

# Early Zoeas of *Alpheus lobidens* De Haan, 1850 and *Alpheus sudara* Banner and Banner, 1966 (Decapoda, Caridea, Alpheidae) Reared in the Laboratory

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Early zoeas  
key

*Alpheus lobidens*  
*Alpheus sudara*  
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Early zoeas of snapping shrimps *Alpheus lobidens* De Haan, 1850 and *A. sudara* Banner and Banner, 1966 are described and illustrated in detail, based on laboratory-reared materials. A provisional key to the known first alpheid zoeas from Korean coast is provided.

Even though the larvae of the Alpheidae constitute one of the most common intertidal communities of inshore meroplankton (Knowlton, 1973; Bhuti et al., 1977), larval descriptions of the family are poorly reported world-wide. Alpheid larvae from Indo-West Pacific waters had been known for only nine genera (about 22%) of the 32 genera recognized world-wide (Yang and Kim, 2002). Similarly, larvae of the family had been known for only 2.9% of the species reported from Japanese waters (Saito et al., 1998). Reports on decapod larvae revealed that larval data play an important role in life history strategies, stock recruitment, population dynamics, and spatio-temporal distribution of the plankton, as well as systematic or phylogenetic studies on different taxon (Rice, 1980; González-Gordillo and Rodriguez, 2000; González-Gordillo et al., 2000). However, in some cases, it is difficult not only to assign decapod larvae to those proper genera from plankton sample, but also to construct a key to the known decapod larvae because of lack of larval descriptions. For those problems, detailed descriptions of the alpheid larvae would be necessary.

Off the Korean coast, the family Alpheidae contains seven species belonging to four genera viz. *Alpheus*, *Betaeus*, *Stenualpheops* as *Chelomalpheus*, and *Synalpheus* (The Korean Society of Systematic Zoology, 1997; Kim, 1998; National Fisheries Research and Development Institute, 2001). Yang and Anker (2003) described three other species of *Alpheus lobidens* De Haan, 1850, *Alpheus sudara* Banner and Banner, 1966, and *Alpheus malabaricus* (Fabricius, 1775) from southern parts of Korea. However, recent larval studies (Yang and Kim, 1996, 1999; Yang, 1999, 2003) on four species of both

genera *Alpheus* (*Alpheus euprosyne richardsoni* Yaldwyn, 1971 and *Alpheus heeia* Banner and Banner, 1975) and *Athanas* (*Athanas japonicus* Kubo, 1936 and *Athanas parvus* De Man, 1909) suggest that these species are also distributed in Korean waters.

Consequently, the Korean Alpheidae consists now of 14 species represented by five genera *Alpheus*, *Athanas*, *Betaeus*, *Stenualpheops*, and *Synalpheus*, of which larvae are known for nine species (about 64.3%) including larvae of *A. lobidens* and *A. sudara*, both described here.

In the present paper, the early zoeas of *A. lobidens* and *A. sudara* are described and illustrated in detail for the first time and a provisional key to the known first alpheid zoeas of nine species from Korean coast is provided.

## Materials and Methods

From July to August in 1996, ovigerous females of *Alpheus lobidens* and *A. sudara* were collected intertidally in Gadeok Islands (35°02'00"N, 128°50'00"E) and from the raft culture bed of the oyster *Crassostrea gigas* (Thunberg, 1793) in Sangju (34°43'00"N, 127°59'30"E) in southern parts of Korea, respectively. Newly hatched zoeas were reared by using the method described by Yang (2003) in a growth chamber at 20°C and fed daily with *Dunaliella tertiolecta* Butcher, 1959. Some specimens in each stage were preserved in 7% neutral formalin. Measurements and setal counts were based on the mean of ten specimens for each zoeal stage. Dissected appendages were examined using a Nikon FX II microscope, and drawings were made with the aid of camera lucida. The chromatophore pattern was determined by observing living larvae. Total length (TL) was measured from the rostral tip (postorbital margin for the first zoea) to the postero-median margin of the telson, excluding posterior setae. Carapace length (CL) was measured

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from the postorbital margin to the postero-median margin of the carapace. The setal armature of the appendages is described from proximal segment towards distal segment.

## Results

Four and three zoeal stages of *Alpheus lobidens* and *A. sudara* were obtained, respectively. The first zoeal stage is described in detail. For the subsequent stages, only the main differences from the previous stage are given.

*Alpheus lobidens* De Haan, 1850 (Figs. 1-4)  
First zoea (Fig. 1)

Duration. 18-20 h.

TL, 2.47 (2.38-2.52) mm; CL, 0.68 (0.66-0.70) mm.

Carapace (Fig. 1A, A'). Rostrum absent; anterior dorso-median papilla present; pterygostomial spine present; supraorbital and antennal spines absent; antero-

ventral denticles absent; eyes sessile.

Antennule (Fig. 1C). Peduncle unsegmented; inner flagellum with long plumose seta; outer flagellum with 3 aesthetascs, short plumose seta, and long simple seta.

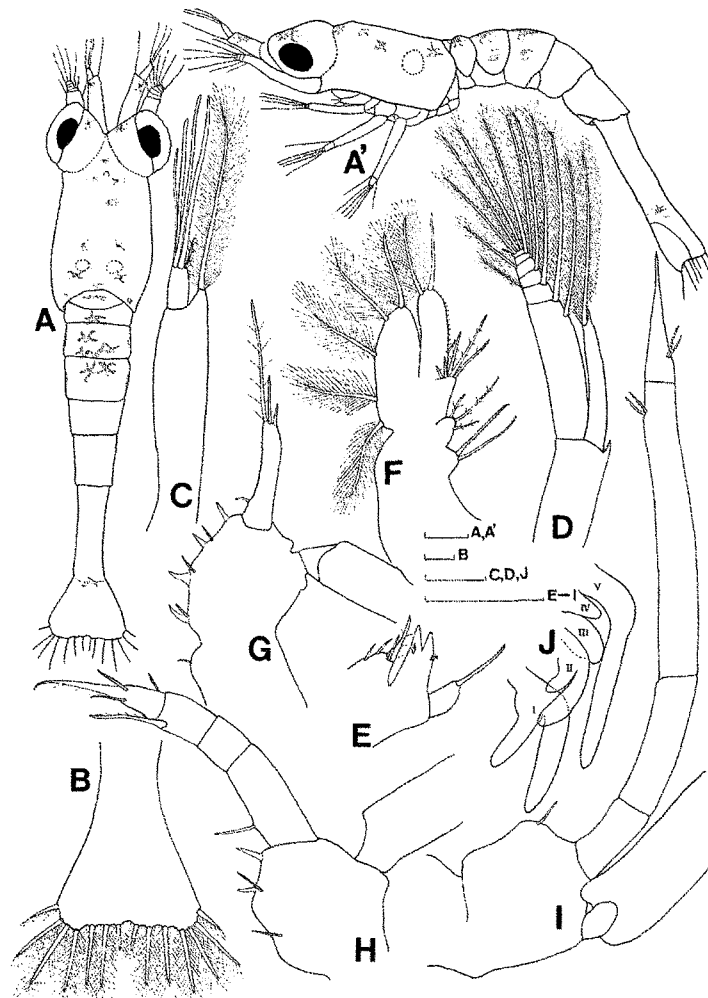
Antenna (Fig. 1D). Peduncle with spine; endopod rod-like, more than half length of scale, with long plumose seta and small spine; scale 6-segmented, with 11 plumose setae and disto-lateral spine.

Mandibles. Rudimentary; palps absent.

Maxillule (Fig. 1E). Coxal endite with 4 setae; basal endite with 2 subterminal plumose setae and 2 stout spines; endopod segmented, with terminal denticulate seta.

Maxilla (Fig. 1F). Coxal endite with 2 setae; basal endite bilobed, with 3 and 5 plumose setae; endopod with simple basal seta, 2 terminal setae, and fine marginal hairs; scaphognathite with 5 marginal plumose setae.

First maxilliped (Fig. 1A', G). Coxa with seta; basis with 4 spiniform setae and 3 setae; endopod segmented, with



**Fig. 1.** First zoea of *Alpheus lobidens* De Haan, 1850. A, Dorsal view. A', Lateral view. B, Telson. C, Antennule. D, Antenna. E, Maxillule. F, Maxilla. G, First maxilliped. H, Second maxilliped. I, Third maxilliped. J, Pereiopods 1-5. Exopod shown truncated in G-I. Scale bars=0.1 mm.

simple basal seta and 3 terminal setae; exopod with 4 terminal natatory setae, symmetrically disposed in 2 pairs.

Second maxilliped (Fig. 1A', H). Coxa unarmed; basis with 2 spiniform setae and 2 setae; endopod 4-segmented, with 1, 0, 1, 3 setae; exopod with subterminal seta and 4 terminal natatory setae, symmetrically disposed in 2 pairs.

Third maxilliped (Fig. 1A', I). Coxa unarmed; basis with simple seta; endopod 4-segmented, with 0, 0, 2, 2 setae, slightly longer than exopod; exopod with 2 subterminal setae and 4 terminal natatory setae, symmetrically disposed in 2 pairs.

Pereiopods (Fig. 1J). Rudimentary; pereiopods 1-3 biramous as bud; pereiopods 4-5 uniramous.

Abdomen (Fig. 1A, A'). Composed of 5 somites; abdominal somite 6 not differentiated; all somites without spines; pleopods absent.

Telson (Fig. 1B). Triangular, with shallow postero-median concavity; posterior margin with 7+7 plumose setae;

outermost 2 pairs plumose only on inner side; base of all setae except outermost with row of minute spinules; uropods absent.

Chromatophores. Red chromatophores present on carapace, junction of thorax and abdominal somites, and dorsally on abdominal somites 1-3. Interspersion of yellow among red chromatophores present on peduncle of antennule, supero-lateral margin of each eye, and telson. Yellow chromatophores present laterally on abdominal somites 2-3.

Second zoea (Fig. 2)

Duration. 1-3 d.

TL, 2.76 (2.60-3.10) mm; CL, 0.69 (0.66-0.72) mm.

Carapace (Fig. 2A, A'). Rostrum short, untoothed, not extending beyond eyes; eyes stalked.

Antennule (Fig. 2C). Peduncle 2-segmented, with 3 and 5 plumose setae.

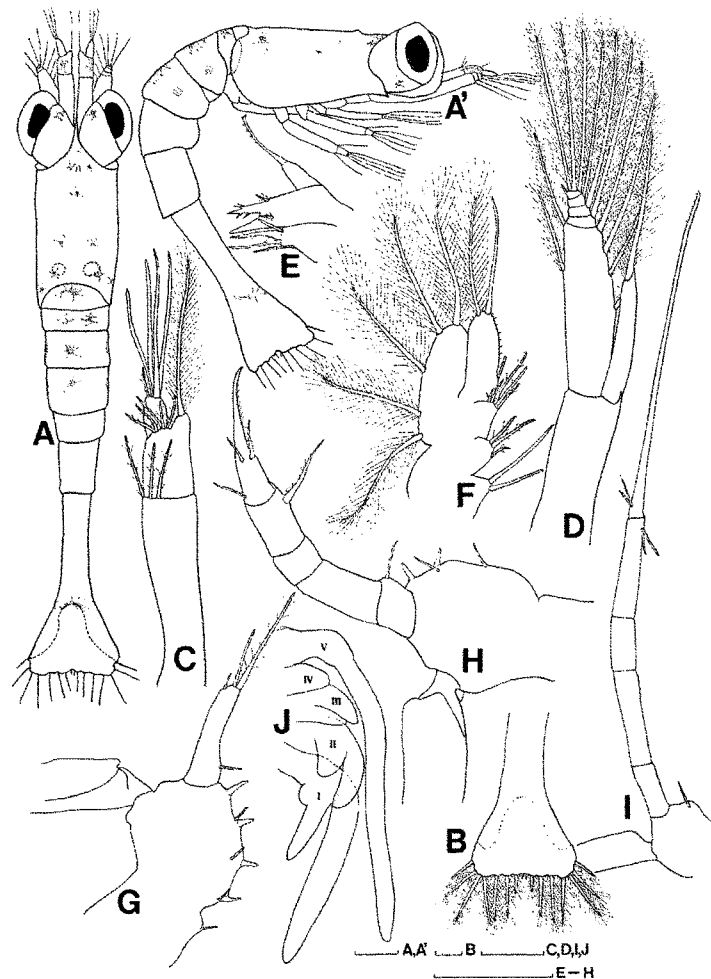


Fig. 2 Second zoea of *Alpheus lobidens* De Haan, 1850. A, Dorsal view. A', Lateral view. B, Telson. C, Antennule. D, Antenna. E, Maxillule. F, Maxilla. G, First maxilliped. H, Second maxilliped. I, Third maxilliped. J, Pereiopods 1-5. Exopod shown truncated in G-I. Scale bars=0.1 mm.

Antenna (Fig. 2D). Scale 5-segmented, with 12 plumose setae and disto-lateral spine.

Maxillule (Fig. 2E). Unchanged.

Maxilla (Fig. 2F). Unchanged.

First maxilliped (Fig. 2G). Unchanged.

Second maxilliped (Fig. 2H). Endopod 5-segmented, with 1, 0, 0, 1, 3 setae.

Third maxilliped (Fig. 2I). Endopod 5-segmented, with 0, 0, 0, 2, 2 setae; dactylus long, sharply pointed, with 5 distal denticles.

Pereiopods (Fig. 2J). Unchanged.

Abdomen (Fig. 2A, A'). Unchanged.

Telson (Fig. 2B). Posterior margin with 8+8 setae; outermost pair plumose only on inner side; uropods visible.

Third zoea (Fig. 3)

Duration. 2-5 d.

TL 2.91 (2.90-2.94) mm; CL 0.70 (0.66-0.72) mm.

Carapace (Fig. 3A, A'). Unchanged.

Antennule (Fig. 3C). Peduncle 2-segmented, with 6 and 7 setae.

Antenna (Fig. 3D). Endopod with slender seta and spine; scale 3-segmented, with 13 plumose setae and disto-lateral spine.

Maxillule (Fig. 3E). Coxal endite with 6 setae.

Maxilla (Fig. 3F). Coxal endite with 3 setae; basal endite with 4 and 5 setae; scaphognathite with 7 marginal plumose setae.

First maxilliped (Fig. 3G). Unchanged.

Second maxilliped (Fig. 3H). Unchanged.

Third maxilliped (Fig. 3I). Dactylus of endopod much shorter.

Pereiopod 1 (Fig. 3J). Endopod rudimentary; exopod with 6 natatory setae.

Pereiopods 2-4 (Fig. 3K). Rudimentary; pereiopods 2-

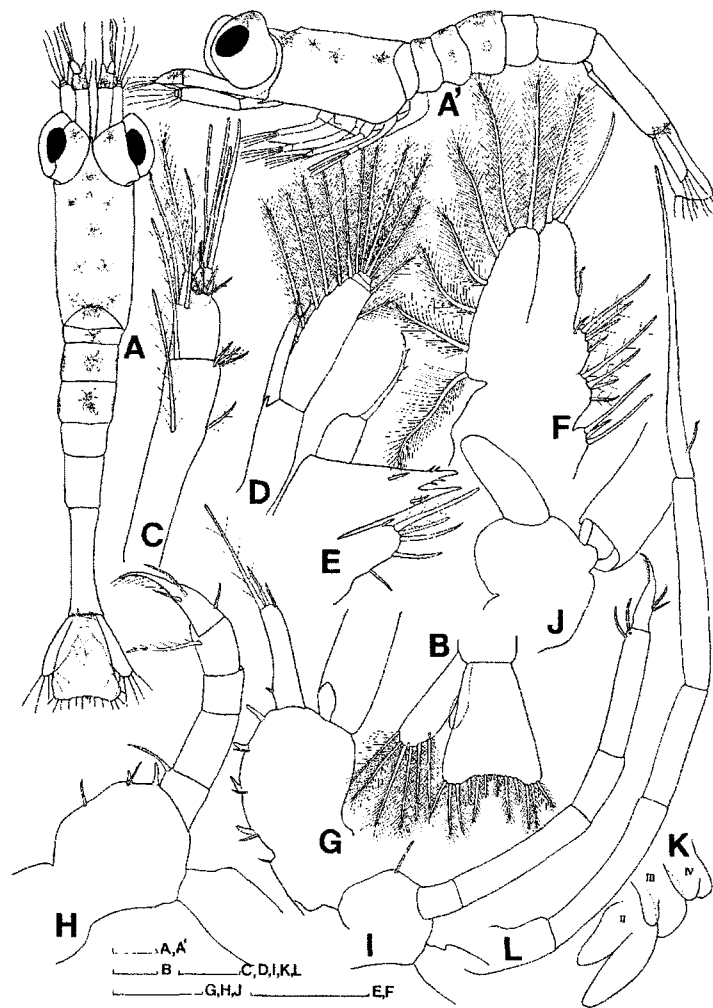


Fig. 3. Third zoea of *Alpheus lobidens* De Haan, 1850. A, Dorsal view. A', Lateral view. B, Telson and uropod. C, Antennule. D, Antenna. E, Maxillule. F, Maxilla. G, First maxilliped. H, Second maxilliped. I, Third maxilliped. J, Pereiopod 1. K, Pereiopods 2-4. L, Pereiopod 5. Exopod shown truncated in G-J. Scale bars=0.1 mm.

3 unchanged; pereiopod 4 biramous as bud.  
 Pereiopod 5 (Fig. 3L). Endopod 5-segmented, with 0, 0, 0, 0, 1 seta; dactylus elongated, sharply pointed, with 5 distal denticles.  
 Abdomen (Fig. 3A, A'). Composed of 6 somites.  
 Telson and uropod (Fig. 3B). Telson with 7+7 posterior setae. Uropod free: endopod rudimentary; exopod with 6 marginal and 2 submarginal plumose setae.

Fourth zoea (Fig. 4)

TL, 3.00 (2.98-3.06) mm; CL, 0.72 (0.68-0.74) mm.  
 Carapace (Fig. 4A). Unchanged.  
 Antennule (Fig. 4C). Peduncle 2-segmented, with 6 and 10 plumose setae.  
 Antenna (Fig. 4D). Scale with 15 plumose setae and disto-lateral spine.  
 Maxillule (Fig. 4E). Unchanged.  
 Maxilla (Fig. 4F). Basal endite with 5 setae each.  
 First maxilliped (Fig. 4G). Basis with 4 spiniform setae and 4 setae.

Second maxilliped (Fig. 4H). Unchanged.  
 Third maxilliped (Fig. 4I). Coxa with simple seta.  
 Pereiopod 1 (Fig. 4J). Unchanged.  
 Pereiopod 2 (Fig. 4K). Endopod rudimentary; exopod with 6 natatory setae.  
 Pereiopods 3-5 (Fig. 4L). Unchanged.  
 Abdomen (Fig. 4A). Unchanged.  
 Telson and uropod (Fig. 4B). Telson narrower; lateral sides parallel, with 6+6 marginal setae. Uropod developed: endopod with 12 plumose setae; exopod with 11 marginal plumose setae, 2 submarginal plumose setae, and distal spine.

*Alpheus sudara* Banner and Banner, 1966 (Figs. 5-7)  
 First zoea (Fig. 5)

Duration. 18-20 h.  
 TL, 2.01 (1.86-2.24) mm; CL, 0.47 (0.44-0.50) mm.  
 Carapace (Fig. 5A). Rostrum absent; anterior dorso-median papilla present; pterygostomian spine present; supraorbital and antennal spines absent; antero-ventral

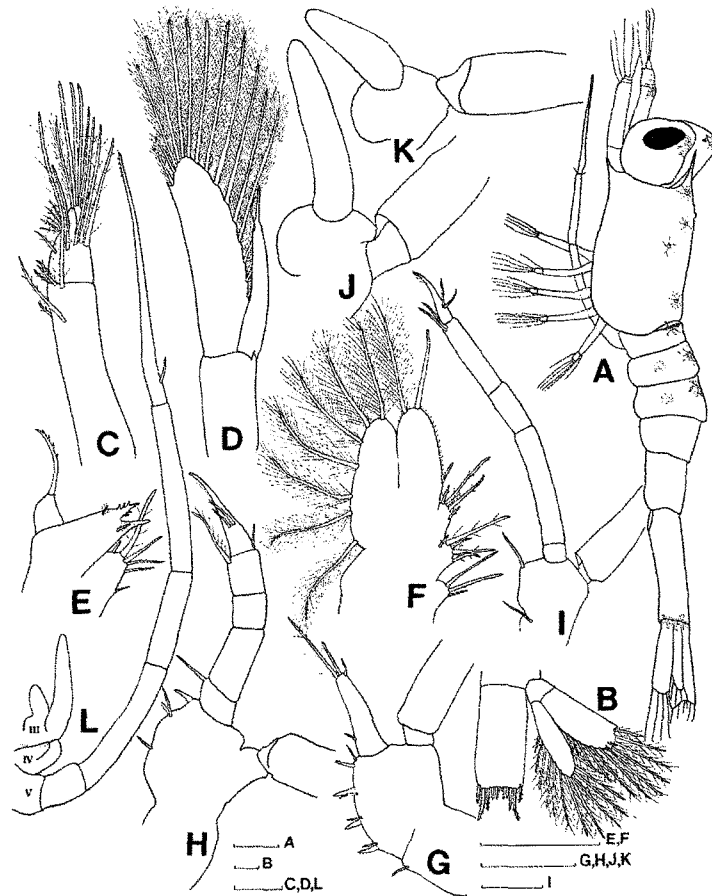
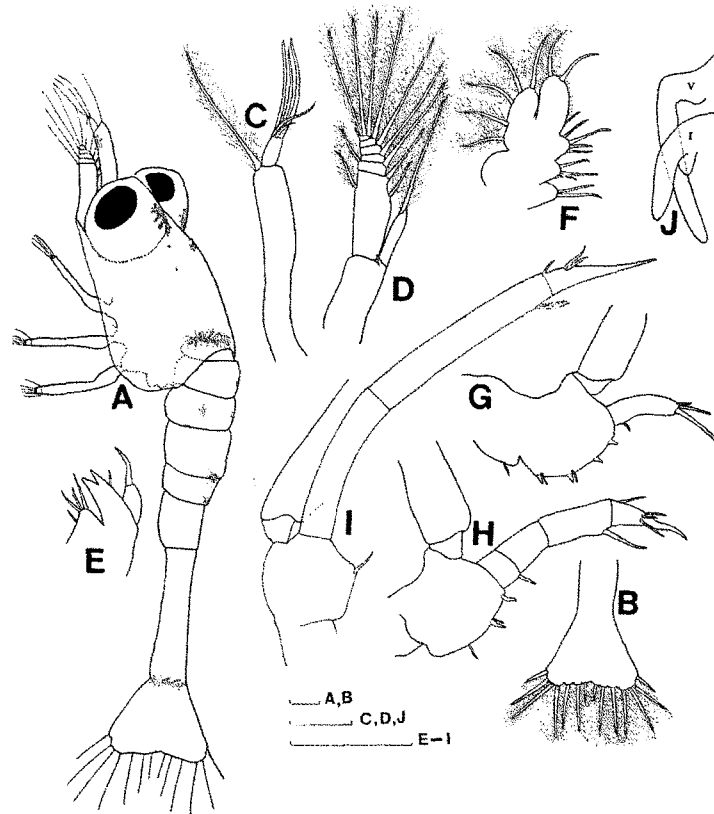


Fig. 4. Fourth zoea of *Alpheus lobidens* De Haan, 1850. A, Lateral view. B, Telson and uropod. C, Antennule. D, Antenna. E, Maxillule. F, Maxilla. G, First maxilliped. H, Second maxilliped. I, Third maxilliped. J, Pereiopod 1. K, Pereiopod 2. L, Pereiopods 3-5. Exopod shown truncated in G-K. Scale bars=0.1 mm.



**Fig. 5.** First zoea of *Alpheus sudara* Banner and Banner, 1966. A, Lateral view. B, Telson. C, Antennule. D, Antenna. E, Maxillule. F, Maxilla. G, First maxilliped. H, Second maxilliped. I, Third maxilliped. J, Pereiopods 1 and 5. Exopod shown truncated in G-I. Scale bars=0.1 mm.

denticles absent; eyes sessile.

Antennule (Fig. 5C). Peduncle unsegmented; inner flagellum with long plumose seta; outer flagellum with 3 aesthetascs, short plumose seta, and simple seta.

Antenna (Fig. 5D). Peduncle with spine; endopod reaching to half length of scale, with long plumose seta and small spine; scale 6-segmented, with 11 plumose setae and disto-lateral spine.

Mandibles. Rudimentary; palps absent.

Maxillule (Fig. 5E). Coxal endite with 4 setae; basal endite with 2 stout spines and seta; endopod segmented, with terminal denticulate seta.

Maxilla (Fig. 5F). Coxal endite with 2 setae; basal endite bilobed, with 3 and 4 setae; endopod with basal seta, 2 terminal setae, and fine marginal hairs; scaphognathite with 5 marginal plumose setae.

First maxilliped (Fig. 5A, G). Coxa with seta; basis with 4 spiniform setae and 2 setae; endopod segmented, with basal seta and 3 terminal setae; exopod with 4 terminal natatory setae, symmetrically disposed in 2 pairs.

Second maxilliped (Fig. 5A, H). Coxa unarmed; basis with 2 spiniform setae and 2 setae; endopod 4-segmented, with 1, 0, 1, 4 setae; exopod with subterminal seta and 4 terminal natatory setae, symmetrically disposed

in 2 pairs.

Third maxilliped (Fig. 5A, I). Coxa unarmed; basis with simple seta; endopod 3-segmented, with 0, 2, 3 setae, slightly longer than exopod; exopod with 2 subterminal setae and 4 terminal natatory setae, symmetrically disposed in 2 pairs.

Pereiopods 1 and 5 (Fig. 5J). Rudimentary; pereiopod 1 biramous as bud; pereiopod 5 uniramous.

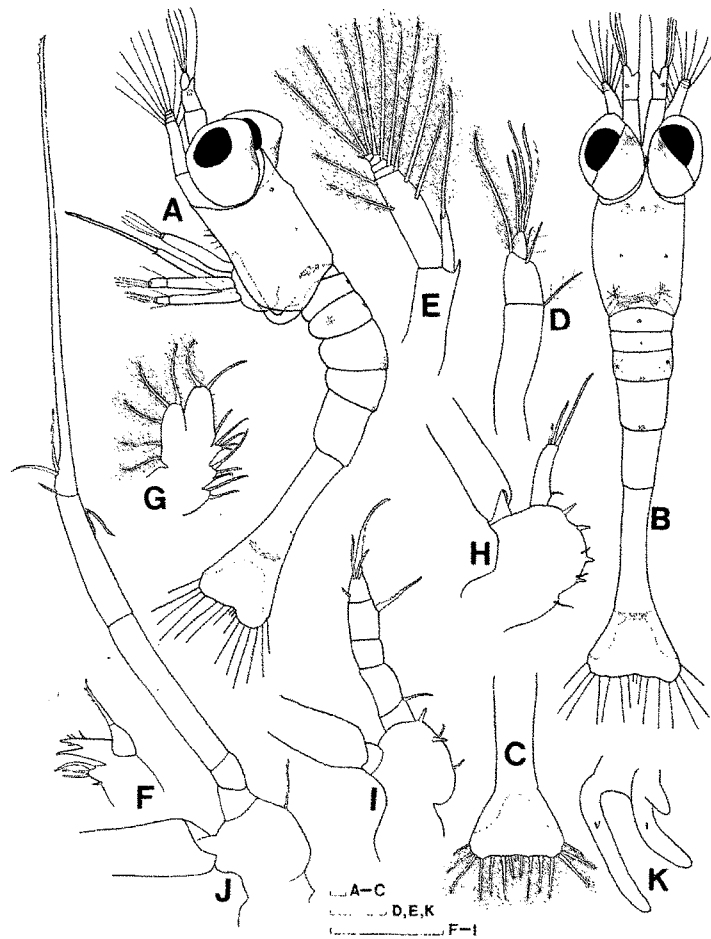
Abdomen (Fig. 5A). Composed of 5 somites; abdominal somite 6 not differentiated; all somites without spines.

Telson (Fig. 5B). Triangular, with shallow postero-median concavity; posterior margin with 7+7 setae; outermost 2 pairs plumose only on inner side; base of all setae except outermost with row of minute spinules; uropods absent.

Chromatophores. Red chromatophores present on carapace, junction of thorax and abdominal somites, dorsally on abdominal somites, and laterally on abdominal somite 2. Interspersion of yellow among red chromatophores present on peduncle of antennule, supero-lateral margin of each eye, and telson.

#### Second zoea (Fig. 6)

Duration. 1-3 d.



**Fig. 6.** Second zoea of *Alpheus sudara* Banner and Banner, 1966. A, Lateral view. B, Dorsal view. C, Telson. D, Antennule. E, Antenna. F, Maxillule. G, Maxilla. H, First maxilliped. I, Second maxilliped. J, Third maxilliped. K, Pereiopods 1 and 5. Exopod shown truncated in H-J. Scale bars=0.1 mm.

TL, 2.32 (2.28-2.40) mm; CL, 0.60 (0.56-0.62) mm.

Carapace (Fig. 6A, B). Rostrum short, untoothed, not extending beyond eyes; eyes stalked.

Antennule (Fig. 6D). Peduncle 2-segmented, each with plumose seta; outer flagellum with submarginal plumose seta, 4 aesthetascs, and simple seta.

Antenna (Fig. 6E). Scale 5-segmented, with 11 plumose setae and disto-lateral spine.

Maxillule (Fig. 6F). Unchanged.

Maxilla (Fig. 6G). Unchanged.

First maxilliped (Fig. 6H). Unchanged.

Second maxilliped (Fig. 6I). Endopod 5-segmented, with 1, 0, 0, 1, 4 setae.

Third maxilliped (Fig. 6J). Endopod 5-segmented, with 0, 0, 0, 2, 3 setae; dactylus long, sharply pointed, with 5 distal denticles.

Pereiopods (Fig. 6K). Unchanged.

Abdomen (Fig. 6A, B). Unchanged.

Telson (Fig. 6C). Posterior margin with 8+8 setae; outermost pairs plumose only on inner side; uropods

visible.

### Third zoea (Fig. 7)

TL, 2.53 (2.48-2.60) mm; CL, 0.65 (0.52-0.70) mm.

Carapace (Fig. 7A). Unchanged.

Antennule (Fig. 7C). Peduncle 2-segmented, with 6 and 8 plumose setae.

Antenna (Fig. 7D). Endopod spine-like; scale 4-segmented, with 12 plumose setae and disto-lateral spine.

Mandibles (Fig. 7E). Incisor and molar processes developed; left mandible with lacinia mobilis between incisor and molar processes; right mandible with acute spine in corresponding site.

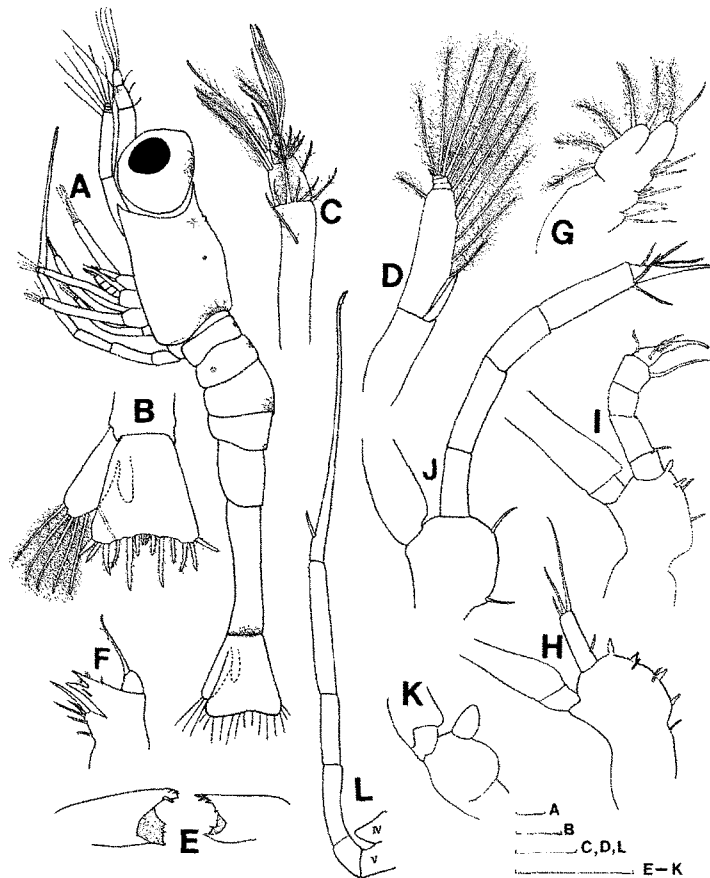
Maxillule (Fig. 7F). Coxal endite with 5 setae; basal endite with 2 stout spines and 2 setae.

Maxilla (Fig. 7G). Unchanged.

First maxilliped (Fig. 7H). Unchanged.

Second maxilliped (Fig. 7I). Unchanged.

Third maxilliped (Fig. 7J). Basis with 2 simple setae;



**Fig. 7.** Third zoea of *Alpheus sudara* Banner and Banner, 1966. A, Lateral view. B, Telson and uropod. C, Antennule. D, Antenna. E, Maridibles. F, Maxillule. G, Maxilla. H, First maxilliped. I, Second maxilliped. J, Third maxilliped. K, Pereiopod 1. L, Pereiopods 4-5. Exopod shown truncated in H-K. Scale bars=0.1 mm.

endopod 5-segmented, with 0, 0, 0, 2, 3 setae; dactylus much shorter.

Pereiopod 1 (Fig. 7K). Endopod rudimentary; exopod with 6 natatory setae.

Pereiopods 4-5 (Fig. 7L). Pereiopod 4 uniramous. Pereiopod 5 developed; endopod 5-segmented, with 0, 0, 0, 0, 1 seta; dactylus elongated, sharply pointed, with 3 distal denticles.

Abdomen (Fig. 7A). Composed of 6 somites.

Telson and uropod (Fig. 7B). Telson with 7+7 posterior setae. Uropod free: endopod rudimentary; exopod with 6 marginal plumose setae.

*Key to the known first alpheid zoeas from Korean coast*

Williamson (1967) first provided a key for identifying alpheid larvae in plankton material from European waters. Subsequently, Packer (1985) constructed an identification key to the known larvae of four alpheid species from New Zealand. More recently, Alborno and Wehrmann (1997) constructed an identification key to the known second zoea of *Betaeus* and *Synalpheus* from Chilean

waters. Since Yang and Kim's (1998) work on a key to the alpheid larvae from Korean waters, several further studies on larval descriptions have been reported (Yang, 1999, 2003; Yang and Kim, 1999, 2002). It is necessary to revise a key to the alpheid larvae from Korean waters. The following key is modified from the one offered by Yang (2003), and provides an aid in identifying plankton-collected material of nine alpheid first zoeas off the Korean coast.

**Discussion**

Larvae of the family Alpheidae are characterized by carapace usually with anterior dorso-median papilla, without antero-ventral or postero-ventral denticles; all abdominal somites without spines in first zoea; exopod of antenna distally segmented in first zoea; base of maxillule without outer seta and outer lobule, endopod of maxillule segmented; maxilla usually with 3 endites; endopod of first maxilliped never 4-segmented, short, not more than half length of exopod; exopods of maxillipeds with 4 distal natatory setae, symmetrically disposed in 2



**Table 1.** Key to the first alpheid zoeas from Korean coast

1.	Endopod of maxillule with 2 terminal setae; proximal segment of endopod of second maxilliped without seta; endopod of antenna spine-like	2
–	Endopod of maxillule with terminal seta; proximal segment of endopod of second maxilliped with seta; endopod of antenna rod-like, with long plumose seta and spine	3
2.	Endopod of antenna 45.0% length of exopod; coxal endite of maxillule with 4 setae	<i>Athanas parvus</i>
–	Endopod of antenna 32.0% length of exopod; coxal endite of maxillule with 2 setae	<i>Athanas japonicus</i>
3.	Scale of antenna 5-segmented	4
–	Scale of antenna 6-segmented	5
4.	Endopod of antenna 55.1% length of exopod; coxal endite of maxillule with 4 setae; basal endite of maxilla with 3 setae on proximal lobe	<i>Alpheus euphrosyne richardsoni</i>
–	Endopod of antenna 47.0% length of exopod; coxal endite of maxillule with 3 setae; basal endite of maxilla with 2 setae on proximal lobe	<i>Alpheus japonicus</i>
5.	Coxal endite of maxillule with 4 setae; basal endite of maxilla with 4 or 5 setae on distal lobe	6
–	Coxal endite of maxillule with 5 setae; basal endite of maxilla with 3 setae on distal lobe	<i>Alpheus digitalis</i>
6.	Basal endite of maxilla with 4 setae on distal lobe; endopod of antenna less than 45.0% length of exopod	7
–	Basal endite of maxilla with 5 setae on distal lobe; endopod of antenna more than 45.0% length of exopod	8
7.	Endopod of antenna 43.5% length of exopod	<i>Alpheus sudara</i>
–	Endopod of antenna 44.8% length of exopod	<i>Alpheus brevicristatus</i>
8.	Endopod of antenna 50.0% length of exopod; basal endite of maxilla with 2 setae on distal lobe	<i>Alpheus heeia</i>
–	Endopod of antenna 65.3% length of exopod; basal endite of maxilla with 3 setae on distal lobe	<i>Alpheus lobidens</i>

pairs; dactylus of pereopod 5 styliform, extending beyond eyes from third zoea onward (Yang, 2003). The zoea of *Alpheus lobidens* and *A. sudara* readily fits into this definition. Moreover, it agrees well with the diagnosis of the larvae of *Alpheus* provided by Yang and Kim (2002).

Information on alpheid larvae from Korean waters is limited to nine species represented by two genera *Alpheus* and *Athanas*: *Al. euphrosyne richardsoni* (see Yang and Kim, 1996), *Al. brevicristatus* De Haan, 1840 (see Yang and Kim, 1998), *Al. heeia* (see Yang and Kim, 1999), *Al. digitalis* De Haan, 1850 and *Al. japonicus* Miers, 1879 (see Yang and Kim, 2002), *Al. lobidens* and *Al. sudara* (present study), *Al. japonicus* (see Yang, 2003), and *Al. parvus* (see Yang, 1999). The first zoea of *A. lobidens* and *A. sudara* is distinguished from that of other five congeners of *Alpheus* by the number of distal segments of the scale of the antenna and the relative length of the endopod to the scale of the antenna, as well as minor differences in the maxillule and maxilla. The seven species of *Alpheus* in the first zoea can be easily separated from the two species of *Athanas* (*A. japonicus* and *A. parvus*) by the setation of the endopod of the antenna and maxillule, and the proximal segment of the endopod of the second maxilliped as pointed out by Yang (2003).

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