ASED http://e-ASED.org
Animal Systematics, Evolution and Diversity

Anim. Syst. Evol. Divers. Vol. 41, No. 1: 24-29, January 2025
https://doi.org/10.5635/ASED.2025.41.1.029

Newly Report of the First Zoea of *Zehntneriana amakusae* (Brachyura: Pilumnidae: Rhizopinae) Hatched in Laboratory Material from Korea

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ABSTRACT

Ovigerous crab of *Zehntneriana amakusae* of Rhizopinae in Pilumnidae was collected from Munseom Islet, Seogwipo, Jeju Is. and the first zoeas were obtained from hatched materials in the laboratory. The morphology of the first zoea of *Z. amakusae* is reported for the first time in the world with a color digital photo. The first zoea of *Z. amakusae* has common zoeal characteristics in the spines of carapace and the satations of maxillule, maxilla, and the first maxilliped of Korean Pilumnids. However, the first zoea of *Z. amakusae* is different from other species of Korean Pilumnids in that it has 1, 1, 5 satae on endopod of the second maxilliped and two lateral spines and one dorsal spine on fork of telson.

Keywords: *Zehntneriana amakusae*, first zoea, Rhizopinae, Pilumnidae, Korea

INTRODUCTION

The life cycle of brachyuran crabs generally consists of naupliar (passed in egg), zoeal (planktonic life, consisting of at least two stages), megalopal (introducing benthic life, one or two stages), and adult (within benthic life) stages (Hong, 2021). To date, most studies of the classification and phylogeny systematics of decapods have been relied on adult morphologies, however, it is difficult to study using the adult morphology with many variations because they are adapted to various habitats (Souza et al., 2013). Most larvae inhabit a planktonic environment, exhibiting fewer morphological variations than adult and aligning more closely with molecular data (Rice, 1980; Hultgren et al., 2009). Therefore, extensie efforts are still required to describe brachyuran larval morphologies.

Currently, 15 species of three subfamilies of the family Pilumnidae have been reported from Korean waters (Lee et al., 2021, 2023). Among them, nine species of zoeal morphologies are known in the Korea (Table 1). The genus *Zehntneriana* Ng and Takeda, 2010 of the subfamily Rhizopinae Stimpson, 1858 includes five species [*Zehntneriana amakusae* (Takeda and Miyake, 1969); *Z. miyakei* (Takeda, 1972); *Z. novaeinsulicola* (Takeda and Kurata, 1977); *Z. serrata* Ng and Lin, 2015; *Z. tadafumii* Lee, Kim and Ng, 2015; *Z. villosa* (Zehntner, 1894)] on record in the world (WoRMS, 2024). Among them, larvae have not been reported yet. During the study about decapod larvae collected an ovigerous crab, and identified as *Z. amakusae* by having covered dense short setae on frontal, supraorbital, and anterolateral regions of transversely ovoid carapace, and divided by three crest-shaped teeth on anterolateral margin. The first zoeas of *Z. amakusae* were obtained from the laboratory hatching materials for the first time in the world.

The purposes of the present study are to illustrate and describe the morphology of the first zoea of *Z. amakusae* for the first time in the world, providing a color digital photo, and comparing its morphological characteristics with those of other the first zoeas of the family Pilumnidae.

MATERIALS AND METHODS

An ovigerous crab of *Zehntneriana amakusae* was collected by SCUBA diving at a depth of approximately 20 m in Munseom Islet, Seogwipo, Jeju Island, Republic of Korea on 13 Aug 2010 and its zoea hatched in the laboratory on 22 Aug 2010. The first zoeas were first fixed in 30% ethanol and then preserved in 94% ethanol for examination. A color digital photo

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eISSN 2234-8190

Table 1. List of species of the family Pilumnidae from Korean waters and its known larval stages

Family	Subfamily	Genus	Species	Larval stages	References
Pilumnidae	Eumedoninae	*Echinoecus*	*nipponicus*	Z1	Lee (2020)
	Pilumninae	*Actumnus*	*elegans*		
			marissinicus		
		Benthopanope	*indica*	Z1-4, M	Ko (1995)
		Harrovia	*elegans*		
			japonica	Z1-4, M	Lee and Ko (2009)
		Heteropilumnus	*ciliatus*	Z1-3	Ko and Yang (2003)
		Neoactumnus	*convexus*		
		Pilumnopeus	*granulatus*	Z1-4, M	Ko (1997)
			makianus	Z1-4	Lee (1993)
		Pilumnus	*longicornis*	Z1	Clark and Paula (2003)
			minutus	Z1-4, M	Ko (1994a, 1997)
			trispinosus	Z1-4, M	Ko (1994b)
	Rhizopinae	*Arges*	*parallelus*		
		Zehntneriana	*amakusae*	Z1	Present study

Z, zoeal stage; M, megalopal stage.

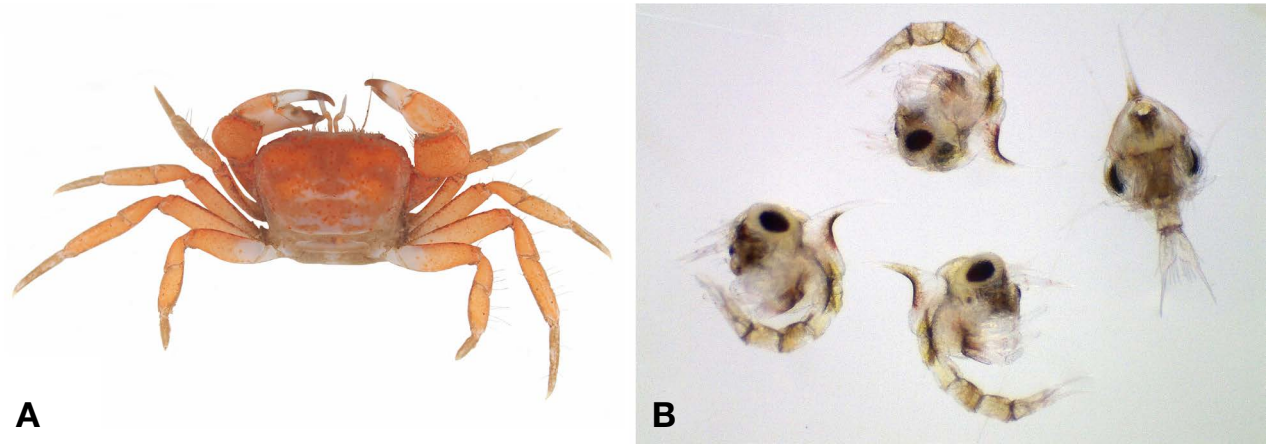

Fig. 1. Color digital photos of adult and the first zoeas of *Zehntneriana amakusae*. A, Adult of *Z. amakusae*; B, First zoeas of *Z. amakusae*.

of living zoeas for observation of chromatophore patterns was taken with Leica EZ40 microscope (Wetzlar, Germany) and subsequently processed in Photoshop (Photoshop 2021, Adobe). The dissection and appendage examined of zoeal specimens and drawings of the morphology of zoea followed the described by Lee (2020).

The sequence of zoeal description follows that of Clark and Cuesta (2015). The observation of chromatophore patterns was determined through a color digital photo of living zoeas. The measurements of zoeas were made using a micrometer. The carapace length and rostral and dorsal carapace spines length were abbreviated as CL and RDL, and their meanings are described in Lee (2020). The examined zoeal specimens and spent female crab have been deposited at the Silla University, Korea.

RESULTS

Order Decapoda Latreille, 1802
Family Pilumnidae Samouelle, 1819
Subfamily Rhizopinae Stimpson, 1858
Genus *Zehntneriana* Ng and Takeda, 2010

***Zehntneriana amakusae* (Takeda & Miyake, 1969)**

Description of Zoea I (Figs. 1B, 2). Size: CL 0.51 ± 0.02

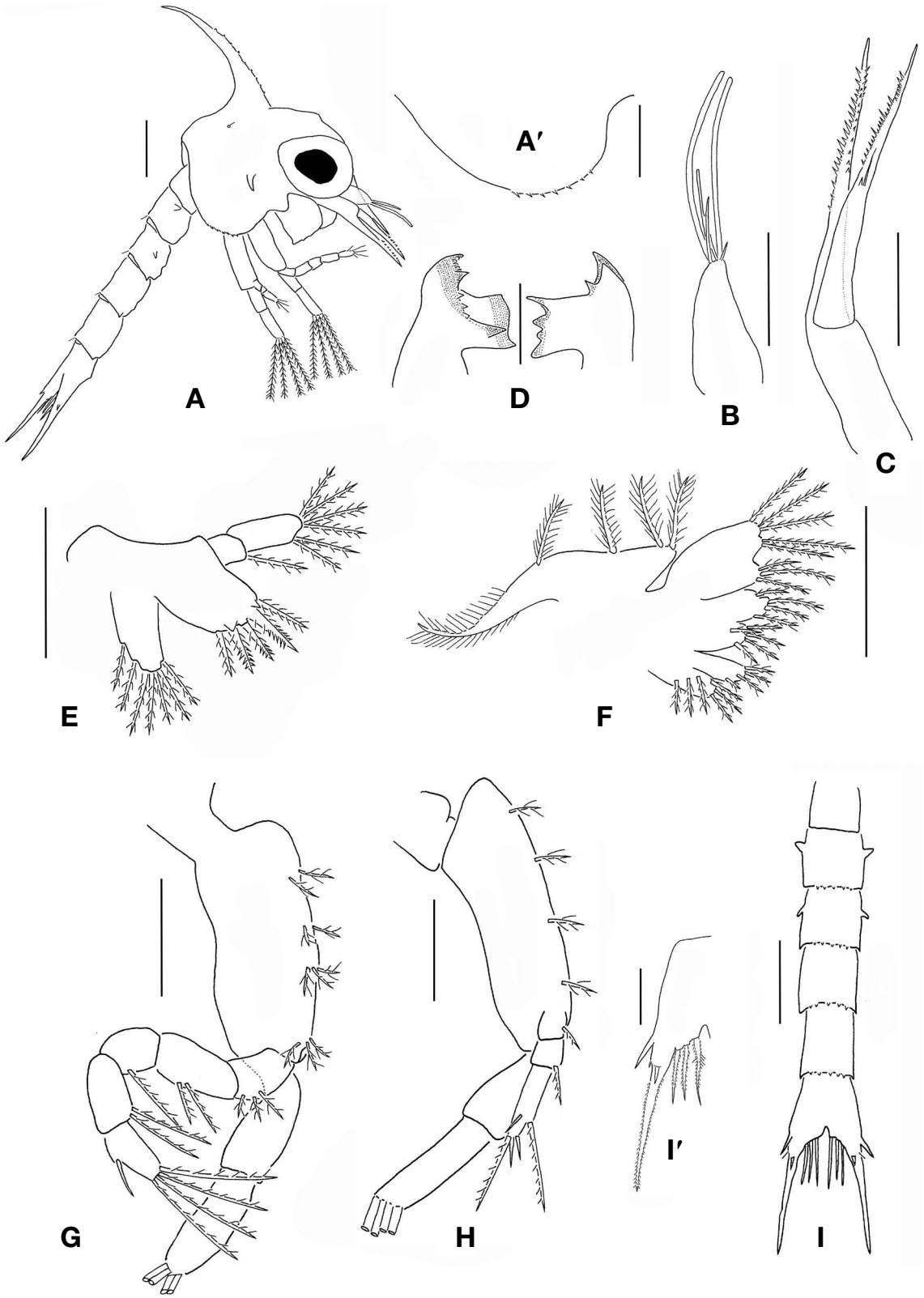

Fig. 2. *Zehntneriana amakusae*, first zoea. A, Lateral view; A′, Lateral expansion of carapace; B, Antennule; C, Antenna; D, Mandibles; E, Maxillule; F, Maxilla; G, First maxilliped; H, Second maxilliped; I, Dorsal view of pleon and telson; I′, Fork of telson. Scale bars: A, I = 0.2 mm, A′–H, I′ = 0.1 mm.

Table 2. Comparison of the characteristics of the first zoeas of family Pilumnidae in Korean waters

Family	Pilumnidae									
Subfamily	Eumedoninae	Pilumninae								Rhizopinae
Species	*Echinoecus nipponicus*	*Harrovia japonica*	*Benthopanope indica*	*Heteropilumnus ciliatis*	*Pilumnopeus granulata*	*P. makiana*	*Pilumnus longicornis*	*P. minutus*	*P. trispinosus*	*Zehntneriana amakusae*
Reference	Lee (2020)	Lee and Ko (2009)	Ko (1995)	Ko and Yang (2003)	Ko (1997)	Lee (1993)	Clark and Paula (2003)	Ko (1994a)	Ko (1994b)	Present study
Carapace										
Dorsal, rostral, lateral spines	Long, short, short	Long, short, short	Long, short, absent	Long, long, short	Long, vestigial, short	Long, long, short	Long, long, short	Long, short, short	Long, short, absent	Long, short, short
Antennule	3 aesthetascs, 2 setae	3 aesthetascs, 2 setae	3 aesthetascs, 2 setae	4 aesthetascs, 2 setae	3 aesthetascs, 3 setae	4 aesthetascs, 1 seta	4 aesthetascs, 2 setae	3 aesthetascs, 3 setae	3 aesthetascs, 3 setae	3 aesthetascs, 2 setae
Antenna										
Protopod	Spinulate	Spinulate	Spinulate	Spinulate	Spinulate	Spinulate	Spinulate	Spinulate	Spinulate	Spinulate
Exopd	Longer than protopod, spinulate	Shorter than protopod, spinulate	Longer than protopod, spinulate	Longer than protopod, spinulate	As same as protopod, spinulate	Longer than protopod, spinulate	As same as protopod, spinulate	Shorter than protopod, spinulate	Longer than protopod, spinulate	Longer than protopod, spinulate
	2 unequal medial setae	2 unequal medial spines	2 unequal medial spines	2 unequal medial spines	2 unequal medial spines	2 unequal medial spines	2 unequal medial spines	2 unequal medial spines	2 unequal medial spines	2 unequal medial setae
Maxillule										
Coxal endite	7 setae	7 setae	7 setae	7 setae	7 setae	5 setae	7 setae	7 setae	7 setae	7 setae
Basial endite	5 setae	5 setae	5 setae	5 setae	5 setae	5 setae	5 setae	5 setae	5 setae	5 setae
Endopod	1, 2+4 setae	1, 2+4 setae	1, 2+4 setae	1, 2+4 setae	1, 2+4 setae	1, 2+4 setae	1, 2+4 setae	1, 2+4 setae	1, 2+4 setae	1, 2+4 setae
Maxilla										
Coxal endite	6+4 setae	6+4 setae	6+4 setae	6+4 setae	6+4 setae	6+3 setae	6+4 setae	6+4 setae	6+4 setae	6+4 setae
Basial endite	5+4 setae	5+4 setae	5+4 setae	5+4 setae	5+4 setae	5+3 setae	5+4 setae	5+4 setae	4+5 setae	4+5 setae
Endopod	3+5 setae	3+5 setae	3+5 setae	3+5 setae	3+5 setae	3+5 setae	3+5 setae	3+5 setae	3+5 setae	3+5 setae
1st maxilliped										
Basis	2, 2, 3, 3 setae	2, 2, 3, 3 setae	2, 2, 3, 3 setae	2, 2, 3, 3 setae	2, 2, 3, 3 setae	2, 2, 3, 3 setae	2, 2, 3, 3 setae	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, 2, 5 setae	3, 2, 1, 2, 5 setae	3, 2, 1, 2, 5 setae	3, 2, 1, 2, 5 setae	3, 2, 1, 2, 5 setae	3, 2, 1, 2, 5 setae	3, 2, 1, 2, 5 setae	3, 2, 1, 2, 5 setae
2nd maxilliped										
Basis	1, 1, 1, 1 setae	1, 1, 1, 1 setae	1, 1, 1, 1 setae	1, 1, 1, 1 setae	1, 1, 1, 1 setae	1, 1, 1, 1 setae	1, 1, 1, 1 setae	1, 1, 1, 1 setae	1, 1, 1, 1 setae	1, 1, 1, 1 setae
Endopod	1, 1, 6 setae	1, 1, 6 setae	1, 1, 6 setae	1, 1, 6 setae	1, 1, 6 setae	1, 1, 6 setae	1, 1, 6 setae	1, 1, 6 setae	1, 1, 6 setae	1, 1, 5 setae
Pleon										
Lateral processes	Pleomeres 2, 3	Pleomeres 2, 3	Pleomere 2	Pleomeres 2, 3	Pleomeres 2, 3	Pleomeres 2, 3	Pleomeres 2, 3	Pleomeres 2-5	Pleomeres 2-5	Pleomeres 2, 3
Telson										
Fork	2 lateral spines, 1 dorsomedial spine	1 lateral spine, 1 lateral seta, 1 dorsomedial spine	1 lateral spine, 1 lateral seta, 1 dorsomedial spine	1 lateral spine, 1 lateral seta, 1 dorsomedial spine	1 lateral spine, 1 lateral seta, 1 dorsomedial spine	1 lateral spine, 1 lateral seta, 1 dorsomedial spine	2 lateral spines, 1 dorsomedial spine	1 lateral spine, 1 lateral seta, 1 dorsomedial spine	1 lateral spine, 1 lateral seta, 1 dorsomedial spine	1 lateral spine, 1 lateral seta, 1 dorsomedial spine
	Spinulate	Spinulate	Spinulate	Spinulate	Spinulate	Spinulate	Spinulate	Spinulate	Spinulate	Spinulate

mm; RDL 1.03 ± 0.02 mm.

Chromatophores (Fig. 1B): Yellowish brown chromatophores which occurring behind eyes, on basis of dorsal spine posteriorly, on basal of basis of each maxillipeds, on abdominal somites 1, 2 ventrally and margins of abdominal somites 4, 5 posteriorly.

Carapace (Figs. 1B, 2A, A′): dorsal spine curved distally, approximately equal CL, with several minute tubercles; rostral spine shorter than antennal protopod length, without digital spinulation; lateral spines short, curved; anterodorsal spine absent; 1 pair of posterodorsal setae present; ventral margin with spinules.

Cephalon. Eyes (Figs. 1B, 2A): sessile.

Antennule (Fig. 2B): primary flagellum unsegmented with 3 (2 broad, 1 slender) aesthetascs, of unequal length plus 2 terminal setae of unequal length; accessory flagellum absent.

Antenna (Fig. 2C): uniramous; protopod distal medially bilaterally spinulate, longer than rostral spine; endopod bud absent; exopod distal medially bilaterally spinulate with 2 medial setae of unequal length.

Mandibles (Fig. 2D): asymmetrical; right molar with 4 teeth, left molar with 1 tooth, confluent with incisor process; palp absent.

Maxillule (Fig. 2E): uniramous; epipod seta absent; coxal endite with 7 setae; basial endite with 5 terminal setal processes + 2 small setal buds; endopod comprising 2 articles, proximal article with 1 seta, distal article with 6 (2 subterminal + 4 terminal) setae; exopod seta absent.

Maxilla (Fig. 2F): Coxal endite bilobed, with 6 + 4 setae; basial endite bilobed, with 5 + 4 setae; endopod bilobed, with 3 + 2 + 3 setae; exopod (scaphognathite) margin with 4 plumose setae, 1 distal process.

Pereion. First maxilliped (Fig. 2G): biramous; coxa without setae; basis with 10 (2 + 2 + 3 + 3) setae; endopod comprising 5 articles with 3, 2, 1, 2, 5 (1 subterminal + 4 terminal) setae respectively; exopod comprising 2 articles, distal article with 4 long terminal plumose natatory setae.

Second maxilliped (Fig. 2H): biramous; coxa without setae; basis with 4 (1 + 1 + 1 + 1) setae; endopod comprising 3 articles, with 1, 1, 5 (2 subterminal + 3 terminal) setae; exopod comprising 2 articles, distal article with 4 long terminal plumose natatory setae.

Third maxilliped: absent.

Pereiopods: absent.

Pleon (Fig. 2I): 5 pleomeres; pleomere 2 with pair of lateral processes directed laterally; pleomere 3 with pair of lateral processes directed posteriorly; pleomeres 2−5 each with 1 pair of posterodorsal setae and spinulated dorsal posterior margin; pleopod bud absent.

Telson (Fig. 2I′): each fork long, spinulated, margin with 1 long lateral spine, 1 small lateral spine, 1 stout dorsomedial spine present; posterior margin with 3 pairs of stout spinulate setae.

DISCUSSION

The first zoea of *Zehntneriana amakusae* is illustrated and described for the first time in the world with a color digital photo. The first zoea of *Z. amakusae* has yellowish brown chromatophores located behind the eyes, on the basis of dorsal spine posteriorly, on the basal of basis of each maxillipeds, on pleomeres 1, 2 ventrally and margins of pleomeres 4, 5 posteriorly, dorsal spine subequal carapace length, rostral, and lateral spines shorter than carapace length, three aesthetascs and two setae on the antennule, two medial setae on the antennal exopod, lateral processes on the pleomeres 2, 3, and two lateral spines and one dorsomedial spine on the telson.

Including present study, the first zoeal stages of 10 species of the family Pilumnidae have been reported in Korean waters (Tables 1, 2). Table 2 summarizes the characteristics of the first zoeal stage of the family Pilumnidae known in Korean waters. The first zoeas of Korean Pilumnids identically by having exopod of antenna with two unequal sized medial spine or seta, endopods of maxillule and maxilla with 1, 2 + 4 and 3 + 5 setae, respectively, and spinulated fork of telson with 2 lateral spines or setae and a dorsomedial spine as suggested by Ko and Lee (2012) (Table 2).

The zoeal characteristics of the first zoea of *Z. amakusae* are almost identical to other species belonging to the family Pilumnidae. However, it has slightly differed from the others by having an endopod of the second maxilliped with 1, 1, 5 setae and the fork of telson with two lateral spines and one dorsomedial spine (Table 2).

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CONFLICTS OF INTEREST

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

AKNOWLEDGMENTS

This work was supported by the management of Marine Fishery Bio-resources Center (2024) funded by the National Marine Biodiversity Institute of Korea (MABIK).

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Received December 3, 2024
Revised December 16, 2024
Accepted December 30, 2024