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First Zoeas of Two *Palaemon* Species (Decapoda: Caridea: Palaemoninae) Hatched in the Laboratory

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ABSTRACT

The first zoeas of Chinese ditch prawn *Palaemon gravieri* (Yu, 1930) and carpenter shrimp *Palaemon serrifer* (Stimpson, 1860) are described and illustrated in detail based on laboratory-hatched material. They are distinguished from those of *Palaemon ortmanni* (Rathbun, 1902) and *Palaemon pacificus* (Stimpson, 1860), previously known larvae from Korean waters by the length of the rostrum and endopod of antenna, the shape of the third abdominal somite, and ornamentation of the fifth abdominal somite. Larval characters of the genus *Palaemon* are revised. A. provisional key to the known first zoeas of *Palaemon* from Korean waters is given.

Key words: zoeas, *Palaemon gravieri*, *Palaemon serrifer*, revision, key, Palaemoninae

INTRODUCTION

The subfamily Palaemoninae contains a species occupying a wide variety of habitats from marine to freshwater conditions. Excluding *Palaemon paucidens* (Stimpson, 1860) and *Palaemon miyadii* (Kubo, 1938) living in freshwater, seven species of the genus *Palaemon* have been reported from Korea (see Kim and Kim, 1997; Cha et al., 2001). Of these, larval descriptions are known for five: *Palaemon gravieri* (Yu, 1930); *Palaemon macrodactylus* (Rathbun, 1902); *Palaemon ortmanni* (Rathbun, 1902); *Palaemon pacificus* (Stimpson, 1860); and *Palaemon serrifer* (Stimpson, 1860) (see Yokoya, 1957; Utunomiya and Maekawa, 1959; Kurata, 1968; Little, 1969; Han and Hong, 1978; Shy and Yu, 1987, 1988; Tsou et al., 1989; Liang and Zhou, 1994; Yang and Ko, 2002). The larvae of two other species *Palaemon guangdongensis* Liu, Liang, and Yan, 1990, and *Palaemon tenuidactylus* Liu, Liang and Yan, 1990 remain unknown.

Yokoya (1957, as *Leander serrifer*), Utunomiya and Maekawa (1959), and Kurata (1968) described laboratory-reared larvae of carpenter shrimp *P. serrifer* from Japan. Later, Liang and Zhou (1994) provided the complete larval development of Chinese ditch prawn *P. gravieri* from Changjian estuary, China. Previous authors, however, failed to give detailed descriptions for the zoeas of *P. serrifer* and *P. gravieri*, omitting an important characteristic of an anterior dorsomedian papilla on the carapace and giving inadequate illustration of the posterior setae of the telson.

In the present study, therefore, the first zoeas of *P. gravieri* and *P. serrifer* are described in detail. They are compared with the first zoeas of *P. ortmanni* and *P. pacificus*, previously known larvae from Korean waters. Larval characters of the genus *Palaemon* are revised. Provisional key to the known first zoeas of *Palaemon* from Korean waters is provided.

MATERIALS AND METHODS

In June and July 1998, ovigerous females of *Palaemon gravieri* and *Palaemon serrifer* were collected by the fisherman in Kwanganri, Busan and Geoje Island, southern Korea, respectively. In the laboratory, they were maintained in 2 L glass beakers, containing well-aerated natural seawater in growth chamber at 20°C until hatching occurred. The hatched first zoeas were fixed in 7% formalin solution for later examination. Drawing and measurements were based on 10 specimens and made using Nikon FX II microscope with a *camera lucida*. Body length (BL) was measured from the postorbital margin to the posteromedian margin of the telson, excluding posterior setae. Carapace length (CL) was measured from the postorbital margin to the posteromedian margin of the carapace. The setal armature of the appendages is described from proximal towards distal segment. The chromatophore pattern was determined by observing living larvae.

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RESULTS

***Palaemon gravieri* (Yu, 1930)**

First zoea (Fig. 1)

Description. BL. 2.21 mm (2.20-2.22 mm); CL. 0.21 mm (0.20-0.22 mm). Carapace (Fig. 1A, B). Rostrum pointed, slightly overreaching to tip of peduncle of antennule in dorsal view, without distoventral teeth; anterior dorsomedian papilla present; pterygostomian spine (not shown) present; supraorbital and antennal spines (not shown) absent; anteroventral and posteroventral margin (not shown) smooth; eyes sessile.

Abdomen (Fig. 1A, C). Composed of 6 somites, last somite fused with telson; third somite dorsal hump-backed; fourth somite with dorsal tuft of setae and pair of dorsal setae; fifth somite with pair of dorsal setae, pair of posterolateral spine absent; last somite with three pairs of dorsal setae. Telson and uropods (Fig. 1A, M). Triangular, broadly expanded posteriorly, posterior margin straight, with 7+7 plumose setae; outermost 2 pairs plumose only on inner side; base of all setae except outermost with row of minute setules; anus (not shown) opening on ventral side; uropods absent.

Antennule (Fig. 1D). Peduncle unsegmented; inner flagellum not differentiated, with long plumose seta; outer flagellum with 4 aesthetascs and plumose seta. Antenna (Fig. 1E). Peduncle with distolateral spine; endopod rod-like, about 0.71 times as long as scale, with distal spine and long distal plumose seta; scale 6-segmented, with 5 distal segments, 10 plumose setae, and distolateral spine.

Mandibles (Fig. 1F). Asymmetrical; palps absent; left mandible with *lacinia mobilis* between molar and incisor processes; right mandible with 2 teeth at corresponding site. Maxillule (Fig. 1G). Coxal endite with subterminal seta and 5 terminal plumodenticulate setae; basal endite with 5 plumodenticulate setae; endopod segmented, with terminal seta. Maxilla (Fig. 1H). Coxal endite with subterminal plumose seta and 3 terminal setae; basal endite bilobed, with 3+4 setae; endopod bilobed, with 2+1 setae and minute marginal setules; scaphognathite with 5 plumose setae and minute marginal setules. First maxilliped (Fig. 1I). Coxa with seta; basis with 6 plumodenticulate setae, arranged 1, 2, 2, 1; endopod 3-segmented, with 0, 1, 4 setae; exopod (not shown) with 4 terminal plumose natatory setae, symmetrically disposed into 2 pairs. Second maxilliped (Fig. 1J). Coxa unarmed; basis with 3 plumose setae, arranged 1, 1, 1; endopod 3-segmented, with 0, 2, 4+1 setae; exopod (not shown) with 6 (2 subterminal, 4 terminal) plumose natatory setae, terminal setae symmetrically disposed in 2 pairs. Third maxilliped (Fig. 1K). Coxa unarmed; basis with 3 plumose setae, arranged 1, 1, 1; endopod 3-segmented, with 2 (1 basal, 1 subterminal), 2, 3+1 setae, terminal segment with spine-like claw; exopod (not shown) with 8 (4 subterminal, 4 terminal) plumose natatory setae, terminal setae symmetrically disposed in 2 pairs. Pereopods (Fig. 1L). First and second pereopods present as biramous rudiments; third to fifth pereopods not differentiated.

Chromatophores (Fig. 1A). Red chromatophores interspersed with yellow chromatophores present on: carapace; base of rostrum; peduncles of antennule and antenna; anterior to eyestalk; mandibles; bases and endopods of second and third maxillipeds; dorsally on third and last abdominal somites, and telson; laterally on first and second abdominal somites; and ventrally on third, fourth, and last abdominal somites. Blue chromatophores present on: base of rostrum; and dorsally on third abdominal somite.

Remarks. Liang and Zhou (1994) provided the description for the first zoeas of *P. gravieri*, omitting an important characteristic of an anterior dorsomedian papilla on the carapace and giving inadequate illustration for outermost pair of posterior setae of the telson as plumose on innerside. In planktotrophic first zoeas of *Palaemon*, the carapace generally has an anterior dorsomedian papilla. Moreover, the telson has 7+7 posterior setae, of which outermost two pairs are plumose on inner side, as this can be also seen in the first zoea of *P. serrifer* (Fig. 2A). The discrepancies for an anterior dorsomedian papilla on the carapace and outermost two pairs of posterior setae of the telson in descriptions likely resulted from Liang and Zhou's (1994) inaccurate observation.

The first zoeas of *P. gravieri* are readily separated from those of *P. ortmanni*, *P. pacificus*, and *P. serrifer* by the third abdominal somite being strongly dorsal hump-backed, the fifth abdominal somite without posterolateral spine, and the rostrum reaching the tip of the peduncle of the antennule. The third abdominal somite in *P. ortmanni*, *P. pacificus*, and *P. serrifer* is slightly dorsal hump-backed and a pair of posterolateral spines is present on the fifth abdominal somite. The rostrum in *P. ortmanni*, *P. pacificus*, and *P. serrifer* overreaches the tip of the outer flagellum of the antennule.

Red chromatophores interspersed with yellow chromatophores are common in caridean zoeas. However, blue chromatophores which are present on the base of the rostrum and dorsally on the third abdominal somite, are observed in the first zoeas of *P. gravieri*. Blue chromatophores can be also seen in the first zoeas of the majid crab *Miccipa philyra* (Herbst, 1803) (see Ko, 1995).

***Palaemon serrifer* (Stimpson, 1860)**

First zoea (Fig. 2)

Description. BL. 1.81 mm (1.80-1.82 mm); CL. 0.36 mm (0.35-0.37 mm). Carapace (Fig. 2A-C). Rostrum pointed, overreaching to tip of outer flagellum of antennule in dorsal

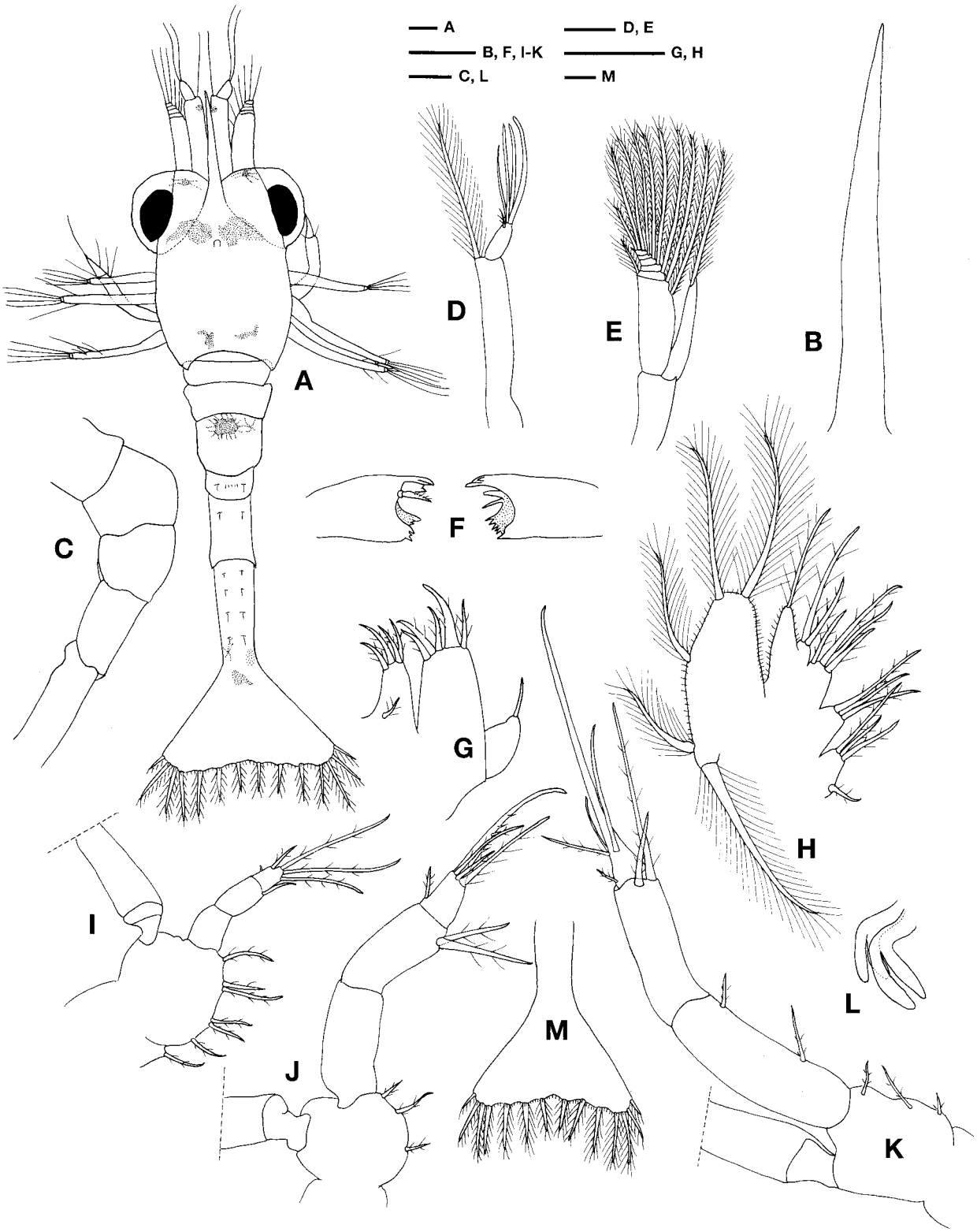

Fig. 1. First zoea of *Palaemon gravieri* (Yu, 1930). A, habitus, dorsal; B, rostrum, lateral; C, abdomen, lateral; D, antennule; E, antenna; F, mandibles; G, maxillule; H, maxilla; I, first maxilliped; J, second maxilliped; K, third maxilliped; L, first and second pereopods; M, telson. Exopods shown truncated in I-K. Scale bars=0.1 mm (A-M).

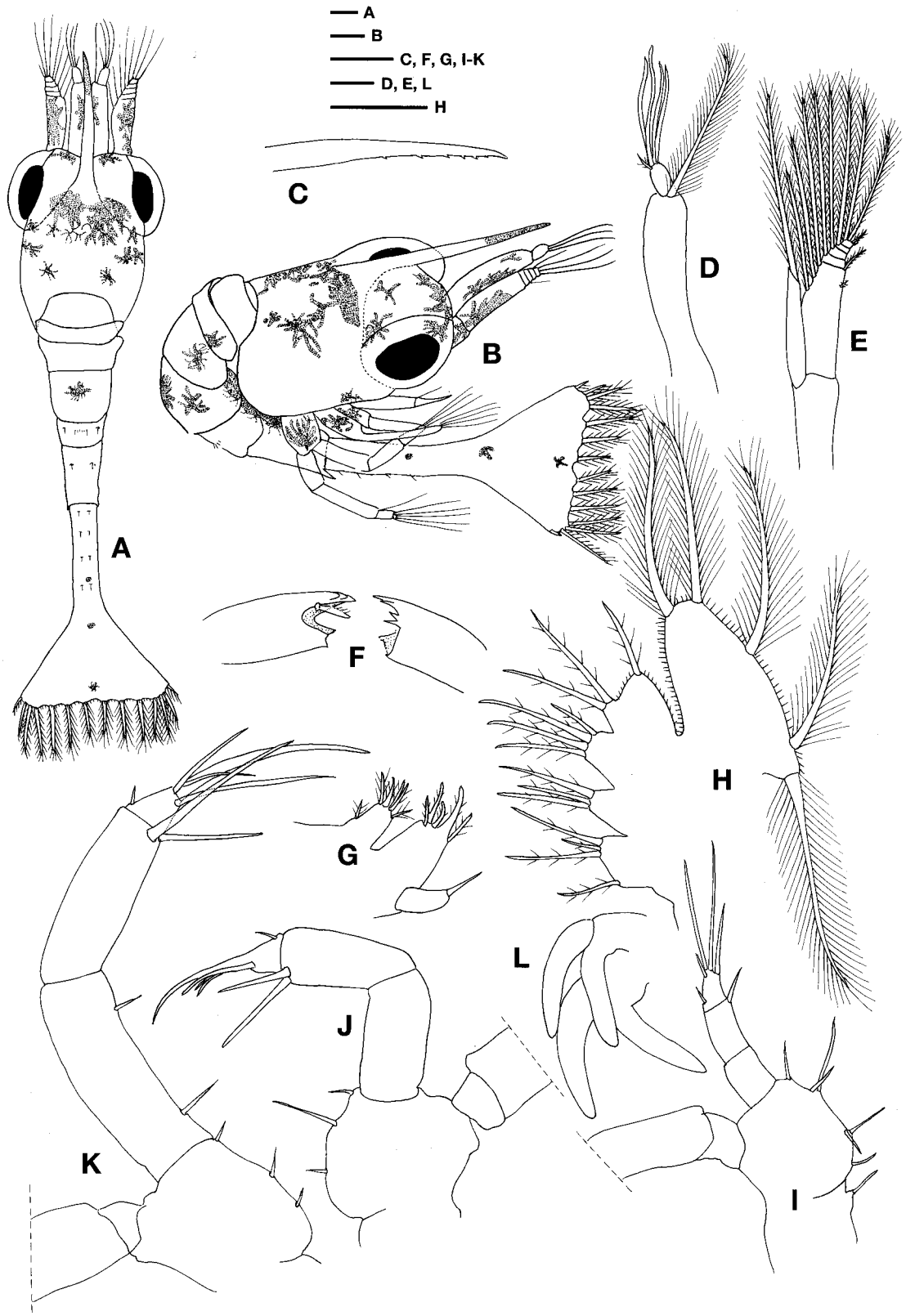

Fig. 2. First zoea of *Palaemon serrifer* (Stimpson, 1860). A, habitus, dorsal; B, same, lateral; C, tip of rostrum, lateral; D, antennule; E, antenna; F, mandibles; G, maxillule; H, maxilla; I, first maxilliped; J, second maxilliped; K, third maxilliped; L, first and second pereopods. Exopods shown truncated in I-K. Scale bars=0.1 mm (A-L).

view, with 6 distoventral teeth; anterior dorsomedian papilla present; pterygostomian spine present; supraorbital and antennal spines absent; anteroventral and posteroventral margin smooth; eyes sessile.

Abdomen (Fig. 2A, C). Composed of 6 somites, last somite fused with telson; third somite slightly dorsal hump-backed; fourth somite with dorsal tuft of setae and pair of dorsal setae; fifth somite with pair of dorsal setae, pair of posterolateral spine present; last somite with three pairs of dorsal setae. Telson and uropods (Fig. 2A). Triangular, broadly expanded posteriorly, posterior margin straight, with 7+7 plumose setae; outermost 2 pairs plumose only on innerside; base of all setae except outermost with row of minute setules; anus (not shown) opening on ventral side; uropods absent.

Antennule (Fig. 2D). Peduncle unsegmented; inner flagellum not differentiated, with long plumose seta; outer flagellum with 4 aesthetascs and plumose seta. Antenna (Fig. 2E). Peduncle with distolateral spine; endopod rod-like, about 0.75 times as long as scale, with distal spine and long distal plumose seta; scale 5-segmented, with 4 distal segments, 11 plumose setae, and distolateral spine.

Mandibles (Fig. 2F). Asymmetrical; palps absent; left mandible with *lacinia mobilis* between molar and incisor processes; right mandible with 2 teeth at corresponding site. Maxillule (Fig. 2G). Coxal endite with subterminal seta and 5 terminal plumodenticulate setae; basal endite with 5 plumodenticulate setae; endopod segmented, with terminal seta. Maxilla (Fig. 2H). Coxal endite with 4 (1 basal, 3 terminal) plumose setae; basal endite bilobed, with 3+4 setae; endopod bilobed, with 2+1 setae and minute marginal setules; scaphognathite with 5 plumose setae and minute marginal setules.

First maxilliped (Fig. 2I). Coxa with seta; basis with 6 plumodenticulate setae, arranged 1, 2, 2, 1; endopod 3-segmented, with 0, 1, 4+1 setae; exopod (not shown) with 4 terminal plumose natatory setae, symmetrically disposed into 2 pairs. Second maxilliped (Fig. 2J). Coxa unarmed; basis with 3 plumose setae, arranged 1, 1, 1; endopod 3-segmented, with 0, 2, 4+1 setae; exopod (not shown) with 6 (2 subterminal, 4 terminal) plumose natatory setae, terminal setae symmetrically disposed in 2 pairs. Third maxilliped (Fig. 2K). Coxa unarmed; basis with 3 plumose setae, arranged 1, 1, 1; endopod 3-segmented, with 2 (1 basal, 1 subterminal), 2, 3+1 setae, terminal segment with spine-like claw; exopod (not shown) with 8 (4 subterminal, 4 terminal) plumose natatory setae, terminal setae symmetrically disposed in 2 pairs. Pereopods (Fig. 2L). First and second pereopods present as biramous rudiments; third to fifth pereopods not differentiated.

Chromatophores (Fig. 2A, B). Red chromatophores interspersed with yellow chromatophores present on: carapace; tip of rostrum; peduncle of antennule; peduncle and scale of antenna; anterior to eyestalk; mandibles; basis of first maxilliped; bases and endopods of second and third maxillipeds; dorsally on third and last abdominal somites and telson; and laterally on first to third abdominal somites. Yellow chromatophores present ventrally on third, fourth, and last abdominal somites.

Remarks. Of the known larvae (*P. gravieri*, *P. ortmanni*, and *P. pacificus*) of the genus *Palaemon* from Korea, the first zoeas of *P. serrifer* are most similar to those of *P. ortmanni* by having the third abdominal somite being slightly dorsal hump-backed, the fifth abdominal somite with a pair of posterolateral spines, and the rostrum with 6 distoventral denticles, reaching to the tip of the outer flagellum of antennule. The first zoeas of *P. serrifer* and *P. ortmanni*, however, are readily distinguished from each other by the presence (in *P. ortmanni*) or absence (in *P. serrifer*) of an inner papilla on the scale of antenna.

DISCUSSION

The presence or absence of a pair of posterolateral spines on the abdominal somites is generally considered as one of specific characteristics for the caridean first zoeas (Yang, 2005). However, when Knowlton and Vargo (2004) summarized larval characters of the genus *Palaemon*, they regarded that the presence of a pair of posterolateral spines on the fifth abdominal somite during the first and second zoeas is a valid characteristic to the genus *Palaemon*. Because the fifth abdominal somite in the first zoeas of *P. gravieri* lacks a pair of posterolateral spines in this study, however, it should be revised on the criterion suggested by Knowlton and Vargo (2004). For the revision of the larval characters of *Palaemon*, the followings can be incorporated into Knowlton and Vargo's (2004) summary: 1) carapace with anterior dorsomedian papilla, posterior dorsomedian papilla absent, anteroventral and posteroventral margins smooth; 2) antenna bearing endopod rod-like, with distal spine and long plumose distal seta in first zoeas; 3) maxilla bearing coxal endite without proximal lobe; 4) first maxilliped bearing basis with 6 setae, arranged 1, 2, 2, 1 in first zoeas; 5) second maxilliped bearing basis with 3 setae, arranged 1, 1, 1 in first zoeas; and 6) third maxilliped bearing basis with 3 setae, arranged 1, 1, 1 in first zoeas.

A provisional key to the known first zoeas of *Palaemon* from Korean waters

1. Rostrum not reaching tip of outer flagellum of antennule; third abdominal somite strongly dorsal hump-backed; fifth abdominal somite without pair of posterolateral spines ····
····· *P. gravieri*

- Rostrum overreaching tip of outer flagellum of antennule; third abdominal somite slightly dorsal hump-backed; fifth abdominal somite with pair of posterolateral spines 2
2. Rostrum without distoventral denticles; endopod of antenna more than 80% scale ..... *P. pacificus*
- Rostrum with 6 distoventral denticles; endopod of antenna less than 80% scale 3
3. Scale of antenna with inner papilla ..... *P. ortmanni*
- Scale of antenna without inner papilla ..... *P. serrifer*

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