

Title	Poecilostomatoid Copepods Parasitic in Bivalve Mollusks of Taiwan
Author(s)	Lin, Ching-Long; Ho, Ju-Shey
Citation	PUBLICATIONS OF THE SETO MARINE BIOLOGICAL LABORATORY (1999), 38(5-6): 201-218
Issue Date	1999-09-30
URL	<a href="http://hdl.handle.net/2433/176288">http://hdl.handle.net/2433/176288</a>
Right	
Type	Departmental Bulletin Paper
Textversion	publisher

## Poecilostomatoid Copepods Parasitic in Bivalve Mollusks of Taiwan

CHING-LONG LIN<sup>1)</sup> and JU-SHEY HO<sup>2)</sup>

<sup>1)</sup>Department of Aquaculture, National Chiayi Institute of Technology,  
Chiayi 60083, Taiwan

<sup>2)</sup>Department of Biological Sciences, California State University,  
Long Beach, California 90840-3702, U.S.A.

**Abstract** Three species of poecilostomatoid copepods parasitic in bivalve mollusks of Taiwan were described. They are: *Ostrincola similis* sp. nov. from the cultured oyster, *Crassostrea gigas* (Thunberg), and green mussel, *Perna viridis* (Linnaeus), attached to this species of oyster; *Mycicola formosanus* sp. nov. from the circular clam, *Cyclina sinensis* (Gmelin); and *Anthessius mytilicolus* Reddiah, 1966 from the green mussels attached to the cultured *C. gigas*. This is the first report of parasitic copepods from the bivalve mollusks of Taiwan.

**Key words:** parasitic copepods, Poecilostomatoida, Myicolidae, Anthessiidae, bivalve mollusks, Taiwan

### Introduction

Although the culture of bivalve mollusks has been in practice for more than a century in Taiwan, their parasitic copepods have not been studied in the past. However, knowing parasitic copepods can cause mass mortality of clams in culture (Ho, 1996), study of them has become more necessary.

In Taiwan, the oyster, *Crassostrea gigas* (Thunberg), and the hard clam, *Meretrix lusoria* (Roeding), are the two most widely cultured bivalve mollusks. Thus, they were purchased monthly from the market for examination of their copepod parasites. It is interesting to point out that while the oysters were found to harbor parasitic copepods, the hard clams were not. However, we consider this discrepancy is due to an artifact: while the oysters are cultured on the coastal inlets or bays, the hard clams are always cultured on the land in fish ponds, in which the salinity often rises up to 40 ‰ and prevents the occurrence of stenohaline poecilostomatoid copepods. Examination of the hard clams collected from the wild will be conducted in the future to check on this speculation.

During our one-year examination of oysters and hard clams for copepod parasites, the circular clams, *Cyclina sinensi* (Gmelin), were occasionally found on sale in the market; therefore, they were also included in our examination. Furthermore, the green mussel, *Perna viridis* (Linnaeus), were sometimes found attached to the cultured *C. gigas*, thus, they too were included in our survey.

### Materials and Methods

The bivalves purchased from the market were brushed clean in running tap water to remove all debris on the shells. Then, the cleaned shells were opened one by one by cutting the adductor muscles and washed in a large beaker filled with seawater. After all shells of the same species were washed, the water in the beaker was decanted into a fine mesh plankton net. The debris collected in the net was then transferred into a petri dish filled with seawater and examined under a dissection microscope for copepods. The copepod parasites were picked with a pair of fine forceps and preserved in 70% alcohol.

In studying the morphology of the copepods, the alcoholized specimens were first soaked in lactic acid for a couple of hours, measured, and then dissected under a dissection microscope. The removed

appendages were studied on a wooden slide following the method described by Humes & Gooding (1964) under a compound microscope.

All drawings were made with the aid of a camera lucida and the measurements for the whole animal were taken from 20 randomly selected individuals. In the following, a full description is given of the female and for the male only those features exhibiting sexual dimorphism are mentioned. In the description of the new species, the habitus of the specimen is based on the holotype and paratype but the appendages are based on the dissected paratypes.

Table 1. Infection of *Ostrincola similis* in *Crassostrea gigas* cultured in Bu-Dai in Chiayi County, Taiwan.

Collection date	Number of host examined	Number of parasite collected
1997 0814	252	52 (38 ♀♀, 13 ♂♂, 1 copepodid)
0908	482	36 (28 ♀♀, 6 ♂♂, 2 copepodids)
1002	135	14 (13 ♀♀, 1 ♂)
1104	91	89 (70 ♀♀, 12 ♂♂, 7 copepodids)
1204	143	9 (6 ♀♀, 1 ♂, 2 copepodids)
1998 0112	161	6 (5 ♀♀, 1 ♂)
0209	165	5 (3 ♀♀, 1 ♂, 1 copepodid)
0305	89	2 (2 ♀♀)
0416	169	2 (2 ♀♀)
0504	111	0
0603	215	0
0701	202	3 (3 ♀♀)
Total	2,215	218(170 ♀♀, 35 ♂♂, 13 copepodids)

Table 2. Infection of *Ostrincola similis* in *Crassostrea gigas* cultured in Wang-Gong in Zhan-Hwa County, Taiwan.

Collection date	Number of host examined	Number of parasite collected
1997 0820	306	100 (79 ♀♀, 20 ♀♂, 1 copepodid)
0918	294	84 (75 ♀♀, 9 ♂♂)
1016	325	45 (42 ♀♀, 3 ♂♂)
1113	283	112 (79 ♀♀, 29 ♂♂, 4 copepodids)
1210	259	54 (41 ♀♀, 12 ♂♂, 1 copepodid)
1998 0114	271	41 (34 ♀♀, 6 ♂♂, 1 copepodid)
0205	348	41 (32 ♀♀, 6 ♂♂, 3 copepodids)
0303	309	29 (26 ♀♀, 2 ♂♂, 1 copepodid)
0414	311	85 (63 ♀♀, 15 ♂♂, 7 copepodids)
0519	266	79 (64 ♀♀, 9 ♂♂, 6 copepodids)
0616	298	58 (48 ♀♀, 6 ♂♂, 4 copepodids)
0713	257	97 (81 ♀♀, 14 ♂♂, 2 copepodids)
Total	3,527	825 (664 ♀♀, 131 ♂♂, 30 copepodids)

**Descriptions**  
**Family Myicolidae Yamaguchi, 1936**  
*Ostrincola similis* sp. nov.  
(Figs. 1–3)

Material examined

218 specimens (170 ♀♀, 35 ♂♂, 13 copepodids) recovered from washings of 2,215 oysters, *Crassostrea gigas* (Thunberg), collected between August 1997 and July 1998 at Bu-Dai in Chiayi County, Taiwan (see Table 1 for collection dates and number of individuals recovered) and 825 specimens (644 ♀♀, 131 ♂♂, 30 copepodids) recovered from washings of 3,527 oysters collected between August 1997 and July 1998 at Wang-Gong in Zhan-Hwa County, Taiwan (see Table 2 for collection dates and number of individuals recovered). 8 specimens (7 ♀♀, 1 ♂) recovered from washings of 36 green mussels, *Perna viridis* (Linnaeus) collected on September 1, 1998 at Bu-Dai in Chiayi County. Holotype (USNM 243655), allotype (USNM 243656) and 50 paratypes (USNM 243657, 25 ♀♀ and 25 ♂♂) have been deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D. C., U.S.A.

Female

Body (Fig. 1A) 1,086 (963–1,221)  $\mu\text{m}$  long (excluding setae on caudal rami) and 276 (243–294)  $\mu\text{m}$  wide, with first pediger clearly separated from cephalosome. Urosome 5-segmented, genital double-somite (Fig. 1B) slightly longer than wide (1.156 : 1), bearing 4 transverse rows of spinules on ventral surface. Genital aperture (Fig. 1C) located dorsolaterally on widest part of somite and bearing 2 short setae representing remnants of leg 6. Abdomen (Fig. 1B) 3-segmented; first segment nearly as long as wide (1.04 : 1) and bearing spinules along posteroventral margin; second segment longer than wide (1.19 : 1) but anal segment wider than long (1.29 : 1). Caudal ramus (Fig. 1D) slender, 10 times longer than wide, bearing 6 naked setae. Egg sac (Fig. 1A) uniseriate, with 2 to 5 eggs (mostly with 3 or 4). Antennule (Fig. 1E) 7-segmented, with formula of armature: 4, 14, 5, 3, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete; all setae naked. Antenna (Fig. 1F) 3-segmented, with formula of armature: 1, 1 and 6+1 claw. First segment (coxobasis) largest, with a row of spinules on anterior surface; second segment smallest; third segment about 6.5 times longer than wide, bearing a row of spinules on proximal outer surface. Labrum (Fig. 1G) broad, posteroventral edge concave with wide indentation; spinules on lateral edges forming densely packed patches and rows but scattered widely on ventral surface. Mandible (Fig. 1H) drawn out into a long, spinulated lash and with 3 setae bearing short, lateral spinules. Maxillule (Fig. 1I) a simple lobe armed with 4 unequal, simple setae. Maxilla (Fig. 2A) 2-segmented; first segment large, with patches of spinules on ventral surface; second segment small, with 2 spinulose setae and 1 small naked seta. Maxilliped absent.

Legs 1–4 (Figs. 2B, C, D, E) biramous with 3-segmented rami. Armature of legs as follows (Roman numerals indicating spines, Arabic numerals representing setae):

Leg	Coxa	Basis	Exopod	Endopod
1	0-1	1-I	I-0; I-1; III,I,4	0-1; 0-1; I,5
2	0-1	1-0	I-0; I-1; III,I,5	0-1; 0-2; III,3
3	0-1	1-0	I-0; I-1; II,I,5	0-1; 0-2; IV,2
4	0-1	1-0	I-0; I-1; II,I,5	0-1; 0-2; IV,1

Anterior surface of coxa on legs 1 and 2 with fine spinules. Basis of leg 1 with a posterior row of coarse spinules adjacent to inner spine in addition to scattered fine spinules. Outer surface

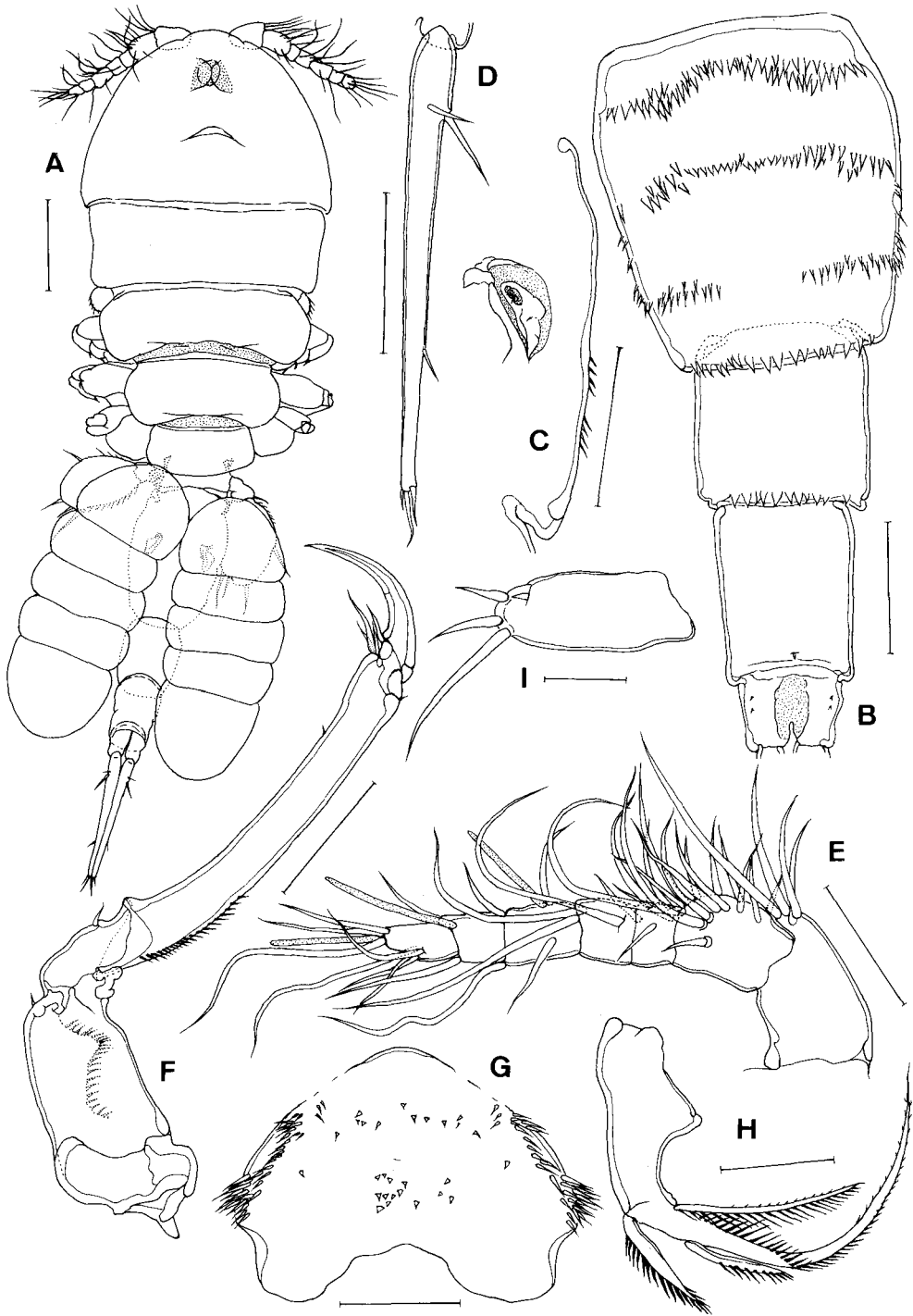


Fig. 1. *Ostrincola similis* sp. nov., female: A. habitus, dorsal; B. genital-double somites and abdomen, ventral; C. egg sac attachment area; D. caudal ramus; E. antennule; F. antenna; G. labrum; H. mandible; I. maxillule. Scale bars: 0.1 mm in A; 0.05 mm in B, C, D; 0.04 mm in E, F; 0.03 mm in G; 0.02 mm in H; 0.01 mm in I.

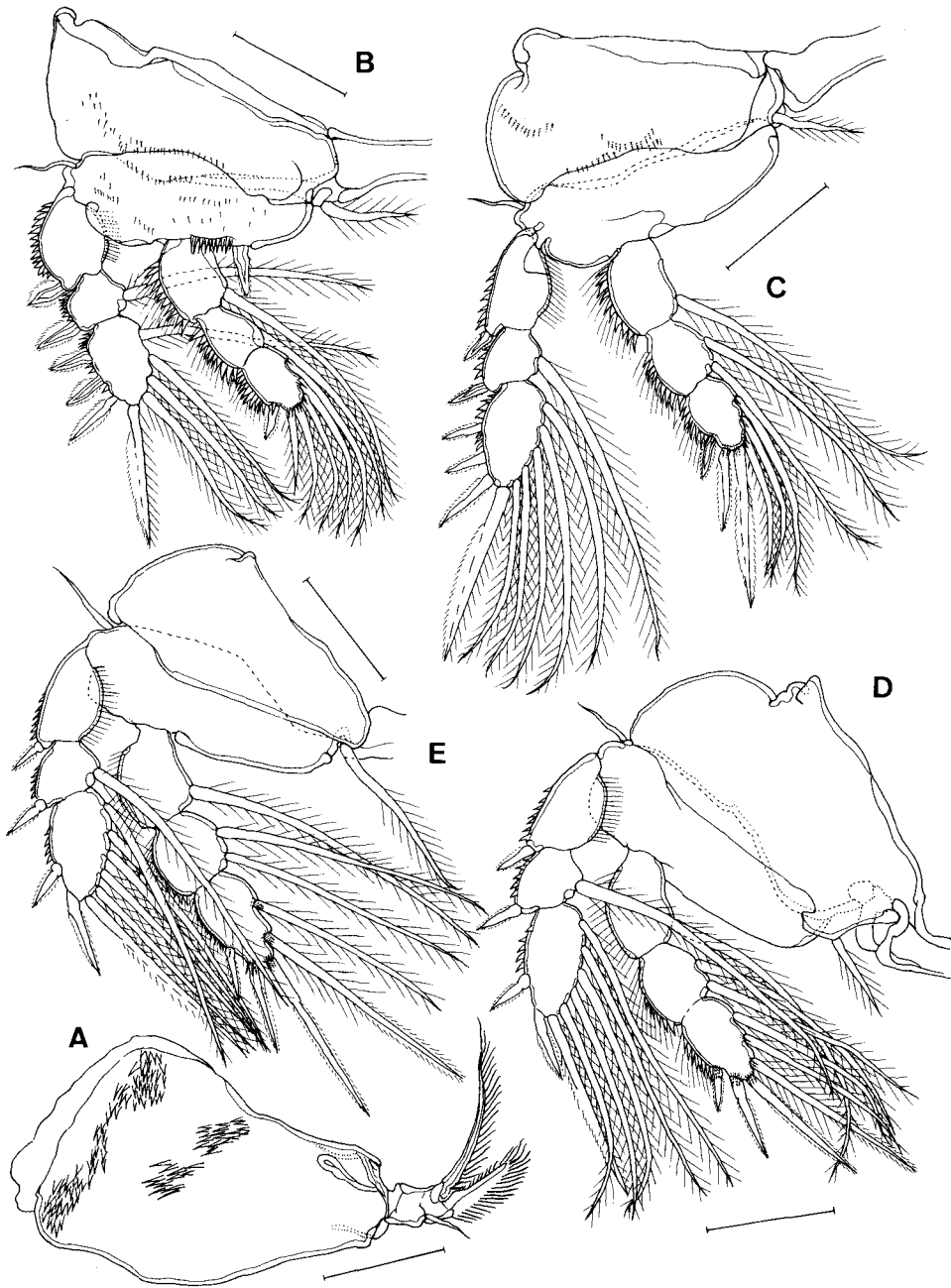


Fig. 2. *Ostrincola similis* sp. nov., female: A. maxilla; B. leg 1; C. leg 2; D. leg 3; E. leg 4. Scale bars: 0.03 mm in A; 0.04 mm in B, C, D, E.

of both rami on all legs bearing rows of spinules. Row of hairs in addition to spinules on all endopodal segments except for basal segments on legs 3 and 4.

Leg 5 (Fig. 3A) 2-segmented, with 1 outer seta on proximal segment and 2 setae and

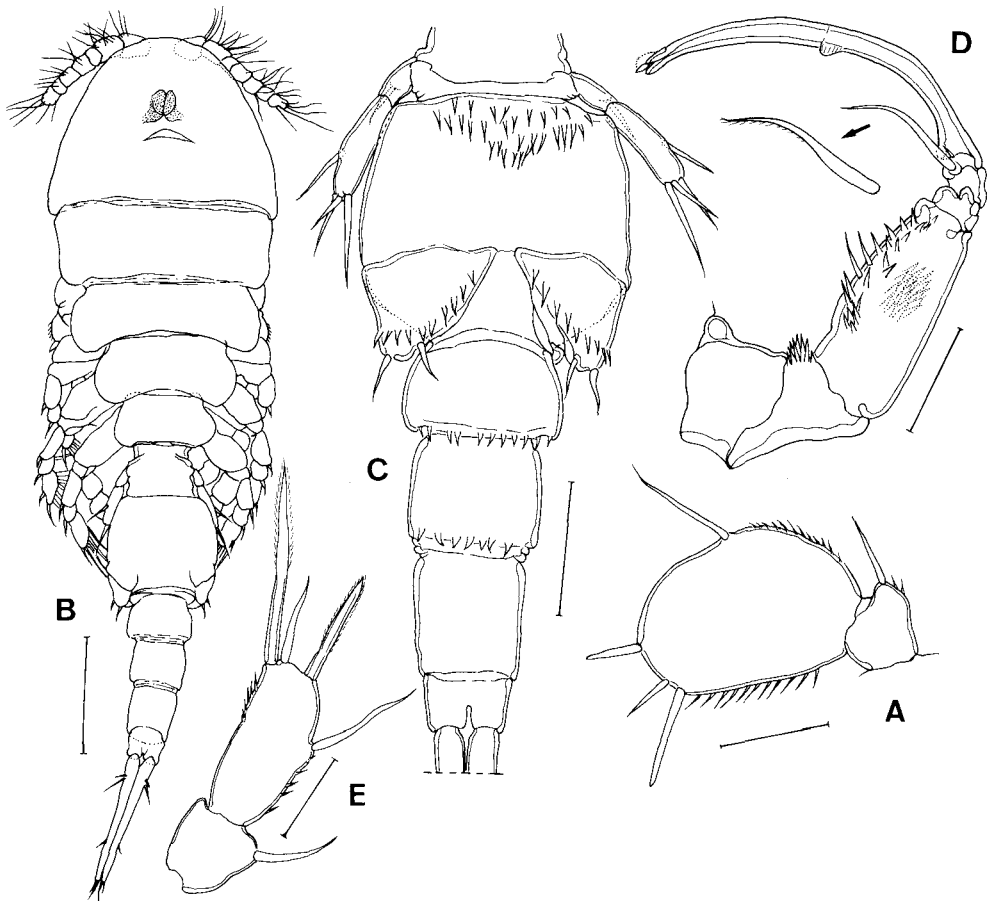


Fig. 3. *Ostrincola similis* sp. nov. Female: A. leg 5. Male: B. habitus, dorsal; C. urosome, ventral; D. maxilliped; E. leg 5. Scale bars: 0.04 mm in A; 0.1 mm in B; 0.05 mm in C; 0.03 mm in D; 0.02 mm in E.

2 blunt-tipped, spine-like setae on distal segment. Distal segment oval, about 1.5 times longer than wide; with row of spinules on both lateral and medial edges proximal to insertations of setae. Leg 6 represented by 2 minute setae located in egg sac attachment area (Fig. 1C).

#### Male

Body (Fig. 3B) 836 (662–954)  $\mu\text{m}$  long (not including setae on caudal rami) and 209 (193–242)  $\mu\text{m}$  wide. Urosome 6-segmented; ventral surface of genital somite with a patch of spinules on anteroventral surface and oblique row of spinules on each ventrolateral, genital lobe; 2 setae on genital lobe representing leg 6. First 2 abdominal somites with posteroventral row of spinules. Caudal ramus about 11.2 times longer than wide. Antennule as in female, except for addition of 1 aesthete on second segment and 2 aesthetes on fourth segment. Maxilliped (Fig. 3D) 4-segmented; first 2 segments with denticles; formula of armature: 0, 2, 0 and 2. Terminal segment drawn out into a curved claw, with a small hyaline lamella at midway on medial edge. Leg 5 (Fig. 3E) slender than female; distal

Table 3. Morphological differences between *Ostrincola japonica* and *O. similis*.

Characters	<i>Ostrincola japonica</i>	<i>Ostrincola similis</i>
Female:		
Antennular 2 <sup>nd</sup> & 3 <sup>rd</sup> segments with	15 & 6 setae	14 & 5 setae
Antennal 3 <sup>rd</sup> segment	short (L/W=4.3 : 1)	long (L/W=6.5 : 1)
Proximal 2 setae on caudal ramus	set far apart	closely set
Male:		
Medial spine on leg 5	shorter than ramus (0.51)	longer than ramus (1.18)
Leg 5 distal segment	long (L/W=2.90 : 1)	short (L/W=2.11 : 1)

segment about 2.03 times longer than wide, with spines much heavier than those in female. Leg 6 (Fig. 3C) represented by posteroventral flap on genital somite bearing row of coarse spinules and 2 small setae.

#### Etymology

The specific name, *similis* (=“like, resembling” in Latin), alludes to the great resemblance between *Ostrincola japonica* and the present species.

#### Remarks

It is not surprising to find out that in following the “Key to the species of *Ostrincola*” constructed by Ho & Yoosukh (1994), the present new species of *Ostrincola* from Taiwan was identified with *O. japonica* Tanaka, 1961, which is known from both Japan and Korea. However, a close comparison of the details of the appendages revealed that the *Ostrincola* from Taiwan is a different species. Since the original description of *O. japonica* made by Tanaka (1961) is inadequate, lacking fine features which are significant in species recognition, we compared the specimens from Taiwan with the redescription made by Ho & Kim (1991). The major differences are summarized in Table 3. Besides, the female leg 5 in *O. similis* is in general more weakly armed than in *O. japonica*.

Having an armature of I,5 on the third segment of leg 1, a long caudal ramus (greater than 6:1 in L/W ratio), a long third segment of antenna (greater than 6:1 in L/W ratio) and a long leg 5 (greater than 1.6:1 in L/W ratio), the new species also shows close affinity with *O. falcatus* Humes, 1984 and *O. patagonianus* Humes, 1988. Nevertheless, it can be distinguished from the former by having a much longer caudal ramus (10.0:1 vs 6.7:1) and bearing spinules on outer margin of leg 5 in the female, and from the latter by carrying shorter setae (at most 1/5 of ramus length) at the tip of the caudal ramus and with the first two abdominal somites being longer than wide in the female.

#### ***Myicola formosanus* sp. nov.**

(Figs. 4–6)

#### Material examined

All specimens were recovered from the washings of the circular clams, *Cyclina sinensis* (Gmelin), collected from Bu-Dai area in Chiayi County as follows: 69 copepods (19 ♀♀, 23 ♂♂, 27 copepodids) from washings of 148 clams purchased on 18 November 1997; 34 copepods (11 ♀♀, 6 ♂♂, 18 copepodids) from washings of 136 clams purchased on 4 July 1998; 22 copepods (11 ♂♂, 3 ♀♀, 8 copepodids) from washings of 104 clams purchased on 5 July 1998; 263 copepods (87 ♀♀, 98



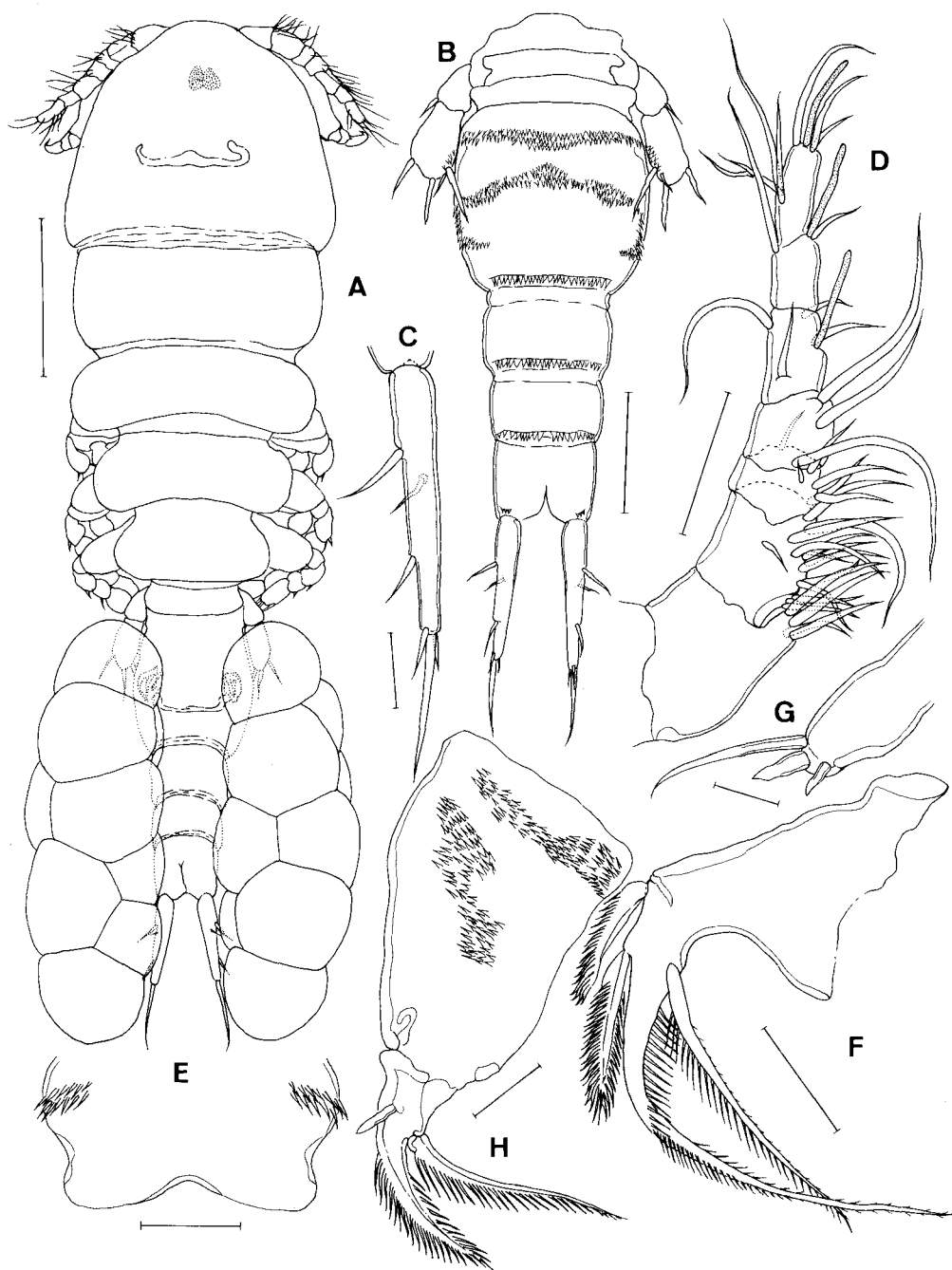


Fig. 4. *Myicola formosanus* sp. nov., female: A. habitus, dorsal; B. urosome, ventral; C. caudal ramus; D. antennule; E. labrum; F. mandible; G. maxillule; H. maxilla. Scale bars: 0.2 mm in A; 0.1 mm in B; 0.03 mm in C; 0.05 mm in D, E; 0.02 mm in F, H; 0.01 mm in G.

♂♂, 78 copepodids) from washings of 167 clams purchased on 19 July 1998. Holotype (USNM 243658), allotype (USNM 243659) and 20 paratypes (USNM 243660, 10 ♀♀ and 10 ♂♂) have been deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C.,

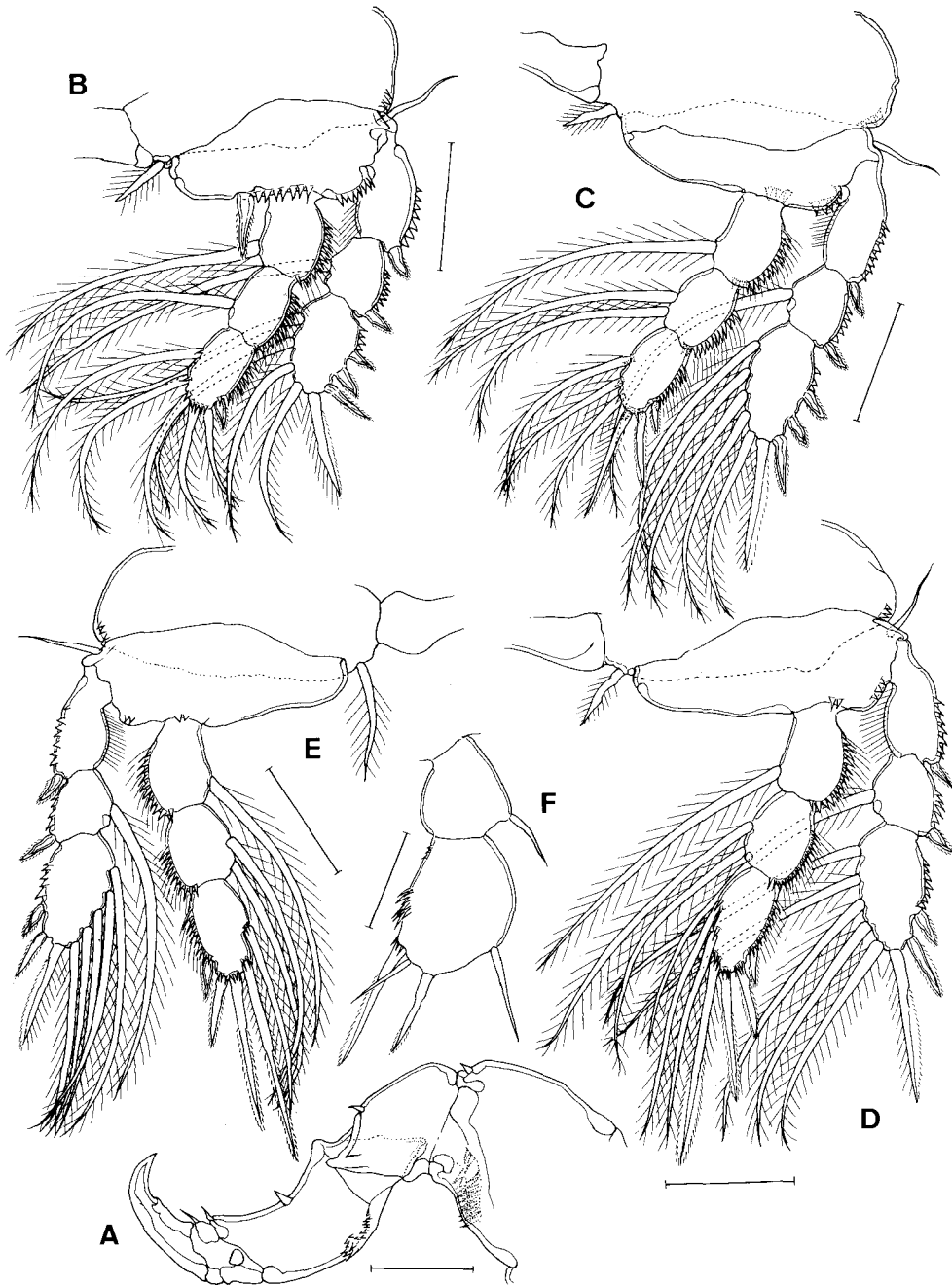


Fig. 5. *Mycicola formosanus* sp. nov., female: A. antenna; B. leg 1; C. leg 2; D. leg 3; E. leg 4; F. leg 5. Scale bars: 0.04 mm in A, F; 0.05 mm in B,C,D,E.

U.S.A. Following description is based on the paratypes.

#### Female

Body (Fig. 4A) 1,182 (874–1,423)  $\mu\text{m}$  long (excluding setae on caudal rami) and 334

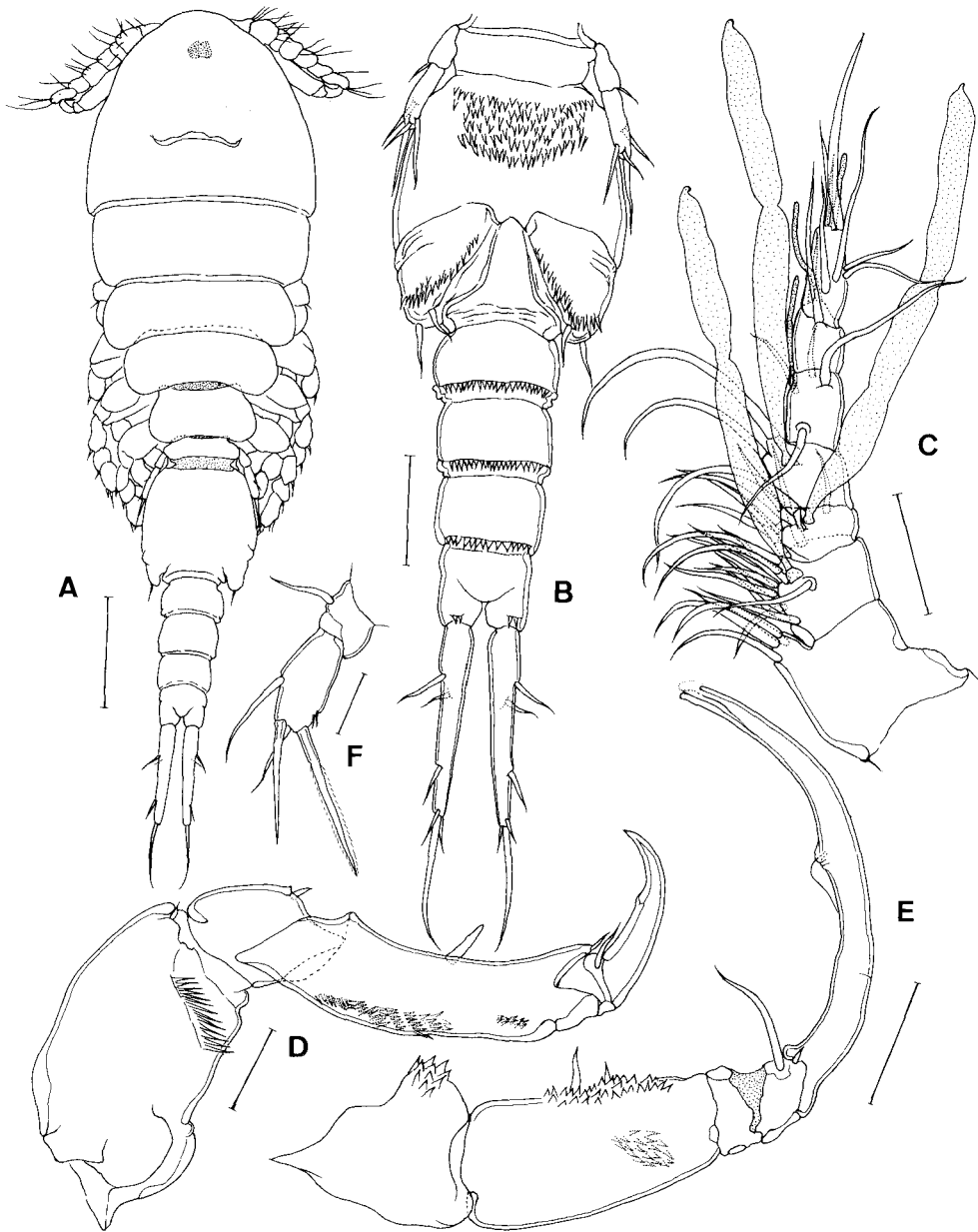


Fig. 6. *Myicola formosanus* sp. nov., male: A. habitus, dorsal; B. urosome, ventral; C. antennule; D. antenna; E. maxilliped; F. leg 5. Scale bars: 0.1 mm in A; 0.05 mm in B; 0.03 mm in C, E; 0.02 mm in D, F.

(283–371)  $\mu\text{m}$  wide, with first pediger clearly separated from cephalosome. Urosome (Fig. 4B) 5-segmented, genital double-somite bearing 2 complete and 2 partial transverse rows of spinules on ventral surface. Abdomen (Fig. 4B) 3-segmented; width of somites gradually narrowed from anterior to posterior; proximal 2 somites with a complete, posteroventral transverse row of spinules and anal somite with only a few spinules in the same area. Caudal ramus (Fig. 4C) 4.92 times longer than wide, bearing 6 naked setae. Egg sac (Fig. 4A) multiseriate, containing about 10–12 eggs.

Antennule (Fig. 4D) 7-segmented, with formula of armature: 4, 15, 5, 3, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete; all setae naked. Antenna (Fig. 5A) 3-segmented. First segment (=coxobasis) largest, armed distally with transverse rows of spinules and 1 small inner distal seta; second segment (=first endopodal segment) with 1 small inner seta; third segment 2.29 times longer than wide, armed with 1 median seta on inner surface, 2 distal setae, and a number of spinules on outer surface. Terminal claw strong, rather short and acutely pointed. Labrum (Fig. 4E) broad, posteroventral edge concave with wide but shallow indentation; 2 rows of spinules on lateral, protruded area. Mandible (Fig. 4F) constructed as in *O. similis*. Maxillule (Fig. 4G) a simple lobe tipped with 3 unequal setae. Maxilla (Fig. 4H) 2-segmented; first segment large, with patches of spinules on ventral surface; second segment small, with 2 spinulose setae and 1 small naked seta. Maxilliped absent.

Legs 1–4 (Figs. 5B, C, D, E) biramous with 3-segmented rami. Armature of legs as in previous species. Outer-distal surface of coxa and posterior margin of basis on legs 1–4 with denticles. Outer surface of both rami on all legs also bearing denticles. Row of hairs in addition to denticles on all outer surface of endopodal segments.

Leg 5 (Fig. 5F) 2-segmented, with 1 outer seta on proximal segment and 2 setae and 2 spines on distal segment. Distal segment with straight medial margin and convex lateral margin, about 1.34 times longer than wide, and bearing spinules on medial surface and base of inner spine. Leg 6 represented by 2 small setae located in egg sac attachment area.

#### Male

Body (Fig. 6A) 854 (633–962)  $\mu\text{m}$  long (not including setae on caudal rami) and 213 (174–233)  $\mu\text{m}$  wide. Urosome (Fig. 6B) 6-segmented; ventral surface of genital somite bearing a large patch of spinules on anteroventral surface and oblique row of spinules on each ventrolateral, genital lobe. First 3 abdominal somites with posteroventral row of spinules, but only a few spinules on same area of anal somite. Caudal ramus about 6.25 times longer than wide. Antennule (Fig. 6C) 7-segmented, with formula of armature as in female except for segments 2, 3 and 4 which are: 14+1 aesthete, 6+1 aesthete and 2+1 aesthete, respectively. Antenna 3-segmented; with formula of armature as in female but different in arrangement of spinules; 3<sup>rd</sup> segment longer, about 3.55 times longer than wide. Maxilliped (Fig. 6E) 4-segmented; first 2 segments with denticles; formula of armature: 0, 2, 0 and 2. Terminal segment drawn out into a curved claw, with a small hyaline lamella and denticles at midway on medial edge. Leg 5 (Fig. 6F) more slender than female; distal segment about 1.95 times longer than wide, with both terminal spines distinctly longer than segment.

#### Etymology

The specific name, *formosanus*, is a Latinized word of “Formosa” which is the name of Taiwan in Portuguese commonly used in the western history before the 20<sup>th</sup> century.

#### Remarks

Three species of *Mycicola* are known so far: *M. metisiensis* Wright, 1885 from the Atlantic coast of North America (Humes, 1986), *M. ostreae* Hoshina & Sugiura, 1953 from Japan and Korea (Ho & Kim, 1991), and *M. intumidus* Kim, 1997 from Korea (Kim, 1997). Having a combination of (1) an unflated prosome, (2) a pair of egg sacs with a few rows of eggs, and (3) a large aesthete on the second, third and fourth antennular segments of the male, the new species of *Mycicola* from Taiwan seems to be more closely related to *M. intumidus* than to either one of the remaining two species. However, a close comparison with Kim's

Table 4. Morphological differences between *Mycicola intumidus* and *M. formosanus*.

Characters	<i>Mycicola intumidus</i>	<i>Mycicola formosanus</i>
Urosome in female	short, 0.29 of body length	long, 0.42 of body length
Number of eggs in egg sac	about 30	no more than 12
Median spine on leg 5 in female	distinctly shorter than ramus	about as long as ramus
Median spine on leg 5 in male	shorter than ramus	distinctly longer than ramus
Caudal ramus in female	3.91 longer than wide	4.92 longer than wide

(1997) original description revealed that they are not conspecific. Some major species distinctions between *M. intumidus* and the new species are summarized as in Table 4. Copepods of the genus *Mycicola* are distinguished from those of *Ostrincola* chiefly by their ovigerous females, with the former bearing a pair of egg sacs with multiseriate eggs and the latter, a pair of uniseriate egg sacs (Ho & Kim, 1992). Thus, it is rather significant when Kim (1997) stated that species of *Ostrincola* tend to have slender caudal ramus (with the ratio of length to width greater than 5.25 in adult female) than those of *Mycicola*, in which the most slender one is 4.95 as seen in *M. ostreae*. Furthermore, both Humes (1986) and Kim (1997) claimed that the body size of *Mycicola* is generally larger than that of *Ostrincola*, even the smallest measures 1.65 mm in length as seen in *M. ostreae*.

However, with the discovery of *M. formosanus*, Kim's (1997) conclusion needs to be reconsidered. The new species from Taiwan is not only smaller (1.18 mm in length) than the largest *Ostrincola* (1.32 mm seen in *O. portonoviensis*) but also has its caudal ramus (4.92 in length to width) as thin as those in the *Ostrincola*. Thus, the distinction between *Mycicola* and *Ostrincola* is again left with only the number of the rows of eggs in the egg sac as claimed by Ho & Kim (1992).

**Family Anthessiidae Humes, 1986**  
***Anthessius mytilicolus* Reddiah, 1966**  
(Figs. 7–9)

Material examined

All specimens were recovered from the washings of green mussels, *Perna viridis* (Linnaeus), attached to cultured *Crassostrea gigas* collected from Bu-Dai, Chiayi County: 17 (10 ♀♀ and 7 ♂♂) copepods from washings of 5 *P. viridis* collected on July 28, 1998 and 112 (40 ♀♀, 62 ♂♂, 10 copepodids) copepods from washings of 36 *P. viridis* collected on September 1, 1998.

Female

Body (Fig. 7A) measuring 1,734 (1,641–1,824)  $\mu\text{m}$  long (excluding setae on caudal rami) and 633 (603–642)  $\mu\text{m}$  wide, with first pediger clearly separated from cephalosome. Urosome 5-segmented, fifth pediger carrying a plumose outer seta on dorsal surface, genital double-somite (Fig. 7B) constricted anteriorly but dimension being as wide as long. Genital aperture (Fig. 7C) located dorsolaterally and posterior to widest part of somite, bearing 2 short setae representing remnants of leg 6. Abdomen (Fig. 7B) 3-segmented; first and second segments nearly equally in length and shorter than anal segment, which is distinctly longer than wide (1.29:1) and bearing rows of spinules on posteroventral margin. Caudal ramus (Fig. 7D) slender, 5.5 times longer than wide; bearing usual 6 setae. Egg sac (Fig. 7A) multiseriate.

Rostrum (Fig. 7E) not well defined. Antennule (Fig. 7F) 7-segmented, with formula

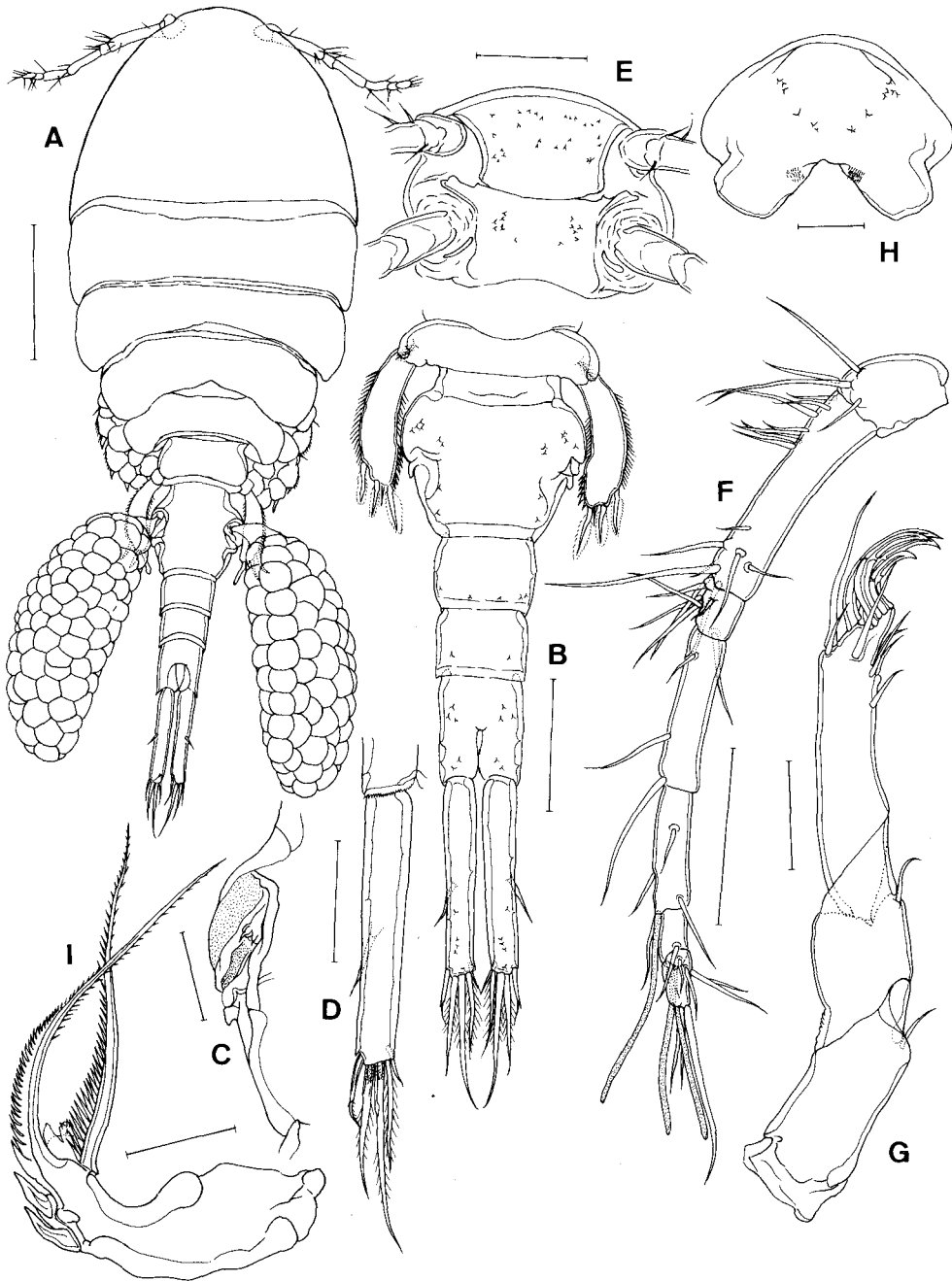


Fig. 7. *Anthessius mytilicolus* Reddiah, 1966, female: A. habitus, dorsal; B. urosome, ventral; C. genital area, dorsal; D. caudal ramus, ventral; E. rostral area, ventral; F. antennule, dorsal; G. antenna; H. labrum, ventral; I. mandible. Scale bars: 0.3 mm in A; 0.15 mm in B; 0.05 mm in C, G, H; 0.1 mm in D, E, F; 0.03 mm in I.

of armature: 4, 15, 6, 3, 4+1 aesthete, 2+laesthete, and 7+1 aesthete; all setae naked. Antenna (Fig. 7G) 3-segmented, with formula of armature: 1, 1 and 7+IV.

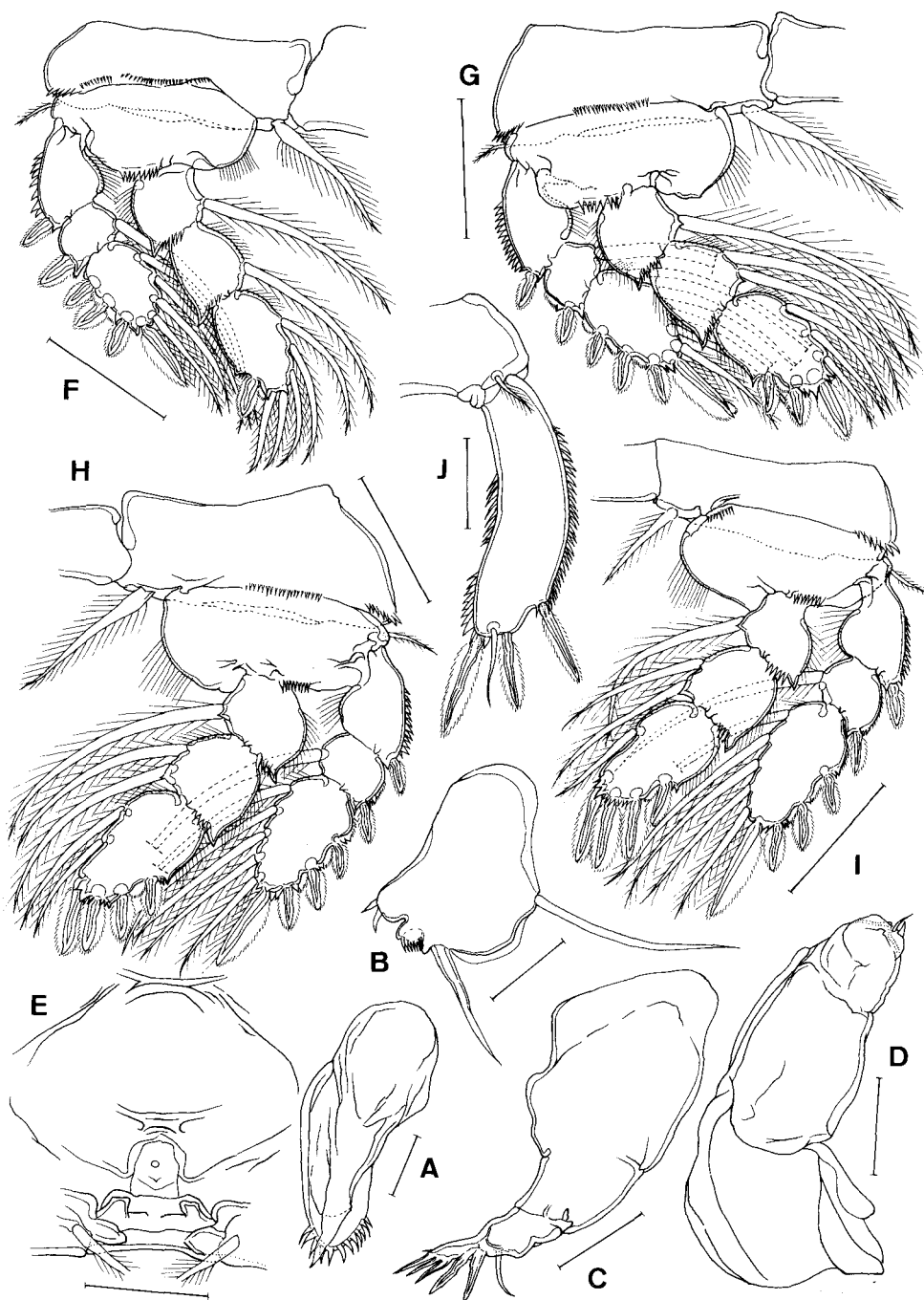


Fig. 8. *Anthessius mytilicolus* Reddiah, 1966, female: A. paragnath; B. maxillule; C. maxilla; D. maxilliped; E. area between maxilliped and intercoxal plate of leg 1; F. leg 1, anterior; G. leg 2, anterior; H. leg 3, anterior; I. leg 4, anterior; J. leg 5, dorsal. Scale bars: 0.01 mm in A; 0.02 mm in B; 0.04 mm in C; 0.03 mm in D; 0.1 mm in E, F, G, H, I; 0.05 mm in J.

Terminal 4 claws strongly recurved. Labrum (Fig. 7H) broad, posteroventral lobe truncated

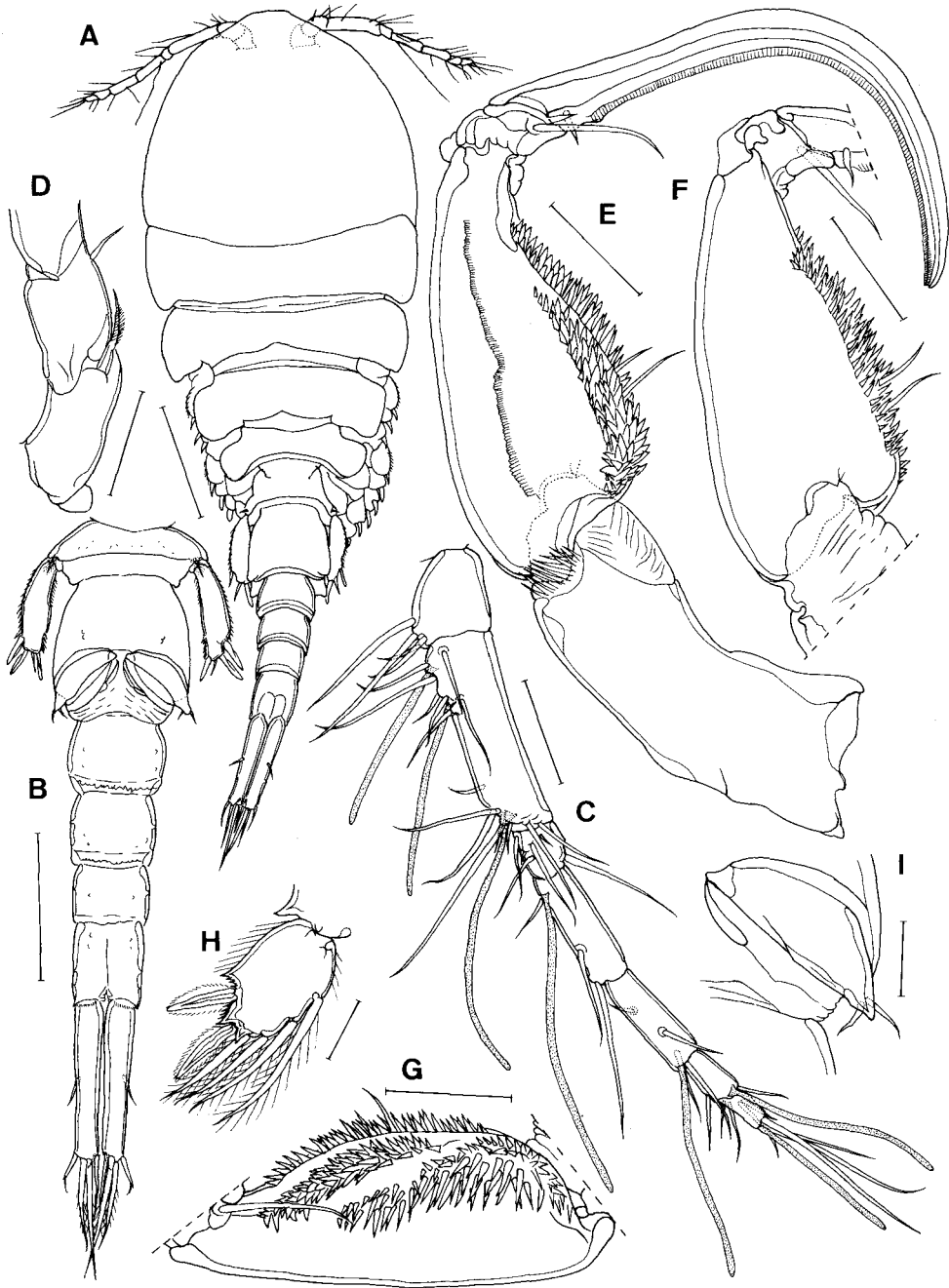


Fig. 9. *Anthessius mytilicolus* Reddiah, 1966, male: A. habitus, dorsal; B. urosome, ventral; C. antennule, dorsal; D. basal portion of antenna; E. maxilliped, anterior; F. second and third segments of maxilliped, posterior; G. second segment of maxilliped, medial; H. third segment of leg 1 endopod, anterior; I. leg 6, ventral. Scale bars: 0.2 mm in A; 0.15 mm in B; 0.05 mm in C, D, E, F, G; 0.03 mm in H, I.



distally and bearing patch of spinules at medial base. Mandible (Fig. 7I) typical of *Anthessius* with setiform terminal extension carrying 2 basal outer spines and 1 long inner seta, with a hyaline membranous lamella between these two elements. Paragnath (Fig. 8A) elongate and tipped with denticles. Maxillule (Fig. 8B) with 2 long terminal setae and 2 small lobes, one bearing spinules and other tipped with 2 short setae. Maxilla (Fig. 8C) 2-segmented, first segment large and unarmed; second segment with small proximal seta, larger anterior seta, and 5 smooth, distal spines. Maxilliped (Fig. 8D) 3-segmented, first two segments unarmed, third segment tipped with small spiniform process and 1 small seta. Ventral surface between maxillipeds and first pair of legs (Fig. 8E) not protuberant and smooth.

Legs 1–4 (Figs. 8F, G, H, I) biramous with 3-segmented rami. Armature of legs as follows (Roman numerals indicating spines, Arabic numerals representing setae):

Leg	Coxa	Basis	Exopod	Endopod
1	0-1	1-0	I-0; I-1; III,I,4	0-1; 0-1; I,5
2	0-1	1-0	I-0; I-1; III,I,5	0-1; 0-2; III,3
3	0-1	1-0	I-0; I-1; III,I,5	0-1; 0-2; IV,2
4	0-1	1-0	I-0; I-1; III,I,5	0-1; 0-2; IV,1

Anterior surface of coxa and basis on all legs with row of marginal spinules and medial margin of basis with row of long hairs. Outer surface of exopod on all legs with marginal row of spinules but that of endopod with row of hairs.

Leg 5 (Fig. 8J) with elongate free segment 3.75 times longer than wide; row of spinules on both lateral and medial surface; terminal elements consisting of 3 spines and 1 naked seta. Leg 6 represented by 2 minute setae located in egg sac attachment area (Fig. 7C).

### Male

Body (Fig. 9A) measuring 1,434 (1,323–1,581)  $\mu\text{m}$  long (not including setae on caudal rami) and 454 (422–483)  $\mu\text{m}$  wide. Urosome (Fig. 9B) 6-segmented; caudal ramus 5.7 times longer than wide. Antennule as in female except for addition of 3 aesthetes on second segment and 1 aesthete on fourth segment (Fig. 9C). Antenna essentially as in female, except for bearing a spiniform element on basal segment (Fig. 9D). Maxilliped (Fig. 9E) 4-segmented; first segment elongate and unarmed; second segment robust and bearing 3 groups of spines (Fig. 9G), 2 medial setae and a row of corrugated membrane on anterior surface (Fig. 9E); third segment smallest, carrying 2 unequal setae (Fig. 9F); terminal segment drawn out into a long, curved claw bearing a corrugated membrane along medial margin and a small proximal seta. Third segment of first endopod (Fig. 9H) armed with 2 spines and 4 setae. Leg 6 (Fig. 9I) represented by a pointed posteroventral flap on genital somite bearing 2 small, subterminal setae.

### Remarks

*Anthessius mytilicolus* seems to be a host specific poecilostome copepod with wide distribution. So far, it is reported only from the green mussel, *Perna viridis*, found in Asia. It was first recorded by Reddiah (1966) from the Ennore Estuary in the vicinity of Madras, India, and subsequently by Humes & Lee (1985) from Hong Kong and Yusookuh (1991) from the Gulf of Thailand. The present report extends the northern limit of this species from Hong Kong to Taiwan. Thus, a full description is given for showing possible geographical variations in morphology.

Upon the discovery of *A. mytilicolus* at Hong Kong, Humes & Lee (1985) reexamined

the type specimens of this species deposited in the Zoological Survey of India and made an excellent redescription based on the specimens obtained from Hong Kong. Comparison of *A. mytilicolus* from Taiwan with Humes & Lee's (1985) redescription (where Fig. 1 and Fig. 3 were reversed) shows that there are some discrepancies in the male; such as possession of 3 (instead of 2) aesthetes on the second segment of antennule, carrying setiform element on the proximal segment of antenna (see Fig. 9D), and bearing a membranous medial fringe on the claw (see Fig. 9E). However, we consider these discrepancies to be the result of geographical variations.

### Occurrence of Symbiotic Hydrozoa

During the course of our examination for the parasitic copepods of the oyster, *Crassostrea gigas*, cultured in Taiwan, the polypoid stage of a species of symbiotic hydrozoan, *Eugymnanthea japonica* Kubota, was encountered. This species of hydrozoan was discovered first by Kubota (1979) from the bivalves in central Japan (Shimoda) and later from the bivalves in southern Japan (Okinawa) near Taiwan (Kubota, 1979, 1987, 1991). The present discovery extends its southern limit to central part of Taiwan—Bu-Dai.

In Taiwan *E. japonica* was observed throughout the year in the washings of the oysters from Bu-Dai area and never found in those obtained from Wang-Gong area, which is about 80 km north to Bu-Dai. The hydrozoans were found attached to the mantle of the host, but, just like the attachment of those parasitic copepods, they were easily dislodged from their attachment by gently shaking the opened oysters in sea water.

Although two other species of bivalves, the circular clam, *Cyclina sinensis*, and the hard clam, *Meretrix lusoria*, both obtained from Bu-Dai area were regularly examined in our year-long survey for parasitic copepods, hydrozoans were not recovered from them.

### Acknowledgements

We would like to acknowledge with thanks Ms. Yu-Fen Pai, Ms. Chia-Ling Hwang and Ms. Hsiau-Wen Yang for their assistance in the examination of the bivalve mollusks for copepod parasites. Dr. Shin Kubota of Seto Marine Biological Laboratory, Kyoto University kindly identified for us the symbiotic hydrozoans from the oysters and placed in our disposal the specimens of *Anthessius mytilicolus* that he recovered from the green mussels collected from Bu-Dai, Taiwan. This study was made possible through a grant (NSC 87-2313-13-021-012) from the National Science Council of Taiwan to Ching-Long Lin and another grant from the Paramitas Foundation of U.S.A. to Ju-Shey Ho.

### References

- Ho, J.-S. 1996. Mycolid copepods and mass mortality of cultured hard clams (*Meretrix*). Phuket Mar. Biol. Ctr. Spe. Publ., No. 16, pp. 61–70.
- Ho, J.-S. & Kim, I.-H. 1991. Copepod parasites of commercial bivalves in Korea. II. Copepods from cultured bivalves. Bull. Korean Fish. Soc., 24: 369–396.
- Ho, J.-S. & Kim, I.-H. 1992. A new genus of poecilostome copepod of the family Mycolidae parasitic in a commercial clam from Malaysia. J. Nat. Hist., 26: 303–309.
- Ho, J.-S. & Yoosukh, W. 1994. *Ostrincola humesi* sp. nov., a mycolid copepod (Poecilostomatoida) parasitic in rock oysters cultured in the Gulf of Thailand. Hydrobiol., 288: 151–155.
- Humes, A. G. 1986. *Mycicola metisiensis* (Copepoda: Poecilostomatoida), a parasite of the bivalve *Mya arenaria* in eastern Canada, redefinition of the Mycolidae, and diagnosis of the Anthessiidae n. fam. Can. J. Zool., 64: 1021–1033.
- Humes, A. G. & Gooding, R. U. 1964. A method for studying the external anatomy of copepods. Crustaceana, 6(3): 238–240.

- Humes, A. G. & Lee, S. Y. 1985. The poecilostome copepod *Anthessius mytilicolus* Reddiah, 1966, associated with the mussel, *Perna viridis* (L.) at Hong Kong. *Asian Mar. Biol.*, 2: 85-92.
- Kim, I.-H. 1997. Two new species of poecilostomatoid copepods associated with the bivalve *Dosinella penicillata* in the Yellow Sea. *Korean J. Biol. Sci.*, 1: 15-23.
- Kubota, S. 1979. Occurrence of a commensal hydroid *Eugymnanthea inquilina* Palombi from Japan. *J. Fac. Sci. Hokkaido Univ. Ser. VI, Zool.*, 21(4): 396-406.
- Kubota, S. 1987. Occurrence of a bivalve-inhabiting hydroid *Eugymnanthea inquilina japonica* Kubota from Okinawa Island, southwest of Japan, with notes on parthenogenesis. *Galaxea*, 6:31-34.
- Kubota, S. 1991. The stability of diagnostic characters of the medusa of bivalve-inhabiting hydrozoan *Eugymnanthea japonica* Kubota in Japan. *Proc. Japan. Soc. Syst. Zool.*, 44:1-7.
- Reddian, K. 1966. Copepods associated with Indian molluscs—[E]. *Anthessius mytilicolus* n. sp. from *Mytilus viridis* at Ennore. *J. Mar. Biol. Assoc. India*, 8: 290-294.
- Tanaka, O. 1961. On copepods associated with marine pelecypods in Kyushu. *J. Fac. Agr., Kyushu Univ.*, 11: 249-273.
- Yoosukuh, W. 1991. Poecilostome copepods symbiotic with cultured bivalve molluscs in the Gulf of Thailand. *Proc. 4th Internatl. Conf. Copepoda, Bull. Plank. Soc. Japan, Spec. Vol.*, pp. 637-641.