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A review of copepods associated with bivalves in Japan, with description of two new species (Crustacea, Copepoda, Cyclopoida)

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Abstract. A taxonomical review is given for the copepods associated with bivalves from Japan. Two new species *Herrmannella macomae* n. sp. associated with *Macoma contabulata* (Deshayes) and *Myicola gamoensis* n. sp. associated with *Laternula* (*Exolaternula*) *marilina* (Reeve) are described from tidal flats in northern Japan. *Herrmannella hiatellai* Avdeev, *H. longicaudata* Avdeev, *H. longichaeta* Avdeev, and *H. soleni* Kim and Ho are reported as new to Japan. *H. longichaeta* Avdeev and *Trochicola japonicus* Shimura and Kuwabara are redescribed. Old scientific names of bivalve hosts recorded previously are replaced to up-to-date ones.

Key words: Parasitic Copepoda, Cyclopoida, new species, new records, bivalves, Japan.

Introduction

Marine mollusks are well known as hosts of copepod associates. Since Humes (1994) counted 431 species of copepods associated with mollusks, many more species have been recorded. Among the mollusks, the class Pelecypoda is the most preferred host taxon of the copepod associates.

Although the marine bivalve fauna of Japan is well known, knowledge of their copepod associates is quite insufficient (Kim et al., 2004). Mori (1935) probably is the first record in Japan of copepod associated with bivalves, who reported *Mytilicola orientalis* as new species from *Mytilus coruscus* Gould and *Crassostrea gigas* (Thunberg). More than 20 species of copepods associated with bivalves have since been recorded from Japan. While the first author was visiting at the Tohoku University Museum for several months, the authors made several field surveys to collect bivalves and their copepod parasites from tidal flats. The present report deals with the result of these surveys, with a review of previously known copepod parasites of Japanese bivalves. We believe that many more species of bivalve-parasitic copepod are yet to be found and described from Japan. We hope that this report will be helpful to marine biologists in studying this group of copepods.

Material and methods

Copepod specimens examined in this work were collected in 2008 from bivalves caught mainly from several tidal flats in Japan. On the tidal flats the bivalves 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. Some bivalves were also bought from fish markets located near the tidal flats and examined for copepods. Each bivalve was opened and washed, and the washings were filtered through fine mesh net. The copepods were picked from the sediments under a dissecting microscope at a low magnification. Before microscopic observation and dissection, copepod specimens were immersed in lactic acid for about an hour. Dissections were done using the reversed slide method (Humes and Gooding, 1964). All drawings were made with the aid of a camera lucida. In the formula for the armature of legs 1-4 Roman numerals indicate spines and Arabic numerals represent setae. The type specimens of the new species described in the present paper have been deposited in the Tohoku University Museum.

Systematic account

Family Anthessiidae Humes, 1986
Genus *Anthessius* Della Valle, 1880

Anthessius graciliunguis Do and Kajihara, 1984

Previous record in Japan: From *Mytilus galloprovincialis* Lamarck (as *M. edulis galloprovincialis*) at Himeji Harbor, Hyogo Prefecture (Do and Kajihara, 1984); from plankton samples collected in Miike Harbor, Ohmuta, Ariake Bay (Ueda et al., 2006).

Remarks. This species is also known from Korea as a parasite of the bivalves *Patinopecten* (*Mizuchopecten*) *yessoensis* (Jay), *Pecten* (*Notovola*) *albicans albicans* (Schröter) (as *P. albicans*), *Chlamys squamata* (Gmelin) and *Solecurtus divaricatus* (Lischke) (Kim, 1998, 2004). Ueda et al. (2006) reported from plankton samples collected in Ariake Bay and claimed that the specimens reported from scallops in Korea belong to a different species because of differences in the caudal setae and ornamentation of the male maxilliped. A careful examining of the Korean specimens is needed to confirm the contention of Ueda et al.

Anthessius pectinis Tanaka, 1961

Previous record in Japan: From *Pecten* (*Notovola*) *albicans albicans* (Schröter) (as *Pecten laqueatus* Sowerby) at Sasebo Bay (type locality), Nagasaki Prefecture (Tanaka, 1961); from *Pecten* (*Notovola*) *albicans albicans* at Sasebo Bay (Ko et al., 1962).

Remarks. This species needs to be redescribed to make a distinction between it and *A. graciliunguis* both recorded as parasites of *Pecten* (*Notovola*) *albicans albicans.*

Family Clausidiidae Embleton, 1901
Genus *Conchyliurus* Bocquet and Stock, 1957

Conchyliurus quintus Tanaka, 1961

Previous records in Japan: From *Paphia undulata* (Born) and *Ruditapes philippinarum* (Adams and Reeve) (as *Tapes japonica*) at Sakibe (type locality) near Sasebo, Nagasaki Prefecture (Tanaka, 1961); from *Merisca* (*Pistris) capsoides* (Lamarck) (as *Arcopagia diaphana*) and *Cyclina sinensis* (Gmelin) at Hiroshima (Ko et al., 1962); from *Ruditpaes philippinarum* (as *Tapes japonica*) and *Caecella chinensis* Deshayes at Sasebo Bay (Ko et al., 1962); from *Mactra veneriformis* Reeve, *Meretrix lusoria* (Röding), and *Sinonovacula constricta* (Lamarck) at Ariake Bay (Ko et al., 1962); from *Nuttallia japonica* (Deshayes) (as *Soletellina olivacea*) at Hakata Bay (Ko et al., 1962); from *Ruditapes philippinarum* (Adams and Reeve) (as *Tapes philippinarum*) at Sasebo Bay (Ko et al., 1962; Ko, 1969c) and Nagasaki City (Yoshikoshi and Ko, 1974).

Material examined. Four ♀♀ from 3 *Macoma contabulata* (Deshayes), west coast of Hiroura, Natori City, Miyagi Prefecture, collected by S. Sato, 22 May 2008; 6 ♀♀ from 8 *Nuttallia japonica* (Deshayes), Uno-o, Souma City, Fukushima Prefecture (Matsukawa-ura), collected by S. Sato, 4 June 2008; 2 ♀♀ from 7 *Nuttallia japonica*, Gamo, Sendai City, Miyagi Prefecture, collected by S. Sato, 23 May 2008; 8 ♀♀ 8 ♂♂ from more than 30 *Nuttallia japonica*, Gamo, Sendai City, Miyagi Prefecture, collected by I.-H. Kim, 13 Oct. 2008; 2 ♂♂, 8 copepodids from 36 *Macoma contabulata*, Ashizaki, Mutsu City, Aomori Prefecture (Mutsu Bay), collected by I.-H. Kim, 26 October 2008; 1 ♀, 1 copepodid from 3 *Cyclina sinensis* (Gmelin), Ashizaki, City, Aomori Prefecture (Mutsu Bay), collected by S. Sato, 26 October 2008; 4 ♀♀, 1 ♂ from 30 *Ruditapes philippinarum* (Adams and Reeve), Kojiro, Shimabara City, Nagasaki Prefecture, collected by S. Sato, 22 November 2008; 14 ♀♀, 2 ♂♂ from 6 *Mactra veneriformis* Reeve, Kojiro, Shimabara City, Nagasaki Prefecture, collected by S. Sato, 22 November 2008; 14 ♀♀, 19 ♂♂, and 21 copepodids from *Trapezium liratum* (Reeve), mouth of Rokkaku River, Ogi City, Saga Prefecture, collected by I.-H. Kim, 23 November 2008; 1 copepodid V from 5 *Ruditapes philippinarum*, Minami-Arao, Arao City, Kumamoto Prefecture, collected by S. Sato, 24 November 2008; 3 ♀♀, 1 ♂, and 4 copepodids, from 13 *Mactra veneriformis*, Minami-Arao, Arao City, Kumamoto Prefecture, collected by S. Sato, 24 November 2008;

Remarks. Kim (2004) reported 12 species of bivalves from Korea as hosts of this species of copepod. Three species of bivalves are herein added newly as hosts: *Macoma contabulata* (Deshayes), *Nuttallia japonica* (Deshayes), and *Trapezium liratum* (Reeve). Therefore, a total of 15 bivalve species are known to be hosts of *C. quintus*.

Genus *Hyphalion* Humes, 1987

Hyphalion sagamiense Toda, Miura and Nemoto, 1992

Previous record in Japan: From *Calyptogena soyoae* Okutani at a cold seep in the depth of 1170 m in Sagami Bay (Toda et al., 1992)

Family Lichomolgidae Kossmann, 1877
Genus *Herrmannella* Canu, 1891

Herrmannella macomae n. sp. (Figs. 1-3)

Material examined. Seven ♀♀ and 4 ♂♂ collected from washings of 15 *Macoma contabulata* (Deshayes), Ashizaki (41°15′02.3″N, 141°09′18.1″E) (Mutsu Bay), Mutsu City,

Aomori Prefecture, collected by S. Sato, 11 May 2008. Holotype (♀, TUMC-85726), allotype (♂, TUMC-85727), and paratypes (3 ♀♀, 1 ♂, TUMC-85728) have been deposited in the Tohoku University Museum.

Female. Body (Fig. 1A) slender and 1.55 mm (1. 48-1.74 mm) long, excluding caudal setae, based on 6 specimens. Dissected specimen 1.66 mm long. Maximum width 414 µm. Cephalosome demarcated from first pedigerous somite by dorsal furrow, 293×414 µm. Urosome (Fig. 1B) 5-segmented, longer than prosome. Fifth pedigerous somite 160 µm wide. Genital double-somite distinctly longer than wide, 316×182 µm, slightly broadened at portion anterior to genital area. Genital area large and located dorsally in position slightly anterior to midlength of somite. Three abdominal somites longer than wide, 126×102, 105×83, and 100×71 µm, respectively. Caudal ramus (Fig. 1C) 140×29 µm, 4.83 times as long as wide, armed with 1 minute outer proximal setule, 1 seta at place slightly anterior to midlength of outer margin, 1 dorsodistal seta, 1 outer distal seta, and 3 terminal setae; terminal margin ornamented with row of fine spinules; all caudal setae smooth. Egg sac (Fig. 1D) 511 ×195 µm.

Rostrum beak-like and extending to first segement of antenna (Fig. 1E). Antennule (Fig. 1F) 254 µm long and 7-segmented; armature formula 4, 13, 6, 3, 4+aesthetasc, 2+aesthetasc, and 7+aesthetasc; fourth segment thickened subdistally; all setae smooth except for some setae on 3 distal segments. Antenna (Fig. 1G) 4-segmented, with armature formula 1, 1, 3, and 4+claw; second segment ornamented with small spinules on outer margin and proximal portion of inner margin; terminal claw massive and strongly curved distally; terminal segment about 38×27 µm.

Labrum (Fig. 1H) short and broad, with wide median incision; posterior lobes divergent. Mandible (Fig. 2A) with shallow inner proximal notch; distal lash slender and elongate, with 1 row of spinules on both inner and outer (convex) margins and 1 subsidiary row of spinules on proximal half of outer margin. Maxillule (Fig. 2B) armed with 1 lateral setiform process and 2 apical pinnate setae of unequal lengths. Maxilla (Fig. 2C) 2-segmented; robust proximal segment (syncoxa) armed with minute spinules; distal segment (allobasis) with weakly plumose anterior seta (seta II), large inner seta (seta I) armed densely with spinules on outer margin; distal lash heavily armed with spinules. Maxilliped (Fig. 2D) 3-segmented; first segment unarmed; second segment with 2 small, similar setae subdistally; terminal segment small, terminated by nipple-shaped knob, with 1 small subdistal seta.

Legs 1-4 with 3-segmented exopod and endopod. Legs 1-3 with row of spinules on posterior margin of basis (Fig. 2E, F). Outer seta on basis and inner seta on coxa of legs 1-4 plumose (Fig. 2E-G). 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,2,3
Legs 2 & 3: coxa 0-1; basis 1-0; exp. I-0; I-1; III,I,5;
enp. 0-1; 0-2; II,I,3
Leg 4: coxa 0-1; basis 1-0; exp. I-0; I-1; II,I,5;
enp. 0-1; 0-1; II

Third endopodal segment of leg 4 (Fig. 2H) 62×22 µm, with small subdistal cusp on outer margin; two distal spines on this segment 56 (outer) and 81 µm (inner).

Leg 5 represented by free segment and 1 small, naked dorsal seta on fifth pedigerous somite; free segment (Fig. 2I) 41×24 µm, armed with smooth inner spine (75 µm long) and smooth outer seta (41 µm). Leg 6 represented by 1 small seta in genital area (Fig. 1B).

Male. Body (Fig. 3A) slender as in female. Body length of dissected specimen 1.32 mm (other 2 specimens 1.28 and 1.30 mm, respectively). Maximum width 346 µm across cephalothorax. Urosome (Fig. 3B) 6-segemented. Fifth pedigerous somite 117 µm wide. Genital somite 195×205 µm and anteriorly tapering; genital flap ornamented with 2 rows of small spinules (Fig. 3B). Four abdominal somites 94 ×103, 96×88, 79×73, and 73×60 µm, respectively. Caudal ramus 111×24 µm (ratio 4.63+1), with 6 setae.

Antennule different from that of female in bearing 3 additional aesthetascs, 2 on second and 1 on fourth segments. Antenna (Fig. 3C) with scales on proximal half of inner margin of second segment; third segment with 4 setae; fourth segment with claw and 5 setae, two of latters being bifurcated at tip.

Labrum, mandible, maxillule, and maxilla as in female. Maxilliped (Fig. 3D) 4-segmented; first segment (syncoxa) broadest but unarmed; second segment (basis) with pair of small inner setae and longitudinal row of minute spinules on lateral surface; small third segment unarmed; fourth segment forming long claw bearing 2 unequal setae proximally.

Leg 1 with pronounced inner distal process on terminal segment of endopod (Fig. 3E). Legs 2-4 as in female. Free segment of leg 5 (Fig. 3F) small, 26×13 µm (ratio 2.0+1), armed with spear-shaped spine (34 µm) and simple seta (42 µm), both elements naked. Leg 6 represented by 2 small setae and 1 minute cusp on distal part of genital flap (Fig. 3B).

Etymology. The specific name of the new species *macomae* is derived from the generic name of the bivalve host *Macoma*.

Remarks. In the revision of the lichomolgid copepods, Humes and Stock (1973) included 16 species in the key of the genus *Herrmannella*, including *H. perplexa* (Illg, 1949)

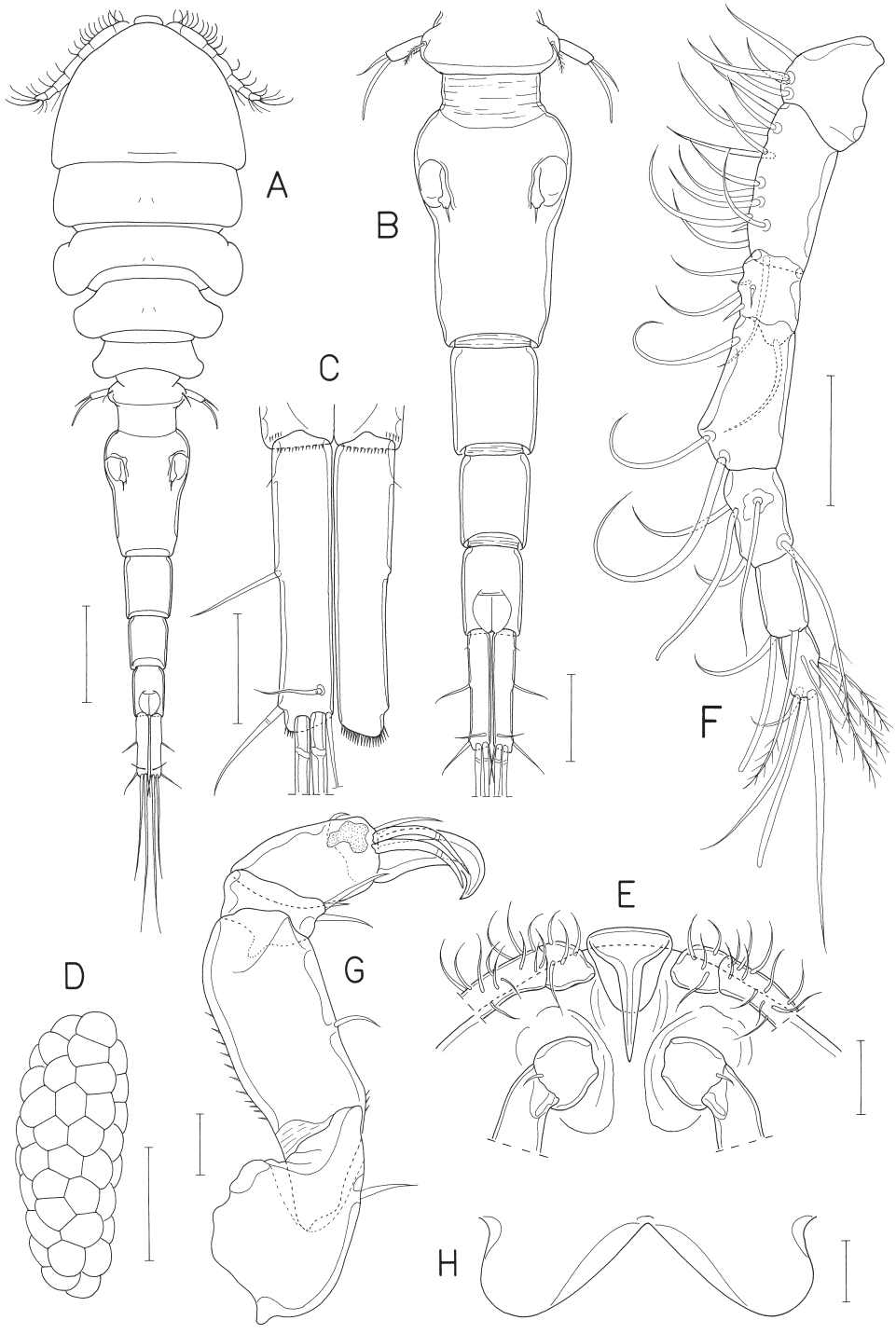

Fig. 1. *Herrmannella macomae* n. sp., female. A, habitus, dorsal; B, urosome, dorsal; C, caudal rami, dorsal; D, egg sac; E, rostral area, ventral; F, antennule; G, antenna; H, labrum. Scales: A, D, 0.2 mm; B, 0.1 mm; C, E, F, 0.05 mm; G, H, 0.02 mm.

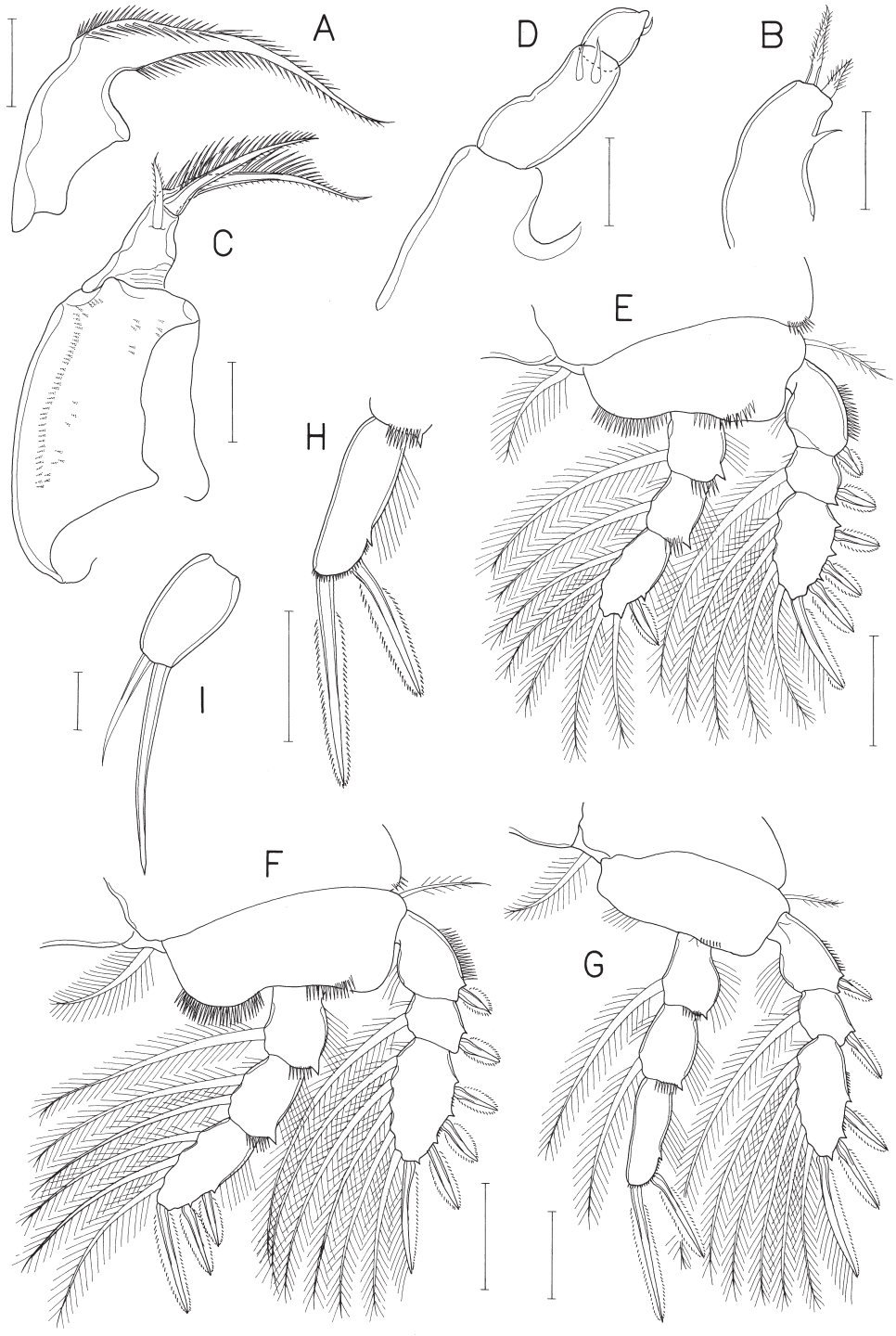

Fig. 2. *Herrmannella macomae* n. sp., female. A, mandible; B, maxillule; C, maxilla; D, maxilliped; E, leg 1; F, leg 2; G, leg 4; H, third endopodal segment of leg 4; I, free segment of leg 5. Scales: A-D, I, 0.02 mm; E-H, 0.05 mm.

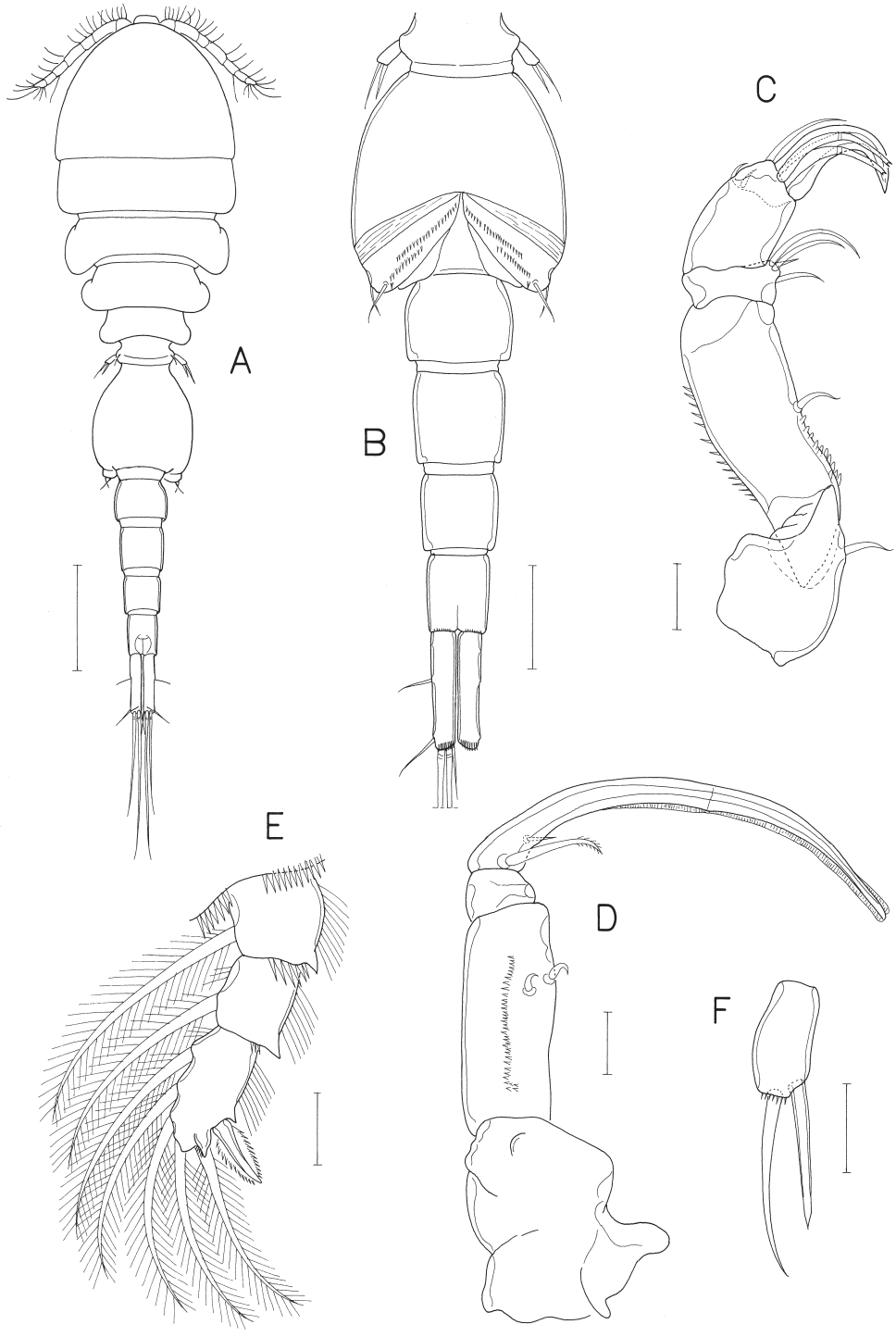

Fig. 3. *Herrmannella macomae* n. sp., male. A, habitus, dorsal; B, urosome, ventral; C, antenna; D, maxilliped; E, endopod of leg 1; F, free segment of leg 5. Scales: A, 0.2 mm; B, 0.1 mm; C-F, 0.02 mm.

and *H. protothacae* (Humes, 1967) both omitted in their species list. Since then nine more species have been added in the genus: *H. longicaudata* Avdeev, 1975; *H. longichaeta* Avdeev, 1975; *H. hiatellai* Avdeev, 1975; *H. dentata* Avdeev, 1987; *H. soleni* Kim and Ho, 1991; *H. duggani* Holmes and Minchin, 1991; *H. hoonsooi* Kim, 1992; *H. exigua* Kim, 1993; and *H. kodiakensis* Humes, 1995. Therefore, a total of 25 species are comparable with *H. macomae* n. sp.

The known species of *Herrmannella* may be grouped by the following diagnostic features:

1) The third exopodal segment of leg 4 bears four spines and five setae (armature formula III, I, 5, rather than II, I, 5): *H. caribaea* (Humes, 1970), *H. dentata*, and *H. dissidens* (Humes, 1970).
2) The rostrum is simple, without beak-like process(es): *H. bullata* Humes and Stock, 1973, *H. inflatipes* (Humes and Cressey, 1958), *H. perplexa, H. mesodesmatis* (Humes, 1967), *H. duggani*, *H. protothacae*, and *H. kodiakensis*.
3) The free segment of leg 5 female bears a prominent proximal swelling: *H. bullata*, *H. inflatipes*, *H. longicaudta*, *H. perplexa*, *H. saxidomi* (Illg, 1949), *H. soleni*, and *H. kodiakensis*.
4) The free segment of female leg 5 is armed with one compound (serrate) spine and one seta: *H. barneae* (Pelseneer, 1929), *H. inflatipes*, *H. mesodesmatis*, *H. duggani*, *H. protothacae*, *H. haploceras* (Bocquet and Stock, 1959), *H. hiatellai*, *H. pecteni* (Sowinski, 1884), and *H. rostrata* Canu, 1881.

Seven species of *Herrmannella* and *H. macomae* n. sp. do not exhibit any of the above characteristics. *H. macomae* can be distinguished from these seven species by the following diagnostic features of its seven congeners.

In *H. columbiae* (Thompson, 1897) the proximal four segments of antennules are markedly swollen, about three times thicker than the distal three segments and the antenna and the free segment of female leg 5 are much more slender than those of *H. macomae*.

In *H. exigua* the caudal ramus is more than six times longer than wide (4.83 times in *H. macomae*) and the third endopodal segment of leg 4 bears two pointed processes on outer margin (one process in *H. macomae*).

In *H. hoonsooi* the prosome is broad and the margins of cephalothorax and the anterior margin of antennules are covered with a hyaline material.

In *H. longichaeta* which is redescribed in the following, there is a claw on ventral surface posterior to the insertion of antennules and the third endopodal segment of leg 4 bears two pointed processes on outer margin.

In *H. panopeae* (Illg, 1949) the caudal ramus is about seven times as long as wide and the third endopodal segment of leg 4 bears three spines.

In *H. tivelae* (Illg, 1949) the caudal ramus is 7.9 times longer than wide (Humes and Stock, 1973) and the antenna is slender, with its second segment being about four times as long as wide, according to Fig. 20g of Humes and Stock (1973) (less than three times as long as wide in *H. macomae*).

In *H. valida* Sars, 1918 the caudal ramus is relatively short, less than twice as long as wide and the third endopodal segment of leg 4 bears no process on the outer margin, according to the illustrations of Sars (1918).

Herrmannella hiatellai Avdeev, 1975

Material examined. One ♀ from washings of 1 *Panopea japonica* A. Adams bought at a fish market in Yanagawa City, Fukuoka Prefecture, collected by I.-H. Kim, 23 November 2008.

Remarks. This species is new to Japan. The type host of this copepod is *Hiatella orientalis* (Yokoyama) (as *Hiatella artica orientalis*) reported from the Peter the Great Bay in Russia (Avdeev, 1975). Kim (1998) also reported this copepod from *Panopea japonica* A. Adams on the Korean coast of the Sea of Japan. As we collected this copepod species in Ariake Bay, off Yanagawa City in Kyushu, it turned out to be a species having a wide distribution from the Siberian coast to the west coast of Kyushu, Japan.

Herrmannella longicaudata Avdeev, 1975

Material examined. Four ♀♀ from 2 *Chlamys* (*Azumapecten*) *farreri farreri* (Jones and Preston), Ashizaki (Mutsu Bay), Mutsu City, Aomori Prefecture, collected by S. Sato, 11 May 2008.

Remarks. Avdeev (1975) recorded originally this species from *Patinopecten* (*Mizuchopecten*) *yessoensis* (Jay) (as *Mizuchopecten yessoensis*) in the Russian coast of the Sea of Japan. Ho and Kim (1991) and Kim (1998) reported this species from Korea as a parasite of *P. yessoensis, Chlamys swifti* (Bernardi) and *C. squamata* (Gmelin). *H. longicaudata* is new to Japan and easily distinguishable by the elongate urosome and the possession of several foliaceous setae on the antennule.

Herrmannella longichaeta Avdeev, 1975 (Figs. 4, 5)

Material examined. One ♀ and 874 copepodids (copepodid III or IV stages) collected from one of 3 *Spisula sachalinensis* (Schrenck) bought at the Aomori fish market by I.-H. Kim, 27

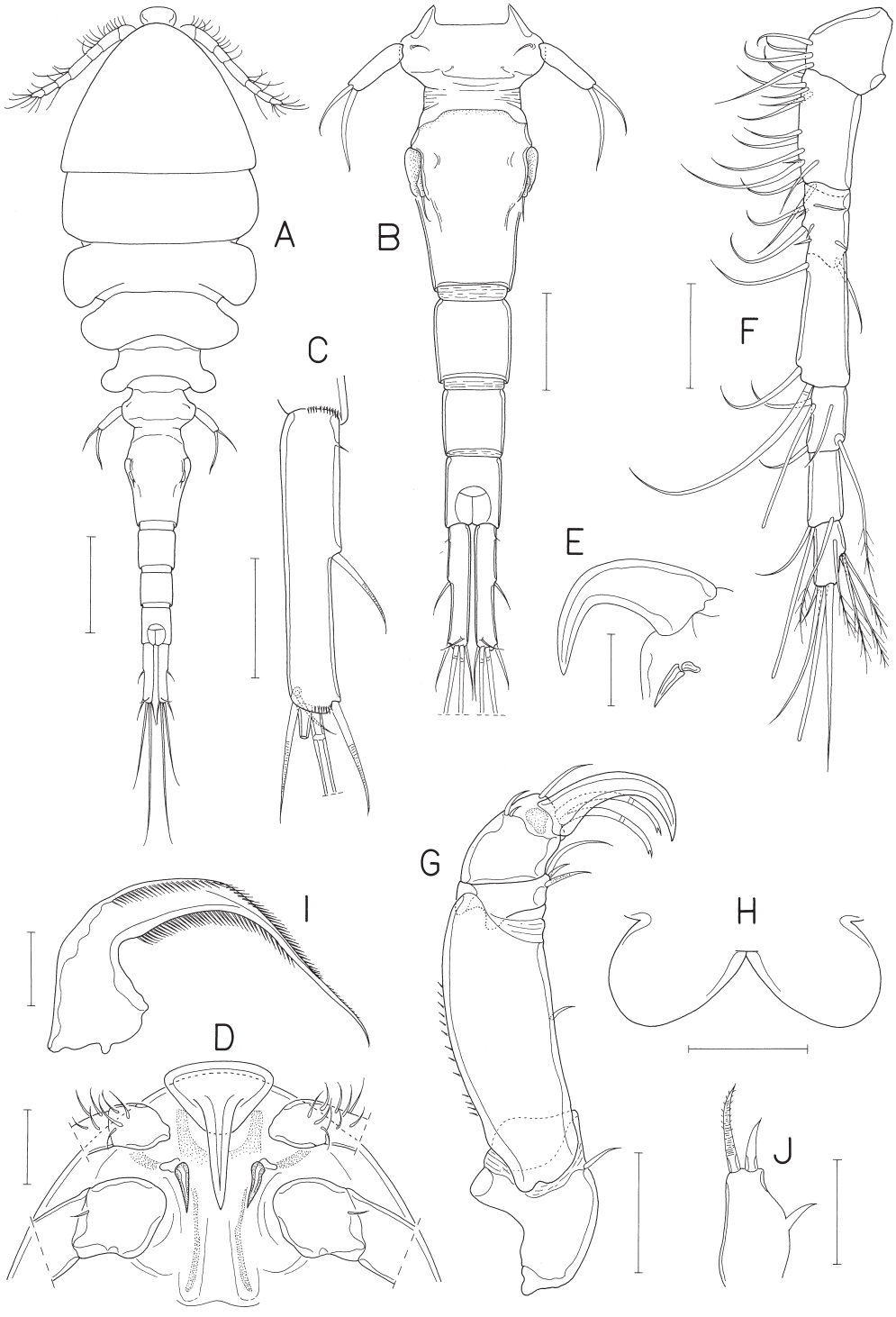

Fig. 4. *Herrmannella longichaeta* Avdeev, female. A, habitus, dorsal; B, urosome, dorsal; C, left caudal ramus, ventral; D, rostral area, ventral; E, rostrum, lateral; F, antennule; G, antenna; H, labrum; I, mandible; J, maxillule. Scales: A, 0.2 mm; B, 0.1 mm; C-H, 0.05 mm; I, J, 0.02 mm.

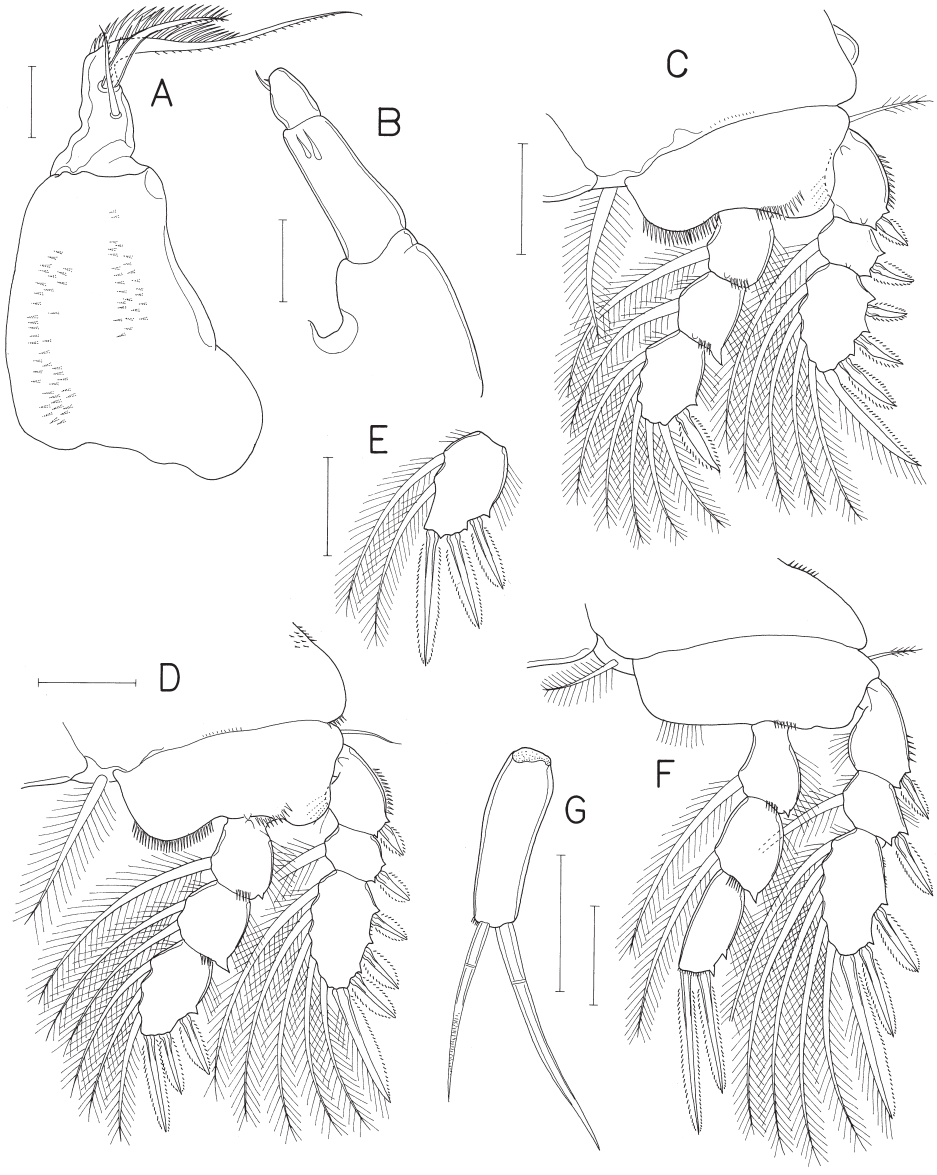

Fig. 5. *Herrmannella longichaeta* Avdeev, female. A, maxilla; B, maxilliped; C, leg 1; D, leg 2; E, third endopodal segment of leg 3; F, leg 4; G, free segment of leg 5. Scales: A, B, 0.02 mm; C-G, 0.05 mm.

October 2008.

Female. Body (Fig. 4A) narrow. Body length 1.43 mm, excluding caudal setae. Maximum width 414 µm. Cephalosome 316 µm long, sub-triangular and clearly demarcated from first pedigerous somite by dorsal furrow. Urosome (Fig. 4B) 5-segmented, slightly shorter than prosome. Fifth pedigerous somite 160 µm wide. Genital double-somite distinctly longer than wide, 218×141 µm, broadest across region of genital areas and gradually narrowed posteriorly. Genital area large and located dorsolaterally in position slightly anterior to midlength of somite. Three abdominal somites longer than wide, 94×81, 71×68, and 75×60 µm, respectively. Caudal ramus (Fig. 4C) 128×25 µm, 5.12 times as long as wide, armed with 1 minute outer proximal setule, 1 seta at midlength of outer margin, 1 dorsodistal seta, and 4 terminal setae; terminal margin ornamented with row of fine spinules; all caudal setae smooth. Egg sac not seen.

Rostrum beak-like and extending to insertion of antenna (Fig. 4D, E). Antennule (Fig. 4F) 280 µm long and

7-segmented, but with incomplete segmentation between third and fourth segments; armature formula 4, 13, 6, 3, 4+aesthetasc, 2+aesthetasc, and 7+aesthetasc; all setae smooth except for some setae on 3 distal segments. Postantennular hook locating between insertions of antennule and antenna (Fig. 4D, E). Antenna (Fig. 4G) 4-segmented, with armature formula 1, 1, 3, and 5+claw; second segment ornamented with small spinules on outer margin; fourth segment short, 41 μm long (average length of outer and inner margins) and 35 μm wide; terminal claw massive; 2 of setae on terminal segment claw-like, weakly bifurcate at tip.

Labrum (Fig. 4H) with rounded lobes and broad median incision. Mandible (Fig. 4I) with shallow inner proximal notch; distal lash slender and elongate, with row of spinules on both margins. Maxillule (Fig. 4J) armed with 1 lateral setiform process and 2 apical setae of unequal lengths. Maxilla (Fig. 5A) 2-segmented; robust proximal segment ornamented with 2 patches of minute spinules; distal segment with anterior seta (seta II) and inner seta (seta I), but proximal seta lacking; distal lash elongate and armed with spinules on proximal half of outer (convex) margin. Maxilliped (Fig. 5B) 3-segmented; first segment unarmed; second segment with 2 small setae subdistally; terminal segment small and blunt, distally with 1 small seta and 1 minute spinule.

Legs 1-4 with 3-segmented exopod and endopod. Legs 1-3 with row of spinules on posterior margin of basis (Fig. 5C, D). 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,2,3
Legs 2 & 3: coxa 0-1; basis 1-0; exp. I-0; I-1; III,I,5;
enp. 0-1; 0-2; I,II,3
Leg 4: coxa 0-1; basis 1-0; exp. I-0; I-1; II,I,5;
enp. 0-1; 0-1; II

Third endopodal segment of leg 4 (Fig. 5F) 52×23 μm, with 2 cusps on outer margin; two distal spines on this segment 63 (outer) and 84 μm (inner).

Leg 5 consisting of free segment and 1 small, naked dorsal seta on fifth pedigerous somite (Fig. 4B); free segment (Fig. 5G) 66×22 μm (ratio 3.0 : 1), with smooth margins and armed with spiniform inner seta (90 μm) and simple outer seta (67 μm). Leg 6 represented by 1 small seta in genital area (Fig. 4B).

Male. Not found in our collection.

Remarks. This species is new to Japan. Avdeev (1975) originally recorded this species from the bivalves *Mactra chinensis* Philippi and *Spisula sachalinensis* (Schrenck) in the Russian coast of the Sea of Japan. Because he briefly described and illustrated this species, the above redescription may be helpful to understand the species in detail. The most significant diagnostic features of this species probably are the possession of the postantennular hook between insertions of the antennule and antenna and a pair of cusp-like processes on the outer margin of the third endopodal segment of leg 4. It is noted that the Avdeev's female specimens were 1.12-1.21 mm in lengths, but our single female was measured as 1.43 mm long.

Our finding of a single adult female with a vast number of copepodid larvae (874 individuals) of similar developmental stages from one of 3 samples of the bivalve *Spisula sachalinensis* may inform the following interesting phenomena: 1) the copepodid larvae are of a same litter; 2) the adult female is the mother of the larvae; 3) and the adult female did a parental care for her offsprings.

Herrmannella soleni Kim and Ho, 1991

Material examined. One ♀, 1 ♂ from 13 *Mactra veneriformis* Reeve, Minami-Arao, Arao City, Kumamoto Prefecture, collected by S. Sato, 24 November 2008; 1♀ from 6 *Mactra veneriformis*, Kojiro, Shimabara City, Nagasaki Prefecture, collected by S. Sato, 22 November 2008.

Remarks: This species is a new record of Japan. In addition to the above bivalve, three other bivalve species *Solen grandis* Dunker, *S. strictus* Gould and *Solecurtus divaricatus* (Lischke) were reported in Korea as hosts of this copepod (Kim and Ho, 1991; Kim, 2004).

Genus *Lichomolgus* Thorell, 1860

Lichomolgus bidentipes Ho, 1980

Previous records in Japan: From *Septifer virgatus* (Wiegmann) at Sirahama, Wakayama Prefecture (Ho, 1980); from *Mytilus galloprovincialis* Lamarck (as *Mytilus edulis galloprovincialis*) from Omura Bay, Nagasaki Prefecture (Do and Kajihara, 1986b).

Material examined. One ♀, 1 copepodid V female from 1 *Modiolus metcalfei* (Hanley), Kojiro, Shimabara City, Nagasaki Prefecture, collected by S. Sato, 22 November 2008; 24 ♀♀, 65 ♂♂ from 30 *Ruditapes philippinarum* (Adams and Reeve), Kojiro, Shimabara City, Nagasaki Prefecture, collected by S. Sato, 22 November 2008; 1 ♂ from 4 *Corbicula japonica* Prime, mouth of Okinohata River, Yanagawa City, Fukuoka Prefecture, collected by S. Sato, 23 November 2008; 1 ♀, 2 ♂♂, and 2 copepodid V from 5 *Ruditapes philippinarum*, Minami-Arao, Arao City, Kumamoto Prefecture, collected by S. Sato, 24 November 2008; 3 ♀♀, 3 ♂♂ from 13 *Mactra veneriformis*, Minami-Arao, Arao City,

Kumamoto Prefecture, collected by S. Sato, 24 November 2008; 15 ♀♀, 8 ♂♂ from 25 *Musculista senhousia* (Benson), Minami-Arao, Arao City, Kumamoto Prefecture, collected by S. Sato, 24 November 2008.

Remarks. Two species of bivalves were previously known as hosts of *Lichomolgus bidentipes*: *Septifer virgatus* (Wiegmann) reported by Ho (1980) from Sado Island, the type locality, and *Mytilus galloprovincialis* Lamarck (as *Mytilus edulis galloprovincialis*) by Do and Kajihara (1986b) from Omura Bay, Nagasaki Prefecture. With the addition in the present report of six more bivalve species as hosts, *L. bidentipes* turned out to be a copepod showing very low host specificity. It is notable that this species may infest to small bivalves such as *Musculista senhousia* which seldom exceeds 2 cm in length.

Lichomilgus inflatus Tanaka, 1961

Previous records in Japan: From *Paphia* sp. at Sasebo Bay (type locality), Nagasaki Prefecture (Tanaka, 1961); from *Pinctada fucata martensii* (Dunker), *Ruditapes philippinarum* (Adams and Reeve) (as *Tapes japonica*) and *Saxidomus purpurata* (Sowerby) at Sasebo Bay (Ko et al., 1962); from *Ruditapes philippinarum* (as *Tapes japonica*) at Sasebo Bay (Ko, 1969c).

Remarks. Kim (2002) redescribed this species based on a single female found in *Phacosoma japonicum* (Reeve) (as *Dosinorbis japonicus*) from southern coast of Korea. Ko et al. (1962) reported this species as a parasite of three species of bivalves and briefly described their specimens. We have examined a vast number of samples of *Ruditapes philippinarum* from various localities in Japan and Korea, but no specimen of *L. inflatus* has been obtained from these clams. Kim (2002) was questionable to the identification of *L. inflatus* by Ko et al., because their description is not for *L. inflatus* but applicable generally to *Herrmannella hoonsooi* Kim, 1992 and because two (*Saxidomus purpurata* and *Ruditapes philippinarum*) of three bivalve species they recorded as hosts are the known hosts of *H. hoonsooi*. Recently we have found that *Tresus keenae* (Kuroda and Habe) is the major bivalve host of *L. inflatus* in Korea.

Lichomolgus sadoensis Ho, 1980

Previous records in Japan: From *Septifer virgatus* (Wiegmann) at Sado Island, Niigata Prefecture (Ho, 1980); from *Mytilus galloprovincialis* Lamarck (as *M. edulis galloprovincialis*) at Sado Island (Do and Kajihara, 1986b).

Remarks. It is notable that Do and Kajihara (1986b) examined more than six thousand samples of *Mytilus galloprovincialis* taken from Kyushu to Hokkaido Islands and extracted copepods from these blue mussels. They found *L. sadoensis* only in the blue mussels collected from Sado Island. This result reveals that *L. sadoensis* has a very limited distribution.

Lichomolgus spondyli Yamaguti, 1936

Previous record: From *Spondylus barbatus* Reeve (as *Spondylus japonicus* Kuroda) from Wakayama Prefecture (exact locality is unknown) (Yamaguti, 1936).

Remarks. This species of copepod has never been rediscovered since the original find. In general figure of body shown by the illustration of Yamaguti (1936), it appears similar to *L. inflatus*.

Genus *Modiolicola* Aurivillius, 1882

Modiolicola bifidus Tanaka, 1961

Previous records in Japan: From *Paphia* sp. at Sasebo Bay (type locality), Nagasaki Prefecture (Tanaka, 1961); from *Ruditapes philippinarum* (Adams and Reeve) (as *Tapes japonica*) at Sakibe, Sasebo Bay (Ko et al., 1962) and Nagasaki City (Yoshikoshi and Ko, 1974); from *Mactra chinensis* Philippi (as *M. sulcataria* Reeve) at Matsubara, Omura Bay (Ko et al., 1962); from *Ruditapes philippinarum* (as *Tapes japonica*) at Sasebo Bay (Ko, 1969c); from *Ruditapes philippinarum* (as *Tapes philippinarum*) at Nagasaki City (Yoshikoshi and Ko, 1974); from *Mytilus galloprovincialis* Lamarck (as *M. edulis galloprovincialis*) at Himeji Harbor, Hyogo Prefecture and Toyo, Ehime Prefecture (Do and Kajihara, 1984, 1986b).

Material examined. One ♀ from 6 *Cyclina sinensis* (Gmelin), Ashizaki (Mutsu Bay), Mutsu City, Aomori Prefecture, collected by S. Sato, 11 May 2008; 15 ♀♀, 8 ♂♂, from 30 *Ruditapes philippinarum* (Adams and Reeve), Ashizaki (Mutsu Bay), Mutsu City, Aomori Prefecture, collected by S. Sato. 11 May 2008; 3 ♀♀ from 30 *Ruditapes philippinarum*, Kojiro, Shimabara City, Nagasaki Prefecture, collected by I.-H. Kim, 22 November 2008; 1 ♀, 4 ♂♂ from 13 *Mactra veneriformis* Reeve, Minami-Arao, Arao City, Kumamoto Prefecture, collected by S. Sato, 24 November 2008; 2 ♀ ♀ from 25 *Musculista senhousia* (Benson), Minami-Arao, Arao City, Kumamoto Prefecture, collected by S. Sato, 24 November 2008.

Remarks. This species is one of the copepods having very low host specificity. Kim (2004) recorded 11 species of bivalves as hosts of this copepod in Korea, not including

Mactra chinensis Philippi recorded by Ko et al. (1962) as host in Japan. We add *Cyclina sinensis* (Gmelin) herein as a new host record.

Modiolicola gracilicaudus Avdeev, 1977

Previous records in Japan: From *Mytilus coruscus* Gould at Sado Island, Niigata Prefecture (Ho, 1980), Obama Bay, Fukui Prefecture and Iwami, Tottori Prefecture (Do and Kajihara, 1986b); *Mytilus galloprovincialis* Lamarck (as *M. edulis galloprovincialis*) at Sado Island, Niigata Prefecture (Do and Kajihara, 1986b).

Remarks. This species infests to three species of mussels: *Crenomytilus grayanus* (Dunker) in the Far Eastern coast of Russia (Avdeev, 1977), *Mytilus coruscus* in Japan and Korea and *M. galloproncialis* in Japan.

Genus *Philoconcha* Yamaguti, 1936

Philoconcha amygdalae Yamaguti, 1936

Previous record in Japan: From *Ruditapes philippinarum* (Adams and Reeve) (as *Venerupis philippinarum*) in Chiba Prefecture (exact type locality is unknown) (Yamaguti, 1936).

Remarks. This species has not been rediscovered since the original description. Yamaguti (1936) did not mention the site of parasitism of this species, but it certainly lived in the pericardium of the host clam.

Philoconcha paphiae Yamaguti, 1936

Previous record in Japan: From *Paphia euglypta* (Philippi) at “Inland Sea” as type locality (probably Seto Inland Sea) (Yamaguti, 1936).

Remarks. Kim (2002) redescribed this species found in the pericardium of *Phacosoma japonicum* (Reeve) (as *Dosinorbis japonicas*) from Korea.

Genus *Paraphiloconcha* Yamaguti, 1936

Paraphiloconcha meretricis Yamaguti, 1936

Previous records in Japan: From *Meretrix lamarckii* Deshayes from the Sea of Japan (exact locality is unknown) (Yamaguti, 1936); from the same bivalve species at Oharai, Ibaraki Prefecture (Kim et al., 2004).

Remarks. Kim et al. (2004) redescribed this species based on three females and seven males found in the pericardium of one individual of *Meretrix lamarckii*.

Family Myicolidae Yamaguti, 1936
Genus *Myicola* Wright, 1885

Myicola ostreae Hoshina and Sugiura, 1953

Previous records in Japan: From *Crassostrea gigas* (Thunberg) (as *Ostrea gigas*) at Yawata (type locality), Chiba Prefecture (Hoshina and Sugiura, 1953); from the same bivalve species at Tsushima Island, Nagasaki Prefecture (Tanaka, 1961).

Remarks. In Korea, this species was found also from *Sinonovacula constricta* (Lamarck) (Kim, 2004).

Myicola gamoensis n. sp. (Figs. 6-8)

Material examined. Five ♀♀ from gut of about 60 *Laternula* (*Exolaternula*) *marilina* (Reeve), tidal flat in mouth of Nanakita River (38°15′11.4″N, 141°00′36.6″E), Gamo, Sendai City, Miyagi Prefecture, collected by I.-H. Kim, 13 November 2008. Holotype (♀, TUMC-85729) and paratypes (3 ♀♀, TUMC-85730) have been deposited in the Tohoku University Museum. One dissected paratype (♀) is retained in the collection of I.-H. Kim.

Other material examined. One ♀ (dissected) from gut of 3 *Laternula* (*Exolaternula*) *marilina*, west coast of Hiroura, Natori City, Miyagi Prefecture, collected by S. Sato, 22 May 2008; 3 ♀♀ (1 ♀ dissected) from gut of 15 *Laternula* (*Exolaternula*) *marilina*, Gamo, Sendai City, Miyagi Prefecture, collected by I.-H. Kim, 13 October 2008.

Female. Body (Fig. 6A) cyclopiform. Total length 1.35 mm, excluding caudal seta, in dissected paratype. Prosome 808 μm long. Cephalothorax clearly divided in dorsal view into cephalosome and first pedigerous somite. Cephalosome 271×402 μm. Second and third pedigerous somites with rudimentary dorsal tergite narrower than somite. Urosome (Fig. 6B) 5-segmented and occupying 40% of whole body length. Fifth pedigerous somite 145 μm wide. Genital double-somite 179×160 μm, bearing 3 rows of spinules on ventral surface (Fig. 6C). Genital areas located dorsally. Three abdominal somites 75×98, 56×82, and 62×77 μm, respectively. Proximal 2 abdominal somites with transverse row of spinules on ventral surface near posterior border. Anal somite with several spinules on posteroventral area near base of caudal ramus. Caudal rami widely separated from each other. Each ramus (Fig. 6D) 102×20 μm (ratio 5.10 : 1), tapering, with 6 naked setae; proximal seta located at 30% length of outer margin; 3 terminal setae much shorter than caudal ramus, 57, 16, and 14 μm, respectively.

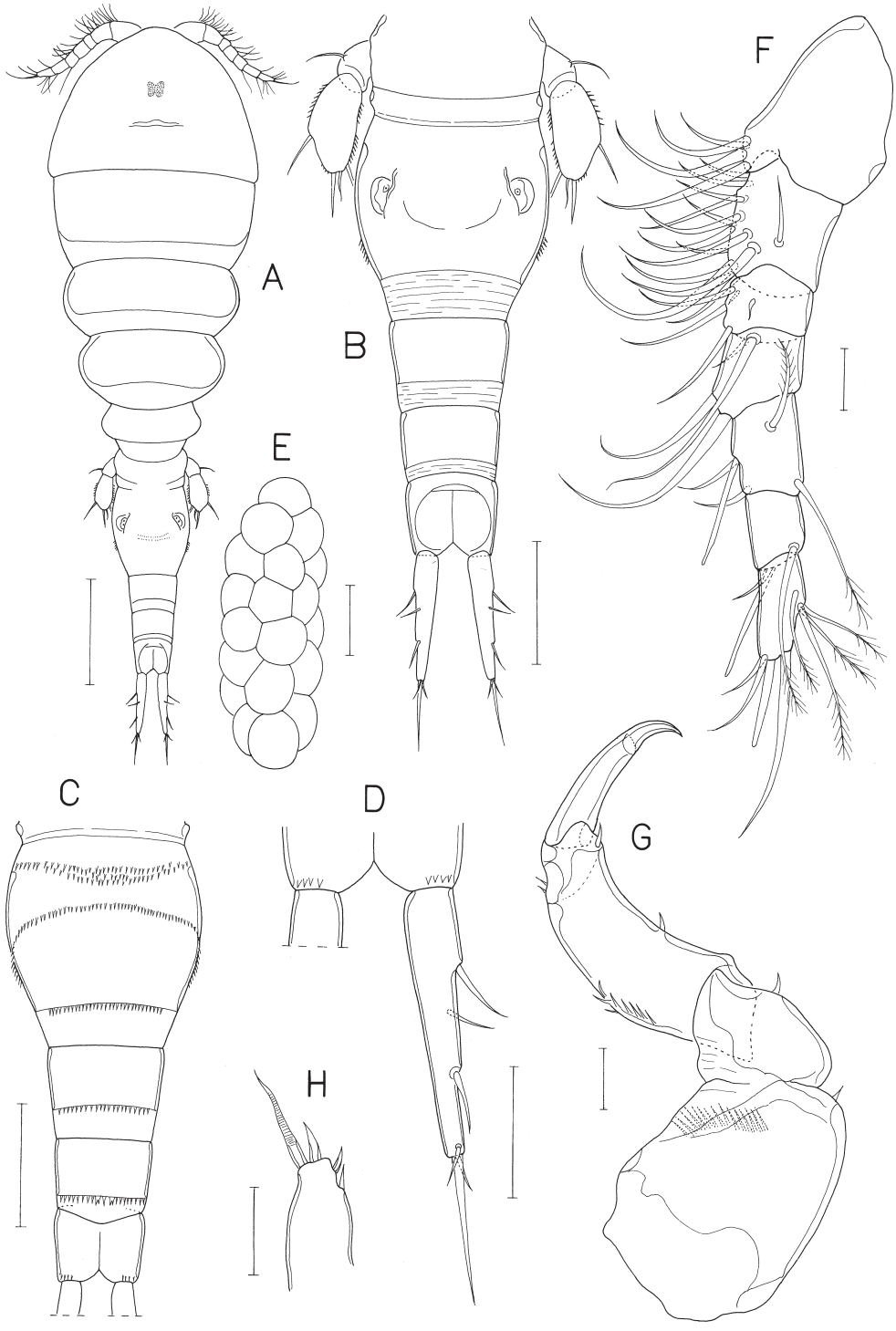

Fig. 6. *Myicola gamoensis* n. sp., female. A, habitus, dorsal; B, urosome, dorsal; C, genital double-somite and abdomen, ventral; D, right caudal ramus, dorsal; E, egg sac; F, antennule; G, antenna; H, maxillule. Scales: A, E, 0.2 mm; B, C, 0.1 mm; D, 0.05 mm; F-H, 0.02 mm.

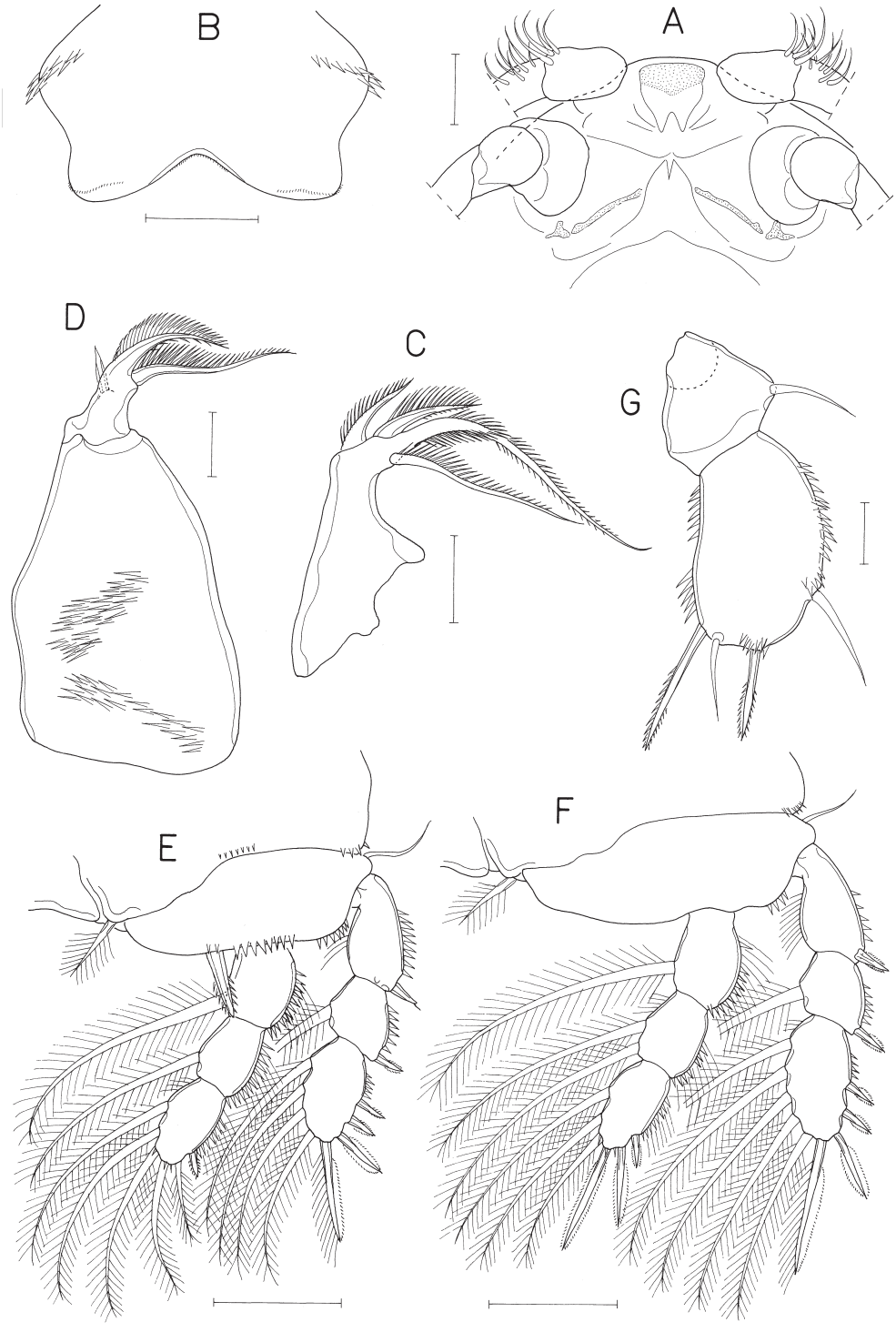

Fig. 7. *Myicola gamoensis* n. sp., female. A, rostral area, ventral; B, labrum; C, mandible; D, maxilla; E, leg 1; F, leg 2; G, leg 5. Scales: A, B, E, F, 0.05 mm; C, D, G, 0.02 mm.

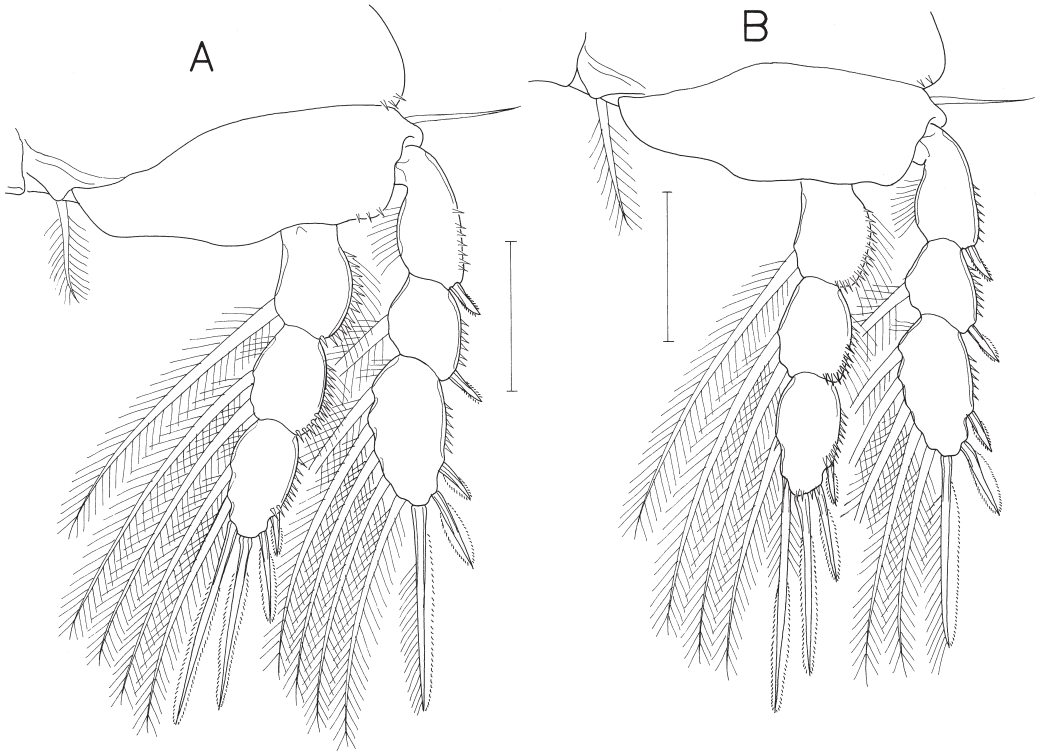

Fig. 8. *Myicola gamoensis* n. sp., female. A, leg 3; B, leg 4. Scales: A, B, 0.05 mm.

Egg sac (Fig. 6E) with multiseriate eggs, containing about 25 eggs. Each egg about 150 µm in diameter.

Rostrum appearing as faint sclerotization (Fig. 7A). Antennule (Fig. 6F) 212 µm long and 7-segmented, with armature formula: 4, 14, 6, 3, 4+aesthetasc, 2+aesthetasc, and 7+aesthetasc. Several setae on distal 3 segments plumose, other setae naked. Antenna (Fig. 6G) 3-segmented. First segment massive, distally with transverse row of spinules and 1 small inner distal seta. Second segment with 1 small inner seta. Third segment 77 µm long (average length of inner and outer margins) and 31 µm wide (ratio 2.48 : 1), with several spinules on outer margin and 4 small setae (1 near midway of inner margin, 1 inner distal, and 2 outer distal). Terminal claw stong and 55 µm long.

Labrum (Fig. 7A) broad, with wide but shallow posterior incision. Mandible (Fig. 7C) terminated by long spiniferous lash, with 2 plate-like elements and 1 elongate seta. Maxillule (Fig. 6H) armed with 4 unequal setae. Maxilla (Fig. 7D) 2-segmented. First segment large, with 2 patches of spinules on ventral surface. Second segment with small, naked anterior seta, and inner seta bearing spinules on distal margin. Distal lash spiniferous and distinctly shorter than inner seta. Maxilliped lacking.

Legs 1-4 (Figs. 7E, F, 8A, B) biramous with 3-segmented rami. Outer margin of both rami of legs 1-4 bearing spinules. Armature formula of these legs as follows:

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

Leg 5 (Fig. 7G) 2-segmented. Proximal segment with 1 outer naked seta. Distal segment 71×43 µm (ratio 1.65 : 1), with 2 spines and 2 naked setae and spinules on slightly concave inner margin and convex outer margin. Longest inner spine 45 µm, inner seta 27 µm, median terminal spine 30 µm, and outer seta 36 µm. Leg 6 not discernible.

Male. Unknown.

Etymology. This species is named after the type locality, Gamo, a tidal flat located in Sendai City.

Remarks. Four species are currently known in the genus *Myicola*: *M. formosanus* Lin and Ho, 1999 from Taiwan, *M. intumidus* Kim, 1997 from Korea, *M. metisiensis* Wright, 1885 from the Atlantic coast of North America, and *M. ostreae* Hoshina and Sugiura, 1953 from Japan and Korea. With an uninflated body in the female, the *M. gamoensis* n. sp. is easily distinguishable from *M. metisiensis* and *M. ostreae* both having an inflated, vermiform body. However, a careful comparison is needed to distinguish *M. formosanus*, *M. intumidus*, and the new species.

To distinguish *M. formosanus* from *M. intumidus*, Lin and Ho (1999) selected five characters, four of them are of the female as follows: 1) the female urosome occupies 0.29 of body length in *M. intumidus* and 0.42 in *M. formosanus* (0.40 in *M. gamoensis*), 2) the number of eggs in an egg sac is about 30 in *M. intumidus* and less than 12 in *M. formosanus* (about 25 in *M. gamoensis*), 3) the median (inner) spine on the female leg 5 is distinctly shorter than ramus in *M. intumidus* and about as long as ramus in *M. formosanus* (distinctly shorter than ramus in *M. gamoensis*), and 4) the caudal ramus in the female is 3.91 times longer than wide in *M. intumidus* and 4.92 times longer than wide in *M. formosanus* (5.10 times in *M. gamoensis*).

Myicola gamoensis appears to be an intermediate morphological state of *M. intumidus* and *M. formosanus*, because, as above, in the first and last characters *M. gamogenesis* is closer to *M. formosanus*, whereas in the second and third characters it is closer to *M. intumidus*. However, *M. gamoensis* exhibits other obvious differences from the two relatives: the maxillule is armed with four setae (three in *M. intumidus* and *M. formosanus*) and the free segment of female leg 5 bears spinules on both inner and outer margins (spinules only on inner margin in the two species, as shown in the original descriptions by Kim, 1997 and Lin and Ho, 1999).

Genus *Ostrincola* Wilson, 1944

Ostrincola japonica Tanaka, 1961

Previous records in Japan: From *Saccostrea kegaki* Torigoe and Inaba (as *Ostrea echinata* (Quoy and Gaimard)) at Sasebo, Nagasaki Prefecture (Tanaka, 1961); from *Crassostrea gigas* (Thunberg) at Hiroshima and *Saccostrea kegaki* (as *S. echinata*) at Sakibe, Sasebo Bay (Ko et al., 1962).

Material examined. One ♀ from 10 *Crassostrea gigas*, Onagawa Port, Miyagi Prefecture, collected by I.-H. Kim, 30 November 2008.

Remarks. This species is an oyster parasite. In Korea, it has been found only from *Ostrea densellamellosa* Lischke which is considered to be the major host of this copepod.

Ostrincola koe Tanaka, 1961

Previous records in Japan: From *Paphia undulata* (Born) at Sakibe (type locality) near Sasebo, Nagasaki Prefecture, and from *Paphia* sp. at Tsuyazaki, Fukutsu City, Fukuoka Prefecture (Tanaka, 1961); from *Merisca* (*Pistris) capsoides* (Lamarck) (as *Arcopagia diaphana*), *Cyclina sinensis* (Gmelin) at Hiroshima (Ko et al., 1962); from *Ruditapes philippinarum* (as *Tapes japonica*), *Caecella chinensis* Deshayes and *Claudiconcha japonica* (Dunker) at Sasebo Bay (Ko et al., 1962); from *Mactra veneriformis* Reeve and *Meretrix lusoria* (Röding) at Ariake Bay (Ko et al., 1962); from *Ruditapes philippinarum* (as *Tapes philippinarum*) at Nagasaki City (Yoshikoshi and Ko, 1974); from *Ruditapes philippinarum* (as *Tapes japonica*) at Nagasaki City (Ko, 1969a, 1969d, Ko et al., 1974) and at Sasebo Bay (Ko, 1969b, 1969c); from *Ruditapes philippinarum* (as *Tapes philippinarum*) at Nagasaki City (Ko and Yoshikoshi, 1974a, 1974b; Yoshikoshi and Ko, 1974).

Material examined. Six ♀♀, 2 ♂♂ from 5 *Ruditapes philippinarum* (Adams and Reeve), Minami-Arao, Arao City, Kumamoto Prefecture, collected by S. Sato, 24 November 2008; 7 ♀♀, 5 ♂♂ and 3 copepodids from 13 *Mactra veneriformis* Reeve, Minami-Arao, Arao City, Kumamoto Prefecture, collected by S. Sato, 24 November 2008; 1 ♀ from 1 small individual of *Meretrix lusoria* (Röding), Minami-Arao, Arao City, Kumamoto Prefecture, collected by S. Sato, 24 November 2008.

Remarks. This species is one of the most prevalent copepod parasites of bivalves in the Far East. It was responsible for the mass mortality of the *Meretrix meretrix* (Linnaeus) cultured in the vicinity of Yangze River estuary, China (Ho and Zheng, 1994). In 2002, the first author learned from a Chinese fisheries biologist that the mass mortality of the clams in Yangze River estuary had occurred once in every four years. The known hosts of *O. koe* are 15 species of bivalves, as follows:

Barnea dilatata (Souleyet) in Korea; *Barnea manilensis* (Philippi) in Korea; *Caecella chinensis* Deshayes in Japan; *Claudiconcha japonica* (Dunker) in Japan; *Cryptomya busoensis* Yokoyama in Korea; *Cyclina sinensis* (Gmelin) in Korea; *Mactra veneriformis* Reeve in Japan and Korea; *Meretrix lusoria* (Röding) in Japan and Korea; *Meretrix meretrix* (Linnaeus) in China; *Paphia undulata* (Born) in Japan; *Merisca* (*Pistris) capsoides* (Lamarck) in Japan; *Ruditapes philippinarum* (Adams and Reeve) in Japan and Korea; *Sinonovacula constricta* (Lamarck) in Korea; *Solen grandis* Dunker in Korea; and *Solen strictus* Gould in Korea.

Genus *Pseudomyicola* Yamaguti, 1936

Pseudomyicola spinosus (Rafaele and Monticelli, 1885)

Previous records in Japan: From *Ostrea denselamellosa* Lischke at Hutami, Hyogo Prefecture (Yamaguti, 1936, as *Pseudomyicola ostreae* n. gen. n. sp.); from *Laternula* (*Exolaternula*) *marilina* (Reeve) (as *L. kamakurana* Pilsbry) at Kanazawa Bay (Hoshina and Sugiura, 1953, as *P. ostreae*); from *Mytilus galloprovincialis* Lamarck (as *M. edulis galloprovincialis*) in Tokyo Bay (Nakamura and Kajihara, 1979; Nakamura et al., 1979; Kajihara et al., 1980; Do et al., 1984; Kajihara and Nakamura, 1985; Do and Kajihara, 1986a); from the same bivalve species (as *M. edulis*) at Sado Island in Niigata Prefecture, Suzu City in Ishikawa Prefecture, and Tokyo Bay near Yokohama (Ho, 1980) and various localities from west coast of Hokkaido to Kyushu (Do and Kajihara, 1986b); from *Septifer virgatus* (Wiegmann) at Sirahama, Wakayama Prefecture (Ho, 1980); from *Modiolus kurilensis* Bernard (as *M. difficilis* (Kuroda and Habe)) from Pacific coast of Aomori Prefecture (Do and Kajihara, 1986b).

Material examined. Ten ♀♀, 4 ♂♂ from 3 *Ostrea denselamellosa* Lischke, Ashizaki (Mutsu Bay), Mutsu City, Aomori Prefecture, collected by S. Sato, 11 May 2008; 11 ♀♀, 6 ♂♂ from 4 *Mytilus galloprovincialis* Lamarck, Ashizaki, Mutsu City, Aomori Prefecture, collected by S. Sato, 11 May 2008; 2 ♀♀ from 5 *Mytilus galloprovincialis* Lamarck, Uno-o (Matsukawa-ura), Souma City, Fukushima Prefecture, collected by S. Sato, 4 June 2008.

Remarks. *Pseudomyicola spinosus* is not a host specific parasite. Ho (1992) listed 51 species of bivalves in the world as hosts of this copepod. Do et al. (1984) and Do and Kajihara (1986b) studied very intensively about the biology of this cosmopolitan species.

Family Mytilicolidae Bocquet and Stock, 1957Genus *Mytilicola* Steuer, 1902

Mytilicola orientalis Mori, 1935

Previous records in Japan: From *Mytilus coruscus* Gould (as *Mytilus crassitesta* Lischke) and *Crassostrea gigas* (Thunberg) (as *Ostrea gigas* Thunberg) at “Inland Sea” (probably Seto Inland Sea) (Mori, 1935); from *Mytilus galloprovincialis* Lamarck (as *M. edulis galloprovincialis*) at Hiwasa, Tokushima Prefecture (Do and Kajihara, 1986b).

Remarks. *Mytilicola orientalis* has been accidently introduced to Europe and the Pacific coast of North Amereca, along with the oyster *Crassostrea gigas* transplanted from Japan. It is considered a serious pest of native bivalves of received regions (Torchin et al, 2002).

Mytilicola mactrae Hoshina and Kuwabara, 1959

Previous record in Japan: From *Mactra veneriformis* Reeve at Kisarazu, Chiba Prefecture (Hoshina and Kuwabara, 1959).

Remarks. This species can be clearly separated by the presence of a pair of dorsolateral processes on the cephalothorax in the female (Do and Kajihara, 1986b).

Genus *Pectenophilus* Nagasawa, Bresciani and Lützen, 1988

Pectenophilus ornatus Nagasawa, Bresciani and Lützen, 1988

Previous records: From *Patinopecten* (*Mizuchopecten*) *yessoensis* (Jay) from southern coast of Hokkaido and northern coast of Honshu (Nagasawa et al., 1988, 1991, 1993; Nagasawa and Nagata, 1992); from *Chlamys farreri nipponensis* Kuroda from southern coast of Hokkaido (Nagasawa et al., 1993).

Remarks. The familial position of *Pectenophilus* had not been determined until Huys et al. (2006) have shown a molecular evidence that it belongs to the family Mytilicolidae. This copepod species is a pest of the commercially important bivalve *Patinopecten* (*Mizuchopecten*) *yessoensis* in the northern coasts of Japan.

Genus *Trochicola* Dollfus, 1914

Trochicola japonica Shimura and Kuwabara, 1984 (Figs. 9, 10)

Previous record in Japan: From *Ruditapes philippinarum* (Adams and Reeve) (as *Tapes phillipinarum*) at Lake Hamana (type locality), Shizuoka Prefecture (Shimura and Kuwabara, 1984).

Material examined. One ♂ from gut of 30 *Ruditapes philippinarum*, Ashizaki (Mutsu Bay), Mutsu City, Aomori Prefecture, collected by S. Sato, 11 May 2008; 1 ♂ from 13 *Ruditapes philippinarum*, Hatsutsu-ura, Miyatojima, Higashi-Matsushima City, Miyagi Prefecture, collected by S. Sato, 21 May 2008.

Male. Body (Fig. 9A) cylindrical and 1.36 mm long. Prosome well-segmented, consisting of cephalosome and first to fourth pedigerous somite. Prosomal somites

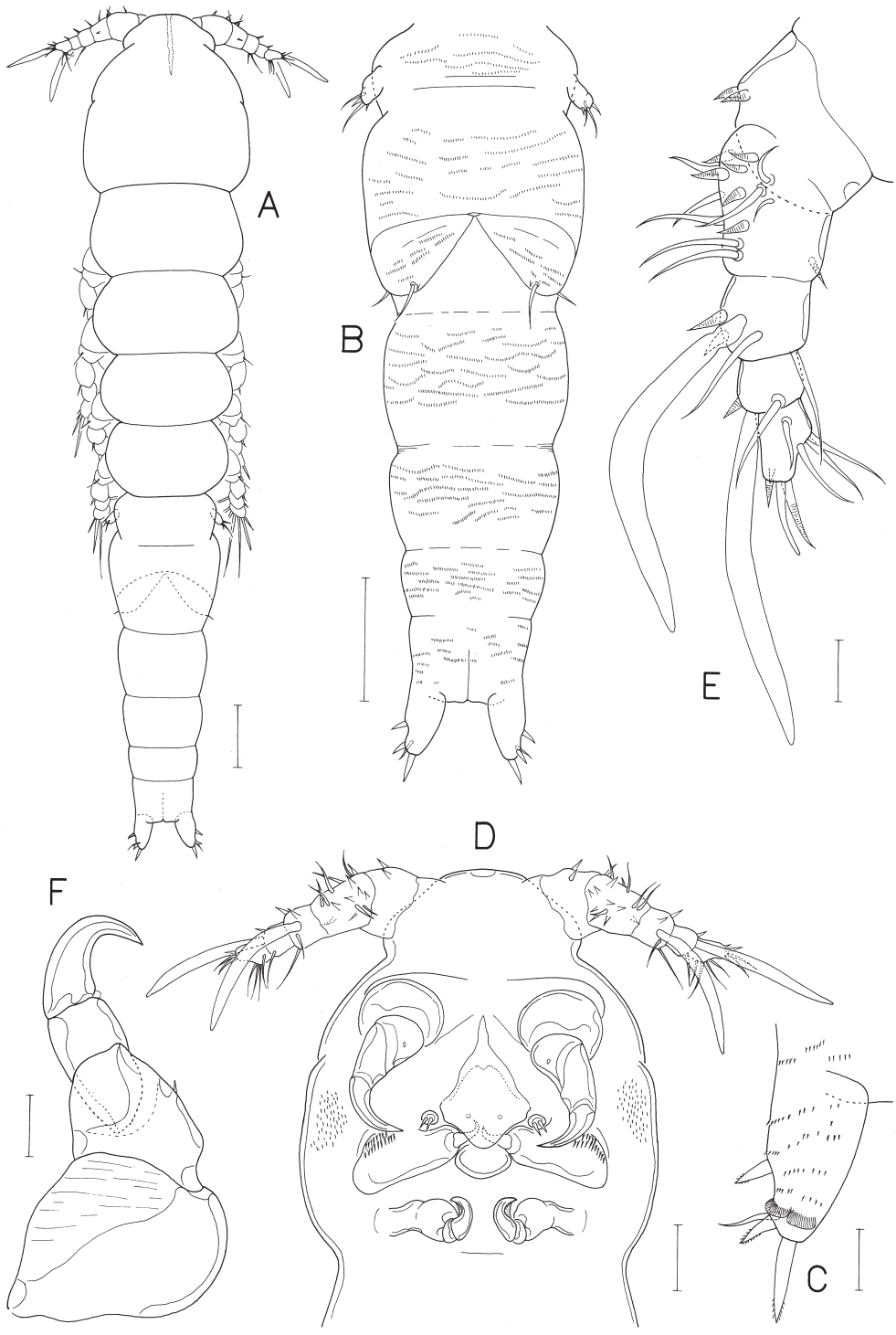

Fig. 9. *Trochicola japonicus* Shimura and Kuwabara, male. A, habitus, dorsal; B, urosome, ventral; C, cephalosome, ventral; D, right caudal ramus, dorsal; E, antennule; F, antenna. Scales: A, B, 0.1 mm; C, E, F, 0.02 mm; D, 0.05 mm.

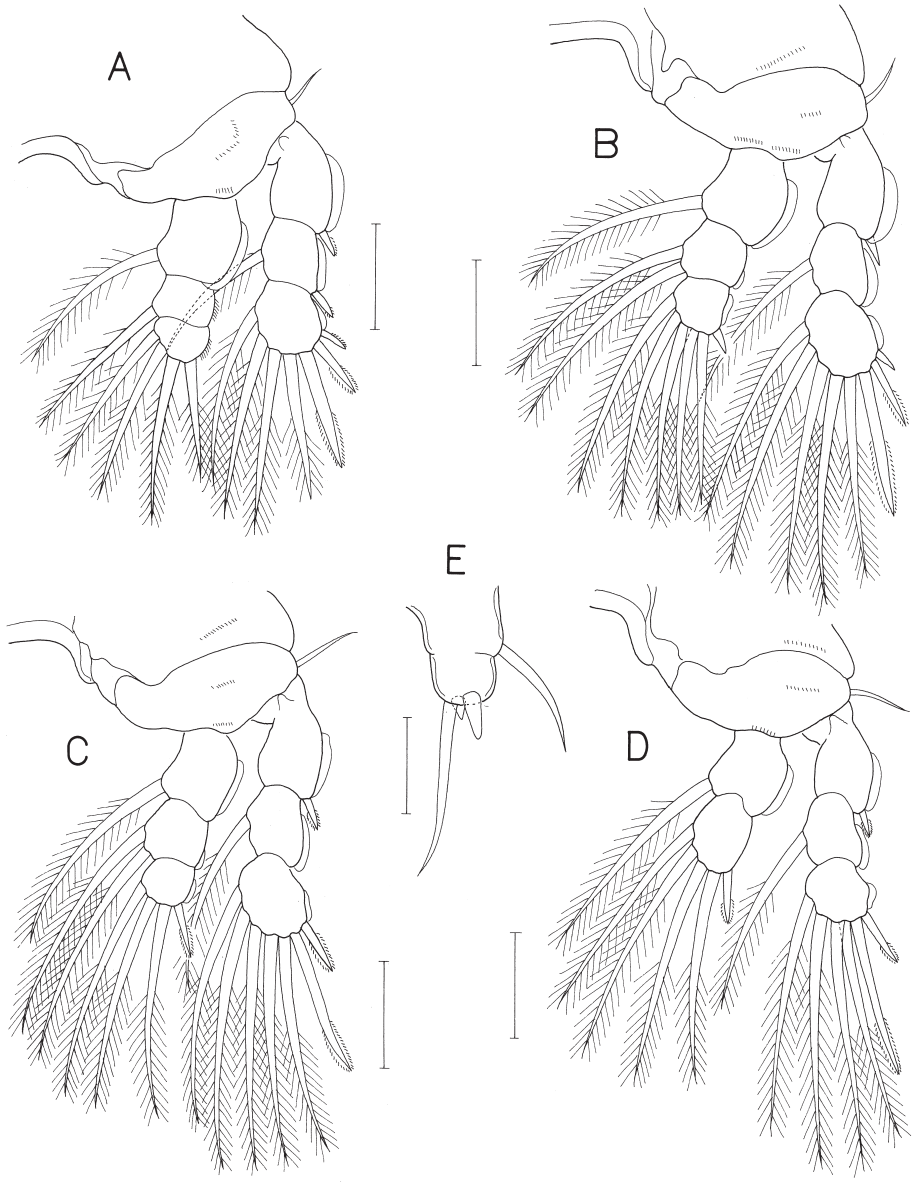

Fig. 10. *Trochicola japonicus* Shimura and Kuwabara, male. A, leg 1; B, leg 2; C, leg 3; D, leg 4; E, leg 5. Scales: A-D, 0.05 mm; E, 0.02 mm.

gradually shorter and narrower from anterior to posterior. Cephalosome 274×271 μm. Rostral area pronounced anteriorly. Urosome (Fig. 9B) 6-segmented; suture lines indistinct, but each segments distinctly recognizable by lateral constrictions. Urosomal somites ornamented by many transverse rows of minute spinules on all surfaces. Fifth pedigerous somite 169 μm wide. Genital somite 165×182 μm. Four abdominal somites 113×150, 86×138, 55×118, and 70×100 μm, respectively. Caudal rami slightly divergent, 56 ×32 μm (ratio 1.75 : 1), armed with 1 simple seta, 3 thick, spiniform setae, 2 membraneous flaps, and ornamented with rows of minute spinules (Fig. 9C).

Rostrum absent (Fig. 9D). Antennule (Fig. 9E) 147 μm long and 5-segmented, with armature formula 2, 15, 4+aesthetasc, 2+aesthetasc, and 7+aesthetasc. Aesthetascs on third and fourth segments enlarged. Antenna (Fig. 9F) 3-segmented. First and third segments unarmed. Second segment with small seta on inner margin. Terminal claw strong and markedly curved.

Labrum with convex posterior margin (Fig. 9D). Mandible absent. Maxillule lobate and armed with 2 apical setae. Maxilla 2-segmented. Proximal segment large, with patch

of spinules on anteroventral surface. Distal segment small and tapering, with serrated posterior margin. Maxilliped rudimentary, consisting of 2 unarmed segments and terminal claw. Proximal segment broadened distally. Distal segment short. Terminal claw strongly curved, with membrane along concave margin. Spermatophore 177×70 μm.

Legs 1-3 (Fig. 10A-C) with 3-segmented rami. Leg 4 (Fig. 10D) with 3-segmented exopod and 2-segmented endopod. Exopod of legs 1-4 with membrane along outer margin. Outer margin of endopodal segments also with membrane except for second and third segments of leg 1 and distal segment of leg 4. 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; 0-1; 4
Leg 2: coxa 0-0; basis 1-0; exp. I-0; 0-1; II,I,5;
enp. 0-1; 0-2; I,5
Leg 3: coxa 0-0; basis 1-0; exp. I-0; 0-1; I,I,5;
enp. 0-1; 0-2; I,3
Leg 4: coxa 0-0; basis 1-0; exp. I-0; 0-1; I,I,4;
enp. 0-1; I,4

Leg 5 obscurely 2-segmented. Proximal segment with outer seta. Distal segment armed with 2 short and 1 longer setae. Leg 6 represented by 2 setae and 1 minute spinule on posterior part of genital flap.

Female. Not discovered in our collection.

Remarks. Our male specimens exhibit some differences from the original description of Shimura and Kuwabara (1984) as follows: 1) The third exopodal segment of leg 1 is armed with seven elements (armature formula II, I, 4) instead of eight elements (III, 5); 2) the endopod of leg 4 is two-segmented instead of three-segmented condition; 3) the caudal ramus bears a pair of membranes in addition to the four setae; and 4) leg 5 is indistinctly segmented.

Although Shimura and Kuwabara did not mentioned the variability of *Trochicola japonicus*, we consider the above differences are variations within a species or artifacts, because the type specimens and our male specimens reveal similarities in many important characters as follows: 1) legs 2-4 lack an outer spine on the second exopodal segment; 2) the distal segment of leg 5 is armed with three setae; 3) the shape and size of caudal ramus are same between the type specimens and our specimens; 4) the body lengths are not different between them; and finally 5) they were found from the same species of bivalve host.

Genus *Piratasta* Leigh-Sharpe, 1934

Piratasta brachidontis Yamaguti, 1939

Previous record: From *Musculista senhousia* (Benson) (as *Brachiodontes senhausi* (Reeve)) at Lake Hamana, Shizuoka Prefecture (Yamaguti, 1939).

Remarks. The Lake Hamana is the type locality of both *Piratasta brachidontis* Yamaguti, 1939 and *Trochicola japonica* Shimura and Kuwabara, 1984. The genera of the family Mytilicolidae can barely be distinguishable by female morphological traits. For example, the genera *Myticlicola* and *Trochicola* can only be separated by morphological differences of male legs. The genus *Piratasta* is poorly known, without a record for the male. Thus Boxshall and Halsey (2004) could not distinguish *Piratasta* from the type genus *Mytilicola*. It is conceivable that *Piratasta brachiodontis* is synonymous with *Trochicola japonica*, both recorded from the same place.

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