced posteriorly. Maxilliped hook with no accessory processes. Legs 1-4 biramous, rami 2-segmented except leg 4 endopod 3-segmented. Leg 1 rami flattened. Last segment of exopod of legs 2-4 with smooth, stout, clawlike spine.

*Male*.—Unknown.

*Type-species*.—*Pumiliopes opisthopteri* Shen 1957.

*Remarks*.—In Shen's (1957) description of *P. opisthopteri* he reported no setae on the first maxilla, and based on that report we have included it in the generic diagnosis. This condition, however, is unique in bomolochids; therefore, we consider Shen's description of the first maxilla to be tentative until additional material of this species can be examined.

*Pumiliopes opisthopteri* Shen 1957

Originally described from the "left eye" of *Opis-*

*thopterus tardoore* from Yin-ku Bay, Hainan Island, China. This copepod has not been reported since and we did not recover specimens in our examination of 24 specimens of the original host species (including specimens from China).

*Pumiliopes jonesi* (Bennet 1967)

Syn: *Bomolochus jonesi* Bennet 1967:132.  
*Pumiliopes capitulatus* Cressey and Boyle 1973:1.

Bennet originally described this copepod as *Bomolochus jonesi* from a collection of over 200 specimens collected from under the adipose eyelids of *Rastrelliger kanagurta* (Scombridae) from Calicut, India. In 1973 we collected the same species of copepod, which we reported as *P. capitulatus*, from the orbit of *Clupanodon punctatus* (a clupeid). Our additional collections from clupeids include 1 ♀ from *C. punctatus* (BM 93.4:21-28) from Hae-yoe Chi Kiang and 3 ♀ from *Herklotsichthys displonotus* (BM 1967.11.13:1-9) from Singapore.

We also recovered 35 females from the orbits of the following scombrid fishes (all USNM collections): 17 from *R. kanagurta* from the Red Sea, Sri Lanka, Madras, India, Philippine Islands, and Java; 2 from *R. faughni* from the Philippine Islands; 13 from *Scomber japonicus* from the Gulf of Guinea, Mauritania, and Zanzibar; 3 from *S. australasicus* from the Philippine Islands. We have reported these scombrid collections in more detail in a paper describing the parasitic copepods of scombrid fishes (Cressey and Cressey 1980).

Due to the larger numbers of *P. jonesi* collected from scombrids rather than clupeids, we consider scombrids to be the preferred hosts of this copepod.

A comparison of Bennet's (1967) description of *Bomolochus jonesi* and our (Cressey and Boyle 1973) specimens and description of *Pumiliopes capitulatus* indicates that they are the same species and that Bennet's species clearly belongs in the genus *Pumiliopes*. We note the following differences in details of the two descriptions.

Bennet found only four setae on each caudal ramus; there are actually six, five apical (one long) and one lateral. Bennet reported the first antenna to be 6-segmented while we reported it to be 5-segmented, with the second segment relatively long; the exact segmentation of this appendage is often difficult to determine, but we agree on its general ornamentation. The second antenna has

one stout claw, three hooked spines, and two setae rather than five digitate claws as reported by Bennet. Bennet, like Shen in describing *P. opisthopteri*, reported no setae on the first maxilla; there are, however, three short setae present which may be difficult to detect in some specimens. The second segment of the second maxilla is produced posteriorly, a character not apparent from Bennet's figure. The exopod second segment of leg 1 has six plumose setae and three small spinules rather than seven plumose setae; the endopod second segment has six rather than four plumose setae. Bennet stated that the basipods of legs 2-4 are 2-segmented, these 2 segments are actually the coxopod and the basipod; the basipod of leg 2 has a patch of scalelike spinules near the insertion of the endopod. The second exopod segment of legs 2-4 each have small patches of spinules and weak outer spines in addition to the apical clawlike spine noted by Bennet. The "hairs" present on the outer endopod margins of legs 2-4, as noted by Bennet, are actually flattened, scalelike spinules. The free segment of leg 5 is 1-segmented, not 2-segmented, and has one lateral and three terminal setae. Leg 6 consists of three rather than two setae on the genital segment.

*Pumiliopes squamosus* Cressey  
and Boyle 1973

Originally described from *Sardinella zunasi* from Nagasaki, Japan. Additional collections include 4 ♀ from *S. fimbriata* (BM 1965.7.5:1-10) from Hong Kong; 3 ♀ from *S. fimbriata*

(BM 1966.11.16:57-70) from Nosy Bé, Madagascar; 13 ♀ from *S. zunasi* (BM 1905.6.6:13-22, BM 1971.2.8:151-153) from Japan; 2 ♀ from *S. jussieu* (MCZ 30806) from Batavia. All copepods collected from the orbit of the host fish.

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