

Early zoeal stages of edible crab *Erimacrus isenbeckii* (Brandt, 1848) (Crustacea: Decapoda: Brachyura: Cheiragonidae) and a comparison with other cheiragonid zoeae

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Ovigerous crabs of *Erimacrus isenbeckii* were collected from the northeastern coast of South Korea and their larvae were reared in the laboratory. Two zoeal stages were described and illustrated in detail. The first zoeal characteristics between the present material and Sasaki and Mihara's (1993: J Crust Biol. 13:511–522) were different especially in the setations of the endopods of the maxillipeds. The zoea of *Erimacrus isenbeckii* strongly resembled those of two *Telmessus* species in the Cheiragonidae, but the former could be distinguished from the latter by having spinulate carapace spines, a lateral process on the abdominal somite 3, and longer lateral spines on the telson fork.

Keywords: Cheiragonidae; larva; zoea; *Erimacrus isenbeckii*; *Telmessus*; South Korea

Introduction

The family Cheiragonidae Ortmann, 1893 is a small family including only three species in the world: *Erimacrus isenbeckii* (Brandt, 1848), *Telmessus cheiragonus* (Tilesius, 1812) and *Telmessus acutidens* (Stimpson, 1858) (see Kim 1973; Ng et al. 2008). All of them are from the northern Pacific. These species had been previously regarded as atelecyclid crabs, but they were separated from atelecyclid crabs based mainly on the positions of gonophores in female crabs. The gonophores of the three species are exposed, whereas they are completely covered by the abdomens in atelecyclid female crabs (Tavares and Cleva 2010). The edible hair crab, *Erimacrus isenbeckii*, has been reported from the northeastern coast of Korea, the coast of Hokkaido of Japan, and the Bering Sea to Alaska (Kim 1973; Sakai 1976). It is commercially important as a fishery resource; however, its population has gradually declined at present (Abe 1992).

The larvae of the Cheiragonidae were reported for *T. cheiragonus* by Kurata (1963) and Rice (1980), *T. acutidens* by Kurata (1963) and Ko (2006), *E. isenbeckii* by Marukawa and Yasunari (1931), Marukawa and Chong (1933), Aikawa (1937), Kurata (1963) and Sasaki and Mihara (1993). Marukawa and Yasunari (1931), Marukawa and Chong (1933) and Aikawa (1937) described larvae of *E. isenbeckii* based on the plankton-caught materials. Kurata (1963) described all larval stages of *E. isenbeckii* from laboratory-hatched materials. However, all these old descriptions were very brief and not fit for current comparative morphological

studies as suggested Clark et al. (1998). Later, Sasaki and Mihara (1993) described the first zoeal stage of *E. isenbeckii*. Although the first zoeal stage was illustrated in detail, some characteristics were overlooked or were not described; moreover, their setations of the endopods of the maxillipeds were questionable. Therefore, the purpose of this paper is to describe the two zoeal stages of the species in detail and compare its morphology with the previously described zoeae from the same family.

Materials and methods

Two ovigerous crabs of *Erimacrus isenbeckii* were collected from Koseong off the northeastern part of South Korea, on 13 September 2000. They were transported to the East Sea Fisheries Research Institute and maintained at a constant temperature chamber at 12°C. The first-stage zoeae hatched on 17 April 2001 and were reared using the methods described by Ko (1995). Larvae were fixed and preserved in 10% neutral formalin. Zoeal specimens were dissected using a Leitz zoom stereomicroscope and appendages were examined using a Leitz Laborlux S microscope. Appendages were mounted in polyvinyl lactophenol and allowed to clear for 24 hrs. Cover slips were sealed with clear nail varnish and drawings were made with the aid of a camera lucida. Setal counts and measurements were based on 10 specimens for each zoeal stage. The sequence of the zoeal description is based on the malacostracan somite plan and described from anterior

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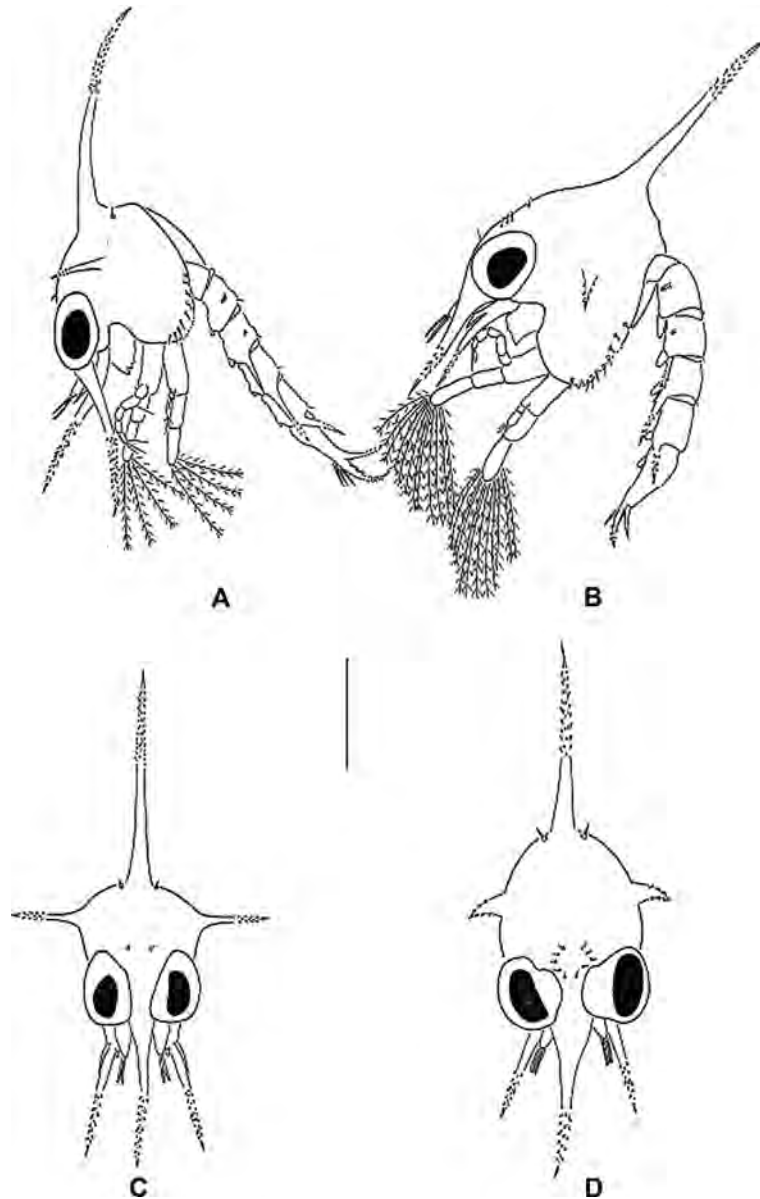


Figure 1. *Erimacrus isenbeckii* (Brandt 1848). Lateral view of zoea: (A) first zoea, (B) second zoea. Anterior view of carapace: (C) first zoea, (D) second zoea. Scale bar is 1 mm.

to posterior. The setal armature of the appendages was described from the proximal to distal segments and in the order of endopod to exopod (Clark et al. 1998). The zoeal series and the spent females were deposited at Silla University, Korea. The two zoeal stages were described and fully illustrated. The long plumose natatory setae of the first and second maxillipeds and the telson fork were drawn truncated. A micrometer was used for the zoeal measurements: CL (carapace length) from the base of the rostral spine to the most posterior carapace margin and RDL (rostral and dorsal spine length) from the tip of rostral carapace spine to the tip of the dorsal carapace spine. The

approximate measurement of the antennal exopod (for its ratio with the protopod) was taken from the base to the tip excluding the terminal setae.

Results

Five zoeal stages occurred before metamorphosis to the megalopa. The durations of the zoeal stages I to V at 12°i were 7, 11, 11, 13 and 15 days each, respectively. Metamorphosis to megalopa occurred 57 days after the first-stage zoeae hatched from eggs. The first and second zoeal stages were described and illustrated in detail, but the zoeal stages III to V could

not be described because of the setal variation of the mouthpart appendages, the bad condition of the preservation, and the shortage in the number of specimens. Also, the moult to megalopa was not entirely successful because they were unable to extricate themselves from the zoeal exoskeleton and consequently this phase could not be properly described and illustrated.

First zoea (Figure 1A, 1C, 2A, 2C, 2E, 2G, 3A, 3C, 4A, 4B, 4E, 4G, 5A, 5C, 5E) Size. CL 1.291C, 2A, 2C, 2E, 2G, 3A, 3C, Carapace (Figure 1A, C). Dorsal spine slightly curved, distally spinulate, longer than rostral spine; rostral spine distally spinulate, slightly longer than antennal protopod; lateral spines present, distally spinulate; pair of anterodorsal setae

present; pair of posterodorsal setae present; each ventral margin denticulate, with 9 setae; eyes sessile. Antennule (Figure 2C). With four long (two stout and two thinner) terminal and two shorter subterminal aesthetascs.

Antenna (Figure 2E). Protopod shorter than rostral spine, distally spinulate; endopod bud present; exopod ca. 1/4 length of protopod, with two short terminal setae.

Mandibles (Figure 2G). Asymmetrical; right molar with three teeth, left molar with tooth, confluent with incisor process.

Maxillule (Figure 3A). Coxal endite with 13 terminal setae; basal endite with 12 terminal setae; endopod 2-segmented, proximal segment with seta, distal

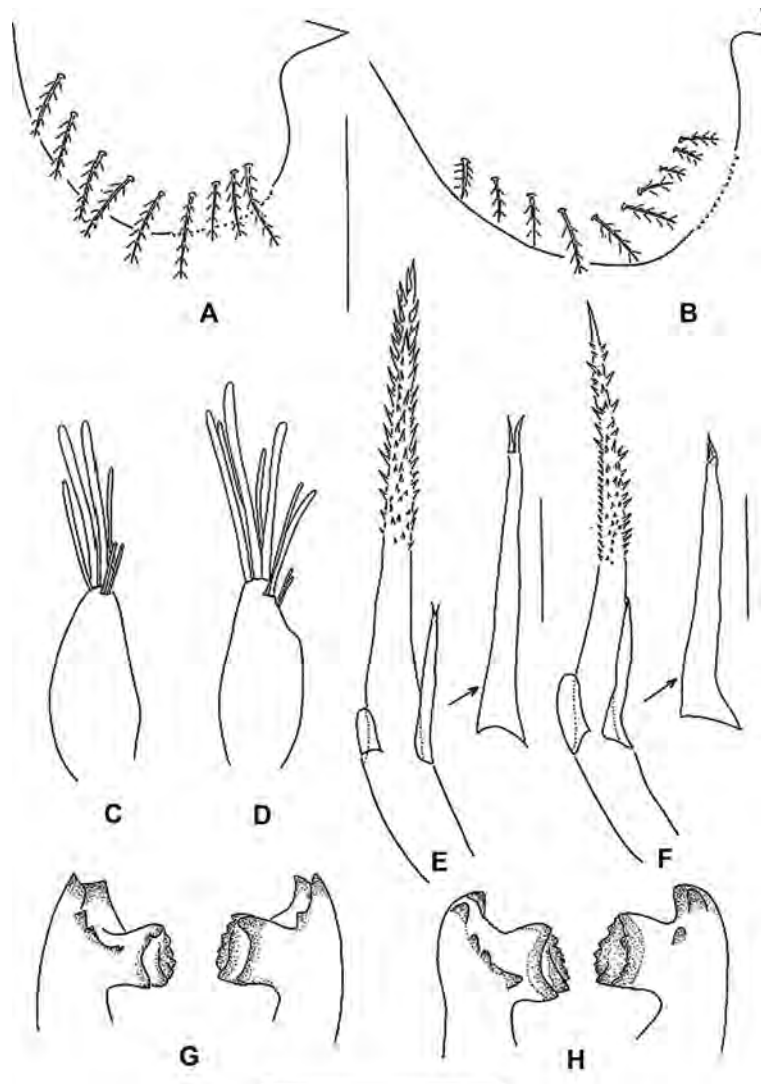


Figure 2. *Erimacrus isenbeckii* (Brandt 1848). Chaetotaxy of ventral carapace margin: (A) first zoea, (B) second zoea; antennule: (C) first zoea, (D) second zoea; antenna: (E) first zoea, (F) second zoea; mandible: (G) first zoea, (H) second zoea. Scale bar is 0.5 mm.

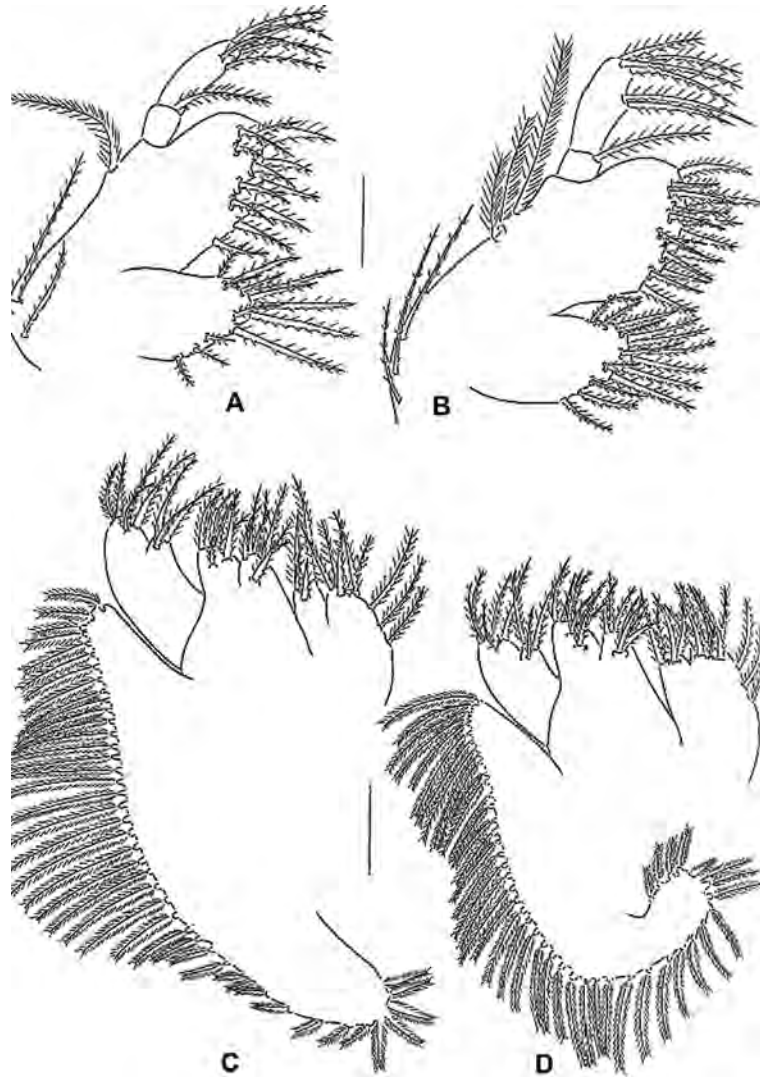


Figure 3. *Erimacrus isenbeckii* (Brandt 1848). Maxillule: (A) first zoea, (B) second zoea; maxilla: (C) first zoea, (D) second zoea. Scale bar is 0.1 mm.

segment with six (two subterminal and four terminal) setae; exopod with one medial plumose and two proximal setae.

Maxilla (Figure 3C). Coxal endite bilobed, with 8 + 4 setae; basal endite bilobed, with 7 + 7 setae; endopod bilobed, with 3 + 2 + 3 (9) setae; exopod (scaphognathite) margin with 43 plumose setae.

First maxilliped (Figure 4A). Coxa with 1 seta; basis with 10 setae arranged 2 + 2 + 3 + 3; endopod 5-segmented, with 3, 3, 1, 2, 5 (one proximal and four terminal) setae, respectively; exopod 2-segmented, distal segment with four terminal plumose setae.

Second maxilliped (Figure 4B). Coxa without seta; basis with four setae; endopod 3-segmented, with 1, 1, 5 (two subterminal and three terminal) setae, respectively; exopod 2-segmented, distal segment with four terminal plumose setae.

Third maxilliped (Figure 4E). Developing as biramous. **Pereopods** (Figure 4G). Developing as buds.

Abdomen (Figure 5A, 5C). Five somites; somite 2 with pair of lateral processes directed laterally; somite 3 with pair of lateral processes directed posteriorly; somites 3–5 with long posterolateral processes, which distally spinulate, posterolateral process of somite 4 longest; somites 2–5 with pair of posterodorsal setae; pleopod buds present.

Telson (Figure 5E). Each fork long, distally spinulate, with one lateral long (about equal in length of telson fork), two lateral smaller spines; posterior margin with three pairs of spinulate setae and pair of small setae.

Second zoea (Figure 1B, 1D, 2B, 2D, 2F, 2H, 3B, 3D, 4C, 4D, 4F, 4H, 5B, 5D, 5F) Size. CL 1.561D, 2B, 2D, 2F, 2H, 3B, 3D, Carapace (Figure 1B, 1D, 2B).

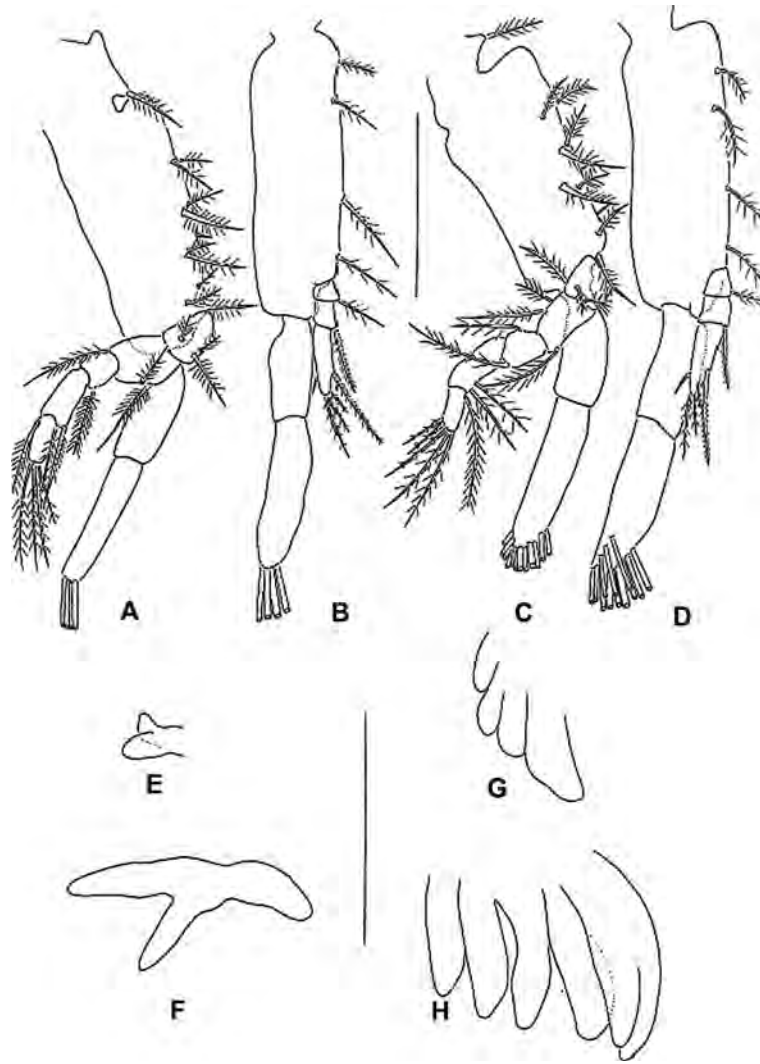


Figure 4. *Erimacrus isenbeckii* (Brandt 1848). First maxilliped: (A) first zoea, (C) second zoea; second maxilliped: (B) first zoea, (D) second zoea; third maxilliped: (E) first zoea, (F) second zoea; pereopods: (G) first zoea, (H) second zoea. Scale bar is 0.5 mm.

Lateral spine relatively shorter than that of previous stage; five pairs of anterodorsal setae present; eyes stalked; each ventral margin with 10 setae; otherwise unchanged.

Antennule (Figure 2D). Endopod bud rudimentary present; exopod with five long (three stout and two thinner) terminal, two thinner and two shorter subterminal aesthetascs; otherwise unchanged.

Antenna (Figure 2F). Endopod bud larger than that of previous stage; otherwise unchanged.

Mandibles (Figure 2H). Unchanged.

Maxillule (Figure 3B). Coxal endite with 15 setae; basal endite with 16 setae; exopod with three plumose and three setae; otherwise unchanged.

Maxilla (Figure 3D). Coxal endite bilobed, with 10 + 4 setae; basal endite bilobed, with 7 + 8 setae; exopod (scaphognathite) margin with 47 plumose setae; otherwise unchanged.

First maxilliped (Figure 4C). Endopod 5-segmented, with 3, 3, 2, 2, 5 (one proximal and four terminal) setae, respectively; exopod distal segment with 12 terminal plumose setae; otherwise unchanged.

Second maxilliped (Figure 4D). Exopod distal segment with 12 terminal plumose setae; otherwise unchanged.

Third maxilliped (Figure 4F). Biramous; gill present.

Pereopods (Figure 4H). Undifferentiated into segments; cheliped bilobed.

Abdomen (Figure 5B, D): Six somites; pleopod buds more developing but without endopod buds; otherwise unchanged.

Telson (Figure 5F). Posterior margin with three pairs of stout spinulate setae and two pairs of small setae; one lateral long spine slightly shorter than length of telson fork; otherwise unchanged.

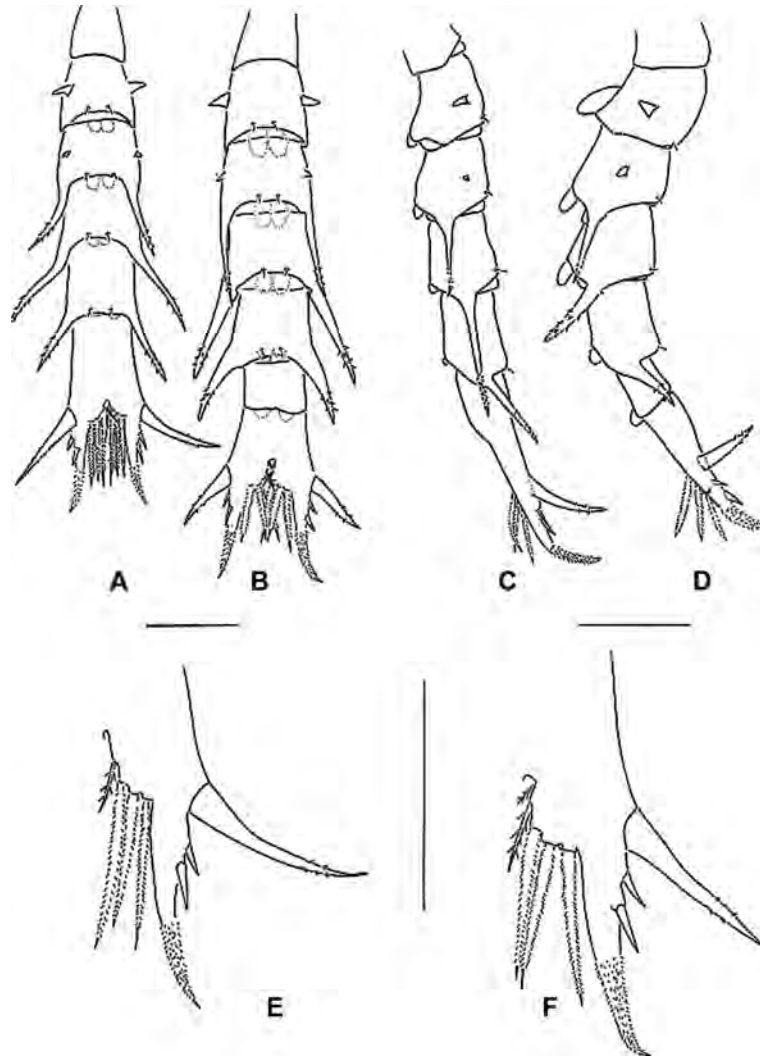


Figure 5. *Erimacrus isenbeckii* (Brandt 1848). Dorsal view of abdomen: (A) first zoea, (B) second zoea; lateral view of abdomen: (C) first zoea, (D) second zoea; dorsal view of telson: (E) first zoea, (F) second zoea. Scale bar is 0.5 mm.

Discussion

Although Aikawa (1937) described the fifth zoeal and megalopal stages of *Erimacrus isenbeckii* from the materials of plankton sampling, it is not informative enough for this study. Also, Kurata (1963) described all the larval stages of this species from eggs hatched in the laboratory; however, his description and figures are very brief and not adequate for a modern comparison (see the zoeal description of *T. cheiragonus* by Kurata (1963) in Table 2). The first zoeal stage was described later by Sasaki and Mihara (1993). However, we found some important setal differences in the endopods of the maxillipeds (Table 1). In our study, the setations of the endopods of both maxillipeds were not 2, 2, 1, 2, 5 and 1, 1, 4 but 3, 3, 1, 2, 5 and 1, 1, 5. These setations were agreed well with those of *T. acutidens* within the same family (Table 2). In addition, some setae or buds were

found on the carapace, the mouthpart appendages, and the pereopods in the present study (Table 1).

As a result of our study, whether incomplete or complete, zoeal descriptions of all three species are available in the Cheiragonidae (Table 2). The common zoeal characteristics of the three species, which are almost consistent during zoeal development, can be summarized as follows: carapace with long dorsal, rostral, and short lateral spines; antennal exopod less than 1/3 length of protopod, with two setae; endopod of maxillule with 1, 2+4 setae; endopod of maxilla with 3+2+3 setae; basis of first maxilliped with 2+2+3+3 setation, proximal segment of endopod with three setae; basis of second maxilliped with 1+1+1+1 setation, endopod with 1, 1, 5 setation; telson fork with one long and two smaller lateral spines. Therefore, the Cheiragonidae seem to be homogeneous based on the zoeal characteristics.

Table 1. A comparison of the first zoeal characteristics of *Erimacrus isenbeckii* described by Sasaki and Mihara (1993) with those of the present study.

Authors	Sasaki and Mihara (1993)	The present study
First zoea		
Carapace		
anterodorsal	No description	1 pair of setae
posterodorsal	No description	1 pair of setae
Maxillule		
basial endite	10 setae	12 setae
coxal endite	9 setae	13 setae
Maxilla		
basial endite	6 + 5 setae	7 + 7 setae
scaphognathite	31 setae	43 setae
First maxilliped		
endopod	2, 2, 1, 2, 5 setae	3, 3, 1, 2, 5 setae
coxa	No description	1 seta
Second maxilliped		
endopod	1, 1, 4 setae	1, 1, 5 setae
coxa	No description	1 seta
Third maxilliped	No description	Biramous buds
Pereopods	No description	Buds

Rice (1980) suggested the derived zoeal characteristics as reductions or losses of the carapace spines, setations of the mouthpart appendages, lateral processes and posterolateral processes on the abdominal somites, and lateral spines on the telson. Based on his suggestion, *E. isenbeckii* may be the primitive taxon and *T. acutidens* the most derived taxon within the family because the zoea of *E. isenbeckii* has heavily spinulate carapace spines, more setae of the mouthpart appendages than those in zoeae of two *Temessus* species, additional processes on the abdominal somites, and a very long lateral spine on the telson (Table 2).

In the previous study of the cheiragonid zoeae (Ko 2006), only two diagnostic characteristics were used for identifying the zoea of *E. isenbeckii*, that is, (1) lateral processes on the abdominal somites 2 and 3 and (2) posterolateral process on the somite 4 spinulate and longer than the length of the somite 5. In addition, three diagnostic characteristics are found in this study: (1) heavily spinulate rostral and dorsal carapace spines, (2) the antennal exopod with two short equal sized setae, and (3) the telson fork with a very long (more or less the length of the telson fork) and two smaller lateral spines (Table 2).

Table 2. A comparison of the zoeal characteristics from three known species of the family Cheiragonidae.

Species: Authors:	<i>Temessus cheiragonus</i> Kurata (1963)	<i>Temessus acutidens</i> Ko (2006)	<i>Erimacrus isenbeckii</i> The present study
First zoea			
Carapace spines	Slightly spinulate	Smooth	Heavily spinulate
Antennal exopod	Less than 1/3 length of protopod, with 2 long, unequal-sized setae	Less than 1/3 length of protopod, with 2 long, unequal-sized setae	Less than 1/3 length of protopod, with 2 short, equal-sized setae
Maxillule			
endopod	1, 2 + 4 setae	1, 2 + 4 setae	1, 2 + 4 setae
basial endite	No description	8 setae	12 setae
coxal endite	No description	9 setae	13 setae
Maxilla			
endopod	3 + 2 + 3 setae	3 + 2 + 3 setae	3 + 2 + 3 setae
basial endite	No description	5 + 6 setae	7 + 7 setae
coxal endite	No description	5 + 4 setae	8 + 4 setae
scaphognathite	No description	28 setae	43 setae
First maxilliped			
basis	No description	2 + 2 + 3 + 3 setae	2 + 2 + 3 + 3 setae
endopod	No description	3, 2, 1, 2, 5 setae	3, 3, 1, 2, 5 setae
exopod	4 setae	4 setae	4 setae
Second maxilliped			
basis	No description	1 + 1 + 1 + 1 setae	1 + 1 + 1 + 1 setae
endopod	No description	1, 1, 5 setae	1, 1, 5 setae
exopod	4 setae	4 setae	4 setae

Table 2 (Continued)

Species:	<i>Telmessus cheiragonus</i>	<i>Telmessus acutidens</i>	<i>Erimacrus isenbeckii</i>
Authors:	Kurata (1963)	Ko (2006)	The present study
Abdomen			
lateral process	On somite 2	On somite 2	On somites 2, 3
posterolateral process on somites 3–5	Tips not overreaching to length of next somite, not spinulate	Tips short, not spinulate	Tips overreaching to length of next somite, spinulate
Telson			
lateral spines	1 long (less than 1/2 length of fork), 2 smaller	1 long (less than 1/2 length of fork), 2 smaller	1 very long (about equal length of fork), 2 smaller
Second zoea			
Carapace spines	Slightly spinulate	Smooth	Heavily spinulate
Antennal exopod	Less than 1/3 length of protopod, with 2 long, unequal-sized setae	Less than 1/3 length of protopod, with 2 long, unequal-sized setae	Less than 1/3 length of protopod, with 2 short, equal-sized setae
Maxillule			
endopod	1, 2 + 4 setae	1, 2 + 4 setae	1, 2 + 4 setae
basial endite	No description	9 setae	16 setae
coxal endite	No description	10 setae	15 setae
Maxilla			
endopod	3 + 2 + 3 setae	3 + 2 + 3 setae	3 + 2 + 3 setae
basial endite	No description	6 + 7 setae	7 + 8 setae
coxal endite	No description	6 + 4 setae	10 + 4 setae
scaphognathite	No description	32 setae	47 setae
First maxilliped			
basis	no description	2 + 2 + 3 + 3 setae	2 + 2 + 3 + 3 setae
endopod	no description	3, 3, 2, 2, 5 setae	3, 3, 2, 2, 5 setae
exopod	10 setae	8 setae	12 setae
Second maxilliped			
basis	No description	1 + 1 + 1 + 1 setae	1 + 1 + 1 + 1 setae
endopod	No description	1, 1, 5 setae	1, 1, 5 setae
exopod	10 setae	8 setae	12 setae
Abdomen			
lateral processes	On somite 2	On somite 2	On somites 2, 3
posterolateral process on somites 3–5	Tips not overreaching to length of next somite, not spinulate	Tips short, not spinulate	Tips overreaching to length of next somite, spinulate
Telson			
lateral spines	1 long (less than 1/2 length of fork), 2 smaller	1 long (less than 1/2 length of fork), 2 smaller	1 very long (slightly shorter than length of fork), 2 smaller

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