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Abstract

The eggs of three deep-sea pandalid shrimps *Heterocarpus abulbus*, *H. hayashii* and *H. sibogae* are successfully hatched in the laboratory. The first zoal stage of these shrimps are described, with those of *H. abulbus* and *H. hayashii* being reported for the first time. First zoae of different *Heterocarpus* species can be distinguished by the spination at the anteroventral carapace, body size, rostral length and appendage setation.

Key words: *Heterocarpus*, caridean shrimp, morphology, zoea

Introduction

Members of the pandalid genus *Heterocarpus* A. Milne-Edwards, 1881, are widely distributed in the tropical and subtropical seas at depths of 73–2834 m (Chace 1985). At present 30 species are known for this genus (De Grave & Fransen 2011) and some of them have commercial values or potential (Holthuis 1980; Ralston 1986; Chan 1998; Pérez 2007; Wehrtmann & Echeverría-Sáenz 2007). However, little is known for the larval development of these deep-water shrimps. Only the larval characters of two species *H. ensifer* A. Milne-Edwards, 1881 (Landeira et al. 2010) and *H. sibogae* De Man, 1917 (Iwata et al. 1986) have been reported.

The present work succeeded in hatching the eggs of three *Heterocarpus* species collected in Taiwan, namely *H. abulbus*, *H. hayashii* and *H. sibogae*. The morphological characteristics of the first zoae of these three species are reported herein, with those of *H. abulbus* and *H. hayashii* being described for the first time. The first zoae of all known *Heterocarpus* species are compared and found that they can be readily separated by some distinctive characters.

Materials and methods

Ovigerous females of three *Heterocarpus* species (*H. abulbus*, *H. hayashii* and *H. sibogae*) were captured by commercial trawls at depth of 200–300 m off northeastern Taiwan (24°52.395’ N – 121°59.264’ E) from September to November in 2012. Each individual was separated in different aquaria (100 l volume) and raised in sea water (salinity of 35 PSU) at 14 ± 1°C. Once the eggs hatched, about 10 first stage zoae were immediately collected and preserved in 70% ethylene glycol solution. More than ten larvae from each species were dissected and examined on glass slides under a stereo microscope (OLYMPUS SZX12) using fine entomological needles. Appendages were drawn using compound microscope (OLYMPUS BX50) installed with a camera lucida. Morphological terminology generally follows Yang & Ko (2004) and Landeira et al. (2010). Abbreviations of larval measurements were as follows: Carapace length (CL), from the postorbital margin to the posterovertical end.
With respect to the genus *Heterocarpus*, the first zoeae of only two species were known, namely *H. ensifer* (Landeira et al. 2010) and *H. sibogae* (Iwata et al. 1986). However, the description of *H. sibogae* is rather brief and the present work re-describes the first zoea of this species in details. With the addition of *H. abulbus* and *H. hayashii*, the first zoeae of four species in this genus are now known. All of them share the common characters of anteroventral margin of carapace bearing spines, carapace with dorsomedian tubercles on anterior and posterior parts, and antennule with spatulate seta. On the other hand, the first zoeae of these four species can be readily distinguished by the following characters (also see Table 1):

1. **Spines on anteroventral margin of carapace:** Other than the pterygostomian spine, *H. sibogae* differs from the other three species in bearing only one additional spine at the anteroventral margin of carapace (vs. 2 spines in others). *Heterocarpus abulbus* can also be separated from *H. ensifer* and *H. hayashii* in the one of the two additional spines at the anteroventral carapace being rather weak (both spines very distinct in *H. ensifer* and *H. hayashii*).

2. **Body size and rostral length:** The size of the zoea is much larger for *H. abulbus* (body length 2.44 mm) as compared to the other three species (body lengths 1.93 mm, 1.89 mm, 1.88 mm in *H. ensifer*, *H. hayashii* and *H. sibogae*, respectively). The rostrum of *H. ensifer* is distinctly shorter than the other three species in only extending to the middle of the antennular peduncle (vs. reaching or overreaching distal margin of antennular peduncle).

3. **Appendage setation:** The endopod of maxillule has three subterminal setae in *H. ensifer*, whilst the other three species have only two subterminal setae. *Heterocarpus abulbus* can be further separated from *H. hayashii* and *H. sibogae* in having two instead of one seta on the coxa of the second maxilliped. Moreover, *H. sibogae* has a somewhat different endopod setation at the second maxilliped (2, 1, 2, 4 vs. 3, 1, 2, 4–5 in the other three species, see Table 1).

As in adults, the first zoeae of *H. ensifer*, *H. hayashii* and *H. sibogae* are more similar than with *H. abulbus*, which belongs to a different species group than the former three. On the other hand, although adults of *H. ensifer*, *H. hayashii* and *H. sibogae* are rather similar, distinct differences are already present amongst the zoeae of these closely related species. All these suggested that larval characters can provide important insights to the understanding of the taxonomy and phylogenetic relationships amongst *Heterocarpus* shrimps.

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**References**


