

Species Diversity, 2004, 9, 331–341

**Redescription and Taxonomic Remarks of the Lichomolgid  
Copepod *Paraphiloconcha meretricis* (Crustacea:  
Copepoda: Poecilostomatoida) Parasitic on the  
Bivalve *Meretrix lamarckii* from Japan**

**Il-Hoi Kim<sup>1</sup>, Susumu Ohtsuka<sup>2</sup>, Kaichi Yokosaka<sup>3</sup>  
and Katsuhiko Ito<sup>3</sup>**

<sup>1</sup>Department of Biology, Kangnung National University, Kangnung 210-702, Korea  
E-mail: [ihkim@kangnung.ac.kr](mailto:ihkim@kangnung.ac.kr)

<sup>2</sup>Takehara Marine Science Station, Setouchi Field Science Center, Graduate  
School of Biosphere Science, Hiroshima University, 5-8-1 Minato-machi,  
Takehara, Hiroshima, 725-0025 Japan  
E-mail: [ohtsuka@hiroshima-u.ac.jp](mailto:ohtsuka@hiroshima-u.ac.jp)

<sup>3</sup>Tokyo Metropolitan Sunagawa High School, 935-4 Izumi-cho,  
Tachikawa, Tokyo, 190-8583 Japan

(Received 11 May 2004; Accepted 19 August 2004)

*Paraphiloconcha meretricis* Yamaguti, 1936, an incompletely known lichomolgid copepod living in the pericardium of the hard clam *Meretrix lamarckii* Deshayes, 1853, is redescribed from the southeastern coast of Japan. Although the genus *Paraphiloconcha* is closely related to *Philoconcha*, it can be differentiated from the latter by the presence of large lateral processes on the metasomites, a three-segmented maxilliped, and relatively more developed leg setation. In consideration of the morphology and development of mollusk-associated lichomolgid genera, *Philoblenna* and *Briarella*, both of which have been assigned to the family Philoblennidae until now, are transferred to the Lichomolgidae.

**Key Words:** *Paraphiloconcha meretricis*, Lichomolgidae, Philoblennidae, Poecilostomatoida, Copepoda, parasitic, bivalve.

### Introduction

Among all host phyla, copepods are most frequently associated with the Mollusca (Humes 1994). Although Japan is proud of its wealth of marine mollusks, with about 5000 species living in its surrounding seas (cf. Okutani 2000), knowledge about their copepod associates is quite insufficient.

Both sexes of *Paraphiloconcha meretricis* Yamaguti, 1936, a bizarre copepod bearing large lateral processes on the metasomites, were found originally in the pericardium of the hard clam *Meretrix lamarckii* Deshayes, 1853 in the Sea of Japan. In the original description Yamaguti (1936) placed this monotypic genus in the family Clausiidae, but later it was removed to the Lichomolgidae by Humes and Stock (1973). After the original find, this species was not rediscovered for nearly 70 years. Recently, though, it was found in *M. lamarckii* from a tidal flat on the Pacific coast of Japan. Because this species of copepod was incompletely de-

scribed originally, we redescribe it here, with thorough illustrations. We also discuss other mollusk-associated genera of the lichomolgid complex.

The copepod order Poecilostomatoida has been regarded for some decades as a valid taxon defined by the characteristic mouthparts and lack of a geniculation in the male antennule (Huys and Boxshall 1991). Recently Boxshall and Halsey (2004) subsumed it into the order Cyclopoida, due to the discovery of an intermediate taxon, the family Frantiidae. However, here we follow the traditional classification and await further cladistic and molecular analyses to confirm whether this synonymization is justified.

### Materials and Methods

The copepods were found within the pericardium of the only one individual (shell length 93 mm) of the hard clam *M. lamarckii* that two of the authors (KY, KI) purchased at a market at Oharai, Ibaraki Prefecture, Japan, on 5 February 2004. The copepods were measured and dissected in lactic acid. The dissection was done using the reversed slide method of Humes and Gooding (1964). In the following re-descriptions, the body length does not include setae on the caudal rami. Roman and Arabic numerals represent spines and setae, respectively. All figures were drawn with the aid of a camera lucida. A single male of the species was dehydrated through an alcohol series, freeze-dried, sputter-coated with gold, and then observed with a scanning electron microscope (Jeol T-20).

#### *Paraphiloconcha meretricis* Yamaguti, 1936

(Figs 1–4)

**Material examined.** Three ♀♀ and 7♂♂ in the pericardium of a hard clam *Meretrix lamarckii* taken from a tidal flat near Oharai, Ibaraki Prefecture, on 5 February 2004. One ♀ and 1♂ deposited at the Department of Biology, Kangnung National University, Korea; 2♀♀ and 6♂♂ in the collection of the second author.

**Redescription.** *Female.* Body (Fig. 1A) large, unsegmented, with weak exoskeleton. Body length 5.21 mm in dissected largest specimen. Cephalothorax triangular, 1.08×1.69 mm. Second to fourth pedigerous somites each with pair of large, digitiform lateral processes. All lateral processes distinctly longer than wide, usually more than twice as long as wide. Second pedigerous somite 2.46 mm wide, measured between tips of lateral processes. Lateral processes of third and fourth pedigerous somites directed posterolaterally. Urosome not distinct from prosome, slender and cylindrical. Genital somite discernible, bounded by anterior and posterior lateral constrictions. Caudal rami (Fig. 1B) fused with anal somite but demarcated from somite by weak basal constriction, tapering, 417×121 μm (ratio 3.45:1), each ramus armed with 1 outer lateral and 5 distal setae; outer lateral seta located in middle of outer margin; largest mid-terminal seta 200 μm long; all caudal setae smooth. Egg sac (Fig. 1C) long and narrow, extending beyond caudal rami, containing 2 rows of eggs.

Rostrum blunt, ventrally directed lobe (Fig. 1D; see also Fig. 4A). Antennule (Fig. 1E) tapering, 7-segmented, but proximal 4 segments obscurely divided. Arma-

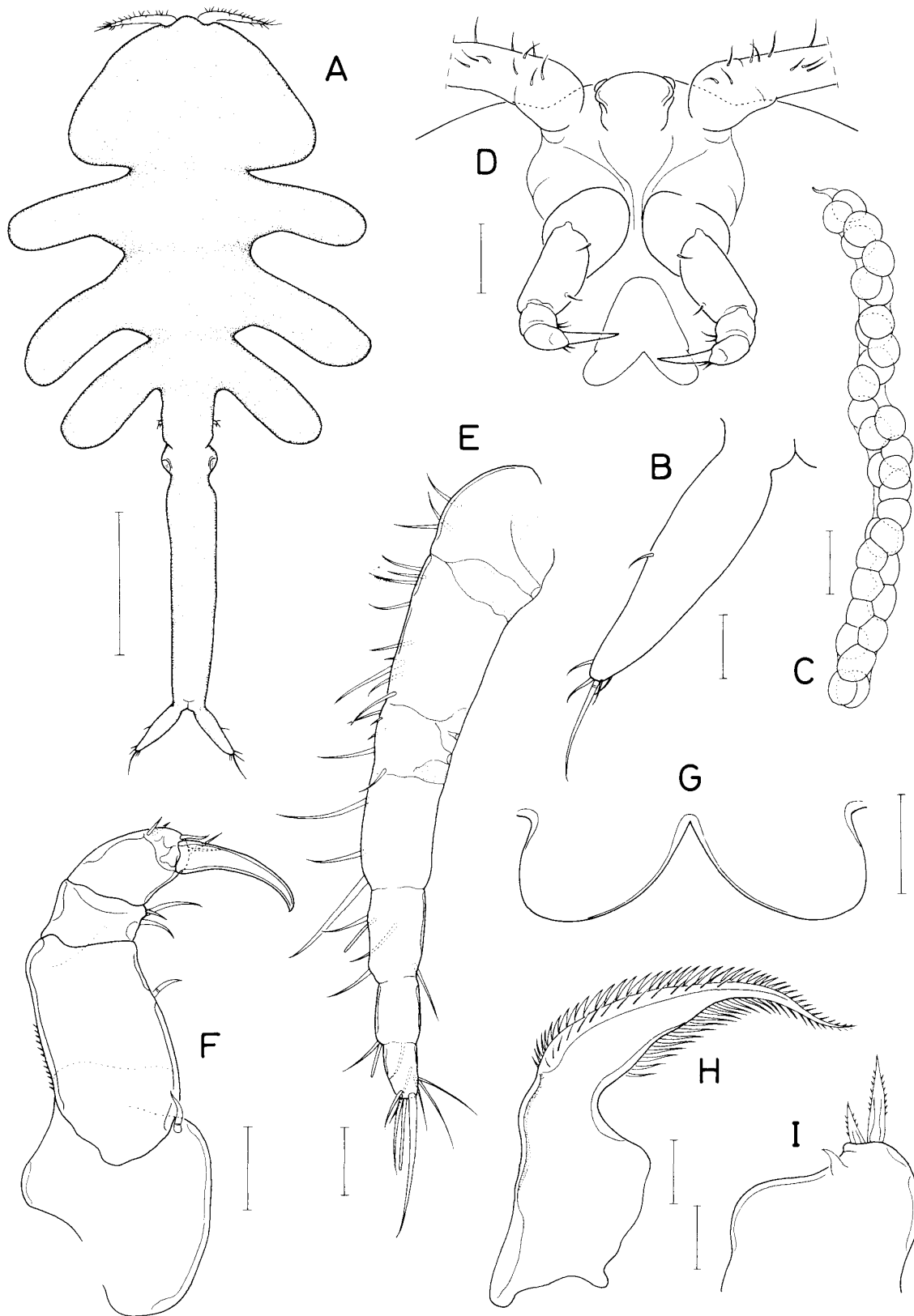


Fig. 1. *Paraphiloconcha meretricis* Yamaguti, female. A, Habitus, dorsal; B, left caudal ramus, dorsal; C, egg sac; D, rostral area, ventral; E, antennule; F, antenna; G, labrum; H, mandible; I, maxillule. Scales: A, 1 mm; B, D, 0.1 mm; C, 0.2 mm; E-G, 0.05 mm; H, I, 0.02 mm.

ture formula 3, 8 to 10, 4 or 5, 3, 4+aesthetasc, 2+aesthetasc, and 7+aesthetasc. Number of setae on second and third segments variable: from 8 to 10 (3 or 4 proximal and 5 or 6 distal) in second and 4 or 5 in third segments; all setae naked and small. Aesthetascs on fifth to seventh segments shorter than nearby setae. Antenna (Fig. 1F) robust and 4-segmented, with armature formula 1, 1, 3, and 5+claw; first segment wider than long; second segment with spinules along proximal half of outer margin. Setae on first and second segments proximally annulated. Terminal claw strong, longer than terminal segment.

Labrum (Fig. 1G; see also Fig. 4B) consisting of 2 posterolaterally directed lobes, with broad median incision. Mandible (Fig. 1H) narrow, with moderately long distal lash; convex margin with row of setules in addition to row of denticles; concave margin linear, with row of long spinules. Paragnath (Fig. 2A) lobate, bearing setules. Maxillule (Fig. 1I) proximally broad, with 2 apical barbed setae and 1 subapical, hyaline process. Maxilla (Fig. 2B) 2-segmented; first segment large, ornamented with numerous spinules on ventral surface; second segment strongly tapering, armed with 1 small subterminal seta and 2 large, spinulated terminal setae, larger one of latter with 2 rows of spinules along outer margin. Maxilliped (Fig. 2C) 3-segmented; first segment broad; second segment obscurely demarcated from first segment, slightly curved, with corrugated outer margin and 2 distal spiniform setae; terminal segment small, longer than wide, with 1 proximal spiniform seta and 2 minute inner setae.

Legs 1–4 (Figs 2D–F, 3A; see also Fig. 4D) with 3-segmented rami, except for 2-segmented endopod of leg 4, with armature formula basically as follows: in leg 1, coxa 0-1, basis 1-0, exopod I-0, I-1, III,I,4, endopod 0-1, 0-1, I,5; in leg 2, coxa 0-1, basis 1-0, exopod I-0, I-1, III,I,5, endopod 0-1, 0-2, II,I,3; in leg 3, coxa 0-1, basis 1-0, exopod I-0, I-1, III,I,4, endopod 0-1, 0-1, II,I,2; in leg 4, coxa 0-0, basis 1-0, exopod I-0, I-1, II,I,4, endopod 0-1, 0-1. Deviations from above armature formula (based on 3 females) as follows: III,I,3 on third exopodal segment of leg 1; II,I,5 on third exopodal segment and 0-1 on second endopodal segment of leg 2; 0-0 on coxa of leg 3; 0-1 on coxa and III,I,3 on third exopodal segment of leg 4. Inner coxal seta of leg 4 small when present. Setae on rami of legs 1-4 weakly plumose, those only of leg 4 smooth. Leg 5 consisting of small free segment and nearby seta; free segment (Fig. 3B)  $35 \times 27 \mu\text{m}$ , terminally armed with broad spine ( $24 \mu\text{m}$ ) and smooth seta ( $37 \mu\text{m}$ ). Leg 6 represented by seta on tip of small posterior process in genital area (Fig. 3C).

*Male.* Body (Fig. 3D) much smaller than that of female, 2.97 mm long in dissected largest specimen, similar in form to that of female except for absence of lateral processes on fourth pedigerous somite. Cephalothorax  $722 \times 989 \mu\text{m}$ . Urosome (Fig. 3E) demarcated from prosome by lateral constriction. Combined fifth pedigerous and genital somites demarcated from abdomen by constriction, broadened distally, and  $467 \times 389 \mu\text{m}$ . Caudal ramus  $294 \times 84 \mu\text{m}$  (ratio 3.50:1).

Rostrum (Fig. 4A) and antennule not different from those of female. Antenna (Fig. 3F) with additional seta on third segment (therefore 4 setae). Maxilliped (Fig. 3G) consisting of 3 segments and terminal claw; first segment unarmed and broad; second segment with 2 thick and similar inner setae and granule-like spinules on inner side; third segment short and unarmed; terminal claw long, proximally bearing seta and small setule.

Legs 1–5 with armature formula basically identical to that of female. Leg 5 (Figs 3H, 4E) with free segment  $37 \times 23 \mu\text{m}$ . Leg 6 represented by genital flap with

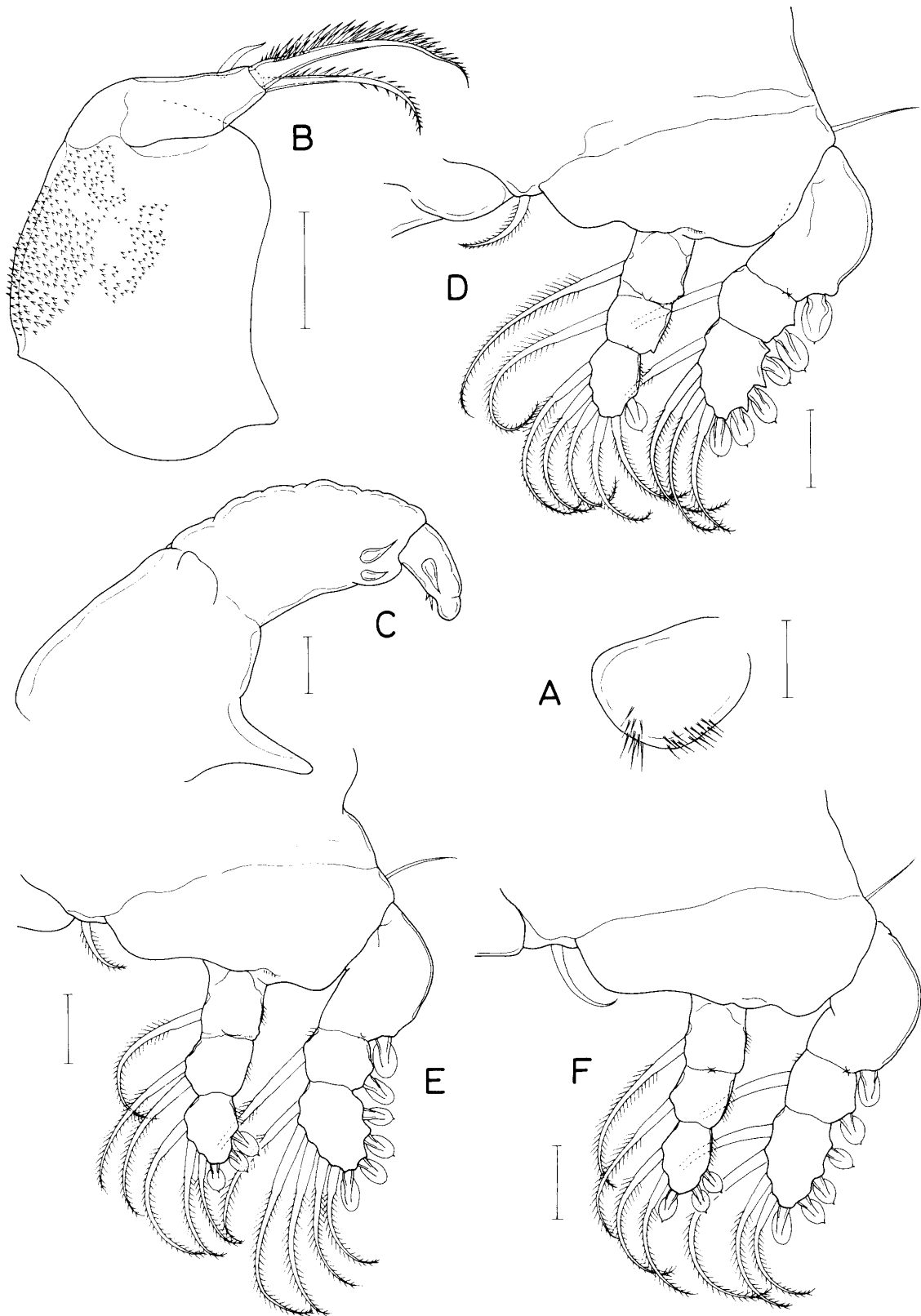


Fig. 2. *Paraphiloconcha meretricis* Yamaguti, female. A, Paragnath; B, maxilla; C, maxilliped; D, leg 1; E, leg 2; F, leg 3. Scales: A, C, 0.02 mm; B, D-F, 0.05 mm.

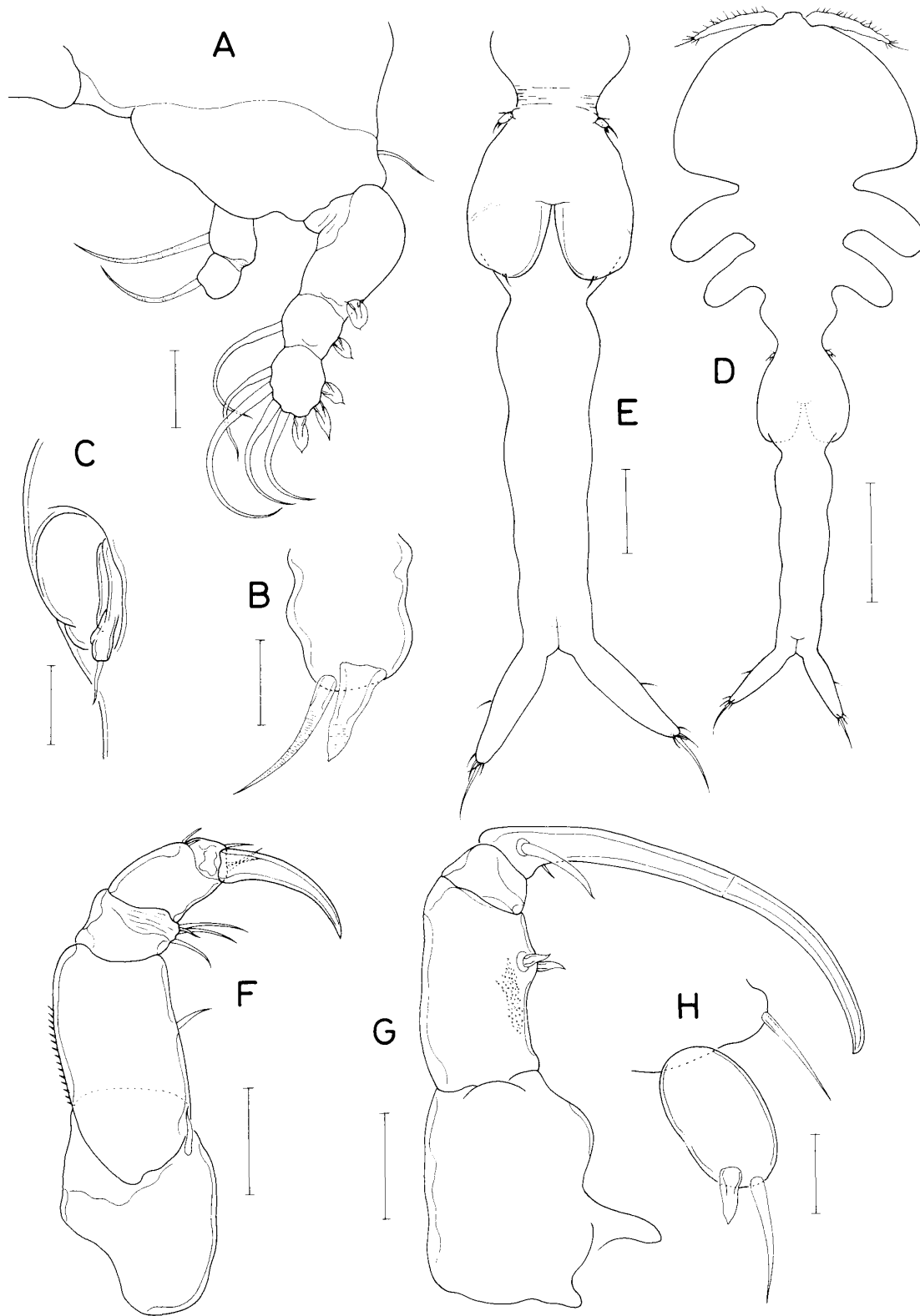


Fig. 3. *Paraphiloconcha meretricis* Yamaguti, female (A-C) and male (D-H). A, Leg 4; B, free segment of leg 5; C, genital area; D, habitus, dorsal; E, urosome, ventral; F, antenna; G, maxilliped; H, leg 5. Scales: A, C, F, G, 0.05 mm; B, H, 0.02 mm; D, 0.5 mm; E, 0.2 mm.

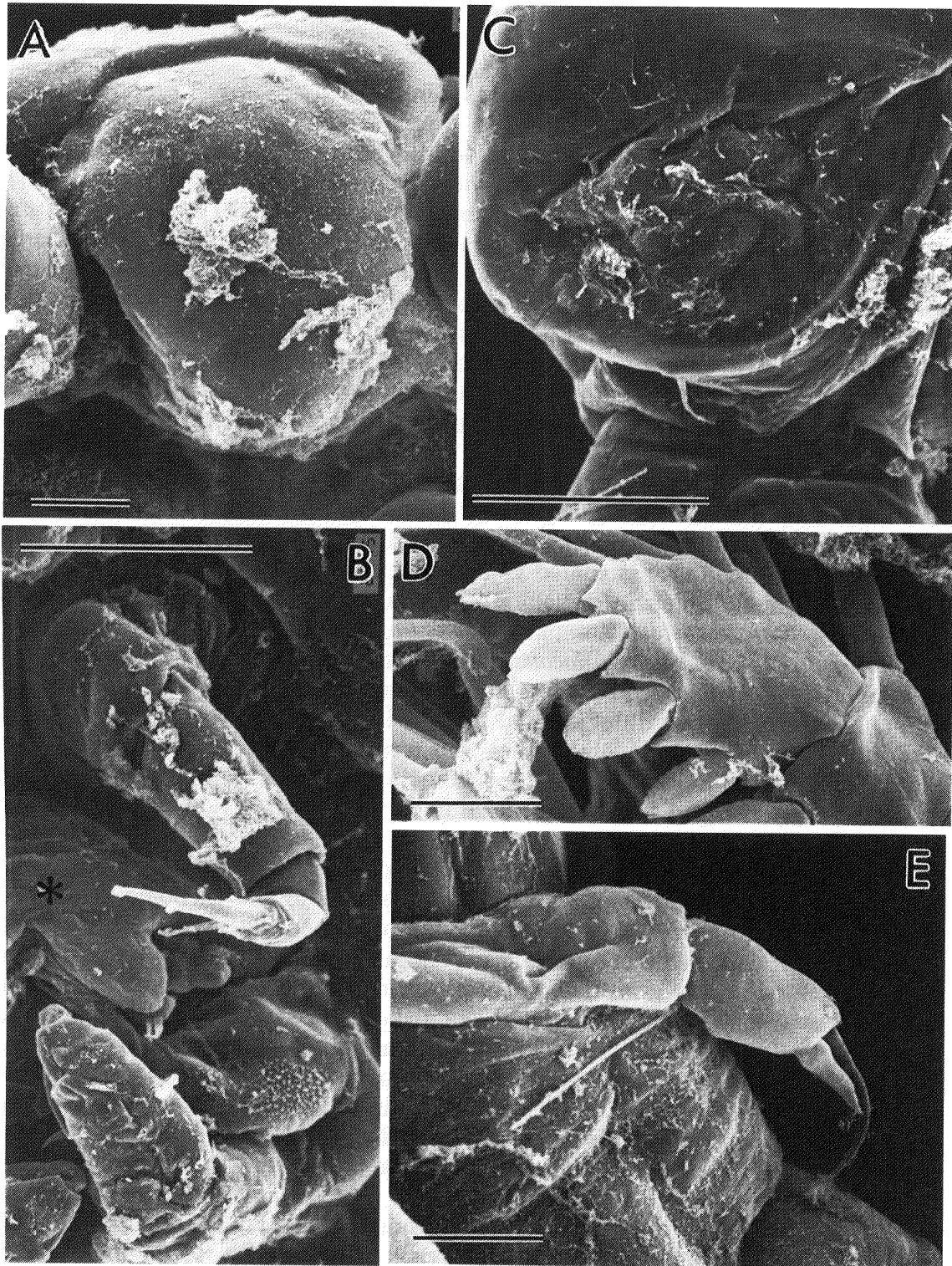


Fig. 4. *Paraphiloconcha meretricis* Yamaguti, male, scanning electron micrographs. A, Rostrum; B, antenna to maxilliped and labrum (indicated by asterisk); C, leg 6 representing genital flap; D, terminal exopodal segment of leg 1; E, leg 5. Scales: A, D, E, 0.02 mm; B, C, 0.1 mm.

seta and minute denticle posteriorly (Figs 3E, 4C).

### Discussion

It is evident from the original record and the above redescription that the setation and spinulation of the legs of *Paraphiloconcha meretricis* are extremely variable. Such a plasticity of the leg setation also occurs in species of *Philoconcha* Yamaguti, 1936 (see Yamaguti 1936; Kim 2002), which is a genus closely related to *Paraphiloconcha*; therefore, the leg armature in these genera may not be a reliable taxonomic character. Although *Paraphiloconcha* is similar closely to *Philoconcha*, it can be differentiated from the latter genus by the large lateral processes on the metasomites and the three-segmented maxilliped of the female, which is not reduced as in *Philoconcha*. In addition, the setae on the legs and other appendages of *Paraphiloconcha* are generally more developed (therefore more primitive) in number and size than in *Philoconcha*.

According to the redefinition of the families of the lichomolgid complex made by Humes and Boxshall (1996), the family Lichomolgidae is characterized mostly by the simple mandible, which is slender with linear margins. The Lichomolgidae includes several mollusk-associated genera displaying a vermiform body and reduction of segmentation and/or setation of legs, as follows: *Neomenicola* Avdeev and Avdeev, 1991, *Paclabius* Kossmann, 1877, *Parapanaietis* Hoshina and Sugiura, 1953, *Paraphiloconcha*, and *Philoconcha*. Of these, the species of *Paclabius*, *Paraphiloconcha*, and *Philoconcha* possess in common a single terminal claw on the antenna. They can be thus differentiated from the remaining two genera, *Neomenicola* and *Parapanaietis*, which possess two terminal claws on the antenna. *Paclabius* exhibits the most primitive morphological condition among the three genera associated with the bivalves, according to the redescription of the male by Humes (1973).

In addition to the above five genera, we consider that the genera *Briarella* Bergh, 1876 and *Philoblenna* Izawa, 1976 also belong to the Lichomolgidae. *Briarella* is similar to *Paraphiloconcha* in having prominent lateral processes on the prosome, but it can be distinguished from the latter genus by the three-segmented antenna with two claws terminally. Species of *Briarella* are endoparasites of dorid nudibranchs (Monod 1928). When he established the genus *Philoblenna*, Izawa (1976) proposed a new family Philoblennidae to accommodate it and suggested that *Briarella* might be a genus of Philoblennidae. Huys (2001) compared these two genera in detail and gave an evidence supporting the Izawa's idea. He also considered *Philoblenna* to be more primitive than *Briarella* in leg segmentation and armature. There are further similarities between these two genera: the mandible is simple and linear, the maxilla terminates in a claw, and, as mentioned above, the antenna is armed with two terminal claws. Izawa (1976) recognized that *Philoblenna* belongs to the lichomolgid complex, but he placed his genus in an independent family due to the condition of the labrum, bearing lateral lobes, and the maxilla, terminating in a strong claw. Since the description of *Philoblenna arabici* Izawa, 1976, the type species of the genus, another species, *P. tumida* Ho, 1981, has been added. Ho (1981) reported a simple labrum (bearing no lateral lobes) in his species, which showed that the lateral lobes of the labrum of *P. arabici* are merely a



species-specific trait. In a later report, Izawa (1986) described copepodid I of *P. arabici*, in which the second segment of the maxilla is not different from those of other lichomogoid copepods of the same copepodid stage, i.e. not claw-like in appearance; therefore, the claw-like second segment of the maxilla in the adult of *P. arabici* is derived during the copepodid development. Consequently, we consider the morphological features of the labrum and maxilla in adults of *Philoblenna* not to be traits that can support the establishment of a distinct family Philoblennidae.

Recently, Boxshall and Halsey (2004) included the Philoblennidae in the splanchnotrophid family-group, based on a misinterpretation of the copepodid I mandible of *Philoblenna arabici*. However, Kim (2003) described an identical form of mandible for copepodid I of *Critomolgus anthopleurus* Kim, 1996, a species of the family Rhynchomolgidae within the lichomolgid complex. At this developmental stage, the mandible of both *C. anthopleurus* and *P. arabici* displays distally a setiform process, one anterior seta, and a thick, spiniferous element. This form of the copepodid I mandible is not limited to the Rhynchomolgidae and *Philoblenna*, but is almost universal in the families of the lichomolgid complex (Kim 2003). Moreover, the first copepodid stage of both *P. arabici* and *C. anthopleurus* carry almost identical maxillae, in which the first segment is armed with a single seta and the second segment terminates in a spiniferous spine (lash) with two proximal setae. The copepodid I maxillipeds of both species are identical. At this developmental stage the maxilliped of *C. anthopleurus* and *P. arabici* is four-segmented and bears an armature formula 1, 2, 1, and 3 plus a spiniform terminal process. This form of maxilliped is almost universal in the copepodid I of the lichomolgid complex. These facts all strongly suggest that *Philoblenna* belongs to the lichomolgid complex. Within the complex, we consider that *Philoblenna* belongs to the Lichomolgidae, because the adults of this genus possess the simple, linear mandible that is typical for the Lichomolgidae.

Within the Lichomolgidae, *Philoblenna* appears to be related to the genera *Parapanaietis* associated with gastropods and *Neomenicola* found on the gills of a deep-water aplacophoran from the western Pacific. Although both *Philoblenna* and *Neomenicola* closely resemble *Parapanaietis* in many respects, Izawa (1976) and Avdeev and Avdeev (1991) did not cite *Parapanaietis* in comparing their genera with others. These three genera share an inflated body, a pair of terminal claws on the antenna, and reduction or simplification of the legs. The similarity of *Philoblenna* with these two lichomolgid genera supports our contention that *Philoblenna* also belongs to Lichomolgidae. Consequently, its closely related genus *Briarella* is considered to belong to this family as well.

Boxshall and Halsey (2004) proposed to include the genus *Myzotheridion* Laubier and Bouchet, 1976, recorded from a bathyal gastropod in the eastern Atlantic (Laubier and Bouchet 1976), in the Philoblennidae; however, this genus is too incompletely known, especially concerning the mouthparts, to determine its taxonomic position. Likewise, the genus *Chondrocarpus* Basset-Smith, 1903, which Huys (2001) treated as *incertae sedis* in the Philoblennidae, reveals no evidence allowing it to be incorporated in any known family, although it carries metasomal processes like those of *Paraphiloconcha*.

In poecilostomatoid copepods loss of the outer spine on the second exopodal segment of legs is hardly observed; however, this trait occurs in leg 2 of *Neomenicola* and in all or some of legs 2–4 of *Parapanaietis* (see Hoshina and Sugiura 1953;

Ho 1981; Kim 1992), suggesting the relatedness between these two genera.

The following key differentiates the mollusk-associated genera of the Lichomolgidae with a vermiform body.

1. Antenna with 2 terminal claws (associated with Gastropoda or Aplacophora) .....2  
– Antenna with single terminal claw (associated with Bivalvia) .....5
2. Antenna 4-segmented .....*Parapanaietis*  
– Antenna 3-segmented.....3
3. Metesomites with prominent digitiform lateral processes.....*Briarella*  
– Metasomites without prominent lateral processes .....4
4. Legs 1 and 2 with 3-segmented endopod .....*Neomenicola*  
– Legs 1 and 2 with 2-segmented endopod.....*Philoblenna*
5. Metasomites with prominent digitiform lateral processes distinctly longer than wide .....*Paraphiloconcha*  
– Lateral processes absent on metasomites or much wider than long .....6
6. First segment of antennule with 4 setae; third exopodal segment of leg 4 armed with 4 spines and 5 setae (armature III,I,5) .....*Paclabius*  
– First segment of antennule with 3 setae; third exopodal segment of leg 4 armed with 3 spines and 3 setae (II,I,3) or 3 spines and 2 setae (II,I,2).....*Philoconcha*

### Acknowledgements

This study was partially supported by grants from the Korea Science and Engineering Foundation (R05-2004-000-10302-0) to IHK and from the Japan Society of the Promotion of Science (No. 14560151) to SO.

### References

- Avdeev, G. V. and Avdeev, V. V. 1991. *Neomenicola gibber* gen. et sp. n. (Lichomolgidae), an endoparasitic copepod of Aplacophora from the Japanese Pacific. *Zoologicheskii Zhurnal* 70: 142–147. [In Russian with English summary]
- Boxshall, G. A. and Halsey, S. H. 2004. *An Introduction to Copepod diversity*. The Ray Society, London, 966 pp. (in 2 parts).
- Ho, J.-S. 1981. Parasitic Copepoda of gastropods from the Sea of Japan. Report of the Sado Marine Biological Station, Niigata University (11): 23–41.
- Hoshina, T. and Sugiura, Y. 1953. On two new species of parasitic copepods of mollusks. *Journal of the Tokyo University of Fisheries* 40: 25–29.
- Humes, A. G. 1973. Cyclopoid copepods associated with marine bivalve mollusks in New Caledonia. *Cahiers ORSTOM Océanographie* 11: 3–25.
- Humes, A. G. 1994. How many copepods? *Hydrobiologia* 292/293: 1–7.
- Humes, A. G. and Boxshall, G. A. 1996. A revision of the lichomolgid 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 Stock, J. H. 1973. A revision of the family Lichomolgidae Kossmann, 1887, cyclopoid copepods mainly associated with marine invertebrates. *Smithsonian Contribu-*

- tions to Zoology 127: 1-368.
- Huys, R. 2001. Splanchnotrophid systematics: a case of polyphyly and taxonomic myopia. *Journal of Crustacean Biology* 21: 106-156.
- Huys, R. and Boxshall, G. A. 1991. *Copepod Evolution*. The Ray Society, London, 468 pp.
- Izawa, K. 1976. A new parasitic copepod, *Philoblenna aravici* gen. et sp. nov., from a Japanese gastropod, with proposal of a new family Philoblennidae (Cyclopoida: Poecilostoma). *Publications of the Seto Marine Biological Laboratory* 23: 229-235.
- Izawa, K. 1986. On the development of parasitic Copepoda. IV. Ten species of poecilostome cyclopoids, belonging to Taeniacanthidae, Tegobomolochidae, Lichomolgidae, Philoblennidae, Mycolidae, and Chondracanthidae. *Publications of the Seto Marine Biological Laboratory* 31: 81-162.
- Kim, I.-H. 1992. Copepod parasites of Gastropoda from Korea. *Korean Journal of Zoology* 35: 240-255.
- Kim, I.-H. 2002. Redescriptions of two species of Copepoda (Poecilostomatoida, Lichomolgidae) associated with the bivalve *Dosinorbis japonicus* from the Korea Strait. *Korean Journal of Systematic Zoology* 18: 23-33.
- Kim, I.-H. 2003. Copepodid stages of *Critomolgus anthopleurus* (Copepoda, Poecilostomatoida, Rhynchomolgidae). *Journal of Crustacean Biology* 23: 558-567.
- Laubier, L. and Bouchet, P. 1976. Un nouveau copépode parasite de la cavité palléale d'un gastéropode bathyal dans le Golfe de Gascogne *Myzotheridion seguenziae* gen. sp. nov. *Archives de Zoologie Experimentale et Générale* 117: 469-484.
- Monod, T. 1928. Sur quelques copépodes parasites de nudibranches. *Bulletin de l'Institut Océanographique, Monaco* (509): 1-18.
- Okutani, T. 2000. Editor's preface. Pp. xxiii-xxv. *In: Okutani, T. (Ed.) Marine Mollusks in Japan*. Tokai University Press, Tokyo.
- Yamaguti, S. 1936. Parasitic copepods from mollusks of Japan, I. *Japanese Journal of Zoology* 7: 113-127, pls VII-XIII.