

Zoeal Stages of *Alpheus euphrosyne richardsoni* Yaldwyne, 1971 (Decapoda: Macrura: Alpheidae) Reared in the Laboratory

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Zoae of *Alpheus euphrosyne richardsoni* Yaldwyne, 1971 reared in the laboratory are described and illustrated. The culture was carried out under the laboratory condition with the photoperiod 14hr light and 10hr darkness and salinity of 33.3‰ at 25°C. This species exhibits extended development on the egg size just before hatching and on the length of the first zoea. The morphological differences between the first zoea of this species and those of five other species in the same genus are discussed.

KEY WORDS: Zoeal Development, *Alpheus euphrosyne richardsoni*, Alpheidae, Korea

The snapping shrimp, *Alpheus euphrosyne richardsoni* inhabits the intertidal mudflats and mangrove swamps (Banner and Banner, 1981). This species is known to occur in Japan, Australia and New Zealand (Banner and Banner, 1981; Miya, 1995; Yaldwyne, 1971).

Yaldwyne (1971) first described this species as *A. richardsoni* from New Zealand. Banner and Banner (1981) reduced *A. richardsoni* from Australia to subspecific rank under *A. euphrosyne*. Three subspecies of *A. euphrosyne* including *A. euphrosyne richardsoni* one another may be separated by the shape of the squame on the antenna and the sculpturing of palm on the small chela of the males (Banner and Banner, 1981; Miya, 1995).

Five species of the Alpheidae represented by two genera have been known to occur in Korean waters: *A. bisincisus*, *A. brevicristatus*, *A. japonicus*, *A. rapax* and *Betaeus granulimanus* (Kim, 1976, 1977). However, the present species has not been reported from Korean waters.

Incomplete larval descriptions of *Alpheus* are known for *A. audouini* by Gurney (1927, 1938), *A. armillatus* (as *A. heterochaelis*) by Brooks and Herrick (1892), *A. brevicristatus* by Miyazaki (1937), *A. dentipes* by Bourdillon-Casanova (1960), *A. glaber* (as *A. ruber*) by Webb (1921) and Lebour (1932), *A. laevis* by Coutière (1899), *A. normanni* (as *A. minus* and *A. minor*) by Brooks and Herrick (1892), *A. pacificus* by Gurney (1938) and Gohar and Al-Kholy (1957), *A. rapacida* by Prasad and Tampi (1957), *A. rapax* by Al-Kholy (1960), *A. strenuus* by Prasad and Tampi (1957), *A. ventrosus* by Gurney (1938) and Al-Kholy (1960). The complete larval development is only known for *A. heterochaelis* with abbreviated development (Knowlton, 1973). No larval stages of the present species has been described yet.

In this paper, the zoeal stages of *A. euphrosyne richardsoni* is described in detail and the morphology of the first zoea of this species are compared with those of five other species of *Alpheus*.

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Materials and Methods

Ovigerous females of *Alpheus euphrosyne richardsoni* were collected from the mudflat at the peninsula of Pyönsan (35°45' N, 126°30' E), Chöllabuk-do, on 22 May 1993. They were placed individually in the glass containers (130mm diameter × 200 mm depth) filled with seawater.

Ten newly hatched larvae were placed in glass bowls containing 80 ml filtered seawater of 33.3 ‰ and kept at 25°C with the light regime of 14hr light and 10hr darkness. A mixture of diatoms (*Skeletonema costatum*, *Chaetoceros calcitrans*) and flagellates (*Tetraselmis suecica*, *Nannocloris* sp., *Dunaliella tertiolecta*) was supplied as food. Food and seawater were changed daily.

Specimens of living larvae, exuviae and dead larvae were preserved in a mixture of equal parts of seawater, 4% neutral formalin and glycerin. Larval descriptions were made after examining more than 10 specimens at each stage. Drawings and measurements were made with a camera lucida and an ocular micrometer, respectively. Measurements of larvae were based on the method of Shokita (1985). Chromatophore patterns were examined by the observation of living larvae. The terminology of setal type after that of Laballi and Factor (1992) was followed.

Results

The newly spawned eggs of *Alpheus euphrosyne richardsoni* were approximately 0.65mm in diameter. As the development proceeded, the eggs went ellipsoidal with the diameters of 0.86 × 0.78 mm just before hatching.

First Zoea (Fig. 1)

Duration. 3-12 hours.

Size. Body length 2.30-2.80 mm; carapace length 0.52-0.66mm.

Carapace (Fig. 1A). Fused with eyes anteriorly. Lacking spines. Rostrum absent. Eyes sessile.

Abdomen (Fig. 1A). Without any spines, with 5 somites and telson. Combined length of sixth somite and telson subequal to that of other somites combined.

Telson (Fig. 1B). Triangular, not separated from sixth abdominal somite and with moderate median notch. Posterior margin with 7+7 plumose setae; outer 2 pairs plumose only on inner side; third and fourth setae longest; innermost seta shortest. Margin slightly indented between each seta. Minute setules between setae 4-7. Uropods undeveloped.

Antennule (Fig. 1C). Peduncle unsegmented, with long plumose seta on inner distal end. Outer flagellum with 3 aesthetascs, short plumose seta and long simple seta.

Antenna (Fig. 1D). Peduncle with basal spine. Endopodite less than half length of exopodite, with long plumose seta and small spine. Exopodite flattened, 4-segmented at distal end, and with 11 plumose setae plus external seta on terminal margin.

Maxillule (Fig. 1E). Coxal endite with 3 terminal and 1 subterminal setae. Basal endite with 2 stout spines and 1 short simple seta subterminally. Endopodite unsegmented, with distal denticulate seta.

Maxilla (Fig. 1F). Coxal endite with 2 simple setae. Proximal and distal lobes of basal endite each with 3, 4 simple setae, respectively. Endopodite unsegmented, with simple seta at base and 2 terminal setae. Scaphognathite with 5 long plumose setae, of which 3 directed anteriorly, one posteriorly.

First maxilliped (Fig. 1G). Protopodite with 4 spines and 2 hair-like setae on inner margin. Endopodite unsegmented, with 3 terminal setae and 1 simple seta at base. Exopodite with 4 plumose natatory setae.

Second maxilliped (Fig. 1H). Protopodite with 3 small spines. Endopodite incompletely 4-segmented, with setal formula 1, 0, 1, 2, progressing distally. Exopodite with 5 plumose natatory setae and 1 short seta laterally.

Third maxilliped (Fig. 1I). Protopodite with simple seta. Endopodite slightly longer than exopodite and incompletely 4-segmented, with setal formula 0, 0, 2, 3, progressing distally. Exopodite with 6 plumose natatory setae.

Pereiopods (Fig. 1J₁₋₆). Pereiopods 1-3 of biramous rudiments. Pereiopods 4-5 of uniramous rudiments.

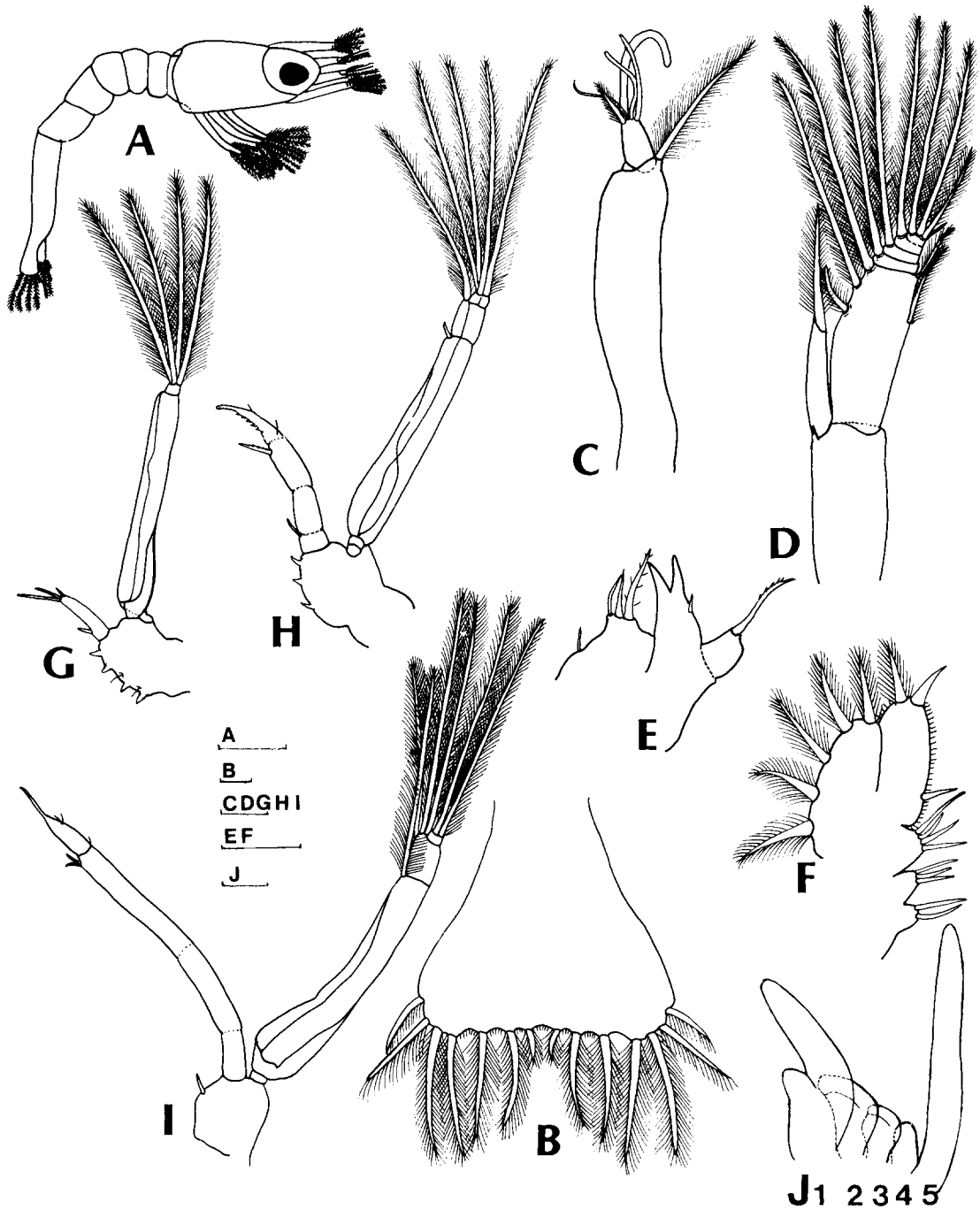


Fig. 1. *Alpheus euphrosyne richardsoni* Yaldwyne, 1971. First zoeal stage, A, lateral view; B, telson; C, antennule; D, antenna; E, maxillule; F, maxilla; G, first maxilliped; H, second maxilliped; I, third maxilliped; J₁₋₅, pereiopods 1-5. Scale bars = 0.5 mm.

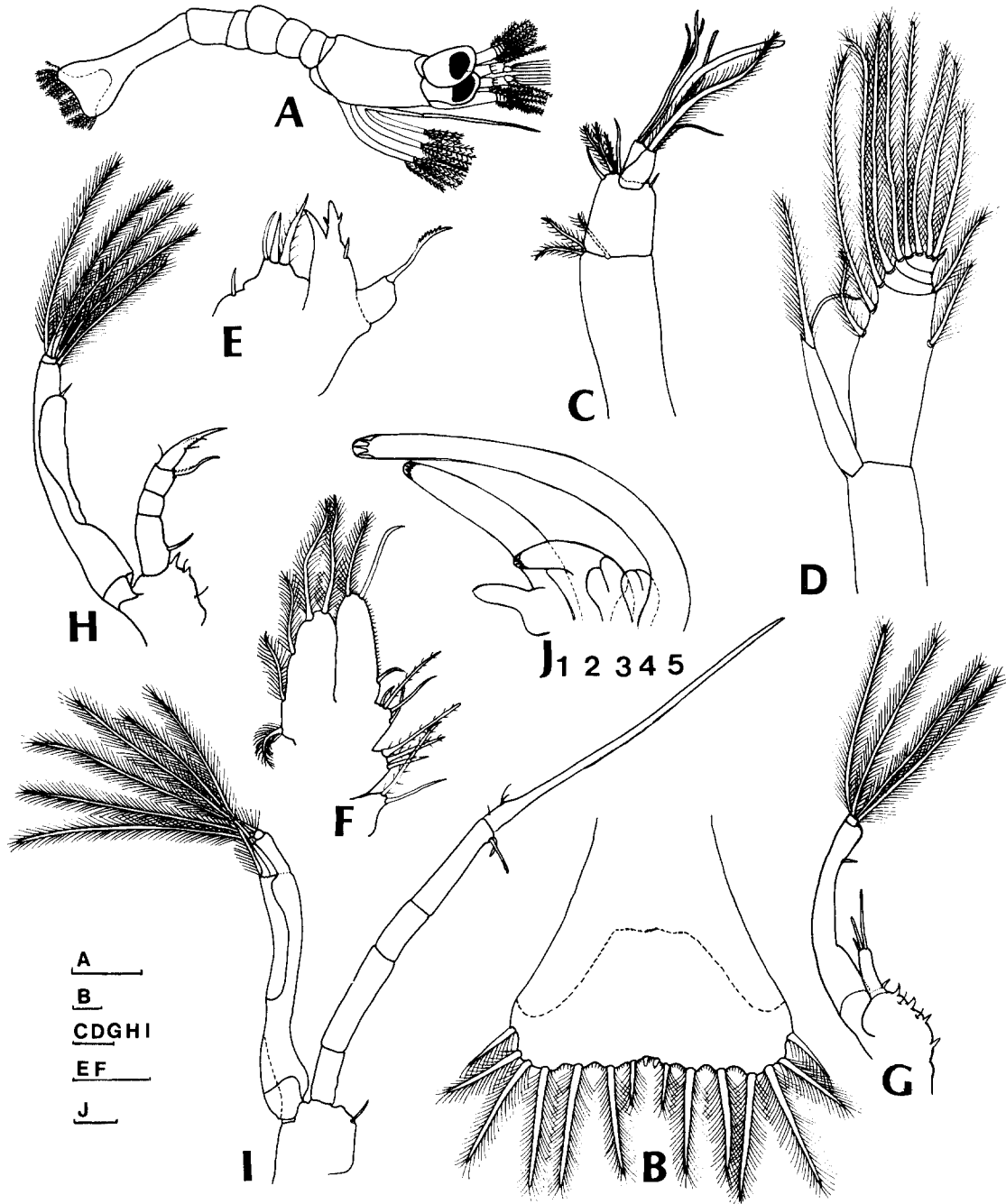


Fig. 2. *Alpheus euphrosyne richardsoni* Yaldwyne, 1971. Second zoeal stage, A, lateral view; B, telson; C, antennule; D, antenna; E, maxillule; F, maxilla; G, first maxilliped; H, second maxilliped; I, third maxilliped; J₁₋₅, pereopods 1-5. Scale bar = 0.5 mm.

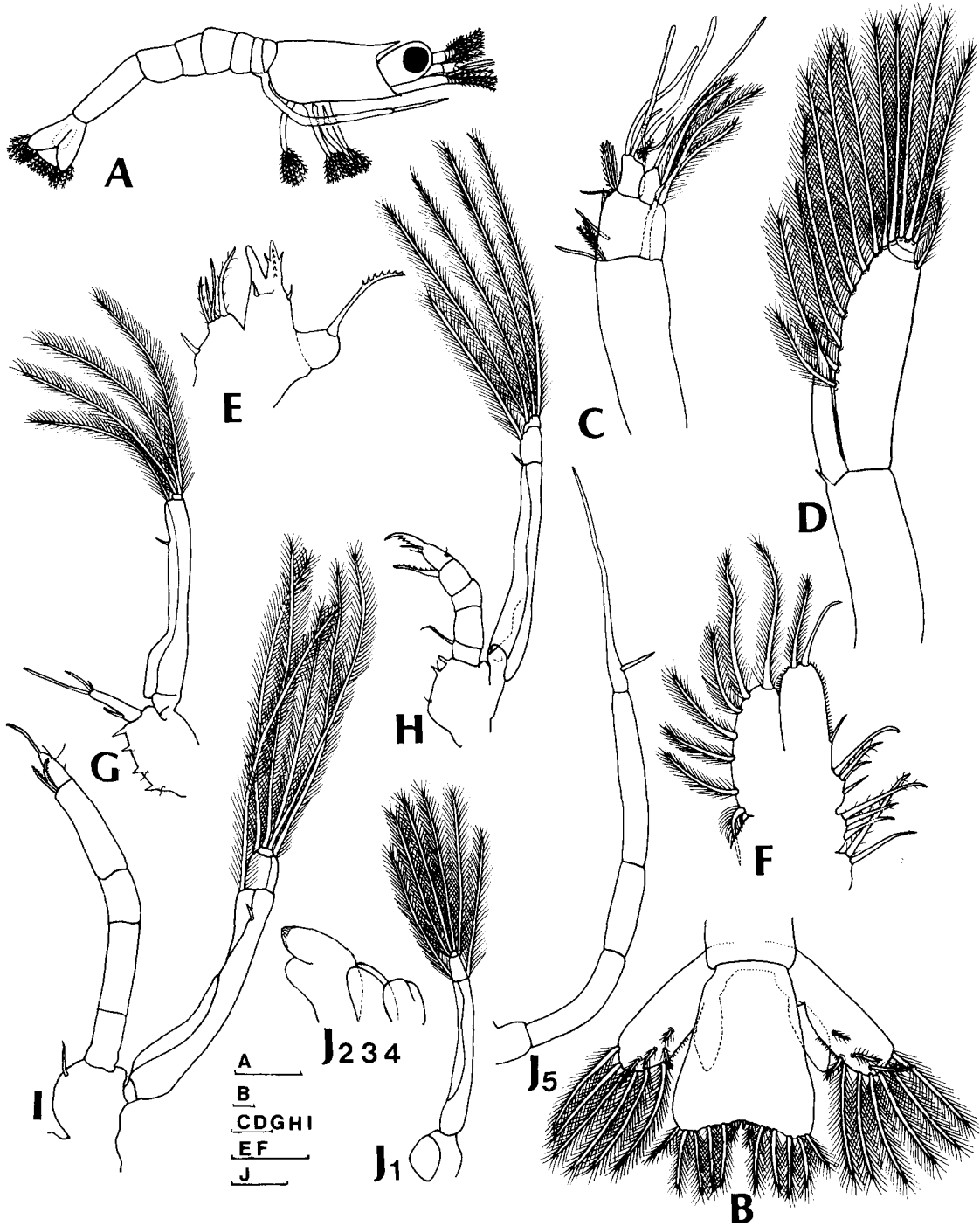


Fig. 3. *Alpheus euphrosyne richardsoni* Yaldwyne, 1971. Third zoeal stage. A, lateral view; B, telson; C, antennule; D, antenna; E, maxillule; F, maxilla; G, first maxilliped; H, second maxilliped; I, third maxilliped; J₁₋₅, pereiopods 1-5. Scale bar = 0.5 mm.

Chromatophores. Pale yellow pigments present on base and endopodites of thoracic appendages. Interspersion of red chromatophores present among yellow in front of eye stalks, on distal antennular peduncle, on segments 2-4 and supraregion of telson. Bright red chromatophores present on base of rostrum, on junction of thorax and abdomen.

Second Zoea (Fig. 2)

Duration. 1-3 days.

Size. Total length 2.64-2.82 mm; body length 2.40-2.80 mm; carapace length 0.46-0.70 mm.

Carapace (Fig. 2A). Untoothed rostrum longer than that in first zoea. Eyes stalked. Pterygostomial and supraorbital spines developed.

Abdomen (Fig. 2A). Still with 5 somites.

Telson (Fig. 2B). Posterior margin of telson with 8+8 setae; outermost seta on each side plumose only on inner side. Uropod visible within cuticle.

Antennule (Fig. 2C). Peduncle 2-segmented: proximal segment with 3 plumose setae distally; distal segment with 3 plumose and 3 simple setae. Inner flagellum of short conical bud terminating with long plumose seta. Outer flagellum with 5 aesthetascs and 1 slender seta.

Antenna (Fig. 2D). Endopodite now with slender seta. Exopodite 3-segmented at distal end.

Maxillule (Fig. 2E). Basal endite with spine armed with setules

Maxilla (Fig. 2F). Coxal endite with 1 plumose and 1 simple setae. Proximal lobe of basal endite with 2 plumose and 1 simple setae. Distal lobe of basal endite with 1 plumose and 3 simple setae.

First maxilliped (Fig. 2G). Exopodite with short simple seta laterally.

Second maxilliped (Fig. 2H). Protopodite with 2 spines and 2 hair-like setae. Endopodite 4-segmented, with setal formula 1, 0, 1, 3, progressing distally.

Third maxilliped (Fig. 2I). Endopodite 5-segmented, with setal formula 0, 0, 0, 2, 3, progressing distally; dactylus long, sharply pointed.

Pereiopods (Fig. 2J). Exopodites of pereiopods 1, 2 and 5 with minute protuberances. Pereiopod 4 now biramous rudiment.

Third Zoea (Fig. 3)

Duration. 2-5 days.

Size. Total length 2.84-3.10 mm; body length 2.64-2.90 mm; carapace length 0.60-0.76 mm.

Carapace (Fig. 3A). Rostrum slightly elongated. Pterygostomial and supraorbital spines well developed.

Abdomen (Fig. 3A). Sixth somite separated from telson.

Telson and Uropods (Fig. 3B). Telson with 7+7 setae posteriorly; outermost seta of each side disappeared. Uropods free, endopodite still narrow, elongated buds. Exopodites of uropod with 6 plumose setae on terminal margin and 4 small setae scattered over dorsal surface.

Antennule (Fig. 3C). Peduncle 2-segmented: proximal segment with 1 long plus 2 short plumose and 1 simple setae; distal segment with 2 long plus 2 short plumose and 4 simple setae. Inner flagellum with long simple seta. Outer flagellum with 3 aesthetascs, 1 plumose and 2 slender setae.

Antenna (Fig. 3D). Endopodite with spine and slender seta at distal end. Exopodite 2-segmented at distal end, with 13 plumose setae.

Maxillule (Fig. 3E). Coxal endite with 4 terminal and 1 subterminal setae. Basal endite with 2 setae subterminally.

Maxilla (Fig. 3F). Scaphognathite with 7 plumose setae.

First maxilliped (Fig. 3G). As in previous stage.

Second maxilliped (Fig. 3H). Endopodite 5-segmented, with setal formula 1, 0, 0, 1, 3, progressing distally.

Third maxilliped (Fig. 3I). Dactylus much shorter than that in second zoea. Exopodite with short seta laterally.

Pereiopods (Figs. 3J₁₋₅). Endopodite of pereiopod 1 rudimentary; exopodite functional, with 6 plumose natatory setae. Endopodite of pereiopod 5 4-segmented, with setal formula 0, 0, 0, 1, progressing distally.

Discussion

The family Alpheidae exhibits a bewildering array of larval development from the standpoint of

larval stage and morphology. Therefore, it is difficult to establish a generalized developmental patterns owing to the degree of larval variation. Knowlton (1973), however, categorized three types of larval development within the Alpheidae based on the number of larval stage, the size of eggs just before hatching and the body length of the first zoeae without classifying upon the basis of habitat types: (1) Extended development, with a large number of small-sized eggs (<1 mm just before hatching) and the larvae hatched as a typical zoea which molted 4 or more times with larval development lasting several weeks, (2) Abbreviated development, with slightly fewer, large-sized eggs (>1 mm just before hatching) and the instar hatched as an advanced zoea completing larval development in 4 or fewer molts, e.g., *A. heterochaelis* (see Knowlton, 1973), (3) Direct development, without larval instar, hatched as the adult form, e.g.,

Synalpheus brooksi (see Dobkin, 1965).

According to Knowlton's scheme, larval development of *A. euphrosyne richardsoni* can be placed in the first category in several respects. First, the eggs carried by ovigerous females are numerous and very small (0.86 × 0.78 mm just before hatching). Second, the length of the first zoea (2.3-2.8 mm) is subequal to that of other species with the extended development of *Alpheus* (see Knowlton, 1973). Third, the first zoea is a typical form of the genus.

The zoea of the present species is easily characterized by following features: untoothed rostrum; poorly-developed mouthparts; maxilla without the fourth internal lacinia; the first maxilliped with reduced endopodite; the third maxilliped with elongated and sharply pointed endopodite in the second stage; precocious development of the fifth pereopod (which develops prematurely along with the first and

Table 1. Comparison of morphological features of the first zoeae in six species of *Alpheus*.

	<i>A. b.</i>	<i>A. h.</i>	<i>A. p.</i>	<i>A. e. r.</i>	<i>A. r.</i>	<i>A. s.</i>
Eyes	sessile*	sessile	stalked*	sessile	stalked	sessile
Rostrum	absent*	absent	present*	absent	present	absent
Telson	7+7S	7+7S	7+7S	7+7S	8+8S	7+7S
Antennule						
Peduncle seg.	0	0	2	0	0	0
Outer flagellum	3A	3A	?	3A	2A	2A
Antenna						
Exopodite						
Dist. seg.	3	5	4	4	incompl. 6-7	incompl. 6
Margin	11S	11S	7S	11S	11S	11S
Maxillule						
Endopodite	1S	1S	1S	1S	1S	2S
Maxilla						
Scaphognathite	5P	8-10P	3P	5P	4P	5P
Basal endite						
Prox. lobe	3S	2S	3S	3S	3S	1S
Dist. lobe	?	2S	2S	4S	3S	2S
Coxal endite	2-4S	2S	2S	2S	?	1S
Second maxilliped						
Endopodite seg.	incompl. 3	4	0	incompl. 4	0	incompl. 2

*=data based on figure; A=aesthetascs; S=setae; P=plumose setae; seg.=segmented; incompl.=incompletely; ?=no description; Prox.=proximal; Dist.=distal; *A. b.*=*Alpheus brevicristatus* (Miyazaki, 1937); *A. h.*=*Alpheus heterochaelis* (Knowlton, 1973); *A. p.*=*Alpheus pacificus* (Gohar and Al-Kholy, 1957); *A. e. r.*=*Alpheus euphrosyne richardsoni* (Present study); *A. r.*=*Alpheus rapacida* (Prasad and Tampi, 1957); *A. s.*=*Alpheus strenuus* (Prasad and Tampi, 1957).

before the second, third and fourth pereopod) with a long spine in the third stage; abdominal segment without any spines. In this respect, the larvae of the present species agree well with the characteristics of the family Alpheidae noted by Gurney (1938) and Lebour (1932).

Although many species of *Alpheus* have been described in terms of their larval stages, most of these descriptions are too brief to be used in comparison with those of other known species of the same genus. Currently, the first zoeal descriptions of *Alpheus* are available for *A. brevicristatus*, *A. heterochaelis*, *A. pacificus*, *A. rapacida* and *A. strenuus*. As shown in table 1, stalked eyes and rostrum are present in *A. pacificus* and *A. rapacida*, whereas those appendages are absent in *A. euphrosyne richardsoni*. Most of species including *A. euphrosyne richardsoni* in *Alpheus* have 7+7 and 11 setae on the margin of telson and antennal exopodite, respectively, whereas *A. rapacida* has 8+8 marginal setae on telson and *A. pacificus* has 7 setae on antennal exopodite. Distal end of antennal exopodite is 4-segmented in *A. euphrosyne richardsoni* and *A. pacificus*, while those of *A. rapacida* and *A. strenuus* are incompletely 6 or 7-segmented. In contrast, those of *A. brevicristatus* and *A. heterochaelis* are 3-segmented and 5-segmented, respectively. Other minor features distinguishing six species of *Alpheus* are given in table 1.

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Alpheus euphrosyne richardsoni(새우아목, 딱총새우과)의 Zoea 유생
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실험실에서 사육된 *Alpheus euphrosyne richardsoni*의 zoea 유생을 기재 및 도시하였다. 사육은 수온 25°C, 염분농도 33.3‰, 광주기 14hr light: 10hr dark의 조건하에서 진행되었다. *A. euphrosyne richardsoni*는 부화직전의 난의크기와 제1기 zoea 유생의 길이에서 장기발생(extended development)을 보였다. 딱총새우속에 속하는 6종의 제1기 zoea 유생의 형태적인 특징에 대하여 논의하였다.