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First Zoeas of *Nursia rhomboidalis* and *Pyrhila carinata* (Crustacea: Decapoda: Leucosiidae) with a Key to the Known Zoeas of Ten Leucosiid Species from Korean Waters

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ABSTRACT

The first zoeas of *Nursia rhomboidalis* and *Pyrhila carinata* were obtained from laboratory condition. They are described and illustrated for the first time. Morphological comparison with those of other Korean described species of the family Leucosiidae reveals that the zoea of *N. rhomboidalis* is very similar to those of *Myra fugax* and *Arcania undecimspinosa* based on characteristics of the carapace spines length, the antenna morphology, the maxilla endopod setation, and the telson, whereas, the zoea of *Py. carinata* coincides well with those of *Philyra kanekoi* and *Pyrhila pisum* based on characteristics of the carapace spines length, the antenna morphology, the maxilla endopod setation, and the telson. Furthermore, we find that at least two groups of zoeas exist in the Korean species of the subfamily Ebaliinae. A provisional key to the known zoeas of ten leucosiid species from Korean waters is provided.

Keywords: *Nursia rhomboidalis*, *Pyrhila carinata*, zoea, Leucosiidae, Ebaliinae, key, Korean waters

INTRODUCTION

The family Leucosiidae Samouelle, 1819 comprises more than 470 species of 62 genera in the world (Ng et al., 2008), of which 14 species belonging to 11 genera are reported from Korean waters (Kim, 1973; Lee and Ko, 2007; Lee et al., 2009). However, larval stages are known for eight species in this region: Ebaliinae Stimpson, 1871, *Arcania undecimspinosa* De Haan, 1841 by Terada (1984) and Quintana (1986); *Hiplyra platycheir* (De Haan, 1841) (=*Philyra platychira*) by Ko (2000); *Myra fugax* (Fabricius, 1798) by Terada (1979); *Philyra kanekoi* Sakai, 1934 by Ko (2001), *Philyra syndactyla* Ortmann, 1892 by Terada (1979); *Pyrhila pisum* (De Haan, 1841) (=*Philyra pisum*) by Aikawa (1929), Terada (1979), and Ko (1996); Leucosiinae Samouelle, 1819, *Euclosia obtusifrons* (De Haan, 1841) (=*Leucosia obtusifrons*) and *Leucosia anatum* (Herbst, 1783) (=*Leucosia longifrons*) by Terada (1984).

Nursia rhomboidalis (Miers, 1879) inhabits mud bottom of 5−30 m depth and is recorded from Taiwan (Shih et al., 2015), China, Japan, and Korea (Lee et al., 2009). *Pyrhila carinata* (Bell, 1855) inhabits sandy mud bottom of the intertidal region and is known to occur along the coasts of Borneo Island, China, and Korea (Galil, 2009). Larval stages of these two species are unknown. Therefore, the purpose of this paper is to describe their first zoeas, compare them with previously described zoeas, and provide a key to the known zoeas of Korean leucosiid species.

MATERIALS AND METHODS

Ovigerous crabs of *Nursia rhomboidalis* and *Pyrhila carinata* were collected from Jindo Island, Jeollanam-do, on 27 May 2015 and from Muan, Jeollanam-do, on 5 Jun 2014. They were reared in the laboratory. Their first zoeas were collected from hatched specimens and preserved in 95% EtOH for examination. Digital photos of living zoeas were taken using a Leica EZ40 microscope (Leica, Wetzlar, Germany) for observation of chromatophore patterns and then processed in a photoshop. Dissected appendages were examined using a Leitz Laborlux S microscope and drawings were made with the camera lucida. Measurements and setal counts on appendages were based on ten specimens. The sequence of the zoeal description is based on the malacostracan somite plan and described from anterior to

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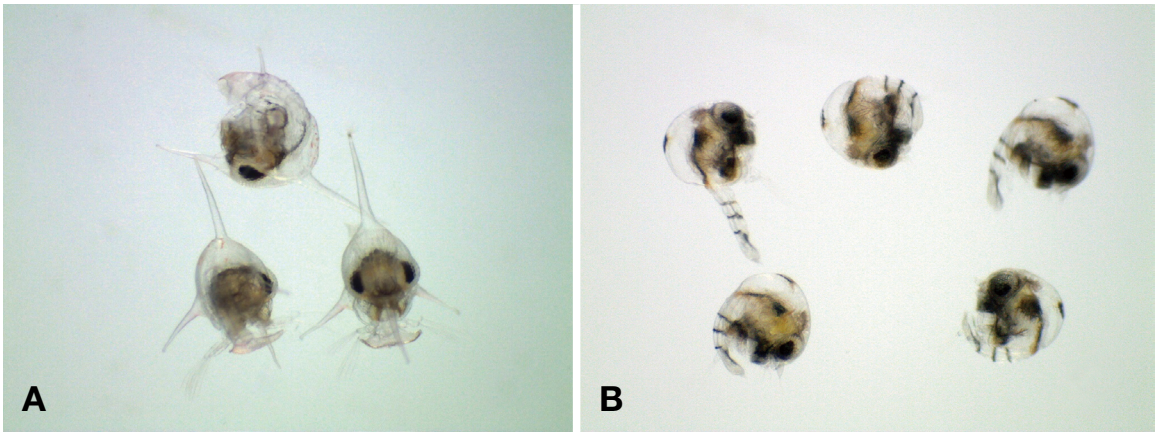

Fig. 1. First zoeas of *Nursia rhomboidalis* (A) and *Pyrhila carinata* (B).

posterior. Setal armature on appendages is described from proximal to distal segments and in order of endopod to exopod (Clark et al., 1998). A micrometer was used for the measurements: CL means carapace length from the base of the rostral carapace spine to the most posterior carapace margin; RDL means rostral and dorsal spine length from the tip of the rostral carapace spine to the tip of the dorsal carapace spine. The remaining zoeas and the spent female were deposited in Silla University, Korea.

RESULTS

Order Decapoda Latreille, 1802
Superfamily Leucosioidea Samouelle, 1819
Family Leucosiidae Samouelle, 1819
Subfamily Ebaliinae Stimpson, 1871
Genus *Nursia* Leach, 1817

***Nursia rhomboidalis* (Miers, 1879)**
Zoea I (Figs. 1A, 2)

Size: CL 0.46 ± 0.01 mm; RDL 1.27 ± 0.02 mm.

Chromatophores (Fig. 1A): Black or brownish black chromatophores occurring on bases of antennule, antenna, labrum, and mandible, behind eye, on basis of first and second maxillipeds, and on base of lateral carapace spine. Reddish brown chromatophores scattered on posteromedial region of carapace.

Carapace (Fig. 2A): Rostral spine *ca*. 0.9 CL, dorsal spine *ca*. 1.2 CL, lateral spine *ca*. 0.6 CL, tips blunt; 1 pair of posterodorsal setae present; ventral margin without setae; eyes sessile.

Antennule (Fig. 2B): Uniramous, endopod absent; exopod with 3 (2 long, 1 shorter, slender) aesthetascs and 2 setae terminally.

Antenna (Fig. 2C): Uniramous process, with rounded tip: endopod and exopod absent.

Mandibles (Fig. 2D): Asymmetrical; right molar with 3 teeth, left molar with 2 teeth confluent with incisor process; endopod palp absent.

Maxillule (Fig. 2E): Coxal endite with 6 setae; basial endite with 2 setae and 4 denticulate setae; endopod 2-segmented, proximal segment without setae; distal segment with 4 terminal setae; exopod seta absent.

Maxilla (Fig. 2F): Coxal endite bilobed, with 3 + 2 setae; basial endite bilobed, with 4 + 4 setae; endopod with 4 (2 subterminal, 2 terminal) setae; exopod (scaphognathite) margin with 4 plumose setae and 1 distal process.

First maxilliped (Fig. 2A, G): Coxa with seta; basis with 8 setae arranged 2 + 2 + 2 + 2; endopod 5-segmented with 2, 2, 1, 2, 5 (1 subterminal, 4 terminal) setae, respectively; exopod 2-segmented, distal segemnt with 4 long terminal plumose natatory setae.

Second maxilliped (Fig. 2A, H): Coxa without seta; basis with 4 setae arranged 1 + 1 + 1 + 1; endopod with 3 (1 subterminal, long, 2 terminal, shorter) setae; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Third maxilliped absent.

Pereipods absent.

Abdomen (Fig. 2A, I): Five somites; somites 2, 3 with 1 pair of dorsolateral processes; somites 2−5 with 1 pair of posterodorsal setae; pleopod bud absent.

Telson (Fig. 2I): Subtriangular plate; forks absent; each posterolateral margin with 1 spine; posteromedial margin with 3 pairs of setae arranged in a single row, innermost setae longest, outermost setae shortest.

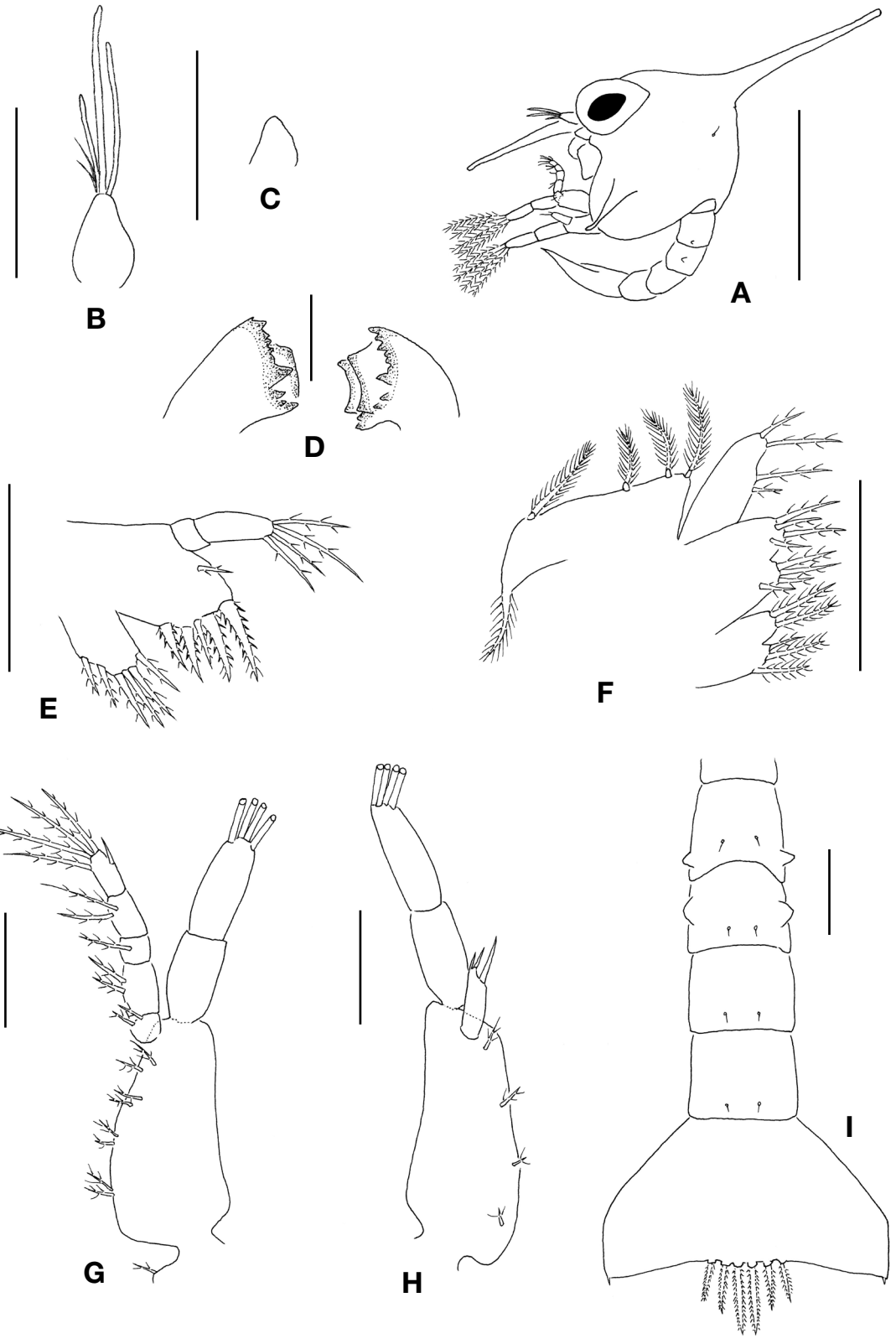

Fig. 2. *Nursia rhomboidalis*, first zoea. A, Lateral view; B, Antennule; C, Antenna; D, Mandibles; E, Maxillule; F, Maxilla; G, First maxilliped; H, Second maxilliped; I, Dorsal view of abdomen and telson. Scale bars: A=0.5 mm, B–I=0.1 mm.

Genus *Pyrhila* Galil, 2009

***Pyrhila carinata* (Bell, 1855)**

Zoea I (Figs. 1B, 3)

Size: CL 0.49 ± 0.01 mm.

Chromatophores (Fig. 1B): Predominantly black, ranging brownish black to reddish black. These occurring on bases of antennule, antenna, labrum, and mandible, behind eye, on basis of first and second maxillipeds, on dorsomedial region and marginal expansion of carapace, on each abdominal somite, and on telson.

Carapace (Fig. 3A): Globose, dorsal and lateral spines absent, rostral spine very short; 1 pair of posterodorsal setae present; ventral margin without setae; eyes sessile.

Antennule (Fig. 3B): Uniramous, endopod absent; exopod with 3 (2 long, 1 shorter, slender) aesthetascs and 1 seta terminally.

Antenna (Fig. 3C): Uniramous process, with serrated apical process; endopod and exopod absent.

Mandibles (Fig. 3D): Asymmetrical; right molar with 2 teeth, left molar with 3 teeth confluent with incisor process; endopod palp absent.

Maxillule (Fig. 3E): Coxal endite with 6 setae; basial endite with 1 seta and 4 denticulate setae; endopod 2-segmented, proximal segment without setae; distal segment with 4 terminal setae; exopod seta absent.

Maxilla (Fig. 3F): Coxal endite with 5 setae; basial endite with 8 setae; endopod with 3 (1 subterminal, 2 terminal) setae; exopod (scaphognathite) margin with 4 plumose setae and 1 distal process.

First maxilliped (Fig. 3A, G): Coxa with seta; basis with 8 setae arranged 2 + 2 + 2 + 2; endopod 5-segmented with 2, 2, 1, 2, 5 (1 subterminal, 4 terminal) setae, respectively; exopod 2-segmented, distal segemnt with 4 long terminal plumose natatory setae.

Second maxilliped (Fig. 3A, H): Coxa without seta; basis with 4 setae arranged 1 + 1 + 1 + 1; endopod 2-segmented, proximal segment without seta, distal segment with 3 (1 subterminal, long, 2 terminal shorter) setae; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Third maxilliped (Fig. 3A): Uniramous bud.

Pereipods (Fig. 3A): Uniramous bud.

Abdomen (Fig. 3A, I): Five somites; somites 2, 3 with 1 pair of dorsolateral processes; somites 2-5 with 1 pair of posterodorsal setae; pleopod bud absent.

Telson (Fig. 3I): Subtriangular plate; forks absent; each posterolateral margin with 3 small spines; posteromedial margin with 3 pairs of setae arranged in a single row, innermost 2 setae longest, outermost setae shortest.

DISCUSSION

Rice (1980) reported that the main zoeal characteristic which immediately allow the separation of leucosiid zoeas from other brachyuran zoeas is their equally distinctive telson, which is triangular with three pairs of setae arranged in a single row. In this respect, the present first zoeas of *Nursia rhomboidalis* and *Pyrhila carinata* show well the common zoeal telson of the family Leucosiidae. However, within a subfamily Ebaliinae, we found that the zoea of *N. rhomboidalis* is significantly different from that of *Py. carinata* in characteristics of the carapace spines (length of rostral, dorsal, and lateral spines shorter than CL in *N. rhomboidalis* vs. length of rostral spine short and dorsal and lateral spines absent in *Py. carinata*), the antenna (rounded in *N. rhomboidalis* vs. spinous in *Py. carinata*), the maxilla (endopod with 2 + 2 setae in *N. rhomboidalis* vs. endopod with 1 + 2 setae in *Py. carinata)*, and the telson (with 1 outer spine in *N. rhomboidalis* vs. 3 outer spines in *Py. carinata*) (Table 1).

The first zoea of *N. rhomboidalis* is very similar to those of *Myra fugax* and *Arcania undecimspinosa* because all they have well developed carapace spines, a rounded antenna, an endopod of the maxilla with four setae, and a telson with an outer spine. However, the first zoea of *Py. carinata* coincides well with those of *Philyra kanekoi* and *Pyrhila pisum* because they have only a short rostral carapace spine, a spinous antenna, an endopod of the maxilla with three setae, and a telson with three outer spines. Therefore, we found that at least two groups of zoeas exist in the Korean species of the Ebaliinae. Furthermore, the first zoea of *N. rhomboidalis* shows similarity to those of *Euclosia obtusifrons* and *Leucosia anatum* of the Leucosiinae and not to those of *Philyra* and *Pyrhila* species of the Ebaliinae on the basis of the carapace spines and the antenna (Table 1).

Although, the first zoeas of *N. rhomboidalis*, *M. fugax*, and *A. undecimspinosa* are very similar, they can be distinguished from each other in lengths of the carapace spines: *N. rhomboidalis* with *ca.* 0.9 CL rostral and 1.2 CL dorsal spines, *M. fugax* with *ca.* 0.6 CL rostral and 0.9 CL dorsal spines (Terada, 1979), and *A. undecimspinosa* with *ca.* 1.4 CL rostral and 1.6 CL dorsal spines (Terada, 1984). However, the first zoeas of *Py. carinata*, *Py. pisum*, and *Ph. kanekoi* are slightly different in the chromatophore pattern, the coxal endite of the maxillule, and the scaphognathite of the maxilla. The two *Pyrhila* species have a chromatophore on the dorsomedial region of the carapace (Ko, 1996), whereas *Ph. kanekoi* has no chromatophore on the region (Ko, 2001). In addition, the coxal endite of the maxillule and the scaphognathite of the maxilla are bearing six and four setae in *Py. carinata*, whereas they are bearing five and three setae in *Py. pisum* (see Ko, 1996).

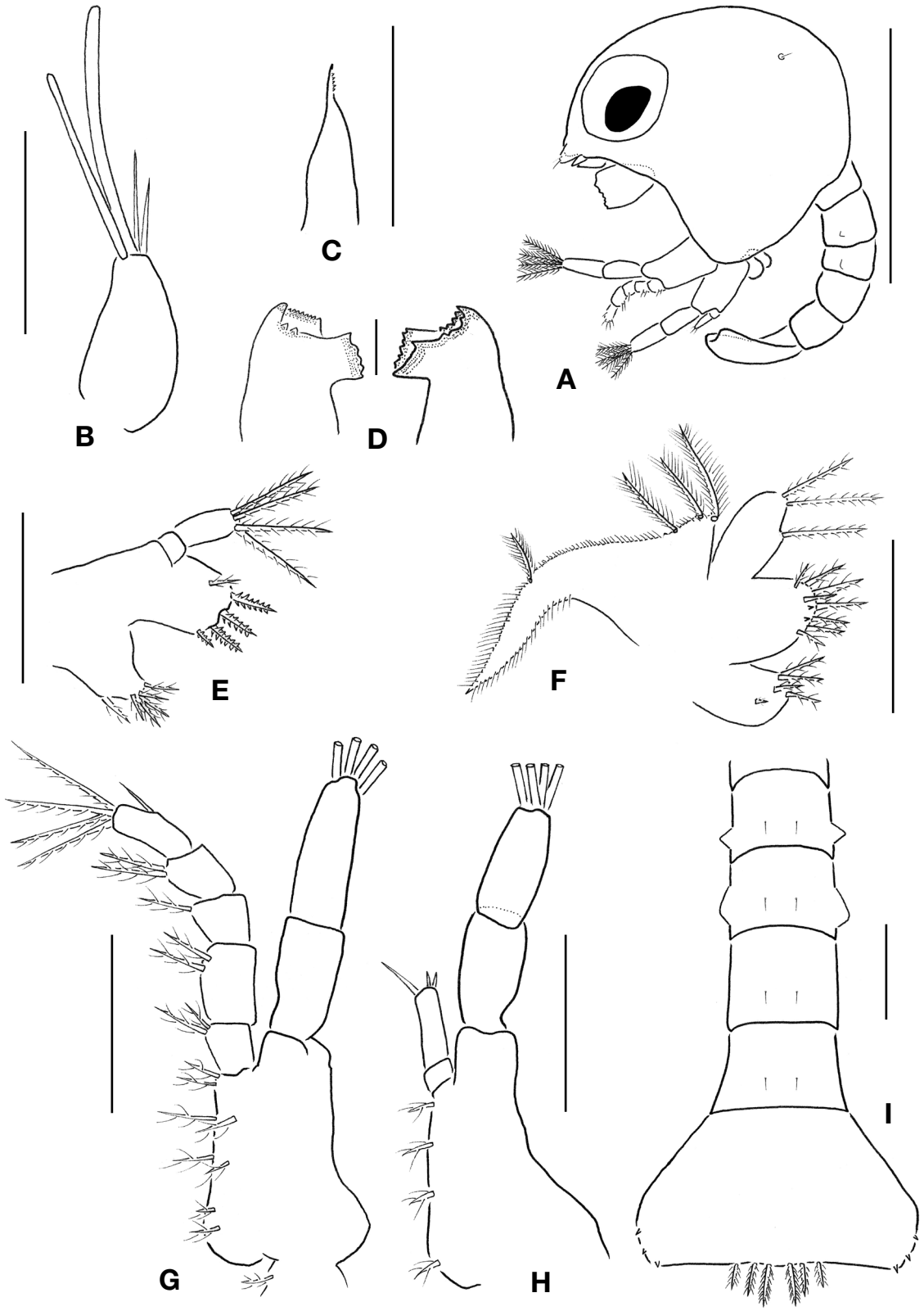

Fig. 3. *Pyrhila carinata*, first zoea. A, Lateral view; B, Antennule; C, Antenna; D, Mandibles; E, Maxillule; F, Maxilla; G, First maxilliped; H, Second maxilliped; I, Dorsal view of abdomen and telson. Scale bars: A = 0.5 mm, B–I = 0.1 mm.

Table 1. Comparison of the first zoeal characteristics of 10 leucosiid species from Korean waters

Species	Carapace			Antenna	Maxilla endopod	Telson outer spine	Reference
	Rostral spine	Lateral spine	Dorsal spine				
Ebaliinae							
Arcania undecimspinosa	Present, >1 CL	Present, >1 CL	Present, >1 CL	Rounded	2+2	1	Terada (1984)
Myra fugax	Present, <1 CL	Present, <1 CL	Present, 1 CL	Rounded	2+2	1	Terada (1979)
Nursia rhomboidalis	Present, <1 CL	Present, <1 CL	Present, >1 CL	Rounded	2+2	1	Present study
Hiplyra platycheir	Present, short	Absent	Absent	Rounded	1+2	3	Ko (2000)
Philyra syndactyla	Present, <1 CL	Absent	Present, <1 CL	Spinous	1+2	4	Terada (1979)
Philyra kanekoi	Present, short	Absent	Absent	Spinous	1+2	3	Ko (2001)
Pyrhila carinata	Present, short	Absent	Absent	Spinous	1+2	3	Present study
Pyrhila pisum	Present, short	Absent	Absent	Spinous	1+2	3	Ko (1996)
Leucosiinae							
Euclosia obtusifrons	Present, <2 CL	Present, <1 CL	Present, <2 CL	Rounded	1+2	4	Terada (1984)
Leucosia anatum	Present, >2 CL	Present, 1 CL	Present, 2 CL	Rounded	1+2	4	Terada (1979)

The following provisional key is provided for planktologists to aid in the identification of zoeas of the Leucosiidae from Korean waters.

Key to known zoeas of family Leucosiidae from Korean waters

Rostral carapace spine present. Antenna uniramous process, without endopod and exopod. Endopods of maxillule and maxilla each with 2+2 and 1+2 (rarely 2+2) setae on distal segment, respectively. Basis and endopod of maxilliped 1 each with 2+2+2+2 and 2, 2, 1, 2, 5 setae, respectively. Basis and endopod of maxilliped 2 each with 1+1+1+1 and 3 setae, respectively. Lateral processes on abdominal somites 2, 3. Telson triangular plate, with 1 or 3 (4) outer spines, fork absent.

1. Dorsal carapace spine present ····· 2
− Dorsal carapace spine absent ····· 7
2. Lateral carapace spine present ····· 3
− Lateral carapace spine absent ····· *Philyra syndactyla*
3. Endopod of maxilla with 3 setae ····· 4
− Endopod of maxilla with 4 setae ····· 5
4. Lateral carapace spine with blunt tip ···· *Leucosia anatum*
− Lateral carapace spine with spinous tip ····· *Euclosia obtusifrons*
5. Dorsal carapace spine longer than 1.5 CL ····· *Arcania undecimspinosa*
− Dorsal carapace spine shorter than 1.5 CL ····· 6
6. Dorsal carapace spine *ca*. 1.2 CL ···· *Nursia rhomboidalis*
− Dorsal carapace spine *ca*. 1.0 CL ····· *Myra fugax*
7. Antenna rounded tip ····· *Hiplyra platycheir*
− Antenna spinous tip ····· 8
8. Dorsomedial region of carapace with chromatophore ···· 9
− Dorsomedial region of carapace without chromatophore ····· *Philyra kanekoi*
9. Coxal endite of maxillule with 6 setae in first zoea ····· *Pyrhila carinata*
− Coxal endite of maxillule with 5 setae in first zoea ····· *Pyrhila pisum*

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