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

Jung-Ha Kang¹, Yong-Seok Lee², Ji-Eun Jeong², Hyun-Sook Ko³,*
¹Biotechnology Research Division, National Fisheries Research and Development (NFRDI), Busan 619-705, Korea
²Department of Parasitology, College of Medicine and UHRC, Inje University, Busan 614-735, Korea
³Department of Biological Science, Silla University, Busan 617-736, Korea

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. phillyra (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. phillyra 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
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 megalopa 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 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, postero lateral 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 basial endites both with 7 setae; endopod 2-segmented, proximal segment with 1 seta, distal segment with 6 (2 subterminal, 4 terminal) setae; exopod (scaphognathite) margin with 10 plumose setae plus 1 distal stout process.

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

**Maxilliped I** (Fig. 2G). Coxa without seta; basis with 9 setae; endopod 5-segmented, proximal segment with 1 seta, distal segment with 6 (2 subterminal, 4 terminal) setae; exopod seta and epipod absent.

**Maxilliped II** (Fig. 2H). Coxa without seta; basis with 3 setae; endopod 2-segmented, proximal segment with 1 seta, distal segment with 6 (2 subterminal, 4 terminal) setae; exopod 2-segmented, distal segment with 4 terminal plumose natatory setae.

**Telson** (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-
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). Basial endite with 8 setae. Exopod plumose seta now present.
Maxilla (Fig. 3F). Basial 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 developed.
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 informations 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.
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
   – Dorsal carapace spine absent
2. Tip of exopod longer than that of protopod in antenna
   – Tip of exopod shorter than that of protopod in antenna

<table>
<thead>
<tr>
<th>Species</th>
<th>Micippa philyra</th>
<th>Micippa thalia</th>
<th>Tiarinia cornigera</th>
<th>Maja spinigera</th>
<th>Schizephyrs aspera</th>
<th>Schizephyrida simodaensis</th>
<th>Leptomithrax bifidus</th>
<th>Leptomithrax edwardsii</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL (mm)</td>
<td>0.80</td>
<td>ND</td>
<td>ND</td>
<td>0.91</td>
<td>0.60</td>
<td>0.79</td>
<td>0.68</td>
<td>1.11</td>
</tr>
<tr>
<td>RDL (mm)</td>
<td>ND</td>
<td>0.92</td>
<td>0.93</td>
<td>1.26</td>
<td>1.22</td>
<td>1.25</td>
<td>0.88</td>
<td>1.56</td>
</tr>
<tr>
<td>Carapace</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rostral spine</td>
<td>1/2 CL</td>
<td>1/2 CL</td>
<td>Reduced</td>
<td>1/2 CL</td>
<td>1/2 CL</td>
<td>1/5 CL</td>
<td>1/7 CL</td>
<td>1/5 CL</td>
</tr>
<tr>
<td>Dorsal spine</td>
<td>Absent</td>
<td>Absent</td>
<td>1/3 CL</td>
<td>1/4 CL</td>
<td>1/2 CL</td>
<td>1/2 CL</td>
<td>1/4 CL</td>
<td>1/3 CL</td>
</tr>
<tr>
<td>Lateral spine</td>
<td>Present</td>
<td>Present</td>
<td>Absent</td>
<td>Absent</td>
<td>Present</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>Maxillule</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endopod setae</td>
<td>1, 2+4</td>
<td>3+3</td>
<td>ND</td>
<td>1, 2+4</td>
<td>1, 2+4</td>
<td>3+2</td>
<td>ND</td>
<td>3+2</td>
</tr>
<tr>
<td>Exopod spine</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>Maxilliped I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endopod setae</td>
<td>3, 2, 1, 2, 5</td>
<td>ND</td>
<td>ND</td>
<td>3, 2, 1, 2, 5</td>
<td>3, 2, 1, 2, 5</td>
<td>3, 2, 1, 2, 5</td>
<td>3, 2, 1, 2, 5</td>
<td>3, 2, 1, 2, 5</td>
</tr>
<tr>
<td>Basis setae</td>
<td>2, 2, 3, 3</td>
<td>ND</td>
<td>ND</td>
<td>2, 2, 3, 3</td>
<td>2, 2, 3</td>
<td>2, 2, 3</td>
<td>2, 2, 3</td>
<td>2, 2, 3</td>
</tr>
<tr>
<td>Maxilliped II</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endopod setae</td>
<td>0, 1, 4</td>
<td>0, 1, 4</td>
<td>ND</td>
<td>0, 1, 6</td>
<td>0, 1, 6</td>
<td>0, 7</td>
<td>0, 1, 6</td>
<td>0, 7</td>
</tr>
<tr>
<td>Basis setae</td>
<td>1, 1, 1</td>
<td>ND</td>
<td>ND</td>
<td>1, 1, 1</td>
<td>1, 1, 1</td>
<td>ND</td>
<td>1, 1, 1</td>
<td>1, 1, 1</td>
</tr>
<tr>
<td>Abdomen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral process</td>
<td>Somites 2, 3</td>
<td>Somites 2, 3</td>
<td>Somite 2</td>
<td>Somites 2, 3</td>
<td>Somites 2, 3</td>
<td>Somite 2</td>
<td>Somite 2</td>
<td>Somite 2</td>
</tr>
<tr>
<td>Telson fork</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral spine</td>
<td>1 large, 2 smaller</td>
<td>1 large, 1 smaller</td>
<td>1 large</td>
<td>1 large, 1 smaller</td>
<td>1 large, 2 smaller</td>
<td>1 large, 2 smaller</td>
<td>1 large, 2 smaller</td>
<td>1 large, 2 smaller</td>
</tr>
</tbody>
</table>

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
   – Dorsal carapace spine absent
2. Tip of exopod longer than that of protopod in antenna
   – Tip of exopod shorter than that of protopod in antenna

3. Lateral carapace spine present
   – Lateral carapace spine absent
4. Lateral processes on abdominal somites 2, 3
   – Lateral process on abdominal somite 2
5. Rostral carapace spine reduced or extremely short
   – Rostral carapace spine approximately 1/2 length of dorsal carapace spine
6. Endopod of second maxilliped with 0, 1, 6 setae
   – Endopod of second maxilliped with 0, 7 setae
7. Fork of telson with 1 large lateral spine
   – Fork of telson with 1 large and 2 smaller lateral spines

ACKNOWLEDGMENTS

This work was supported by the National Fisheries Research and Development Institute (RP-2012-BT-010).
REFERENCES


Received April 27, 2012
Revised July 15, 2012
Accepted July 18, 2012