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## Poecilostomatoid Copepods from an Intertidal Mud Flat in the Yellow Sea

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Thirteen new species and one new genus of poecilostomatoid copepods are described from intertidal mud flats in the central west coast of the Korean Peninsula facing the Yellow Sea. Nine species are found in association with invertebrates: *Hemicyclops ventriplanus* n. sp. from the decapod crustacean *Upogebia major* (De Haan); *Clausia lobata* n. sp. from the polychaete *Marphysa sanguinea* (Montagu); *Presynaptiphilus minutus* n. sp. from the ophiuroid *Amphiura sinicola* (Matsumoto); *Synaptiphilus longicaudus* n. sp. and *Enterophilus cercomegalus* n. gen. et n. sp. from the holothurian *Protankyra bidentata* (Woodward and Barrett); *Goidelia pelliviva* n. sp. from an echiuroid *Thalassema* sp.; *Lichomolgus bullatus* n. sp. from the bivalve *Striarca (Didimacar) tenebrica* (Reeve); *Critomolgus nudus* n. sp. from the pennatulacean *Virgularia gustaviana* (Herklots); and *Notoxynus tertius* n. sp. from the sea anemone *Cerianthus filiformis* Carlgren. The other four species are found in stagnant water on the mud flat: *Kelleria vaga* n. sp., *Macrochiron anormalum* n. sp., *Pseudomacrochiron wrostenum* n. sp. and *Pseudanthessius dentatus* n. sp.

KEYWORDS: Copepoda, Poecilostomatoida, new species, Korea, Yellow Sea.

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### Introduction

Kim (1998) recorded 162 species of copepods either associated with or parasitic on marine animals. Eighty species were recorded as associates of invertebrates. This number is likely to be only a small fraction of the total number of copepods associated with invertebrate hosts, considering several new and as yet unrecorded species of invertebrates are known to occur in Korean coastal waters.

The Korean coast of the Yellow Sea is known for its well developed mud flats, providing a suitable habitat for a diverse tubicolous invertebrate fauna. Copepod associates of invertebrates in mud flats are generally very poorly investigated. This assumption was reinforced by the author's visit to Jakyak-do Island, a small island in the Yellow Sea with an area of about 0.5 km<sup>2</sup> and located about 2 km away from Inchon, which unexpectedly revealed a number of poecilostomatoid copepods from the invertebrates and stagnant water on the mud flat. Three of these copepods were already described: *Polyankylis orientalis* by Ho and Kim (1997), and *Mycicola*

*intumidus* and *Conchyliturus inchonensis* by Kim (1997). The present report describes the remaining 13 species that are new to science. They belong to 13 genera in nine families as listed below.

Family Clausidiidae

1. *Hemicyclops ventriplanus* n. sp. from the crustacean *Upogebia major* (De Haan).

Family Clausiidae

2. *Clausia lobata* n. sp. from the polychaete *Marphysa sanguinea* (Montagu).

Family Synaptiphilidae

3. *Presynaptiphilus minutus* n. sp. from the ophiuroid *Amphiura sinicola* (Matsumoto).
4. *Synaptiphilus longicaudus* n. sp. from the holothurian *Protankyra bidentata* (Woodward and Barrett).
5. *Enterophilus cercomegalus* n. gen. et n. sp. from the alimentary canal of the holothurian *Protankyra bidentata* (Woodward and Barrett).

Family Catiniidae

6. *Goidelia pelliviva* n. sp. from an echiuroid, *Thalassema* sp.

Family Kelleriidae

7. *Kelleria vaga* n. sp. from stagnant water on the mud flat.

Family Lichomolgidae

8. *Lichomolgus bullatus* n. sp. from the bivalve *Striarca (Didimacar) tenebrica* (Reeve).

Family Macrochironidae

9. *Macrochiron anomalum* n. sp. from stagnant water on the mud flat.
10. *Pseudomacrochiron urostenum* n. sp. from stagnant water on the mud flat.

Family Pseudanthessiidae

11. *Pseudanthessus dentatus* n. sp. from stagnant water on the mud flat.

Family Rhynchomolgidae

12. *Critomolgus nudus* n. sp. from the pennatulacean *Virgularia gustaviana* (Herklots).
13. *Notoxynus tertius* n. sp. from the gastrovascular cavity of the sea anemone *Cerianthus filiformis* Carlgren.

## Materials and Methods

The copepods examined in the present study were recovered from washings of the invertebrate hosts or netted directly from stagnant water. On the mud flat the host animals were dug out with a shovel and collected in plastic bags, with different species being placed in different bags and subsequently being fixed in alcohol. Later in the laboratory, the hosts were agitated in the water in order to isolate the copepod associates. Some copepods were sucked up directly from the host's burrows on the mud flat with a large pipette, or collected by scooping stagnant water on the mud flat or between rocks using a small hand net.

Before microscopic observation and dissection, copepod specimens were immersed in lactic acid. Dissections were done using the reversed slide method (Humes and Gooding, 1964). The intact type specimens have been deposited in the US National Museum of Natural History, Smithsonian Institution, Washington, DC. Dissected specimens are retained in the collection of the author. In the description of species all measurements were made invariably on one fully grown large specimen of each sex. The body lengths were measured from the anterior tip of the

cephalothorax to the posterior margin of the caudal rami of a selected large specimen, excluding the caudal setae. In the formula for the armature of legs 1–4 Roman numerals indicate spines and Arabic numerals represent setae.

## Descriptions of species

### Family CLAUSIDIIDAE Embleton, 1901

#### *Hemicyclops ventriplanus* n. sp.

(Figures 1–3)

*Material examined.* Numerous specimens, including copepodids I–V, found in the washings of the thalassinidean crustacean, *Upogebia major* (De Haan), collected from the intertidal mud flat at Jakyak-do Island, off Inchon, on 28 September 1996. Holotype (ovigerous ♀), allotype (♂), and 80 paratypes (50 ♀♀, 30 ♂♂) have been deposited in the US National Museum of Natural History, Smithsonian Institution. Other specimens are kept in the collection of the author.

*Female.* Body (figure 1A) cyclopiform. Selected specimen 1.39 mm long. Greatest width 0.55 mm. Prosoma composed of cephalothorax and three pedigerous somites. Rostral area of cephalosome produced anteriorly. Prosomal somites with well developed epimera. Second and third pedigerous somites with posterior margin of tergite fringed with membrane. Fourth pedigerous somite with pointed posterior corners. Urosome (figure 1B) five-segmented. Fifth pedigerous somite 194 µm wide, with round lateral margins. Genital double-somite ventrally flat, dorsally complex as in figure 1B, 212 × 188 µm (1.13:1). Genital area located laterally near anterior portion of somite at area of greatest width. Three abdominal somites 103 × 117, 74 × 109, and 62 × 101 µm, respectively. Posterodorsal border of second abdominal somite convex, fringed with membrane. Anal somite with spinules on medial side of posteroventral border (figure 1C). Caudal ramus 102 × 40 µm (2.55:1), with nearly parallel lateral margins and six setae. Outermost seta divided into two parts: thick basal and plumose distal parts. Longest inner median terminal seta 653 µm. Next longest, outer median terminal seta 359 µm. Egg sac oval (figure 1A), 441 × 223 µm.

Rostrum incorporated with ventral surface of cephalothorax. Antennule (figure 1D) seven-segmented, 363 µm long, with armature formula 4, 15, 6, 3, 4 + 1 aesthetasc, 2 + 1 aesthetasc, and 7 + 1 aesthetasc. Antenna (figure 1E) four-segmented, with armature formula 1, 1, 4, 7. Third segment with distinct inner distal protuberance and spinules on inner margin. Terminal segment slightly wider than long.

Labrum variously ornamented with spinules and setules as figure 1F. Mandible (figure 1G) armed terminally with four elements: one dorsal, plate-like element bearing denticles, another plate-like element bearing spinules on dorsal side, and two ventral plumose setae. Paragnath a lobe bearing distal process and a posterior row of spinules (figure 2A). Postoral region armed as in figure 2A. Maxillule (figure 2B) distally bilobed, with five setae on larger lobe and three setae on smaller lobe. Maxilla (figure 2C) two-segmented. Basal segment with a row of setules basally and two distal, barbed setae, one of them accompanied basally with one setule. Maxilliped (figure 2D) four-segmented, with formula of armature: 2, 2, 0, 3 + II. First and second segments each with row of spinules in addition to setae. Inner margin of second segment produced near base of setae. Terminal spine on terminal

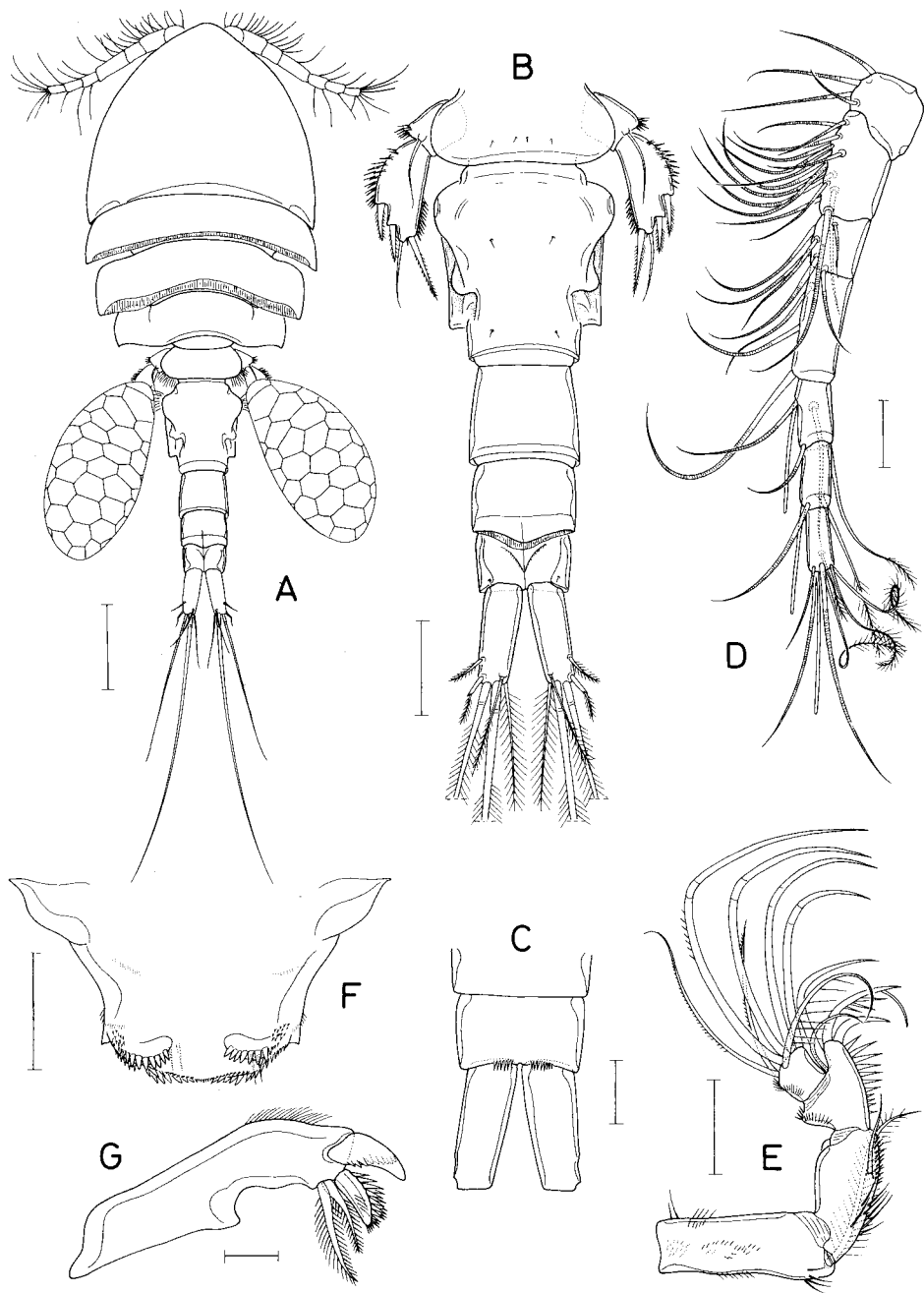


FIG. 1. *Hemicyclops ventriplanus* n. sp., female: (A) habitus, dorsal; (B) urosome, dorsal; (C) distal portion of abdomen, ventral; (D) antennule; (E) antenna; (F) labrum; (G) mandible. Scales: A = 0.2 mm; B = 0.1 mm; C-F = 0.05 mm; G = 0.02 mm.

segment with one basal, terminally-forked seta and six or seven setules on outer side of proximal half. Inner spine enlarged, with several stiff spinules on both margins.

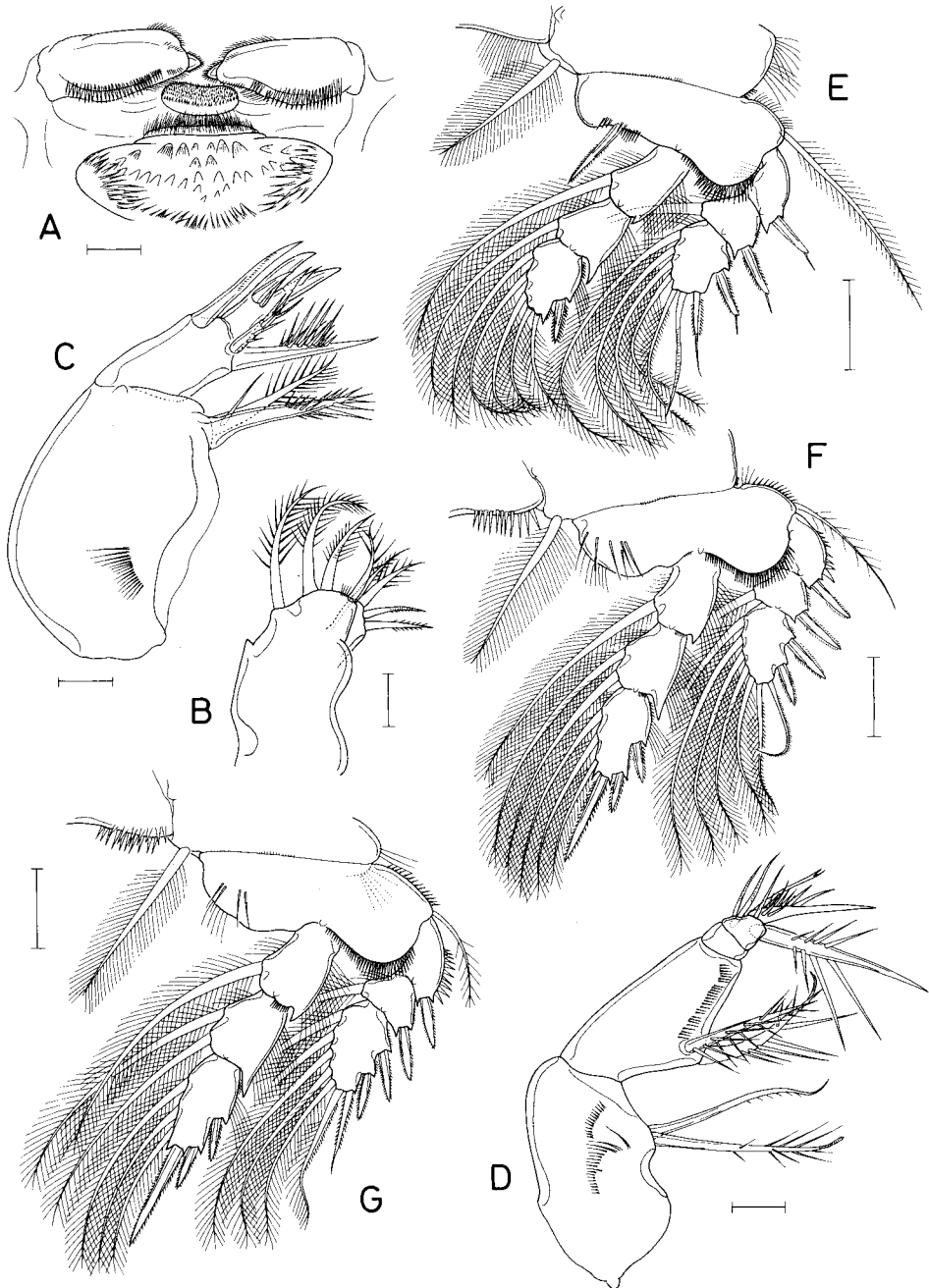


FIG. 2. *Hemicyclops ventriplanus* n. sp., female: (A) paragnath and postoral region; (B) maxillule; (C) maxilla; (D) maxilliped; (E) leg 1; (F) leg 2; (G) leg 3. Scales: A-D=0.02 mm; E-G=0.05 mm.

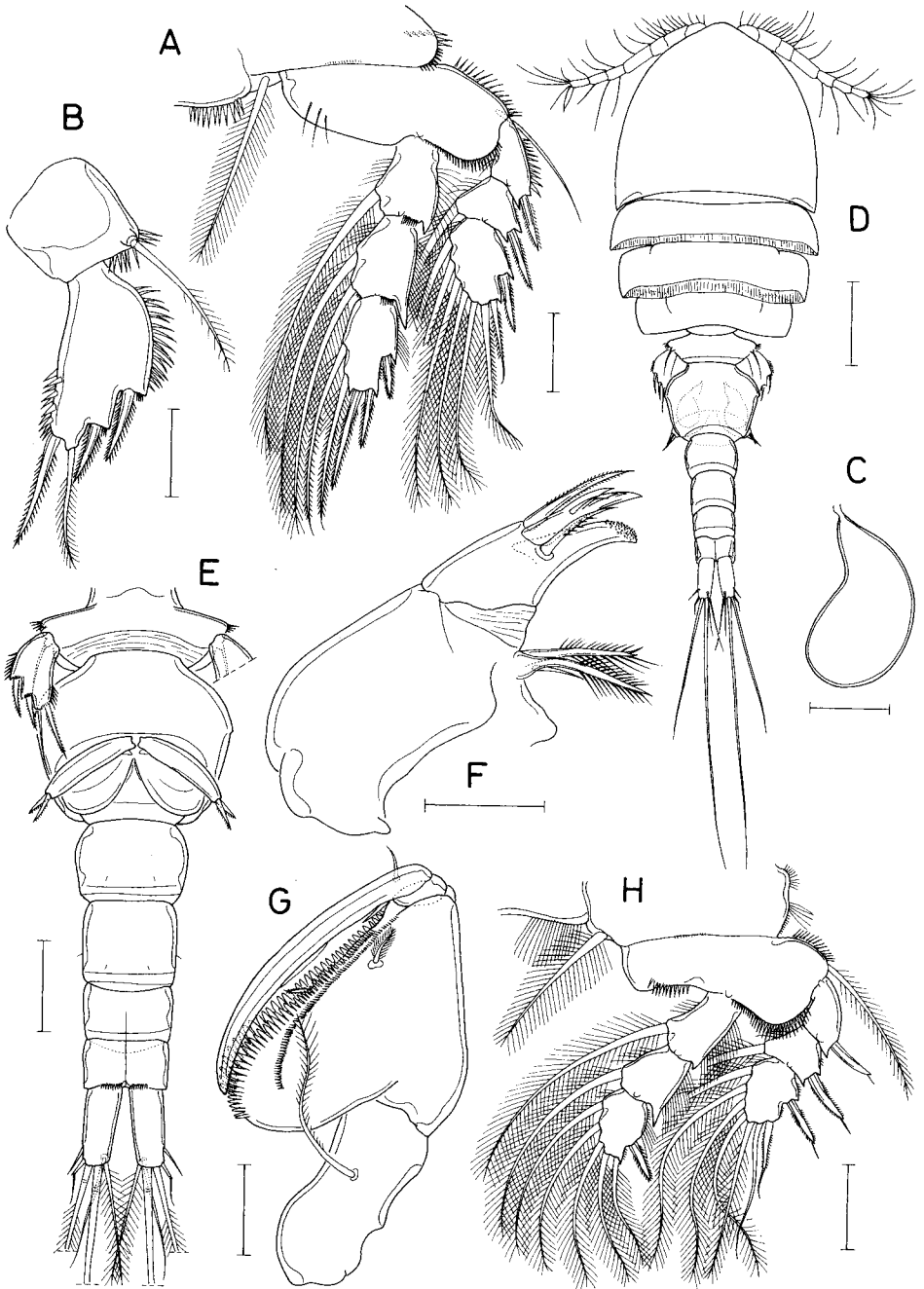


FIG. 3. *Hemicyclops ventriplanus* n. sp. Female: (A) leg 4; (B) leg 5; (C) spermatophore. Male: (D) habitus, dorsal; (E) urosome, ventral; (F) maxilla; (G) maxilliped; (H) leg 1. Scales: A-C, F-H=0.05 mm; D=0.2 mm; E=0.1 mm.

Legs 1–3 (figure 2E–G) and leg 4 (figure 3A) with three-segmented rami. Formula of armature of these legs as follows:

	Coxa	Basis	Exp	Enp
Leg 1	0-1	1-1	I-0; I-1; II, 6	0-1; 0-1; I, 5
Leg 2	0-1	1-0	I-0; I-1; II, 7	0-1; 0-2; III, 3
Leg 3	0-1	1-0	I-0; I-1; II, 7	0-1; 0-2; III, 3
Leg 4	0-1	1-0	I-0; I-1; I, 7	0-1; 0-2; III, 2

Median portion of posterior margin of basis of legs 1–4 spinulated. Posterior margin of intercoxal plate of leg 1 with hairs, but those of legs 2–4 with spinules. Outer margin of basis in leg 1 with setae, but those in legs 2–4 with spinules. Inner spine of basis of leg 1 slender and longer than first endopodal segment. Outer margin of endopod of all biramous legs with hairs. Outer margin of first exopodal segment smooth but those of legs 2–4 with spinules.

Leg 5 (figure 3B) two-segmented. Basal segment with one seta, and spinules near base of seta. Distal segment  $103 \times 51 \mu\text{m}$  (ratio 2.02:1), with three spines, one seta, and spinules on outer margin and on distal half of inner margin. Leg 6 not observable, concealed from dorsal and ventral views of body.

Spermatophore  $120 \times 62 \mu\text{m}$ , a curved sac as figure 3C.

*Male.* Body (figure 3D) resembling that of female. Length 1.38 mm. Urosome (figure 3E) six-segmented. Fifth pedigerous somite  $212 \mu\text{m}$  wide, narrowed posteriorly. Genital somite nearly hexagonal,  $188 \times 218 \mu\text{m}$ . Four abdominal somites  $88 \times 126$ ,  $91 \times 106$ ,  $62 \times 100$ , and  $52 \times 95 \mu\text{m}$ , respectively. Caudal ramus  $91 \times 38 \mu\text{m}$  (2.39:1).

Antennule, antenna, labrum, mandible, paragnaths, and maxillule identical to those of female. Maxilla (figure 3F) sexually dimorphic; second segment terminated in a claw-like, blunt process armed distally with minute spinules. Maxilliped (figure 3G) composed of three segments and terminal claw. First segment with one long plumose seta. Second segment greatly expanded proximally and narrowed distally, with one row of minute spinules, two rows of larger spinules and distantly separated, two small setae on inner surface. Third segment unarmed. Claw weakly curved, proximally with one seta and one spinule.

Leg 1 (figure 3H) without inner spine on posterior margin of basis. Legs 2–4 as in female. Basal segment of leg 5 completely incorporated into fifth pedigerous somite. Free segment identical in shape to that of female. Leg 6 represented by two small spines on genital flap.

*Etymology.* The specific name *ventriplanus* is a combination of the Latin *venter* (=the belly) and *planus* (=flat). It alludes to the flat ventral surface of the female genital double-somite.

*Remarks.* The new species bears the following diagnostic features: (1) eight (neither six nor nine) elements on the third exopodal segment of leg 4; (2) two (rather than one) setae on the second endopodal segment of leg 4; (3) four (rather than five) setae on the first segment of the antennule; (4) five- (rather than six-) segmented urosome in female; and (5) four (rather than three) elements on mandible.

According to Humes (1995), 36 species are recognized in the genus *Hemicyclops*. The above combination of characters is shared with more than half of its congeners.



Nine of them have, as in the new species, a caudal ramus length to width ratio ranging between 2 and 3: *H. acanthosquillae* Humes, 1965; *H. axiophilus* Humes, 1965; *H. bacescui* (Şerban, 1956); *H. biflagellatus* Humes, 1965; *H. gomsoensis* Ho and Kim, 1992; *H. kombensis* Humes, 1965; *H. mortoni* Boxshall and Humes, 1988; *H. thalassius* Vervoort and Ramirez, 1966; *H. visendus* Humes, Cressey and Gooding, 1958.

Of these nine species, *H. thalassius* shows no sexual dimorphism in leg 1, i.e., its male carries an inner spine on the basis and therefore cannot be confused with the new species. The male of both *H. bacescui* and *H. mortoni* are not known, but the remaining six species have in common males that possess no spine on the basis of leg 1 and only a single seta on the syncoxa of the maxilliped. Morphological features which distinguish *H. ventriplanus* from these eight species are given below.

In *H. acanthosquillae*, *H. biflagellatus*, and *H. kombensis*, all of them described from Madagascar, the genital double-somite consists of an anterior expansion (although weak in *H. kombensis*) and the posterior part is long and narrow with parallel lateral margins. Furthermore, the inner distal angle of the antenna of *H. acanthosquillae* is prominently projected so that it extends beyond the end of the fourth segment. In *H. biflagellatus*, the inner spine on the basis of female leg 1 is very long, extending beyond the distal border of the endopodal second segment. The free segment of leg 5 in *H. kombensis* is characteristic because it is very narrow proximally but strongly expanded distally.

The genital double-somite of *H. axiophilus* has two prominent, anterior and posterior, expansions. In *H. bacescui* the genital double-somite has a dorsal surface suture (Stock, 1959), but is otherwise cylindrical. *Hemicyclops visendus* also has a simple, quadrangular genital double-somite and a stocky free segment of leg 5.

The male leg 6 of *H. gomsoensis* is represented by two spines. In this and other morphological aspects, this other Korean species is very closely related to the new species. The significant differences between the two species can be found in the shape of the female genital double-somite and of the spermatophore. The genital double-somite of *H. gomsoensis* shows a distinct constriction in the middle and a pair of dorsal flaps, while in the new species neither constrictions nor flaps are present. The spermatophore of *H. gomsoensis* is long and slender, whereas that of the new species is vesicular.

The genital double-somite of *H. mortoni* also bears a constriction in the middle and a pair of prominent, lobate projections near each of the posterior corners. The free segment of leg 5 is stockier (ratio 1.61:1) than that of the new species (ratio 2.02:1). The maxilla of *H. mortoni* is peculiar, because its main terminal element of the second segment is a simple process bearing two cusps (figure 1H in Boxshall and Humes, 1987). This main terminal element in the new species is a thick, bifurcate spine (or process) bearing three cusps. The third endopodal segment of leg 4 is armed with four spines and one seta (IV, 1) in *H. mortoni*, compared with three spines and two setae (III, 2) in the new species.

*Hemicyclops japonicus*, a species discovered from a dredged area in Tokyo Bay, Japan (Itoh and Nishida, 1993), is distinguishable from the new species by its broader caudal rami (ratio 1.7:1) and the different structure of male leg 6. Otherwise they are very similar to each other. In particular, the Japanese species bears a pair of lateral processes (Itoh and Nishida called them 'hooks') in the posterior third of the genital double-somite resembling the posterolateral angles of the new species. The oral appendages and leg armature are also very alike in the two species. Itoh

and Nishida (1993) considered *H. axiophilus* as the species most closely related to *H. japonicus*. It is interesting that both *H. axiophilus* and *H. ventriplanus* are associated with thalassinidean hosts. This fact further suggests that *H. japonicus* may well turn out to be an associate of a thalassinidean.

### Family CLAUSIIDAE Giesbrecht, 1895

#### *Clausia lobata* n. sp.

(Figures 4–6)

*Material examined.* Thirty-six ♀♀ and three ♂♂ collected from the polychaete, *Marphysa sanguinea* (Montagu), in the intertidal mud flat of Jakyak-do Island off Inchon, on 1 September 1996. Holotype (♀), allotype, and 23 paratypes (22 ♀♀ and one ♂) will be deposited in the US National Museum of Natural History, Smithsonian Institution. Thirteen ♀♀ and one ♂ (including two ♀♀ and one ♂; dissected) are kept in the collection of the author.

*Female.* Body (figure 4A) small, 650 µm long. Greatest width 265 µm. Ventrolateral sides of cephalothorax with many wavy adhesion ridges (figure 5A). Rostral area of cephalothorax projected, broad, truncate anteriorly, and demarcated by a faint line from remaining part of cephalothorax. Third pedigerous somite narrower but distinctly longer than second pedigerous somite. Fourth pedigerous somite with characteristic lobate protuberance on each lateral side. Urosome (figure 4B, C) six-segmented. Fifth pedigerous somite 103 µm wide, distinctly wider than genital somite. Genital somite 49 × 83 µm, or 1.69 times wider than long, nearly quadrangular, wider posteriorly. Demarcation between genital and first abdominal somites distinct dorsally but obscure ventrally. Abdomen slightly tapering. Four abdominal somites 43 × 53, 38 × 45, 28 × 40, 25 × 39 µm, respectively. Anal somite with two pairs of membranous flaps, each proximally and distally on ventral surface. Caudal rami divergent, 32 × 16 µm (2.0:1). Outer lateral seta located two-thirds length of ramus. Two mid-terminal setae weakly pinnate in distal half. Other four setae naked. Egg sac elongate, longer than urosome, 323 × 105 µm, containing relatively large eggs.

Rostrum completely incorporated into cephalothorax, leaving only faint boundary (figure 5A). Antennule (figure 4D) six-segmented and 142 µm long, with armature formula 4, 9, 9, 4 + 1 aesthetasc, 2 + 1 aesthetasc, and 7 + 1 aesthetasc. Plumose setae are one on both fourth and fifth segments and three on terminal segment. First segment distinctly broader than long. Antenna (figure 4E) three-segmented, with armature formula 1, 0, and 7. Second segment with three membranous flaps. Third segment slightly broadened distally, with one membranous flap; outermost seta on terminal segment plumose, and longest. Innermost seta broadened, spiniform, with membrane on inner margin and tipped with minute spinule. Other five setae naked.

Labrum reduced, not covering mouth parts, with narrow posterior margin (figure 5B). Mandible (figure 5C) small, armed terminally with two spiniform elements of different sizes. Maxillule with three setae terminally and protuberance on inner side; outer one of these setae plumose on outer side, but other two setae naked. Maxilla largest among mouth parts, one-segmented, with three membranous flaps posteroventrally and two sclerotized blades distally, without seta or spine. Maxilliped (figure 5D) three-segmented, blunt, and unarmed. Third segment short, distally truncate, blade-like and indistinctly marked from second segment.

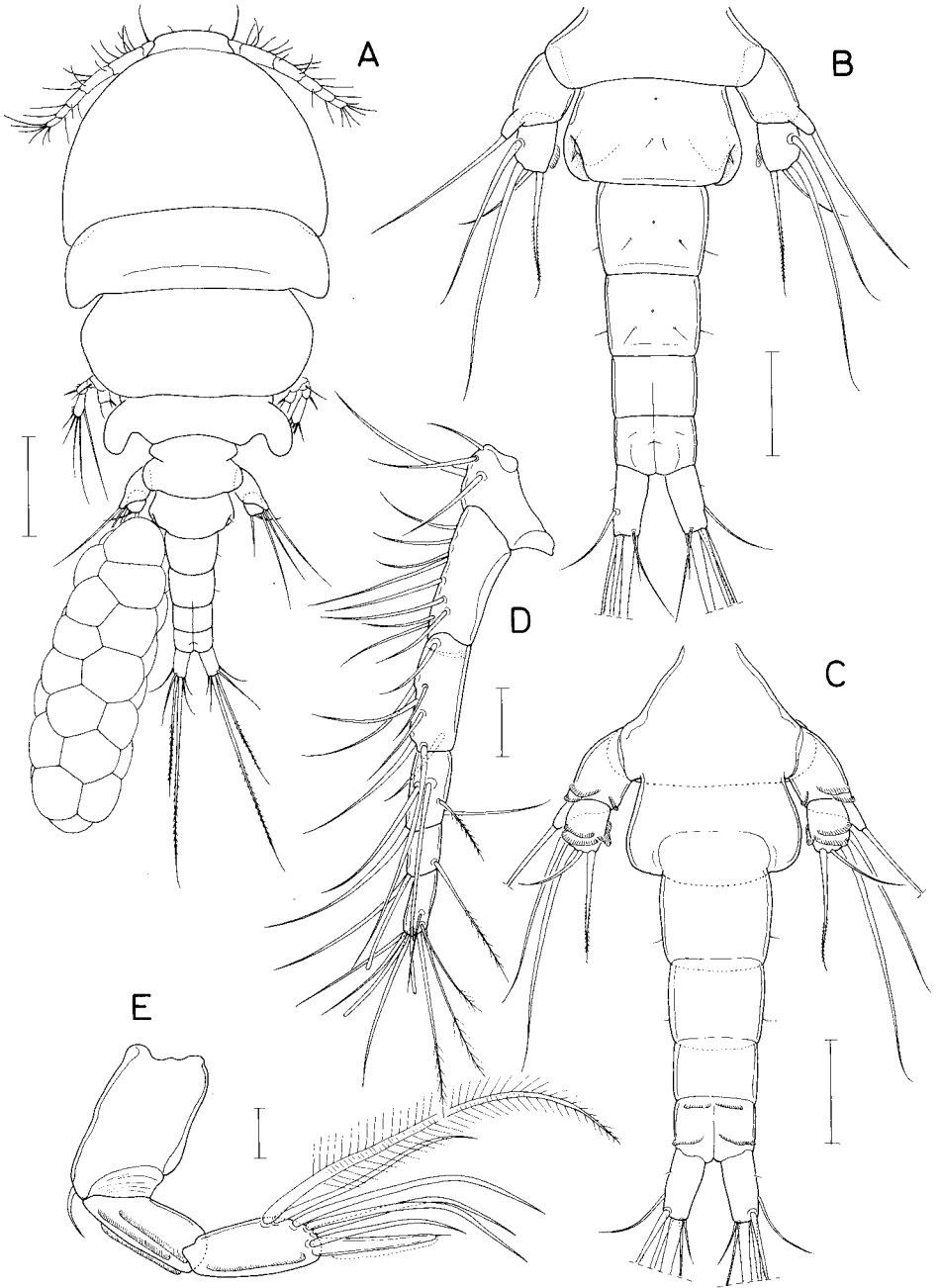


FIG. 4. *Clausia lobata* n. sp., female: (A) habitus, dorsal; (B) urosome, dorsal; (C) same, ventral; (D) antennule; (E) antenna. Scales: A=0.1 mm; B-C=0.05 mm; D=0.02 mm; E=0.01 mm.

Leg 1 (figure 5E), leg 2 (figure 5F) and leg 3 with three-segmented rami. Leg 4 (figure 6A) with two-segmented rami. All spines on rami of these legs setiform. Inner spine on posterior margin of leg 1 thick but short. Membranous flaps seen on

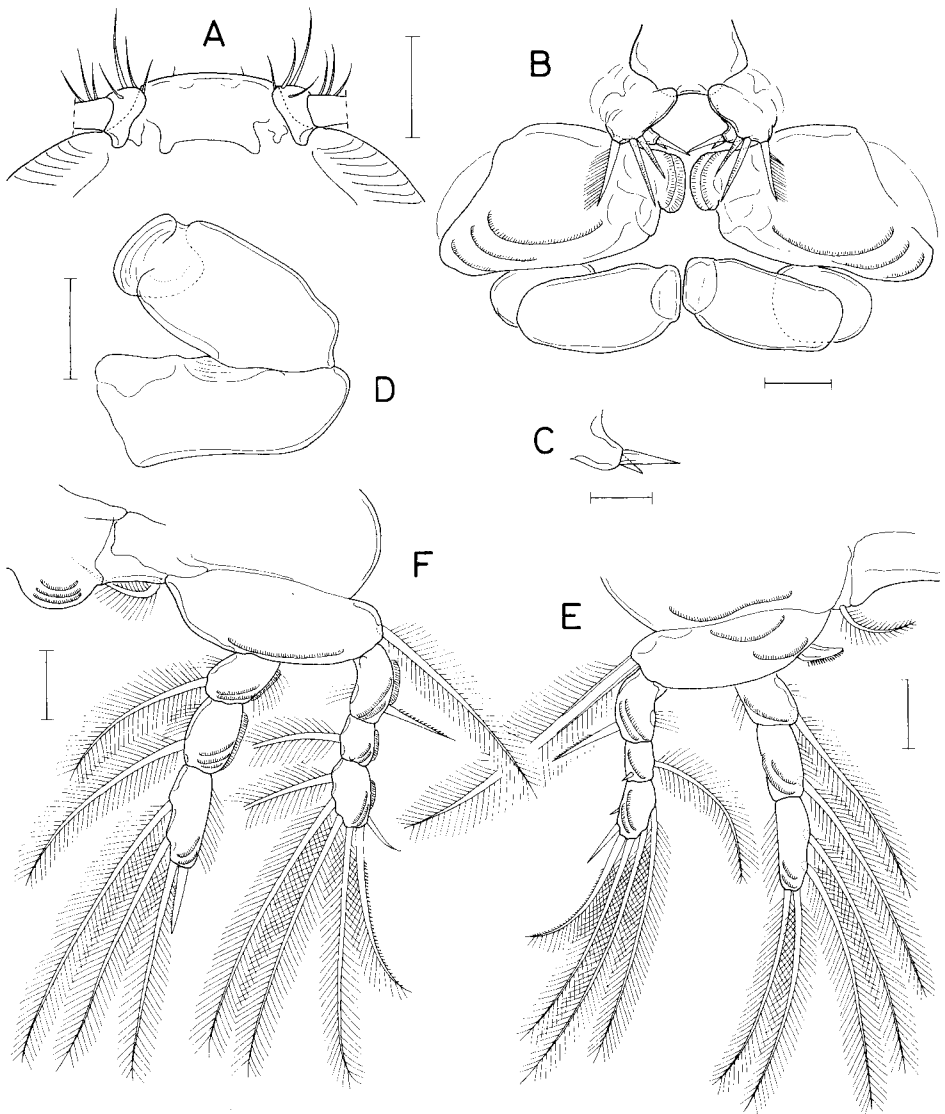


FIG. 5. *Clausia lobata* n. sp., female: (A) rostral area, ventral; (B) mouthparts; (C) mandible; (D) maxilliped; (E) leg 1; (F) leg 2. Scales: A=0.05 mm; B, D-F=0.02 mm; C=0.01 mm.

intercoxal plate, coxa, basis and segments of rami of legs 1-4. Outer seta on basis of leg 3 slender compared with that of leg 2, and that of leg 4 naked. Legs 3 and 4 without inner seta of coxa. Armature formula of legs 1-4 as follows:

	Coxa	Basis	Exp	Enp
Leg 1	0-1	1-1	I-0; I-1; II, 4	0-1; 0-1; 2, 2
Leg 2	0-1	1-0	I-0; 0-1; I, 5	0-1; 0-1; I, 3
Leg 3	0-0	1-0	I-0; 0-1; I, 5	0-1; 0-1; I, 3
Leg 4	0-0	1-0	I-0; 5	0-1; 3

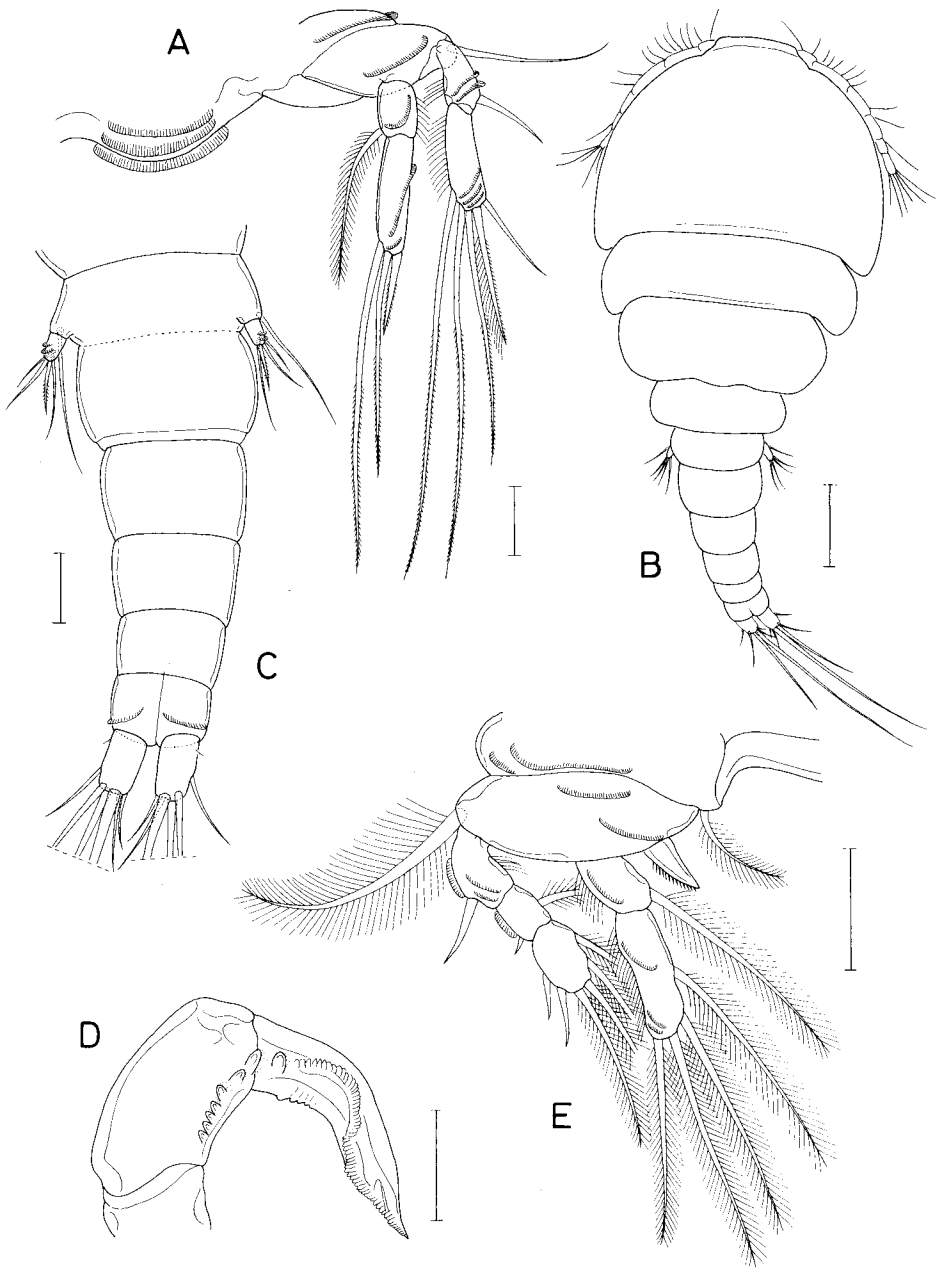


FIG. 6. *Clausia lobata* n. sp. Female: (A) leg 4. Male: (B) habitus, dorsal; (C) urosome, ventral; (D) maxilliped; (E) leg 1. Scales: A, C-E=0.02 mm; B=0.05 mm.

Leg 5 two-segmented (figure 4B, C). Both segments each with three membranous flaps. Basal segment well defined from fifth pedigerous somite, with one outer distal seta mounted on digitiform elevation. Distal segment nearly quadrate,  $25 \times 20 \mu\text{m}$ , with four long, naked terminal setae. Leg 6 represented by one spinule in genital area.

*Male* (in amplexus). Body (figure 6B) distinctly tapering, very small. Length 0.37 mm. Greatest width 177  $\mu$ m. Urosome (figure 6C) six-segmented. Fifth pedigerous somite wider than genital somite. Genital somite 30  $\times$  52  $\mu$ m, dorsally well marked from, but ventrally fused with, fifth pedigerous somite. Genital flap not seen. Four abdominal somites 26  $\times$  42, 21  $\times$  35, 18  $\times$  30, and 18  $\times$  28  $\mu$ m, respectively. Anal somite with membranous flap on each side of ventral surface. Caudal ramus 18  $\times$  11  $\mu$ m (1.64:1).

Maxilliped (figure 6D) three-segmented. First segment very short and unarmed. Second segment with seven small tubercles on inner surface. Third segment the longest, tapering and claw-like, with one tubercle proximally and one curved row of small bead-like spinules. Other mouth organs as those of female.

Endopod of leg 1 two-segmented. First segment with one inner seta. Second segment with four setae. Legs 2–4 with armature formula identical to that of female.

Basal segment of leg 5 completely incorporated into fifth pedigerous somite, leaving one long seta near base of free segment. Free segment small, lobate, 7.7  $\times$  4.6  $\mu$ m (1.67:1), with four setae. Leg 6 not observed.

*Etymology.* The specific name *lobata* alludes to the large, lobate lateral processes on the fourth pedigerous somite.

*Remarks.* Copepods of the Clausiidae may be divided into two groups based on the body form. One group, containing *Pherma* Wilson, 1923, *Rhodinincola* Levinsen, 1878 (= *Seridium* Giesbrecht, 1895), and *Stockia* Sebastian and Pillai, 1974, displays a vermiform body or displays reduced tagmosis. The other group, consisting of *Clausia* Claparède, 1863, *Indoclausia* Sebastian and Pillai, 1974, *Megaclausia* O'Reilly, 1995, *Mesnilia* Canu, 1897, *Pseudoclausia* Bocquet and Stock, 1960, and *Pontoclausia* Băcescu and Por, 1959, show the normal body form. The latter group, to which *Clausia lobata* n. sp. belongs, shows various reductions in the leg segmentation. This reduction in leg segmentation proceeds anteriorly from the fourth to the first legs. A complete leg segmentation is present in the genus *Pontoclausia*, the intermediate state in *Megaclausia*, *Mesnilia* and *Pseudoclausia*, and the most reduced leg segmentation in *Clausia*. Gooding (1963) rejected this classification due to the overlap in various characters between these genera. Gooding's classification is preferred in the present report, particularly because *Clausia lobata* n. sp. is another example demonstrating this morphocline. *Indoclausia* Sebastian and Pillai, 1974 shows no significant difference from the *Clausia* s. str. and therefore is incorporated into *Clausia*.

*Clausia lobata* shows completely segmented rami on leg 3 and two-segmented rami on leg 4. In this respect this species appears intermediate between the *Pontoclausia*-group and the *Mesnilia*-group. At present the '*Pontoclausia*-group' comprises *Clausia tomis* (Băcescu and Por, 1959) and the unpublished *C. wilsoni* Gooding, 1963, and the '*Mesnilia*-group' consists of *C. cluthae* T. and A. Scott, 1896, *C. martinensis* (Canu, 1898) and *C. mirabilis* (O'Reilly, 1995). *Clausia lobata* differs from these five species, respectively, in the small body (only 0.65 mm long), the relatively broad prosome (not harpacticiform), a pair of prominent lobate processes on the fourth pedigerous somite, and no claw-like element on the terminal segment of the antenna.

Although *C. lobata* differs from the '*Clausia* s. str.-group' in the morphology of the legs and other appendages, it shows some affinities with the latter group in the four-segmented female urosome, a well-developed female leg 5, a three-segmented antenna, and sexual dimorphism in the segmentation of the endopod of leg 1.

Most species of *Clausia* were described on the basis of few specimens and it has been assumed that at least some members are associated with annelids (Gooding, 1963). Therefore, the association of *C. lobata* with *Marphysa sanguinea* seems to be the first unambiguous host record for the genus *Clausia*.

Family SYNAPTIPHILIDAE Bocquet, 1953

*Presynaptiphilus minutus* n. sp.

(Figures 7–9)

*Material examined.* Nineteen ♀♀ and 13 ♂♂ from the external surface of the ophiuroid *Amphiura sinicola* (Matsumoto), collected from the intertidal mud flat at Jakyak-do Island, on 29 September 1996. Holotype (♀), allotype (♂), and 26 paratypes (16 ♀♀, 10 ♂♂) have been deposited in the US National Museum of Natural History, Smithsonian Institution. Two ♀♀ and two ♂♂ (dissected) are kept in the collection of the author.

*Female.* Body (figure 7A) very small, elongate, 0.59 mm long. Greatest width 235 µm. Prosome comprising cephalothorax, second and third pedigerous somites. Cephalothorax roughly pentagonal, becoming wider posteriorly. Posterior corners of cephalothorax and succeeding two prosomites rounded. Posteromedian part of tergites of latter two somites fringed with membrane. Third pedigerous somite (second metasome) narrower but distinctly longer than second pedigerous somite.

Urosome (figure 7B) six-segmented, almost cylindrical, comprising fourth and fifth pedigerous somites, genital double-somite and three-segmented abdomen. Fourth pedigerous somite very narrow, without epimerae, only slightly wider than fifth pedigerous somite. The latter 82 µm wide. Genital double-somite quadrangular (figure 7B), 49 × 75 µm. Genital area small, located dorsolaterally at about anterior third. Genital double-somite and abdominal somites armed with spinules at posterior corners. Three abdominal somites 35 × 51, 53 × 43, and 15 × 39 µm, respectively. Second abdominal somite very long, and third abdominal somite characteristically short. The latter becoming narrower posteriorly. Caudal rami in contact with each other, small, 19 × 15 µm (1.27:1). Outer one of two mid-terminal setae shortest among six setae, spiniform, whereas inner one longest, more than four times as long as next longest, outermost terminal seta. All six setae naked.

Rostrum quadrate, with truncate posterior margin. Antennule (figure 7C) six-segmented, 125 µm long, tapering, with armature formula 4, 14, 9, 4, 2 + 1 aesthetasc, and 7 + 1 aesthetasc. Antenna (figure 7D) four-segmented, with armature formula 1, 1, 3 + 1 claw, and 7. Third segment very short; claw strong; innermost one of three setae very tiny. Fourth segment distinctly shorter than wide; three inner ones of seven setae claw-like.

Labrum relatively narrow, only covering part of mandible, and unarmed (figure 7E). Mandible (figure 7F) armed with one terminal, distally bifurcate, spiniform element and one subterminal seta. Maxillule (figure 7G) bilobed, armed with three plumose setae on larger lobe and one smaller glabrous seta on smaller lobe. Maxilla (figure 7H) two-segmented; first segment with one dorso-distal, proximally thick, spiniform seta; distal segment slender, terminated in spiniform element, with one minute seta on ventral margin and two distal setae. Maxilliped (figure 8A) two-segmented. First segment prolonged, articulated in the middle, and distally with spinules along posterior margin. Second segment originated from basal part of first

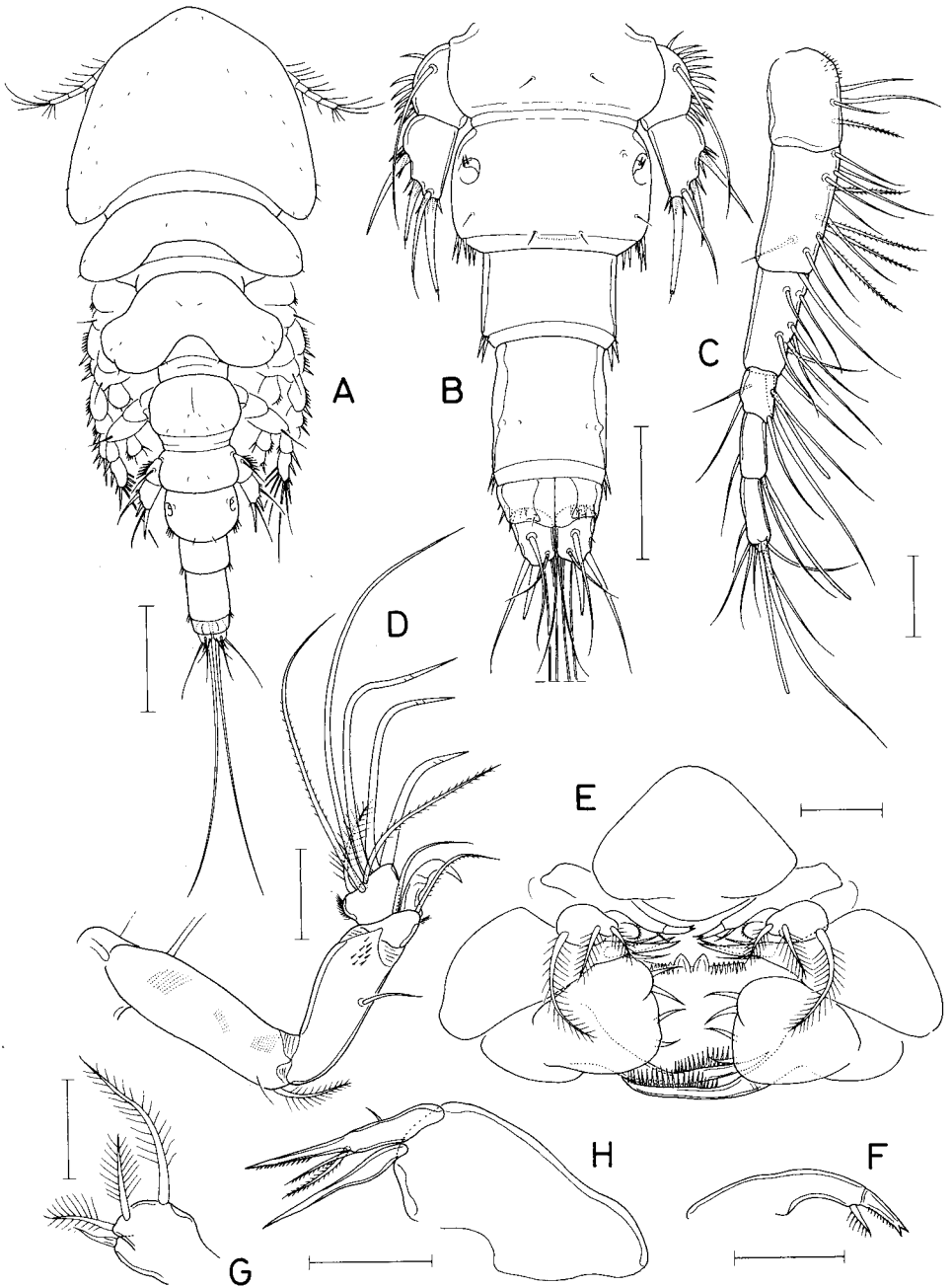


FIG. 7. *Presynaptiphilus minutus* n. sp., female. (A) habitus, dorsal; (B) urosome, dorsal; (C) antennule; (D) antenna; (E) mouthparts; (F) mandible; (G) maxillule; (H) maxilla. Scales: A = 0.1 mm; B = 0.05 mm; C–H = 0.02 mm.

segment, pouch-like,  $34 \times 25 \mu\text{m}$ , weakly bilobed terminally, with a pair of small setae on each lobe, and setules on dorsal surface.

Leg 1 (figure 8B), leg 2 (figure 8C) and leg 3 with three-segmented rami, but leg 4 (figure 8D) with two-segmented rami. Posterior margin of intercoxal plates of



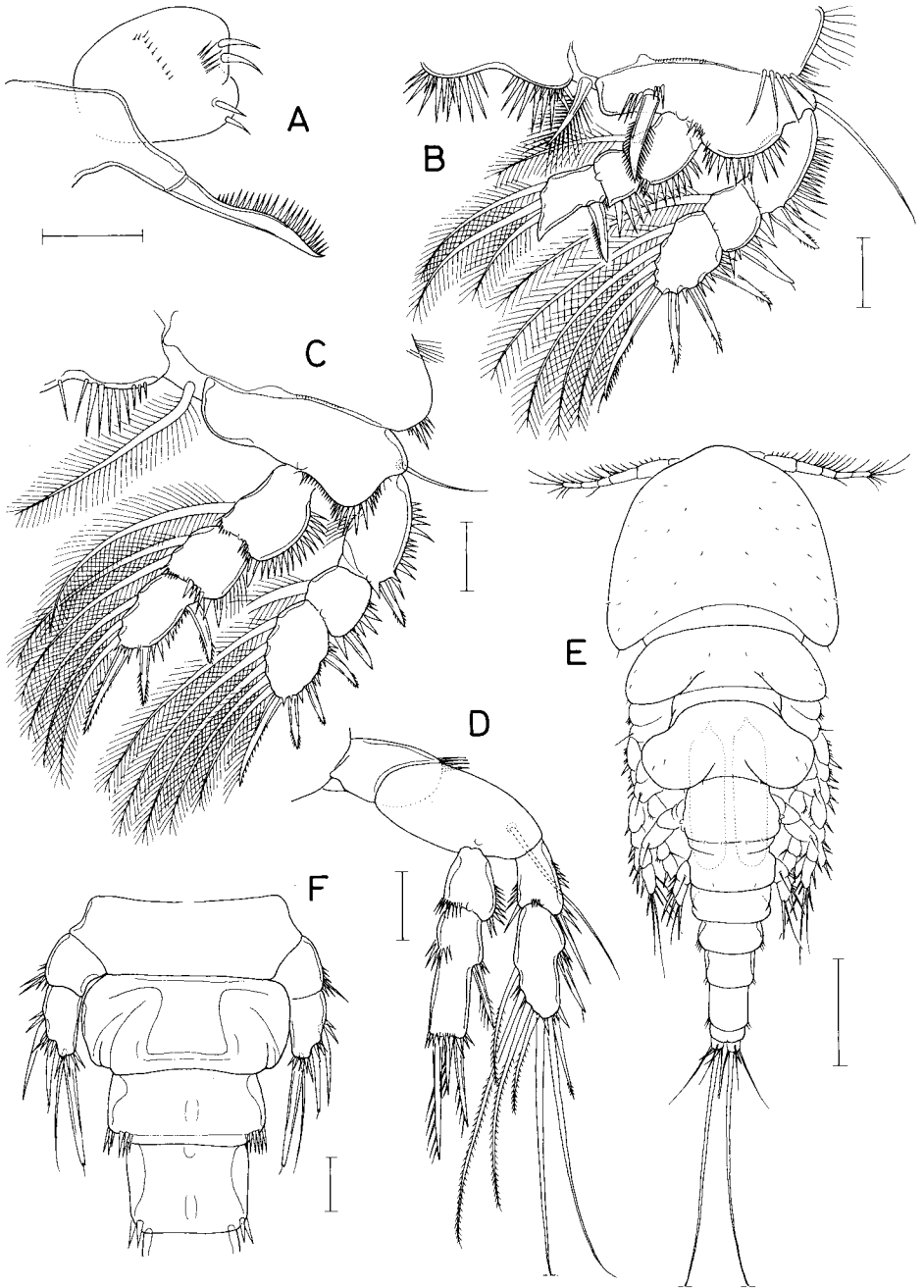


FIG. 8. *Presynaptiphilus minutus* n. sp. Female: (A) maxilliped; (B) leg 1; (C) leg 2; (D) leg 4. Male: (E) habitus, dorsal; (F) anterior part of urosome, ventral. Scales: A-D, F=0.02 mm; E=0.1 mm.

legs 1-3 armed with acute spinules. These spinules also occurring on posterior margin of basis of legs 1-3 and outer margins of nearly all exopodal and endopodal segments of legs 1-4. Terminal endopodal segment of leg 1 with tapering outer

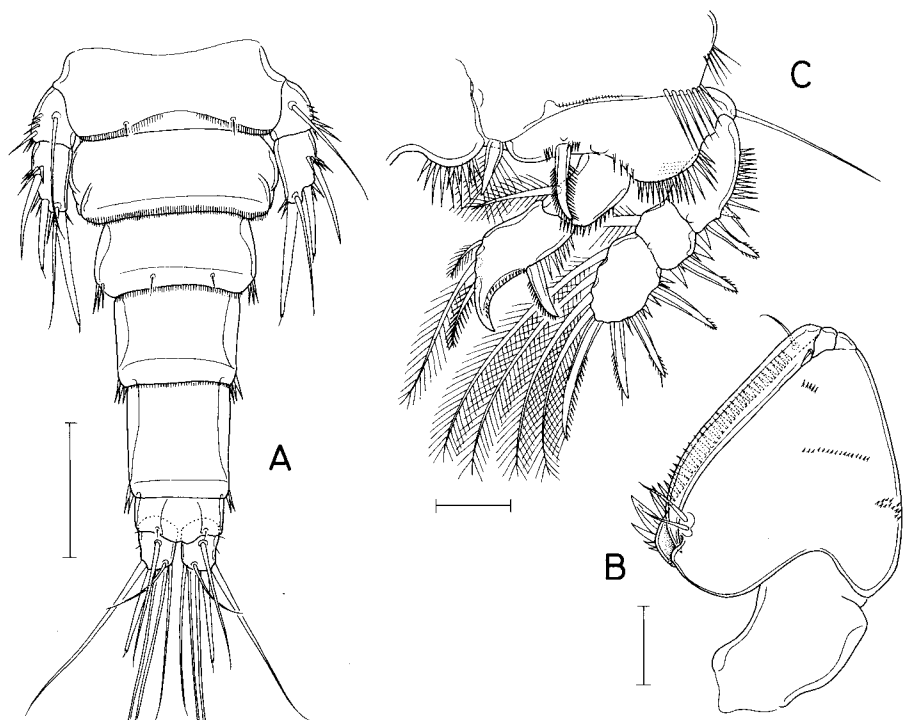


FIG. 9. *Presynaptiphilus minutus* n. sp., male: (A) urosome, dorsal; (B) maxilliped; (C) leg 1. Scales: A=0.05 mm; B, C=0.02 mm.

terminal process; outer spine of this segment located proximally, near border of second segment.

	Coxa	Basis	Exp	Enp
Leg 1	0-1	1-I	I-0; I-1; III, I, 4	0-1; 0-0; I, 3
Leg 2	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; III, 3
Leg 3	0-0	1-0	I-0; 0-1; III, I, 5	0-1; 0-1; III, 3
Leg 4	0-0	1-0	I-0; I, 7	0-0; I, III

Leg 5 two-segmented (figure 7B). Basal segment well marked from fifth pedigerous somite, with one long seta and spinules on outer side. Distal segment  $29 \times 19 \mu\text{m}$  (1.53:1), with inner margin about twice longer than outer margin; distal margin bevelled, with one seta and three setiform spines. Leg 6 represented by two minute spinules in genital area.

*Male.* Body (figure 8E) resembling that of female, gradually narrowed posteriorly. Length  $573 \mu\text{m}$ . Maximum width  $218 \mu\text{m}$ . Prosome three-segmented, and urosome (figure 9A) seven-segmented. Genital somite  $31 \times 78 \mu\text{m}$ , more than twice as wide as long. Four abdominal somites  $27 \times 60$ ,  $34 \times 46$ ,  $42 \times 38$ , and  $14 \times 32 \mu\text{m}$ , respectively. Caudal ramus  $17 \times 14 \mu\text{m}$  (1.21:1).

Antennule with two additional setae: one added on second segment (therefore 15), and another on third (ten). Antenna as in female.

Mouth parts as in female, except for maxilliped. Maxilliped (figure 9B) consisting of three segments and terminal claw. First segment unarmed. Second segment greatly expanded proximally and strongly tapering; inner proximal region with two setae and a folded area where tip of terminal claw inserts; inner margin with one row of spinules, one of proximal spinules distinctly enlarged. Third segment small and unarmed. Claw long and slender, curved terminally, and proximally with two small setae.

Leg 1 (figure 9C) with three-segmented exopod and two-segmented endopod. Armature formula of endopod 0-1; I, 3. Inner seta on coxa spiniform, shorter but thicker than that of female. Outer terminal process of distal endopodal segment curved and more prominent than that of female. Outer and inner terminal setae of this segment smaller. Legs 2-4 as in female. Basal segment of leg 5 well marked from fifth pedigerous somite as in female; distal segment of leg 5  $26 \times 16 \mu\text{m}$  (1.63:1). Leg 6 not seen.

*Etymology.* The specific name *minutus* refers to the small body size of the new species.

*Remarks.* The genus *Presynaptiphilus* includes two known species, *P. acrocnidae* Bocquet and Stock, 1960 and *P. amphiopli* Humes and Hendler, 1972, both from the Atlantic. The new species differs from these in the following features: (1) the pre-anal somite is longer than wide in both sexes; (2) the terminal endopodal segment of leg 1 with one spine and three setae (I, 3), instead of one spine and five setae (I, 5) as in the other two species; and (3) a short caudal ramus with a length to width ratio of 1.27:1, compared with 2:1 in *P. amphiopli* or 3:1 in *P. acrocnidae*. Other important differences are found in leg 1: the first endopodal segment bears one seta (none in *P. acrocnidae*), the endopod of this leg in male is two-segmented (three-segmented in *P. acrocnidae*); and, the inner element on the the basis is a spine (rather than a seta in *P. amphiopli*).

### *Synaptiphilus longicaudus* n. sp.

(Figures 10-12)

*Material examined.* One hundred and thirty-five ♀♀ and 47 ♂♂ from the external body surface of about 40 individuals of the holothurian, *Protankyra bidentata* (Woodward and Barrett), collected in the intertidal mud flat at Jakyak-do Island off Inchon, on 1 September 1996. Holotype (♀), allotype (♂) and 52 paratypes (40 ♀♀ and 12 ♂♂) have been deposited in the US National Museum of Natural History, Smithsonian Institution. Remaining specimens (94 ♀♀ and 34 ♂♂) are kept in the collection of the author.

*Female.* Body (figure 10A) dorsoventrally flattened, and  $853 \mu\text{m}$  long. Greatest width  $438 \mu\text{m}$ . Prosome broad, composed of cephalothorax and three pedigerous somites. Somites with well developed epimera. Tergites of cephalothorax and two following somites with acutely pointed posterolateral processes. Cephalothorax much wider than long. Fourth pedigerous somite distinctly narrower than those of anterior somites, its mid-posterior margin curved, W-shaped, with round lateral margins. Urosome (figure 10B) five-segmented, narrow, tapering, and originating from ventral side of fourth pedigerous somite. Ventral surface of first three urosomites with minute spinules. Fifth pedigerous somite much broader than genital double-somite. Genital double-somite obscurely delimited dorsally from fifth pedigerous somite but distinctly delimited ventrally,  $53 \times 88 \mu\text{m}$  (measured ventrally). Genital areas located

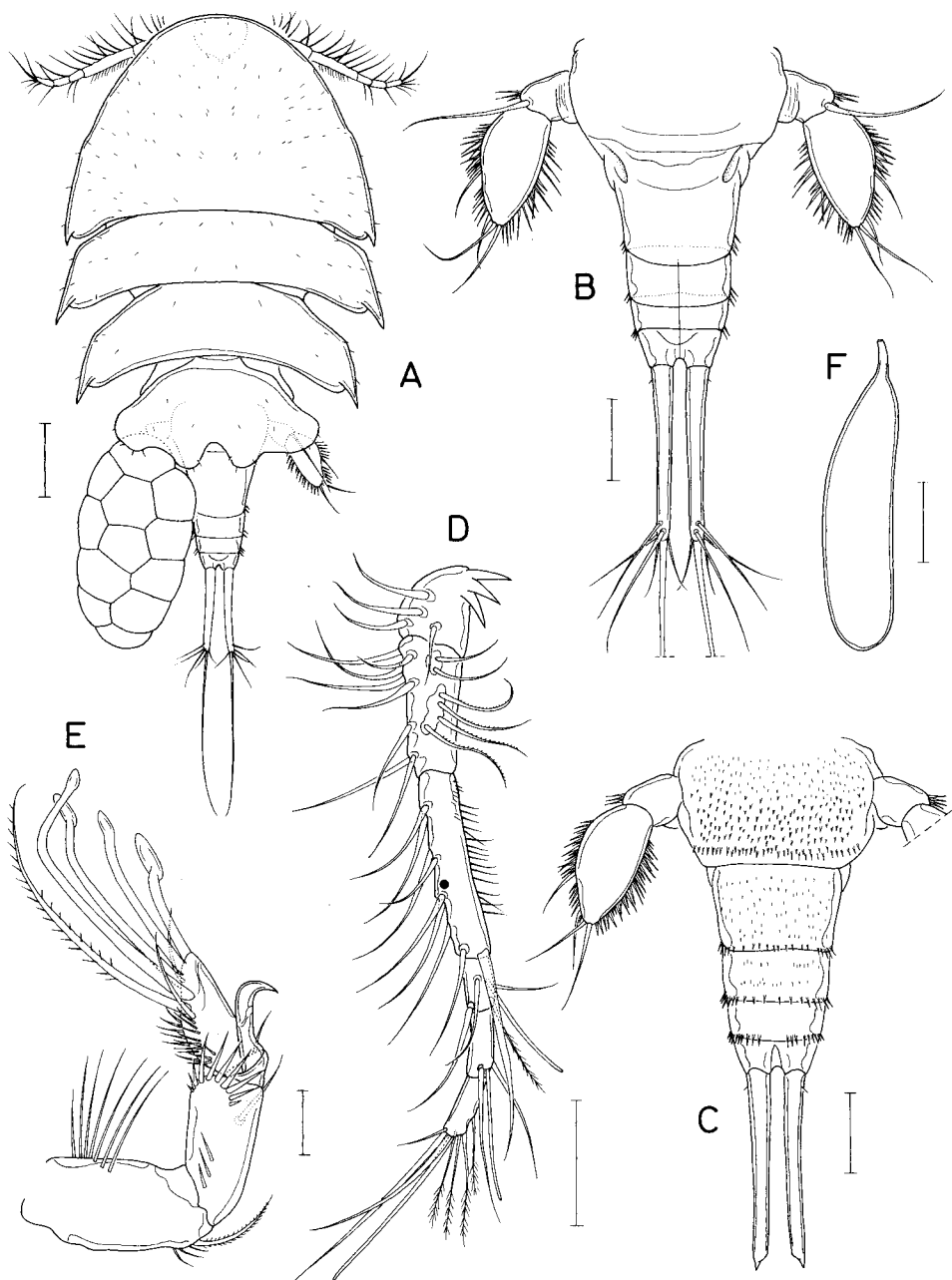


FIG. 10. *Synaptiphilus longicaudus* n. sp., female: (A) habitus, dorsal; (B) urosome, dorsal; (C) same, ventral; (D) antennule; (E) antenna; (F) spermatophore. Scales: A = 0.1 mm; B–D, F = 0.05 mm; E = 0.02 mm.

dorsolaterally in anterior part. Posteroventral border of genital double- and first two abdominal somites fringed with row of spinules. Three abdominal somites  $32 \times 65$ ,  $23 \times 60$ , and  $23 \times 50 \mu\text{m}$ , respectively (measured ventrally). Anal somite narrowed distally and incised posteromedially. Caudal ramus very long and slender,

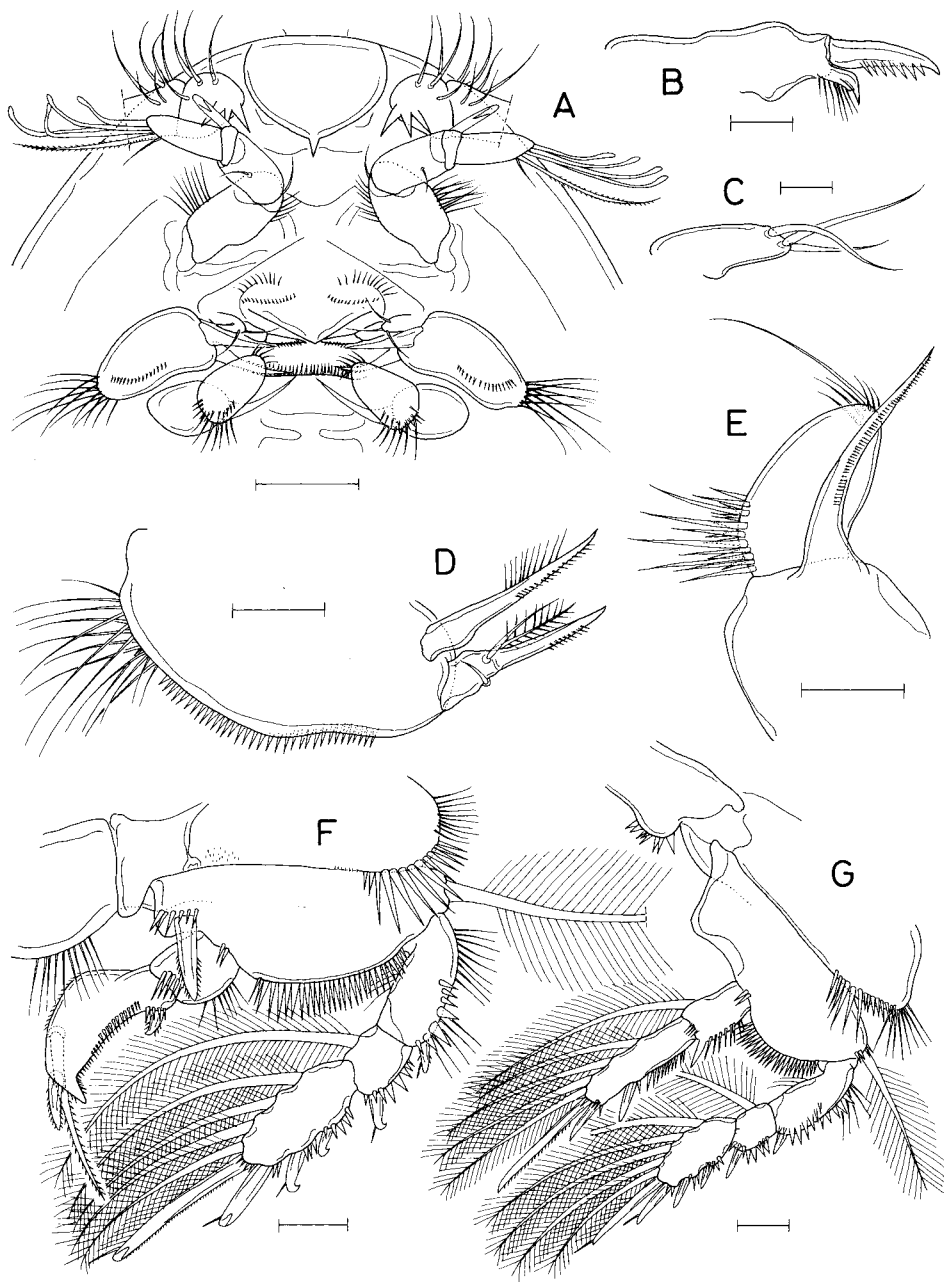


FIG. 11. *Synaptiphilus longicaudus* n. sp., female: (A) anterior part of cephalothorax, ventral; (B) mandible; (C) maxillule; (D) maxilla; (E) maxilliped; (F) leg 1; (G) leg 2. Scales: A=0.05 mm; B, C=0.01 mm; D-G=0.02 mm.

113 × 13 μm (8.7:1), terminated in pointed process (figure 10C). All six caudal setae smooth, aggregated in terminal portion of caudal ramus. Inner one of two median terminal setae distinctly larger than others.

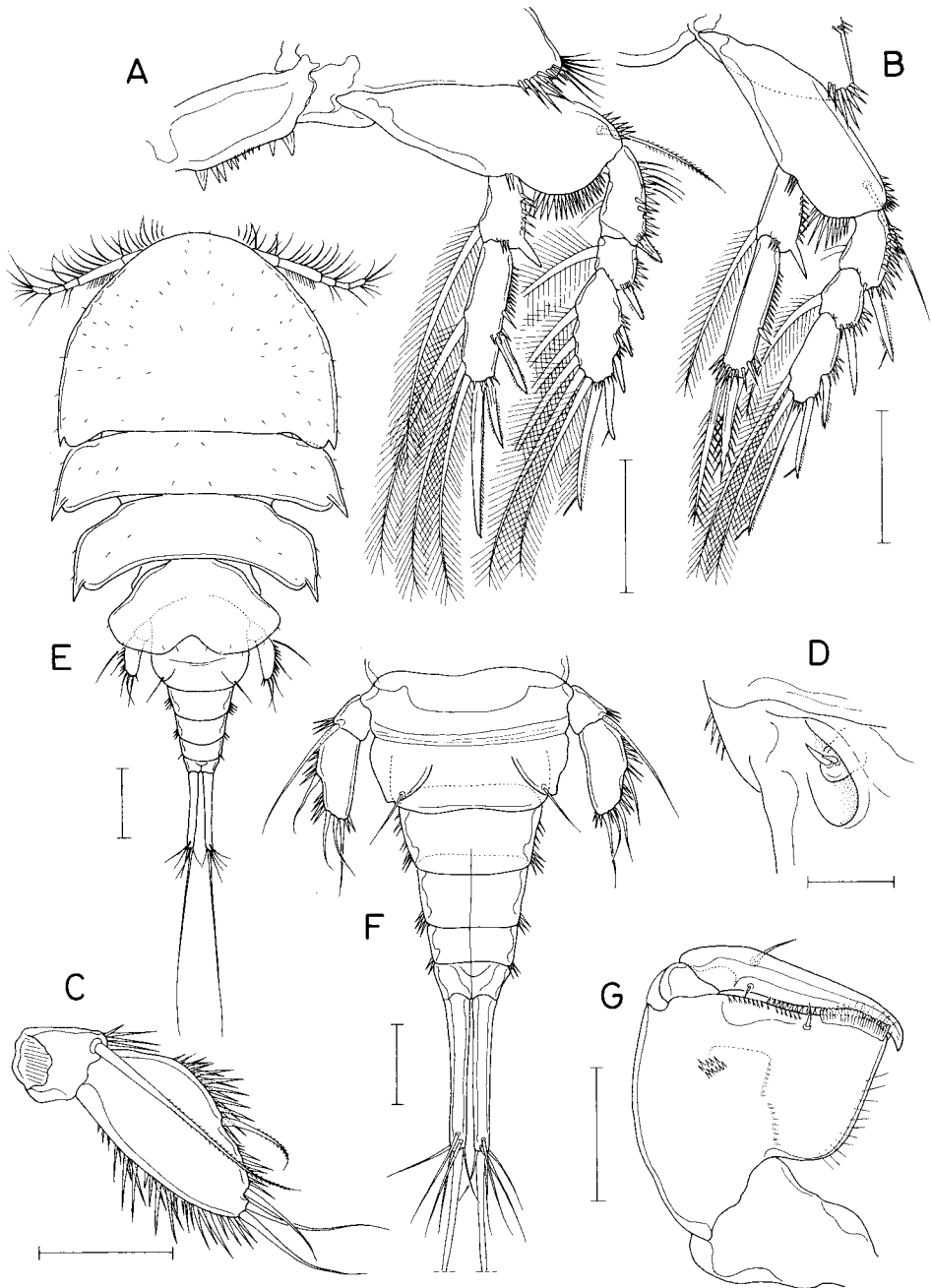


FIG. 12. *Synaptiphilus longicaudus* n. sp. Female: (A) leg 3; (B) leg 4; (C) leg 5; (D) genital area. Male: (E) habitus, dorsal; (F) urosome, ventral; (G) maxilliped. Scales: A-C, E-G=0.05 mm; D=0.02 mm.

Spermatophore (figure 10F) elongate,  $192 \times 42 \mu\text{m}$ . Egg sac  $290 \times 155 \mu\text{m}$ , extending beyond tip of caudal rami.

Rostrum nearly circular, with point at posterior tip (figure 11A). Antennule (figure 10D) six-segmented, with armature formula 4 (or 5), 14, 9, 4+1 aesthetasc,

2+1 aesthetasc, and 7+1 aesthetasc. First segment with three or four proximal claws in addition to setae. Third segment with hairs on posterior margin. Antenna (figure 10E) four-segmented. First segment with one inner distal seta and long setules on outer margin. Second segment with one subterminal seta and long spinules near outer distal corner. Third segment very short, with one strong claw and one seta. Terminal segment with setules on outer side, and terminally three setae and four spatulate claws.

Labrum tapering posteriorly and not covering mouth parts (figure 11A). Mandible (figure 11B) armed with one strong, posteriorly pectinated, terminal element and one subterminal process-like element. The latter distally bifid, with setules on posterior margin. Paragnath not seen. Maxillule (figure 11C) a lobe armed distally with three setae. Maxilla (figure 11D) two-segmented. First segment with long setules basally, ventral row of spinules, and one large spine distally. Second segment small, terminally with one strong spine and two dorsal setae (one of them plumose), and one smaller ventral seta; the latter directed laterally, recurved around segment. Maxilliped (figure 11E) two-segmented. Basal segment very broad, armed distally with one large spine extending beyond end of distal segment. Distal segment elongate-oval, tapering but roundly ended, with many spinules basally, and distally one seta and several setules.

Legs 1-4 with three-segmented exopod and two-segmented endopod. Intercoxal plate of leg 1 with long setules on posterior margin (figure 11F), but those of legs 2 (figure 11G) and 3 (figure 12A) with spinules on this margin. All legs 1-4 without inner seta on coxa. Middle portion of posterior margin of legs 1-4 pectinated. Distal endopodal segment of leg 1 curved outward and bearing terminal process. Outer distal corner of first endopodal segment of legs 1-4 with acutely pointed process. Armature formula of legs 1-4 as follows:

	Coxa	Basis	Exp	Enp
Leg 1	0-0	1-I	I-0; I-1; III, I, 4	0-0; I, I, 1
Leg 2	0-0	1-0	I-0; I-1; III, I, 5	I-1; I, II, 4
Leg 3	0-0	1-0	I-0; I-1; III, I, 5	I-1; I, II, 3
Leg 4	0-0	1-0	I-0; I-1; II, I, 2	I-1; 2

Leg 5 (figure 12C) two-segmented. Basal segment as long as wide, well delimited from fifth pedigerous somite, with one distal seta and spinules near base of seta. Free segment  $77 \times 40 \mu\text{m}$  (1.93:1), tapering in distal half, with four setae and densely arranged spinules on both margins.

Leg 6 represented by two spiniform elements in genital area (figure 12D).

*Male.* Body (figure 12E) similar to that of female. Length  $842 \mu\text{m}$ . Greatest width  $400 \mu\text{m}$ . Posterior margin of fourth pedigerous somite incised medially, its curvature different from that of female. Urosome (figure 12F) six-segmented. Genital somite slightly narrower than fifth pedigerous somite, much wider than long,  $42 \times 123 \mu\text{m}$ . Four abdominal somites gradually shorter and narrower,  $42 \times 88$ ,  $37 \times 68$ ,  $25 \times 57$ , and  $22 \times 48 \mu\text{m}$ , respectively. Caudal ramus  $98 \times 13 \mu\text{m}$  (7.54:1).

Antennule different from that of female in bearing ten setae on third segment, instead of nine. Antenna as in female.

Maxilliped (figure 12G) consisting of three segments and terminal claw. First segment unarmed, distally broadened. Second segment greatly expanded inwards, nearly quadrangular, as long as wide, more broadened distally, armed on distal margin with one seta, about two rows of spinules and a membranous fringe on inner part of distal margin and spinules on lateral surfaces. Third segment short and unarmed. Claw thick, long, weakly curved terminally, with two small proximal setae. Other mouth organs as in female.

Legs 1–4 not different from those of female. Basal segment of leg 5 well delimited from fifth pedigerous somite as in female. Distal segment  $58 \times 26 \mu\text{m}$  (2.23:1), without spinules on inner margin. Leg 6 represented by one thin seta on genital flap (figure 12F).

*Etymology.* The specific name *longicaudus* alludes to the very long caudal rami of the new species.

*Remarks.* The genus *Synaptiphilus* is known by three species associated with Atlantic holothurians: *S. luteus* Canu and Cuenot, 1892, *S. tridens* T. and A. Scott, 1894, and *S. cantacuzenei* Bocquet and Stock, 1957. The latter is a polytypic species, with a subspecies *S. cantacuzenei mixtus* Guille and Laubier, 1965.

Identification of *S. longicaudus* n. sp. is very easy due to its extremely long caudal rami, a characteristic observable without dissection. The ratio of length to width of its caudal rami is 8.7:1, whereas in all other known species it does not exceed 3:1. Other salient morphological features of the new species are: (1) first endopodal segment of leg 1 unarmed (one medial seta on this segment in other species) and (2) second endopodal segment of leg 1 with two spines and one seta (I, I, 1) compared with one spine and two setae (I, 2) in other species.

### *Enterophilus* n. gen.

*Diagnosis.* Synaptiphilidae. Body consisting of cephalothorax, three prosomites and five-segmented (in female) or six-segmented (in male) urosome. Cephalothorax and first two pedigerous somites with well developed epimera. Caudal rami greatly dilated, bearing four caudal setae, with terminal one enlarged. Antennule six-segmented, armature formula of 5, 14, 9, 4+1 aesthetasc, 2+1 aesthetasc, and 7+1 aesthetasc; without sexual dimorphism. Antenna four-segmented, with armature formula of 1, 1, 1+1 claw, and 3+4 claws; claw of third segment very strong; claws of terminal segment with spatulate tip. Mandible with only one thick element. Maxillule armed with three setae. Maxilla two-segmented; first segment with one distal spine; second segment armed terminally with one spine and three setae. Maxilliped has unsegmented digitiform process in female, but well-developed in male. Legs 1–4 with three-segmented exopod and two-segmented endopod; setae and spines reduced in number. Legs 1–5 without sexual dimorphism. Basal segment of leg 5 incorporated into somite. Living in alimentary canal of holothurians.

*Etymology.* The generic name is derived from the Greek *enteron* (=intestine) and *philos* (=loving). It alludes to the discovery of the new genus in the digestive tract of the holothurian. The gender is masculine.

*Type species.* *Enterophilus cercomegalus* n. sp.

*Remarks.* Along with the genera *Presynaptiphilus* and *Synaptiphilus*, the new genus is classified in the Synaptiphilidae. This family is characterized by the primitive, clausidiid type maxilla and male maxilliped; transformed female maxilliped; reduced setation on the legs; and four-segmented antenna with a strong claw on the third



segment. Of the other two confamilial genera, *Enterophilus* is closer to *Synaptiphilus* than to *Presynaptiphilus* in the following characteristics: (1) three-segmented exopod and two-segmented endopod on legs 1–4; (2) antenna with one claw and one seta on the third segment, and four spatulate elements on the terminal segment; (3) nearly identical maxilla and male maxilliped; and (4) equally reduced number of setae on the maxillule.

However, the new genus can be differentiated from *Synaptiphilus* by the following features: (1) mandible with only one element; (2) female maxilliped reduced to a non-functional process; (3) greatly expanded caudal rami, with an enlarged caudal seta; and (4) free single segment of leg 5 resulting from fusion of original first and second segments.

***Enterophilus cercomegalus* n. sp.**

(Figures 13, 14)

*Material examined.* Twenty-six ♀♀ and three ♂♂ in the alimentary canal of the holothurian, *Protankyra bidentata* (Woodward and Barrett), collected from the intertidal mud flat at Jakyak-do Island off Inchon, on 1 September 1996. Holotype (♀), allotype (♂) and 17 paratypes (♀♀) have been deposited in the US National Museum of Natural History, Smithsonian Institution. Other specimens (eight ♀♀, two ♂♂, including two ♀♀ and one ♂ dissected) are kept in the collection of the author.

*Female.* Body (figure 13A) dorsoventrally flat, 1.05 mm long, Maximum width 430 µm. Prosome consisting of cephalothorax and three pedigerous somites. Cephalothorax, second and third pedigerous somites much wider than long, with well developed, wing-like epimera. Rostral area of cephalothorax roundly produced. Fourth pedigerous somite hexagonal, 170 × 240 µm, distinctly narrower than preceding somite, without epimerae. Urosome (figure 13B) five-segmented. Fifth pedigerous somite 182 µm wide, concealed dorsally by fourth pedigerous somite, with round lateral margins. Genital double-somite 78 × 140 µm, much narrower than fifth pedigerous somite, with angular lateral protrusions in anterior third; genital area located near this protrusion; a tuft of hairs present near posterior fourth of lateral margin. Three abdominal somites 63 × 90, 68 × 100, and 50 × 120 µm, respectively. Boundaries of these abdominal somites indistinct, but discernible by lateral constrictions. Anal somite deeply notched posteromedially and divergent. Caudal ramus greatly dilated, 175 × 53 µm (3.30:1), with three minute and one enlarged setae; this enlarged seta naked, longer than caudal ramus, 198 × 18 µm, with constriction just distal to midlength. Proximal half of outer lateral margin with minute spinules. Outer lateral seta located at midlength of caudal ramus. Other three setae located distally. Egg sac containing only two large eggs, extending to distal border of anal somite.

Rostrum almost absent, represented only by a triangular area of faint sclerotization. Antennule (figure 13C) six-segmented, tapering distally, with armature formula: 5, 14, 9, 4 + 1 aesthetasc, 2 + 1 aesthetasc, and 7 + 1 aesthetasc. All setae naked and relatively small. Antenna (figure 13D) four-segmented, with armature formula: 1, 1, 1 + 1 claw, and 3 + 4 claws. Second segment with many spinules on outer surface. Third segment short; claw very large and strongly curved. Fourth segment about twice as long as wide, with spinules on outer margin; one of four distal claws distinctly longer than other three; distal parts of these four claws spatulate.

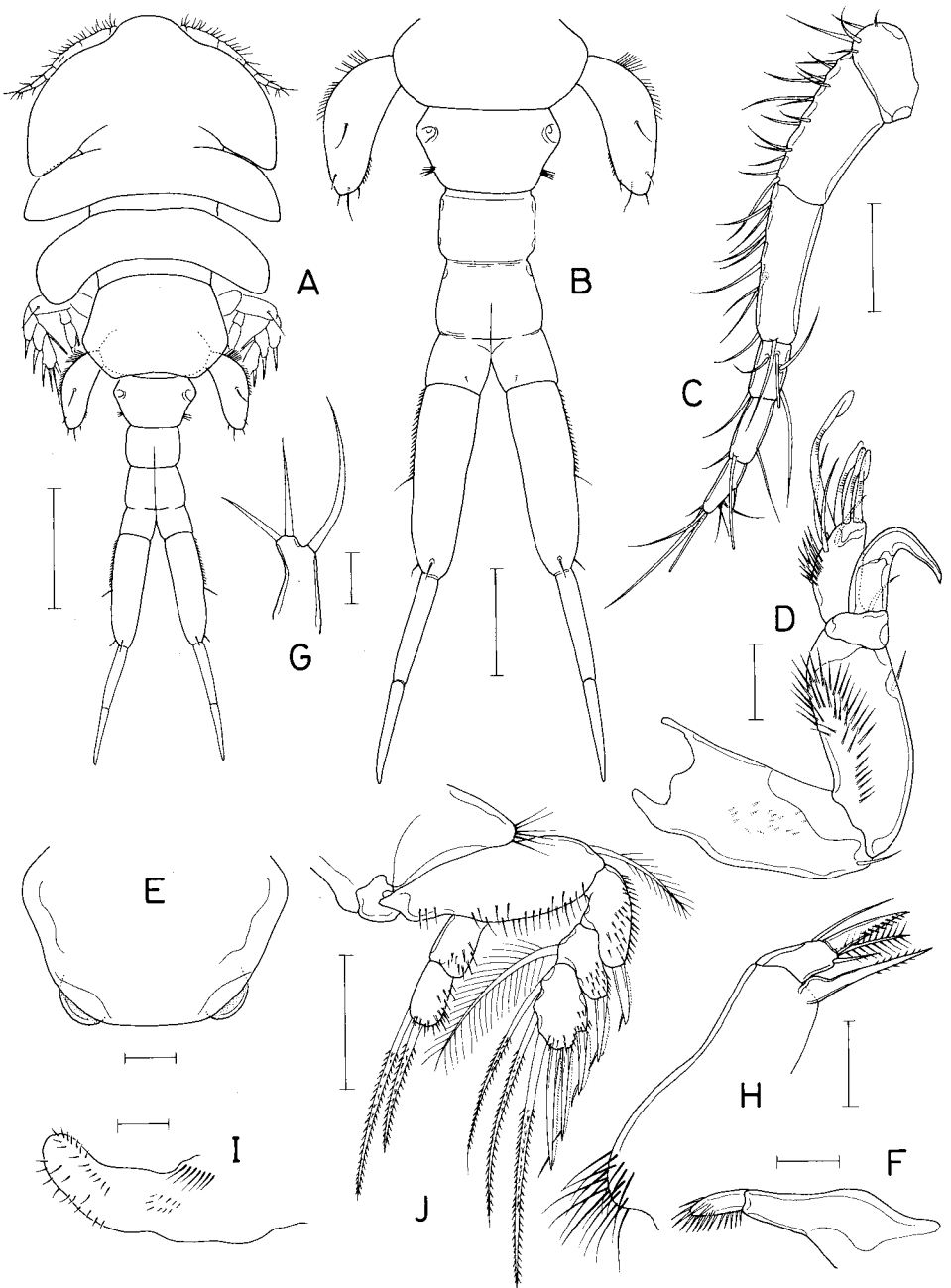


FIG. 13. *Enterophilus cercomegalus* n. gen. et n. sp., female: (A) habitus, dorsal; (B) urosome, dorsal; (C) antennule; (D) antenna; (E) labrum; (F) mandible; (G) maxillule; (H) maxilla; (I) maxilliped; (J) leg 1. Scales: A=0.2 mm; B=0.1 mm; C, J=0.05 mm; D, H=0.02 mm; E, F, G, I=0.01 mm.

Labrum as figure 13E, with lobate outgrowth at posterior corner, otherwise unarmed. Mandible (figure 13F) with one thick, blunt terminal element; this element with spinules. Maxillule (Fig 13G) as a lobe distally armed with three glabrous

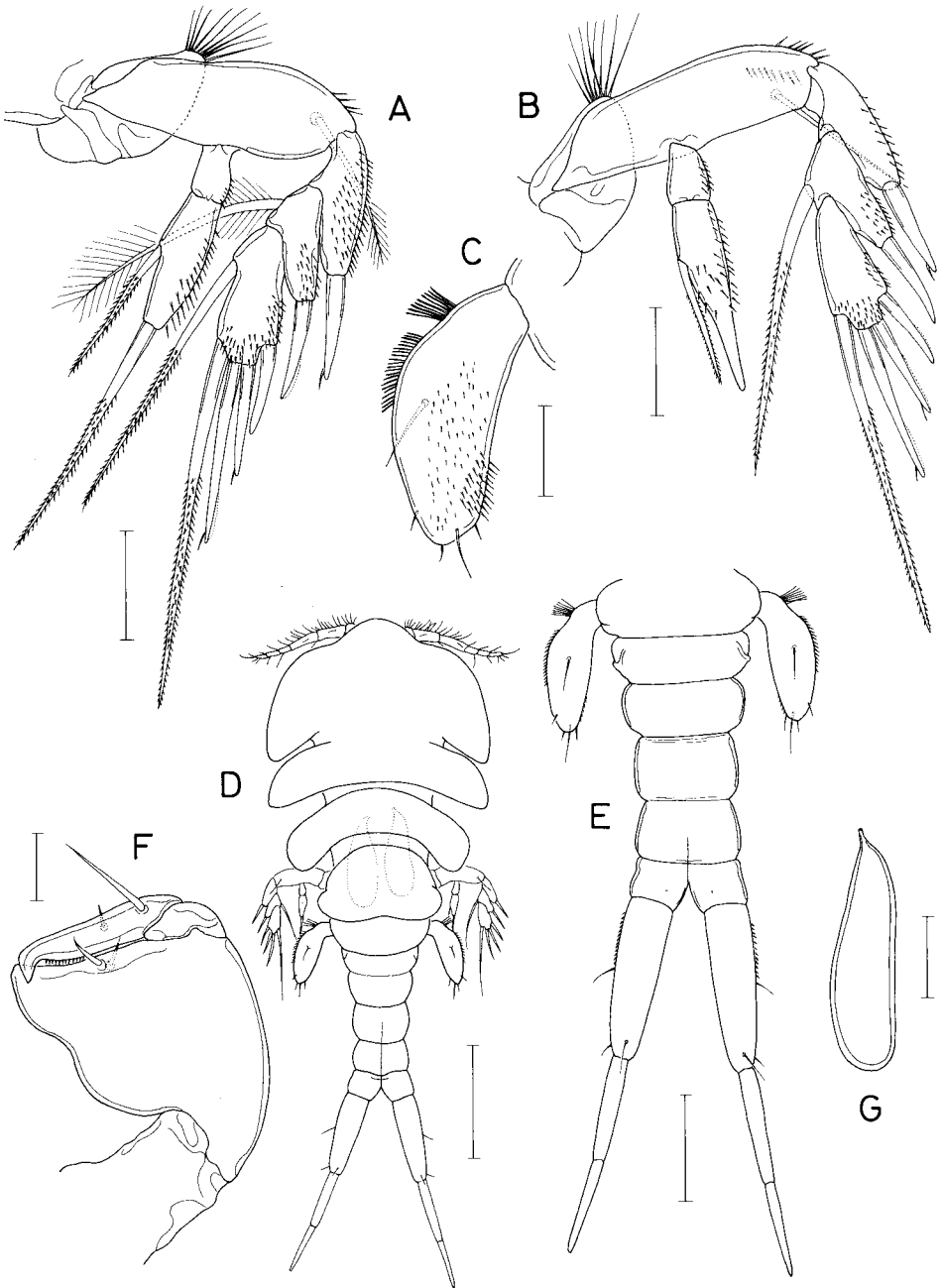


FIG. 14. *Enterophilus cercomegalus* n. gen. et n. sp. Female: (A) leg 2; (B) leg 3; (C) leg 5. Male: (D) habitus, dorsal; (E) urosome, dorsal; (F) maxilliped; (G) spermatophore. Scales: A-C, G=0.05 mm; D=0.2 mm; E=0.1 mm; F=0.02 mm.

setae. Maxilla (figure 13H) two-segmented. First segment with a patch of hairs proximally on ventral surface and one spiniform seta distally. Second segment armed terminally with one spine and three setae. Maxilliped (figure 13I) a weakly sclerotized digitiform process, having scattered spinules.

Leg 1 (figure 13J), leg 2, leg 3 (figure 14A), and leg 4 (figure 14B) with three-segmented exopod and two-segmented endopod. All these legs without inner seta on coxa. Rami of all these legs with many scattered minute spinules on outer side. All spines of exopod of leg 1 and some spines of legs 2–4 with subterminal flagellum. All setae on rami of legs 1–4, except for setae on second exopodal segment of legs 1–3, rather stiff, spiniform and armed with spinules. Distal endopodal segment of leg 4 terminating in a long process. Armature formula of legs 1–4 as follows:

	Coxa	Basis	Exp	Enp
Legs 1 and 2	0-0	1-0	I-0; I-1; III, 3	0-0; 2
Leg 3	0-0	1-0	I-0; I-1; III, 2	0-0; 1, 1
Leg 4	0-0	1-0	I-0; I-1; III, 1	0-0; 1

Leg 5 (figure 14C) consisting of one free segment, formed by fusion of original basal and distal segments; nearly elliptical, slightly curved inward, widest in the middle,  $142 \times 58 \mu\text{m}$  (2.45:1), with five setae. One of these five setae located on dorsal surface halfway the length of segment; other four setae located distally, very small; outer margin with two rows of setules in proximal half; setules of proximal row longer than those of distal row; setules of both rows blunt terminally, small aesthetasc-like; inner distal area and ventral surface with minute spinules. Leg 6 not observed.

*Male.* Body (figure 14D) resembling that of female. Length 0.99 mm. Urosome (figure 14E) six-segmented. Genital somite  $43 \times 127 \mu\text{m}$ , about three times as wide as long, narrower than fifth pedigerous somite and shorter than first abdominal somite. Four abdominal somites  $50 \times 115$ ,  $59 \times 98$ ,  $56 \times 97$ , and  $42 \times 110 \mu\text{m}$ , respectively. First three abdominal somites with minute spinules on ventral surface. Caudal ramus  $153 \times 43 \mu\text{m}$  (3.49:1); caudal setae as in female.

Antennule, antenna and mouth organs not different from those of female, except for maxilliped (figure 14F) which consists of three segments and terminal claw. First segment unarmed. Second segment greatly expanded inwards, more broadened distally, with slightly concave inner margin and two setae on distal margin. Third segment short and unarmed. Claw rather massive, curved terminally, not extending over inner distal corner of second segment, with minute spinules on inner margin and two extremely unequal proximal setae.

Terminal seta on endopodal distal segment of leg 4 well marked from segment, not fused to segment as in female. No other significant sexual dimorphism seen in legs 1–5. Leg 6 not observed.

Spermatophore from male (figure 14G) elongate,  $148 \times 40 \mu\text{m}$ .

*Etymology.* The specific name *cercomegalus* is from the Greek *kerkos* (=tail) and *megalos* (=large). It alludes to the enlarged caudal rami of the new species.

#### Family CATINIIDAE Bocquet and Stock, 1957

##### *Goidelia pelliviva* n. sp.

(Figures 15–19)

*Material examined.* Twenty-three ♀♀ (including one ovigerous female), eight ♂♂, one copepodid IV ♀, and one copepodid V ♀ on the skin of an echiuroid (*Thalassema*

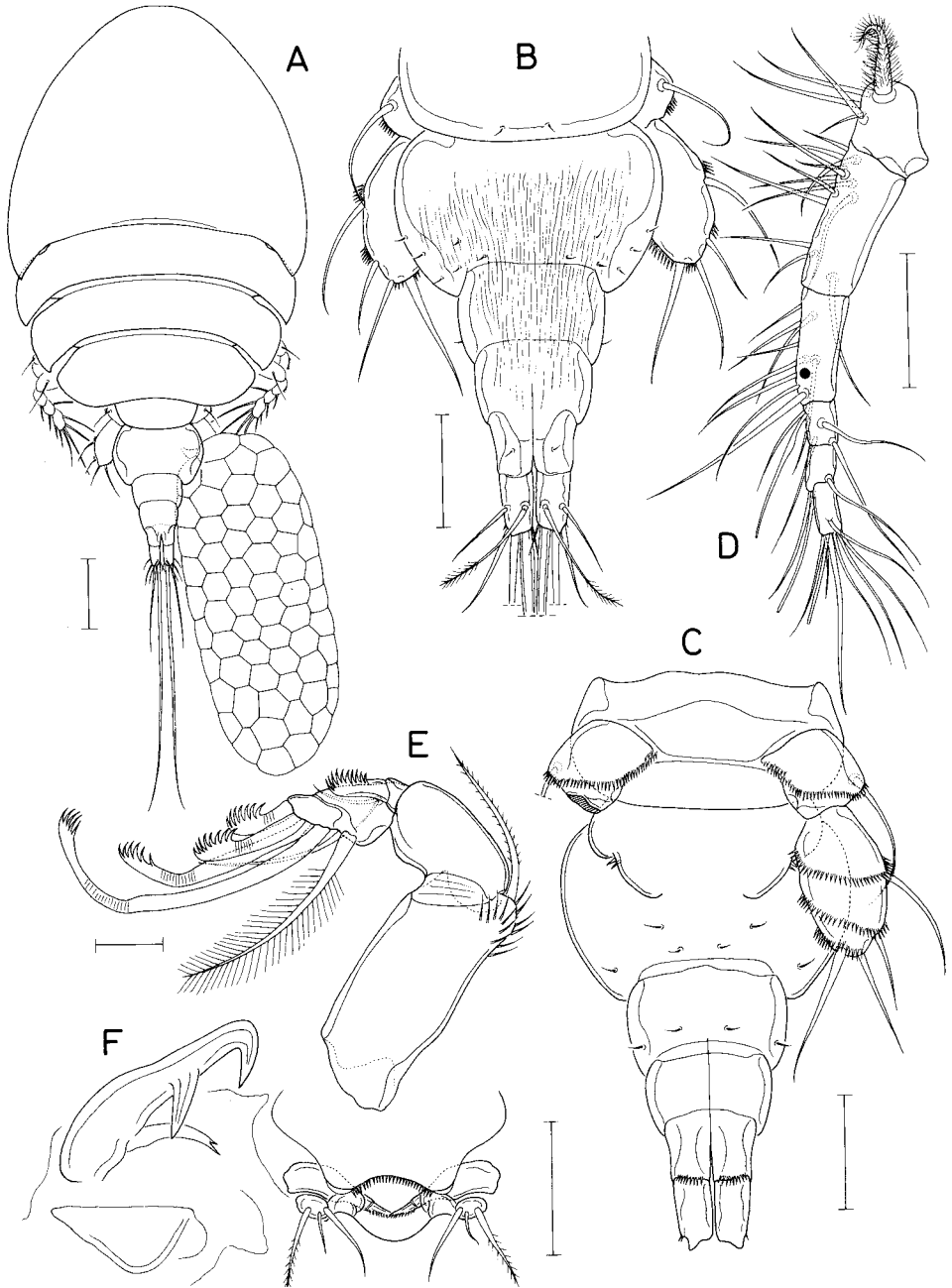


FIG. 15. *Goidelia pelliviva* n. sp., female: (A) habitus, dorsal; (B) urosome, dorsal; (C) same, ventral; (D) antennule; (E) antenna; (F) mouthparts. Scales: A=0.1 mm; B–D, F=0.05 mm; E=0.02 mm.

sp.) collected from the intertidal mud flat at Jakyak-do Island off Inchon, on 29 September 1996. Holotype (ovigerous ♀), allotype (♂), and 26 paratypes (20 ♀♀, six ♂♂) have been deposited in the US National Museum of Natural History,

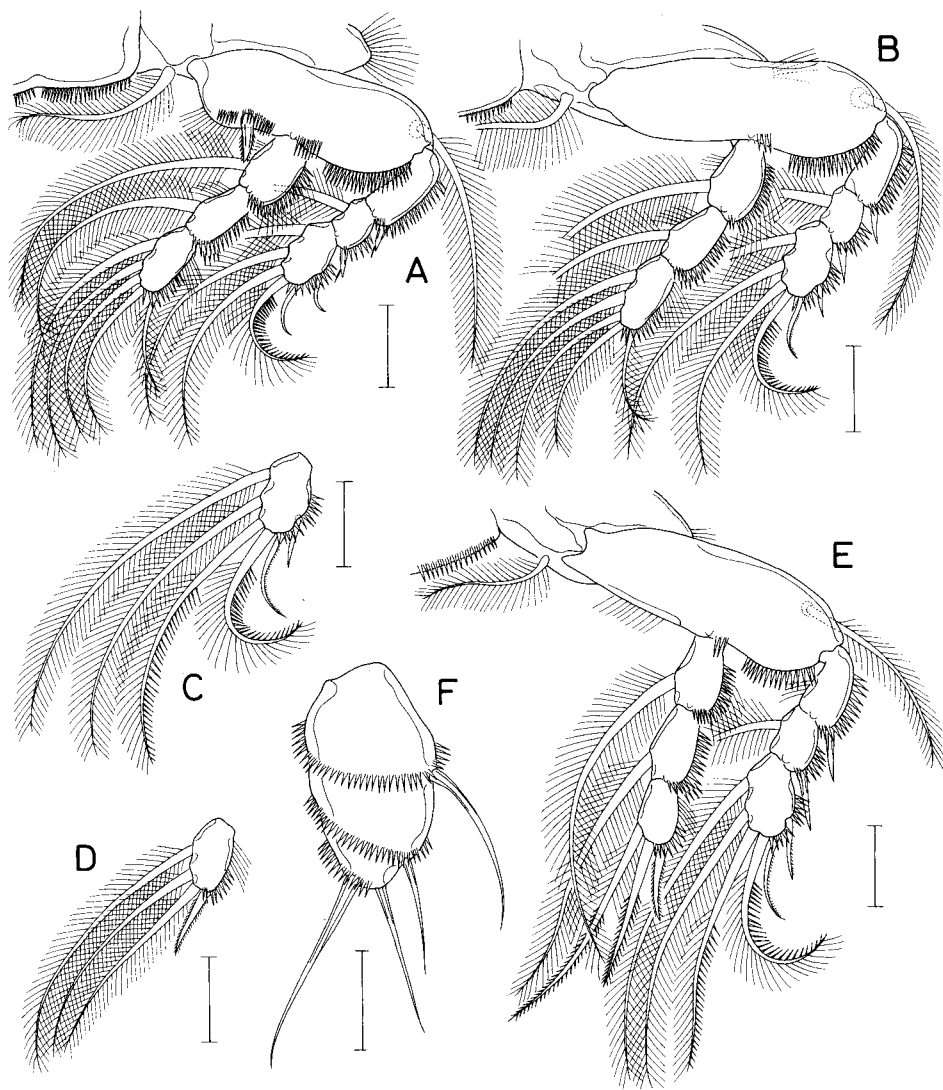


FIG. 16. *Goidelia pelliviva* n. sp., female: (A) leg 1; (B) leg 2; (C) third exopod segment of leg 3; (D) third endopod segment of leg 3; (E) leg 4; (F) free segment of leg 5. Scales: A–F = 0.03 mm.

Smithsonian Institution). Dissected specimens (two ♀♀, one ♂, and copepodids) are kept in the collection of the author.

**Female.** Body (figure 15A) small, 0.79 mm long. Greatest width 0.43 mm. Prosome very flat, oval in dorsal view, occupying about 70% of body length, and consisting of cephalothorax and three pedigerous somites. Urosome (figure 15B, C) five-segmented. Fifth pedigerous somite 119  $\mu$ m wide. Genital double- and first two abdominal somites with fine striations on dorsal surface. Genital double-somite 71 (measured along median axis of ventral surface)  $\times$  126  $\mu$ m, laterally expanded and well sclerotized. Genital area located ventrally (figure 15C). Three abdominal somites 42  $\times$  70, 29  $\times$  55, and 25  $\times$  39  $\mu$ m, respectively, with faint segmentation lines between

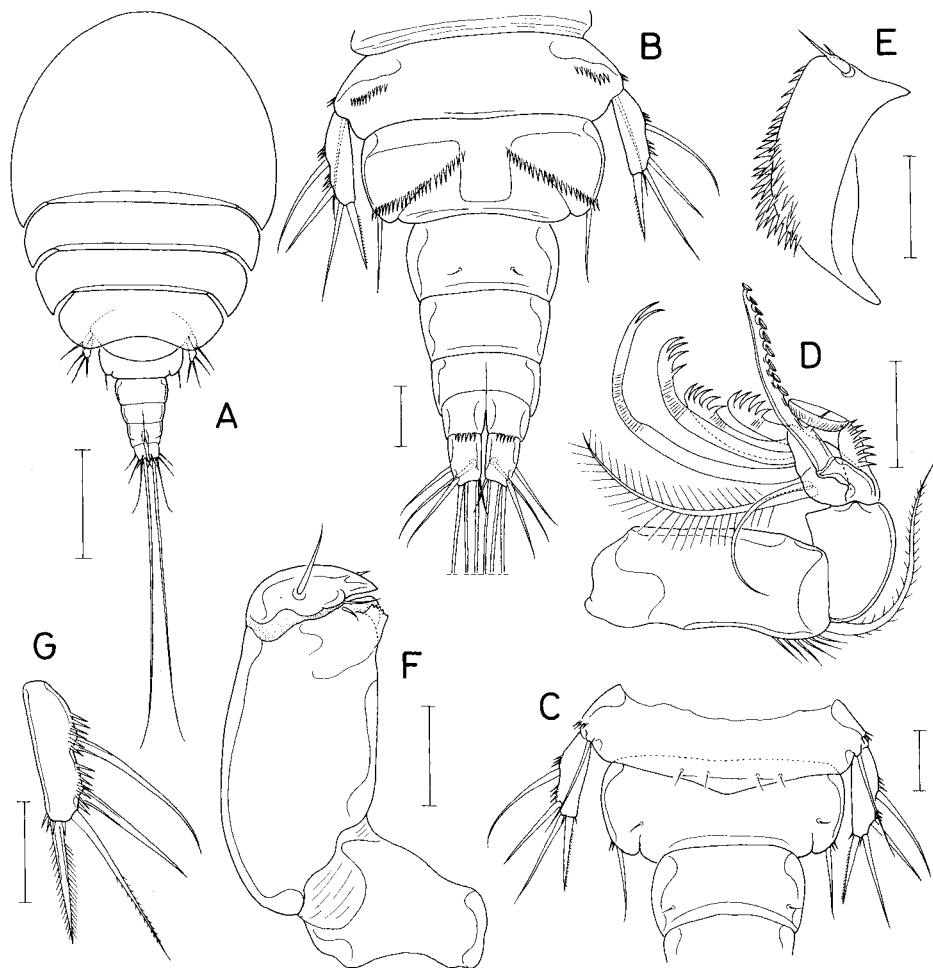


FIG. 17. *Goidelia pelliviva* n. sp., male: (A) habitus, dorsal; (B) urosome, ventral; (C) anterior part of urosome, dorsal; (D) antenna; (E) maxilla; (F) maxilliped; (G) free segment of leg 5. Scales: A=0.1 mm; B–G=0.02 mm.

thera. Anal somite with spinules on posterior border of ventral surface. Anal operculum not discernible. Caudal ramus  $29 \times 16 \mu\text{m}$  (1.81:1), with six setae. Inner dorsal seta plumose distally, but other setae naked. Inner one of mid-terminal setae  $353 \mu\text{m}$  long, about three times as long as next longest, outer one of mid-terminal seta. Egg sac characteristically flat dorsoventrally, plate-like, eggs arranged in two layers, and  $493 \times 193 \mu\text{m}$ .

Rostrum hardly differentiated, leaving only faint sclerotized outline, broad, with truncate posterior margin. Antennule (figure 15D) six-segmented, with armature formula 5, 13, 9, 4+1 aesthetasc, 2+1 aesthetasc, and 7+1 aesthetasc. First seta on first segment different from other setae, thick and densely hairy. All other setae naked. Antenna four-segmented, with armature formula 1, 0, 4+1 claw, and 4 claws. Segmentation between third and fourth segments obscure. First segment longest. Basal two setae on third segment small, setule-like, and with same base; one of terminal setae plumose; claw on this segment pectinate distally, with 8–10

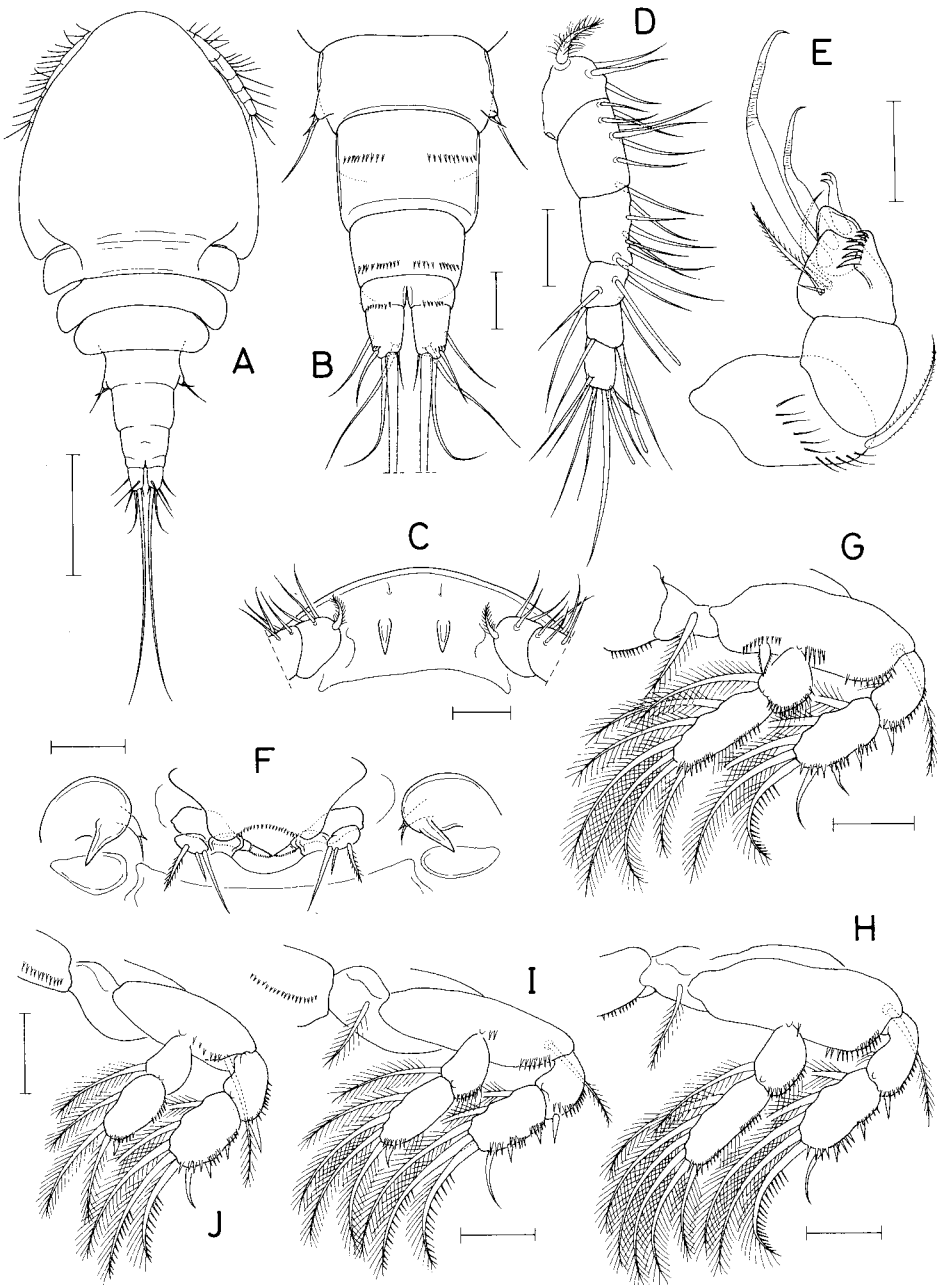


FIG. 18. *Goidelia pelliviva* n. sp., copepodid V, female: (A) habitus, dorsal; (B) urosome, ventral; (C) rostral area, ventral; (D) antennule; (E) antenna; (F) mouthparts; (G) leg 1; (H) leg 2; (I) leg 3; (J) leg 4. Scales: A=0.1 mm; B-J=0.02 mm.

pectines. Claws on terminal segment different in length, outermost one longest and innermost one shortest, with number of pectines from inner to outer claws 6 or 7, 8 or 9, 5 or 6, 3-5, respectively.



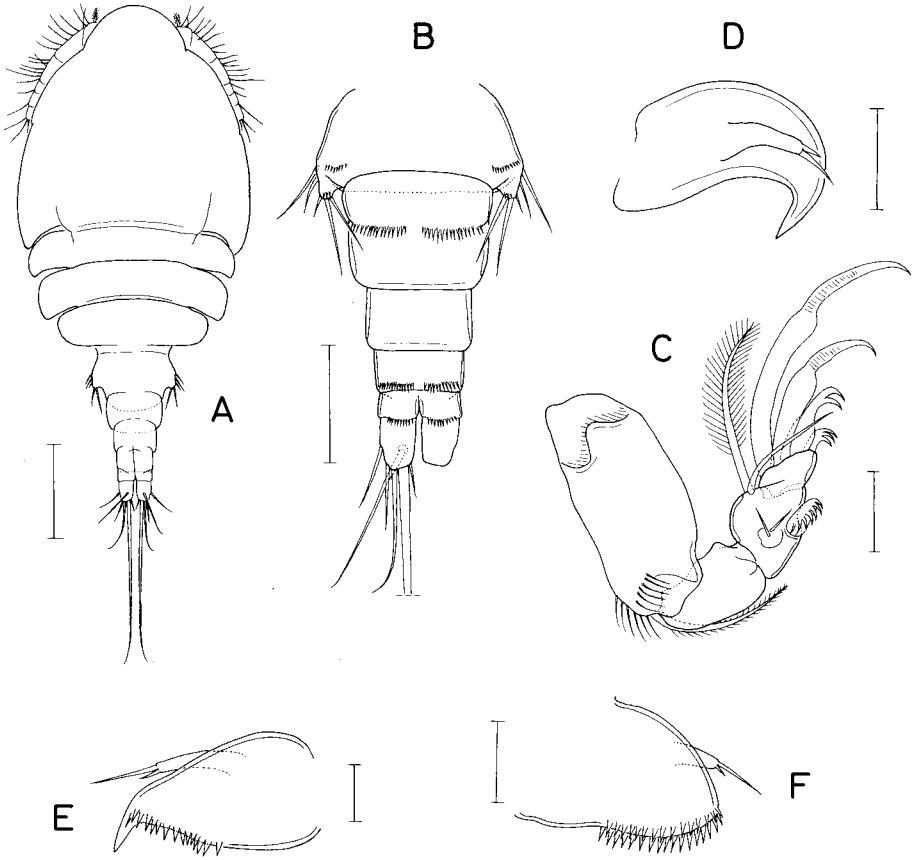


FIG. 19. *Goidelia pelliviva* n. sp., copepodid V, male: (A) habitus, dorsal; (B) urosome, ventral; (C) antenna; (D) maxilla. *Goidelia japonica* Embleton, copepodid V: (E) female maxilla; (F) male maxilla. Scales: A=0.1 mm; B=0.05 mm; C–F=0.02 mm.

Labrum covering only part of mouth parts, distally narrowed (figure 15F), with concave posterior margin bearing fine spinules. Mandible with one thick terminal element bearing spinules on posterior margin. Paragnath as an unarmed lobe. Maxillule terminally with three setae, median one smaller, and outermost one plumose. Maxilla located lateral to mouth area (figure 15F), two-segmented; first segment highly sclerotized, strong, bearing one terminal and one subterminal hook (figure 15F); second segment originating from proximal inner side of first segment, a slender digitiform process bearing two terminal processes (or spinules). Maxilliped reduced to a triangular sclerotized rudiment.

Legs 1–4 with three-segmented rami, and with row of spinules on posterior margin of intercoxal plate, mid-posterior margin of basis, and outer margin of both rami (figure 16A–E). Inner spine on basis of leg 1 short, not longer than width of endopodal first segment. Spines of exopods setiform. Terminal seta on exopodal third segment of first two legs and terminal two setae on same segment of legs 3 and 4 with spinules on outer side. Armature formula of legs 1–4 as follows:

	Coxa	Basis	Exp	Enp
Leg 1	0-1	1-I	I-0; I-1; II, 4	0-1; 0-1; 5
Leg 2	0-1	1-0	I-0; I-1; II, 4	0-1; 0-1; 5
Leg 3	0-1	1-0	I-0; I-1; II, 4	0-1; 0-1; I, 3
Leg 4	0-1	1-0	I-0; I-1; II, 4	0-1; 0-1; I, 2

Leg 5 two-segmented. Basal segment well demarcated basally from fifth pedigerous somite (figure 15C), nearly quadrate, with one long seta on outer distal corner and one row of spinules on ventral surface. Distal segment (figure 16F) elongate,  $69 \times 40 \mu\text{m}$  (1.73:1), with four long setae and on ventral surface three obliquely transverse rows of spinules. Leg 6 represented by two small spinules on genital area (figure 15C).

*Male.* Body (figure 17A) resembling that of female. Length 0.41 mm. Greatest width 248  $\mu\text{m}$ . Urosome six-segmented. Fifth pedigerous somite 94  $\mu\text{m}$  wide, wider than genital somite, ventrally with one row of spinules on both sides. Posterodorsal border of fifth pedigerous somite triangularly projected (figure 17C). Genital somite much wider than long,  $31 \times 80 \mu\text{m}$ , nearly quadrangular, ventrally with one row of spinules along genital flap. Four abdominal somites  $25 \times 50$ ,  $22 \times 43$ ,  $17 \times 35$ , and  $12 \times 28 \mu\text{m}$ , respectively. Caudal ramus  $16 \times 11 \mu\text{m}$  (1.45:1).

Antennule with one additional seta on third segment (at place of dark dot in figure 15D). Antenna sexually dimorphic. Third segment armed with two setae, one pectinated claw, and one long, sucker-bearing spine; claw with six or seven pectines; spine articulated basally, with one proximal larger sucker and row of nine minute suckers along one side of spine distal to larger sucker. Number of pectines of four claws on terminal segment, from inner to outer suckers, 5 or 6, 4 or 5, 3 or 4, and 2 or 3, respectively.

Mandible and maxillule as in female. Maxilla (figure 17E) a flap-like element bearing many spinules on ventral surface and one palp-like element (probably second segment) tipped by two unequal spinules. Maxilliped (figure 17F) three-segmented. First segment unarmed. Second segment the largest, terminally with one setule; inner terminal corner bilobed. Third segment being a short, massive claw, beak-like, as long as width of second segment, with one lateral seta and two distal setules on each side.

Legs 1-4 as in female. Basal segment of leg 5 completely incorporated into somite, leaving only one seta (figure 17B); free segment (figure 17G) slender,  $28 \times 8.7 \mu\text{m}$  (3.22:1), with three setae on outer margin and one terminal spine; setae as long as or longer than segment, but spine slightly shorter than segment. Leg 6 represented by one large seta on posterior corner of genital somite.

*Copepodid IV female.* Body (Fig 18A) consisting of cephalothorax, three pedigerous somites, and four urosomites. Body length 394  $\mu\text{m}$ . Genital double-somite and abdominal somites with one transverse row of spinules on ventral surface (figure 18B).

Rostrum obscure, but with one pair of claw-like spines on ventral surface (Fig 18C). Antennule (figure 18D) six-segmented, with armature formula: 4, 8, 7, 4+1 aesthetasc, 2+1 aesthetasc, and 7+1 aesthetasc. Antenna (figure 18E) four-segmented, with armature formula 1, 0, 4+1 claw, and 3 claws; claw on third

segment with six pectines; innermost claw of terminal segment bifurcate terminally, but other two claws simple.

Labrum, mandible, maxillule and maxilliped as in adult. First segment of maxilla terminated in one claw (figure 18F).

Legs 1-4 (figure 18G-J) with two-segmented rami and following armature formula:

	Coxa	Basis	Exp	Enp
Leg 1	0-1	1-1	I-0; III, 5	0-1; 6
Leg 2	0-1	1-0	I-0; III, 5	0-1; 6
Leg 3	0-1	1-0	I-0; III, 5	0-1; I, 4
Leg 4	0-0	1-0	I-0; III, 5	0-1; I, 3

Leg 5 represented by a small lobe tipped with two extremely unequal setae and one minute setule near posterior corners of fifth pedigerous somite. Leg 6 not present.

*Copepodid V female.* Body (figure 19A) nine-segmented, 525 µm. Rostral area more produced anteriorly. Urosome (figure 19B) five-segmented. First abdominal somite without spinules on ventral surface.

Antennule as in adult. Antenna (figure 19C) with same armature formula as that of adult, but claws of terminal segment not yet completely developed.

Labrum, mouth parts, including maxilla (figure 19D), as in copepodid IV.

Legs 1-4 fully developed. Leg 5 represented by a tapering lobe bearing five setae of different lengths (figure 19B).

*Etymology.* The specific name *pelliviva* is derived from the Latin *pellis* (=skin) and *vivus* (=living). It alludes to the fact that the new species is inhabiting the external surface of the host, unlike the only other known species *Goidelia japonica* Embleton, 1901.

*Remarks.* Gooding (1963) recognized *Goidelia* Embleton, 1901 as a genus belonging to a group containing four other genera: *Presynaptiphilus*, *Synaptiphilus*, *Myzomolgus*, and *Catinia*. In the present report, *Presynaptiphilus* and *Synaptiphilus* are placed in a separate family Synaptiphilidae, and the three remaining genera in the Catiniiidae. The unity of the Catiniiidae is justified by morphological similarities between the genera *Catinia*, *Myzomolgus* and *Goidelia*. The most typical morphological similarity is found in the maxilla which consists of a plate-like first segment and a small, process-like second segment. Gooding (1963) was correct when he interpreted the 'paragnath' in Bocquet and Stock's (1957) description of *Catinia stupendus* as the second segment. Closer similarity in the maxilla is found between those of *Myzomolgus* and *Goidelia*, in which this oral appendage bears an expanded, spinulated first segment and the digitiform second segment tipped with two spinules. However, in *Goidelia* this form of maxilla is found only in the male. In the adult female of this genus, the first segment of the maxilla is transformed into an appendage bearing distally two powerful hooks. This transformation occurs at the last moult from copepodid V to adult (cf: figures 15F and 19D).

The catiniid genera also show similarity in the antenna in which the third segment bears a large sucker. Again, this morphological feature is found in the female of *Myzomolgus* (male is unknown in this genus) and in both sexes of *Catinia*, but only in the male in *Goidelia*. Together with these characteristics, the flat, large prosome,

small urosome, and the absence or reduction of the female maxilliped typify the Catiniiidae. As a result of a cladistic analysis, Ho (1984) previously recognized the 'catiniid complex' to which he assigned *Catinia*, *Myzomolgus*, *Goidelia*, in addition to *Cotylomolgus* Humes and Ho, 1967 and *Cotylemyzon* Stock, 1982 (see Figures 4, 5 and discussion of Ho, 1984). The sexual dimorphism in the antennule of *Goidelia* (addition of one aesthetasc on the third segment in the male antennule) is remarkable. Gooding (1963) also found a similar sexual dimorphism of the antennule in *Catinia stupendus* Bocquet and Stock.

*Goidelia pelliviva* n. sp. is the second species of the genus. The type species *G. japonica* was recorded from the alimentary canal of the echiuran, *Urechinus unicinctus* Embleton in Japan. *Goidelia japonica* can be easily collected in Korea from the same host, allowing a comparison of both species.

At first, before examination of the copepodids of both species, the author was inclined to treat the new species as conspecific with the type species. However, the different ornamentation on the maxillae of copepodid V of both species (cf. figure 19D and E) confirmed that they were not conspecific. The easiest way to distinguish between the two species is to compare body sizes, because *Goidelia pelliviva* n. sp. is distinctly smaller than *G. japonica*. The fully grown adult female of the latter is 1.26 mm long. Besides the smaller size, *G. pelliviva*, unlike *G. japonica*, bears spinules along the posteroventral border of the female anal somite. In addition, the free segment of leg 5 of *G. pelliviva* is more slender than that of *G. japonica*. In spite of the prominent size difference, distinction between the two species requires very careful comparison, since size is known to be a frequently unreliable taxonomic trait in copepods. This in turn indicates that members of *Goidelia* show quite a homogeneous morphology. The differences between the two species may be summarized as in table 1.

The discovery of the new species from Korea, especially a female carrying egg sacs, leads to a reconsideration of the identity of the 'male' of *Echiurophilus fizei* Delamare-Deboutteville and Nunes-Ruivo, 1955, a species found as an associate of an echiuroid from Viet Nam. Delamare-Deboutteville and Nunes-Ruivo (1955) described their species on the basis of five females and one male. Later, Gooding (1963) suspected that the 'male' in the original description was an immature female.

It seems certain that the 'male' in the original description is a female, possibly of an unknown species of *Goidelia*, because the specimen shows an abdomen of less than four somites, a two-segmented leg 5 with well delimited basal segment, and, as noted by Gooding (1963), the absence of maxilliped. The well developed maxilla as illustrated in figure 5 of the original description (it is certain that the structure denoted as the maxilliped in the original description is in fact the first segment of

Table 1. Differences between *Goidelia japonica* and *G. pelliviva* n. sp.

Characters	<i>G. japonica</i>	<i>G. pelliviva</i> n. sp.
Spinules on posteroventral border of female anal somite	Absent	Present
Body length	1.26 (♀); 0.81 (♂)	0.79 (♀); 0.41 (♂)
Ratio (L/W) of free segment of leg 5	2.00:1	1.63:1
Ratio (W/L) of male genital somite	1.92:1	2.80:1
Maxilla of copepodid V female	With denticles	Without denticles
Spinules on basal segment of leg 5	Scattered in about 3 rows	In 1 row

the maxilla) confirms that the specimen is a mature female. Moreover, the discovery of a female of the new species bearing both the usual body form and egg sacs suggests that the species of *Goidelia* do not transform their body like that of *Echiurophilus fizei* as Gooding had assumed.

It is worth mentioning here that I have examined more than several hundred adult females of *Goidelia japonica* collected from Korean seas, but an ovigerous female is yet to be discovered.

### Family KELLERIIDAE Humes and Boxshall, 1996

#### *Kelleria vaga* n. sp.

(Figures 20–22)

*Material examined.* Three ♀♀, one ♂, one copepodid V ♀ collected from stagnant water on the intertidal mud flat at Jakyak-do Island, off Inchon, on 1 September 1996. Holotype (♀) and two paratypes (one ♀ and one copepodid V ♀) will be deposited in the US National Museum of Natural History, Smithsonian Institution. Allotype and one paratype (both dissected) are kept in the collection of the author.

*Female.* Body (figure 20A) narrow, 1.01 mm long. Greatest width 331 µm. Prosome spindle-shaped and consisting of cephalosome and four metasomites. Urosome (figure 20B) five-segmented. Fifth pedigerous somite 102 µm wide. Genital double-somite 125 × 160 µm, with distinctly expanded anterior two-thirds and narrower posterior part. Three abdominal somites 39 × 63, 27 × 58, 48 × 54 µm, respectively, without ornamentation. Caudal ramus elongate, 100 × 22 µm (4.55:1), with parallel margins. Lateral seta located slightly posterior to mid-point of caudal ramus. Outer lateral and inner dorsal setae naked. Other setae plumose. Outer posterior corner of caudal ramus with a small duct and terminal pore.

Rostrum narrow and long, with round posterior tip (figure 20C). Antennule (figure 20D) 249 µm long, seven-segmented, with armature formula 4, 13, 6, 3, 4 + 1 aesthetasc, 2 + 1 aesthetasc, and 7 + 1 aesthetasc. Plumose setae are one on fifth and sixth segment, and four on terminal segment. Antenna (figure 20E) slender, four-segmented, with armature formula 1, 1, 3 + 1 claw, and 5 + 2 claws. Claws on third and terminal segments slender and setiform. Second and terminal segments with minute spinules on outer margin, each segment about 2.4 and 3.3 times longer than wide, respectively.

Labrum (figure 20F) deeply incised, with round posterior corners; posterior margin of each lobe unornamented. Mandible (figure 20G) with tapering, moderately long lash; proximal notch shallow; inner margin oblique to lash, with rather large spinules; outer margin denticulate and proximally with a row of several small spinules. Maxillule (figure 20H) with three terminal spinulated setae, one lateral seta, and serrate membrane on distal half of outer margin. Maxilla (figure 21A) two-segmented; first segment unarmed; second segment with one slender seta and one large, terminally bifurcate, spinulated seta; distal portion of second segment curved perpendicularly to proximal portion, tapering and sharply pointed, with nine or ten large spines of unequal sizes. Maxilliped (figure 21B) three-segmented. First segment unarmed and longest. Second segment with two large setae of similar size; proximal seta with long and thick setules both sides of proximal third, and small

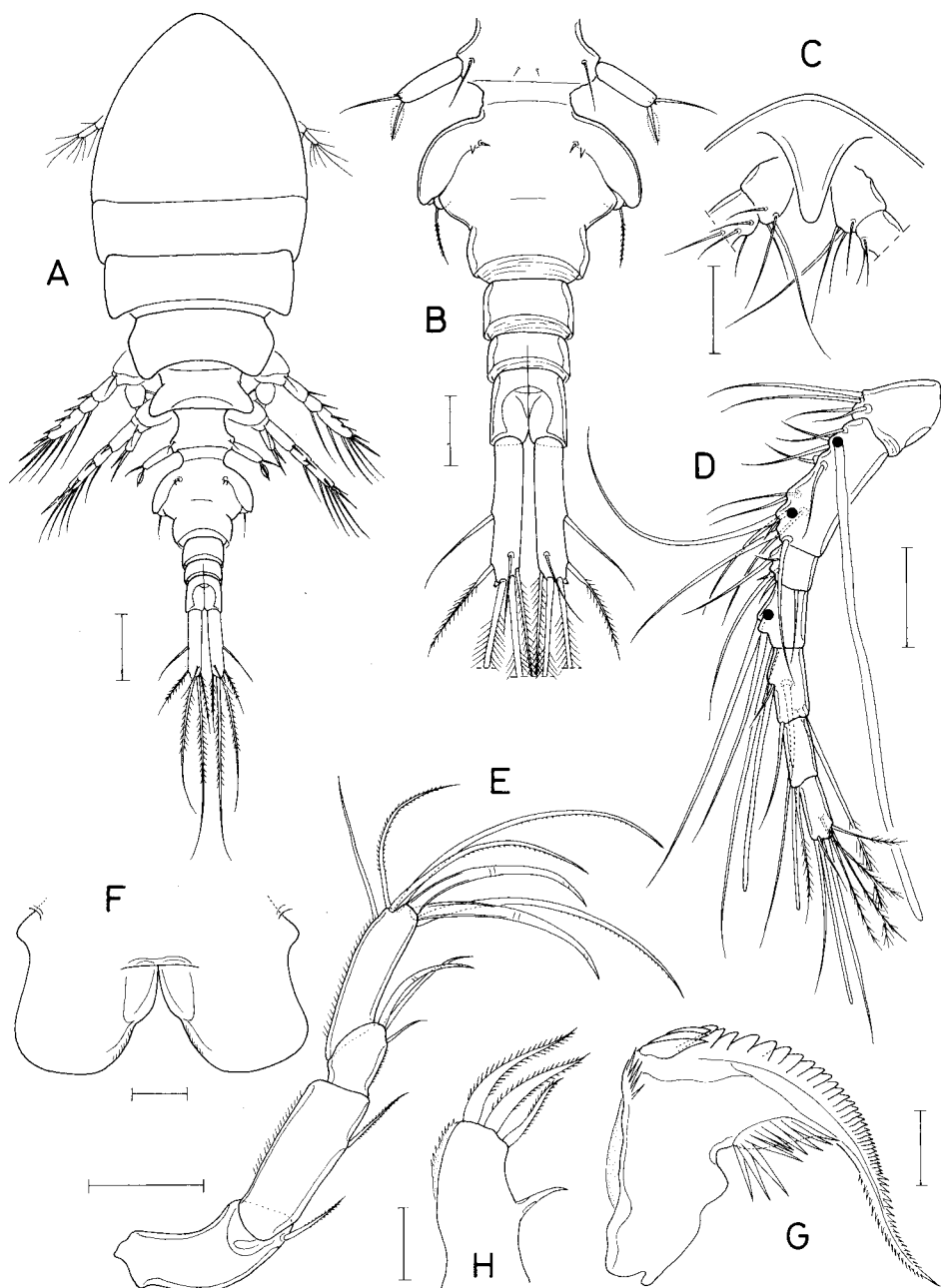


FIG. 20. *Kellieria vaga* n. sp., female: (A) habitus, dorsal; (B) urosome, dorsal; (C) rostral area, ventral; (D) antennule; (E) antenna; (F) labrum; (G) mandible; (H) maxillule. Scales: A=0.1 mm; B-E=0.05 mm; F-H=0.02 mm.

setules on distal margin of remaining two-thirds. Third segment small, with one long (86  $\mu$ m), naked seta, one small plumose seta, and two more smaller, naked setae.

Leg 1 (figure 21C), leg 2 (figure 21D) and leg 3 with three-segmented rami. Leg 4 (figure 21F) with three-segmented exopod and one-segmented endopod; inner seta

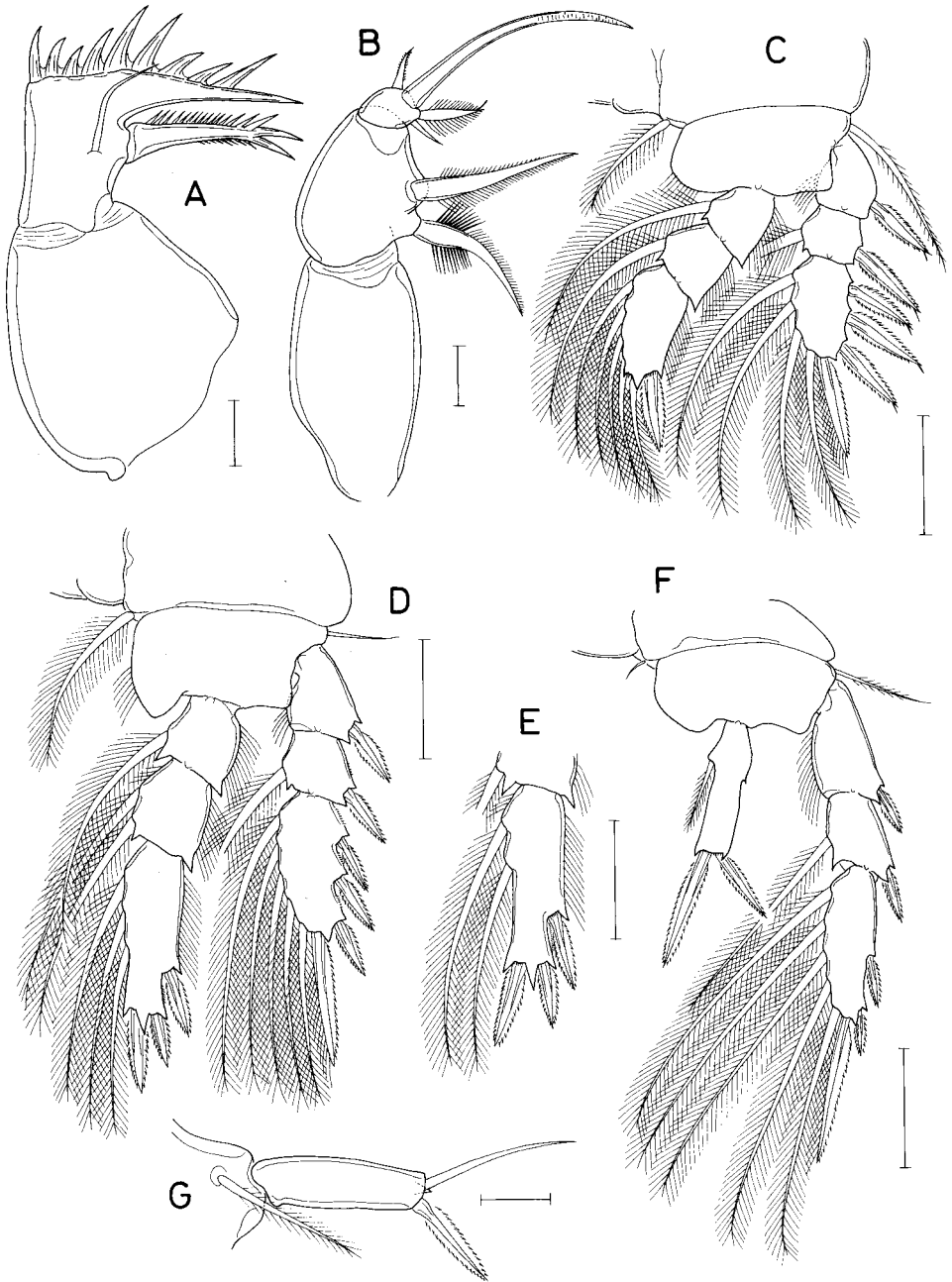


FIG. 21. *Kelleria vaga* n. sp., female: (A) maxilla; (B) maxilliped; (C) leg 1; (D) leg 2; (E) third endopod segment of leg 3; (F) leg 4; (G) leg 5. Scales: A, B, G=0.02 mm; C-F=0.05 mm.

on coxa minute; exopod with three or two spines on outer margin (formula III, I, 5 or II, I, 5); endopod with or without spinule-like small process on outer margin; median one of two terminal spines larger than the inner. Armature formula of legs 1-4 as follows:

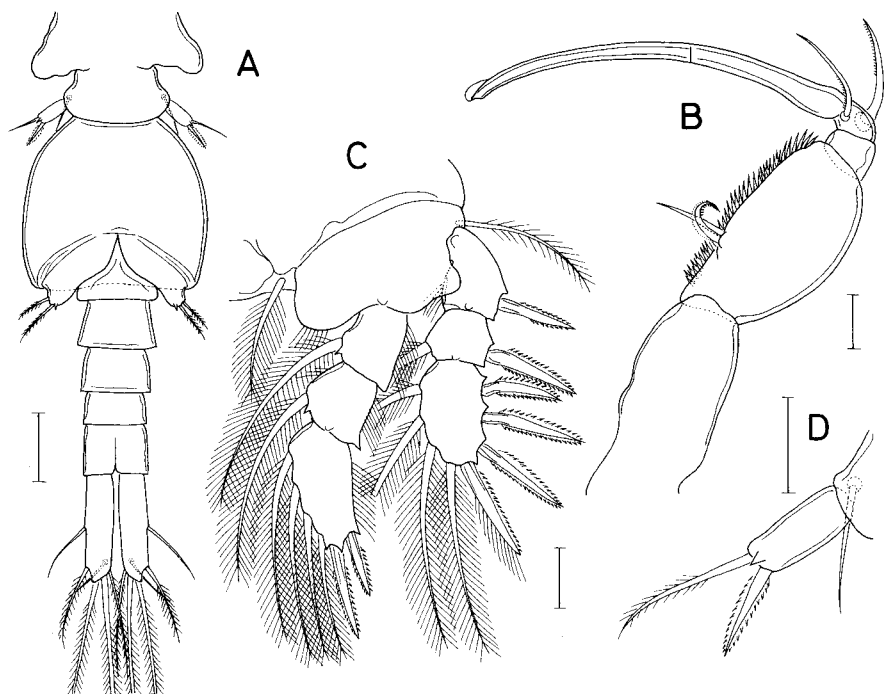


FIG. 22. *Kellieria vaga* n. sp., male: (A) urosome, ventral; (B) maxilliped; (C) leg 1; (D) leg 5. Scales: A=0.05 mm; B–D=0.02 mm.

	Coxa	Basis	Exp	Enp
Leg 1	0-1	1-0	I-0; I-1; III, I, 4	0-1; 0-1; I, 5
Leg 2	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; III, 3
Leg 3	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; III, 2
Leg 4	0-1	1-0	I-0; I-1; II, I, 5 (or III, I, 5)	II, 1

Leg 5 (figure 21G) composed of one seta near corner of fifth pedigerous somite and free segment; free segment  $50 \times 15 \mu\text{m}$  (3.3:1), margins nearly parallel, with small angular proximal protuberance on inner margin, one terminal spiniform process, and terminally one spine ( $31 \mu\text{m}$ ) and one naked seta ( $45 \mu\text{m}$ ). Leg 6 represented by one seta in genital area and distantly isolated, one spinule and one setule; the latter two located on dorsal surface of genital double-somite (figure 20B).

*Male*. Body more slender than that of female,  $877 \mu\text{m}$  long. Urosome (figure 22A) six-segmented. First urosomal somite  $75 \mu\text{m}$  wide. Genital somite  $131 \times 130 \mu\text{m}$ , as long as wide, with round lateral margins. Four abdominal somites  $35 \times 56$ ,  $31 \times 48$ ,  $23 \times 44$ , and  $35 \times 46 \mu\text{m}$ , respectively. Caudal ramus  $75 \times 21 \mu\text{m}$  (3.57:1).

Rostrum and antenna as in female. Antennule with three more aesthetascs than in female: two on second and one on fourth segment (indicated by dark dots in figure 20D). All aesthetascs extending over end of antennule.



Mouth parts as in female, except for maxilliped. Maxilliped (figure 22B) consisting of three segments and terminal claw. First segment unarmed. Second segment with two setae at proximal third of inner margin and spinules on entire inner margin. Third segment unarmed. Claw long, 152  $\mu\text{m}$ , evenly curved, proximally with two moderately long setae.

Leg 1 (figure 22C) with two spines and four setae (II, 4) on terminal endopodal segment. Legs 2–4 as in female. Free segment of leg 5  $23 \times 10 \mu\text{m}$  (2.30:1), without proximal protuberance; terminal spine 21  $\mu\text{m}$ , and seta 34  $\mu\text{m}$ . Leg 6 represented by two setae and one spinule on genital flap (figure 22A).

*Etymology.* The specific name *vaga* is derived from the Latin *vagus* (= wandering). It alludes to its unknown host relationship.

*Remarks.* No further species have been added to this genus since Humes and Stock's (1973) revision of the lichomolgoid copepods. According to Humes and Stock's key to the species of *Kelleria*, *K. vaga* n. sp. keys out to *K. camortensis* Sewell, 1949 in couplet 7. The latter species, recorded from the Indian Ocean by Sewell (1949), has caudal rami which are 2.75 longer than wide, and two subequal terminal setae on the free segment of leg 5. These features are not applicable to the Korean species, because the caudal rami of the latter are 4.76 times longer than wide, and the free segment of leg 5 has one spine and one seta.

*Kelleria vaga* seems to be related to *K. pectinata* (A. Scott, 1909) which was redescribed by Humes and Ho (1969). Both have the well developed anterior expansion of the genital double-somite, and a similar maxilla and terminal armature of the maxilliped. However, the new species has more slender caudal rami, a shorter free segment of the female leg 5, and different type of armature on the male leg 5.

#### Family LICHOMOLGIDAE Kossmann, 1877

##### *Lichomolgus bullatus* n. sp.

(Figures 23–25)

*Material examined.* Three ♀♀ and four ♂♂ from the mantle cavity of a small bivalve, *Striarca (Didimacar) tenebrica* (Reeve), collected on the intertidal mud flat at Jakyak-do Island off Inchon, on 29 September 1996. Holotype (♀), allotype (♂), and three paratypes (one ♀, two ♂♂) have been deposited in the US National Museum of Natural History, Smithsonian Institution. Dissected specimens (one ♀ and one ♂) are kept in the collection of the author.

*Female.* Body (figure 23A) relatively narrow, 1.10 mm long. Greatest width 0.37 mm. Prosome elongate-oval and five-segmented. Urosome (figure 23B) five-segmented, slender and tapering. Fifth pedigerous somite 101  $\mu\text{m}$  wide. Genital double-somite  $118 \times 101 \mu\text{m}$  (1.17:1), with broad anterior expansion and narrower posterior third. Genital area large, located dorsolaterally in posterior part of anterior expansion. Three abdominal somites  $30 \times 49$ ,  $26 \times 45$ , and  $50 \times 45 \mu\text{m}$ , respectively. Anal somite with one row of spinules on each proximal and distal border of ventral surface (figure 23C). Caudal ramus elongate,  $126 \times 16 \mu\text{m}$  (7.88:1), with six setae; outer lateral seta naked, short, not reaching to end of caudal ramus, and positioned at 60% length of caudal ramus; inner dorsal seta naked, other four setae plumose.

Rostrum tapering, longer than wide, but rounded anteriorly. Antennule (figure 23D) seven-segmented; armature formula 4, 13, 6, 3, 4 + 1 aesthetasc, 2 + 1 aesthetasc, and 7 + 1 aesthetasc; all setae naked. Antenna (figure 23E) slender and four-segmented; armature formula 1, 1, 1 + 1 claw, and 3 + 4 claws. Claw on third

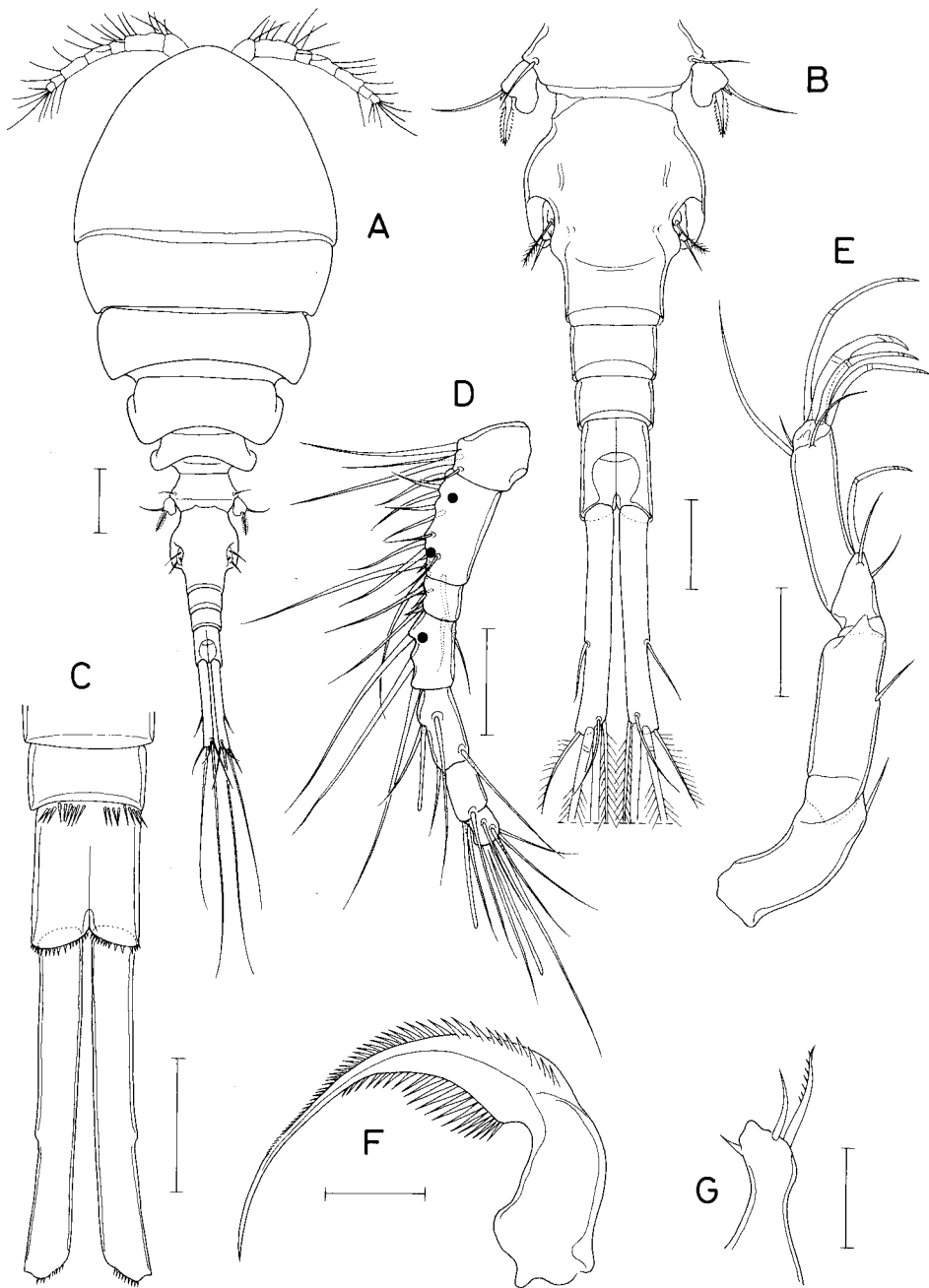


FIG. 23. *Lichomolgus bullatus* n. sp., female: (A) habitus, dorsal; (B) urosome, dorsal; (C) distal part of urosome, ventral; (D) antennule; (E) antenna; (F) mandible; (G) maxillule. Scales: A=0.1 mm; B-E=0.05 mm; F, G=0.02 mm.

segment setiform. One of four terminal claws moderately thick, but other three setiform. Terminal segment about 3.4 times as long as wide.

Labrum not examined. Mandible (figure 23F) slender, tapering into long lash, with spinulated margins; proximal notch broad and relatively distinct. Maxillule

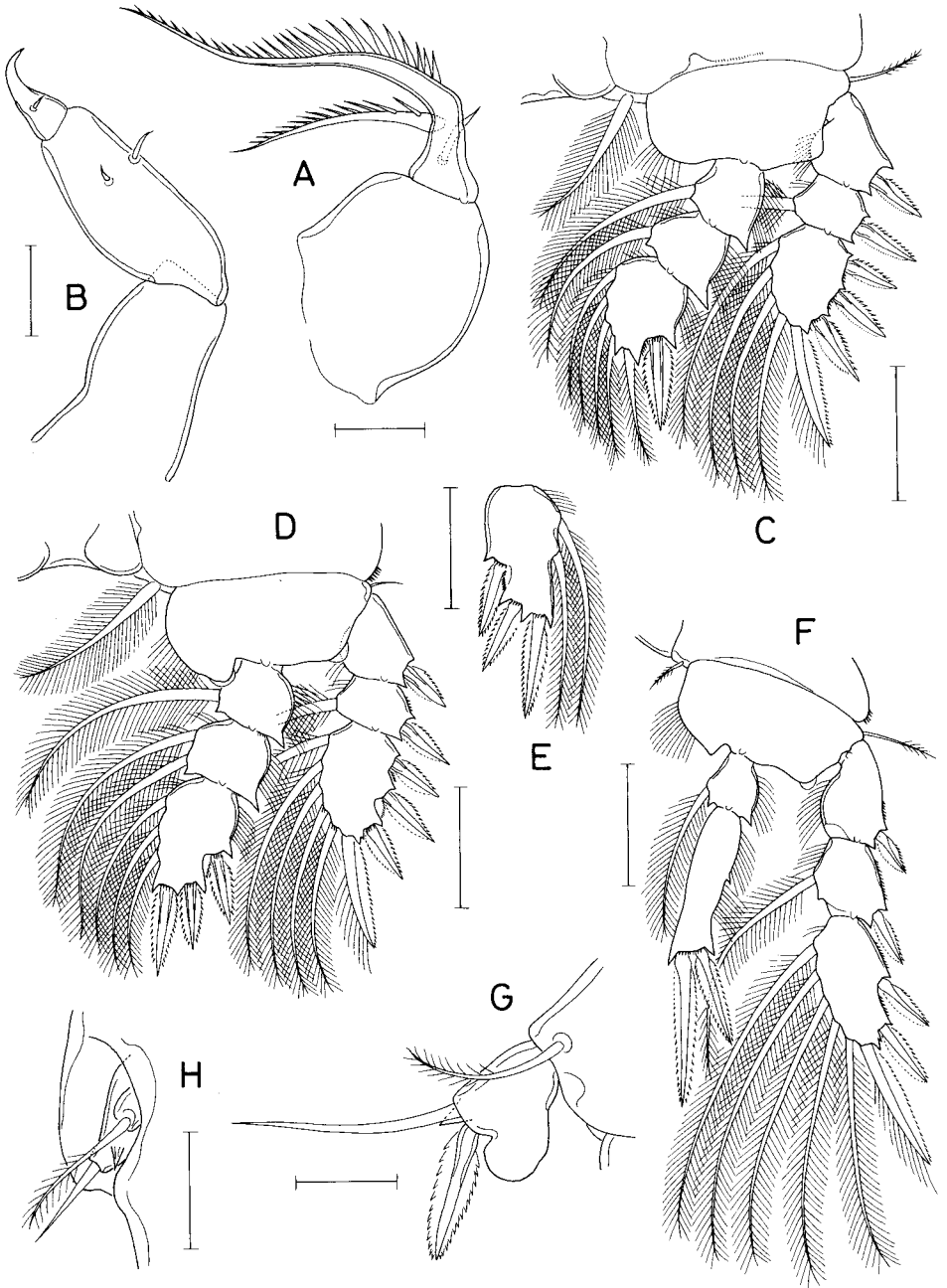


FIG. 24. *Lichomolgus bullatus* n. sp., female: (A) maxilla; (B) maxilliped; (C) leg 1; (D) leg 2; (E) third endopod segment of leg 3; (F) leg 4; (G) leg 5; (H) genital area. Scales: A, B, G, H=0.02 mm; C–F=0.05 mm.

(figure 23G) a lobe, constricted in the middle, with two terminal setae and one spinule-like subterminal seta. Maxilla (figure 24A) two-segmented; first segment broad and unarmed; second segment terminating in a long lash bearing spinules on convex side, proximally with one smaller naked seta and one larger seta, the

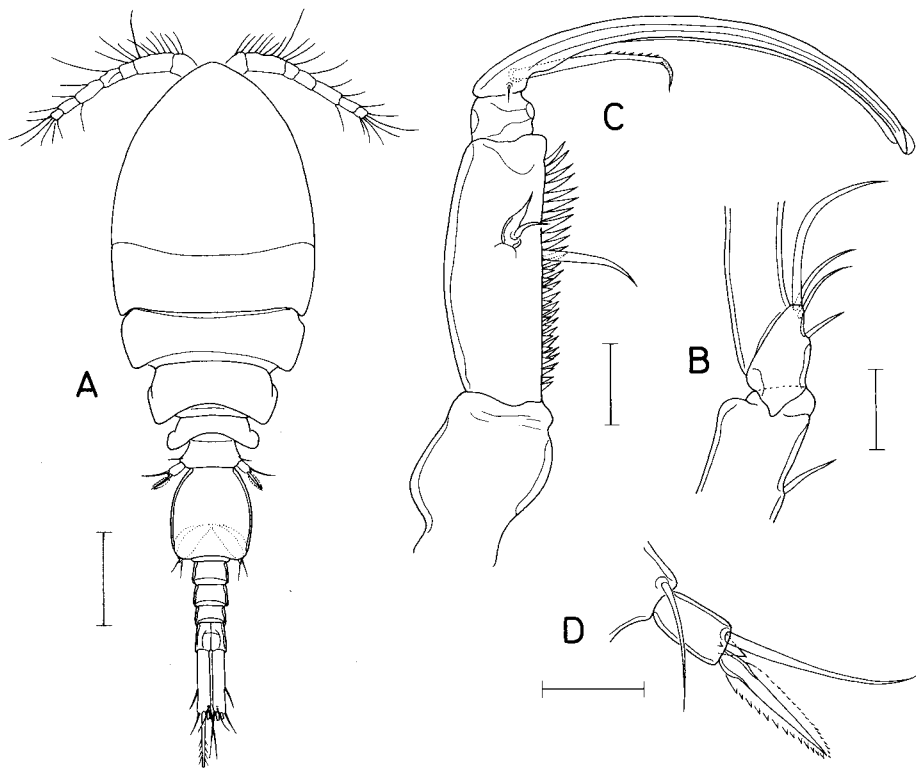


FIG. 25. *Lichomolgus bullatus* n. sp., male: (A) habitus, dorsal; (B) area of third segment of antenna; (C) maxilliped; (D) leg 4. Scales: A = 0.1 mm; B–D = 0.02 mm.

latter spinulated on distal margin. Maxilliped (figure 24B) three-segmented; first segment unarmed; second segment with two small setae, one of them smaller than the other; terminal segment tapering, terminally curved and pointed, with one small seta.

Leg 1 (figure 24C), leg 2 (figure 24D) and leg 3 with three-segmented rami. Leg 4 (figure 24F) with three-segmented exopod and two-segmented endopod. Outer margin of endopodal second segment of leg 4 with small spiniform process; two terminal spines of this segment unequal. Armature formula of legs 1–4 as follows:

	Coxa	Basis	Exp	Enp
Leg 1	0-1	1-0	I-0; I-1; III, I, 4	0-1; 0-1; I, 5
Leg 2	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; III, 3
Leg 3	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; III, 2
Leg 4	0-1	1-0	I-0; I-1; II, I, 5	0-1; II

Leg 5 (figure 24G) consisting of one plumose seta on fifth pedigerous somite and free segment. Free segment  $21 \times 22 \mu\text{m}$ , characteristically with profound inner inflation, and terminally with one spinule, one naked seta ( $46 \mu\text{m}$ ) and one spine ( $27 \mu\text{m}$ ). Leg 6 represented by one plumose and one spiniform seta, and one spinule in genital area (figure 24H).

*Male.* Body (figure 25A) more slender than that of female and 0.71 mm long. Greatest width 221  $\mu\text{m}$ . Urosome six-segmented. Genital somite  $103 \times 88 \mu\text{m}$ , longer than wide. Anal somite about as long as wide and distinctly longer than pre-anal somites. Caudal ramus short compared with that of female, 4.60 times as long as wide.

Antennule with three additional aesthetascs: two on second and one on third segments as indicated by dark dots in figure 23D. Antenna with four setae on third segment.

Mandible, maxillule and maxilla as in female. Maxilliped (figure 25C) consisting of three segments and terminal claw. First and third segments unarmed. Second segment with spinules on entire inner margin and two setae at posterior slightly distal to midlength of segment; one of these two setae transformed as in figure 25C. Claw slender, evenly curved, nearly as long as three proximal segments combined, proximally with one minute setule and one large seta.

Legs 1–4 as in female. Free segment of leg 5 quadrangular (figure 25D),  $17 \times 9 \mu\text{m}$  (1.89:1), terminally with one spinule, one naked seta (39  $\mu\text{m}$ ) and one spine (29  $\mu\text{m}$ ). Leg 6 represented by two setae on posterior corner of genital flap.

*Etymology.* The specific name *bullatus* is Latin, meaning 'inflated'. It alludes to the inflated free segment of female leg 5.

*Remarks.* The genus *Lichomolgus* comprises 26 species, including the most recently recorded *L. hoi* Stock, 1995. *Lichomolgus bullatus* n. sp. is easy to differentiate from all congeners by the unique greatly dilated free segment of leg 5. In the description of *L. hoi*, Stock (1995) emphasized the inflated inner margin of the same segment of leg 5 as a conspicuous feature of this species. This inflation is more pronounced in *L. bullatus* and cannot be confused with *L. hoi* or any other known species of *Lichomolgus*.

## Family MACROCHIRONIDAE Humes and Boxshall, 1996

### *Macrochiron anomalum* n. sp.

(Figures 26–28)

*Material examined.* Two ♀♀ and five ♂♂ collected from stagnant water on the intertidal mud flat at Jakyak-do Island off Inchon, on 29 September 1996. Holotype (♀), allotype (♂), and three paratypes (♂♂) have been deposited in the US National Museum of Natural History, Smithsonian Institution. Dissected specimens (one ♀ and one ♂) are kept in the collection of the author.

*Female.* Body (figure 26A) relatively narrow. Body length 1.19 mm. Greatest width 0.42 mm. Prosome occupying 61% of body length and five-segmented. Urosome (figure 26B) five-segmented as well. Fifth pedigerous somite 159  $\mu\text{m}$  wide. Genital double-somite  $200 \times 162 \mu\text{m}$ , with anterior two-thirds expanded broadly and roundly. Posterior third slightly tapering. Genital area located dorsally in the middle of anterior broad part. Genital double- and first two abdominal somites with serrate membranous fringe along posterodorsal and posteroventral margins. Three abdominal somites  $63 \times 72$ ,  $45 \times 63$ , and  $37 \times 55 \mu\text{m}$ , respectively. Anal somite with minute spinules along posterodorsal and posteroventral margins (figure 26C). Caudal ramus  $55 \times 22 \mu\text{m}$  (2.50:1), terminating in a duct with terminal pore at tip.

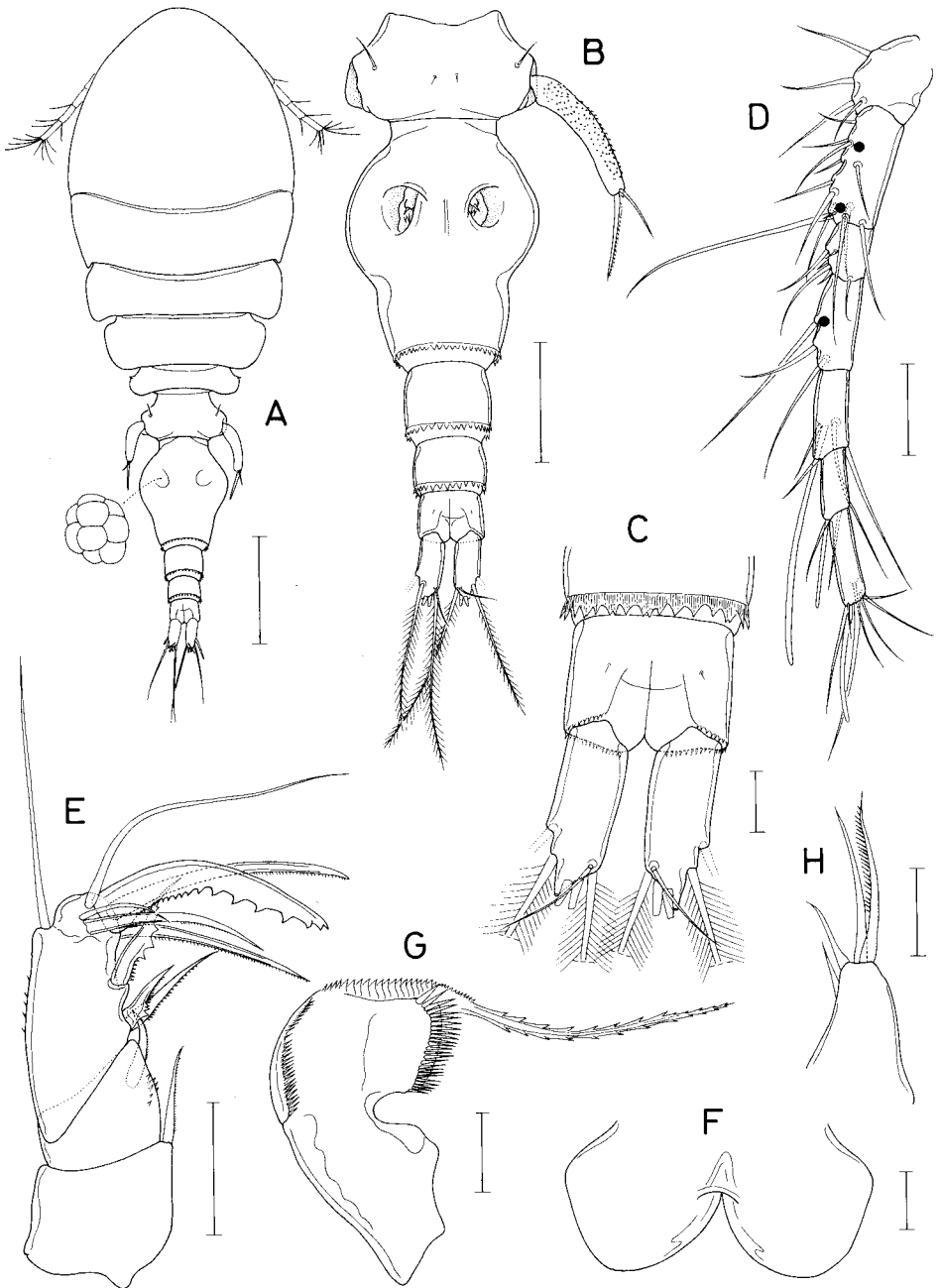


FIG. 26. *Macrochiron anomalum* n. sp., female: (A) habitus, dorsal; (B) urosome, dorsal; (C) distal part of urosome, ventral; (D) antennule; (E) antenna; (F) labrum; (G) mandible; (H) maxillule. Scales: A=0.2 mm; B=0.1 mm; C, F-H=0.02 mm; D, E=0.05 mm.

Rostrum short, wider than long, with angular posterior tip. Antennule (figure 26D) seven-segmented, 313  $\mu$ m long, with armature formula 4, 13, 4+1 aesthetasc, 2+1 aesthetasc, and 7+1 aesthetasc; all setae naked. Antenna

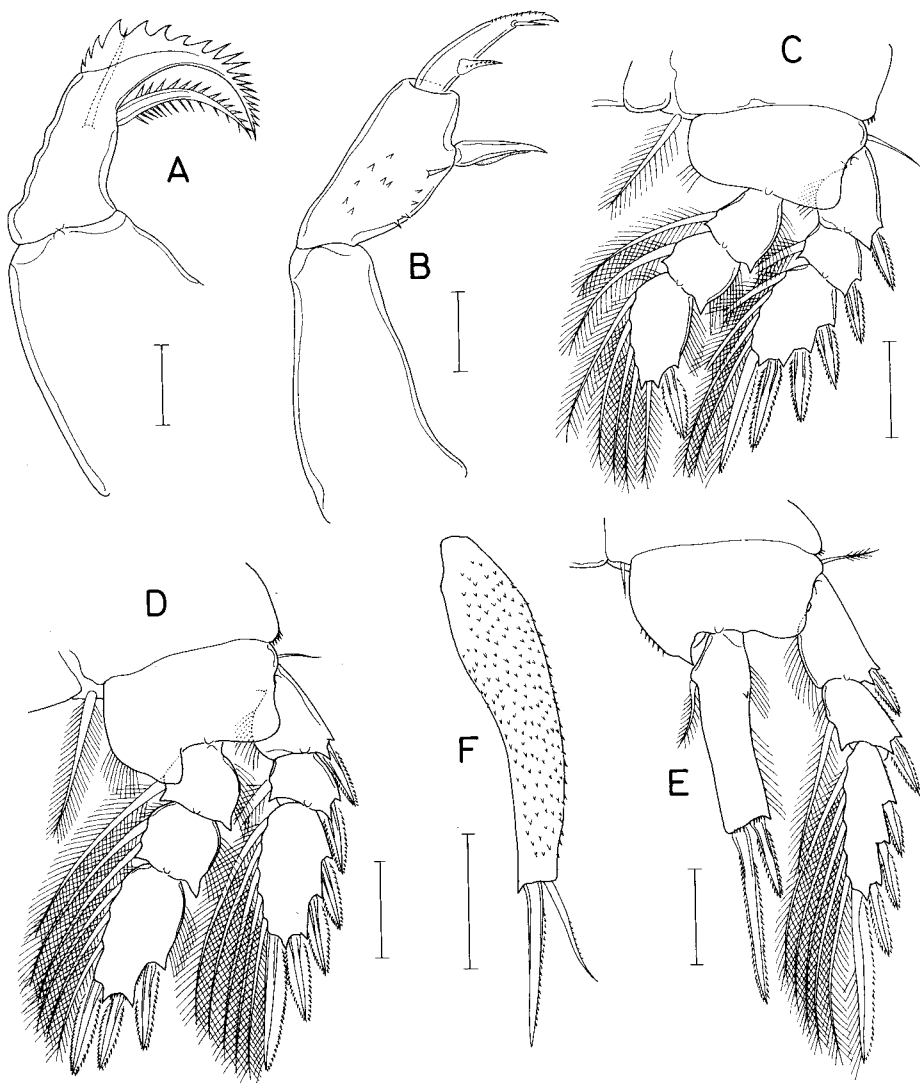


FIG. 27. *Macrochiron anomalum* n. sp., female: (A) maxilla; (B) maxilliped; (C) leg 1; (D) leg 2; (E) leg 4; (F) free segment of leg 5. Scales: A, B=0.02 mm; C–F=0.05 mm.

(figure 26E) massive, three-segmented. First and second segment each much wider than long, with one inner distal seta respectively. Third segment with ten setae; three setae on inner margin broad, proximal two of them with spinulated inner margin, and remaining one with serrate inner margin; of seven terminal setae, one large, curved with serrate concave margin; remaining six setae comprising two long, thin, simple setae, one small naked seta, and three moderately thick, spiniform setae; the latter three setae with minute spinules on concave margin.

Labrum (figure 26F) with two round, unornamented posterior lobes. Mandible (figure 26G) with deep proximal notch; terminal lash long, thin, and well defined proximally; inner margin perpendicular to terminal lash, with one row of spinules; outer margin with proximal row of spinules and continued to serrate margin.

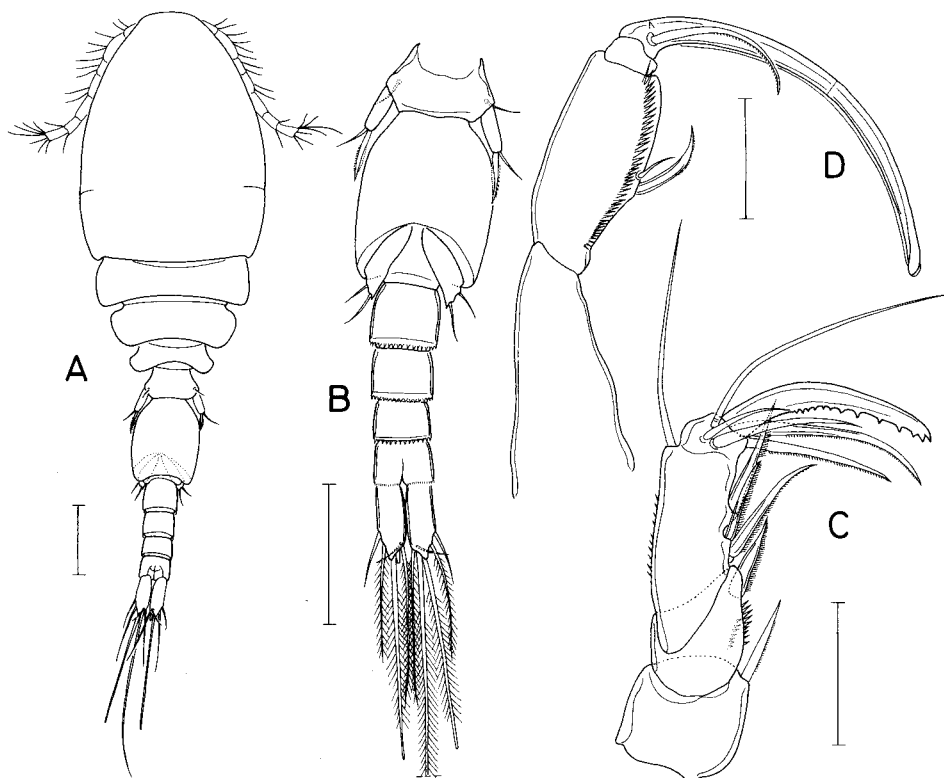


FIG. 28. *Macrochiron anomalum* n. sp., male: (A) habitus, dorsal; (B) urosome, ventral; (C) antenna; (D) maxilliped. Scales: A, B=0.1 mm; C, D=0.05 mm.

Maxillule (figure 26H) tapering, with three terminal and one subterminal setae. Maxilla (figure 27A) two-segmented. First segment unarmed. Second segment drawn out into moderately long lash bearing serrate convex margin, with two setae, one of the latter large and spinulated on both margins. Maxilliped (figure 27B) three-segmented. First segment longest, slightly tapering and unarmed. Second segment with spinules and two extremely unequal setae. Third segment slender and tapering, with one proximal and one distal setae.

Leg 1 (figure 27C), leg 2 (figure 27D) and leg 3 with three-segmented rami. Leg 4 (figure 27E) with three-segmented exopod and one-segmented endopod. Seta on outer margin of basis of legs 1–4 small. Inner posterior corner of basis of legs 3 and 4 pointed. Endopod of leg 4  $103 \times 31 \mu\text{m}$  (3.32:1); inner of terminal spines more than twice as long as outer one; proximal seta on inner margin slightly longer than width of endopod; outer margin with small spinule at proximal one-third. Armature formula of legs 1–4 as follows:

	Coxa	Basis	Exp	Enp
Leg 1	0-1	1-0	I-0; I-1; III, I, 4	0-1; 0-1; I, 5
Leg 2	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; III, 3
Leg 3	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; III, 2
Leg 4	0-1	1-0	I-0; I-1; III, I, 5	II, 1



Leg 5 consisting of one small seta on fifth pedigerous somite and free segment. Free segment (figure 27F)  $131 \times 30 \mu\text{m}$  (4.37:1), tapering, with minute spinules all over surface and with one spine ( $61 \mu\text{m}$ ) and one seta ( $42 \mu\text{m}$ ) terminally. Leg 6 represented by three spinules in genital area.

*Male.* Body (figure 28A) distinctly narrower than that of female. Length  $858 \mu\text{m}$ . Segmentation between cephalosome and first pedigerous somite incomplete. Urosome six-segmented. Fifth pedigerous somite  $79 \mu\text{m}$  wide. Genital somite distinctly longer than wide,  $123 \times 96 \mu\text{m}$ . Four abdominal somites  $46 \times 48$ ,  $38 \times 44$ ,  $29 \times 41$ , and  $31 \times 42 \mu\text{m}$ , respectively. All abdominal somites with denticulated posteroventral margin. Caudal ramus  $54 \times 21 \mu\text{m}$  (2.57:1). Outer one of two median terminal setae truncate.

Antennule with three additional aesthetascs (indicated by dark dots in figure 26D): two on second, and one on third. All aesthetascs extending beyond distal end of antennule. Antenna (figure 28C) with one extra seta on inner margin of third segment (thus ten setae).

Maxilliped (figure 28D) consisting of three segments and terminal claw. First segment distinctly tapering and unarmed. Second segment with one longitudinal row of spinules and two extremely unequal setae on inner side. Claw long, slender, evenly curved, proximally with one long seta and one minute spinule. Other mouth parts as in female.

Terminal endopodal segment of leg 1 armed with two spines and four setae (II, 4; instead of I, 5 as in female). Legs 2–4 as in female. Free segment of leg 5 relatively short,  $33 \times 12 \mu\text{m}$  (2.75:1), with nearly parallel margins. Leg 6 represented by two setae on genital flap.

*Etymology.* The specific name *anomalum* alludes to the 'anomalous' armature of the endopod of leg 4.

*Remarks.* The new species is unusual in the extraordinary armature of the endopod of leg 4, in which there is one inner proximal seta in addition to the two terminal spines. This setation is characteristic of the Rhynchomolgidae, according to Humes and Boxshall's (1996) recent revision of the lichomolgoid complex. However on the basis of the structure of other appendages, *Macrochiron anomalum* n. sp. clearly belongs to *Macrochiron* in the Macrochironidae. This incongruence suggests that the Macrochironidae and Rhynchomolgidae need to be redefined. A narrow boundary such as this between two families is also demonstrated by *Telestacicola* of the Rhynchomolgidae and *Pseudomacrochiron* of the Macrochironidae.

According to the key of Humes and Stock (1973), there are five species of *Macrochiron* displaying an armature formula of III, I, 5 (rather than II, I, 5) on the terminal exopodal segment of leg 4 as in the new species. These are *Macrochiron echinicum* Humes and Stock, 1973; *M. lobatum* Humes and De Maria, 1969; *M. lytocarpi* Humes, 1966; *M. mutatum* Stock, 1957; and *M. sargasii* Sars, 1916. No more species with this armature formula have been added to this genus since. These five species can be differentiated from the new species by the following characteristics which are not observed in the new species.

*Macrochiron echinicum* has a distally broadened free segment of leg 5; *M. lobatum* has a distinct lobe on the fifth pedigerous somite near the base of leg 5 and a needle at the tip of rostrum; *M. lytocarpi* has a needle at the tip of rostrum, a single terminal claw on the antenna, and a genital double-somite broadened near the middle; *M. mutatum* has a two-segmented endopod of leg 4, a single terminal

claw on the antenna, and a slender leg 5 (ratio of L/W more than 6); *M. sargasii* has a long, evenly narrowed leg 5 (ratio of L/W more than 7).

*Pseudomacrochiron urostenum* n. sp.  
(Figures 29–31)

*Material examined.* Seven ♀♀ and five ♂♂ collected from stagnant water on the intertidal mud flat at Jakyak-do Island off Inchon, on 29 September 1996. Holotype (♀), Allotype (♂), and eight paratypes (five ♀♀, three ♂♂) have been deposited in the US National Museum of Natural History, Smithsonian Institution. Dissected specimens (one ♀ and one ♂) are kept in the collection of the author.

*Female.* Body (figure 29A) slender, 1.03 mm long. Prosome five-segmented. Segmentation between cephalosome and first pedigerous somite distinct. Lateral margins of second pedigerous somite almost straight, its posterior corners pointed. Lateral margins of third and fourth pedigerous somites with narrow membranous fringe. Urosome (figure 29C) slender and five-segmented. Fifth pedigerous somite 97 µm wide. Genital double-somite 132 × 98 µm, with moderately expanded anterior part and narrower posterior part; genital area located at area of maximum width in expanded anterior part. Three abdominal somites 33 × 56, 27 × 53, and 67 × 51 µm, respectively. Anal somite distinctly longer than wide, longer than combined preceding two abdominal somites, with minute spinules on posteroventral margin. Caudal ramus elongate, 120 × 19 µm (6.32:1), with six setae. Outer lateral seta located at 61% length of caudal ramus.

Rostrum (figure 29B) longer than wide, tapering, with angular posterior tip. Antennule seven-segmented, 259 µm long, with armature formula 4, 13, 6, 3, 4+1 aesthetasc, 2+1 aesthetasc, and 7+1 aesthetasc. All setae naked. Antenna (figure 29E) slender and four-segmented, with armature formula 1, 1, 2+1 claw, and 5+2 claws. Claws on third and fourth segments slender, setiform. Fourth segment about 55 × 18 µm (3.06:1).

Labrum (figure 29F) widely incised; posterior margins of both lobes fringed with narrow membrane. Mandible (figure 29G) with deep proximal notch; terminal lash long, slender, spinulated, and well defined proximally; inner margin with one row of spinules; outer margin with proximal row of spinules and continued to serrate margin. Maxillule (figure 29H) tapering, with three terminal and one subterminal setae. Maxilla (figure 29I) two-segmented. First segment unarmed. Second segment drawn out into relatively short lash bearing spines on convex margin and one spiniform process on concave margin, with two setae and one proximal setule; seta on concave margin small and plumose. Maxilliped (figure 30A) three-segmented. First segment longest and unarmed. Second segment with two identical setae on inner margin proximal to middle. Third segment tapering and terminating in sharp point, with two proximal (one being spiniform) and two distal setae.

Leg 1 (figure 30B), leg 2 (figure 30C) and leg 3 with three-segmented rami. Leg 4 (figure 30D) with three-segmented exopod and one-segmented endopod. Endopod of leg 4 shorter than combined first two segments of exopod, 52 × 19 µm, with small spiniform process on outer margin; both margins with hairs; two terminal spines subequal. Armature formula of legs 1–4 as follows:

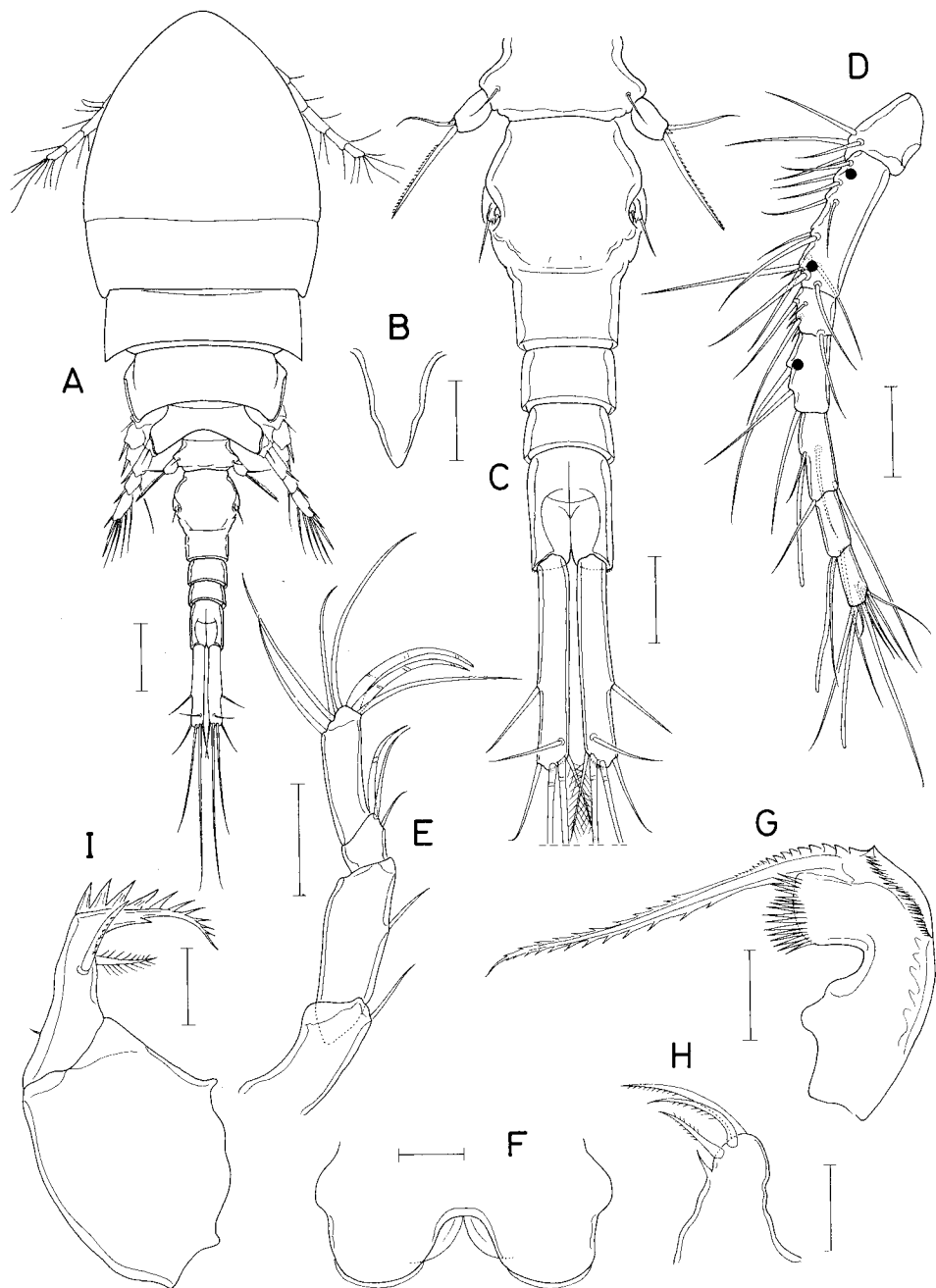


FIG. 29. *Pseudomacrochiron urostenum* n. sp., female: (A) habitus, dorsal; (B) rostrum; (C) urosome, dorsal; (D) antennule; (E) antenna; (F) labrum; (G) mandible; (H) maxillule; (I) maxilla. Scales: A=0.1 mm; B-E=0.05 mm; F-I=0.02 mm.

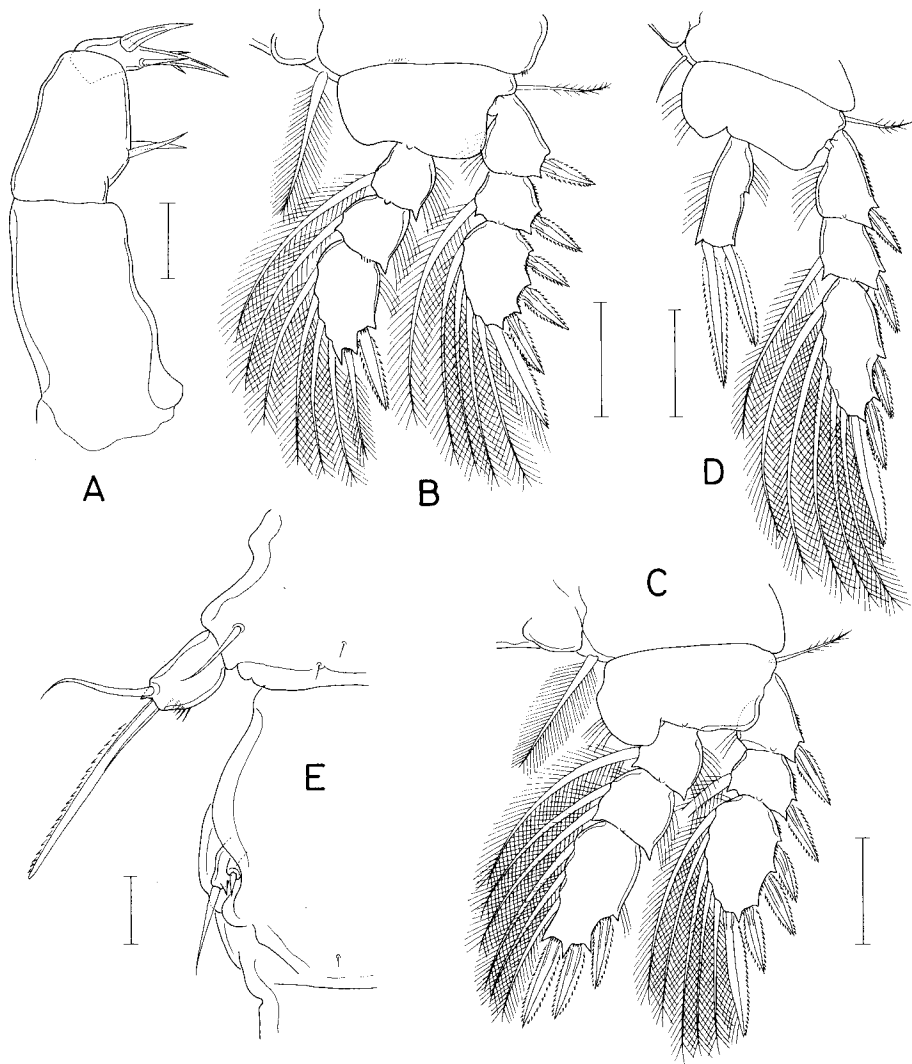


FIG. 30. *Pseudomacrochiron urostenum* n. sp., female: (A) maxilliped; (B) leg 1; (C) leg 2; (D) leg 4; (E) leg 5 and genital area, dorsal. Scales: A, E=0.02 mm; B-D=0.05 mm.

	Coxa	Basis	Exp	Enp
Leg 1	0-1	1-0	I-0; I-1; III, I, 4	0-1; 0-1; I, 5
Leg 2	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; III, 3
Leg 3	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; III, 2
Leg 4	0-1	1-0	I-0; I-1; II, I, 5	II

Leg 5 consisting of one seta on fifth pedigerous somite and free segment (figure 30E). Free segment small, lobate,  $26 \times 16 \mu\text{m}$  (1.63:1), with several setules on convex inner margin and terminally with one long spine ( $65 \mu\text{m}$ ), one seta ( $45 \mu\text{m}$ )

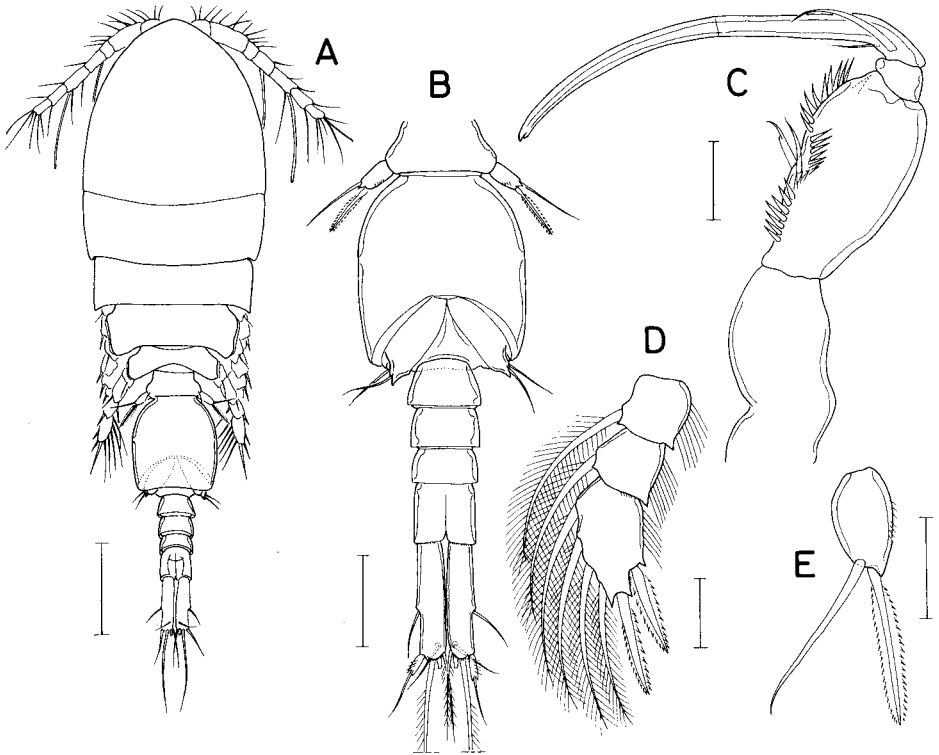


FIG. 31. *Pseudomacrochiron urostenum* n. sp., male: (A) habitus, dorsal; (B) urosome, ventral; (C) maxilliped; (D) endopod of leg 1; (E) free segment of leg 5. Scales: A = 0.1 mm; B = 0.05 mm; C–E = 0.02 mm.

and one spiniform process. Leg 6 represented by one seta and two spinules in genital area (figure 30E).

*Male.* Body (figure 31A) 0.67 mm long. Greatest width 0.20 mm. Lateral margins of prosome nearly parallel. Urosome (figure 31B) two-segmented. Fifth pedigerous somite 62  $\mu$ m wide. Genital somite 107  $\times$  93  $\mu$ m. Four abdominal somites 21  $\times$  44, 22  $\times$  38, 19  $\times$  36, 33  $\times$  34  $\mu$ m, respectively. Caudal ramus 63  $\times$  22  $\mu$ m (2.86:1). Outermost terminal seta transformed, basally thickened.

Antennule with three additional aesthetascs: two on second and one on third (opposite to dark dots in figure 29D). All aesthetascs large, extending beyond end of antennule. Antenna spinulated on inner surface of second segment, otherwise, identical to that of female.

Maxilliped (figure 31C) with unarmed first and third segments. Second segment proximally narrow and distally expanded, with one longitudinal row of spinules and two setae on inner side; the latter two located proximal to middle of segment, and one of them slightly expanded in proximal two-thirds. Claw long, weakly curved, as long as proximal three segments combined, with proximally one seta and one setule.

Leg 1 with terminal endopodal segment bearing two spines and four setae (II, 4; instead of I, 5 as in female) (figure 31D). Legs 2–4 as in female. Free segment of leg 5 (figure 31E) ovoid,  $19 \times 12 \mu\text{m}$  (1.58:1), both margins convex. Terminal spine  $32 \mu\text{m}$ , and seta  $37 \mu\text{m}$ . Leg 6 represented by two setae and one spiniform process on genital flap (figure 31B).

*Etymology.* The specific name *urostenum* is derived from the Greek *oura* (=tail) and *stenos* (=narrow), alluding to the narrow urosome of this species.

*Remarks.* The genus *Pseudomacrochiron* consists of five incompletely described species: *P. fucicolum* (T. Scott, 1912); *P. malayense* (Sewell, 1949); *P. ornatum* (Krishnaswamy, 1952); *P. parvum* (A. Scott, 1908); *P. stocki* Reddiah, 1969.

*Pseudomacrochiron urostenum* n. sp. can be distinguished from those five species by the structure of the caudal rami and female leg 5. The new species has long caudal rami with a length to width ratio of 6.32 in contrast to less than 4 in the other five species. The free segment of leg 5 of the new species is very short, with the ratio of length to width being 1.63, while this ratio in the other known species is more than 3.

### Family PSEUDANTHESSIIDAE Humes and Stock, 1972

#### *Pseudanthessius dentatus* n. sp.

(Figures 32–34)

*Material examined.* Eight ♀♀ and four ♂♂ collected from stagnant water on the intertidal mud flat at Jakyak-do Island off Inchon, on 29 September 1996. Holotype (♀), allotype (♂), and eight paratypes (six ♀♀, two ♂♂) have been deposited in the US National Museum of Natural History, Smithsonian Institution. Dissected specimens (one ♀ and three ♂) are kept in the collection of the author.

*Female.* Body (figure 32A) narrow, 0.89 mm long. Greatest width 0.31 mm. Prosome five-segmented, occupying 58% of body length, with weak segmentation between cephalosome and first pedigerous somite. Fourth pedigerous somite tapering laterally, weakly notched at end. Urosome (figure 32B) slender, tapering and five-segmented. Fifth pedigerous somite  $125 \mu\text{m}$  wide, with membranous fringe on both sides of posterior margin. Genital double-somite  $135 \times 96 \mu\text{m}$ , with weakly expanded anterior two-thirds and narrower, slightly tapering, posterior one-third. Genital area located laterally. Three abdominal somites  $36 \times 54$ ,  $19 \times 48$ , and  $42 \times 42 \mu\text{m}$ , respectively. Second abdominal somite very short. Anal somite as long as wide, more than twice as long as second abdominal somite. Caudal ramus elongate,  $113 \times 16 \mu\text{m}$  (7.06:1), slightly broadened distally. Outer lateral seta of caudal ramus located at 75% length of caudal ramus. This and inner dorsal seta naked. Other setae plumose.

Rostrum narrow, much longer than wide, with rounded posterior tip. Antennule (figure 32C) seven-segmented and  $222 \mu\text{m}$  long. First two segments broader. Armature formula 4, 13, 6, 3, 4 + 1 aesthetasc, 2 + 1 aesthetasc, and 7 + 1 aesthetasc. Terminal segment short, blunt, half as long as penultimate segment. All setae naked. Antenna (figure 32D) slender and four-segmented. Armature formula 1, 1, 2 + 1 claw, and 3 + 4 claws. Second segment slightly broadened distally, with minute spinules on outer margin. Terminal segment about  $50 \times 18 \mu\text{m}$  (2.78:1). Claws on third and terminal segments slender, setiform.

Labrum (figure 32E) deeply incised, with relatively long and narrow lobes. Posterior margin of both lobes fringed with broad membrane. Mandible (figure 32F) with one spiniform outer scale. Concave margin with three large teeth and several

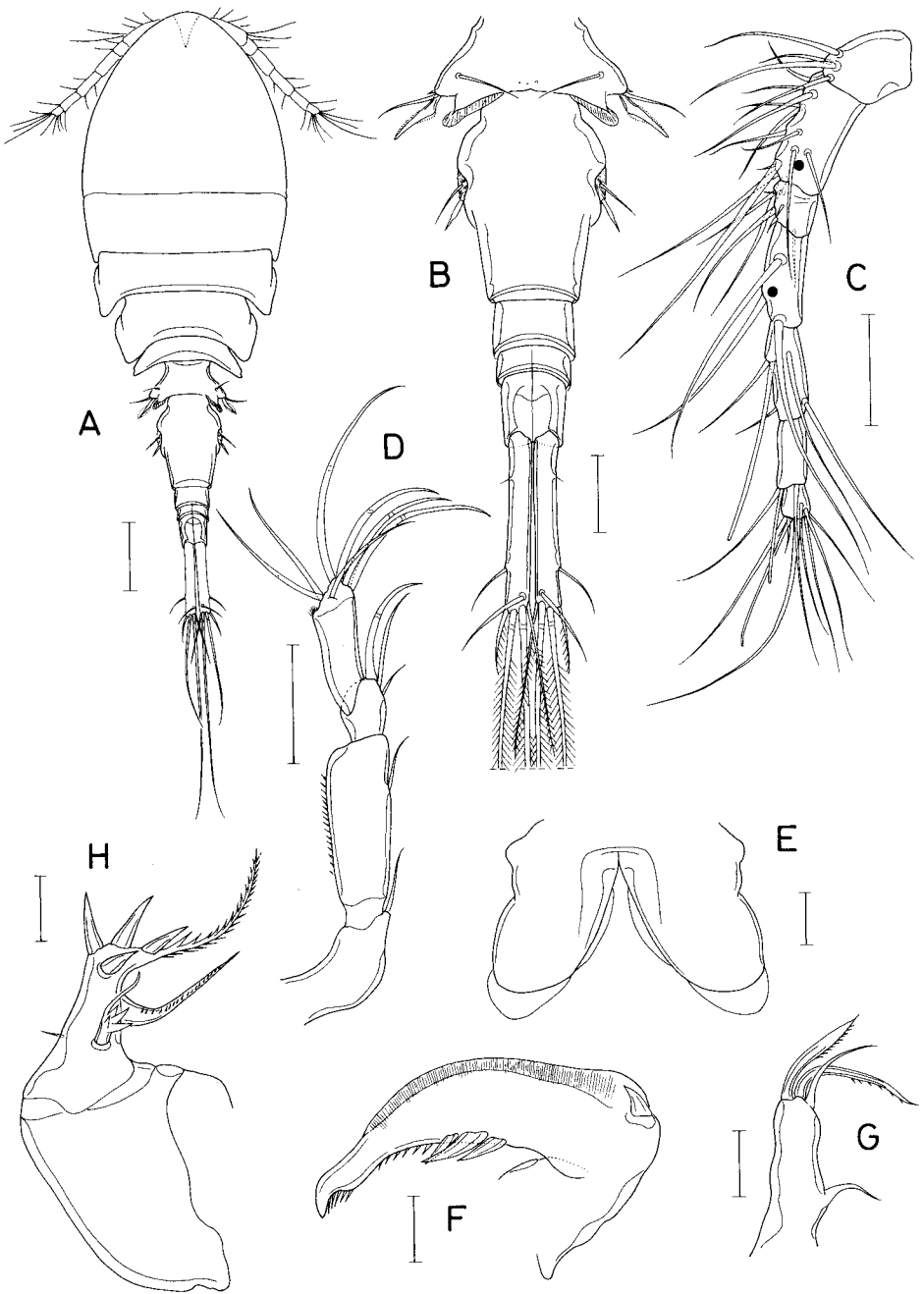


FIG. 32. *Pseudanthessius dentatus* n. sp., female: (A) habitus, dorsal; (B) urosome, dorsal; (C) antennule; (D) antenna; (E) labrum; (F) mandible; (G) maxillule; (H) maxilla. Scales: A=0.1 mm; B-D=0.05 mm; E-H=0.02 mm.

spinules. Lash blunt and terminally twisted. Maxillule (figure 32G) with three terminal (one of them broad) and one lateral setae. Maxilla (figure 32H) two-segmented. First segment unarmed. Second segment distally with four strong spines

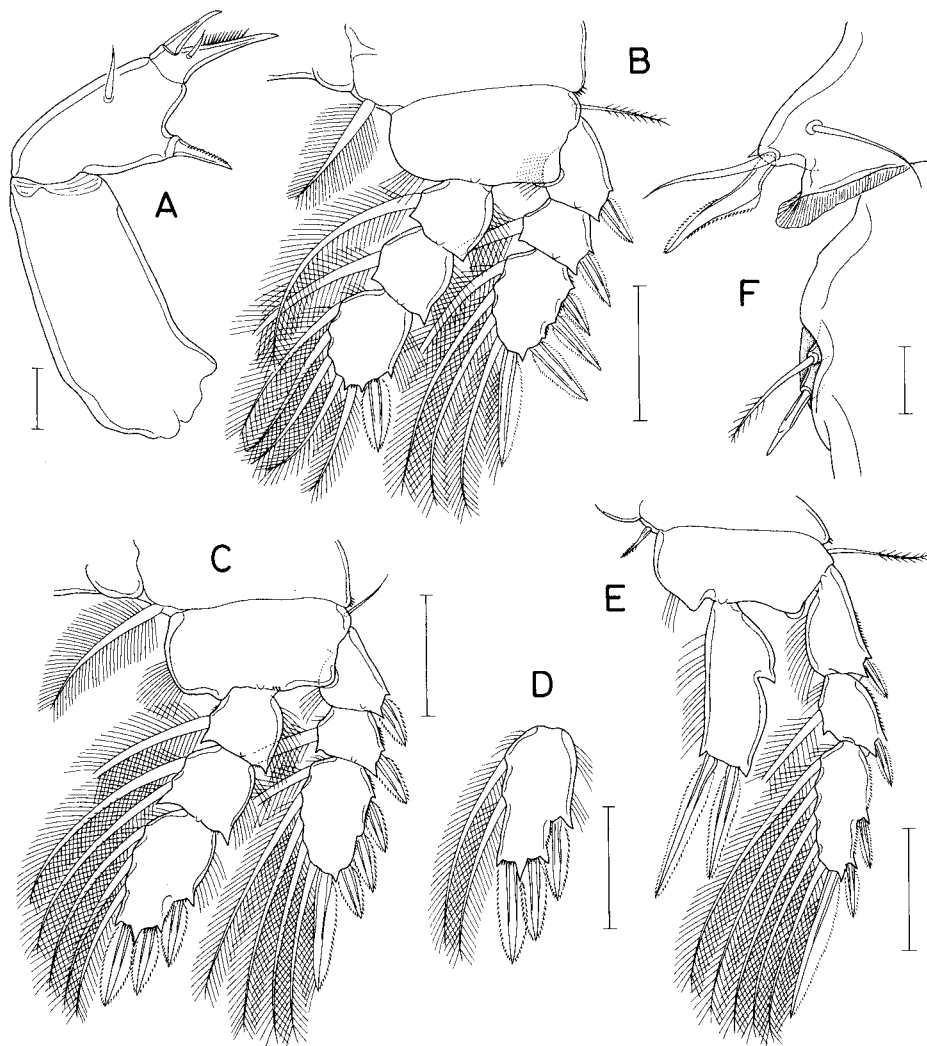


FIG. 33. *Pseudanthessius dentatus* n. sp., female: (A) maxilliped; (B) leg 1; (C) leg 2; (D) third endopod segment of leg 3; (E) leg 4; (F) legs 5 and 6, dorsal. Scales: A, F=0.02 mm; B-E=0.05 mm.

(one of them on outer surface) and terminating in a thin, spinulated lash, and with three setae; seta on outer margin minute; seta on concave margin thick and curved basally, with spinules; seta on outer surface characteristic, terminating in four spiniform processes and one setule. Maxilliped (figure 33A) three-segmented. First segment longest, margins nearly parallel. Second segment with one spiniform seta based on elevation on inner margin and one remotely isolated seta. Third segment sharply tapering, pointed at end, proximally with one spiniform seta and one small seta, and ornamented with setules on outer margin.

Leg 1 (figure 33B), leg 2 (figure 33C) and leg 3 with three-segmented rami. Leg 4 (figure 33E) with three-segmented exopod and one-segmented endopod. Endopod of leg 4 longer than combined first two exopodal segments, with deep notch and



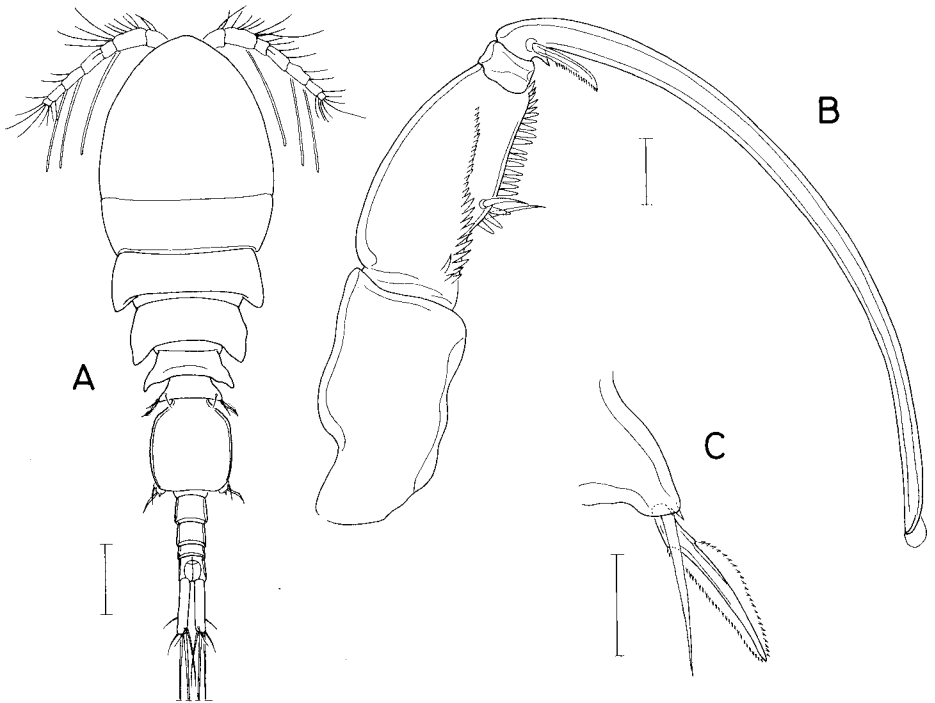


FIG. 34. *Pseudanthessius dentatus* n. sp., male: (A) habitus, dorsal; (B) maxilliped; (C) leg 5. Scales: A=0.1 mm; B, C=0.02 mm.

process on outer margin; terminal two spines subequal. Armature formula of legs 1–4 as follows:

	Coxa	Basis	Exp	Enp
Leg 1	0-1	1-0	I-0; I-1; III, I, 4	0-1; 0-1; I, 5
Leg 2	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; III, 3
Leg 3	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; III, 2
Leg 4	0-1	1-0	I-0; I-1; II, I, 5	II

Leg 5 completely incorporated into fifth pedigerous somite, leaving only one seta on dorsal surface near corner of somite, and one slightly curved spine, one naked seta and one spinule on corner of somite (figure 33F). Terminal spine and seta identical in length. Leg 6 represented by 1 spine and 1 seta in genital area (figure 33F).

*Male.* Body (figure 34A) resembling that of female, 0.85 mm long. Greatest width 248  $\mu$ m. Urosome six-segmented. Genital somite nearly quadrangular, slightly longer than wide. Caudal ramus 4.55 times as long as wide.

Antennule with two additional aesthetascs, each on second and fourth segments (indicated by dark dots in figure 32C). All aesthetascs extending beyond distal end of antennule. Antenna with two larger spinules in addition to minute spinules on outer margin of second segment.

Maxilliped (figure 34B) composed of three segments and claw. First and third segments unarmed. Second segment with two longitudinal rows of spinules and two

simple setae on inner surface. Claw very long, curved weakly and evenly, much longer than basal three segments combined, proximally with one spiniform process and one broad seta. Other mouth parts as in female.

Legs 1–4 as in female, without sexual dimorphism. Leg 5 as in female, but terminal spine nearly straight (figure 34C).

*Etymology.* The specific name is derived from the Latin *dentatus*, meaning 'toothed', and alludes to the presence of large teeth on the blade of the mandible.

*Remarks.* The most distinctive feature of the new species is the mandible in which the convex side bears one scale (or tooth), and the concave side three large teeth. In other known species of *Pseudanthessius*, the maximum armature on the mandible is, as far as known, one scale (or tooth) on each convex and concave side as in *P. limatus* Humes, 1978. Eleven other species bear only a single tooth on the mandible. Among these 12 species there are only two species, viz. *P. deficiens* Stock, Humes and Gooding, 1964 and *P. limatus* Humes, 1978 both from the western Atlantic, in which the caudal ramus is long, more than six times as long as wide. *Pseudanthessius deficiens* differs from *P. dentatus* n. sp., as well as from all other known congeners, in bearing a four-segmented urosome. *Pseudanthessius limatus* differs from the new species in its anal somite being slightly longer than the pre-anal somite (ratio 1.2:1, in contrast to 2.2:1 in the new species), the lateral margins of the genital double-somite being straight and bearing processes, and the antenna with one distinct claw on the third segment but no claw on the terminal segment.

*Pseudanthessius dentatus* is very similar to *P. aestheticus* Stock, Humes and Gooding, 1964. Both species have a similar body form, long caudal rami and anal somite, and same armature for the antenna. However, *P. aestheticus* has, unlike *P. dentatus*, an unarmed mandible, sexually dimorphic leg 1, and slender, simple endopod of leg 4 without notch or point.

Except for the characteristic mandible, a combination of the following diagnostic features of *P. dentatus* can be used to separate the Korean species from all of its congeners: (1) the caudal rami are very slender, with a ratio of length to width 7.06, (2) the anal somite is more than twice as long as the pre-anal somite, (3) the antenna carries four setiform claws on the terminal segment, in addition to setae, (4) the endopod of leg 4 has a notch and a point on the outer margin, and (5) there are one setiform claw and two setae on the inner distal corner of the third antennary segment.

### Family RHYNCHOMOLGIDAE Humes and Stock, 1972

#### *Critomolgus nudus* n. sp.

(Figures 35–37)

*Material examined.* Seven ♀♀, 13 ♂♂ from the pennatulacean, *Virgularia gustaviana* (Herklots), dug from the intertidal mud flat at Jakyak-do Island, on 13 December 1996. Holotype (♀) allotype and 14 paratypes (four ♀♀, ten ♂♂) have been deposited in the US National Museum of Natural History, Smithsonian Institution. Dissected specimens (two ♀♀, two ♂♂) are kept in the collection of the author.

*Female.* Body (figure 35A) 2.00 mm long. Greatest width 1.00 mm. Prosome ovoid, broad and dorsoventrally flat, with weak suture line between cephalosome and first pedigerous somite. Urosome five-segmented, with thick exoskeleton. Fifth pedigerous somite 290 µm wide. Genital double-somite 293 × 305 µm, with greatest

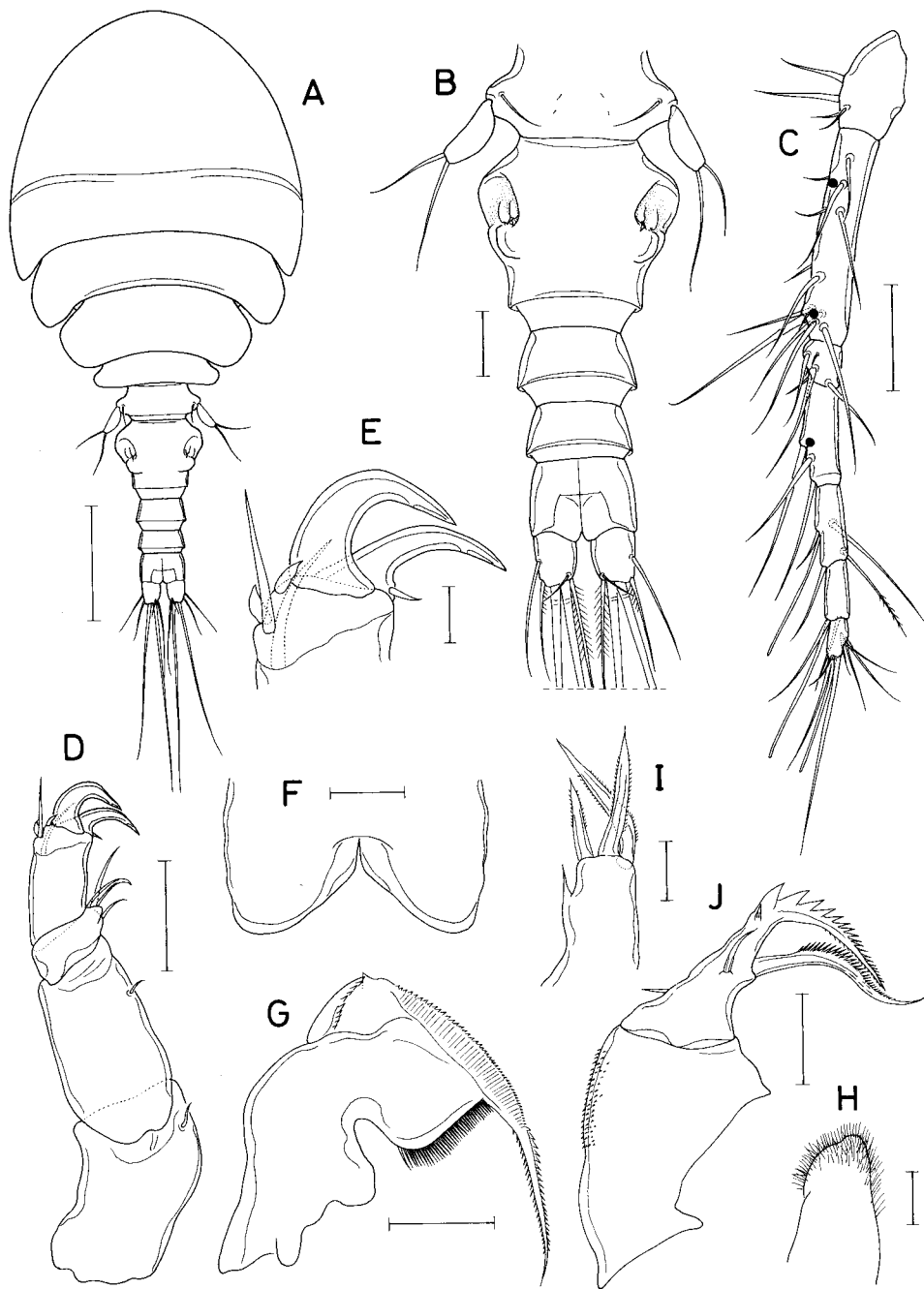


FIG. 35. *Critomolgus nudus* n. sp., female: (A) habitus, dorsal; (B) urosome, dorsal; (C) antennule; (D) antenna; (E) distal part of terminal segment of antenna; (F) labrum; (G) mandible; (H) paragnath; (I) maxillule; (J) maxilla. Scales: A=0.5 mm; B-D=0.1 mm; E, H, I=0.02 mm; F, G, J=0.05 mm.

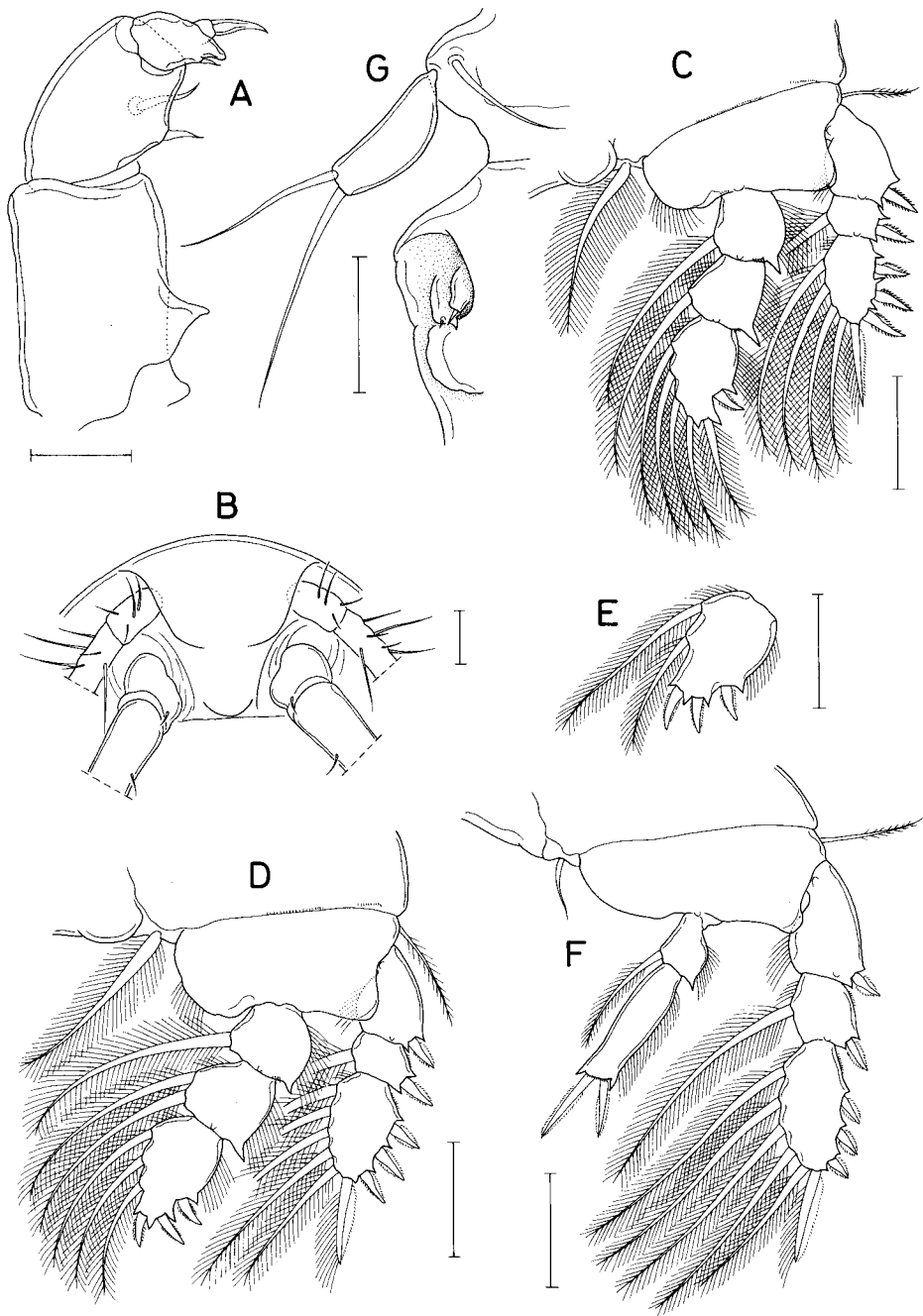


FIG. 36. *Critomolgus nudus* n. sp., female: (A) maxilliped; (B) rostral area, ventral; (C) leg 1; (D) leg 2; (E) third endopod segment of leg 3; (F) leg 4; (G) leg 5 and genital area, dorsal. Scales: A = 0.05 mm; B–G = 0.1 mm.

width across anterior third and weak lobate process just posterior to genital area. Genital area located dorsolaterally. Three abdominal somites  $115 \times 180$ ,  $85 \times 163$ , and  $110 \times 162 \mu\text{m}$ , respectively. First two abdominal somites each broadened

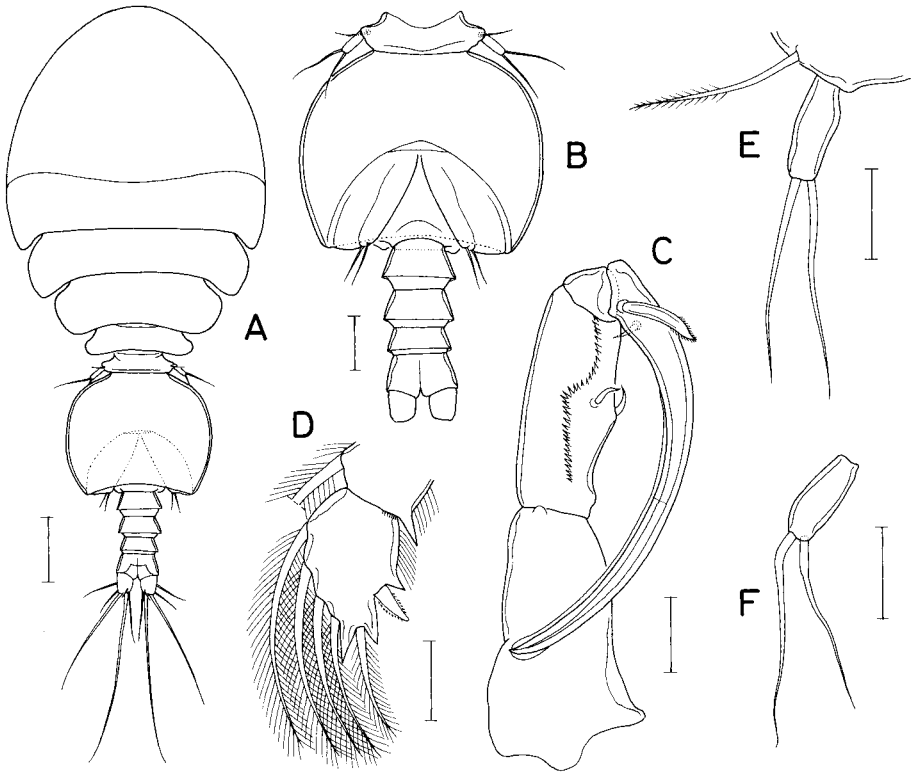


FIG. 37. *Critomolgus nudus* n. sp., male: (A) habitus, dorsal; (B) urosome, ventral; (C) maxilliped; (D) third endopod segment of leg 1; (E) leg 5; (F) free segment of leg 5. Scales: A=0.2 mm; B=0.1 mm; C-F=0.05 mm.

posteriorly. Caudal ramus short,  $77 \times 64 \mu\text{m}$  (1.20:1), with six setae. Outer lateral seta naked, located in the middle of, and about twice as long as, caudal ramus. Inner dorsal seta naked. Other four setae plumose.

Rostrum weakly developed, its posterior margin obscure (figure 36B). Antennule slender,  $592 \mu\text{m}$  long, with armature formula 4, 13, 6, 3, 4+1 aesthetasc, 2+1 aesthetasc, and 7+1 aesthetasc. Setae relatively short. Antenna (figure 35D) stocky, with armature formula 1, 1, 2+1 claw, 5+2 claws. Setae on first two segments small. Terminal segment about twice as long as wide; two of setae near outer distal corner short and broad. Two terminal claws strong.

Labrum (figure 35F) deeply incised; lateral margins nearly parallel; posterior margin unornamented. Mandible (figure 35G) with deep proximal notch; terminal lash narrow, spinulated and moderately long; inner margin perpendicular to lash, with row of fine spinules; convex side broadly produced, with row of spinules and one small, dentiform process. Paragnath (figure 35H) a lobe, distally hairy. Maxillule (figure 35I) with one lateral seta (or process) and three broad terminal setae. Maxilla (figure 35J) two-segmented; first segment with minute spinules on outer (ventral) surface; second segment with one minute outer seta, one long, curved seta (spinulated on inner margin) on inner margin, one small seta on anterior surface, and one small denticle near base of lash; lash shorter than seta on inner margin, with serrate convex margin. Maxilliped (figure 36A) three-segmented and stocky; first segment

unarmed; second segment with two simple setae of unequal length; third segment terminating in a blunt process, with one spine and one small seta.

Leg 1 (figure 36C), leg 2 (figure 36D) and leg 3 with three-segmented rami. Leg 4 (figure 36F) with three-segmented exopod and two-segmented endopod; inner seta on coxa small and naked; both terminal corners of second endopodal segment with pointed process; terminal spines unequal in length. Armature formula of legs 1–4 as follows:

	Coxa	Basis	Exp	Enp
Leg 1	0-1	1-0	I-0; I-1; III, I, 4	0-1; 0-1; I, 5
Leg 2	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; III, 3
Leg 3	0-1	1-0	I-0; I-1; III, I, 5	0-1; 0-2; III, 2
Leg 4	0-1	1-0	I-0; I-1; III, I, 5	0-1; II

Leg 5 consisting of one naked seta on fifth pedigerous somite and free segment (figure 36G). Free segment  $109 \times 38 \mu\text{m}$  (2.87:1), with convex inner margin and two subequal, naked setae; these two setae longer than free segment. Leg 6 represented by two spinules and one spinule-like process in genital area.

*Male.* Body (figure 37A) resembling that of female. Length 1.80 mm. Greatest width 0.80 mm. Urosome (figure 37B) six-segmented. Fifth pedigerous somite short,  $230 \mu\text{m}$  wide. Genital somite nearly spherical, large,  $370 \times 450 \mu\text{m}$ . Four abdominal somites  $75 \times 138$ ,  $70 \times 130$ ,  $50 \times 120$ ,  $70 \times 132 \mu\text{m}$ , respectively. Caudal ramus  $60 \times 52 \mu\text{m}$  (1.15:1).

Antennule with three additional aesthetascs: two on second and one on fourth segments (opposite places of dark dots in figure 35C). Antenna as in female.

Maxilliped (figure 37C) consisting of three segments and claw. First segment unarmed and similar in length to second segment. Second segment with one row of spinules on inner side, and two equal, small setae at midlength of inner margin. Third segment unarmed. Claw strongly curved, proximally with one small and one thick seta.

Terminal endopodal segment of leg 1 with two terminal processes more prominent than in female, but armature formula of legs 1–4 as in female. Free segment of leg 5 rather varied in shape (figure 37E, F),  $55 \times 23 \mu\text{m}$  (2.39:1). Leg 6 represented by two small setae on genital flap.

*Etymology.* The specific name is derived from the Latin *nudus*, meaning 'naked', and alludes to the relatively smooth appearance of the body, especially the naked terminal setae on the caudal rami.

*Remarks.* Since Humes and Boxshall (1996) counted 27 species in *Critomolgus*, Kim (1996) added three new species to this genus from Korean sea anemones. According to Humes (1978) the ornamentation on the first segment of the maxilla is found only in *C. virgulariae* (Humes, 1978) and *C. magnificus* (Humes, 1964). For this point, *C. nudus* n. sp. is comparable with these two species. In addition, these two species and *C. nudus* have in common more important characters, such as lacking sexual dimorphism on the third endopodal segment of leg 1, i.e. one spine and five setae (I, 5) in both sexes. Moreover, they are all found on pennatulaceans in the Indo-West Pacific region.

The easiest way to differentiate the new species from the above mentioned two congeners can be made by their sizes; while the female of *C. magnificus* is unusually large, 3.06 mm long (Humes, 1964), that of *C. virgulariae* is relatively small, 1.12 mm long (Humes, 1978), and the new species is intermediate, being 2.00 mm. More precise differentiation of the females of these species may be summarized as follows:

*Critomolgus nudus*: genital double-somite slightly wider than long; caudal ramus 1.20 times as long as wide; maxillule bearing four setae; and free segment of leg 5 2.87 times as long as wide.

*Critomolgus magnificus*: genital double-somite 1.55 times as long as wide; caudal ramus very long (ratio of length to width 7.8); maxillule with three setae; and free segment of leg 5 2.87 times as long as wide.

*Critomolgus virgulariae*: genital double-somite 1.34 times wider than long; caudal ramus 1.67 times as long as wide; maxillule with three setae; and free segment of leg 5 4.33 times as long as wide.

*Notoxynus tertius* n. sp.

(Figures 38, 39)

*Material examined.* Four ♀♀, three ♂♂ and one copepodid V ♀ from the gastrovascular cavity of the mud-inhabiting sea anemone, *Cerianthus filiformis* Carlgren, collected in the intertidal mud flat at Jakyak-do Island off Inchon, on 28 September 1996. Holotype (♀), allotype (♂), and three paratypes (two ♀♀, one ♂) have been deposited in the US National Museum of Natural History, Smithsonian Institution. Dissected specimens (one adult pair and one copepodid V ♀) are kept in the collection of the author.

*Female.* Body (figure 38A) narrow, almost cylindrical, stocky, 2.39 mm long, with very thin exoskeleton. Greatest width 0.61 mm. Prosome five-segmented, with faint suture line between cephalosome and first pedigerous somite. Epimera of prosomal somites weakly developed. Urosome (figure 38B) five-segmented, tapering, with weak segmentation. Fifth pedigerous somite distinctly wider than genital double-somite, 358 µm wide. Genital double-somite 375 × 296 µm (1.27:1). Genital area small, located dorsolaterally at anterior third of lateral margin. Three abdominal somites 129 × 212, 79 × 188, and 96 × 179 µm, respectively. Posteroventral border of anal somite with minute spinules. Caudal ramus 137 × 71 µm (1.93:1), with distinctly convex inner margin and several minute spinules on terminal margin. Caudal setae relatively short and naked. Outer lateral seta located at midlength of outer margin of caudal ramus.

Rostrum semicircular and much wider than long. Antennule (figure 38C) 487 µm long and seven-segmented. Armature formula 4, 13, 6, 3, 4+1 aesthetasc, 2+1 aesthetasc, and 7+1 aesthetasc. Setae thin and naked. Antenna (figure 38D) four-segmented, with armature formula 1, 1, 3, 6+1 claw. Third segment very short. Terminal segment about 77 × 34 µm (2.26:1), weakly curved. Terminal claw strongly curved. One of terminal setae very large, distinctly longer than terminal segment.

Labrum (figure 38E) deeply incised, with unornamented, weakly tapering lobes. Mandible (figure 38F) with broad proximal notch. Terminal lash long and spinulated. Inner margin oblique to lash, with a row of setules. Maxillule (figure 38G) a slender lobe, with two terminal, subequal setae (in copepodid V, number of these setae being three). Maxilla (figure 38H) two-segmented. First segment unarmed. Second segment terminating in moderately long lash bearing spinules on convex

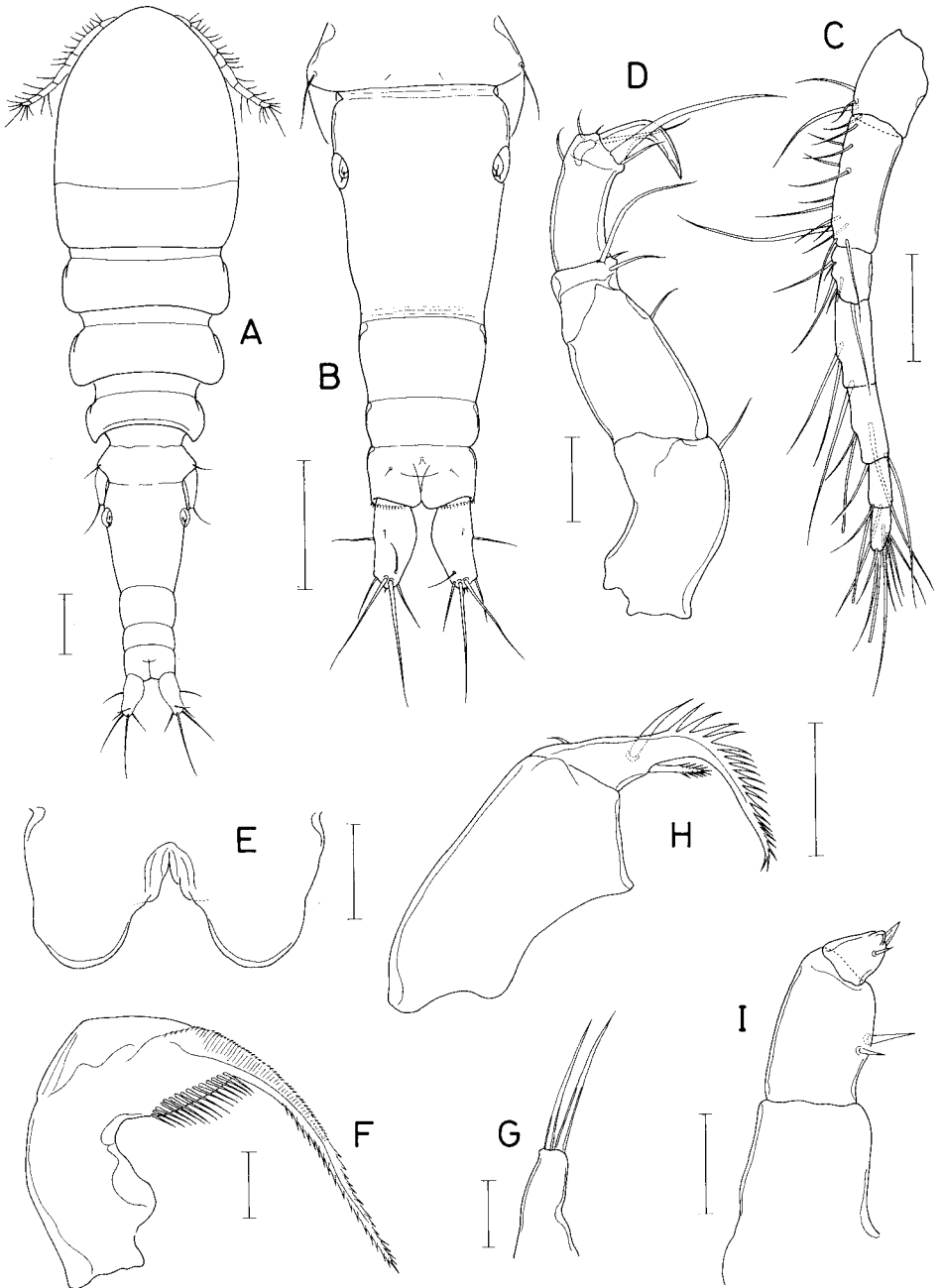


FIG. 38. *Notoxyenus tertius* n. sp., female: (A) habitus, dorsal; (B) urosome, dorsal; (C) antennule; (D) antenna; (E) labrum; (F) mandible; (G) maxillule; (H) maxilla; (I) maxilliped. Scales: A, B=0.2 mm; C=0.1 mm; D, E, H, I=0.05 mm; F, G=0.02 mm.

margin, with one minute outer seta, one naked seta on anterior surface, and one relatively small, distally spinulated seta on concave margin. Maxilliped (figure 38I) three-segmented. First segment unarmed and slightly longer than wide. Second



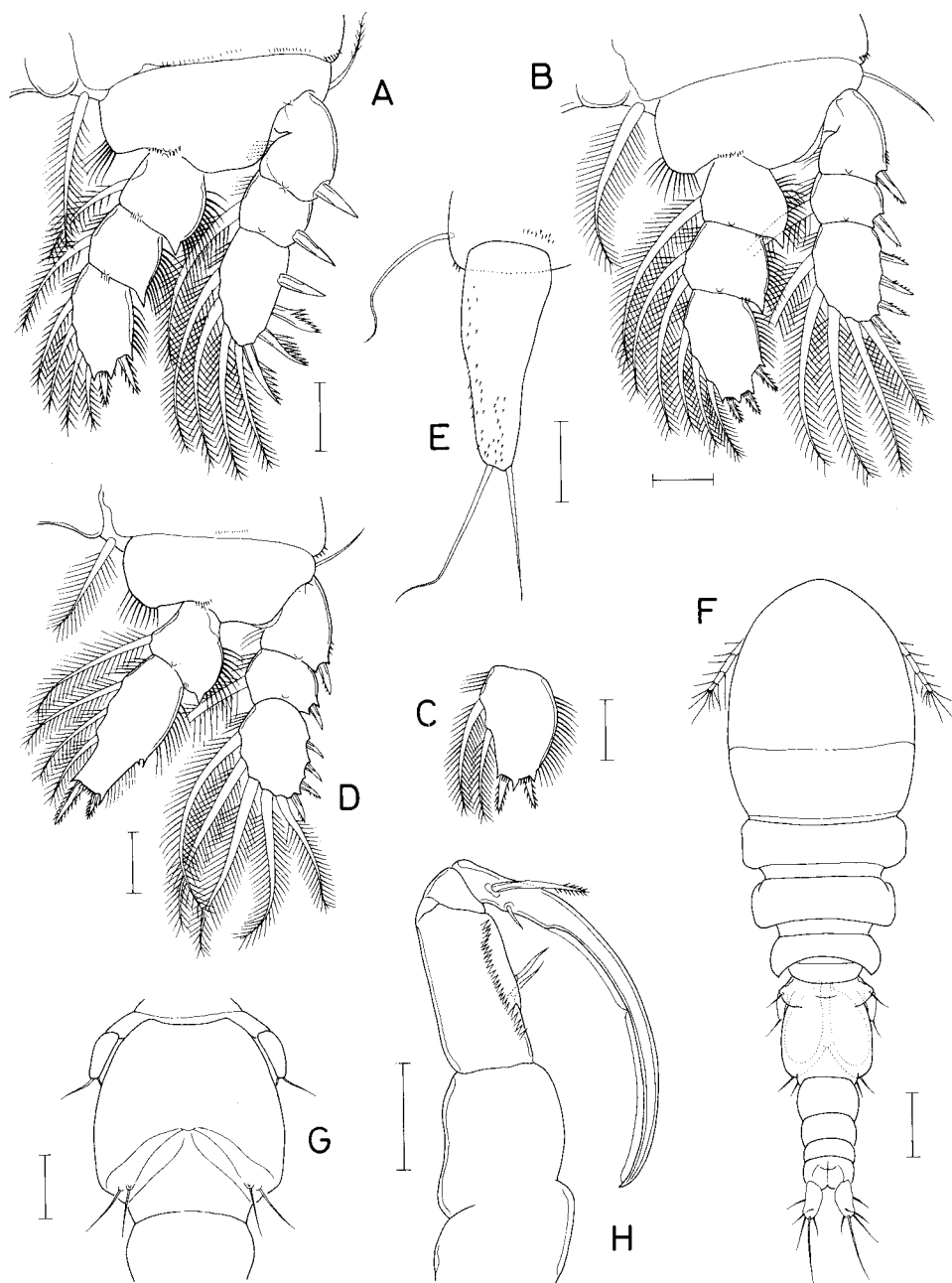


FIG. 39. *Notoxynus tertius* n. sp. Female: (A) leg 1; (B) leg 2; (C) third endopod segment of leg 3; (D) leg 4; (E) leg 5. Male: (F) habitus, dorsal; (G) anterior part of urosome, ventral; (H) maxilliped. Scales: A-E, H=0.05 mm; F=0.2 mm; G=0.1 mm.

segment with two simple, unequal setae on inner margin. Terminal segment blunt, tapering, with small, blunt terminal process, one small spine and one small seta.

Leg 1 (figure 39A), leg 2 (figure 39B), and leg 3 with three-segmented rami. Leg 4 (figure 39D) with three-segmented exopod and two-segmented endopod. Hairs on

setae and segments stiff and relatively thick. Second endopodal segment of leg 4 tapering, with two minute spiniform processes on outer margin; terminal two spines very unequal, inner one of which about twice as long as outer one. Armature formula of legs 1-4 as follows:

	Coxa	Basis	Exp	Enp
Leg 1	0-1	1-0	I-0; I-1; III, I, 4	0-1; 0-1; II, 4
Leg 2	0-1	1-0	I-1; I-1; III, I, 5	0-1; 0-2; III, 3
Leg 3	0-1	1-0	I-1; I-1; III, I, 5	0-1; 0-2; II, 2
Leg 4	0-1	1-0	I-1; I-1; III, I, 5	0-1; II, 3

Leg 5 (figure 39E) composed of one naked seta on fifth pedigerous and free segment. Free segment distinctly tapering,  $142 \times 54 \mu\text{m}$  (2.63:1), with minute spinules on surface and two naked terminal setae (outer one  $110 \mu\text{m}$ , and inner one  $83 \mu\text{m}$ ). Leg 6 represented by two spinules in genital area.

*Male.* Body (figure 39F) resembling that of female. Length 1.96 mm. Greatest width  $258 \mu\text{m}$ . Urosome six-segmented, with incomplete segmentation between fifth pedigerous somite and genital somite. Genital somite distally broadened (figure 39G),  $292 \times 296 \mu\text{m}$ . Four abdominal somites  $120 \times 196$ ,  $96 \times 171$ ,  $54 \times 156$ , and  $71 \times 154 \mu\text{m}$ , respectively. Caudal ramus  $113 \times 56 \mu\text{m}$  (2.02:1).

Antennule with armature formula identical to that of female. Antenna with spinules on outer margin of second segment.

Maxilliped (figure 39H) consisting of three segments and terminal claw. First segment unarmed and longest. Second segment with longitudinal row of spinules and two identical setae on inner side. Third segment unarmed. Claw evenly curved, relatively large, proximally with one setule and one seta bearing spinules distally.

Legs 1-4 with armature formula identical to that of female. Leg 5 identical in shape to that of female,  $92 \times 47 \mu\text{m}$  (1.96:1). Leg 6 represented by two thin setae and one minute spinule on genital flap; the latter located at base of inner seta.

*Etymology.* The specific name is derived from the Latin *tertius*, meaning 'third'. The new species is named as such because it is the third known species in the genus.

*Remarks.* Only two species of *Notoxynus* have been recognized: *N. mundus* Humes, 1975 and *N. crinitus* Humes, 1982. *Notoxynus tertius* can be easily distinguished from these two congeners by the armature on the endopod of legs. The endopod of legs 1, 3, and 4 in the new species carries, respectively, 2 spines + 4 setae (II, 4), 2 spines + 2 setae (II, 2), and 2 spines + 3 setae. In the two congeners, these armatures are 1 spine + 5 setae (I, 5), 3 spines + 2 setae (III, 2), and 2 spines + 1 setae (II, 1), respectively.

In *N. crinitus* and *N. mundus* the maxillule bears three elements, but in *N. tertius* it bears only two setae. It is interesting to find that the maxillule in the copepodid V of *N. tertius* bears three setae (not two as in the adult).

### Acknowledgements

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## References

- BOCQUET, C. and STOCK, J. H., 1957, Copépodes parasites d'invertébrés des côtes de France. IVB. Le double parasitisme de *Sipunculus nudus* L. par *Myzomolgus stupendus* nov. gen., nov. sp. et *Catinia plana* nov. gen., nov. sp., copépodes cyclopoïdes tres remarquables, *Koninklijke Nederlandse Akademie van Wetenschappen-Amsterdam, Series C*, **60**, 4418–424.
- BOXSHALL, G. A. and HUMES, A. G., 1987, A new species of *Hemicyclops* (Copepoda: Poecilostomatoida) associated with an echiuran worm in Hong Kong, *Asian Marine Biology*, **4**, 61–66.
- DELAMARE-DEBOUTTEVILLE, C. and NUNES-RUIVO, L. P., 1955, *Echiurophilus fizei* n. g. n. sp., copépode parasite d'un échiuride d'Indochine, *Vie et Milieu*, **6**, 101–112.
- GOODING, R. U., 1963 (unpublished), External morphology and classification of marine poecilostome copepods belonging to the families Clausidiidae, Clausiidae, Nereicolidae, Eunicolididae, Synaptophilidae, Catiniidae, Anomopsyllidae, and Echiurophilidae, (University of Washington, Ph. D. thesis), 276 pp.
- HO, J.-S., 1984, New family of poecilostomatoid copepods (Spiophanicolidae) parasitic on polychaetes from southern California, with a phylogenetic analysis of nereicoliform families, *Journal of Crustacean Biology*, **4**, 134–146.
- HO, J.-S. and KIM, I.-H., 1997, A new family of poecilostomatoid copepods (Polyankyliidae) from a tide pool on mud flat in Korea, *Korean Journal of Biological Sciences*, **1**, 429–434.
- HUMES, A. G., 1964, New species of *Lichomolgus* (Copepoda, Cyclopoida) from sea anemones and nudibranchs in Madagascar, *Cahiers ORSTOM-Océanographie*, **6** (sér. Nosy Bé II), 59–130.
- HUMES, A. G., 1978, Lichomolgoid copepods (Cyclopoida), with two new species of *Doridicola*, from sea pens (Pennatulacea) in Madagascar, *Transactions of the American Microscopical Society*, **97**, 524–539.
- HUMES, A. G., 1995, Three new species of *Hemicyclops* (Copepoda: Poecilostomatoida: Clausidiidae) from northwestern Madagascar, *Bulletin du Muséum National d'Histoire Naturelle*, 4e sér., **17**, 141–162.
- HUMES, A. G. and BOXSHALL, G. A., 1996, A revision of the lichomolgoid complex (Copepoda: Poecilostomatoida), with the recognition of six new families, *Journal of Natural History*, **30**, 175–227.
- HUMES, A. G. and GOODING, R. U., 1964, A method for studying the external anatomy of copepods, *Crustaceana*, **6**, 238–240.
- HUMES, A. G. and HO, J.-S., 1969, Cyclopoid copepods of the genus *Kelleria* (Lichomolgidae) from intertidal burrows in Madagascar, *Bulletin of the British Museum of Natural History (Zool.)*, **18**, 221–229, pls. 1–8.
- HUMES, A. G. and STOCK, J. H., 1973, A revision of the family Lichomolgidae Kossmann, 1877, cyclopoid copepods mainly associated with marine invertebrates, *Smithsonian Contributions to Zoology*, **127**, 1–368.
- ITOH, H. and NISHIDA, S., 1993, A new species of *Hemicyclops* (Copepoda, Poecilostomatoida) from a dredged area in Tokyo Bay, Japan, *Hydrobiologia*, **254**, 149–157.
- KIM, I.-H., 1996, Three new species of *Critomolgus* (Copepoda, Poecilostomatoida, Rhynchomolgidae) associated with sea anemones in Korea. *Korean Journal of Zoology*, **39**, 362–377.
- KIM, I.-H., 1997, Two new species of poecilostomatoid copepods associated with the bivalve *Dosinella penicillata* in the Yellow Sea, *Korean Journal of Biological Sciences*, **1**, 15–23.
- KIM, I.-H., 1998. *Illustrated Encyclopedia of Fauna and Flora of Korea*, Vol. 38. *Cirripedia, Symbiotic Copepoda, and Pycnogonida* (Republic of Korea: Ministry of Education), 1038 pp.
- SEWELL, R. B. S., 1949, The littoral and semi-parasitic Cyclopoida, the Monstrilloida and Notodelphyoida, *Scientific Reports, John Murray Expedition, 1933-34*, **9**, 17–199.
- STOCK, J. H., 1959, Copepoda associated with Neapolitan invertebrates, *Pubblicazioni della Stazione Zoologica di Napoli*, **31**, 59–75.
- STOCK, J. H., 1995, Copepoda Poecilostomatoida associated with Bivalvia from New Guinea. *Hydrobiologia*, **312**, 37–45.