Korean J Biol Sci 3: 127-131, 1999

First Zoea of *Pachycheles hertwigi* Balss, 1913 (Decapoda: Anomura: Porcellanidae) Reared under Laboratory Conditions

Hyun Sook Ko*

Department of Biology, College of Natural Sciences, Silla University, Pusan 617-736, Korea

Key Words:
Anomura
Porcellanidae
Pachycheles hertwigi
Pachycheles stevensii
Zoea

The first zoeal stage of *Pachycheles hertwigi* Balss is described and illustrated. Its morphological characteristics are compared with those of other known species of *Pachycheles*. The first zoeas of *P. hertwigi* and *P. stevensii* are very similar, but they can be distinguished from each other by the length of carapace spine and the size of antennal exopod spinules.

The porcellanid crab genus *Pachycheles* is essentially tropical and its worldwide distribution consists of 14 Atlantic, 18 Eastern Pacific and 11 Indo-Pacific species (Haig, 1956, 1960). The family Porcellanidae in Korea includes seven species belonging to seven genera: *Enosteoides ornata* (Stimpson, 1858), *Pachycheles stevensii* Stimpson, 1858, *Petrolisthes japonicus* (De Haan, 1849), *Pisidia serratifrons* (Stimpson, 1858), *Polyonyx asiaticus* Shen, 1936, *Porcellana pulchra* Stimpson, 1858, and *Raphidopus ciliatus* Stimpson, 1858 (The Korean Society of Systematic Zoology, 1997). Crabs of the genus *Pachycheles* inhabit the underside of rocks and corals or live on sponges in shallow waters (Haig, 1960; Kim, 1973; Miyake, 1982). The adult of *P. hertwigi* is now recorded for the first time from Korea.

The porcellanid zoeae are easily distinguished from other decapod zoeas by the extremely elongated rostral spine and a pair of posterior spines. Larval descriptions of the genus *Pachycheles* are limited to nine species: *P. haigae* Rodrigues Da Costa, 1960, *P. pubescens* Holmes, 1900, *P. rudis* Stimpson, 1859, *P. natalensis* (Krauss, 1843), *P. monilifer* (Dana, 1852), *P. tomentosus* Henderson, 1893, *P. stevensii* Stimpson, 1858, *P. garciaensis* (Ward, 1842), and *P. sculptus* (H. Milne Edwards, 1837) (see Boschi et al., 1967; MacMillan, 1972; Knight, 1966; Shenoy and Sankolli, 1973; Yaqoob, 1979; Gore, 1973; Tirmizi and Yaqoob, 1979; Kurata, 1964; Konishi, 1987; Osawa, 1997). However, any larval stages of *P. hertwigi* are yet unknown.

This paper describes and illustrates the first zoeal stage of *P. hertwigi*, and compares it with those from other known species in the genus *Pachycheles*.

Materials and Methods

An ovigerous female of *Pachycheles hertwigi* Balss, 1913 was collected by SCUBA diving from Geojedo Island off the southern coast of Korea in May 1998. The larvae hatched in the laboratory were reared using methods described by Ko (1995), under room temperatures of 21℃-26℃. The larvae were fixed and preserved in 10% neutral formalin for later use. Dissected appendages were examined using a Leitz laborlux s microscope and drawings were made with the aid of *camera lucida*. Setal counts on appendages and measurements were based on the mean of 10 specimens for zoeal stage. Setal armature on appendages is described from proximal to distal segments and in order of endopod to exopod. The remaining zoeas and the spent female were deposited in Silla University, Korea.

Results

The first and second zoeal stages were obtained, but the second zoeal specimens could not be described because of the bad preservation condition and shortage in the number of specimens. The first zoeal stage usually lasts six days before molting to the second stage.

First zoea

Carapace length 1.59±0.09 mm; rostral spine length 7.00±0.25 mm; posterior spine length 3.61±0.14 mm. Carapace (Fig. 1A and G) typically porcellanid, with extremely elongate rostral and posterior carapace spines; former heavily armed overall with spinules to its tip and up to 4.3 times carapace length (CL), while latter about 2.2 times CL; both posterior spines bearing ventral pointed spinelets near their basal portion (Fig. 1B and C). Lower margin of carapace from just posterior of eye to origin of posterior spine serrate in middle portion. Eyes sessile.

Antennule (Fig. 1D). Elongate slightly swollen rod; 3

* Tel: 82-51-309-5473, Fax: 82-51-309-5176
E-mail: hsko@lotus.silla.ac.kr

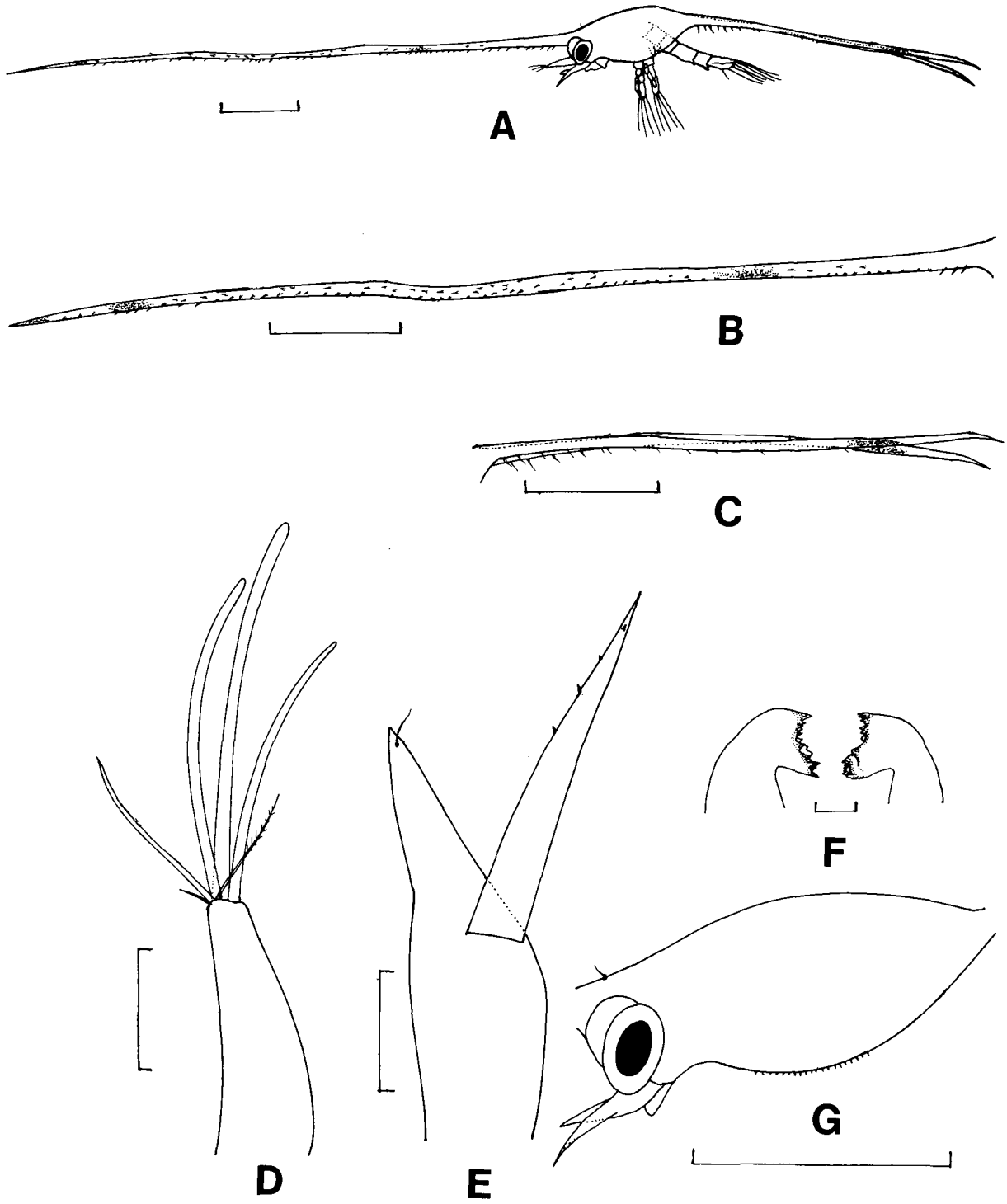

Fig. 1. *Pachycheles hertwigi* Balss, first zoeal stage. A, Lateral view. B, Rostral carapace spine. C, Posterior carapace spine. D, Antennule. E, Antenna. F, Mandible. G, Carapace in lateral view. Scale bars=0.1 mm (D-F) and 1 mm (A-C, G).

aesthetascs, 2 long and short setae on distal portion.

Antenna (Fig. 1E). Endopod fused to protopod; single, thin, subterminal seta. Tip of exopod exceeding that of endopod, with 4 small spinules, 3 in tandem and a lateral.

Mandibles (Fig. 1F). Asymmetrical, heavily dentate processes; no palp.

Maxillule (Fig. 2A). Coxal and basial endites with 8 and 9 setae, respectively. Endopod with 4 terminal setae.

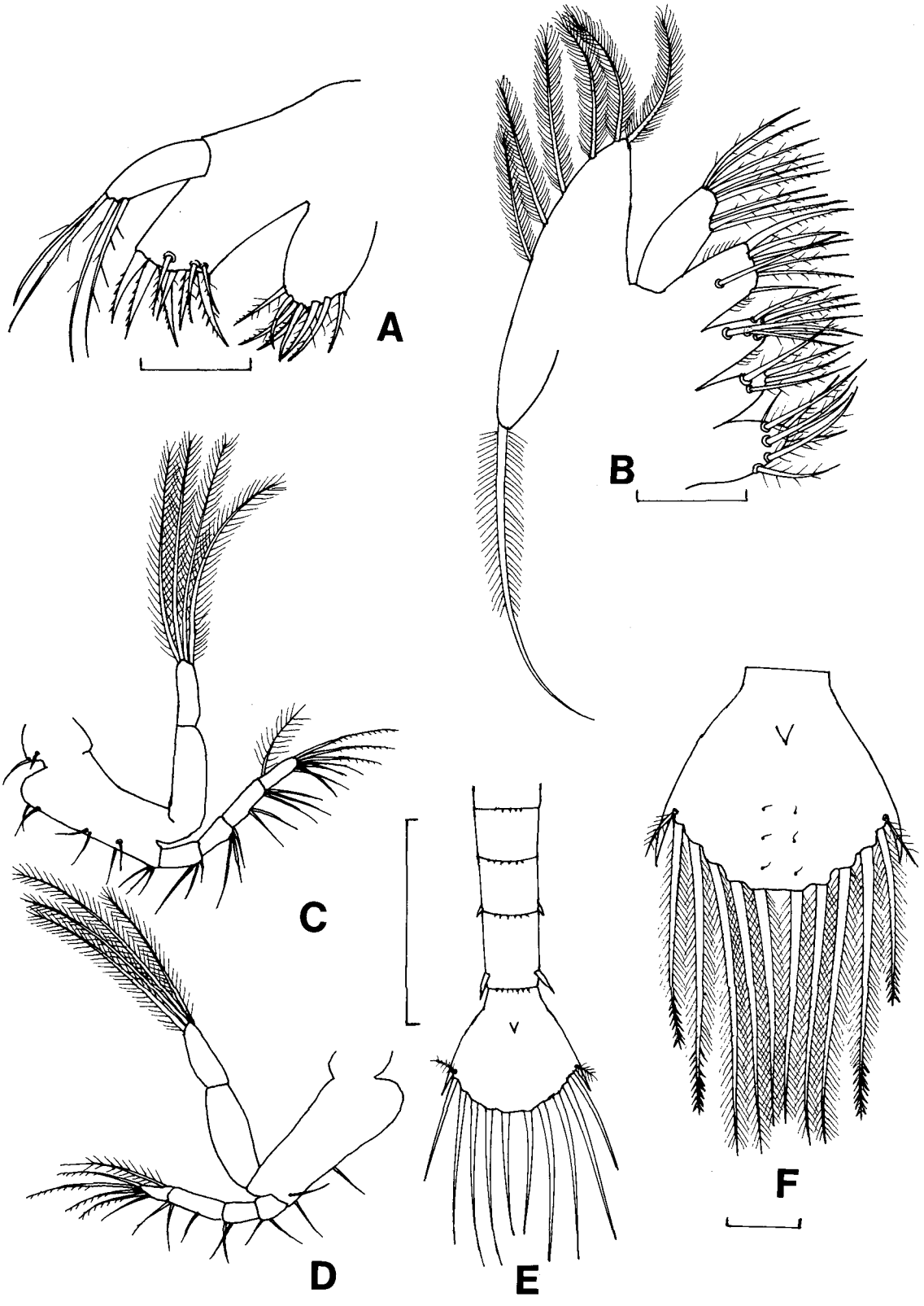

Fig. 2. *Pachycheles hertwigi* Balss, first zoeal stage. A, Maxillule. B, Maxilla. C, First maxilliped. D, Second maxilliped. E, Dorsal view of abdomen and telson. F, Telson. Scale bars=0.1 mm (A, B, F) and 0.5 mm (C-E).

Table 1. Comparison of the first zoeal characteristics in the genus *Pachycheles*

Species	Antenna	Maxillule	Maxilla	Maxilliped 1		Maxilliped 2			Telson	Authors
	Exopod	Endopod seta	Endopod seta	Coxa seta	Basis setation	Coxa seta	Basis setation	Endopod setation	Process with hooklets	
P. stevensii	3S[a], 1LS[b]	4	9	2	2(1), 2, 2, 3	0	1, 2	2, 2, 1+2, 1+5(6)	3rd, 4th	Konishi, 1987
P. hertwigi	3S, 1LS	4	9	2	2, 2, 2, 3	0	1, 2	2, 2, 1+2, 1+5	3rd, 4th	Present study
P. natalensis	3S	4	9	2	2, 2, 2, 3	0	1, 2	2, 2, 1+2, 1+5	3rd, 4th	Yaqoob, 1979
P. tomentosus	3S	4	9	2	2, 2, 2, 3	0	1, 2	2, 2, 1+2, 1+6	3rd, 4th	Tirmizi and Yaqoob, 1979
P. monilifer	3S	4	9	2	2, 2(3), 2, 3	0	1, 2	2, 2, 1+2, 1+5	3rd, 4th	Gore, 1973
P. pubescens	3-4S	3-4	8	2	2, 2, 2(3), 3	0	1, 2	2, 2, 1+2, 1+5(6)	3rd, 4th	MacMillan, 1972
P. rudis	3S	4	9	2	2, 2, 2, 3	0	1, 2	2, 2, 1+2, 1+5	3rd, 4th	Knight, 1966
P. haigae	4S	4	9	ND[c]	2, 2, 3, 3	ND	1, 1	3, 3, 1+1, 1+7	3rd, 4th	Boschi et al., 1967
P. garciaensis	3-4S	3	8	0	1, 1(2), 2, 3	0	1	0, 2, 2, 1+5	3rd, 4th	Osawa, 1997
P. sculptus	3S	3	8	0	1, 2, 2, 3	0	1, 2	2, 2, 2, 1+5	3rd, 4th	Osawa, 1997

[a]Spinule, [b]Lateral spinule, [c]No data

Maxilla (Fig. 2B). Lobes of coxal endite, proximally and distally, with 8 and 4 setae, respectively; those of basal endite with 7 and 7; endopod with setae in two groups of 3 and 6; scaphognathite with 6 soft plumose setae around outer margin, plus long plumose posterior process.

First maxilliped (Fig. 2C). Coxa with 2 setae; basis setae progressing distally 2, 2, 2, 3; endopod setae 3, 3, 2+3, one plumose plus 7 distal setae. Exopod indistinctly 2-segmented, with 4 long natatory setae distally.

Second maxilliped (Fig. 2D). Coxa without seta; basis setae 1, 2; endopod setae 2, 2, 1+2, one plumose plus 5 distal setae; exopod as in first maxilliped.

Third maxilliped and pereopods. Small buds.

Abdomen (Fig. 2E). Lateral spines present on somites 4 and 5, increasing in size posteriorly; dorsal margin of somites 2 to 5 armed with series of minute spinules.

Telson (Fig. 2E and F). 7 pairs of posterior processes present, long plumose except for first and second. First (outermost) process stout spine, second short plumose seta; third and fourth processes armed with distinct hooklets or hooklike spinules at tips. Three pairs of very fine setules found on dorsal surface. Anal spine present on ventral surface.

Discussion

Konish (1987) stated that the common morphological characteristics of the zoeas of *Pachycheles* might be summarized as follows: (1) Endopods of the maxillule and the maxilla bear 4 and 9 setae, respectively; (2) Scaphognathite of the maxilla has 6 or 7 soft plumose setae and a long posterior plumose process; exceptionally 8 in *P. natalensis* as observed by Yaqoob (1979); (3) Coxa of the first maxilliped possesses 2 setae, while that of the second maxilliped has none; (4) Basis of the second maxilliped has setation of 1+2; exceptionally 1+1 in *P. haigae* by Boschi et al. (1967); and (5) Third and fourth telsonal process has evident hooklets along its distal portion. According to Table 1, the zoeas of *P. pubescens*, *P. garciaensis* and *P. sculptus* are markedly different from the zoeas of the other seven species by having endopods of the maxillule and the maxilla have 3 and 8 setae. Moreover, it is unusual that the zoeas of *P. garciaensis* and *P. sculptus* possess the coxa of the first maxilliped being unarmed. Osawa (1997) recognized that they are similar to the zoeas of the genus *Neopisosoma*. He found that *Neopisosma* zoea, *N. augustifrons* (Benedict, 1901) (see Gore, 1977) and *N. neglectum* Werding, 1986 (see Werding and Müller, 1990), could be distinguished from *Pachycheles* zoea only by the absence of the ventral setae on the coxa of the first maxilliped and there was no justification for separating *Neopisosoma* from *Pachycheles*. However, the other seven Pachycheles species agree well with Konish's statement. Especially, the zoea of *P. hertwigi* is very similar to that of *P. stevensii* by having three in tandem plus lateral spinules on an exopod of the antenna. Therefore, it is considered that the present species seems to have great affinities with *P. stevensii* among others.

The general morphology of the first zoeas of *P. hertwigi* and *P. stevensii* is very similar, but they can be distinguished from each other by the length of the carapace spine and the size of antennal exopod spinules. The lengths of rostral and posterior carapace spines in *P. hertwigi* are 7.00±0.25 mm and 3.61± 0.14 mm, respectively (5.53-6.00 mm and 2.47-2.93 mm, respectively, in *P. stevensii*). The former has an antennal exopod with three in tandem plus lateral small spinules, whereas, the latter has three larger in tandem plus lateral small spinules on it. These characteristics may be useful for identifying the first zoeas of two species from plankton collected materials.

Acknowledgements

I am grateful to Dr. M. Osawa, Department of Aquatic Biosciences, Tokyo University of Fisheries, Japan for identifying porcellanid crabs and providing some references. This work was supported by a grant from Muryanghyang Research Society in 1998.

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[Received March 4, 1999; accepted March 29, 1999]