

## **Complete Larval Development of *Gaillardiiellus orientalis* (Odhner, 1925) (Crustacea: Decapoda: Xanthidae) Reared in the Laboratory**

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### **ABSTRACT**

*Gaillardiiellus orientalis* (Odhner, 1925) has been reared in the laboratory, from hatching to the first young crab stage at 25°C. The four zoeal stages and one megalopal stage are described and illustrated in detail. Within the subfamily Actaeinae, the zoea of *G. orientalis* differs from the other known zoeae in the characteristics of the antenna and the telson.

Key words: Xanthidae, Actaeinae, *Gaillardiiellus orientalis*, Zoea, Complete larval development

### **INTRODUCTION**

The family Xanthidae MacLeay, 1838 is currently composed of ten subfamilies: Polydectinae, Cymoinae, Trichiinae, Liomerinae, Euxanthinae, Actaeinae, Zosiminae, Xanthinae, Etisinae, Chlorodiinae (see Serène, 1984). Among these, the subfamily Actaeinae contains 14 Indo-Pacific genera and 40 species (Guinot, 1976; Serène, 1984). *Actaea semblatae* Guinot, 1976 and *Gaillardiiellus orientalis* (Odhner, 1925) of the subfamily Actaeinae, are reported in Korea.

The larval stages of four species have been reported in the subfamily Actaeinae. The first and second zoeal stages of *A. semblatae* (as *A. saignyi*), *Novactaea pulchella* (A. Milne Edwards, 1865) and *N. bella* Guinot, 1976 were described (Terada, 1987, 1990; Lim and Ng, 1997). The larvae of *G. orientalis* (as *Paractaea rueppellii orientalis*) were described by Fukuda (1978). However, this report was only a very brief comment lacking figures and has no value for comparative studies. Ng and Clark (1994) described only the first zoeal stage of it in detail, but, the complete larval development of *G. orientalis* is unknown. Therefore the aim of this paper is to

describe the complete larval development of *G. orientalis* and compare it with previously described zoeae of other Actaeinae.

## MATERIALS AND METHODS

Ovigerous crabs of *Gaillardiiellus orientalis* (Odhner, 1925) were collected by SCUBA diving from Yokchido in Tongnong, Kyungsangnam-Do, Korea in August 1997. The larvae hatched in the laboratory were reared using the methods described by Ko (1995) under the constant water temperature of 25°C. The larvae were fixed and preserved in 10% neutral formalin for later use. Dissected appendages were examined using a Leitz microscope and drawings were done with the aid of camera lucida. Setal counts on appendages and measurements were based on the mean of 10 specimens for each zoeal stage.

## RESULTS

The first zoeal stage is described and illustrated completely. For the second zoeal stage only the main differences from the first zoea are described in detail.

### First Zoea (Figs. 1, 2)

Size. Carapace length  $0.59 \pm 0.06$  mm. Distance from tip of dorsal spine to tip of rostral spine  $2.67 \pm 0.06$  mm.

Carapace (Fig. 1A, B). Dorsal spine long, slightly curved terminally and longer than rostral spine; rostral spine about equal in length to antenna; lateral spine present, spinulate and curving ventrally; 1 pair of posterodorsal setae; each ventral margin without setae; eyes sessile.

Antennule (Fig. 1C). Uniramous, endopod absent; exopod unsegmented with 2 long and 2 short terminal aesthetascs plus 1 long and 1 minute terminal setae.

Antenna (Fig. 1D, E). Protopod not spinulate, about equal in length to rostral spine with rounded tip; endopod absent; exopod segmented, about 14% length to protopod, with 1 long and 2 short setae terminally.

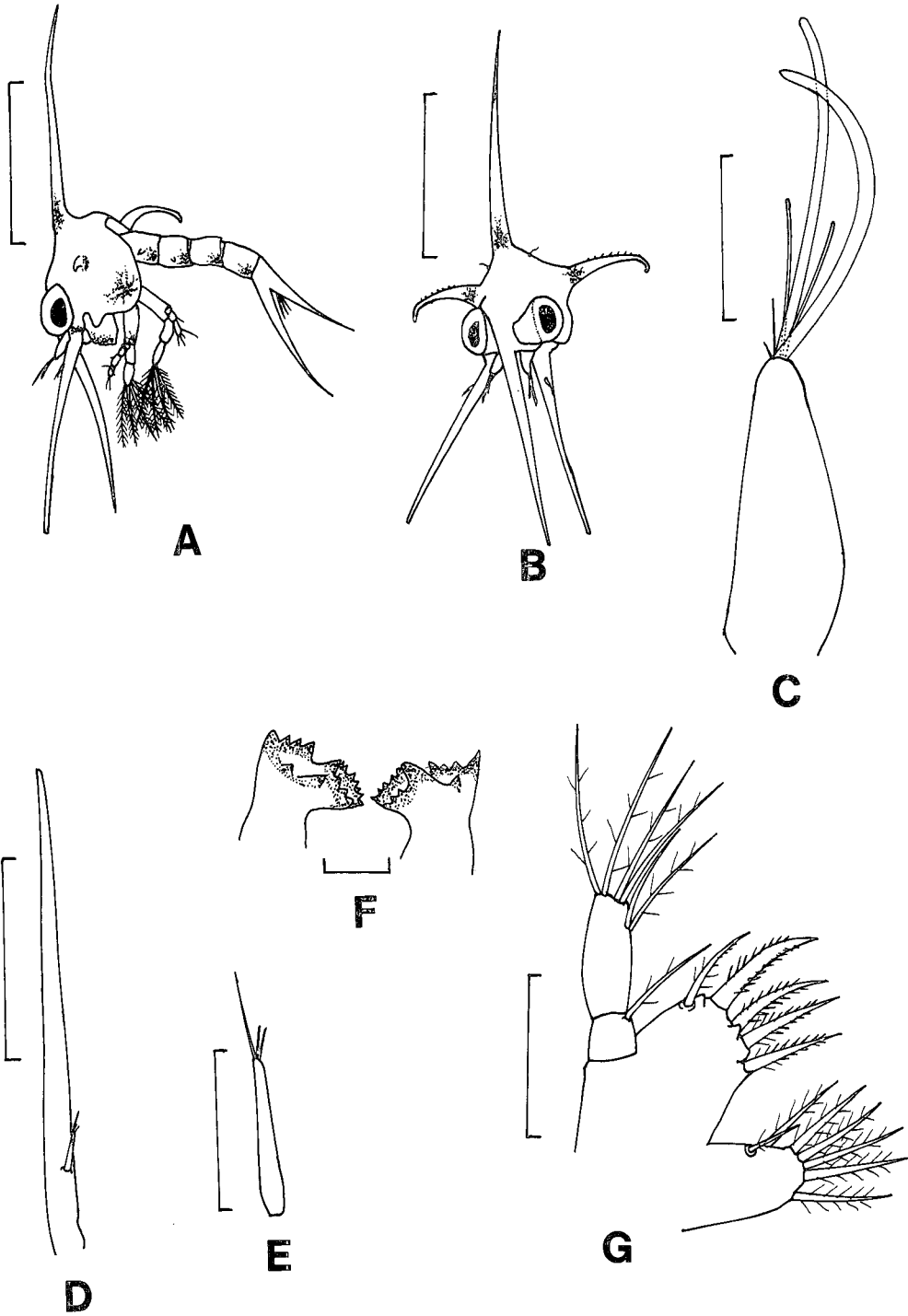
Mandible (Fig. 1F). Asymmetrical; right molar and left molar processes with 2 and 1 teeth, confluent with incisor process, respectively; endopod absent.

Maxillule (Fig. 1G). Coxal endite with 7 setae; basal endite with 5 setae plus 2 teeth; endopod 2-segmented, proximal segment with 1 seta, distal segment with 4 terminal plus 2 subterminal setae.

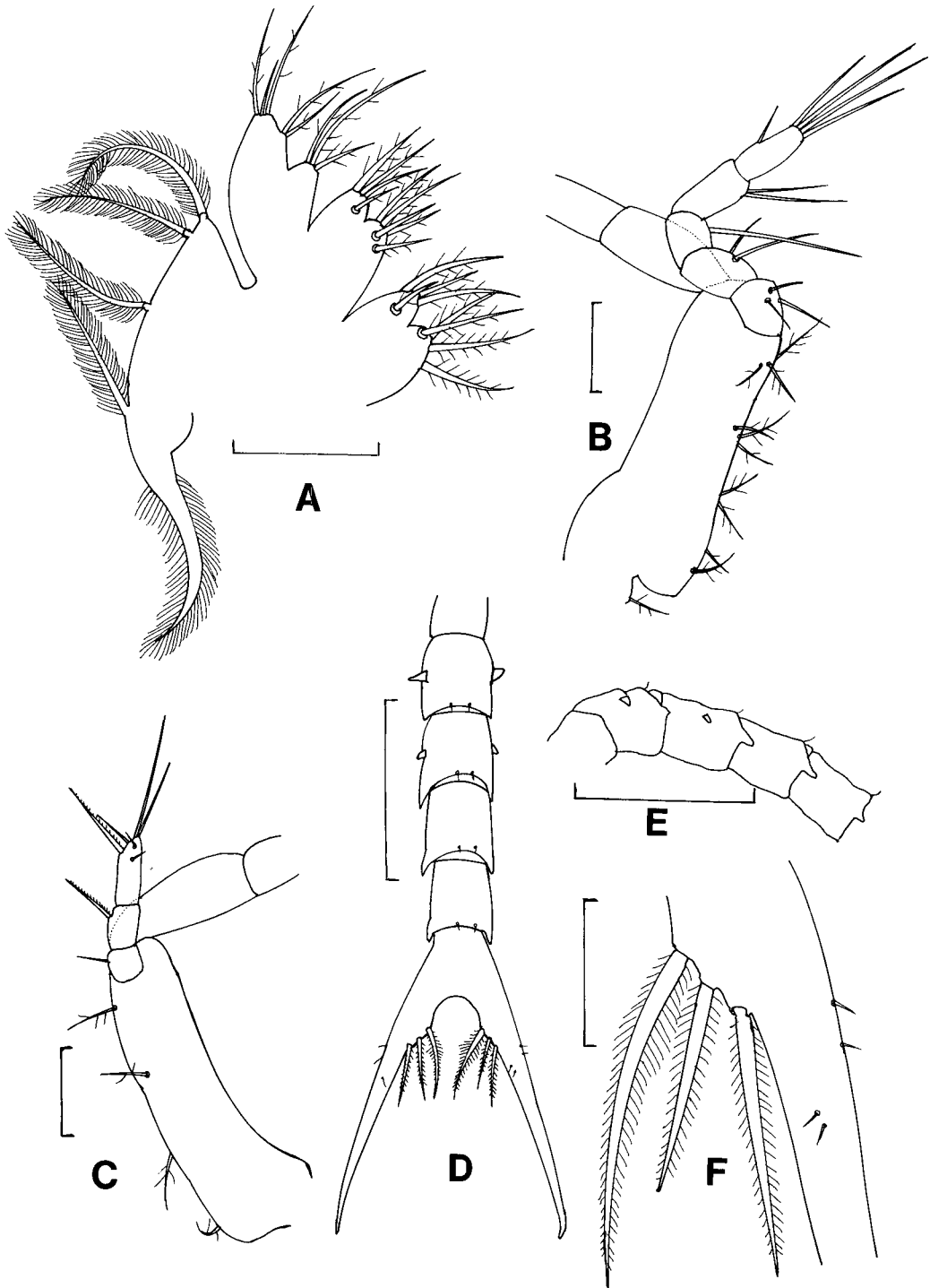
Maxilla (Fig. 2A). Coxal endite bilobed with 4+4 setae; basal endite bilobed with 5+4 setae; endopod not bilobed with 3+2 subterminal, 3 terminal setae; exopod (scaphognathite) margin with 4 plumose setae plus 1 distal stout process.

First maxilliped (Fig. 2B). Coxa with 1 seta; basis with 10 setae arranged as 2, 2, 3, 3; endopod 5-segmented with 2, 2, 1, 2, 5 (1 subterminal+4 terminal) setae, respectively; exopod 2-segmented, distal segment with 4 terminal natatory setae.

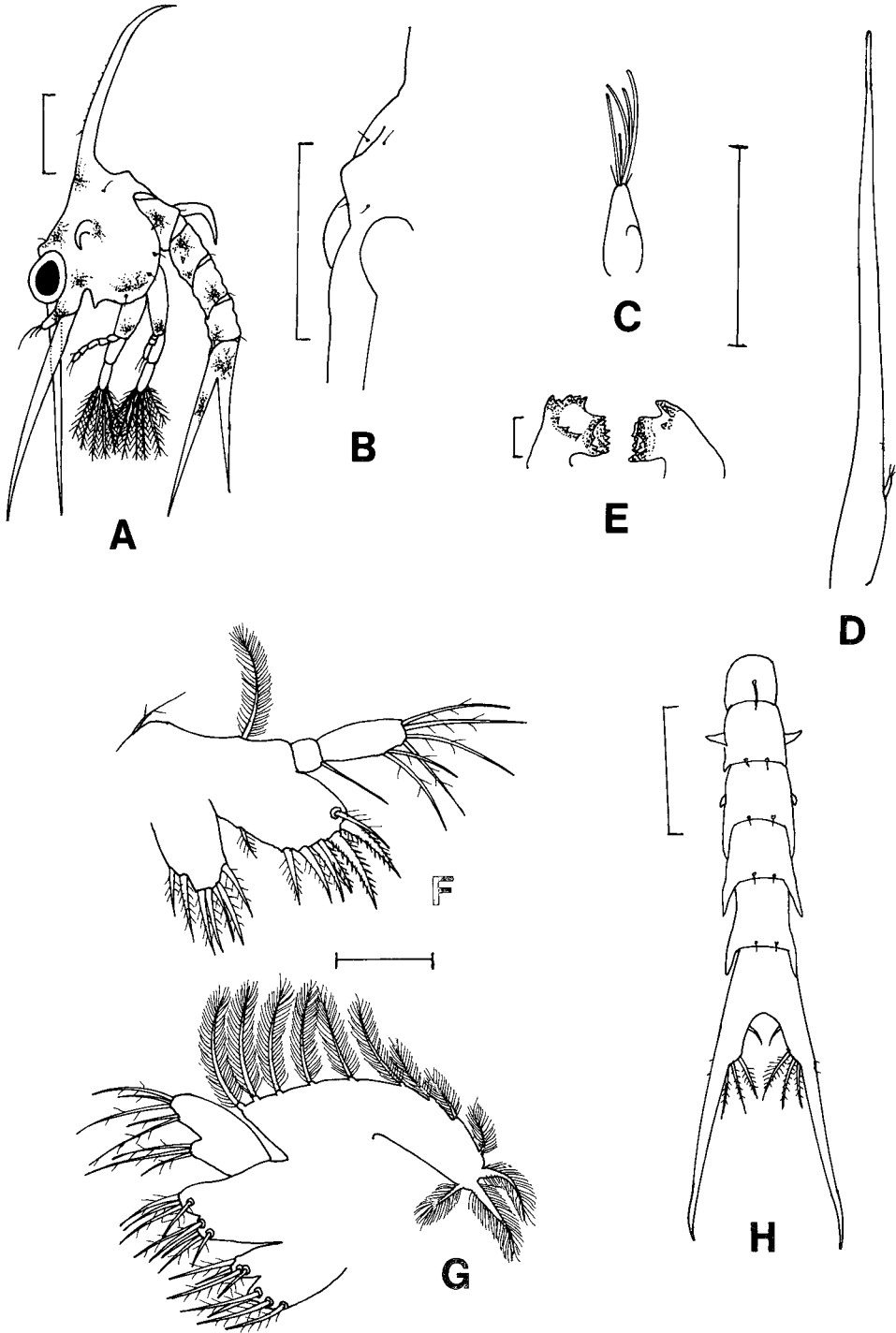
Second maxilliped (Fig. 2C). Coxa without seta; basis with 3 setae; endopod 3-segmented, with 1, 1, 6 (4 subterminal+2 terminal) setae, respectively; exopod 2-segmented, distal segment with 4



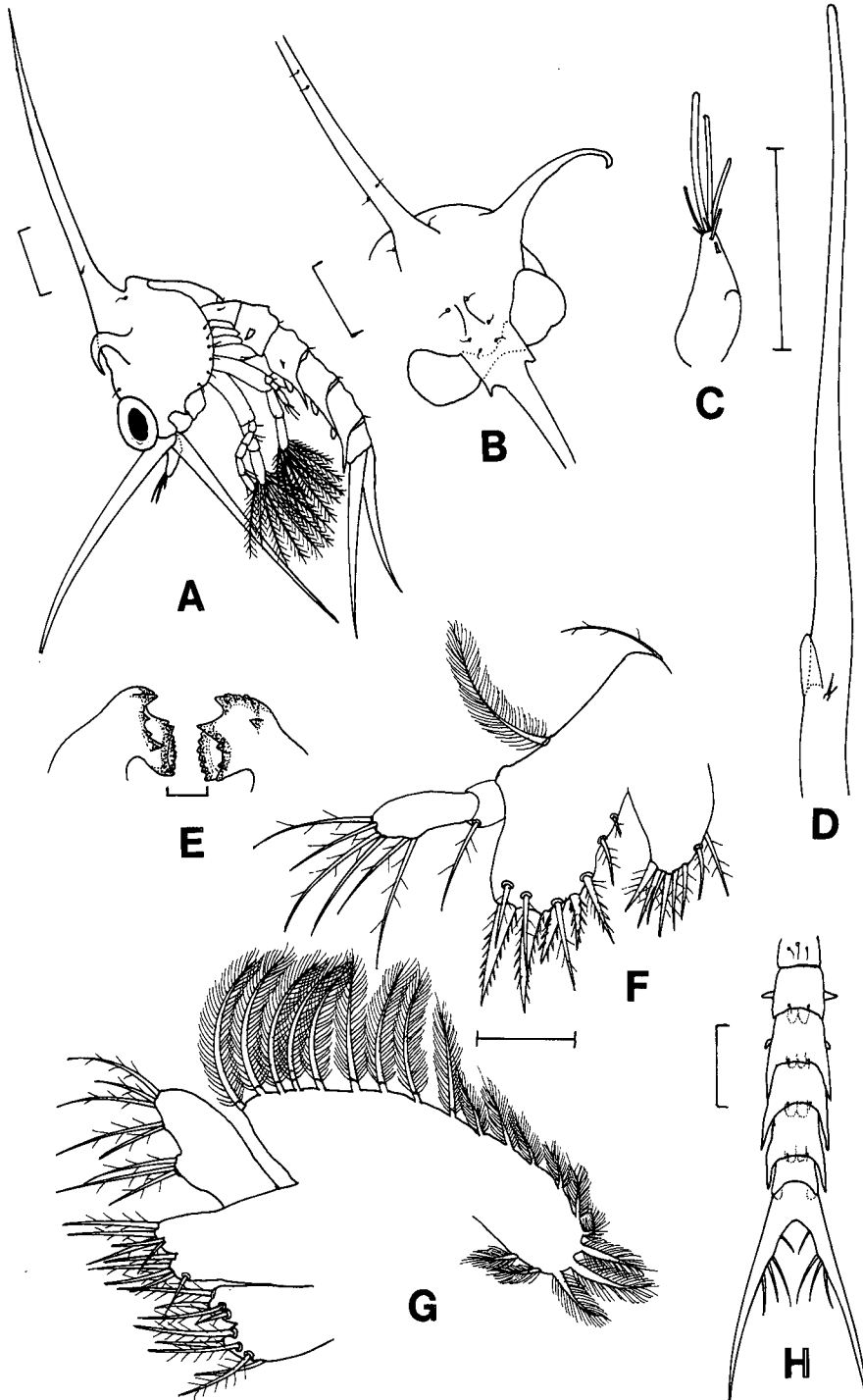
**Fig. 1.** *Gaillardiiellus orientalis* (Odhner, 1925), first zoeal stage. A, lateral view; B, carapace; C, antennule; D, antenna; E, exopod of antenna; F, mandible; G, maxillule. Scale bars: A, B = 1 mm; C, E-G = 0.1 mm; D = 0.5 mm.



**Fig. 2.** *Gaillardiiellus orientalis* (Odhner, 1925), first zoeal stage. A, maxilla; B, first maxilliped; C, second maxilliped; D, dorsal view of abdomen and telson; E, lateral view of abdomen; F, fork of telson. Scale bars: A-C, F = 0.1 mm; D, E = 0.5 mm.



**Fig. 3.** *Gaillardiiellus orientalis* (Odhner, 1925), second zoeal stage. A, lateral view; B, anterodorsal view of carapace; C, antennule; D, antenna; E, mandible; F, maxillule; G, maxilla; H, dorsal view of abdomen and telson. Scale bars: A-D, H = 0.5 mm; E-G = 0.1 mm.



**Fig. 4.** *Gaillardiiellus orientalis* (Odhner, 1925), third zoeal stage. A, lateral view; B, anterodorsal view of carapace; C, antennule; D, antenna; E, mandible; F, maxillule; G, maxilla; H, dorsal view of abdomen and telson. Scale bars: A-D, H = 0.5 mm; E-G = 0.1 mm.

terminal natatory setae.

Third maxilliped. Absent.

Pereopods. Absent.

Abdomen (Fig. 2D, E). 5 somites; somite 2 with 1 pair of lateral processes directed laterally; somite 3 with 1 pair of lateral processes directed posteriorly; somites 3-5 with short posterolateral processes; somites 2-5 with 1 pair of posterodorsal setae; pleopod buds absent.

Telson (Fig. 2D, F). Each fork long, not spinulate, with 2 lateral minute setae and 1 or 2 dorsal medial minute setae, posterior margin with 3 pairs of stout spinulate setae.

Second Zoea (Fig. 3)

Size. Carapace length  $0.63 \pm 0.06$  mm. Distance from tip of dorsal spine to tip of rostral spine  $2.94 \pm 0.08$  mm.

Carapace (Fig. 3A, B). With 2 pairs of anterodorsal setae; each ventral margin with 3 setae; eyes stalked.

Antennule (Fig. 3C). Endopod developing; exopod with 5 aesthetascs and 2 setae.

Antenna (Fig. 3D). Protopod long.

Mandible (Fig. 3E). Right and left molar processes with 3 and 1 teeth, confluent with incisor process, respectively.

Maxillule (Fig. 3F). Basal endite with 8 setae; exopod seta present.

Maxilla (Fig. 3G). Exopod (Scaphognathite) margin with 12 setae.

First maxilliped (Fig. 3A). Exopod distal segment with 6 natatory setae.

Second maxilliped (Fig. 3A). Exopod distal segment with 7 natatory setae.

Abdomen and telson (Fig. 3H). Abdominal somite 1 with 1 dorsal seta; posterior margin of telson with 4 pairs of setae.

Third Zoea (Fig. 4)

Size. Carapace length  $0.83 \pm 0.05$  mm. Distance from tip of dorsal spine to tip of rostral spine  $3.84 \pm 0.32$  mm.

Carapace (Fig. 4A, B). With 3 pairs of anterodorsal setae plus additional 1 pair of setae at base of dorsal spine; each ventral margin with 6 setae.

Antennule (Fig. 4C). Exopod with 4 terminal and 2 subterminal aesthetascs plus 2 setae.

Antenna (Fig. 4D). Endopod developing.

Mandible (Fig. 4E). Unchanged.

Maxillule (Fig. 4F). Coxal endite with 8 setae; basal endite with 10 setae.

Maxilla (Fig. 4G). Coxal endite with 5+4 setae; basal endite with 5+5 setae; exopod (Scaphognathite) margin with 20 setae.

First maxilliped (Fig. 4A). Exopod distal segment with 8 natatory setae.

Second maxilliped (Fig. 4A). Exopod distal segment with 9 natatory setae.

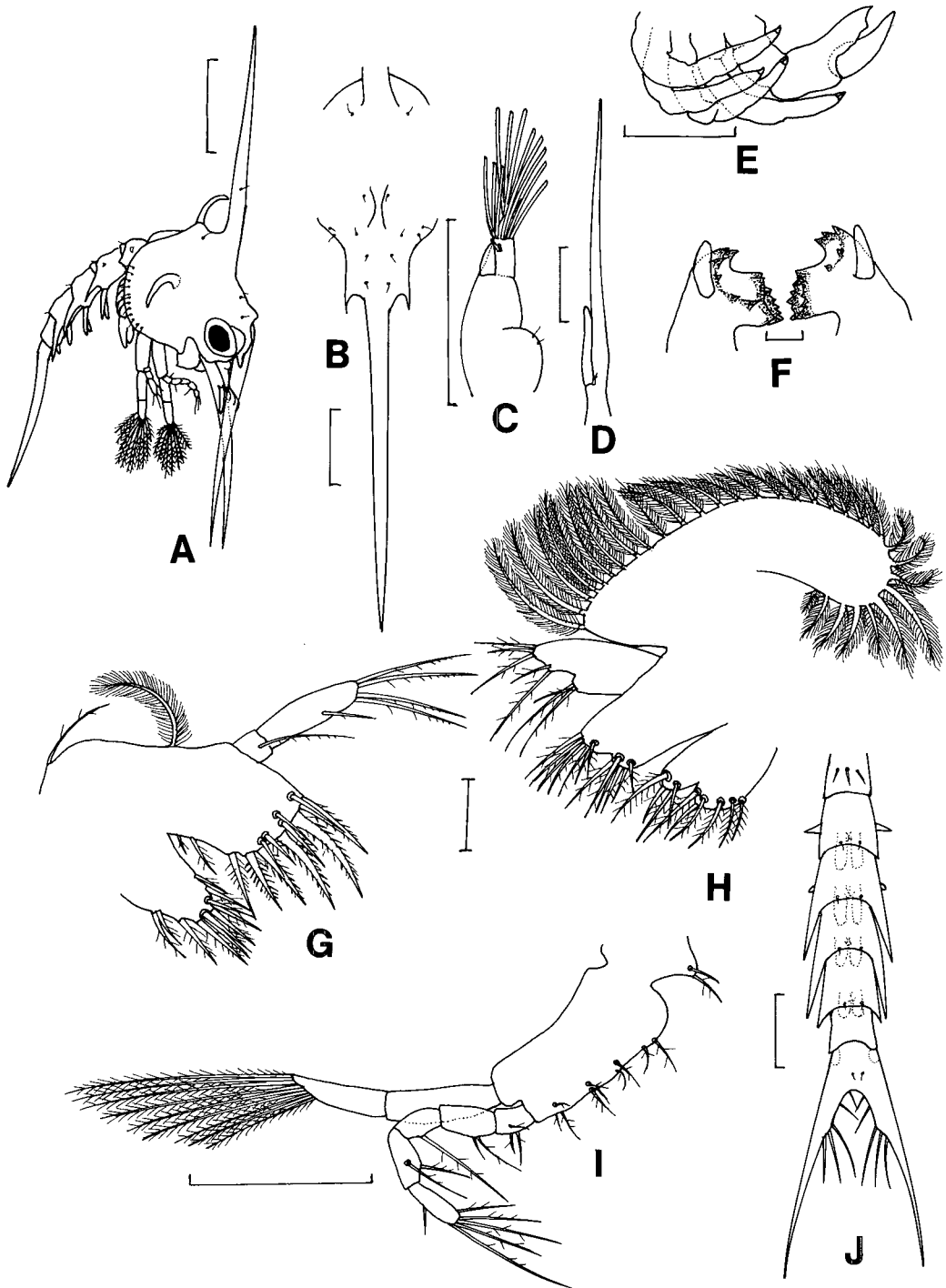
Abdomen (Fig. 4H). With 6 somites; somite 1 with 3 dorsal setae; pleopod buds present.

Fourth Zoea (Fig. 5)

Size. Carapace length  $1.24 \pm 0.06$  mm. Distance from tip of dorsal spine to tip of rostral spine  $5.11 \pm 0.09$  mm.

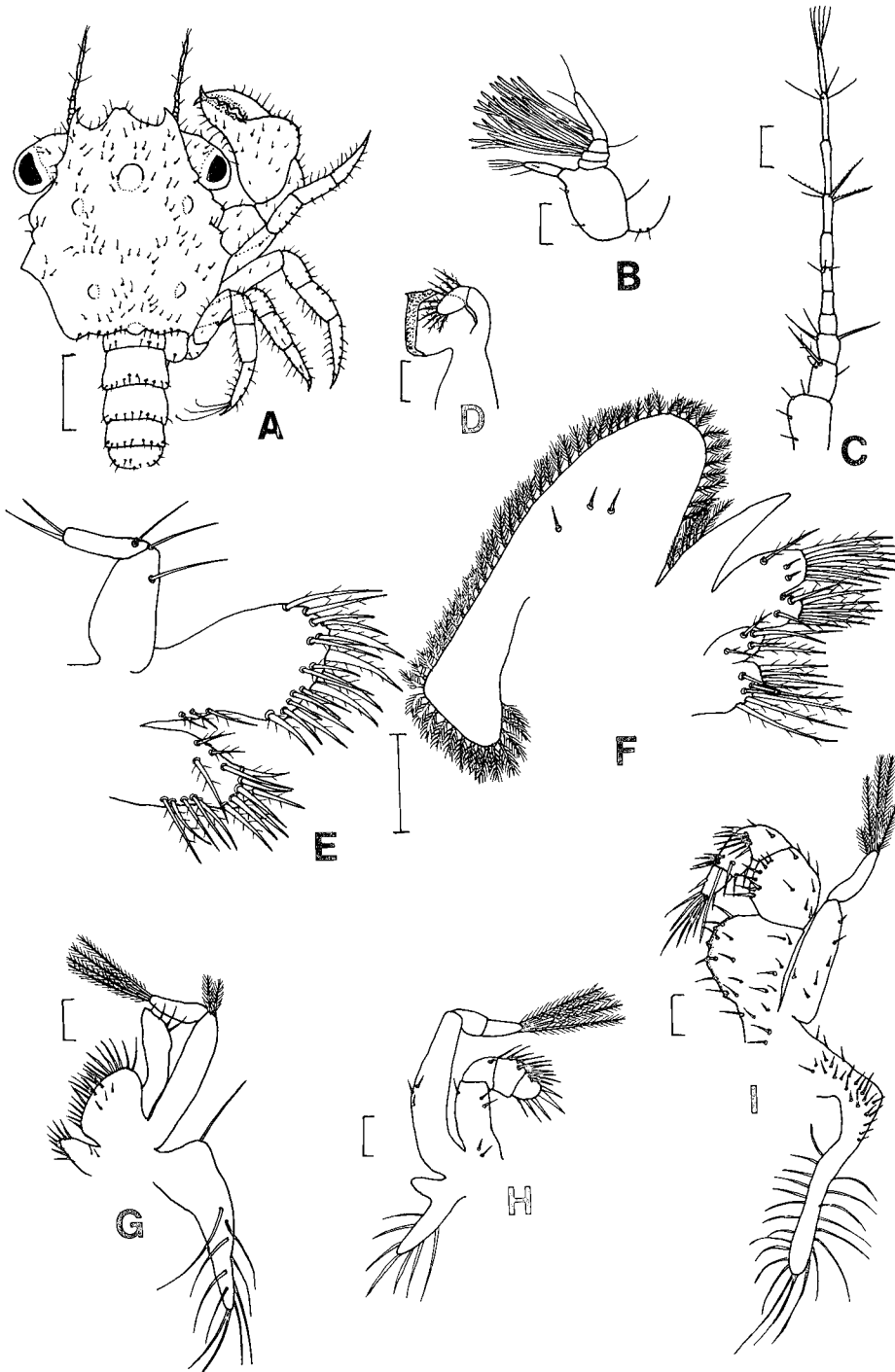
Carapace (Fig. 5A, B). With 6 pairs of anterodorsal setae; each ventral margin with 12 setae.

Antennule (Fig. 5C). Exopod with total of 12 aesthetascs plus 2 setae.

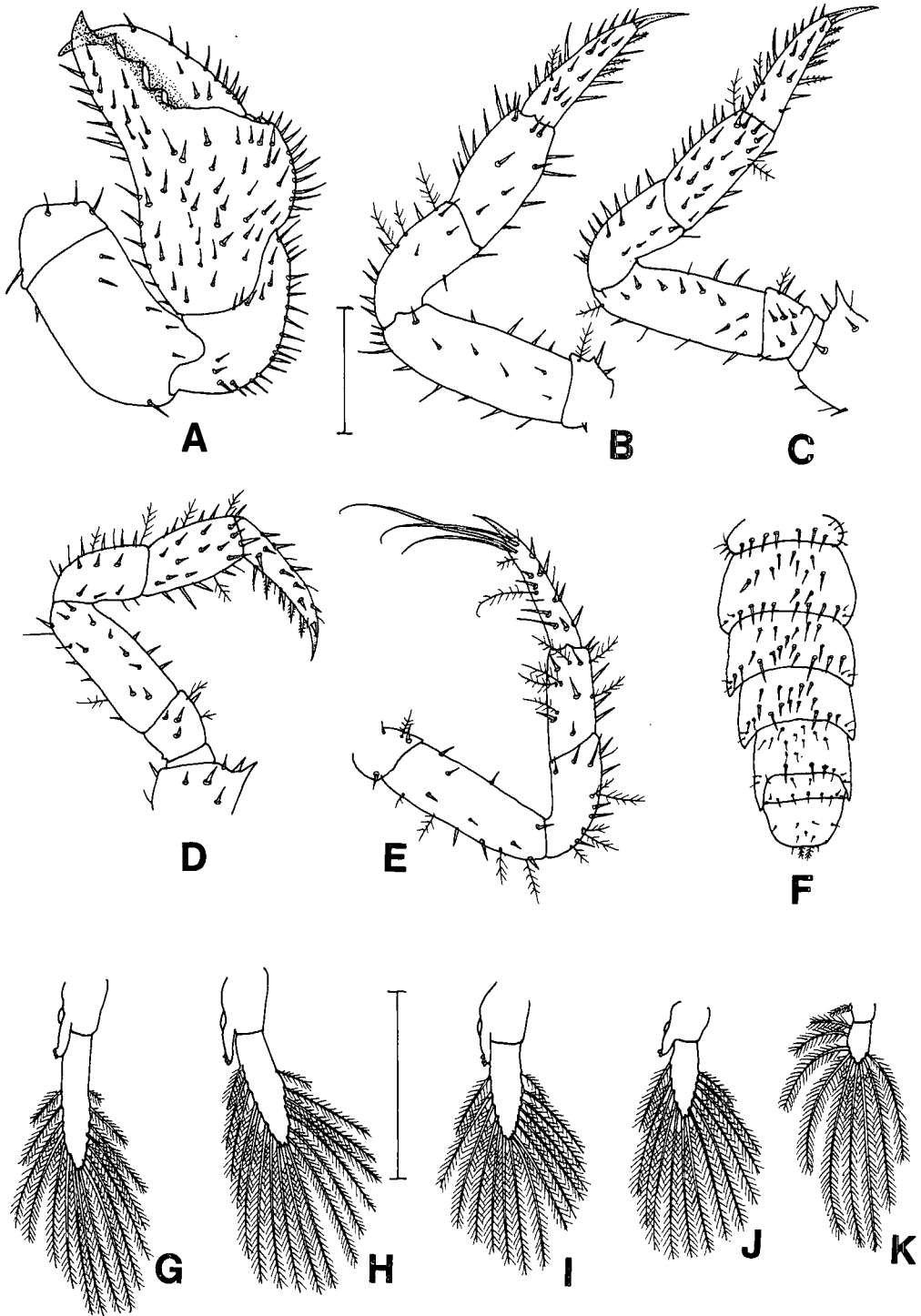


**Fig. 5.** *Gaillardiiellus orientalis* (Odhner, 1925), fourth zoeal stage. A, lateral view; B, anterodorsal view of carapace; C, antennule; D, antenna; E, pereiopods; F, mandible; G, maxillule; H, maxilla; I, first maxilliped; J, dorsal view of abdomen and telson. Scale bars: A = 1 mm; G, H = 0.1 mm; B-E, I, J = 0.5 mm.





**Fig. 6.** *Gaillardius orientalis* (Odhner, 1925), megalopal stage. A, dorsal view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla; G, first maxilliped; H, second maxilliped; I, third maxilliped. Scale bars: A = 0.5 mm; B-I = 0.1 mm.



**Fig. 7.** *Gaillardiiellus orientalis* (Odhner, 1925), megalopal stage. A, chela; B-E, pereopods 1-4; F, abdomen and telson; G-K, pleopods 1-5. Scale bars: A-K = 0.5 mm.

Antenna (Fig. 5D). Endopod more developing.

Chela and Pereiopod (Fig. 5E). Present.

Mandible (Fig. 5F). Endopod bud present.

Maxillule (Fig. 5G). Coxal and basal endites with 11 and 13 setae, respectively.

Maxilla (Fig. 5H). Coxal endite with 6+4 setae; basal endite with 6+7 setae; exopod (scaphognathite) margin with 33 setae.

First maxilliped (Fig. 5A, I). Coxa with 2 setae; endopod 5-segmented with 3, 2, 1, 2, 6 (2 subterminal and 4 terminal) setae; exopod distal segment with 9 natatory setae.

Second maxilliped (Fig. 5A). Exopod distal segment with 11 natatory setae.

Abdomen and telson (Fig. 5J). Pleopods with endopod buds; posterior margin and dorsal surface of telson with 5 and 1 pairs of setae, respectively.

Megalopa (Figs. 6, 7)

Size. Carapace length  $1.48 \pm 0.05$  mm. Carapace width  $1.37 \pm 0.03$  mm.

Carapace (Fig. 6A). With numerous short setae; 1 anterior, 2 anterogastric lateral, 2 postero-gastric lateral, and 1 posterior tubercles present; rostrum as a single median process, 2 pointed lateral spines present.

Antennule (Fig. 6B). Exopod 4-segmented, with total of 22 aesthetascs plus 3 setae; endopod with 2 subterminal plus 4 terminal setae.

Antenna (Fig. 6C). 11-segmented, with 4, 3, 3, 0, 0, 3, 0, 4, 0, 4 and 5 terminal setae.

Mandible (Fig. 6D). Distal segment palp with 9 setae.

Maxillule (Fig. 6E). 2-segmented endopod with 1 and 4 setae; coxal and basal endites with 16 and 22 setae, respectively.

Maxilla (Fig. 6F). Endopod with 5 setae; 2-lobed coxal and basal endites with 9+6, 9+11 setae, respectively; exopod (scaphognathite) margin with 57 setae, surface with 3 setae.

First maxilliped (Fig. 6G). Endopod with 4 setae; coxal and basal endites with 9 and 22-25 setae, respectively; exopod 2-segmented, proximal with 2 terminal and distal with 4 terminal setae; epipod with 11 long simple setae.

Second maxilliped (Fig. 6H). 4-segmented endopod with 5, 1, 6, and 8 setae, respectively; exopod with 4 terminal setae; epipod with 7 long simple setae.

Third maxilliped (Fig. 6I). 5-segmented endopod with 19, 16, 9, 10 and 8 setae; exopod with 5 terminal setae, respectively; epipod with 22 long simple setae.

Pereopods (Fig. 7A-E). With numerous setae; dactylus of ambulatory leg 4 with 3 long setae on inner margin.

Abdomen (Fig. 7F). 6-somites, with numerous setae.

Pleopods (Fig. 7G-K). Pleopods 1-4 with 16, 17, 15 and 13 setae on distal segment, respectively; pleopod 5 with 9 setae on distal and 1 seta on proximal segments.

## DISCUSSION

The first zoea observed in the present study slightly differs from that described for the same species by Ng and Clark (1994) (Table 1). The differences of the setations in an antennule and a

**Table 1.** Differences in the first zoea of *Gaillardieillus orientalis* (Odhner, 1925) as described by Ng and Clark (1994) and in the present study.

Characters	Ng and Clark (1994)	Present study
Carapace		
dorsal spine tip	distinctively rounded	sharp, slightly curved
Antennule	5 setae+aesthetascs	4 aesthetascs+2 setae
Mandibles	not described	asymmetrical, right and left molar processes with 2 and 1 teeth, confluent with incisor process, respectively
First maxilliped		
coxa	not described	1 seta
Telson		
fork	2 lateral, 1 dorsal median setae	2 lateral, 1 or 2 dorsal median setae

telson may result from a lack of detailed examination, but, the morphological difference in a dorsal carapace tip seems to be a geographical variation.

It is unusual that the first zoea of *Gaillardieillus orientalis* (Odhner, 1925) has round tips of an antennal protopod and the telson fork (Ng and Clark, 1994). But this characteristics are not considered to be much significant. Because the tip of an antennal protopod is sharp in the fourth zoeal stage and the telson fork becomes pointed from the second zoeal stage.

The first zoea of *G. orientalis* has 7 setae on the coxal endite of the maxillule, whereas the zoea in other three species has 8 setae (Table 2). It is considered that such difference may due to the number of the zoeal stages. It is now known that there are xanthid species with 6, 5, 4, 3, 2, and 0 zoeal stages. *Novactaea pulchella*, *N. bella* and *Actaea semblatae* have only two zoeal stages. The species having less than four zoeal stages show the abbreviated larval development. Therefore, their zoeae tend to have more setae in the mouthpart appendages than those with the normal development.

Rice (1980) suggested that at least four distinct xanthid groups can be distinguished on the basis of zoeal characteristics. Later Martin (1984) divided the known xanthid zoeae into six groups, based primarily upon morphology of the antennal exopod. According to Rice and Martin's criteria, the zoea of *A. semblatae* and *N. bella* can be included in Rice and Martin's Group I: antennal exopod reduced, less than 25% length of protopod, never armed with more than 2 short terminal setae, these sometimes absent; antennal protopod approximately same length as rostral spine; carapace spines all well-developed; dorsolateral processes always on abdominal somites 2-3, never on more posterior somites; distal segment of endopod of maxillule always with 6 setae of which 2 are subterminal; endopod of first maxilliped always with 3 setae, that of second maxillipes with a single seta; telson fork armature variable; usually 4 zoeal stages. Also the zoea of *G. orientalis* can be included Group I because the three setae of an antennal exopod in the first zoea becomes two

**Table 2.** Comparisons of the first zoeal characteristics in four species of the subfamily Actaeinae.

Characters	<i>Novactaea pulchella</i> (Terada, 1990)	<i>Novactaea bella</i> (Lim and Ng, 1997)	<i>Gaillardiiellus orientalis</i> (Present study)	<i>Actaea semblatae</i> (Terada, 1987)
Carapace				
dorsal spine	present	present	present	present
rostral spine	present	present	present	present
lateral spine	present	present	present	present
Antennule	3 aesthetascs+1 seta	3 aesthetascs+1 seta	4 aesthetascs+2 seta	4 aesthetascs+1 setae
Antenna				
exopod	30% length of spinous process, with 3 setae	12% length of spinous process, with 1 seta	14% length of spinous process, with 3 setae	as 1 seta
Maxillule				
coxal endite	8 setae	8 setae	7 setae	8 setae
basal endite	5 setae, 2 teeth	5 setae, 2 teeth	5 setae, 2 teeth	5 setae, 1 tooth
endopod	1, 2+4 setae	1, 2+4 setae	1, 2+4 setae	1, 2+4 setae
Maxilla				
coxal endite	4+4 setae	4+4 setae	4+4 setae	4+4 setae
basal endite	4+4 setae	4+4 setae	5+4 setae	5+4 setae
endopod	3+2+3 setae	3+2+3 setae	3+2+3 setae	3+2+3 setae
First maxilliped				
basis	2, 2, 3, 3 setae	2, 2, 3, 3 setae	2, 2, 3, 3, setae	2, 2, 3, 3 setae
endopod	3, 2, 1, 2, 4+1 setae	3, 2, 1, 2, 4+1 setae	3, 2, 1, 2, 4+1 setae	3, 2, 1, 2, 4+1 setae
Second maxilliped				
basis	1, 1, 1, 1 setae	1, 1, 1, 1 setae	1, 1, 1, 1 setae	1, 1, 1, 1 setae
endopod	1, 1, 3+3 setae	1, 1, 4+2 setae	1, 1, 4+2 setae	1, 1, 3+3 setae
Abdomen				
lateral process	somites 2-5	somites 2-3	somites 2-3	somites 2-3
Telson				
fork	1 lateral spine. 1 lateral seta, 1 dorsal median spine	naked	2 lateral, 2 or 1 dorsal median setae	2 lateral, 1 dorsal median setae

setae from the third zoea. But, in the case of the zoea of *N. pulchella*, it is difficult to determine its placement. It can be partially included in Rice and Martin's Group I as well as Martin's Group V (antennal exopod as in Group I but tipped 3 short terminal setae; basal segment of endopod of first maxilliped with 2 setae; other characters as in Group I). Moreover its morphology of dorsolateral

process on abdominal somites 2-5 is unusual in the subfamily Actaeinae. Consequently, the subfamily Actaeinae seems to be a little heterogeneous group on the basis of zoeal morphology, although, larvae are known for only four species,

Rice (1980) considered well-developed spines and highly setose and highly segmented appendages to plesiomorphous features and reduced spination, setation, and segmentation to be derived or apomorphous among brachyuran larvae. Using this assumption, Martin *et al.* (1985) suggested that the probable primitive characteristics among xanthid larvae are: (1) a well-developed spinulose antennal exopod, (2) 6 setae on the endopod of the maxillule, (3) 8 setae on the endopod of the maxilla, (4) 3 setae on the proximal segment of the endopod of the first maxilliped, (5) 3 spines on each furca of the telson, and (6) posterodorsal or posterolateral processes on abdominal somites 2-5. The *A. semblatae* has only a seta as an antennal exopod, whereas, other three species have reduced antennal exopods with one or three terminal setae. And the *N. pulchella* has two spines and a seta on the telson fork, whereas, the telson forks are naked or with three or four minute setae in other species. Also, the *N. pulchella* has lateral processes on the abdominal somites 2-5, whereas, it is on the abdominal somites 2-3 in other species. On the basis of above assumption, the *A. semblatae* would be considered more advanced than the other three Actaeinae zoeae. The *G. orientalis* and *N. bella* are intermediately placed. The *N. pulchella* would be recognized as a primitive species. The zoeae of four species could be easily distinguished from each other in the characteristics of an antenna, an abdomen and a telson.

## ACKNOWLEDGEMENTS

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## 털부채계(갑각 강: 십각 목: 부채계 과)의 유생 발생

고 현 숙

(신라대학교 자연대학 생물학과)

### 요 약

털부채계의 제 1 조에아 유생에서 메갈로파 유생기까지, 실험실내 25°C에서 완전 유생발생시키고 4기의 조에아 유생과 1기의 메갈로파 유생에 대해 상세히 기재하고 도시하였다. 털부채계의 조에아 유생은 제 1 촉각과 미절의 특징에 의해 Actaeinae 아과의 다른 조에아 유생들과 구별할 수 있었다.