

Zoal Stages of *Pisidia serratifrons* (Crustacea: Decapoda: Porcellanidae) under Laboratory Conditions

Han Ju Kim, Hyun Sook Ko*

Department of Biological Sciences, Silla University, Busan 617-736, Korea

ABSTRACT

The zoal stages of *Pisidia serratifrons* are described and illustrated for the first time and its morphological characteristics are compared with those of three known *Pisidia* species of the family Porcellanidae. The zoea of *P. serratifrons* differs from those of other *Pisidia* (*P. brasiliensis*, *P. dispar*, and *P. dehaanii*), by having 11 spinules on the exopod of the antenna. In order to facilitate the study of plankton-collected material, a provisional key is provided for identification of the Korean porcellanid zoeae.

Keywords: Anomura, Porcellanidae, *Pisidia serratifrons*, key, zoea, Korea

INTRODUCTION

Crabs of the family Porcellanidae include ten species belonging to seven genera in Korea: *Enosteoides ornata* (Stimpson, 1858), *Pachycheles stevensii* Stimpson, 1858, *Pachycheles hertwigi* Balss, 1913, *Petrolisthes japonicus* (De Haan, 1849), *Petrolisthes militaris* (Heller, 1862), *Petrolisthes coccineus* (Owen, 1839), *Pisidia serratifrons* (Stimpson, 1858), *Polyonyx asiaticus* Shen, 1936, *Porcellana pulchra* Stimpson, 1858, and *Raphidopus ciliatus* Stimpson, 1858 (see Kim, 1973; The Korean Society of Systematic Zoology, 1997; Ko, 2003, 2006). However, in Korea, the larval stage is known either wholly or in part for five species: *P. stevensii*, *P. hertwigi*, *P. japonicus*, *P. coccineus*, and *E. ornata* (see Kurata, 1964; Konishi, 1987; Osawa, 1995; Ko, 1999, 2001).

Pisidia serratifrons is the only representative of the genus *Pisidia* in Korea and its larva is completely unknown. However, larvae of *Pisidia brasiliensis* Haig, 1968, *Pisidia dispar* (Stimpson, 1858), and *Pisidia dehaanii* (Krauss, 1843) have been reported in the western Atlantic by Anhang (2006), in Australia by Shepherd (1969), and in Pakistan by Yaqoob (1979), respectively.

In the present paper, the zoal stages of *P. serratifrons* are described and illustrated for the first time. Its characteristics are compared with those of three other known zoeae in the genus *Pisidia*, and a provisional key is provided for identification of the Korean porcellanid zoeae.

MATERIALS AND METHODS

An ovigerous female of *P. serratifrons* was collected during SCUBA diving from Geojedo Island off the southern part of Korea on 4 August 2008. On 13 August, the zoeae hatched in the laboratory; 30 were reared individually and 30 were reared in mass cultures at water temperatures of $25 \pm 1^\circ\text{C}$. Each of the individually reared zoeae was held in a plastic well containing 15-16 mL of seawater. Water was changed daily and each larva was provided with newly hatched *Artemia* nauplii once per day. The mass culture consisted of three dishes, each containing ten zoeae in 200 mL of seawater, which was also changed daily. Both individual and mass cultures were checked daily for exuviae. Molts and dead larvae were fixed and preserved in 10% buffered formalin for later examination. Dissected appendages were examined using a Leitz laborlux S and drawings were made with the aid of a camera lucida. Setal counts on appendages and measurements were based on the mean of ten specimens of zoeae. Setal armatures of appendages were described from proximal to distal segments and in the order of endopod to exopod. Measurements were obtained using an ocular micrometer. The carapace length (CL) was measured from the anterior margin of the eyes to the midpoint of the posterior carapacial margin. The rostral spine length (RSL) and posterior spine length (PSL) were measured from the tip to the base of the spine. The first zoal stage was described completely. However, for the second zoal stage, only the principal differ-

ences from the previous stage were described. The long plumose natatory setae of the maxillipeds were truncated in drawings. The remaining zoeae and the spent female have been deposited at Silla University, Korea.

RESULTS

Zoeal development of *P. serratifrons* was complete within approximately 18 days. The first and second zoeal stages lasted four and 14 days, respectively. Only one megalopa was obtained; however, due to a shortage in the number of specimens, it could not be described.

First zoea (Fig. 1)

Size: CL, 0.96 ± 0.03 mm; RSL, 3.39 ± 0.02 mm; PSL, 0.67 ± 0.04 mm.

Carapace (Fig. 1A). Typically porcellanid, with pair of small setae on dorsal surface, with 1 extremely elongate rostral and 2 posterior carapace spines; former heavily armed overall with four rows of spinules to its tip and up to 3.5 times CL, while latter about 0.7 times CL; both posterior spines unarmed; lower margin of posterior carapace naked. Eyes stalked.

Antennule (Fig. 1B). Elongate and slightly swollen, with 3 aesthetascs, 2 simple setae, and 1 plumose seta distally; no endopod bud.

Antenna (Fig. 1C). Endopod fused to protopod, spinous distally, with single short subterminal seta; exopod slender rod, about 2.6 times longer than protopod, with submedial seta and 11 small spinules.

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

Maxillule (Fig. 1E). Coxal and basial endites with 9 and 10 setae, respectively; endopod with 3 setae.

Maxilla (Fig. 1F). Coxal endite with 7+5 setae; basial endite with 8+8 setae; endopod with 9 setae in 3 groups of 3+2+4; scaphognathite with 6 marginal plumose setae and long plumose posterior process.

First maxilliped (Fig. 1G). Coxa with 2 setae; basis setae progressing distally 1+2+2+3; endopod 4-segmented, with 3, 3, 3, 1 plumose+6 distal setae; exopod 2-segmented, with 4 long natatory setae distally.

Second maxilliped (Fig. 1H). Coxa without seta; basis setae 1+2; endopod 4-segmented, with 2, 2, 2, 1 plumose+6 distal setae; exopod as in first maxilliped.

Abdomen (Fig. 1I). Somite 5 with lateral spine, pair of setae on posterodorsal margin laterally.

Telson (Fig. 1I). Seven pairs of posterior processes present: first (outermost) process stout spine, second short plumose seta, from third to seventh processes long and plumose, third

armed with distinct hooklets or hooklike spinules distally; 2 pairs of short setae found on posterior central prominence dorsally; anal spine present on ventral surface.

Second zoea (Fig. 2)

Size: CL, 1.61 ± 0.05 mm; RSL, 3.99 ± 0.58 mm; PSL, 0.61 ± 0.07 mm.

Carapace (Fig. 2A). Two pairs of small setae on dorsal surface, both posterior spines bearing a few ventral pointed spinelets near their basal margin; lower margin of posterior carapace margin serrate; postorbital spine present.

Antennule (Fig. 2B). Slightly segmented, with 8 aesthetascs, 2 simple setae and 1 plumose seta; endopod bud present.

Antenna (Fig. 2C). Endopod developed, slightly shorter than exopod.

Mandibles (Fig. 2D). Unchanged.

Maxillule (Fig. 2E). Coxal and basial endites with 11 and 12 setae, respectively.

Maxilla (Fig. 2F). Coxal endite with 10+6 setae; basial endite with 10+9 setae; scaphognathite with 25 plumose setae around outer margin.

First maxilliped (Fig. 1G). Endopod setae 1 plumose+3, 1 plumose+3, 1 plumose+3, 1 plumose+7 distal setae; exopod with 11 long natatory setae distally.

Second maxilliped (Fig. 1H). Endopod setae 1 plumose+2, 1 plumose+2, 1 plumose+2, 1 plumose+7 distal setae; exopod as in first maxilliped.

Third maxilliped (Fig. 2I). Endopod naked; exopod with 6 long plumose setae.

Pereiopods (Fig. 2A). Present as buds.

Abdomen (Fig. 2J). Somites 2-5 with pleopod buds.

Telson (Fig. 2J). Pair of short setae on dorsal surface submedially; 8 pairs of posterior processes present, eighth process (innermost) long and plumose.

DISCUSSION

In zooplankton samples, the porcellanid zoeae are easily distinguished from other decapod zoeae by extremely elongated rostral carapace spines and a pair of posterior spines. At the generic level, a key to them was proposed by Shepherd (1969), who described the genus *Pisidia* as having two zoeal stages, a rostral carapace spine with four rows of spinules, five abdominal somites, a telson with a central prominence posteriorly, and an endopod of the maxillule with three setae based on the only species (*P. dispar*). On the basis of more zoeal information on the genus *Pisidia* (Yaqoob, 1979; Anhang, 2006), including the present study, common zoeal characteristics of the four species (*P. brasiliensis*, *P. dispar*,

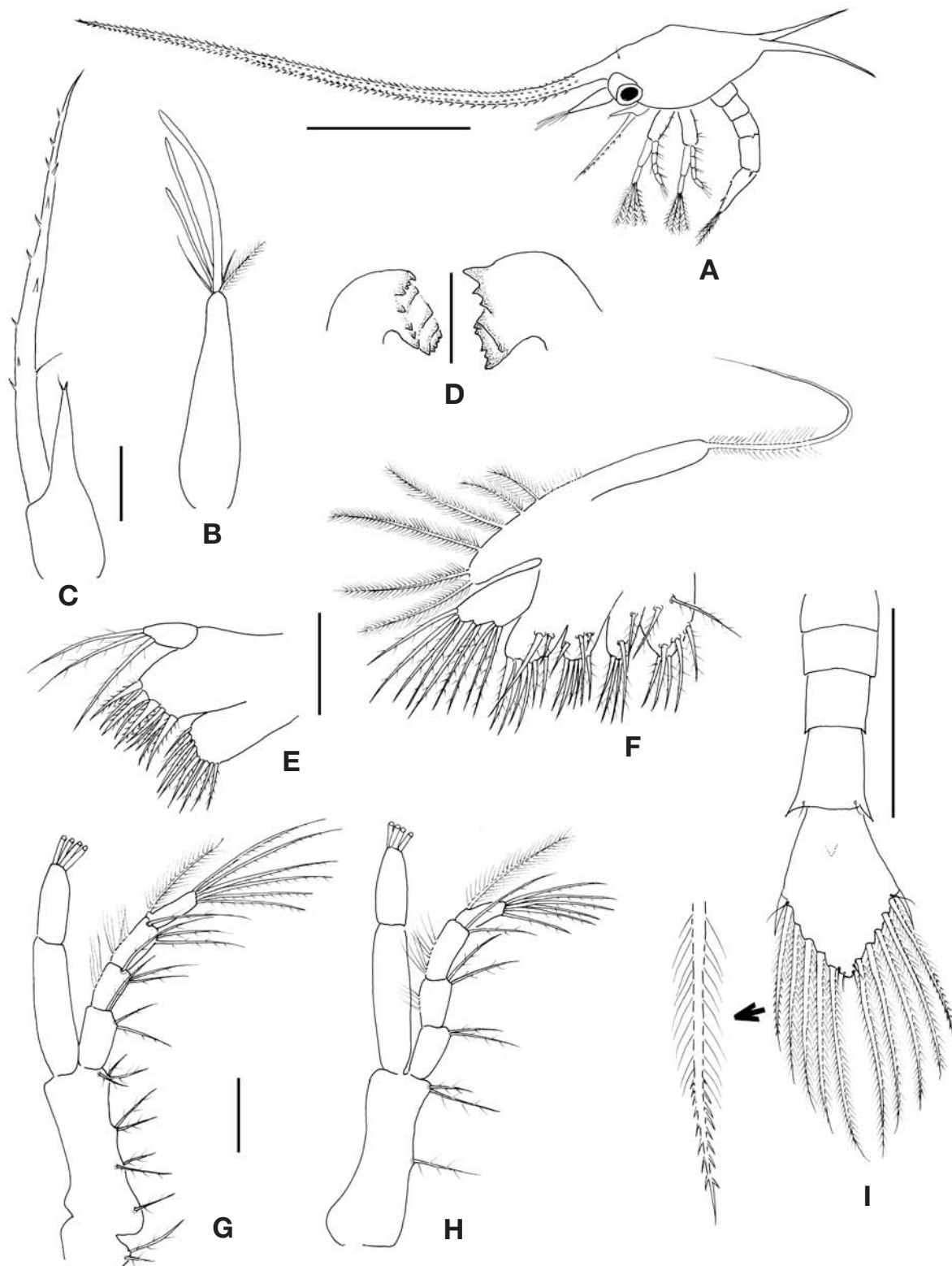


Fig. 1. *Pisidia serratifrons*, first zoal stage. A, Lateral view of the entire animal; B, Antennule; C, Antenna; D, Mandibles; E, Maxillule; F, Maxilla; G, First maxilliped; H, Second maxilliped; I, Dorsal view of the abdomen and telson. Scale bars: A=1 mm, B-H=0.1 mm, I=0.5 mm.

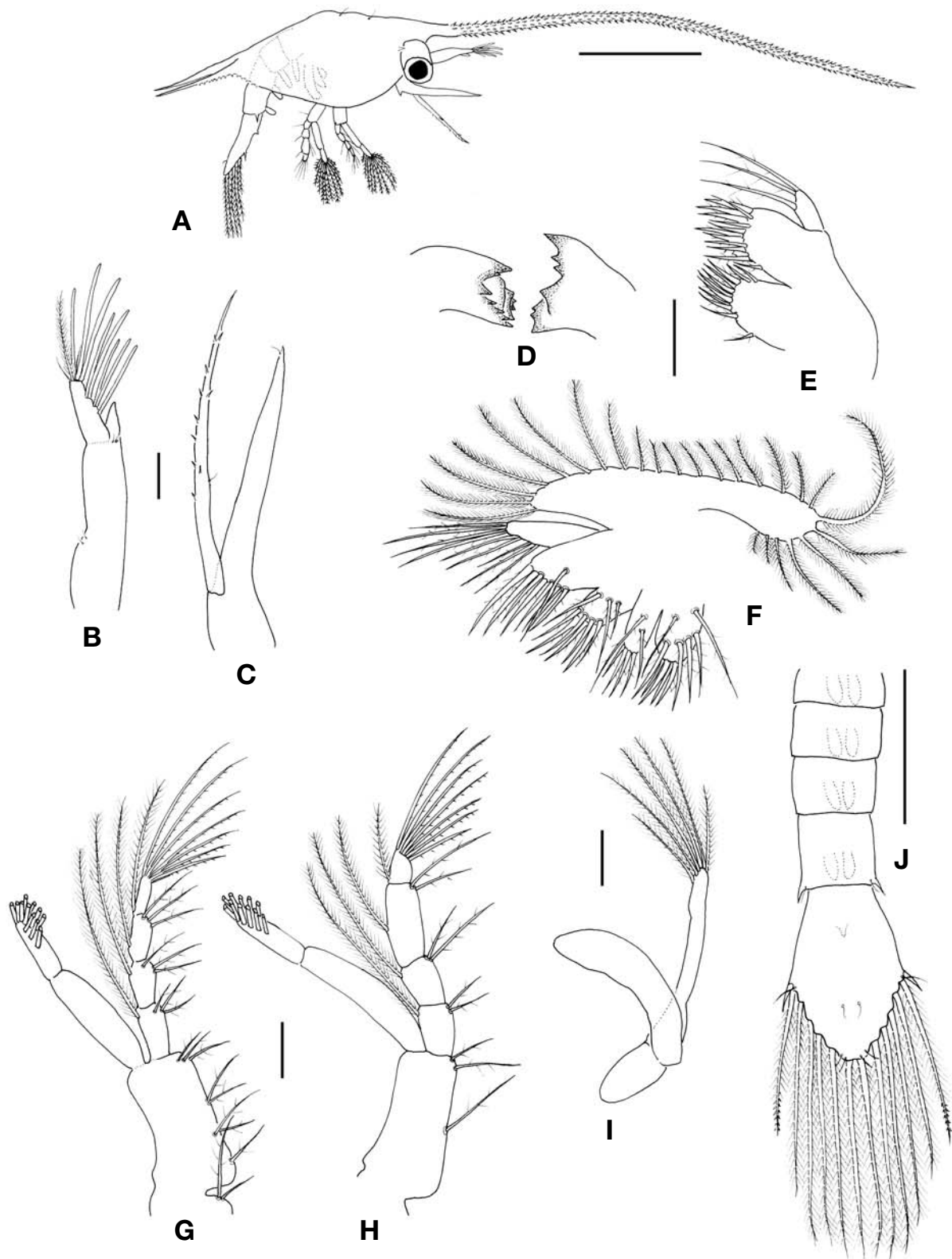


Fig. 2. *Pisidia serratifrons*, second zoeal stage. A, Lateral view of the entire animal; B, Antennule; C, Antenna; D, Mandibles; E, Maxillule; F, Maxilla; G, First maxilliped; H, Second maxilliped; I, Third maxilliped; J, Dorsal view of the abdomen and telson. Scale bars: A=1 mm, B-I=0.1 mm, J=0.5 mm.

Table 1. Comparisons of the first zoeal characteristics of the four species of *Pisidia* in Porcellanidae

Species	<i>P. brasiliensis</i>	<i>P. dispar</i>	<i>P. dehaanii</i>	<i>P. serratifrons</i>
Antenna				
Exopod	1 seta, 4 spinules	1 seta, 3 spinules	1 seta, 5 spinules	1 seta, 11 spinules
Maxillule				
Endopod	3 setae	3 setae	3 setae	3 setae
Maxilla				
Endopod	9 setae	9 setae	9 setae	9 setae
Maxilliped 1				
Coxa	2 setae	No data	2 setae	2 setae
Basis	1+2+2+3 setae	1+2+2+3 setae	1+2+2+2 setae	1+2+2+3 setae
Maxilliped 2				
Coxa	No seta	No data	No seta	No seta
Basis	1+2 setae	1+2 setae	1+2 setae	1+2 setae
Endopod	2, 2, 2, 1+5 setae	2, 2, 2, 1+6 setae	2, 2, 2, 1+6 setae	2, 2, 2, 1+6 setae
References	Anhang, 2006	Shepherd, 1969	Yaqoob, 1979	Present study

P. dehaanii, and *P. serratifrons*) in the genus are suggested as follows: 1) an exopod of the antenna with 1 seta, 2) an endopod of the maxillule with 3 setae, 3) an endopod of the maxilla with 9 setae, 4) the basis of the first maxilliped with 1+2+2+3 setae, and 5) the basis of the second maxilliped with 1+2 setae. Such characteristics remain constant throughout the zoeal stages. Despite their similarities, these zoeae can be separated from each other by the number of spinules on the exopod of the antenna: 3 for *P. dispar*, 4 for *P. brasiliensis*, 5 for *P. dehaanii*, and 11 for *P. serratifrons* (Table 1).

Ten porcellanid species have been reported in Korean waters (The Korean Society of Systematic Zoology, 1997; Ko, 2003, 2006), however, the zoeae of only six of these species (*P. stevensii*, *P. hertwigi*, *P. japonicus*, *P. coccineus*, *E. ornata*, and *P. serratifrons*) from Korean and adjacent waters have been described (Kurata, 1964; Konishi, 1987; Osawa, 1995; Ko, 1999, 2001; present study). Therefore, a provisional key is provided for their identification from Korean waters.

A provisional key to the known zoeae of six Korean porcellanid crabs

- 1. Exopod of antenna with only 3 or 4 spinules 2
 - Exopod of antenna more than 1 seta 3
- 2. Rostral spine length approximately 7 mm in first stage
 - *Pachycheles hertwigi*
 - Rostral spine length less than 6 mm in first stage, more than 7 mm in second stage *P. stevensii*
- 3. Exopod of antenna with 1 seta 4
 - Exopod of antenna with 2 or 3 setae 5
- 4. Exopod of antenna with 5 spinules *Enosteoides ornata*
 - Exopod of antenna with 11 spinules *Pisidia serratifrons*
- 5. Exopod of antenna without spinule

- *Petrolisthes japonicus*
- Exopod of antenna with 2 spinules *P. coccineus*

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