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A New Genus and Two New Species of Copepoda (Poecilostomatoida, Sabelliphilidae) Associated with the Tubicolous Polychaetes in the Yellow Sea

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Terebelliphilus simplex n.

Gen. n. sp.

Myxomolgus invulgas n. sp.

Sabelliphilidae

Polychaeta

Korea

Terebelliphilus simplex n. gen., n. sp. and *Myxomolgus invulgas* n. sp. are described from the tubicolous polychaetes found in the intertidal shores in the Yellow Sea. The new genus *Terebelliphilus* belongs to the family Sabelliphilidae but is characteristic in bearing the reduced segmentations in legs 1-4, an unusual sexual dimorphism in antennule, and the ventral location of genital areas. *Myxomolgus invulgas* is readily distinguishable from its congeners by the morphological features of rostrum, antennule, mandible, maxilla, leg 4 and female leg 5.

Humes (1994) counted 121 species of Copepoda as associates of polychaetes. Most of these copepods are members of lichomolgoid complex, to which the family Sabelliphilidae belongs. In the recent revision of the lichomolgoid complex, Humes and Boxshall (1996) redefined the family Sabelliphilidae and included eight genera in this family. The Sabelliphilidae consists of 20 species, and most of them are known to be associates of polychaetes, with the only exception of *Phoronicola spinulatus* Boxshall and Humes, 1988 which was found on a phoronid worm in Hong Kong. Most polychaete hosts of sabelliphilid copepods are members of the families Sabellidae and Serpuliphilidae. From the Terebellidae only a single species of copepod *Eupolymniphilus finmarchica* (Scott) was reported (Humes and Boxshall, 1996).

During the field survey carried out in 1999 on the intertidal shores in the Yellow Sea, I discovered two new species of Copepoda from the tubicolous polychaetes. One of them belonging to a new genus was found as an associate of *Terebella ehrenbergi* Grube (Terebellidae) and the other one from the wall of mucous tube of a *Myxicola* sp. (Sabellidae). This is the second report on the Korean sabelliphilid copepods, followed after *Nasomolgus firmus* Humes and Ho reported by Kim (1998) from a polychaete of *Sabellastarte* sp.

Materials and Methods

The polychaete hosts were dug out with a shovel, collected in a plastic bag, and fixed with 80% ethanol. In the laboratory, the fixed polychaetes were agitated

and removed from the plastic bag. The remaining sediment was poured into a wide jar, and the copepod specimens were sorted out from the sediment.

Before measuring and dissection, the copepods were soaked in lactic acid for about an hour. The dissection was done using the reversed slide method of Humes and Gooding (1964). In the description, body length does not include setae on the caudal rami. In the armature formula of legs 1-4, Roman numerals represent spines and Arabic numerals indicating setae. All figures were drawn with the aid of a camera lucida.

Description

Sabelliphilidae Gurney, 1927

Terebelliphilus n. gen.

Diagnosis: Body cycloform. Urosome 5-segmented in female, and 6-segmented in male. Rostrum absent. Antennule 6-segmented, with reduced setation. Antenna 4-segmented, with 1 claw on third segment and 3 claws on fourth segment, in addition to setae. Mandible with short lash. Maxillule with 3 setae and 1 setiform process. Maxilla with short terminal lash. Female maxilliped 3-segmented, with armature formula 0, 2, and 2. Male maxilliped composed of 3 segments and terminal claw. Legs 1-3 with 3-segmented exopod and 2-segmented endopod. Leg 4 with 3-segmented exopod, without endopod. Leg 5 1-segmented. Female genital areas located on ventral surface of genital double-somite.

Types species: *Terebelliphilus simplex* n. sp.

Etymology: The generic name *Terebelliphilus* is derived from *Terebella*, the generic name of polychaete host,

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and *philos*, the Greek meaning “loving”. The gender is masculine.

Remarks: *Terebelliphilus* new genus has leg 4 bearing a fully segmented exopod without endopod. In lichomolgoid families, this feature is also observable in *Allopodion* Humes, 1978, *Kawanolus* Humes, 1978, *Mycoxynus* Humes, 1973, *Rakotoa* Humes and Stock, 1972, and *Ravahina* Humes and Ho, 1968. According to Humes and Boxshall (1996), the former four genera belong to the Anchimolgidae, and the latter genus to the Rhynchomolgidae. However, the endopods of legs 1 and 2 in all these five genera, and the endopod of leg 3 in four genera except *Kawanolus*, possess segmentations different from those of *Terebelliphilus*.

Terebelliphilus is placed in the family Sabelliphilidae, although it reveals unusual sexual dimorphism on the antennule: the male antennule has both proximal and distal aesthetascs on the second segment, but none on the fourth segment. This feature does not accord with the definition of the family given by Humes and Boxshall (1996). However, they put emphasis on the form of the mandible and the armature of the antenna as diagnostic features of the Sabelliphilidae, in which *Terebelliphilus* should be placed because it possesses the short mandible, and one and three claws respectively on the third and fourth segments of the antenna. Among eight genera recognized by Humes and Boxshall in the Sabelliphilidae, the fewest leg segmentation is shown by *Phoronicola* Boxshall and Humes, 1988, a monotypic genus associated with a phoronid in Hong Kong. The new genus can not be confused with *Phoronicola*, because the latter genus has an endopod on leg 4, without further reduction of endopodal segmentation in legs 1-3.

Terebelliphilus simplex n. sp.
(Figs. 1-3)

Materials examined: Twenty-five ♀♀, 9 ♂♂ collected from washings of the polychaete *Terebella ehrenbergi* Grube in intertidal mud flat, at Sapsi-do Island (36° 20' N, 126° 21' E) in the Yellow Sea, on 26 October 1999. Holotype (♀), allotype, and paratypes (20 ♀♀, 6 ♂♂) will be deposited in the US National Museum of Natural History, the Smithsonian Institution. Dissected paratypes (4 ♀♀, 2 ♂♂) are kept in the collection of the author.

Female: Body (Fig. 1A) small, narrow, 743 µm long, with thin exoskeleton. Prosome consisting of cephalothorax and 3 pedigerous somites. Cephalothorax narrow, longer than wide, 288 × 238 µm, with round anterior margin, nearly parallel lateral margins, and weak, round lateral expansion at posterior parts of lateral margins. First and second pedigerous somites with round epimera, but fourth pedigerous somite without epimera. Urosome (Fig. 1B) 5-segmented but suture lines faint and incomplete. Fifth pedigerous

somite 44 × 110 µm. Genital double- and first 2 abdominal somites each armed with horizontal row of about 6 denticles near posteroventral border. Genital double-somite 88 × 99 µm, narrower than fifth pedigerous somite, and slightly expanded anteriorly and weakly tapering. Genital area characteristically located on ventral surface. Three abdominal somites 41 × 58, 29 × 54, and 24 × 45 µm, respectively. Caudal rami widely separated from each other, originated posteroventrally from anal somite, each 25 × 14 µm (1.79 : 1), with 6 setae, terminal one of them distinctly larger. All caudal setae naked. Egg sac not seen.

Rostrum absent. Antennule (Fig. 1C) 6-segmented, 150 µm long, with armature formula: 2, 6, 6, 4 + 1 aesthetasc, 2 + 1 aesthetasc, and 7 + 1 aesthetasc. Third segment subdivided proximally by a faint suture line. Antenna (Fig. 1D) 4-segmented, with armature formula: 1, 1, 2 + 1 claw, and 3 + 3 claws. Second segment about 4 times as long as wide, with many denticles on inner margin. One of setae on third segment spinulated along inner margin. Inner one of 3 terminal claws thicker than other two.

Labrum (Fig. 1E) bilobed and deeply incised posteromedially. Mandible (Fig. 1F) with small process proximal to denticulated convex margin. Inner margin short, with row of spinules. Terminal lash very short, strongly tapering. Paragnath not observed. Maxillule (Fig. 1G) armed with 1 lateral setiform process and 3 setae, terminal one of them spiniform, barbed on both margins. Maxilla (Fig. 1H) 2-segmented. First segment thick, with several oblique rows of spinules on ventral and posterior surfaces. Second segment with 2 setae. Inner (dorsal) seta extremely long, basally expanded, with setiferous outer margin. Anterior seta naked. Outer basal seta not observed. Convex margin with 4 large teeth proximal to terminal lash. Terminal lash very short. Maxilliped (Fig. 2A) 3-segmented. First segment unarmed and tapering. Second segment expanded medially, with 2 small setae and strongly convex inner margin. Terminal segment strongly tapering, with 2 unequal setae near inner margin and row of several spinules on both sides near tip.

Legs 1-3 with 3-segmented exopod and 2-segmented endopod. Leg 4 with 3-segmented exopod, endopod lacking. Second endopodal segment of leg 1 with 2 cusps on outer margin. Second endopodal segment in legs 2 and 3 with 1 cusp on outer margin. Legs 1-4 without inner coxal seta. Armature formula of legs 1-4 as follows:

- Leg 1: coxa 0-0; basis 1-0; exp I-0; I-1; II,I,4
enp 0-1; I,6
Leg 2: coxa 0-0; basis 1-0; exp I-0; I-1; II,I,5
enp 0-1; III,4
Leg 3: coxa 0-0; basis 1-0; exp I-0; I-1; II,I,5
enp 0-0; III,3
Leg 4: coxa 0-0; basis 1-0; exp I-0; I-1; I,I,4
enp (absent)

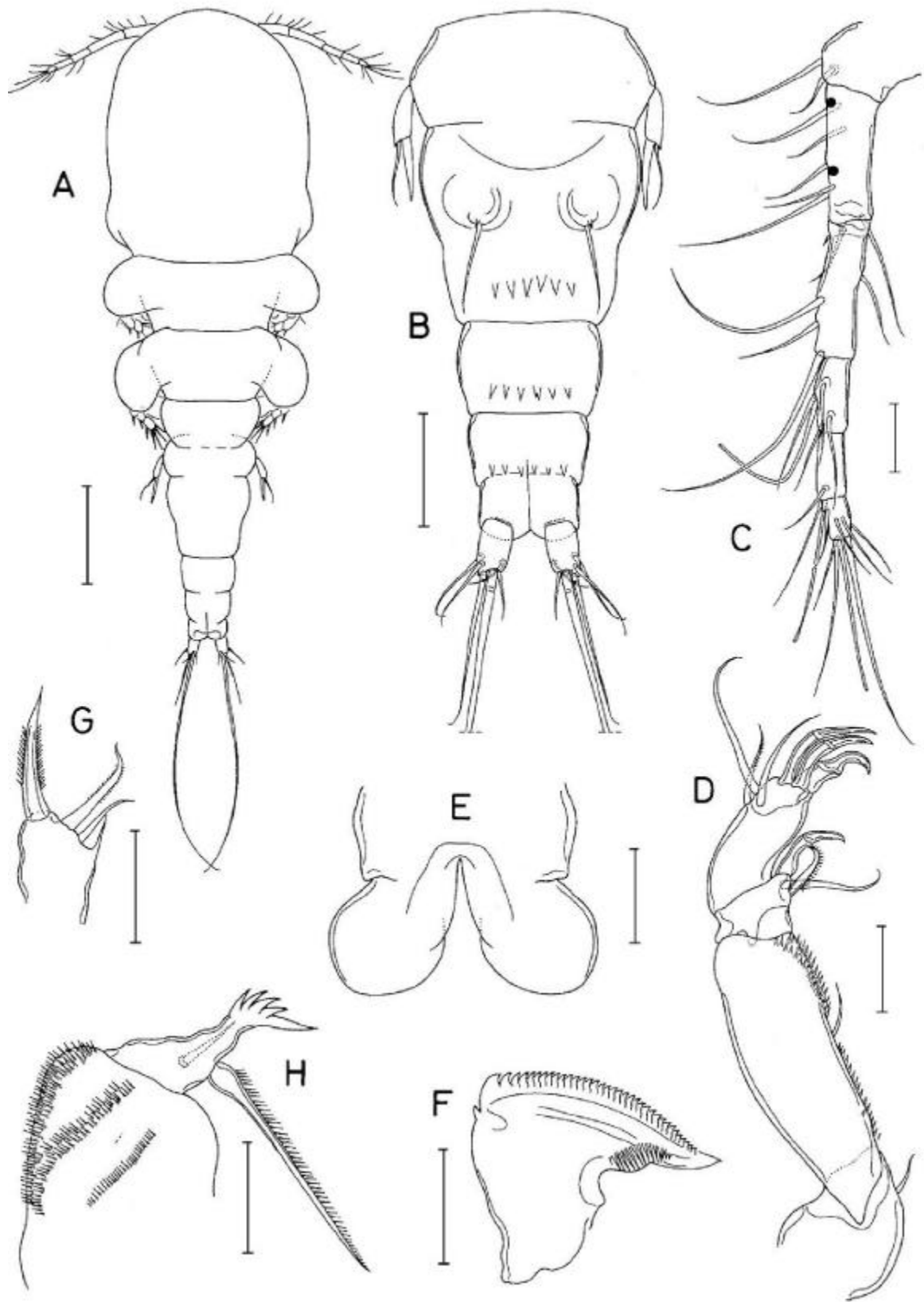


Fig. 1. *Terebelliphilus simplex* n. gen., n. sp., female. A, Habitus, dorsal. B, Urosome, ventral. C, Antennule. D, Antenna. E, Labrum. F, Mandible. G, Maxillule. H, Maxilla. Scale bars=0.02 mm (C-H), 0.05 mm (B), and 0.1 mm (A).

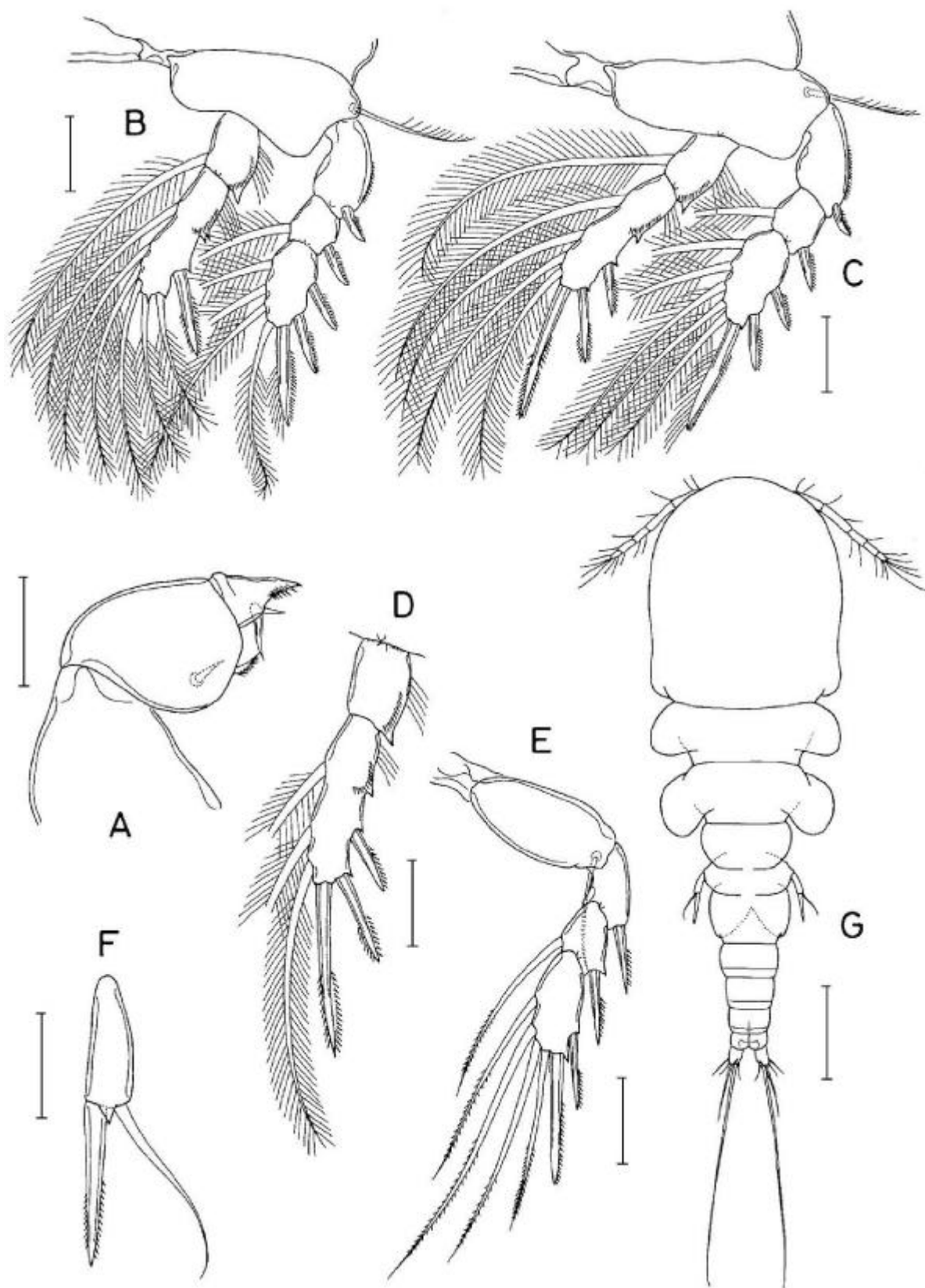


Fig. 2. *Terebelliphilus simplex* n. gen., n. sp. female. A, Maxilliped. B, Leg 1. C, Leg 2. D, Endopod of leg 3. E, Leg 4. F, Leg 5. male. G, Habitus, dorsal. Scale bars=0.02 mm (A-F) and 0.1 mm (G).

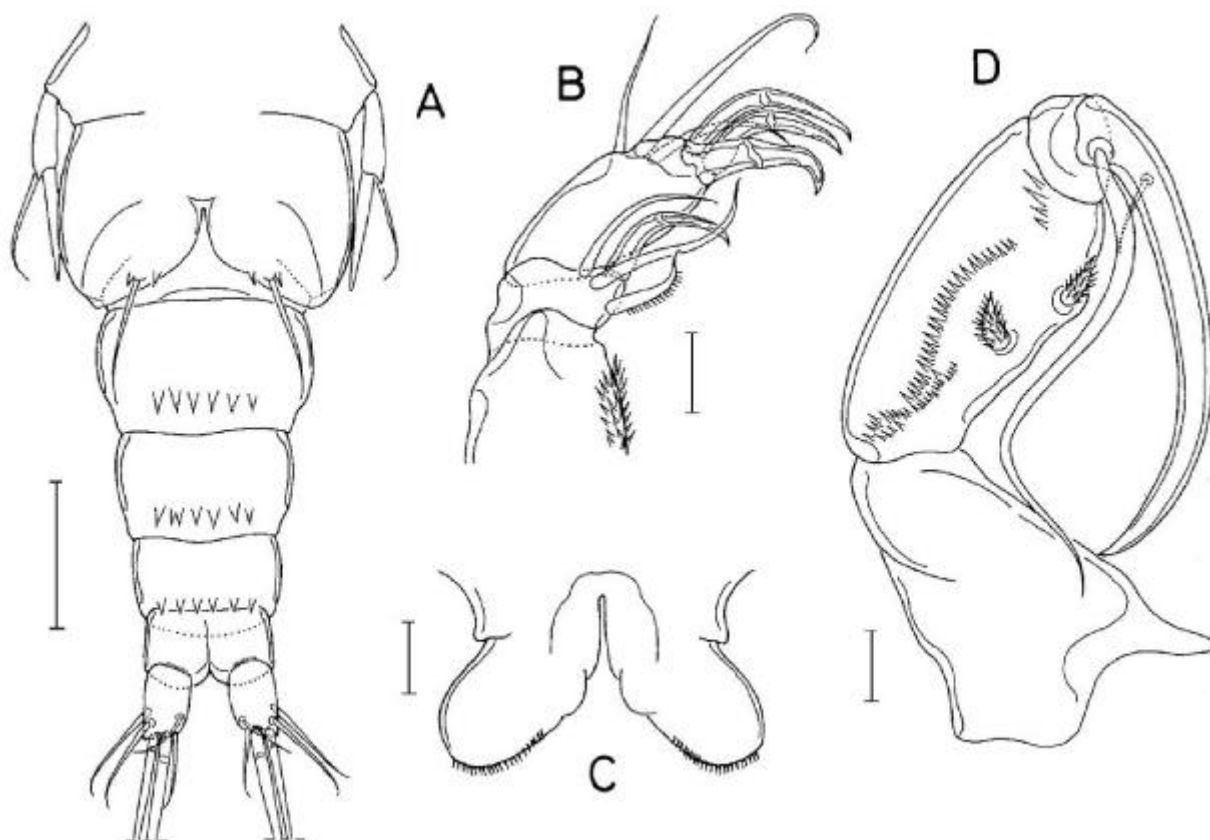


Fig. 3. *Terebelliphilus simplex* n. gen., n. sp., male. A, Urosome, ventral. B, Distal part of antenna. C, Labrum. D, Maxilliped. Scale bars=0.01 mm (B-D) and 0.05 mm (A).

Leg 5 (Fig. 2F) 1-segmented, with no trace of basal segment or seta, distally broadened, $23 \times 8.7 \mu\text{m}$ (2.64 : 1), terminally with a pointed process, 1 spine ($30 \mu\text{m}$) and 1 naked seta ($36 \mu\text{m}$). Leg 6 represented in genital area by 1 small denticle and 1 relatively large seta (Fig. 1B).

Male: Body (Fig. 2G) resembling that of female, $639 \mu\text{m}$ long. Urosome (Fig. 3A) 6-segmented. Genital and 4 abdominal somites 56×89 , 37×65 , 32×54 , 24×45 , and $21 \times 39 \mu\text{m}$, respectively. Caudal ramus $23 \times 14 \mu\text{m}$ (1.64 : 1).

Antennule added by 2 aesthetascs, each proximal and distal, on second segment (dots in Fig. 1C). Antenna added by 1 more seta on third segment (Fig. 3B).

Labrum (Fig. 3C) armed with spinules on posterior margin of lobes. Maxilliped (Fig. 3D) 4-segmented. First segment unarmed, tapering. Second segment with 2 thick, short, spinulated setae and several rows of spinules. Third segment short and unarmed. Fourth segment forming long, curved claw, basally with 2 setae, proximal one of latter greatly enlarged, longer than claw. Other mouthparts as in female.

Legs 1-4 with same armature formula as those of female. Leg 5 $24 \times 7 \mu\text{m}$ (3.43 : 1). Terminal spine $35 \mu\text{m}$.

Leg 6 represented by a seta and 2 spinules on genital flap (Fig. 3A).

Etymology: The specific name *simplex* alludes the simplified legs 1-4 of the new species.

Myxomolgus invulguis n. sp.
(Figs. 4-6)

Materials examined: Twenty ♀♀ and 20 ♂♂, embedded in the mucous wall of the tube of a polychaete of *Myxicola* sp. in the intertidal sand, at Daechon Beach ($36^{\circ} 18' \text{N}$, $126^{\circ} 31' \text{E}$) in the Yellow Sea, collected on 28 October 1999. Holotype ♀, allotype, and paratypes (17 ♀♀, 17 ♂♂) will be deposited in the US National Museum of Natural History, the Smithsonian Institution. Dissected paratypes (2 ♀♀, 2 ♂♂) are kept in the collection of the author.

Female: Body (Fig. 4A) relatively slender. Body length, excluding rostrum, 1.27 mm. Greatest width $491 \mu\text{m}$. Prosome consisting of cephalosome and 4 pedigerous somites. Cephalosome anteriorly tapering. Suture line between cephalosome and first pedigerous somite relatively distinct. Urosome (Fig. 4B) 5-segmented. Fifth pedigerous somite $167 \mu\text{m}$ wide. Genital double-somite

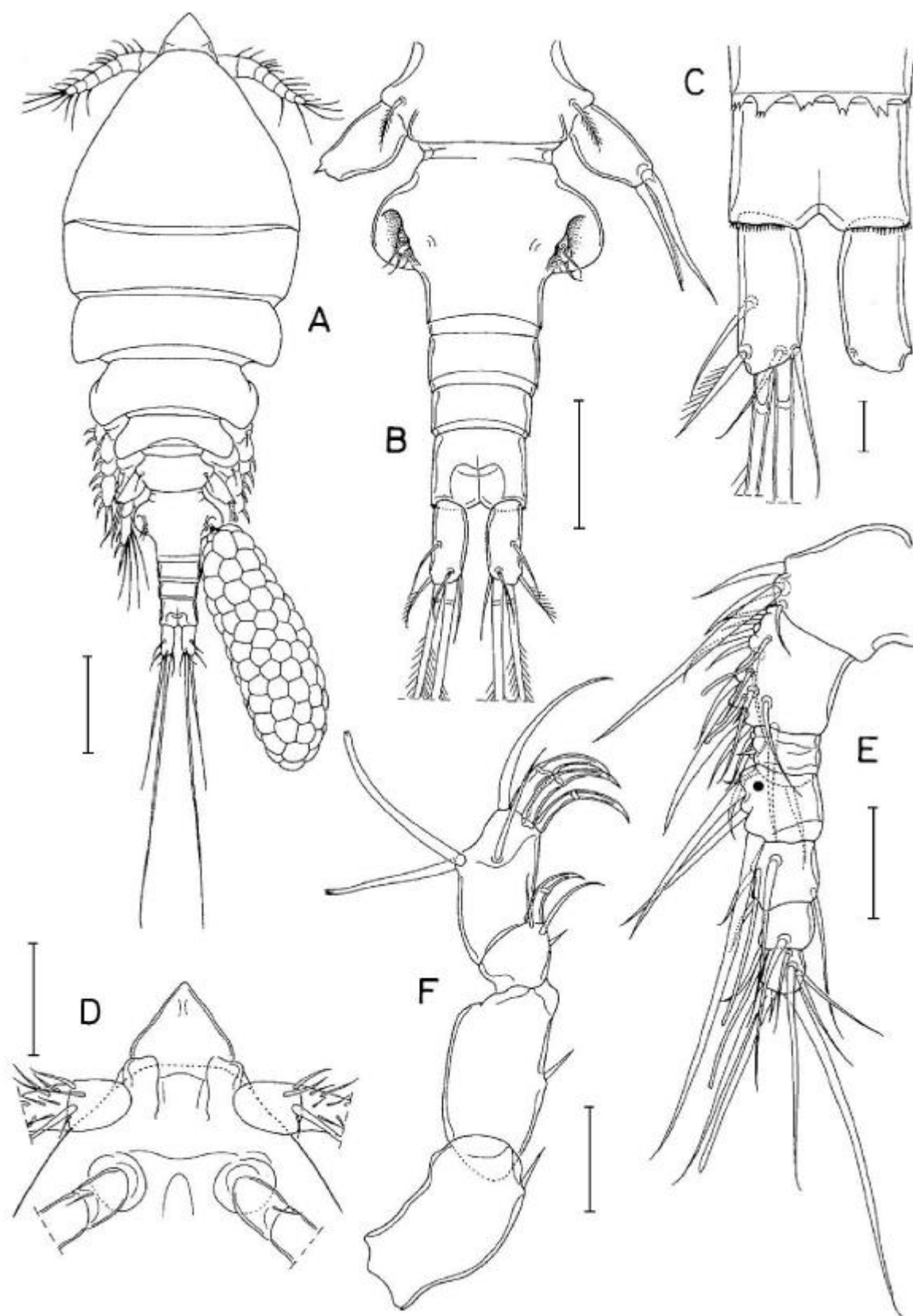


Fig. 4. *Myxomolgus invulvus* n. sp., female. A, Habitus, dorsal. B, Urosome, dorsal. C, Anal somite and caudal rami, ventral. D, Anterior part of cephalosome, ventral. E, Antennule. F, Antenna. Scale bars=0.05 mm (E, F), 0.02 mm (C), 0.1 mm (B, D), and 0.2 mm (A).

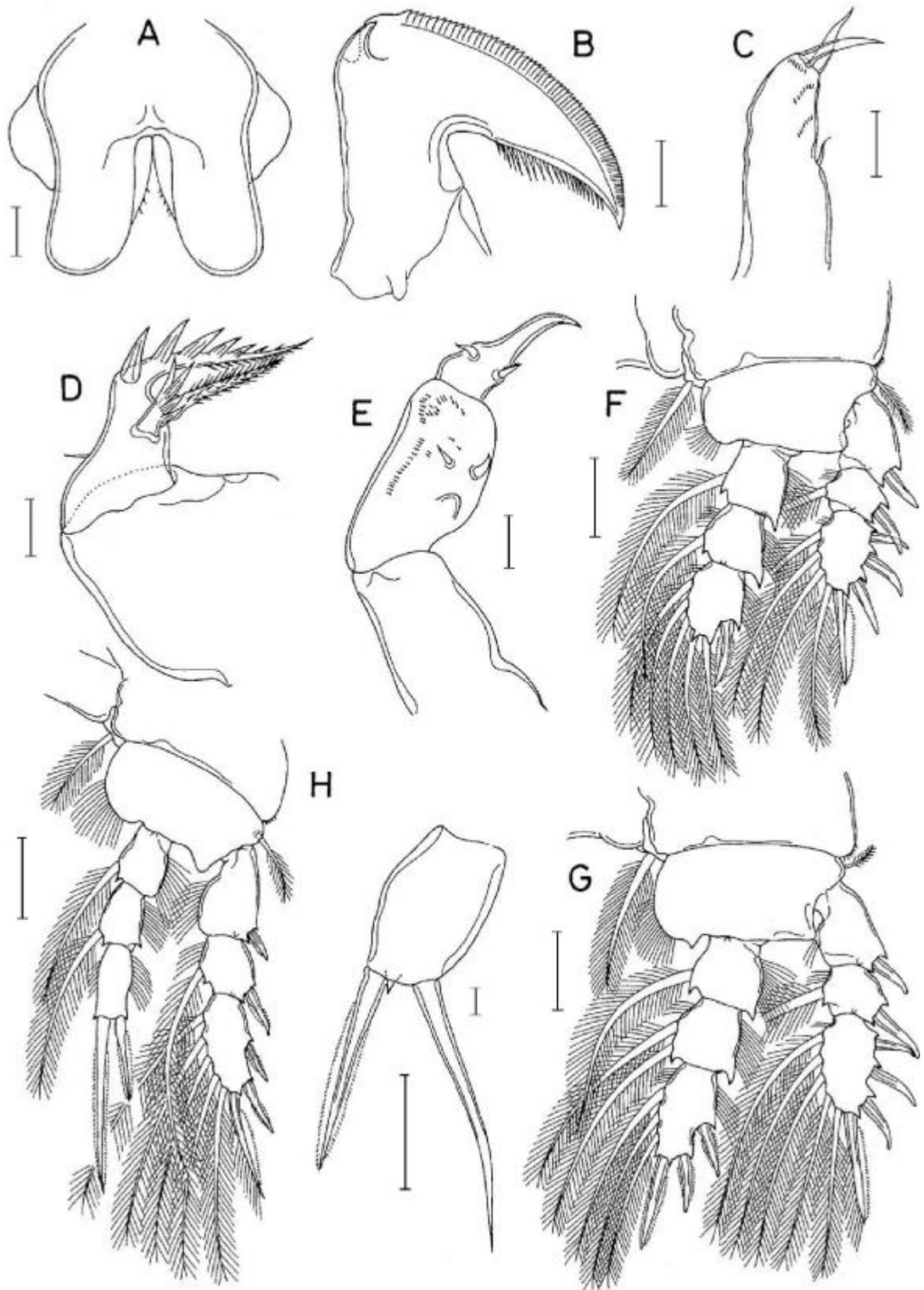


Fig. 5. *Myxomolgus invulvus* n. sp., female. A, Labrum. B, Mandible. C, Maxillule. D, Maxilla. E, Maxilliped. F, Leg 1. G, Leg 2. H, Leg 4. I, Free segment of leg 5. Scale bars=0.02 mm (A-E) and 0.05 mm (F-I).

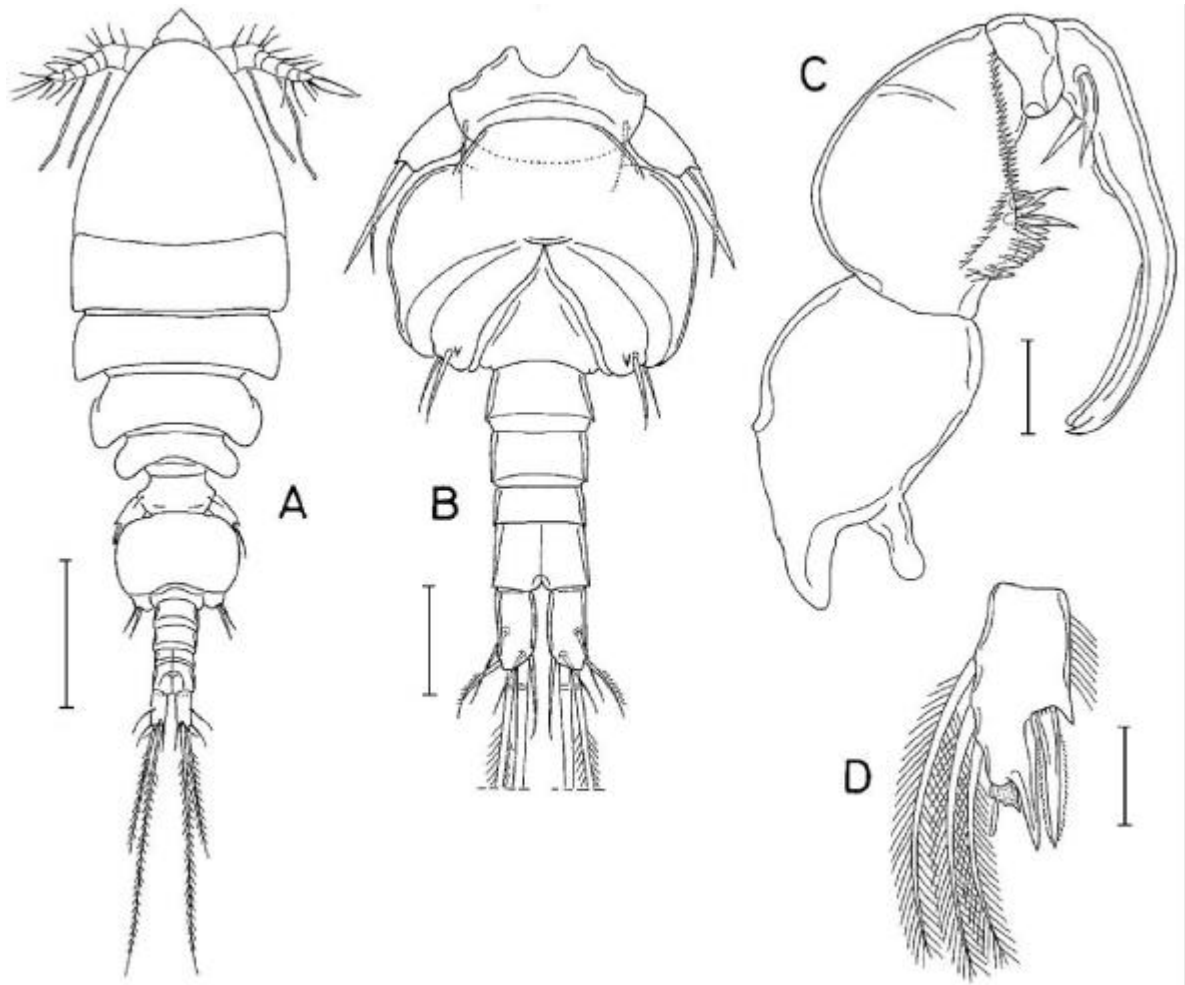


Fig. 6. *Myxomolgus invulvus* n. sp., male. A, Habitus, dorsal. B, Urosome, ventral. C, Maxilliped. D, Terminal endopod segment of leg 2. Scale bars=0.02 mm (C-D), 0.05 mm (B), and 0.2 mm (A).

145 × 181 μm, with anterior part greatly expanded laterally, and lateral margins of narrower posterior part nearly parallel. Three abdominal somites 44 × 87, 35 × 79, and 56 × 75 μm, respectively. Posteroventral margins of genital double- and first 2 abdominal somites rimmed with crenated membrane (Fig. 4C). Posteroventral margin of anal somite with spinules. Caudal ramus 64 × 28 μm (2.29 : 1), with slightly convex inner margin and 6 caudal setae, of which outer terminal and 2 mid-terminal ones plumose.

Rostrum characteristically directed anteriorly, triangular, extending over anterior margin of cephalosome (Fig. 4A, D) with pointed apex. Antennule (Fig. 4E) 214 μm, 7-segmented, short and stocky, characteristically bearing 2 small aesthetascs on second segment, with armature formula: 4, 13 + 2 aesthetascs, 6, 3, 4 + 1 aesthetasc, 2 + 1 aesthetasc, and 7 + 1 aesthetasc. Antenna (Fig. 4F) 4-segmented, with armature formula: 1, 1, 3 + 1 claw, and 4 + 3 claws. Two of 4 setae on terminal segment located on outer margin, their tips weakly bifurcated. Outer one of the 3 claws on

terminal segment slightly thicker than inner two. These 3 claws equal in length.

Labrum (Fig. 5A) with 2 narrow posterior lobes, with deep posteromedian incision and several minute spinules on inner margin of lobes. Mandible (Fig. 5B) short, with strongly tapering blade, without proximal notch. Convex margin with 1 conspicuous, claw-like outer scale and followed by numerous denticles. Inner margin of blade spinulated. Paragnath not observed. Maxillule (Fig. 5C) an elongate lobe with 1 small seta on lateral margin and 2 equal, naked seta at apex. Maxilla (Fig. 5D) 2-segmented. First segment unarmed. Second segment drawn out into moderately long lash bearing 5-6 strong spines on convex margin, with 3 setae. Anterior seta specialized, thick, distally ramified into 3 or 4 spiniform processes. Seta on inner margin spinulated all over surface, slightly shorter than terminal lash. Maxilliped (Fig. 5E) 3-segmented. First segment unarmed, as long as second segment. Second segment with 1 tubercle on proximal part of inner surface and 2 small setae, and scattered minute

spinules. Third segment tapering, distally forming curved claw, proximally with 2 small setae.

Legs 1-4 with 3-segmented rami. Two terminal spines on endopod of leg 4 112 μ m (inner) and 53 μ m (outer). 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,5
 Legs 2 & 3: coxa 0-1; basis 1-0; exp I-0; I-1; III,I,5
 enp 0-1; 0-2; III,3
 Leg 4: coxa 0-1; basis 1-0; exp I-0; I-1; II,I,5
 enp 0-1; 0-1; II

Leg 5 consisting of 1 dorsal seta on fifth pedigerous somite and free segment. Free segment 70 $\times$ 45 μ m (1.56 : 1), slightly widened medially, terminally with 1 denticle, 1 spine (90 μ m) and 1 seta (122 μ m). Leg 6 represented by 1 spinule and 2 setae in genital area (Fig. 4B).

Male: Body (Fig. 6A) more slender than that of female. Urosome (Fig. 6B) 6-segmented. Fifth pedigerous somite 95 μ m wide, distinctly narrower than genital somite. Genital somite expanded, 117 $\times$ 150 μ m, roughly quadrangular. Lateral margins of abdomen nearly parallel. Four abdominal somites 28 $\times$ 52, 27 $\times$ 47, 17 $\times$ 43, and 32 $\times$ 47 μ m, respectively. Caudal ramus 39 $\times$ 18 μ m (2.17 : 1).

Rostrum as in female. Antennule added by 1 aesthetasc on fourth segment. Aesthetascs on second and fourth segments large, longer than whole antennule. Antenna as in female.

Maxilliped (Fig. 6C) 4-segmented. First segment unarmed. Second segment expanded proximally, with 2 setae and rows of spinules on inner margin. Third segment short and unarmed. Fourth segment with 2 proximal setae and distally forming large claw bearing ramified tip and membrane on concave margin. Other mouthparts as in female.

Terminal endopod segment of leg 2 (Fig. 6D) sexually dimorphic: terminal process enlarged, and 2 terminal setae transformed respectively to small setule and irregular process. Legs 1, 3-5 and other parts of leg 2 as in female. Leg 6 represented by 2 setae and 1 denticle on posterior part of genital flap (Fig. 6B).

Etymology: The specific name *invulvus* is derived from the Latin *in* (=among) and *vulgus* (=crowd). The type locality, Daechon Beach, is a bathing resort where a

crowd of people gathers in the summer.

Remarks: There are currently two species recorded in the genus *Myxomolgus*: *M. myxicolae* (Bocquet and Stock, 1958) and *M. proximus* Humes and Stock, 1973, both inhabiting in the wall of polychaete tube of *Myxicola* in the western Europe. *Myxomolgus invulvus* n. sp. is more closely allied to *M. proximus* than to *M. myxicolae* in the respects that the third exopod segment of leg 4 is armed with three spines and five setae (formula II, I, 5), the anterior seta on the second segment of maxilla is multi-furcated, and leg 5 is not longer than twice the width.

Myxomolgus invulvus can not be confused with *M. proximus*, because it shows the following features: the antennule possesses no foliaceous setae, the mandible bears a dentiform scale on the convex margin, and the female leg 5 possesses no proximal swelling. The shape of the rostrum which is directed forward and the presence of two small aesthetascs on the second segment of female antennule may be the unique features of the new species.

Acknowledgements

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