

# Poecilostomatoid Copepods (Rhynchomolgidae) Associated with Sea Anemones (Actiniaria) from Korea

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**Abstract:** *Lichomolgus panikkari* Gnanamuthu, 1955 (= *Indomolgus panikkari*), an incompletely known species, is redescribed based on a male specimen found newly from the Yellow Sea. A new genus of copepods, *Lutumidomus*, is proposed to incorporate *Lichomolgus panikkari*, *Notoxynus tertius* Kim, 2000, and *Lutumidomus parvus* n. sp., all associated with sea anemones. The new genus is differentiated from the related genera by a combination of characters that the antenna is 4-segmented, with a claw and an enlarged seta in addition to other setae on the fourth segment, the third endopodal segment of leg 3 is armed with two spines and two setae, the second endopodal segment of leg 4 is armed with two spines and three setae, and the maxillule is armed with two terminal setae. *Paramolgus nudipes* n. sp. and *Verutipes scutatus* n. sp. are also described as associates of sea anemones from Korean seas.

**Key words:** Copepoda, *Lutumidomus* n. gen., new species, association, actinarians, Korea

According to Humes (1982), 42 species of copepods associated with sea anemones (Actiniaria) and anemone-like forms (Corallimorpharia) had been recorded until that time. In Korea, Kim (1996) described three new species *Critomolgus malmizalus* associated with the sea anemone *Anthopleura japonica* Verrill and *C. vicinus* and *C. anthopleurus* associated with *Anthopleura midori* Uchida and Muramatsu. Kim (2000) reported *Notoxynus tertius*, as new, associated with the ceriantharian *Cerianthus filiformis* Carlgren in the Yellow Sea. In this paper four additional species, three of them as new species, found in the gastrovascular cavity of sea anemones are described from Korea.

Copepod specimens were measured and dissected after soaking in lactic acid. Dissection was done using the

reversed slide method. In the following description, Roman and Arabic numerals in the armature formula represent spines and setae, respectively. All figures were drawn with the aid of a camera lucida.

## DESCRIPTIONS

Order Poecilostomatoida Kabata, 1979  
Family Rhynchomolgidae Humes and Stock, 1972

*Lutumidomus* n. gen.

**Diagnosis:** Body generally large but narrow. Antennule 7-segmented. Antenna 4-segmented; its terminal segment armed with 1 claw and 1 elongated seta in addition to other smaller setae. Labrum with prominent posterior lobes. Mandible narrow. Maxillule terminally armed with 2 setae. Maxilla and maxilliped of general form of family. Legs 1-3 with 3-segmented rami. Leg 4 with 3-segmented exopod and 2-segmented endopod. Third endopodal segment of leg 1 armed with 2 spines and 4 setae in both sexes. Third endopodal segment of leg 3 with 2 spines and 2 setae. Endopod of leg 4 with 1 seta on the first segment and 2 spines plus 3 setae on the second segment.

**Type species:** *Lutumidomus tertius* (Kim, 2000) (originally named as *Notoxynus tertius*) associated with the ceriantharian *Cerianthus filiformis* Carlgren, 1924 in the Yellow Sea.

**Other included species:** *Lutumidomus panikkari* (Gnanamuthu, 1955) (originally as *Lichomolgus panikkari*) and *L. parvus* n. sp.

**Etymology:** The generic name *Lutumidomus* is derived from the Latin *lutum* (= mud) and *domus* (= dwelling). It alludes to the living of the actinarian hosts (hence the

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copepod associates as well) generally in mud flats. Gender masculine.

Remarks: A comparison of *Notoxynus tertius* Kim, 2000, *Lichomolgus panikkari* Gnanamuthu, 1955, and *Lutumidomus parvus* n. sp. with other species in the family Rhynchomolgidae reveals that these three species are closely related. They share the apomorphic traits as follows: (1) the antenna is 4-segmented and its terminal segment is armed with 1 claw and 1 enlarged seta in addition to other smaller setae; (2) the maxillae is armed terminally with 2 setae; (3) the third endopodal segment of leg 3 is armed with 2 spines and 2 setae (formula II, 2); (4) the second endopodal segment of leg 4 is armed with 2 spines and 3 setae (formula II, 3).

The setation of legs 3 and 4 of this genus is remarkable, because in general rhynchomolgids the third endopodal segment of leg 3 bears 3 spines and 2 setae (formula I, II, 2) and the second endopodal segment of leg 4 bears 2 terminal spines (formula II).

Only *Indomolgus* Humes and Ho, 1966, is known to have more than 3 setation elements on the second endopodal segment of leg 4. In fact, one of 4 known species of *Indomolgus*, *I. brevisetosus* Humes and Ho, 1966, bears 2 spines and 3 setae, like *Lutumidomus*, on the same segment of leg 4. In addition, the body form of the two genera is very similar to each other. However, *Lutumidomus* is differentiated from *Indomolgus*, because in *Indomolgus* the antenna bears 2 terminal claws without an enlarged seta and the maxillule is armed with at least 3 setae. *Indomolgus diversus* Humes and Ho, 1966 has 2 spines and 2 setae on the third endopodal segment of leg 3, as in *Lutumidomus*. But this setation state of *I. diversus* is derived from the loss of one of 2 terminal spines (formula I, I, 2; see Fig. 103 of Humes and Ho, 1966), whereas in *Lutumidomus* it is formed by the loss of outer spine (formula II, 2).

There is a remarkable morphological trend in *Lutumidomus* that the posterior swimming legs lose outer spine on the second exopodal segment as displayed by *L. panikkari* and *L. parvus* where the loss of the spine occur on legs 2-4. It is also notable that all of 3 species of *Lutumidomus* bear 2 spines and 4 setae (formula I,I,4) on the third endopodal segment of leg 1 in both sexes. It is interesting to note that other 2 species described in the present paper, each belonging to *Paramolgus* and *Verutipes*, also display the same armature formula on the same segment of the leg. They are all associated with actiniarians dwelling on tidal flats or in estuarine water.

*Lutumidomus panikkari* (Gnanamuthu, 1955)  
(Figs. 1 & 2)

*Lichomolgus panikkari* Gnanamuthu, 1955, p. 151, Figs. 1-3.  
*Indomolgus panikkari*: Humes and Ho, 1966a, p. 11;

Humes & Stock, 1973, p. 185.

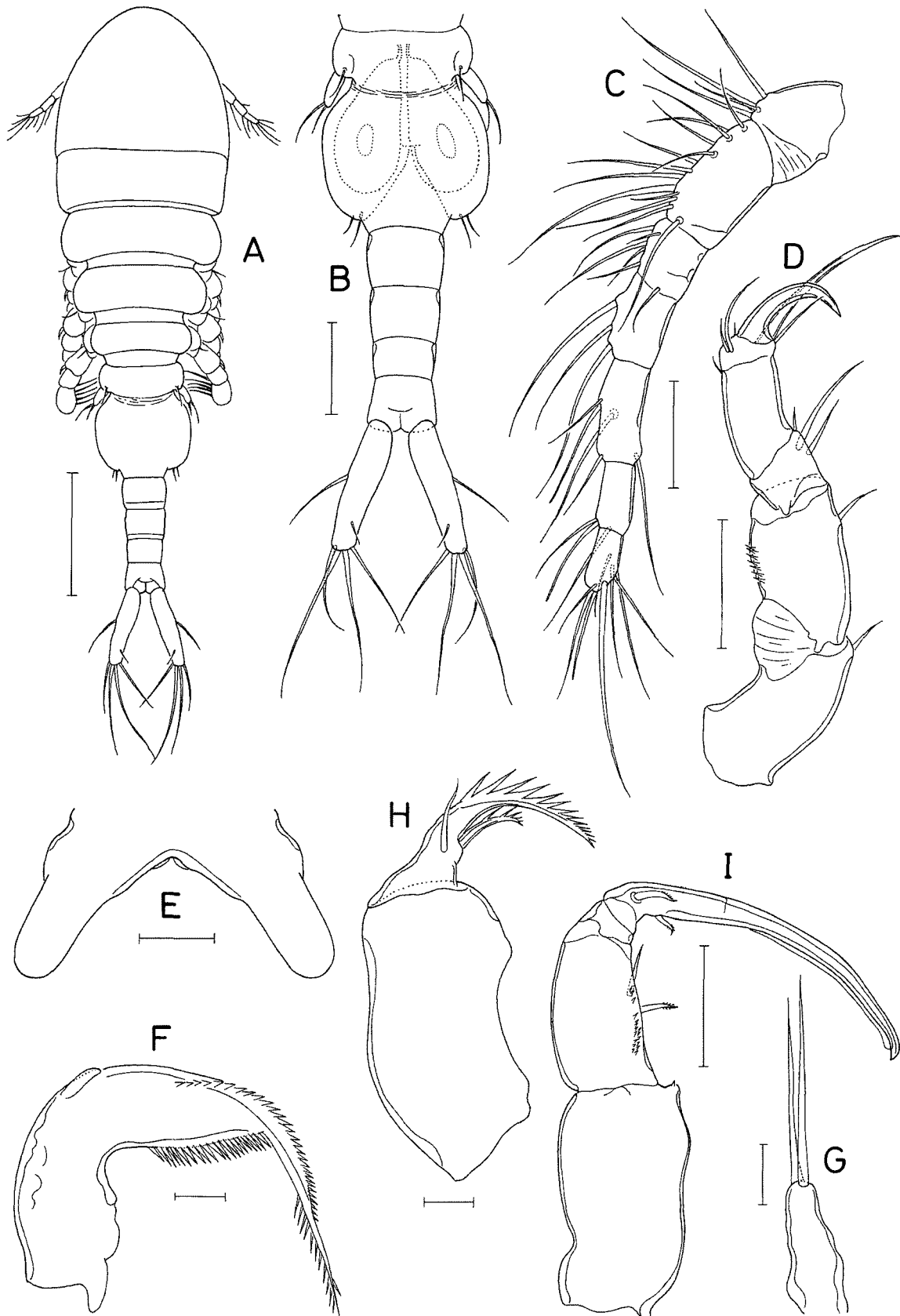
Material examined: One ♂ collected from the gastrovascular cavity of the sea anemone *Paracondylactis hertwigi* (Wassilieff, 1908) living on mud flat in Yongyoo Island (37° 26' 00" N, 126° 23' 30" S), Yellow Sea, 1 March 2006.

Male: Body (Fig. 1A) large and narrow, with weak exoskeleton. Body length 2.68 mm, excluding caudal setae. Prosome 1.46 mm long. Greatest width of prosome 702 µm. Lateral margins of anterior part of prosome parallel. Cephalothorax divided by dorsal suture line into cephalosome and first pedigerous somite. Urosome (Fig. 1B) 6-segmented. Fifth pedigerous somite 333 µm wide. Genital somite nearly circular in dorsal view, 351 × 400 µm. Suture line obscure between fifth pedigerous and genital somites. Four abdominal somites 143 × 184, 123 × 167, 96 × 147, and 123 × 167 µm. All these somites smooth, without ornamentation. Caudal rami divergent from each other. Each ramus 324 × 79 µm or 4.10 times as long as wide, with 6 naked setae. Outer lateral seta located slightly anterior to middle of lateral margin. Two median terminal setae slightly longer than caudal ramus, other 2 terminal setae shorter.

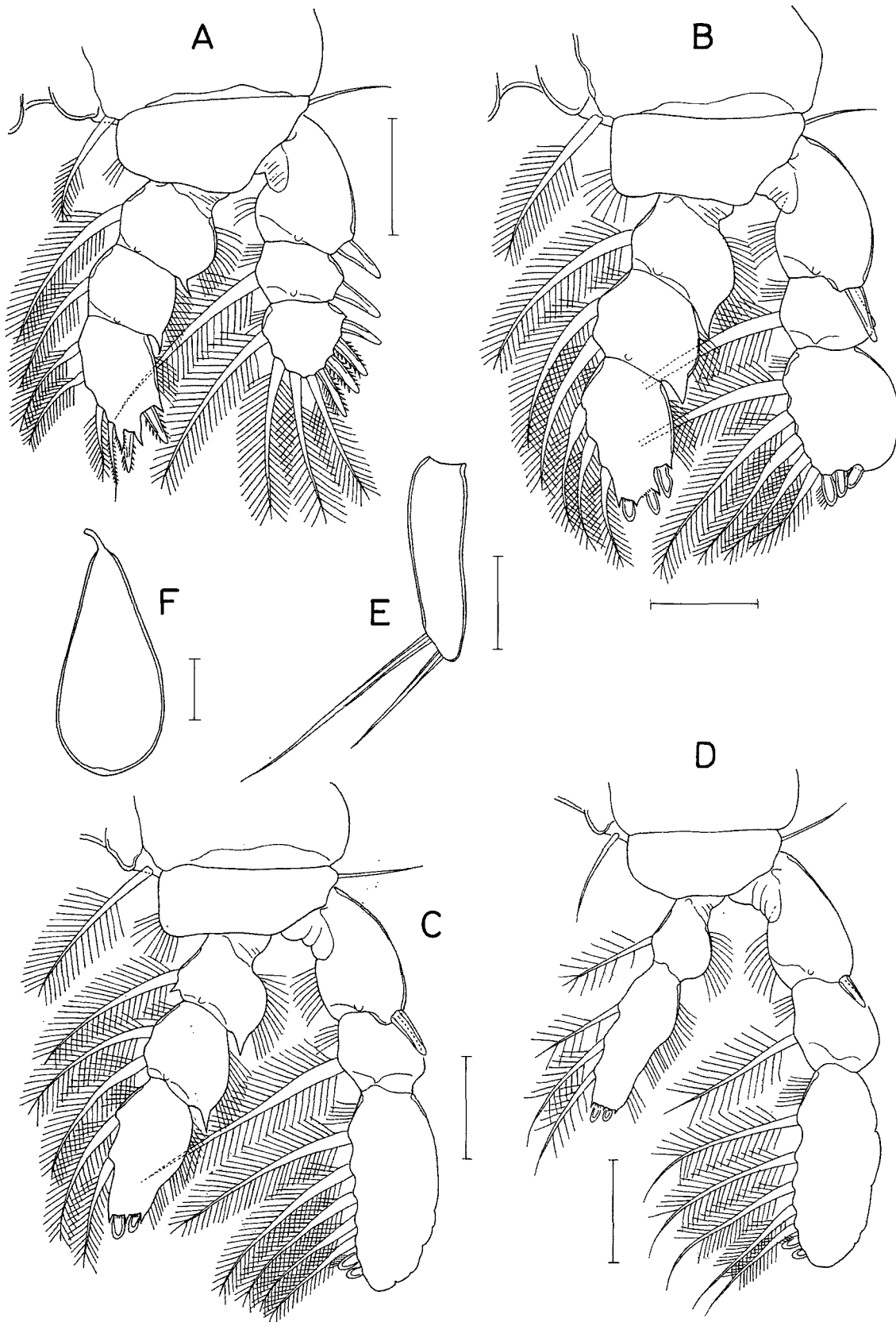
Rostrum longer than wide, with round posterior apex. Antennule (Fig. 1C) 537 µm long and 7-segmented, with armature formula 4, 13, 6, 3, 4 + aesthetasc, 2 + aesthetasc, and 7 + aesthetasc. All setae thin and naked. All aesthetascs setiform and confluent with setae. Antenna (Fig. 1D) 4-segmented, with armature formula 1, 1, 3, and 6 + 1 claw. Second segment similar to first in length, with spinules on outer margin. Distal one of 3 setae on third segment distinctly smaller than 2 proximal ones. Fourth segment approximately 99 × 48 µm (ratio 2.06 : 1). Claw strongly and evenly arched. One of setae enlarged (138 µm) and straight.

Labrum (Fig. 1E) with elongated and divergent posterior lobes. Mandible (Fig. 1F) narrow. Inner proximal notch shallow. Inner margin with row of spinules. Convex outer margin with 1 digitiform scale and distally serrate. Distal lash long, proximally serrate on outer margin and distally spiniferous along inner margin. Maxillule (Fig. 1G) elongate and terminally with 2 large, naked setae. Maxilla (Fig. 1H) 2-segmented. First segment unarmed. Second segment with simple anterior seta, spiniform inner seta bearing several spinules on distal margin. Outer proximal seta not seen. Distal lash arched, with long spinules along outer convex margin. Maxilliped (Fig. 1I) consisting of 3 segments and terminal claw. First segment largest among segments, with 1 minute spinule at inner distal corner. Second segment with 2 inner setae of similar size and small spinules on proximal half of inner side. Third segment small and unarmed. Claw with 2 proximal setae.

Legs 1-3 (Fig. 2A-C) with 3-segmented exopod and



**Fig. 1.** *Lutumidomus panikkari* (Gnanamuthu), male. A, habitus, dorsal; B, urosome, dorsal; C, antennule; D, antenna; E, labrum; F, mandible; G, maxillule; H, maxilla; I, maxilliped. Scales: A, 0.5 mm; B, 0.2 mm; C, D, I, 0.1 mm; E, 0.05 mm; F-H, 0.02 mm.



**Fig. 2.** *Lutumidomus panikkari* (Gnanamuthu), male. A, leg 1; B, leg 2; C, leg 3; D, leg 4; E, free segment of leg 5; F, spermatophore. Scales: A-D, F, 0.1 mm; E, 0.05 mm.

endopod. Leg 4 (Fig. 1D) with 3-segmented exopod and 2-segmented endopod. Third exopodal segment of legs 2-4 swollen, without spine on outer margin. All spines of legs 2-4 minimized and digitiform. All setae and spines on third exopodal segment of legs 3 and 4 characteristically located on inner margin. Outer seta on basis of legs 1-4 naked. Inner coxal seta of leg 4 naked, but that of legs 1-3 plumous. Setules on setae of legs thick. Armature formula of legs 1-4 as follows:

- Leg 1: coxa 0-1; basis 1-0; exp. I-0; I-1; IV, 4;  
 enp. 0-1; 0-1; I, I, 4  
 Leg 2: coxa 0-1; basis 1-0; exp. I-0; 0-1; III, 5;  
 enp. 0-1; 0-2; I, II, 3  
 Leg 3: coxa 0-1; basis 1-0; exp. I-0; 0-1; II, 5;  
 enp. 0-1; 0-2; II, 2  
 Leg 4: coxa 0-1; basis 1-0; exp. I-0; 0-1; II, 5;  
 enp. 0-1; II, 3

Leg 5 consisting of free segment and 1 seta near base free segment. Free segment (Fig. 2E)  $110 \times 32 \mu\text{m}$  or 3.44 times as long as wide, slightly tapering, with 2 stiff, distal setae, each  $149$  and  $72 \mu\text{m}$ . Leg 6 represented by 2 thin setae on posterior margin genital flap (Fig. 1B).

Spermatophore (Fig. 2F) sac-like,  $364 \times 175 \mu\text{m}$ .

Female: Not found, but see Gnanamuthu (1955).

Remarks: This species was originally recorded by Gnanamuthu (1955) under the name *Lichomolgus panikkari* as associate of the sea anemone *Phytocoeteopsis ramunni* Panikkar living in estuarine water from Madras, India. While describing three new species of the genus *Indomolgus* associated with zoantharians (*Palythoa* spp.) from Madagascar, Humes and Ho (1966) included *L. panikkari* in *Indomolgus*. Because of the incompleteness of the original description of *L. panikkari*, Humes and Ho tried to re-examine the type specimens. But they found that the type specimens no longer exist (Humes and Ho, 1966).

A single male specimen from the Yellow Sea available in this study accords with the description by Gnanamuthu (1955) in important points. A large body size, the form of antenna (with an enlarged seta on the terminal segment), the characteristic form and setation formula of legs 1-4 (with setae and spines moved inward), and the presence of a pair of stiff setae on the leg 5 exhibit that this male belongs evidently to the species Gnanamuthu described.

*Lutumidomus parvus* n. sp.  
 (Figs. 3-5)

Material examined: Three ♀♀ and 1 ♂ collected from the gastrovascular cavity of the sea anemone *Flosmaris mutsuensis* (Uchida, 1938) at Gosapo Beach ( $35^{\circ} 39' 28''$  N,  $126^{\circ} 30' 30''$  S), Yellow Sea, 29 October 2000. Holotype (♀,

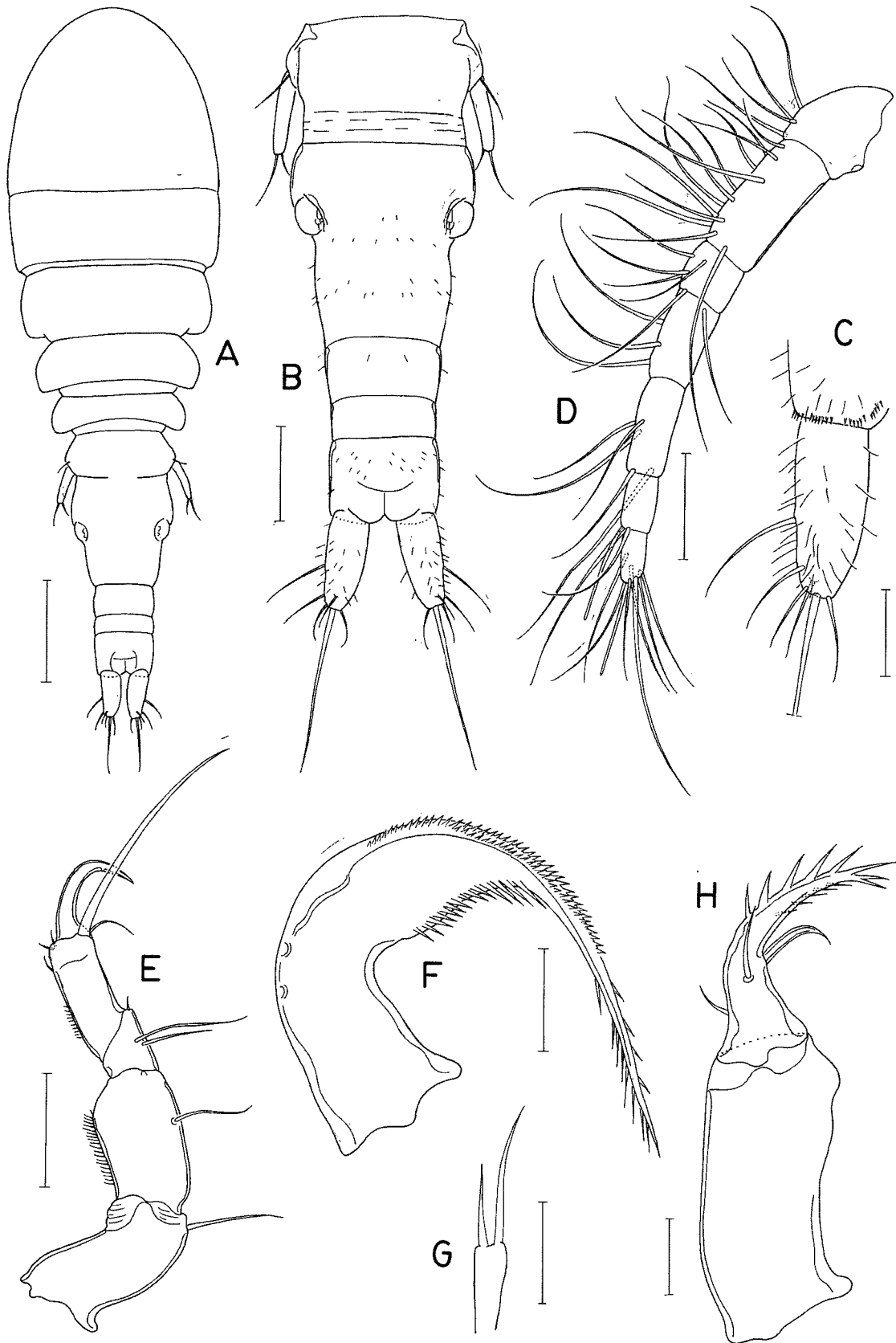
USNM 1087300), allotype (♂, left antennule and right maxilliped dissected out, USNM 1087301), and paratype (1 ♀, USNM 1087302) have been deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA. Dissected paratype (1 ♀) is retained in the collection of the author.

Female: Body (Fig. 3A) narrow, nearly cylindrical, with weak exoskeleton. Body length  $1.41$  mm, excluding caudal setae. Greatest width of prosome  $420 \mu\text{m}$ . Cephalothorax divided by dorsal suture line into cephalosome and first pedigerous somite. cephalosome  $365 \mu\text{m}$  long. Urosome (Fig. 3B) 5-segmented, gradually narrowed posteriorly. Genital double-somite  $212 \times 195 \mu\text{m}$ , with slightly expanded anterior part and narrower, weakly tapering posterior part. Genital area located dorsolaterally at posterior area of slightly expanded anterior part. Suture line faint between fifth pedigerous and genital double-somites. Genital double-somite, abdominal somites and caudal rami with numerous fine setules on surface. Three abdominal somites  $62 \times 120$ ,  $43 \times 110$ , and  $88 \times 115 \mu\text{m}$ . Caudal ramus (Fig. 3C) slightly tapering,  $100 \times 43 \mu\text{m}$  or 2.33 times as long as wide, with 6 naked setae. Outer lateral seta located slightly posterior to middle of lateral margin. One of terminal setae as long as caudal ramus, but other setae shorter.

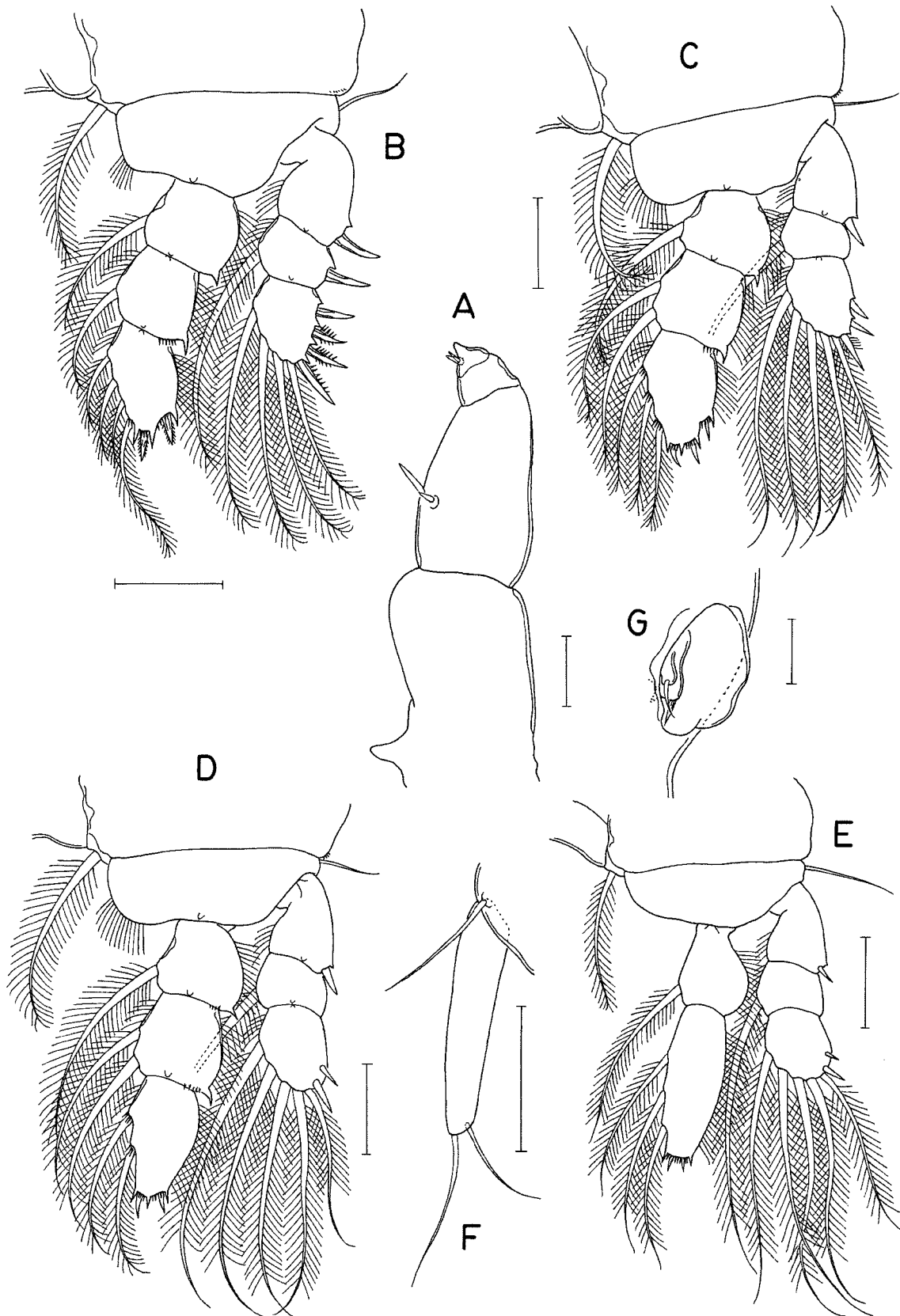
Rostrum conically projected to ventral direction. Antennule (Fig. 3D)  $258 \mu\text{m}$  long and 7-segmented, with armature formula 4, 13, 5, 3, 5, 2 + aesthetasc, and 7 + aesthetasc. All setae thin and naked. Aethetasc setiform and confluent with setae. Antenna (Fig. 3E) 4-segmented, with armature formula 1, 1, 3, and 5 + claw. Second segment similar to first in length, with setules on outer margin. Distal one of 3 setae on third segment distinctly smaller than other 2. Fourth segment approximately  $46 \times 20 \mu\text{m}$  (ratio 2.30 : 1). Claw strongly curved. One of setae on fourth segment enlarged, straight, and more than twice as long as claw.

Labrum lost. Mandible (Fig. 3F) slender and strongly curved. Inner proximal notch obscure. Inner margin with row of spinules. Convex outer margin with 1 longer and 1 shorter rows of spinules. Distal lash long, with several spinules on each side. Maxillule (Fig. 3G) slender and terminally with 2 naked setae. Maxilla (Fig. 3H) 2-segmented. First segment unarmed. Second segment with outer proximal seta, simple anterior seta, and smooth, spiniform inner seta. Distal lash terminally bifurcate, with 6 large spines along outer convex margin and 5 spinules on inner concave margin. Maxilliped (Fig. 4A) 3-segmented. Largest first segment unarmed. Second segment with 2 small, unequal setae on inner side. Third segment (or third and fourth segments) divided by faint suture line into unarmed proximal part and strongly tapering distal part bearing pointed tip and 2 small seta.

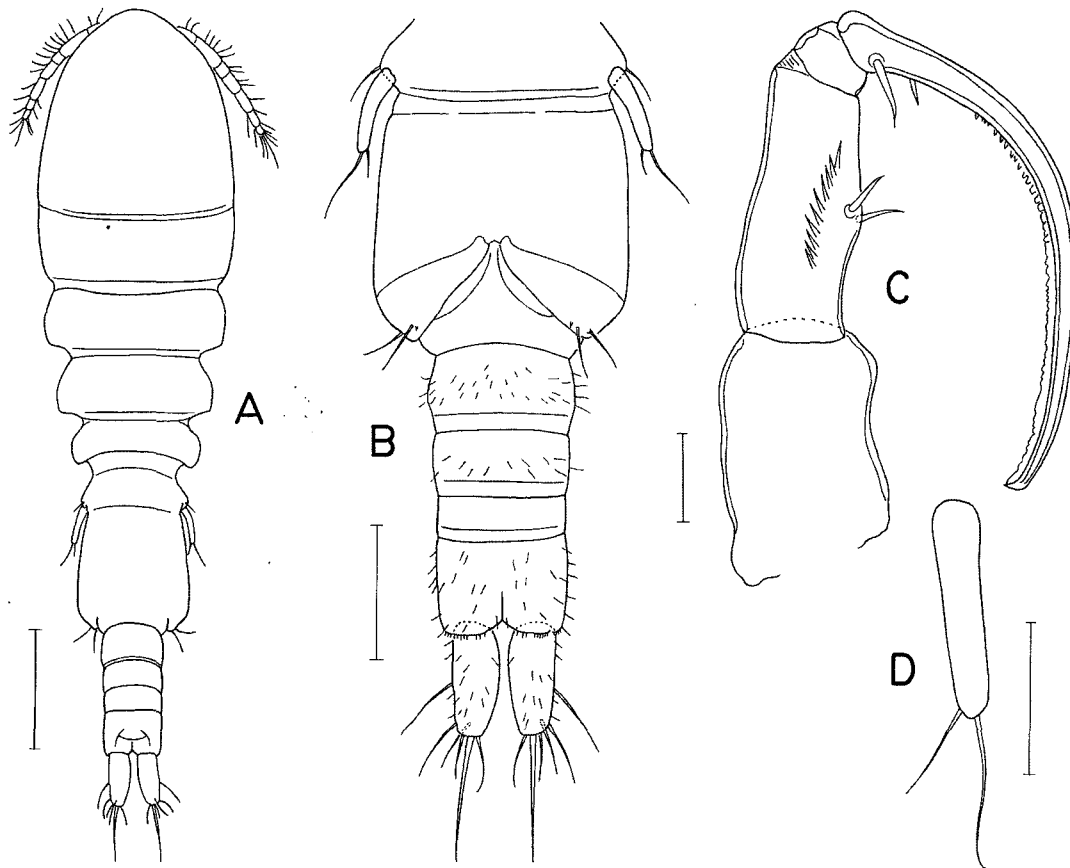
Legs 1-3 (Fig. 4B-D) with 3-segmented exopod and



**Fig. 3.** *Lutymidomus parvus* n. sp., female. A, habitus, dorsal; B, urosome, dorsal; C, right caudal ramus, ventral; D, antennule; E, antenna; F, mandible; G, maxillule; H, maxilla. Scales: A, 0.2 mm; B, 0.1 mm; C-E, 0.05 mm; F-H, 0.02 mm;



**Fig. 4.** *Lutumidomus parvus* n. sp., female. A, maxilliped; B, leg 1; C, leg 2; D, leg 3; E, leg 4; F, leg 5; G, right genital area. Scales: A, G, 0.02 mm; B-F, 0.05 mm.



**Fig. 5.** *Lutumidomus parvus* n. sp., male. A, habitus, dorsal; B, urosome, ventral; C, maxilliped; D, free segment of leg 5. Sclae: A, 0.2 mm; B, 0.1 mm; C, 0.02 mm; D, 0.05 mm.

endopod. Leg 4 (Fig. 4E) with 3-segmented exopod and 2-segmented endopod. All spines on legs 2-4 setiform. Outer seta on basis of legs 1-4 naked. Inner coxal seta of these legs plumous. Armature formula of legs 1-4 as follows:

- Leg 1: coxa 0-1; basis 1-0; exp. I-0; I-1; III, I, 4; enp. 0-1; 0-1; I, I, 4
- Leg 2: coxa 0-1; basis 1-0; exp. I-0; 0-1; II, I, 5; enp. 0-1; 0-2; I, II, 3
- Leg 3: coxa 0-1; basis 1-0; exp. I-0; 0-1; II, 5; enp. 0-1; 0-2; II, 2
- Leg 4: coxa 0-1; basis 1-0; exp. I-0; 0-1; II, 5; enp. 0-1; II, 3

Leg 5 (Fig. 4F) consisting of free segment and 1 seta near base free segment. Free segment  $87 \times 18 \mu\text{m}$ , or 4.83 times as long as wide, smooth, slightly tapering distally, with 2 thin and long distal setae. Leg 6 represented by 1 small seta and 1 small spine in genital area (Fig. 4G).

**Male:** Body (Fig. 5A) similar to that of female. Body length 1.35 mm. Greatest width of body  $330 \mu\text{m}$ . Urosome 6-segmented. Genital somite nearly quadrate in dorsal view (Fig. 5B),  $185 \times 190 \mu\text{m}$ . Four abdominal somites  $63 \times 112$ ,  $48 \times 103$ ,  $33 \times 98$ , and  $67 \times 98 \mu\text{m}$ .

Rostrum, antennule, antenna, mandible, maxillule, and maxilla as in female. Maxilliped (Fig. 5C) consisting of 3 segments and terminal claw. First segment unarmed. Second segment with 1 row of spinules and 2 similar setae. Small third segment unarmed. Terminal claw large, almost as long as 3 proximal segments combined and strongly curved, with 2 unequal proximal setae.

Legs 1-4 with armature formula identical to that of female. Free segment of leg 5  $70 \times 15 \mu\text{m}$  (ratio 4.67 : 1). Leg 6 represented by 2 thin setae and 1 minute denticle on posterior part of genital flap (Fig. 5B).

**Etymology:** The specific name *parvus* is a Latin meaning "small" and alludes to the relatively small size of the new species.

**Remarks:** Although *Lutumidomus parvus* n. sp. possesses the armature formula of legs 1-4 identical to that of *L. panikkari* (Gnanamuthu), it differs from the latter species in having no scale on the convex side of the mandible, the usual form of the third exopodal segment of legs 2-4, the quadrate male genital somite, and the smaller caudal rami.

In the body form, especially in the shape of the urosome,



this species is similar to *Lutumidomus tertius* (Kim, 2000), but is readily distinguished from it by the absence of the outer spine on the second exopodal segment of legs 2-4.

The body length of the female was recorded to be 2.39 mm in *L. tertius* (see Kim, 2000) and 2.7-3.1 mm in *L. panikkari* (see Gnanamuthu, 1955), the dimensions markedly different from 1.41 mm in *L. parvus*.

#### Genus *Paramolgus* Humes and Stock, 1972

##### *Paramolgus nudipes* n. sp. (Figs. 6-8)

Material examined: Nineteen ♀♀ and 1 ♂ collected (along with *Lutumidomus parvus*) from the gastrovascular cavity of the sea anemone *Flosmaris mutsuensis* (Uchida) at Gosapo Beach (35° 39' 28" N, 126° 30' 30" S), Yellow Sea, 20 October 2000. Holotype (♀, USNM 1087303), allotype (♂, left antennule and left maxilliped dissected out; right maxilliped damaged, USNM 1087304), and paratypes (17 ♀♀, USNM 1087305) have been deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA. Dissected paratype (1 ♀) is retained in the collection of the author.

Female: Body (Fig. 6A) stout. Body length of dissected specimen 2.02 mm, excluding setae on caudal rami. Greatest width 792 µm. Prosoma 1.24 mm long. Cephalothorax divided by dorsal suture line into cephalosome and first pedigerous somite. First to fourth pedigerous somites nearly equal in length. Urosome (Fig. 6B) 5-segmented, all somites much wider than long. Fifth pedigerous somite short, 350 µm wide. Genital double-somite 269 × 373 µm, anteriorly expanded laterally. Genital areas located dorsally at anterior one-third. Three abdominal somites 108 × 246, 77 × 215, and 115 × 215 µm. Caudal ramus (Fig. 6C) tapering, 130 × 57 µm or 2.28 times as long as wide, with 6 naked setae. Outer lateral seta located near posterior one-third of lateral margin. One of terminal setae enlarged, more than twice as long as caudal ramus, but other setae shorter than ramus.

Rostrum strongly tapering posteriorly and continued as ridge to labrum (Fig. 6D). Antennule (Fig. 6E) 294 µm long and 7-segmented, with armature formula 3, 11, 6, 3, 4 + aesthetasc, 2 + aesthetasc, and 7 + aesthetasc. All setae short and naked. Aesthetascs small. Antenna (Fig. 6F) 4-segmented, with armature formula 1, 1, 2, and 4 + claw. First segment wider than long, with 1 small inner distal seta. Second segment distinctly longer than first segment, with 1 small seta on inner margin. Fourth segment slightly curved and approximately 3 times as long as wide. Terminal claw strongly curved in middle. Outer distal seta strongly curved to lateral direction.

Labrum (Fig. 6G) with broad posterior lobes, each lobe with small point and minute spinules on posterior margin. Mandible (Fig. 6H) with deep and broad inner proximal notch; inner margin bilobed and expanded. Outer margin distally with several small spinules. Distal lash elongated, denticulated along whole outer margin and along distal half of inner margin. Maxillule (Fig. 6I) with protuberant inner margin and armed with 3 distal setae (inner one of them distinctly smaller) and 1 subdistal setiform element. Maxilla (Fig. 7A) 2-segmented. First segment unarmed. Second segment with spiniform anterior and inner setae. Inner seta with sense spinules along distal margin. Outer proximal seta not seen. Distal lash arched, with spinules along outer convex margin. Maxilliped (Fig. 7B) 3-segmented. First segment broad and unarmed. Second segment with 1 large, spiniform seta and 1 small seta. Third segment tapering, distally with 3 spines and blunt tip.

Legs 1-3 with 3-segmented exopod and endopod (Fig. 7C-E). Leg 4 (Fig. 7F) with 3-segmented exopod and 2-segmented endopod. All setae naked and small. Armature formula of legs 1-4 as follows:

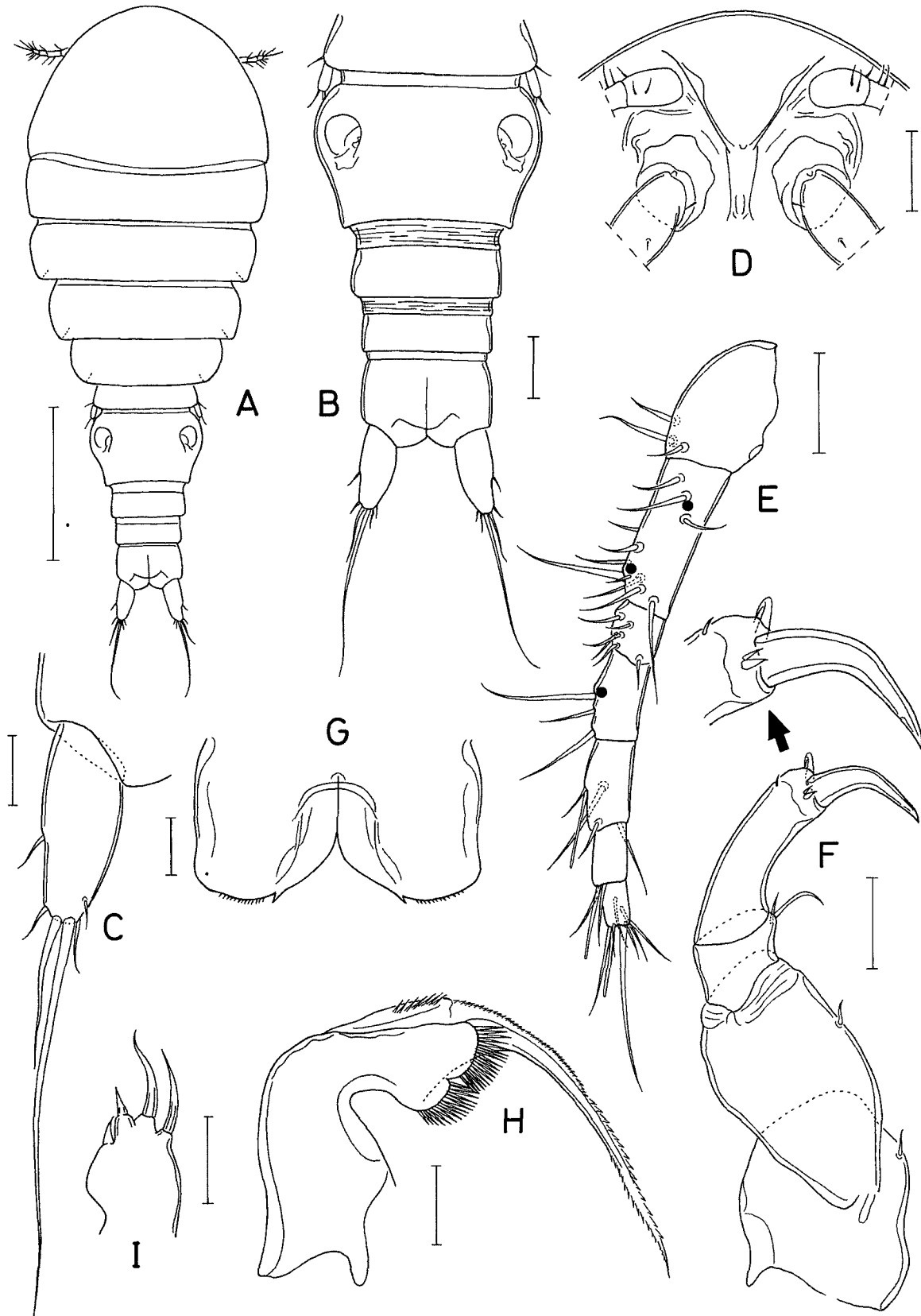
- Leg 1: coxa 0-1; basis 1-0; exp. I-0; I-1; III, I, 4;  
enp. 0-1; 0-1; I, I, 4  
Leg 2: coxa 0-1; basis 1-0; exp. I-0; I-1; III, I, 5;  
enp. 0-1; 0-2; I, II, 3  
Leg 3: coxa 0-1; basis 1-0; exp. I-0; I-1; III, I, 5;  
enp. 0-1; 0-2; I, II, 2  
Leg 4: coxa 0-1; basis 1-0; exp. I-0; I-1; II, I, 5;  
enp. 0-1; II.

Leg 5 (Fig. 7G) consisting of free segment and 1 seta near base of free segment. Free segment 50 × 25 µm (ratio 2.0 : 1), subquadrate, with 2 naked distal setae. Leg 6 represented by 2 small spines in genital area (Fig. 7H).

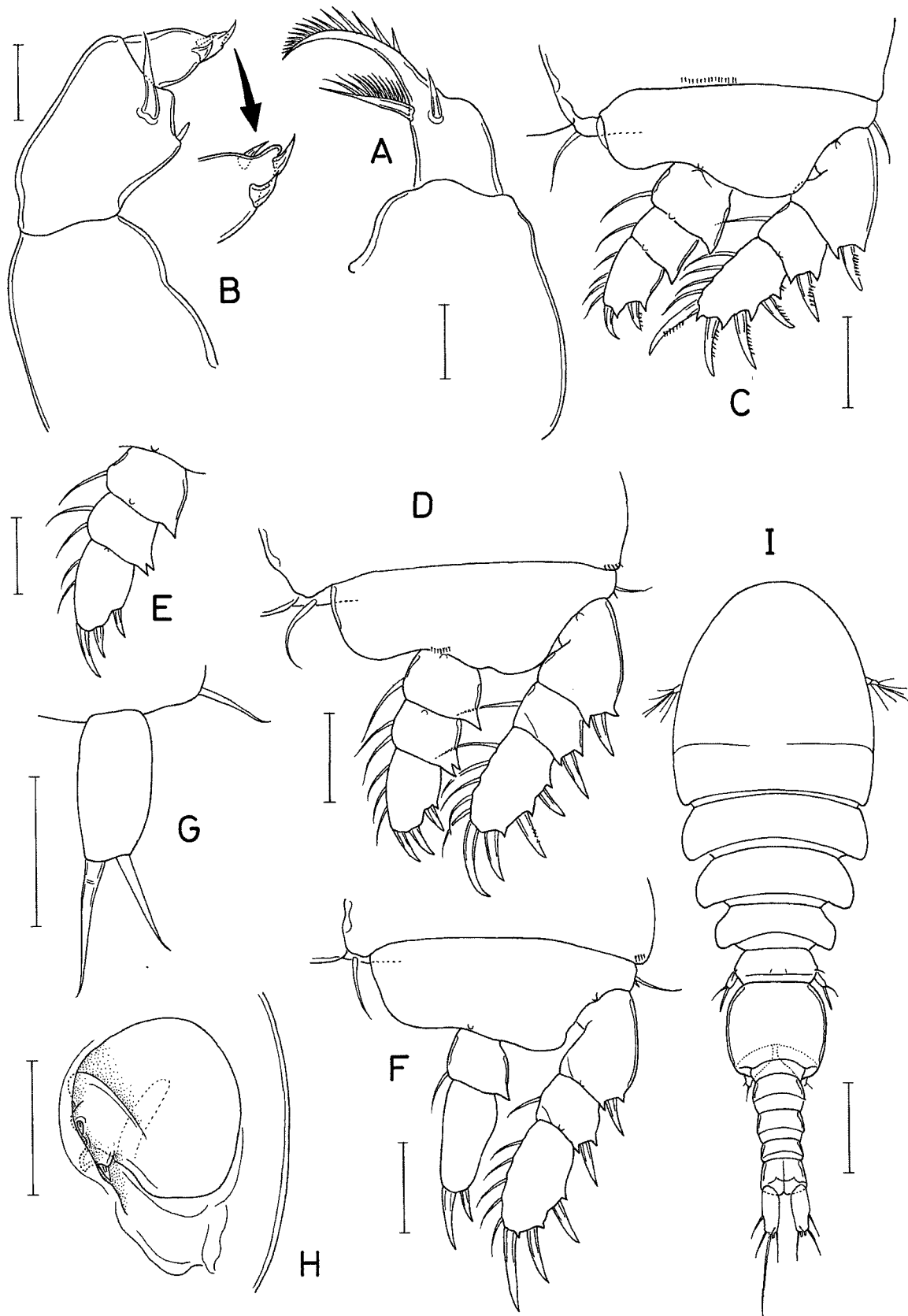
Male: Body (Fig. 7I) narrower than that of female. Body length 1.45 mm. Greatest width of body 444 µm. Urosome 6-segmented. Fifth pedigerous somite 187 µm wide. Genital somite 219 × 223 µm, with round anterior and posterior corners (Fig. 8A). Four abdominal somites 65 × 121, 63 × 106, 42 × 96, and 67 × 104 µm. All somites unornamented.

Rostrum as in female. Antennule with 3 additional aesthetascs: 2 on second and 1 on fourth segments at places of black dots in Fig. 6E. These three aesthetascs longer than antennule. Antenna, mandible, maxillule, and maxilla as in female. Maxilliped (Fig. 8B) consisting of 3 segments and terminal claw. First segment unarmed. Second segment with 2 small spiniform setae of similar sizes. Small third segment unarmed. Terminal claw large, almost as long as 3 proximal segments combined and strongly curved near middle, with 2 unequal proximal setae.

Legs 1-4 with armature formula identical to that of female. Setae of these legs distinctly more developed and plumous (Fig. 8C). Free segment of leg 5 about twice as



**Fig. 6.** *Paramolgus nudipes* n. sp., female. A, habitus, dorsal; B, urosome, dorsal; C, left caudal ramus, dorsal; D, rostral area, ventral; E, antennule (black spots indicating places of additional aesthetascs in male); F, antenna; G, labrum; H, mandible; I, maxillule. Scales: A, 0.5 mm; B, D, 0.1 mm; C, E, F, 0.05 mm; G-I, 0.02 mm.



**Fig. 7.** *Paramolgus nudipes* n. sp. Female: A, maxilla; B, maxilliped; C, leg 1; D, leg 2; E, endopod of leg 3; F, leg 4; G, leg 5; H, right genital area. Male: I, habitus, dorsal. Scales: A, B, 0.02 mm; C-H, 0.05 mm; I, 0.2 mm.

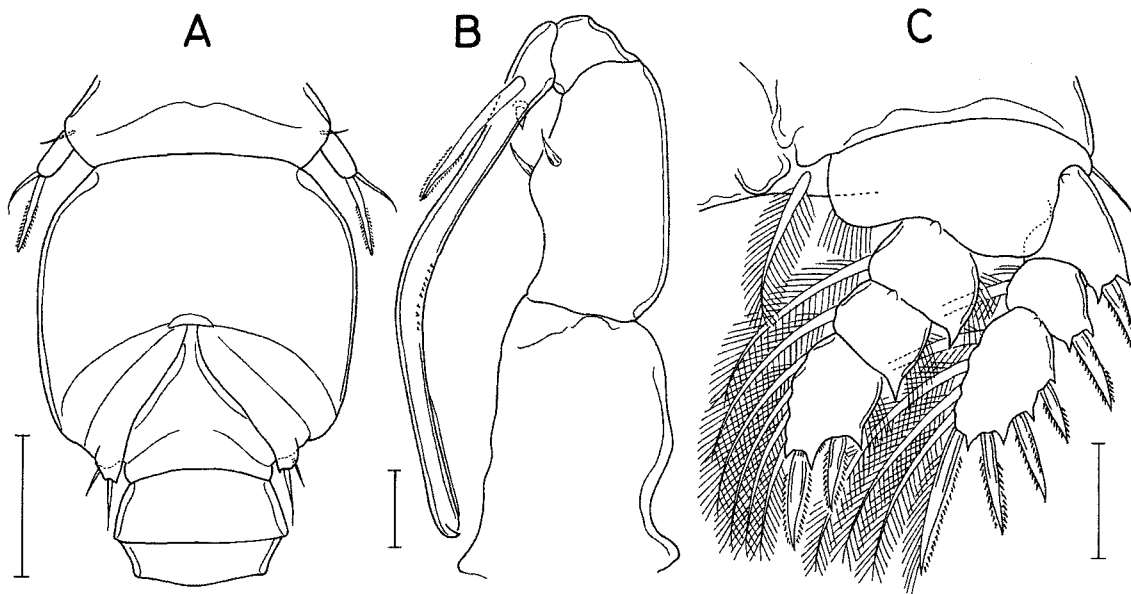


Fig. 8. *Paramolgus nudipes* n. sp., male. A, anterior part of urosome, ventral; B, maxilliped; C, leg 1. Scales: A, 0.1 mm; B, 0.02 mm; C, 0.05 mm.

long as wide, distally with 1 spine and 1 small seta.

**Etymology:** The specific name *nudipes* is a combination of the Latin *nudus* (naked) and *pes* (leg). It alludes to the possession of the small, naked setae on legs of the female.

**Remarks:** The genus *Paramolgus* is a large genus in the Rhynchomolgidae, along with *Doridicola*, *Acanthomolgus*, and *Critomolgus*. Humes (1994) counted 34 species in this genus. Since then two species have been added to this genus. Kim (2003) described *P. galeatus*, as new, associated with the alcyonacean coral *Sarcophyton ehrenbergi* von Marenzeller from New Caledonia, and Kim (2005) added a new species *P. incidentus* associated with a gorgonacean from the Philippines. Of these 36 species, Kim (2006) removed 4 species to the genus *Anchिमolgus* in the Anchimolgidae: *P. angustus* Humes, *P. eparmatoides*, *P. gibberulus*, and *P. setellus*, all described by Humes (1992a) as associates of the scleractinian coral *Gardineroseris planulata* (Dana). Therefore a total of 32 species are comparable with *P. nudipes* n. sp.

*Paramolgus nudipes* may be differentiated from its 32 congeners by the following way. Of these, only six species show, like *P. nudipes*, a combination of characters that the caudal ramus is in a range of the ratio of the length to width 1.5-3.0 : 1 (2.28 : 1 in *P. parvus*) and the female genital double-somite is distinctly wider than long. These six species are *P. abruptus* Humes, 1990, *P. centor* Humes, 1990, *P. congruus* Humes, 1990, *P. ellisellae* Humes, 1974, *P. ostentus* Humes, 1973, and *P. subincisus* Humes, 1990. In *Paramolgus abruptus*, *P. ellisellae*, and *P. subincisus* the free segment of female leg 5 is large and bears a distinct

inner swelling, therefore they can be excluded in further comparison with *P. nudipes*. The remaining three species, *P. centor*, *P. congruus*, and *P. ostentus*, are hardly confusable with *P. nudipes*, because they all have the quadrangular caudal rami, well developed, plumous setae on legs 1-4, and smaller body sizes (body lengths are less than 1.20 mm in females of these species). The two spines and four setae (formula I, I, 4) on the third endopodal segment of leg 1 in both sexes is a diagnostic character of *P. nudipes*, because in the Rhynchomolgidae this setation is observable only in the genera *Temnomolgus* Humes and Ho, 1966, *Visayasia* Humes, 1992, and some species of *Indomolgus* Humes and Ho, 1966 (Humes, 1992b). The bicuspid outer distal angle of the second endopodal segment of legs 2 and 3 is also a distinctive feature of *P. nudipes*.

*Paramolgus nudipes* has a mandible of an unusual form for the Rhynchomolgidae, where the inner margin is distinctly bilobed. Although this form of mandible is typical to the Anchimolgidae (Humes and Boxshall, 1996), I tentatively include *P. nudipes* in the Rhynchomolgidae, on account of the following respects: (1) *P. nudipes* is found from an actiniarian, but the species of the Anchimolgidae are all known to be associated with scleractinian corals; (2) in the Anchimolgidae the distal lash of maxilla is usually strongly curved proximally in a right angle, thus perpendicular to the main axis of the second segment and the inner seta (seta I) is usually expanded and leaf-like (*P. nudipes* possesses a weakly curved distal lash and a spiniform inner seta). If this species should be included in the Anchimolgidae it would belong to the genus *Anchिमolgus*. In this case, this species may be differentiated from all species of *Anchिमolgus* by having a combination of characters that the fourth segment

of antenna is distinctly longer than the third segment and the mandible bears no digitiform process on the convex side.

Genus *Verutipes* Humes, 1982

*Verutipes scutatus* n. sp.

(Figs. 9-11)

Material examined: Four ♀♀ and 4 ♂♂ collected from the gastrovascular cavity of one individual of a sea anemone (green color) taken at the depth of 3 m in Port Mosulpo (33° 13' 00" N, 128° 15' 15" E), Jeju Island, 4 June 2004. Holotype (♀, USNM 1087306), allotype (♂, USNM 1087307), and paratypes (2 ♀♀, 2 ♂♂, USNM1087308) have been deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA. Dissected paratypes (1 ♀, 1 ♂) are kept in the collection of the author.

Female: Body (Fig. 9A) with greatly expanded prosome and narrow urosome. Body length of dissected largest specimen 1.69 mm excluding caudal setae. Prosome shield-shaped, unsegmented, but with 3 dorsal lines as vestigial segmentations. Anterior part of prosome broadened, with 2 pairs of small lateral lobes, posterior pair larger. Greatest length of prosome 1.38 mm, and greatest width 1.08 mm. Urosome (Fig. 9B) 5-segmented, but fifth pedigerous somite obscurely delimited. Genital double-somite much wider than long, anteriorly expanded, about 225 µm long, 270 µm wide, and obscurely delimited from fifth pedigerous somite, with rudimentary dorsal suture line between expanded anterior and narrower posterior parts. Three abdominal somites 85 × 150, 50 × 143, and 87 × 140 µm. Anal somite and caudal rami with fine hairs on surfaces, Caudal ramus distinctly tapering, 60 × 50 (ratio 1.20 : 1) µm, with 6 naked setae.

Rostrum lacking. Antennule (Fig. 9C) 410 µm long and 7-segmented, with armature formula 4, 12, 6, 3, 4 + aesthetasc, 2 + aesthetasc, and 7 + aesthetasc. Plumous setae: 1 on each fifth and sixth segments and 4 on last segments. Antenna (Fig. 9D) 4-segmented, gradually narrowed from proximal to distal, with armature formula 1, 1, 3, and 5 + 2 claws. Setae on these segments very small. Fourth segment approximately 93 × 48 µm. Two terminal claws recurved.

Labrum (Fig. 9E) with divergent posterior lobes. Mandible (Fig. 9F) with moderately distinct inner proximal notch. Inner margin linear, with fine spinules. Outer margin slightly expanded roundly, with row of minute spinules proximally and serration distally. Distal lash thin, elongate, and weakly serrate along both margins. Paragnath (Fig. 9G) lobate, with thick and dense setules distally. Maxillule (Fig.

10A) gradually narrowed distally, curved at distal one-third, proximally with small point, and distally with 3 setae, inner one of them spiniform. Maxilla (Fig. 10B) 2-segmented. First segment expanded and unarmed. Second segment with small outer proximal seta, short, scalpel-like anterior seta and spiniform inner seta bearing serration along distal margin. Distal lash long, with serrated convex margin and minute spinules along distal half of concave margin. Maxilliped (Fig. 10C) 3-segmented. First segment unarmed. Second segment longer than first, with 2 inner setae. Third segment with 1 spine, 1 seta, and spiniform process terminally.

Legs 1 and 2 (Fig. 10D, E) with 3-segmented exopod and endopod. Legs 3 and 4 (Fig. 10F, 11A) with 3-segmented exopod and 2-segmented endopod. First exopodal segment of legs 1-4 distally expanded, with rod-shaped outer spine. Other segments of these legs narrow. Setation of legs 1-4 variable. Setae naked or weakly plumous. Inner coxal seta lacking in legs 1-4. Armature formula of legs 1-4 as follows:

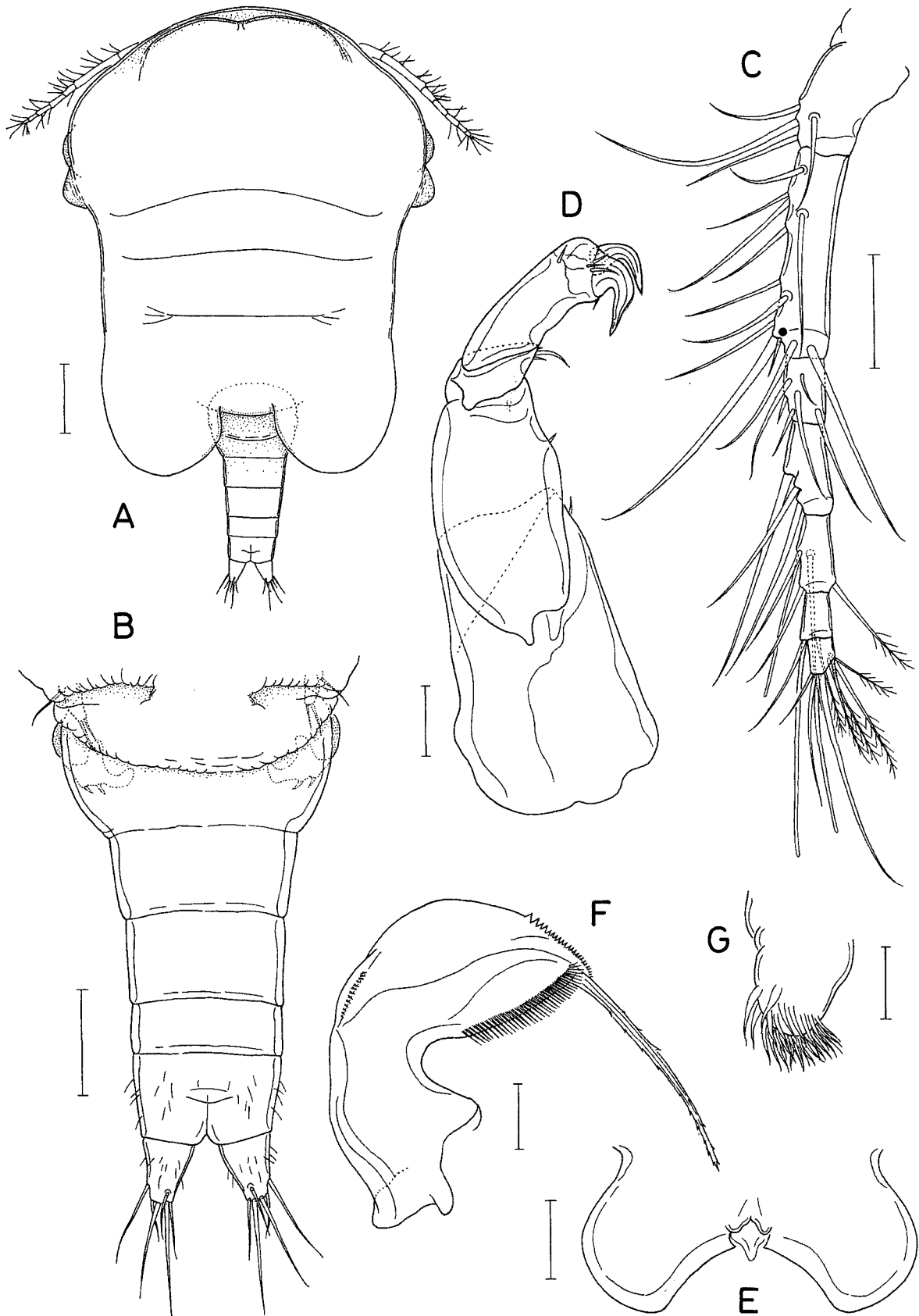
- Leg 1: coxa 0-0; basis 1-0; exp. I-0; I-1; III, I, 3;  
enp. 0-1; 0-1 (or 0-0); II, 4  
Leg 2: coxa 0-0; basis 1-0; exp. I-0; I-1 (or I-0); III, I, 3;  
enp. 0-1; 0-2 (or 0-0); II, I, 2  
Leg 3: coxa 0-0; basis 1-0; exp. I-0; I-1; III, I, 1;  
enp. 0-0; I, 2 (or I)  
Leg 4: coxa 0-0; basis 1-0; exp. I-0; I-1 (or I-0); III, I, 1;  
enp. 0-0; I.

Leg 5 (Fig. 11B) consisting of free segment and nearby seta. Free segment 28 × 14 µm, with convex outer margin; its 2 terminal setae 55 and 35 µm long. Leg 6 represented by 2 thick spines in genital area (Fig. 11C).

Male: Body (Fig. 11D) similar to that of female. Body length of dissected specimen 1.29 mm. Greatest width 740 µm. Greatest length of prosome 800 µm. Urosome (Fig. 11E) 6-segmented. Fifth pedigerous somite fused with genital somite, with faint suture line between these somites. Combined fifth pedigerous and genital somites 213 × 353 µm. Genital somite with lobate posterolateral corners. Four abdominal somites gradually narrowed from proximal to distal, 73 × 197, 60 × 170, 33 × 140, and 60 × 117 µm. First to third abdominal somites with roundly convex lateral margins. Caudal ramus 40 × 40 µm.

Rostrum absent as in female. Antennule with additional aesthetasc on distal area of second segment as indicated by dot in Fig. 8C. Antenna as in female.

Labrum, mandible, paragnath, maxillule, and maxilla as in female. Maxilliped (Fig. 11F) consisting of 3 segments and terminal claw. First segment unarmed. Second segment with strongly projected and tapering, 1 pointed and 1 blunt setae, and row of spinules on inner margin. Small third segment unarmed. Terminal claw stout, distinctly shorter than second segment, proximally with 1 small and 1 large setae.



**Fig. 9.** *Verutipes scutatus* n. sp., female. A, habitus, dorsal; B, urosome, dorsal; C, antennule (black spot indicating place of additional aesthetasc in male); D, antenna; E, labrum; F, mandible; G, paragnath. Scales: A, 0.2 mm; B, 0.1 mm; C-E, 0.05 mm; F, G, 0.02 mm.

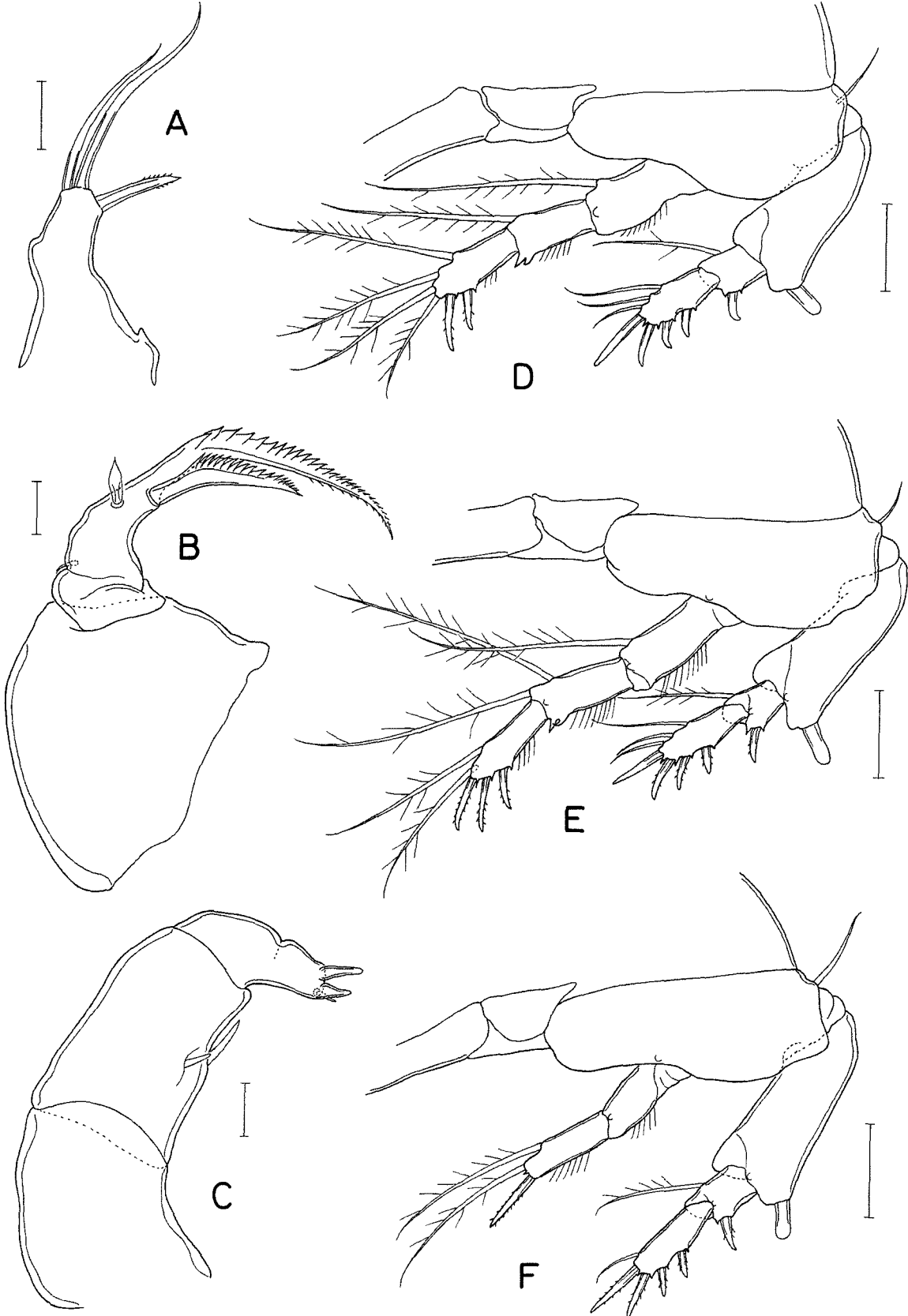
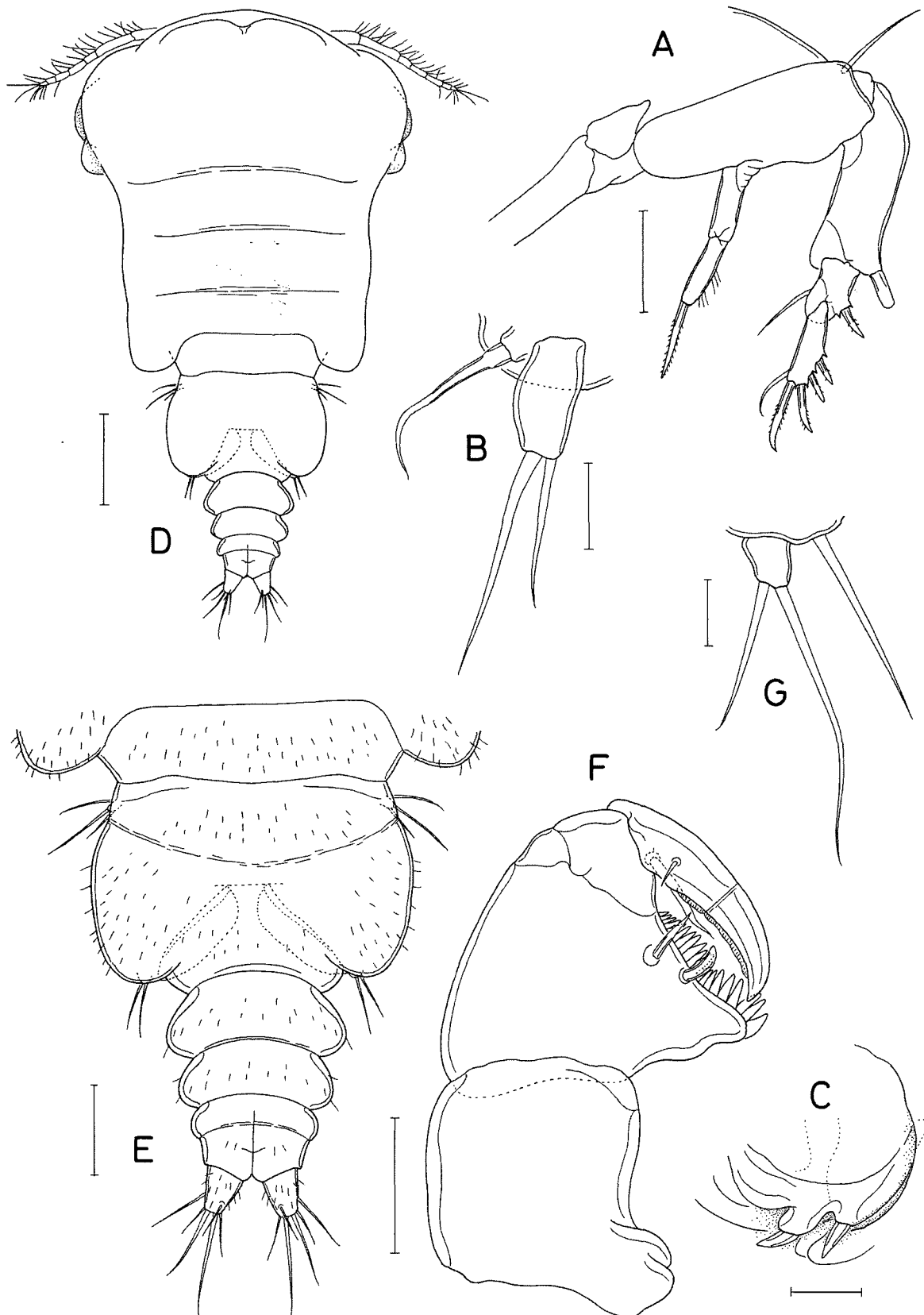


Fig. 10. *Verutipes scutatus* n. sp., female. A, maxillule; B, maxilla; C, maxilliped; D, leg 1; E, leg 2; F, leg 3. Scales: A-C, 0.02 mm; D-F, 0.05 mm.



**Fig. 11.** *Verutipes scutatus* n. sp. Female: A, leg 4; B, leg 5; C, right genital area. Male: D, habitus, dorsal; E, urosome, dorsal; F, maxilliped; G, leg 5. Scales: A, F, 0.05 mm; B, C, G, 0.02 mm; D, 0.2 mm; E, 0.1 mm.



Legs 1-4 basically as those of female, with variable setation. Free segment of leg 5 small (Fig. 11G),  $16 \times 14 \mu\text{m}$ , but its distal setae larger than in female, each 90 and 48  $\mu\text{m}$  long.

**Etymology:** The specific name *scutatus* is a Latin meaning “armed with a shield”. It alludes to the shield-like prosome of the species.

**Remarks:** The genus *Verutipes* Humes, 1982 has been remained as a monotypic genus until now, represented by *V. laticeps* Humes, 1982 associated with the actiniarian *Entacmaea quadricolor* (Rueppell and Leuckart) from New Caledonia. *Verutipes scutatus* is readily distinguished from *V. laticeps*, because the latter species possesses the following features: (1) the body size is much smaller, only 0.73-1.03 mm in the female and 0.61-0.95 mm in the male (in *V. scutatus* it is 1.69 and 1.29 mm respectively); (2) the prosome is distinctly T-shaped and clearly segmented; (3) the caudal ramus is 2.01 times as long as wide in the female (1.20 times in *V. scutatus*); (4) the inner element on the second maxillary segment is setiform (spiniform in *V. scutatus*) and spinulated on both margins; (5) the outer spine on the first exopodal segment of legs 1-4 is tapering and pointed as usual (it is rod-shaped, with rounded tip, in *V. scutatus*); (6) the second segment of the male maxilliped is not expanded, without spines.

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