

Zoeal Stages of *Leptomithrax edwardsii* (Crustacea: Decapoda: Majidae) Described from Laboratory Reared Material

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Abstract

Zoeas of *Leptomithrax edwardsii* were reared in the laboratory. Two zoeal stages are described and illustrated. The first zoeal stage of *L. edwardsii* is compared with those of seven known species of the family Majidae. It differs from previous description in the endopodal setation characters of the maxillule and the second maxilliped. It appears most similar to *L. bifidus* and *Schizophroida simodaensis* of the northwestern Pacific. A provisional key for identifying eight majid zoeas is included.

Keywords: Majidae, spider crab, *Leptomithrax edwardsii*, zoea, *L. bifidus*, *Schizophroida simodaensis*, key, northwestern Pacific

INTRODUCTION

There are eight species of Majidae Samouelle, 1819 from Korean waters: four species of Majinae [*Leptomithrax bifidus* (Ortmann, 1893), *L. edwardsii* (De Haan, 1835), *Maja miersii* Walker, 1887, and *M. spinigera* (De Haan, 1837)] and four species of Mithracinae [*Micippa cristata* (Linnaeus, 1758), *M. philyra* (Herbst, 1803), *M. platipes* Rüppell, 1830, and *M. thalia* (Herbst, 1803)] (see the Korean Society of Systematic Zoology, 1997; Ng et al., 2008). Of these, *L. edwardsii* inhabits the sandy and muddy bottoms at depths between 50-150 m with a report distributed to Korea and Japan (Kim, 1973).

Larval descriptions of Majidae are limited to eight species in the northwestern Pacific: *Schizophrys aspera* (Milne-Edwards, 1834) by Kurata (1969) and Terada (1981), *Schizophroida simodaensis*, Sakai, 1933 by Terada (1981), *L. bifidus* by Kurata (1969) and Terada (1981), *L. edwardsii* by Kurata (1969), *M. spinigera* by Terada (1981), *M. philyra* by Ko (1995), *M. thalia* by Kurata (1969) and *Tiarinia cornigera* (Latreille, 1825) by Kurata (1969). However, *L. edwardsii* is known for its first zoeal stage with a brief description by Kurata (1969) (Table 1). Therefore, in this study, we describe

the zoeal stages of *L. edwardsii* in detail and compare them with previously described majid zoeas from the northwestern Pacific.

MATERIALS AND METHODS

On 30 December 2011 an ovigerous crab of *L. edwardsii* was collected from Gijang (35° 19'N, 129° 17'E), Busan, Korea. And the larvae hatched in the laboratory on 31 January 2012. A total of 120 zoeas was reared individually at a water temperatures of 15 ± 1°C. Each zoea was held in a plastic well containing 5-6 mL of sea water for the first and second stages. The water was changed daily and each zoea was provided with newly hatched *Artemia* nauplii once a day. Each individual culture was checked daily for exuviae and dead zoeas. Moults and dead larvae were fixed and preserved in 10% neutral formalin for later examination. Dissected appendages were examined and drawn using a Leitz Laborlux S microscope (Swiss) with a camera lucida. Setal counts on appendages and measurements were based on the mean of ten specimens for zoeal stage. The sequence of larval description (Clark et al., 1998) is based on the malacostracan somite plan

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Table 1. Comparison of the first zoeal characteristics of *Leptomithrax edwardsii* described by Kurata (1969) with those obtained in the present study

	Kurata (1969)	Present study
CL	ND	1.11 mm
RDL	1.23 mm	1.56 mm
Carapace		
Lateral margin	1 plumose, 3 setae	1 plumose, 4 setae
Rostral spine	Present	Present
Dorsal spine	Present	Present
Lateral spine	Absent	Absent
Antennule	ND	3 aesthetascs, 2 setae
Antenna		
Endopod bud	Present	Present
Exopod	2 subterminal setae	2 subterminal setae
Maxillule		
Endopod	1, 7 setae	1, 2+4 setae
Basal endite	ND	7 setae
Coxal endite	ND	7 setae
Maxilla		
Endopod	5 setae	3+2 setae
Basal endite	ND	5+4 setae
Coxal endite	ND	3+4 setae
Scaphognathite	ND	10+1 setae
Maxilliped I		
Endopod	ND	3, 2, 1, 2, 5 setae
Basis	ND	2, 2, 2, 3 setae
Maxilliped II		
Endopod	0, 1, 6 setae	0, 7 setae
Basis	ND	1, 1, 1 setae
Abdomen		
Lateral process	Somite 2	Somite 2
Telson		
Fork	1 large, 2 smaller spines	1 large, 2 smaller spines

CL, carapace length; RDL, rostral spine to dorsal spine length; ND, no data.

and described from anterior to posterior. Setal armature is described from proximal to distal segments and in order of endopod to exopod. The long plumose natatory setae of the first and second maxillipeds were drawn truncated. A micrometer was used for measurements: Carapace length (CL) was measured from the anterior margin of the eye to the most posterior carapace margin. Rostral spine to dorsal spine length (RDL) was measured from tip of the rostrum to tip of the dorsal spine. The classification follows that of Ng et al. (2008). The zoeas and spent female were deposited at Silla University, Korea.

RESULTS

Zoeal development consists of two zoeal stages. The mean duration of the first zoeal stage at 15°C was 16 days. The second zoeal stage survived for 17 days. The moult to mega-

lopa was not entirely successful because the megalopa was unable to extricate themselves from the zoeal exoskeleton. The first zoeal stage is described and illustrated completely. Only the main differences from the first zoea are described for the second zoeal stage.

First zoea (Figs. 1, 2)

Size: CL, 1.11 ± 0.02 mm; RDL, 1.56 ± 0.03 mm.

Chromatophores (Fig. 1). Predominantly yellow pigments which occurring on carapace, antenna, mandibles, basis of maxillipeds, pleomeres 1-4, and fork of telson; brown and black pigments which occurring behind eye, posterodorsal and posterolateral regions of carapace, mandibles, basis of maxillipeds, posterolateral margins of pleomeres 1-4, fork of telson.

Carapace (Fig. 2A). Dorsal spine slightly shorter than 1/2 CL, slightly curved posteriorly; rostral spine straight, approximately 1/2 length of dorsal spine; lateral spine absent; pair of posterodorsal setae present; each ventral margin with 1 plumose anterior and 4 posterior setae; eyes sessile.

Antennule (Fig. 2B). Uniramous; endopod absent; exopod with 1 long, stout aesthetasc, 2 shorter, thinner aesthetascs, 1 long and 1 shorter setae, all terminal.

Antenna (Fig. 2C). Biramous; endopod bud present; protopod about twice length to rostral spine, spinulate distally; exopod with 2 unequal subterminal setae, its tip shorter than protopod. Mandibles (Fig. 2D). Asymmetrical; right molar and left molar processes each with tooth, confluent with incisor process; palp absent.

Maxillule (Fig. 2E). Coxal and basal endites both with 7 setae; endopod 2-segmented, proximal segment with 1 seta, distal segment with 6 (2 subterminal, 4 terminal) setae; exopod seta and epipod absent.

Maxilla (Fig. 2F). Coxal endite bilobed, with 3+4 setae; basal endite bilobed, with 5+4 setae; endopod bilobed, with 3+2 setae; exopod (scaphognathite) margin with 10 plumose setae plus 1 distal stout process.

First maxilliped (Fig. 2G). Coxa without seta; basis with 9 setae arranged 2+2+2+3; endopod 5-segmented with 3, 2, 1, 2, 5 (1 subterminal, 4 terminal) setae; exopod 2-segmented, distal segment with 4 terminal plumose natatory setae.

Second maxilliped (Fig. 2H). Coxa without seta; basis with 3 setae arranged 1+1+1; endopod 2-segmented, with 0, 7 (1 proximal, 3 subterminal, 3 terminal) setae; exopod 2-segmented, distal segment with 4 terminal plumose natatory setae.

Third maxilliped (Fig. 2I). Biramous.

Pereiopods (Fig. 2J). Present as buds.

Pleon (Fig. 2K). With 5 pleomeres; pleomere 1 with 2 dorsomedial setae; pleomere 2 with a pair of lateral processes directed anteriorly; pleomeres 2-5 each with a pair of pos-



Fig. 1. *Leptomithrax edwardsii*, first stage zoeas, live specimens.

terodorsal setae, pleomeres 3-5 with long posterolateral processes, progressing reduced in size; pleopod present as buds without endopods.

Telson (Fig. 2K, L). Each fork long, covered with setules, with 1 stout, 2 shorter spines laterally; each posterior margin with 3 serrated setae.

Second zoea (Fig. 3)

Size: CL, 1.43 ± 0.05 mm; RDL, 1.68 ± 0.05 mm.

Carapace (Fig. 3A). Each ventral margin with 1 plumose anterior and 7 posterior setae; eyes stalked.

Antennule (Fig. 3B). Biramous, endopod present, exopod with 1 subterminal and 5 terminal aesthetascs, 2 terminal short setae.

Antenna (Fig. 3C). Endopod bud approximately 1/2 length of protopod.

Mandibles (Fig. 3D). Right molar process with 2 teeth, confluent with incisor process; palp present.

Maxillule (Fig. 3E). Basal endite with 8 setae. Exopod plumose seta now present.

Maxilla (Fig. 3F). Basal endite with 5+5 setae; exopod (scaphognathite) margin with 16 marginal plumose setae.

First maxilliped (Fig. 3G). Coxa with 1 seta; exopod distal segment with 6 terminal natatory setae.

Second maxilliped (Fig. 3H). Exopod distal segment with 6 terminal natatory setae.

Third maxilliped (Fig. 3I). Endopod and exopod more devel-

oped.

Pereiopods (Fig. 3J). More developed, segments differentiated, chela bilobed.

Pleon (Fig. 3K). With 6 pleomeres; pleomere 1 with 3 dorsomedial setae; pleopod buds more developed, endopods present.

Telson (Fig. 3K). Unchanged.

DISCUSSION

Kurata (1969) described only the first zoeal stage; however, his description was too brief compared with that of the present study (Table 1). Moreover, he described the endopod of the maxillule as having 1, 7 setae, but it does not coincide with the other six known species of Majidae, which have 1, 2+4 setae. Also, he described the endopod of the second maxilliped as having 0, 1, 6 setae; however, we found 0, 7 setae as in *S. simodaensis*.

In the northwestern Pacific, larval information of the family Majidae are available for eight species [three species (*Micippa philyra*, *M. thalia*, and *Tiarinia cornigera*) of the subfamily Mithracinae and five species (*Maja spinigera*, *Schizophrys aspera*, *S. simodaensis*, *Leptomithrax bifidus*, and *L. edwardsii*) of the subfamily Majinae]. The morphological characteristics of the majid zoeas can be summarized as follows (Table 2): Endopod bud of the antenna present;

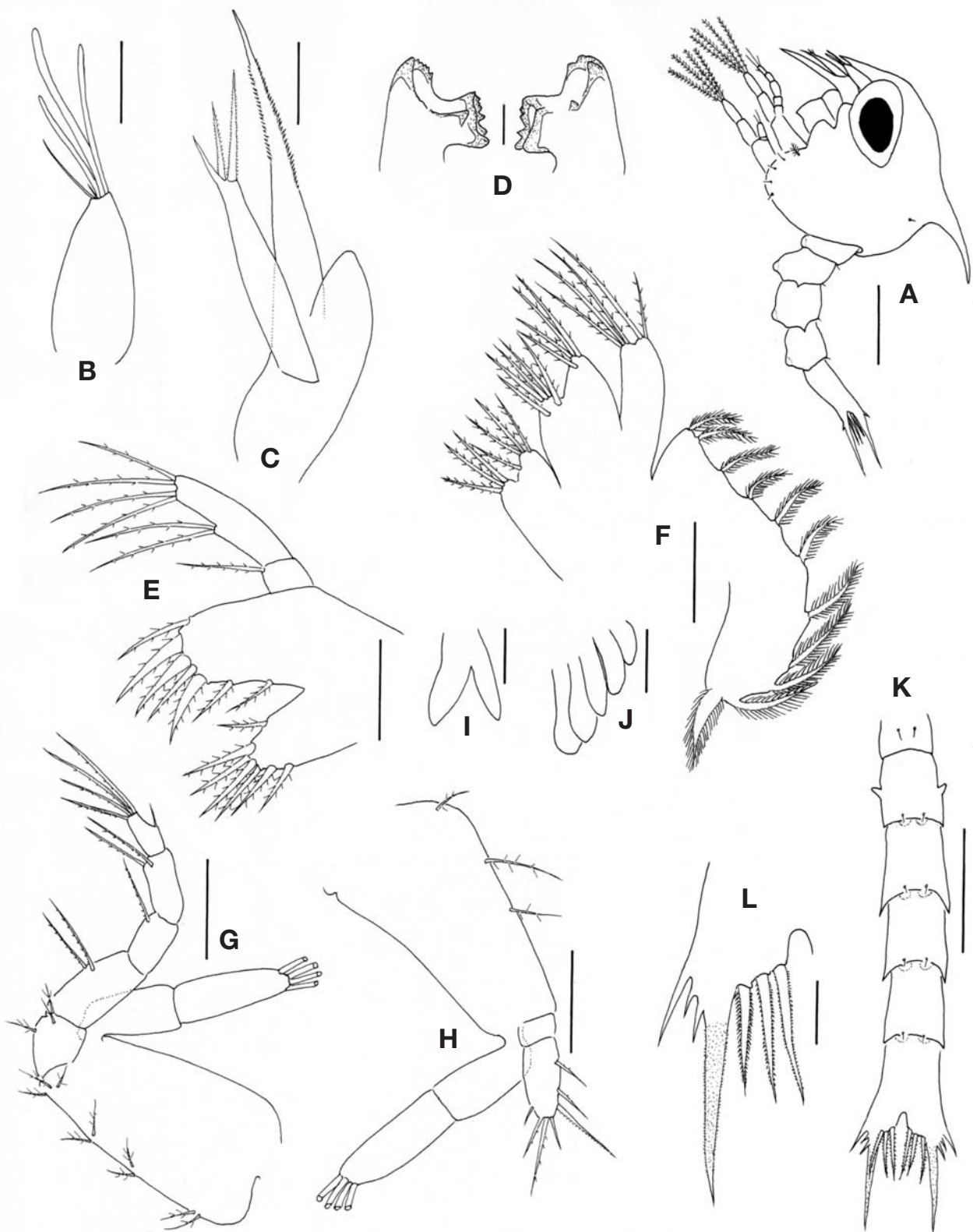


Fig. 2. *Leptomithrax edwardsii*, first zoeal stage. A, Lateral view; B, Antennule; C, Antenna; D, Mandibles; E, Maxillule; F, Maxilla; G, First maxilliped; H, Second maxilliped; I, Third maxilliped; J, Pereiopods; K, Dorsal view of abdomen and telson; L, Fork of telson. Scale bars: A, K=0.5 mm, B-J, L=0.1 mm.

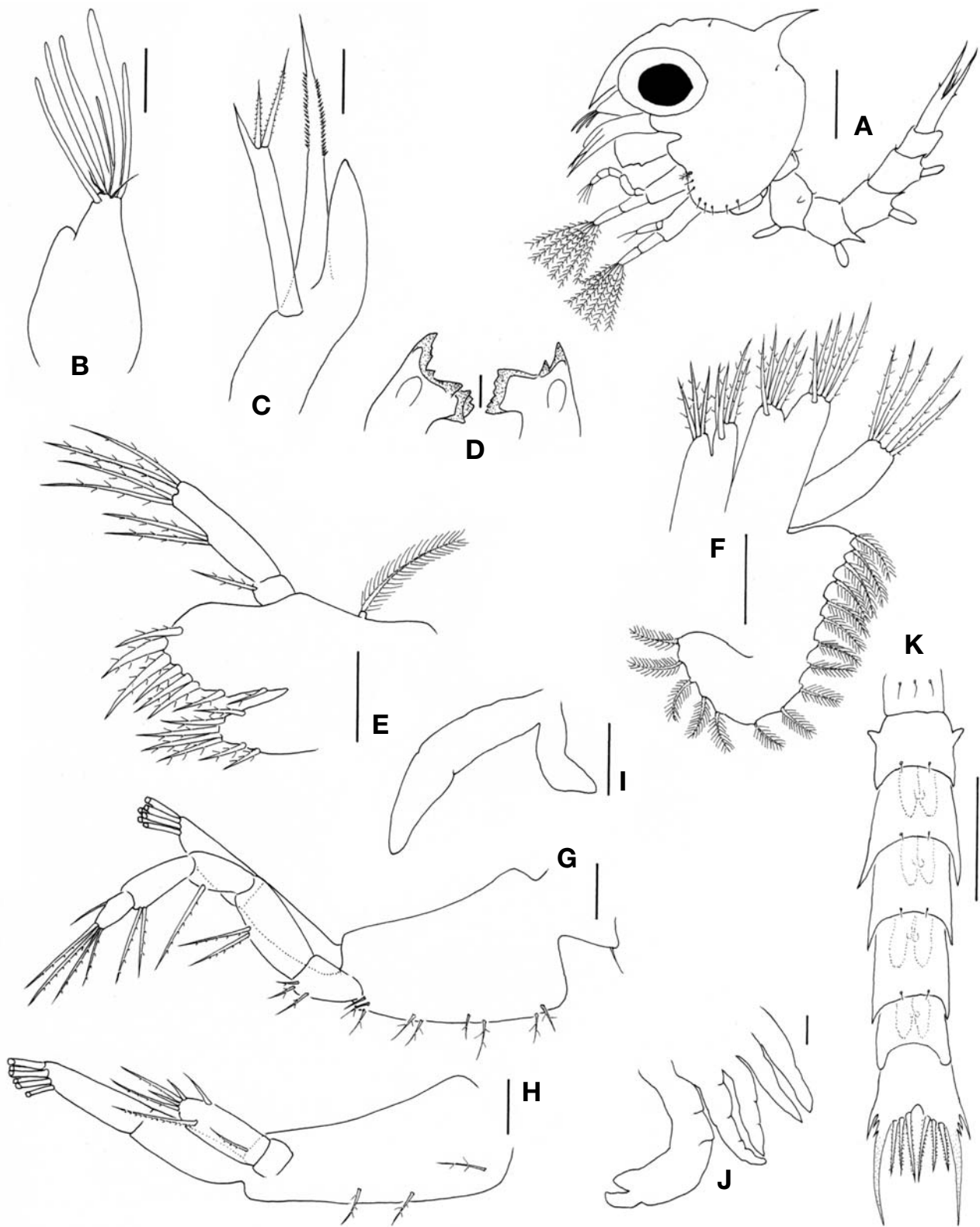


Fig. 3. *Leptomithrax edwardsii*, second zoeal stage. A, Lateral view; B, Antennule; C, Antenna; D, Mandibles; E, Maxillule; F, Maxilla; G, First maxilliped; H, Second maxilliped; I, Third maxilliped; J, Pereiopods; K, Dorsal view of abdomen and telson. Scale bars: A, K=0.5 mm, B-J=0.1 mm.

Table 2. Comparison of the first zoeal characteristics in eight species of Majidae from the northwestern Pacific

Species	<i>Micippa philyra</i>	<i>Micippa thalia</i>	<i>Tiarinia cornigera</i>	<i>Maja spinigera</i>	<i>Schizophrys aspera</i>	<i>Schizophrorda simodaensis</i>	<i>Leptomithrax bifidus</i>	<i>Leptomithrax edwardsii</i>
CL (mm)	0.80	ND	ND	0.91	0.60	0.79	0.68	1.11
RDL (mm)	ND	0.92	0.93	1.26	1.22	1.25	0.88	1.56
Carapace								
Rostral spine	1/2 CL	1/2 CL	Reduced	1/2 CL	1/2 CL	1/5 CL	1/7 CL	1/5 CL
Dorsal spine	Absent	Absent	1/3 CL	1/4 CL	1/2 CL	1/2 CL	1/4 CL	1/3 CL
Lateral spine	Present	Present	Absent	Absent	Present	Absent	Absent	Absent
Antenna								
Endopod bud	Present	Present	Present	Present	Present	Present	Present	Present
Exopod spine	2 medial	2 medial	2 submedial	2 subterminal	2 subterminal	2 subterminal	2 subterminal	2 subterminal
Maxillule								
Endopod setae	1, 2+4	1, 2+4	ND	1, 2+4	1, 2+4	1, 2+4	1, 2+4	1, 2+4
Maxilla								
Endopod setae	3+3	3+3	3	3+2	3+2	ND	3+2	3+2
Maxilliped I								
Endopod setae	3, 2, 1, 2, 5	ND	ND	3, 2, 1, 2, 5	3, 2, 1, 2, 5	3, 2, 1, 2, 5	3, 2, 1, 2, 5	3, 2, 1, 2, 5
Basis setae	2, 2, 3, 3	ND	ND	2, 2, 2, 3	2, 2, 2, 3	2, 2, 2, 3	2, 2, 2, 3	2, 2, 2, 3
Maxilliped II								
Endopod setae	0, 1, 4	0, 1, 4	ND	0, 1, 6	0, 1, 6	0, 7	0, 1, 6	0, 7
Basis setae	1, 1, 1	ND	ND	1, 1, 1	1, 1, 1	ND	1, 1, 1	1, 1, 1
Abdomen								
Lateral process	Somites 2, 3	Somites 2, 3	Somite 2	Somites 2, 3	Somites 2, 3	Somite 2	Somite 2	Somite 2
Telson fork								
Lateral spine	1 large, 2 smaller	1 large, 1 smaller	1 large	1 large	1 large, 2 smaller	1 large	1 large, 2 smaller	1 large, 2 smaller
Sources	Ko (1995)	Kurata (1969)	Kurata (1969)	Terada (1981)	Terada (1981)	Terada (1981)	Terada (1981)	Present study

CL, carapace length; RDL, rostral spine to dorsal spine length; ND, no data.

endopod of the maxillule with 1, 2+4 setae; the endopod of the first maxilliped with 3, 2, 1, 1, 5 setae; the basis of the second maxilliped with 1, 1, 1 setae; and the telson fork with lateral spines. However, the zoeas of Majinae are different from those of Mithracinae by having a dorsal carapace spine, no lateral carapace spines (except in *S. aspera*), 2 subterminal setae in the antennal exopod, 3+2 setae in the endopod of the maxilla, 2, 2, 2, 3 setae in the basis of the first maxilliped, 0, 1, 6 or 0, 7 setae in the endopod of the second maxilliped, and a lateral process in the abdominal somite 2 (except in *M. spinigera* and *S. aspera*).

As shown in Table 2, the first zoea of *L. edwardsii* appears most similar to those of *L. bifidus* and *S. simodaensis* in Majidae; however, it can be separated from the other species on the basis of the endopodal setae of the second maxilliped and the features of telson fork.

The following provisional key is provided for identifying the eight majid zoeas

1. Dorsal carapace spine present 2
- Dorsal carapace spine absent 3
2. Tip of exopod longer than that of protopod in antenna
Micippa thalia
- Tip of exopod shorter than that of protopod in antenna

- *M. philyra*
3. Lateral carapace spine present *Schizophrys aspera*
- Lateral carapace spine absent 4
4. Lateral processes on abdominal somites 2, 3
Maja spinigera
- Lateral process on abdominal somite 2 5
5. Rostral carapace spine reduced or extremely short
Tiarinia cornigera
- Rostral carapace spine approximately 1/2 length of dorsal carapace spine 6
6. Endopod of second maxilliped with 0, 1, 6 setae
Leptomithrax bifidus
- Endopod of second maxilliped with 0, 7 setae 7
7. Fork of telson with 1 large lateral spine
Schizophrorda simodaensis
- Fork of telson with 1 large and 2 smaller lateral spines
L. edwardsii

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