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Morphology of First Zoea Stage of *Sphaerozius nitidus* (Decapoda: Eriphioidea: Menippidae) Reared in the Laboratory Material

Seok Hyun Lee*

Department of Life Science, Silla University, Busan 46958, Korea

ABSTRACT

Ovigerous crab of *Sphaerozius nitidus* of the family Menippidae was collected from Geojedo, Gyeongsangnamdo and hatched in the laboratory. Digital imaging of live zoeas of the first zoea stage of *S. nitidus* has been reported for the first time in the world, and its morphology has been redescribed and illustrated. This study is different from former study in that it has three unequal setae with exopod of antenna, 5+4 setae with basial endite of maxilla, and dorsomedial spine and lateral minute spine with fork of telson. The first zoea of *S. nitidus* has black pigments occurring behind the eyes, on the dorsal spine medially and on the basis of lateral carapace spines, on basal of basis of maxillipeds 1, 2, and posterior margins of somites 1−5, and yellowish green chromatophores on the dorsal spine.

Keywords: *Sphaerozius nitidus*, first zoea, Menippidae, Eriphioidea, Korea

INTRODUCTION

The order of Decapoda includes more than 15,000 species of shrimps, hermit crabs, lobsters, and crabs that belong to four of the 10 infraorders of malacostracan crustaceans (Cumberlidge et al., 2015). The larval stage of decapods consists of the nauplius, prezoea, zoea, and megalopa stages. However, most decapods larvae are hatched in the zoea stage because the nauplius stage is passed in the egg except for Dendrobranchiata, and prezoea stage is just hatched lava still covered by embryonic cuticle (Moore and McCormick, 1969), so, the zoea stage can be regarded as the first stage in the larval stage of decapods. The larval morphology of decapod is more useful in phylogenetic studies than adult morphology (Rice, 1980; Kornienko and Korn, 2009). The adult morphology of decapods has differences between individual variations because of convergent and divergent adaptations of the various life styles. However, larvae of decapods inhabit a planktonic environment with relatively uniform characteristics (Rice, 1980). And, larval morphology of decapods is more accordant with molecular data than with adult morphology (Hultgren et al., 2009). However, the number of studies of decapod larvae is inadequate and still unknown.

Crabs of the superfamily Eriphioidea comprise 68 species 21 genera six families (Ng et al., 2008; WoRMS, 2022) (Table 1). They are generally known as stone or rubble crabs and occupy a diverse range of habitats from intertidal rocky shores, mangrove swamps, coral reefs, to continental slopes about 800 meter in depth (Lai et al., 2013). In Korea, three species [*Eriphia smithii* MacLeay, 1838, *Hypothalassia armata* (De Haan, 1835), *Sphaerozius nitidus* Stimpson, 1858], in three families (Eriphiidae Macleay, 1838, Hypothalassiidae Karasawa and Schweitzer, 2006, Menippidae Ortmann, 1893) are recorded. In the Eriphioidea, larval descriptions have been known for 20 species belonging to nine genera of four families in the world (Table 1), among them two species (*E. smithii* by Terada, 1982, and *S. nitidus* by Aikawa, 1933) have been reported from Korea and adjacent waters. However, the description and illustration of *S. nitidus* by Aikawa (1933) is not accurate in setal amature of appendages. So, the redescription of the first zoea stage of *S. nitidus* (Figs. 1B, 2) is needed.

In this study, the first zoea stage of *S. nitidus* is described and illustrated for the second time, and provided color digital image for the first time in the world. Its morphological characteristics are compared with those of other known belonging to the same superfamily of species in the Korea.

***To whom correspondence should be addressed**
Tel: 82-51-999-6931, Fax: 82-51-999-5471
E-mail: sky3284@silla.ac.kr

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Table 1. List of species of the superfamily Eriphioidea and its known larval stages

Family	Genus	Species	Larval stages and Sources
Dairoididae Števčić, 2005	*Dairoides* Stebbing, 1920	*kusei* (T. Sakai, 1938)	
		margaritatus Stebbing, 1920	
		seafdeci Takeda and Ananpongsuk, 1991	
Eriphiidae MacLeay, 1838	*Eriphia* Latreille, 1817	*ferox* Koh and PKL Ng, 2008	
		gonagra (JC Fabricius, 1781)	Z1-4, M: Fransozo (1987)
		granulosa A. Milne-Edwards, 1880	
		scabricula Dana, 1852	Z1: Clark and Paula (2003)
		sebana (Shaw and Nodder, 1803)	Z1: Ko (2005)
		smithii MacLeay, 1838	Z1-4: Terada (1982)
		squamata Stimpson, 1859	
		verrucosa (Forskål, 1775)	Z1-4, M: Lumare and Gozzo (1972)
	Eriphides Rathbun, 1897	*hispida* (Stimpson, 1860)	
	Garthopilumnus Števčić, 2011	*palmeri* (Garth, 1986)	
Hypothalassiidae Karasawa and Schweitzer, 2006	*Hypothalassia* Gistel, 1848	*acerba* Koh and PKL Ng, 2000	
		armata (De Haan, 1835)	
Menippidae Ortmann, 1893	*Menippe* De Haan, 1833	*adina* AB Williams and Felder, 1986	M: Martin et al. (1988)
		frontalis A. Milne-Edwards, 1879	
		hirtipes (Jacquinot and Lucas, 1853)	
		mercenaria (Say, 1818)	Z1: Hyman (1925) Z1-5, M: Kurata (1970)
		nodifrons Stimpson, 1859	Z1-5, M: Scotto (1979)
		obtusa Stimpson, 1859	
		rumphii (JC Fabricius, 1798)	Z1-5, M: Kakati (1977)
	Myomenippe Hilgendorf, 1879	*fornasinii* (Bianconi, 1851)	
		hardwickii (Gray, 1831)	
	Ruppellioides A. Milne-Edwards, 1867	*convexus* A. Milne-Edwards, 1867	
		philippinensis Ward, 1941	
	Sphaerozius Stimpson, 1858	*nitidus* Stimpson, 1858	Z1: Aikawa (1933)
		scaber (JC Fabricius, 1798)	
Oziidae Dana, 1851	*Baptozius* Alcock, 1898	*vinosus* (H. Milne Edwards, 1834)	Z1-4, M: Saba et al. (1978a)
	Bountiana Davie and PKL. Ng, 2000	*norfolcensis* (Grant and McCulloch, 1907)	
	Epixanthoides Balss, 1935	*anomalus* Balss, 1935	
	Epixanthus Heller, 1860	*corrosus* A. Milne-Edwards, 1873	
		dentatus (White, 1848)	Z1, 2, M: Saba et al. (1978b) Z1: Clark and Paula (2003)
		frontalis (H. Milne Edwards, 1834)	Z1: Clark and Paula (2003) Z1-4, M: Aidaroos et al. (2014)

Continued

Table 1. Continued

Family	Genus	Species	Larval stages and Sources
Oziidae Dana, 1851		*hellerii* A. Milne-Edwards, 1867	
		subcorrosus de Man, 1891	
		tenuidactylos (Lockington, 1877)	
	Eupilumnus Kossmann, 1877	*actumnoides* (A. Milne-Edwards, 1873)	
		africanus (A. Milne-Edwards, 1867)	
		calmani (Balss, 1933)	
		ragaria (SL Yang, Dai and PKL Ng, 1998)	
		globosus (Dana, 1852)	
		kiiensis (Takeda and Nagai, 1983)	
		laciniatus (T. Sakai, 1980)	
		stridulans (Monod, 1956)	
		xantusii (Stimpson, 1860)	
	Lydia Gistel, 1848	*annulipes* (H. Milne Edwards, 1834)	Z1: Clark and Paula (2003)
		granulosa (A. Milne-Edwards, 1867)	
		tenax (Rüppell, 1830)	
		truncata (Strahl, 1862)	
	Ozius H. Milne Edwards, 1834	*deplanatus* (White, 1847)	
		granulosus de Man, 1879	
		guttatus H. Milne Edwards, 1834	
		hawaiiensis Rathbun, 1902	
		lobatus Heller, 1865	
		perlatus Stimpson, 1860	
		reticulatus (Desbonne and Schramm, 1867)	
		rugulosus Stimpson, 1858	Z1-4, M: Kakati and Nayak (1977)
		tricarinatus Rathbun, 1907	
		truncatus H. Milne Edwards, 1834	Z1-4, M: Wear (1968)
		tuberculosus H. Milne Edwards, 1834	
		verreauxii de Saussure, 1853	Z1-4, M: Dittel and Epifanio (1984)
Platyxanthidae Guinot, 1977	*Danielethus* BP Thoma, PKL Ng and Felder, 2012	*crenulatus* (A. Milne-Edwards, 1879)	Z1-4, M: Menu-Marque (1970)
		patagonicus (A. Milne-Edwards, 1879)	Z1-4, M: Iorio and Boschi (1986)
	Homalaspis A. Milne-Edwards, 1863	*plana* (H. Milne Edwards, 1834)	Z1-4, M: Fagetti (1970)
	Otmaroxanthus Števčić, 2011	*balboai* (Garth, 1940)	
	Peloeus Eydoux and Souleyet, 1842	*armatus* Eydoux and Souleyet, 1842	
	Platyxanthus A. Milne-Edwards, 1863	*orbignyi* (H. Milne Edwards and Lucas, 1843)	

Z, zoea stage; M, megalopa stage.

MATERIALS AND METHODS

Ovigerous crab of *Sphaerozius nitidus* was collected from intertidal region in Geojedo, Gyeongsangnamdo, Korea on February 19, 2007 and its zoea was hatched in the laboratory on July 3, 2008. The first zoeas were preserved in 95% ethyl alcohol for examination. Digital photos with Leica EZ40 microscope (Wetzlar, Germany) and then processed in Photoshop were taken of living zoeas. Specimens of zoea were dissected using Leitz zoom stereomicroscope and appendages were examined under a Leitz Laborlux S microscope (Wetzlar, Germany). Appendages were mounted in ethylene glycol and drawings were made with the camera lucida. Setal counts on appendages and measurements were based on the mean of 10 specimens. The sequence of the description of zoea follows that of Clark et al., 1998. The long plumose natatory setae of the first and second maxillipeds were drawn truncated. The chromatophore patterns were observed with living zoeas. A micrometer was used for measurements of zoea: 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. Specimens examined and spent female were deposited at Silla University, Korea.

RESULTS

***Sphaerozius nitidus* Stimpson, 1858 (Fig. 1A)**

First zoea (Figs. 1B, 2)

Size: CL 0.45 ± 0.05 mm; RDL 1.45 ± 0.05 mm.

Chromatophores (Fig. 1B): Black pigments which occurring behind and between eyes, on dorsal carapace spine medially, on basis of lateral carapace spines dorsally, on basal of basis of maxillipeds 1, 2 and on posterior margins of somites 1–5; Yellowish green chromatophores on dorsal spine.

Carapace (Figs. 1B, 2A): Dorsal spine longer than CL, approximately same length as rostral spine, almost straight; rostral spine approximately 3 times longer than antennal protopod; lateral spines present, slightly shorter than rostral spine; all spines with blunt tip; 1 pair of posterodorsal setae present; each ventral margin unarmed; eyes sessile.

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

Antenna (Fig. 2C): Biramous; endopod bud absent; protopod 1/3 length of rostral spine, with 2 rows of spinules on distal half; exopod approximately 2/3 length of protopod, with 3 unequal (2 terminal, 1 subterminal) setae.

Mandibles (Fig. 2D): Asymmetrical; right molar with 3 teeth, left molar with 1 tooth, confluent with incisor process; palp absent.

Maxillule (Fig. 2E): Coxal endite with 7 setae; basial endite with 5 setae and 2 teeth; endopod 2-segmented, proximal segment with 1 seta, distal segment with 4 setae; exopod seta and epipod absent.

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

First maxilliped (Fig. 2G): Basis with 10 setae, arranged 2 + 2 + 3 + 3; endopod 5-segmented, with 3, 2, 1, 2, 5 (1 subterminal, 4 terminal) setae; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Second maxilliped (Fig. 2H): Basis with 4 setae arranged 1 + 1 + 1 + 1; endopod 3-segmented, with 0, 1, 5 setae; exopod 2-segmented, distal segment with 4 long terminal plumose natatory setae.

Fig. 1. Color photos of adult and the first zoeas of *Sphaerozius nitidus*. A, Adult of *S. nitidus*; B, First zoeas of *S. nitidus*.

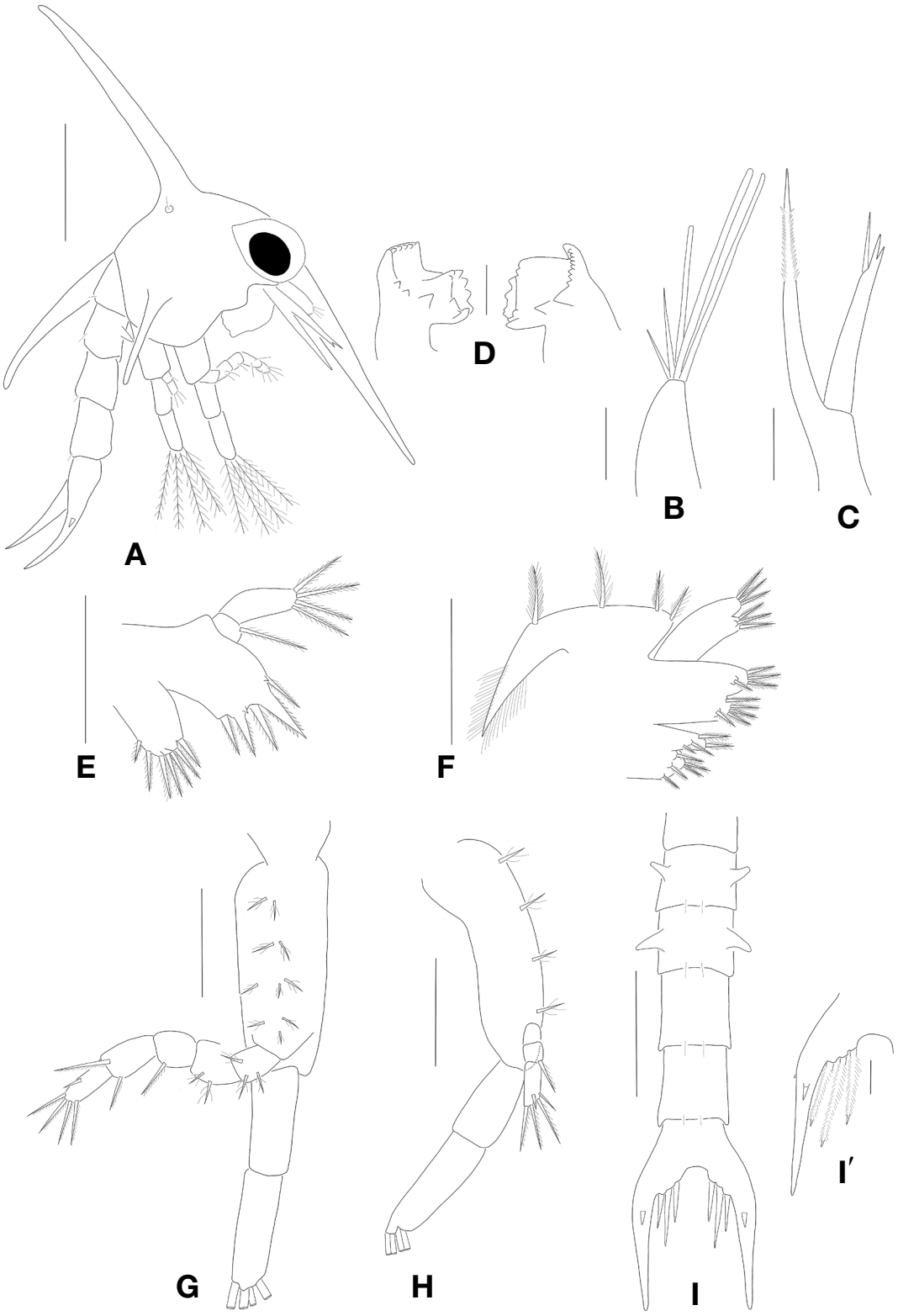

Fig. 2. *Sphaerozius nitidus*, first zoea stage. A, Whole animal, lateral view; B, Antennule; C, Antenna, dorsal view; D, Mandibles, dorsal view; E, Maxillule, dorsal view; F, Maxilla, dorsal view; G, First maxilliped, lateral view; H, Second maxilliped, lateral view; I, Abdomen and telson, dorsal view; I′, Fork of telson, dorsal view. Scale bars: A, I = 0.3 mm, B–D, I′ = 0.05 mm, E–H = 0.1 mm.

Table 2. Comparison of the characteristics of the first zoeas of Eriphioidea from Korea

	Eriphiidae *Eriphia smithii* Terada, 1982	Menippidae *Sphaerozius nitidus*	
		Aikawa, 1933	Present study
Carapace			
Dorsal, rostral, lateral spines	Long, long, short	Long, long, long	Long, long, long
Antennule	2 aesthetascs, 4 setae	2 aesthetascs, 2 setae	3 aesthetascs, 2 setae
Antenna			
Protopod	Spinulate	Spinulate	Spinulate
Exopod	1/2 protopod length, spinulate	1/2 protopod length, not spinulate	2/3 protopod length, not spinulate
	4 unequal terminal spines	2 unequal terminal setae	3 unequal terminal setae
Maxillule			
Coxal endite	7 setae	7 setae	7 setae
Basial endite	5 setae	5 setae	5 setae
Endopod	1, 2+4 setae	1, 4 setae	1, 4 setae
Maxilla			
Coxal endite	5+4 setae	5+3 setae	5+3 setae
Basial endite	6+4 setae	6+4 setae	5+4 setae
Endopod	3+5 setae	3+3 setae	3+3 setae
1st maxilliped			
Basis	2, 2, 3, 3 setae	2, 2, 3, 3 setae	2, 2, 3, 3 setae
Endopod	3, 2, 1, 2, 5 setae	3, 2, 1, 2, 5 setae	3, 2, 1, 5 setae
2nd maxilliped			
Basis	1, 1, 1, 1 setae	1, 1, 1, 1 setae	1, 1, 1, 1 setae
Endopod	1, 1, 6 setae	0, 1, 5 setae	0, 1, 5 setae
Abdomen			
Lateral processes	Somites 2-5	Somites 2, 3	Somites 2, 3
Telson			
Fork	1 lateral spine, 1 lateral seta, 1 dorsomedial spine	1 dorsomedial spine	1 lateral minute spine, 1 dorsomedial spine
	Not spinulate	Not spinulate	Not spinulate

Abdomen (Fig. 2I): With 5 somites; somite 2 with 1 pair of lateral processes directed anteriorly; somite 3 with 1 pair of lateral processes directed posteriorly; somites 2–5 each with 1 pair of posterodorsal setae, respectively; pleopod absent.
Telson (Fig. 2I′): Each fork long, with 1minute lateral spine, and 1 dorsomedial spine; posterior margin with 3 pairs of setae.

DISCUSSION

The characteristics of the first zoea of *Sphaerozius nitidus* is redescribed in this study. So, zoea descriptions of Eriphioidea are available for two species, *Eriphia smithii* (Eriphiidae) and *S. nitidus* (Menippidae) in Korea.

After careful comparison of the first zoea stage of *S. nitidus* described by Aikawa (1933) with the present material, the author found some differences in three characters (Table 2). Aikawa (1933) described that an exopod of antenna has two unequal terminal setae (vs. three unequal setae in this study), a basial endite of the maxilla has 6+4 setae (vs. 5+4 setae) and fork of telson has one dorsomedial spine (vs. a lateral minute spine and dorsomedial spine). These characteristics are considered as in significant and the above differences probably resulted from their mistakes in detailed examination.

Comparison of zoea can be made for only two species of two families, *E. smithii* (see Terada, 1982) of Eriphiidae and *S. nitidus* (present study) of Menippidae (Table 2). They are significantly different from each other in characters of lateral carapace spine, endopods of the maxillule, the maxilla, and the second maxilliped, and the abdomen. The first zoea of *E. smithii* of Eriphiidae has short lateral carapace spine, endopods of the maxillule and the maxilla with 1, 2+4 and 3+5 setae, respectively, an endopod of the second maxilliped with 1, 1, 6 setae, and abdominal somites 2-5 each with a pair of

lateral processes. These characteristics are similar to those of other pilumnoid and xanthoid zoeas except for abdominal somites. While, the first zoea of *S. nitidus* of Menippidae has long lateral carapace spine, endopods of the maxillule and the maxilla with 1, 4 and 3 + 3 setae, respectively, an endopod of the second maxilliped with 0, 1, 5 setae, and abdominal somites 2 and 3 each with a pair of lateral processes. A combination of characteristics of 1, 4 and 3, 3 setae in the endopods of the maxillule and the maxilla is reported for the first time in brachyuran zoeas of Korea and considered a diagnostic one of this species. Thus, the author considers that the Eriphioidea might be heterogeneous because *S. nitidus* is not related to *E. smithii* in characters of lateral carapace spine (long lateral carapace spine in *S. nitidus* vs. short lateral carapace spine in *E. smithii*), endopods of the maxillule (1, 4 setae in *S. nitidus* vs. 1, 2 + 4 setae in *E. smithii*) and the maxilla (3 + 3 setae in *S. nitidus* vs. 3 + 5 setae in *E. smithii*), and the second maxilliped (0, 1, 5 setae in *S. nitidus* vs. 1, 1, 6 setae in *E. smithii*) (Table 2).

ORCID

Seok-Hyun Lee: https://orcid.org/0000-0003-4372-4909

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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