

Zoal Stages of *Actaea semblatae* (Crustacea, Decapoda, Xanthidae), with a Key to the Known Xanthid Zoeas of Korea

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ABSTRACT

Actaea semblatae (Guinot, 1976) has been reared in the laboratory, from hatching to the first young crab stage at 25°C. The two zoeal stages are described and illustrated in detail. The first zoea of *A. semblatae* in the present study slightly differs from that described by Terada (1987) on the respect of the setal presence on the carapace, the antennule, the coxa of the first maxilliped and the first abdominal somite. Within the family Xanthidae, the zoea of *A. semblatae* can be clearly distinguished from the other known zoeas by having a seta as an antennal exopod or a vestigial exopod with a seta. A provisional key is provided to aid the identification of the xanthid zoeas in Korea.

Key words: Xanthidae, *Actaea semblatae*, Antennal exopod, Zoea, Key

INTRODUCTION

The family Xanthidae MacLeay, 1838 is currently composed of eleven subfamilies: Polydectinae, Cymoinae, Trichiinae, Liomerinae, Euxanthinae, Actaeinae, Zosiminae, Xanthinae, Etisinae, Chlorodiinae, Krausiinae (see Seréne, 1984; Ng, 1993). Among them, eight subfamilies including 17 species are known in Korean waters: Trichiinae, Liomerinae, Euxanthinae, Actaeinae, Zosiminae, Xanthinae, Chlorodiinae, Krausiinae (see Ko and Takeda, 1999, 2000). In particular, the subfamily Actaeinae contains 40 species belonging to 14 Indo-Pacific genera (Guinot, 1976;

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Seréne, 1984) and four Korean Actaeinae species, *Actaea semblatae*, *Novactaea pulchella*, *Forestia depressa* and *Gaillardiiellus orientalis*, are known (The Korean Society of Systematic Zoology, 1997; Ko and Takeda, 1999, 2000). *A. semblatae* inhabits the rocky beaches with stones or crevices of rock between the high and low tidal marks, but sometimes down to 300 m depth. It was known to occur on the coasts of Japan, from East Asia to Red Sea, South Africa, Australia and New Caledonia (Sakai, 1976).

The larval stages of 11 xanthid species have been reported in Korean adjacent waters: *Atergatus reticulatus*, *Macromedaeus distinguendus*, *Leptodius exaratus*, *Pilodius nigrocrinitus*, *Actaea semblatae* (as *A. savignyi*), *Calvactaea tumida*, *Medaeops granulipes* and *Novactaea pulchella* by Terada (1980, 1982, 1987, 1988 1990), *Cycloxanthops truncatus* by Hong (1977) and Suzuki (1979), *Nanocassiope granulipes* by Ko and Clark (in press), and *Gaillardiiellus orientalis* by Fukuda (1978), Ng and Clark (1994), and Ko (1999). The zoeas of *A. semblatae* (as *A. savignyi*) were first described by Terada (1987). However, that report was limited to the brief comments and illustrations of them. Therefore, the aim of this paper is to describe the zoeal stages of *A. semblatae* in detail, to compare it with previously described other xanthid zoeas and to provide a key to the known xanthid zoeas of Korean waters.

MATERIALS AND METHODS

An ovigerous female of *Actaea semblatae* was collected by SCUBA diving from Chuja Island off the southern part of Korea in July 2001. The zoeas collected from laboratory hatched specimens were reared using methods described by Ko (1995) at a constant water temperature of 25°C. Larvae were fixed and preserved in 10% neutral formalin. Dissected appendages were examined and drawn using a Leitz laborlux s microscope with *camera lucida*. Setal counts on appendages and measurements were based on the mean of 10 specimens for each zoeal stage. The sequence of the zoeal description (see Clark *et al.*, 1998) is based on the malacostracan somite plan and described from anterior to posterior. Setal armature on appendages is described from proximal to distal segments and in order of endopod to exopod. The remaining zoeal stages and the spent female were deposited in Silla University, Korea.

RESULTS

Two zoeal and one megalopa stages were recognized. Only one megalopa molted into a young crab. Completion of two zoeal stages required at least eight days. 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 0.70 ± 0.05 mm. Distance from tip of dorsal spine to tip of rostral spine 3.49 ± 0.05 mm. Carapace (Fig. 1A, B). Dorsal spine straightly long and slightly longer than rostral spine; rostral spine about equal in length to antenna; lateral spine short and curving ventrally; 1

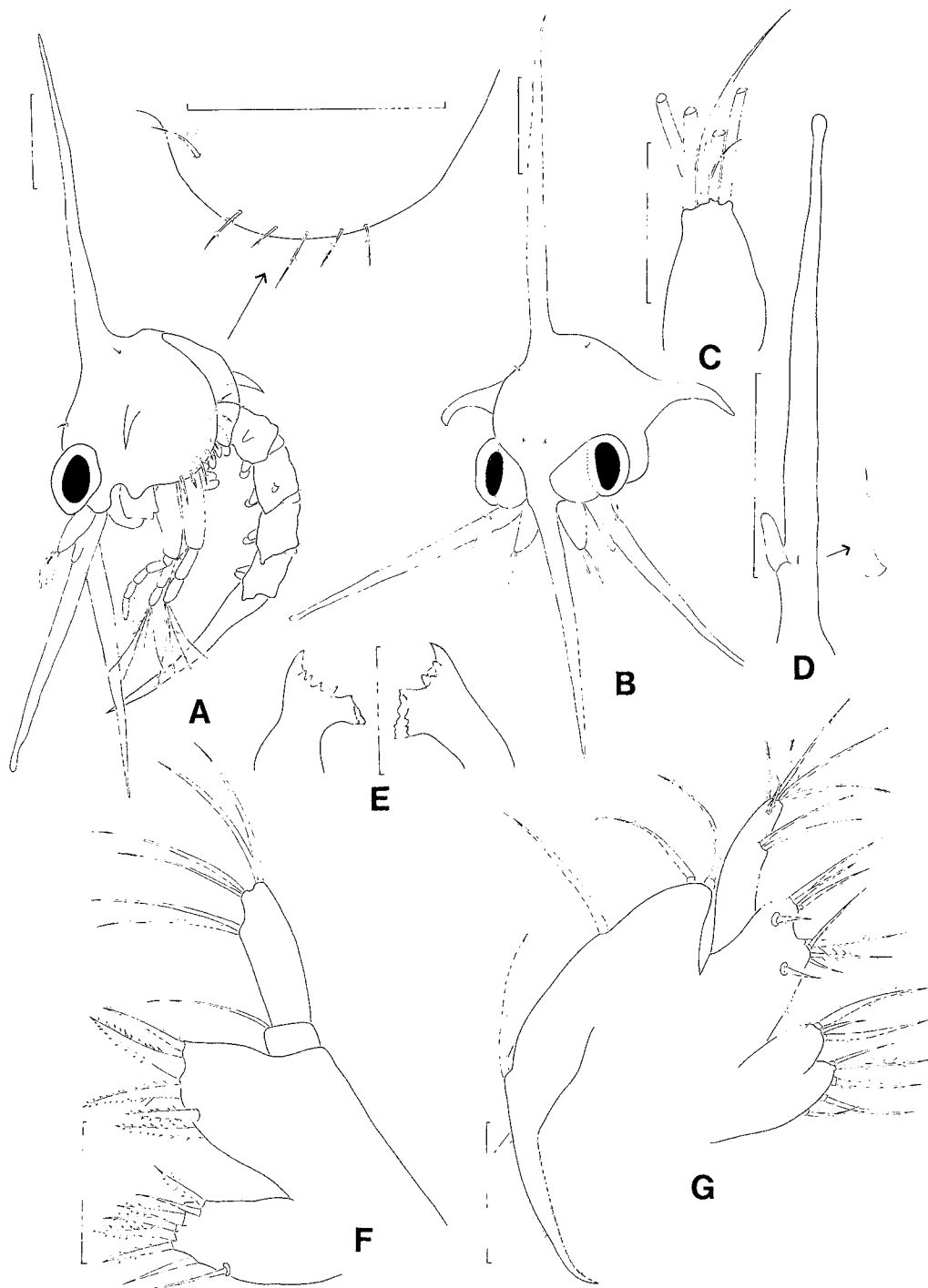


Fig. 1. *Actaea semblatae*, first zoeal stage. A, lateral view; B, anterodorsal view of carapace; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla. Scale bars: A, B, D = 0.5 mm; C, F, G = 0.1 mm; E = 0.25 mm.

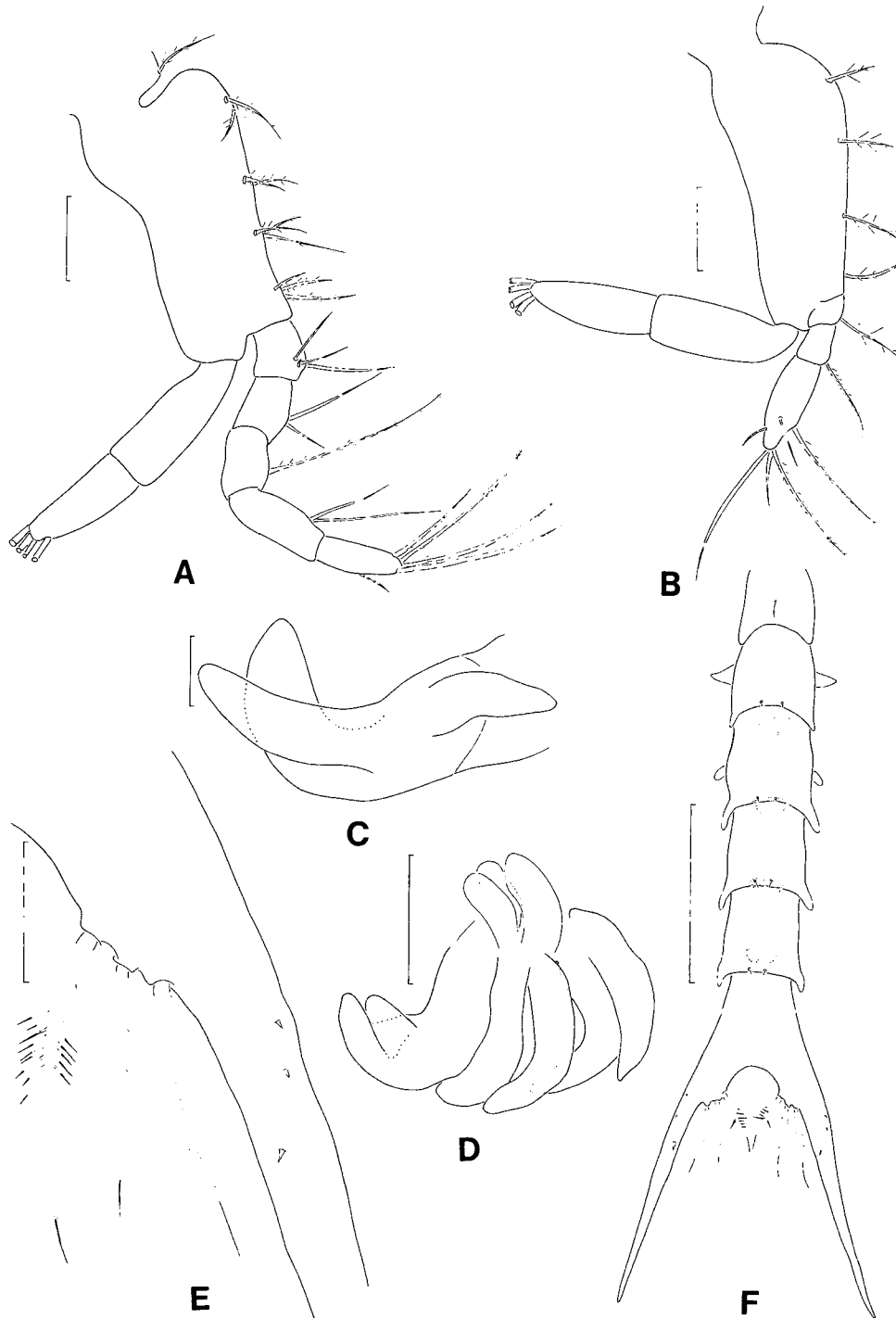


Fig. 2. *Actaea semblatae*, first zoeal stage. A, first maxilliped; B, second maxilliped; C, third maxilliped; D, pereopods; E, fork of telson; F, dorsal view of abdomen and telson. Scale bars: A, B, E = 0.1 mm; C = 0.05 mm; D = 0.25 mm; F = 0.5 mm.

pairs of anterodorsal and posterodorsal setae; each ventral margin with 6 setae; eyes sessile. Antennule (Fig. 1C). Uniramous, endopod absent; exopod unsegmented with 4 terminal aesthetascs plus a long and a minute terminal setae. Antenna (Fig. 1B, D). Protopod not spinulate, about equal in length to rostral spine with rounded tip; endopod present; exopod minute seta. Mandible (Fig. 1E). Asymmetrical; right molar and left molar processes with 4 and 2 teeth, confluent with incisor process, respectively; endopod absent. Maxillule (Fig. 1F). Coxal endite with 8 setae; basal endite with 5 setae; endopod 2-segmented, proximal segment with 1 seta, distal segment with 4 terminal plus 2 subterminal setae. Maxilla (Fig. 1G). Coxal endite bilobed with 5+3 setae; basal endite bilobed with 5+4 setae; endopod with 3 middle+2 subterminal+3 terminal setae; exopod (scaphognathite) margin with 4 plumose setae plus 1 distal stout process.

First maxilliped (Fig. 2A). Coxa with 1 seta; basis with 10 setae arranged as 2, 2, 3, 3; endopod 5-segmented with 3, 2, 1, 2, 5 (1 subterminal+4 terminal) setae, respectively; exopod 2-segmented, distal segment with 4 terminal natatory setae. Second maxilliped (Fig. 2B). Coxa without seta; basis with 4 setae; endopod 3-segmented, with 1, 1, 6 (3 subterminal+3 terminal) setae, respectively; exopod 2-segmented, distal segment with 4 terminal natatory setae. Third maxilliped (Fig. 2C). Biramous.

Pereiopods (Fig. 2D). Rudimentary, undifferentiated into segments; cheliped bilobed. Abdomen (Fig. 2F). Incompletely 6 somites; somite 1 with dorsomedial seta; somite 2 with 1 pair of lateral processes directed laterally; somite 3 with a pair of lateral processes directed posteriorly; somites 2-5 with short posterolateral processes and a pair of posterodorsal setae; pleopod buds present. Telson (Fig. 2E, F). Each fork long, not spinulate, with 2 lateral minute setae and one dorsal medial minute seta; each posterior margin with 3 spinulate setae.

Second Zoea (Figs. 3, 4)

Size. Carapace length 1.01 ± 0.07 mm. Distance from tip of dorsal spine to tip of rostral spine 3.83 ± 0.12 mm. Carapace (Fig. 3A, B). With 4 pairs of anterodorsal setae; each ventral margin with 11 setae; eyes stalked. Antennule (Fig. 3C). Basis with a seta, endopod developing; exopod with 3 rows of subterminal aesthetascs arranged as 5, 1, 2 and in terminal position, 3 aesthetascs plus seta. Antenna (Fig. 3D). Endopod more developing; vestigial exopod with a seta. Mandible (Fig. 3E). Right and left molar processes with 5 and 2 teeth, confluent with incisor process, respectively. Maxillule (Fig. 3F). Coxal endite with 9 setae; basal endite with 10 setae; coxal epipod and exopod setae present. Maxilla (Fig. 3G). Coxal endite bilobed with 5+4 setae; basal endite bilobed with 6+5 setae. Exopod (Scaphognathite) margin with 24 setae.

First maxilliped (Fig. 4A). Coxa with 2 setae; endopod 5-segmented with 3, 2, 1, 2, 6 (2 subterminal+4 terminal) setae, respectively; exopod distal segment with 8 terminal natatory setae. Second maxilliped (Fig. 4B). Exopod distal segment with 9 terminal natatory setae. Third maxilliped (Fig. 4C). Anthrobranch gill present.

Pereiopods (Fig. 4D). Some segmental differentiation into segment. Abdomen (Fig. 4F). Completely 6 somites; pleopod buds 1-5 present. Telson (Fig. 4E, F). Each posterior margin with 4 spinulate setae.

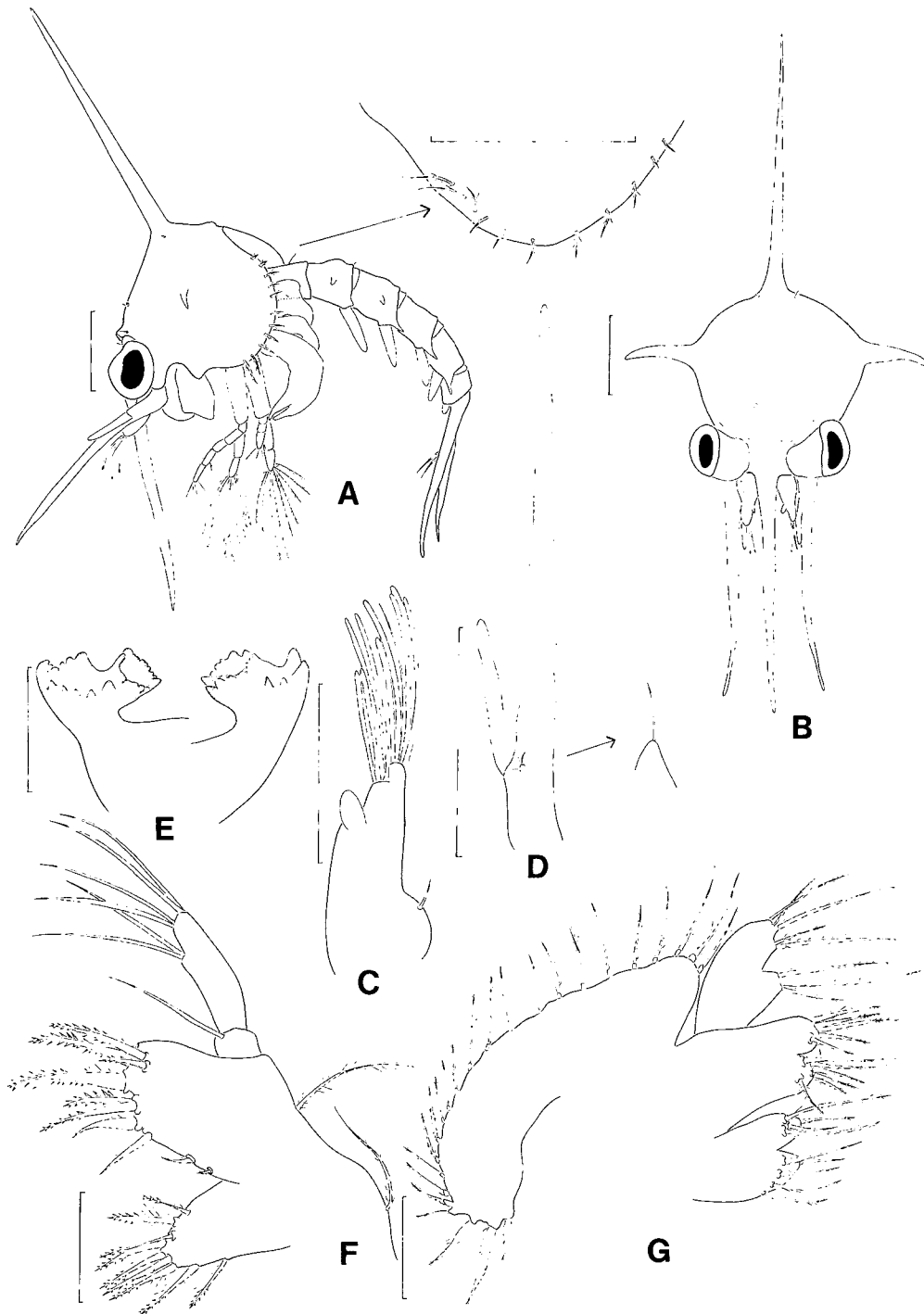


Fig. 3. *Actaea semblatae*, second zoeal stage. A, lateral view; B, anterodorsal view of carapace; C, antennule; D, antenna; E, mandibles; F, maxillule; G, maxilla. Scale bars: A, B, D = 0.5 mm; C, E = 0.25 mm; G, F = 0.1 mm.

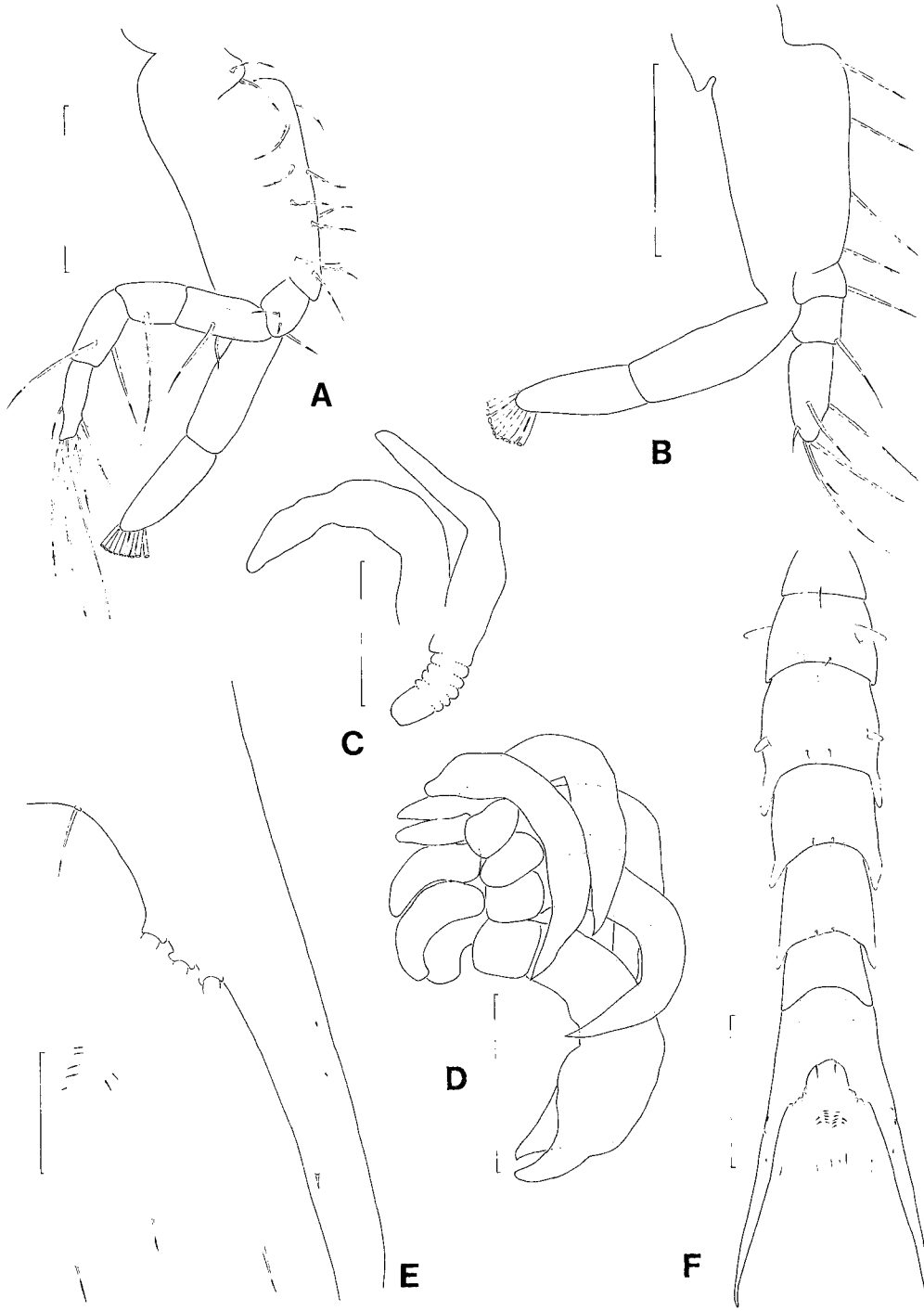


Fig. 4. *Actaea semblatae*, second zoeal stage. A, first maxilliped; B, second maxilliped; C, third maxilliped; D, pereiopods; E, fork of telson; F, dorsal view of abdomen and telson. Scale bars: A, B, C = 0.25 mm; D, F = 0.5 mm; E = 0.1 mm.

DISCUSSION

The first zoea of *Actaea semblatae* reared in the present study somewhat differs from that described by Terada (1987) (Table 1): the carapace with one pairs of anterodorsal and posterodorsal setae, and six setae on the ventral margin; the mandibles asymmetrical; the coxa of the first maxilliped with a seta; the third maxilliped biramous; the pereopods rudimentary. But these characteristics were not described or illustrated by him. Moreover, he described the antennule having one seta, five abdominal somites and the first abdominal somite without a dorsomedial seta. However, in this study it is found that an antennule has two setae, six incomplete abdominal somites are recognized and a dorsomedial seta is present on the first abdominal somite. It is considered that he overlooked the setae of the carapace, the antennule, the coxa of the first maxilliped and the first abdominal somite. Also, the mandibles, the third maxilliped and the pereopod could not be examined in his paper. Because the first zoea of *A. semblatae* has buds of antennal endopod, third maxilliped, pereopod and pleopod, *A. semblatae* may show an abbreviated larval development. Its first stage corresponds to the third zoeal stage of other Actaeine species, which have total four stages.

The zoeas of 11 xanthid species have been reported in Korea and the adjacent waters (Table 2). The general morphology of the first zoeas of the family Xanthidae is similar to each other. Common characteristics of Korean xanthid zoeas are summarized in Table 2: carapace with all spines; endopod of maxillule with 1, 2+4 setae, basal endite with 5 setae; endopod of maxilla with 3+2+3 (5+3) setae; endopod of first maxilliped with 3, 2, 1, 2, 5 setae. But, readily

Table 1. Differences in the first zoea of *Actaea semblatae* as described by Terada (1987) and in the present study.

Characters	Terada (1987)	Present study
Carapace		
anterodorsal setae	not described	one pair
posterodorsal setae	not described	one pair
ventral margin	not described	6 setae
Antennule	4 aesthetascs + one seta	4 aesthetascs + 2 setae
Mandibles	not described	asymmetrical, right and left molar processes with 4 and 2 teeth, confluent with incisor process, respectively
First maxilliped		
coxa	not described	one seta
Third maxilliped	not described	biramous
Pereopod	not described	rudimentary, undifferentiated into segments, cheliped bilobed
Abdomen	5 somites	incompletely 6 somites
dorsomedial seta on somite 1	absent	present

observable morphological characters are useful in distinguish them in the plankton. Martin (1984) attempted to divide the xanthid zoeas into six groups based primarily on the antennal characters. Korean xanthid zoeas exhibit four types of the antennal exopod: exopod less than 20% length to protopod and with a seta (*Leptodius exaratus*, *Macromedaeus distinguendus*, *Nanocassiope granulipes*, *Actaea semblatae*), exopod of less than 20% length to protopod and with 2 terminal setae (*Cycloxanthops truncatus*, *Calvactaea tumida*, *Pilodius nigrocrinitus*), exopod of less than 20% length to protopod and with 3 terminal setae (*Atergatus reticulatus*, *Gaillardiellus orientalis*, *Novactaea pulchella*), exopod more than 20% length to protopod and with 3 terminal setae (*Medaeops granulipes*). Within the zoeas of the subfamily Actaeinae, the tip of an antennal protopod is a spinous process in *Novactaea pulchella*, whereas in *A. semblatae* and *G. orientalis*, both are rounded tips. In *A. semblatae* the antennal exopod is only a seta or vestigial with a seta. Such type of an antennal exopod could not be found any other xanthid zoeas.

The following provisional key is provided for planktologists to aid the identification of xanthid zoeas in Korea.

Key to zoeal stages of the family Xanthidae in Korea

1. Exopod of antenna less than 20% length to protopod 2
 - Exopod of antenna more than 20% length to protopod *Medaeops granulipes*
2. Exopod of antenna with 1 terminal seta 3
 - Exopod of antenna with more than 1 terminal seta 6
3. Endopod of second maxilliped with 1, 1, 6 setae *Actaea semblatae*
 - Endopod of second maxilliped with 1, 1, 5 setae 4
4. Dorsal spine spinulate, long, distally curved as hook *Nanocassiope granulipes*
 - Dorsal spine smooth 5
5. Dorsal spine a little longer than rostral spine; rostral spine with at least two minute spines distally *Leptodius exaratus*
 - Dorsal spine long and approximately equal in length to rostral spine; rostral spines smooth *Macromedaeus distinguendus*
6. Exopod of antenna with 2 terminal seta 7
 - Exopod of antenna with 3 terminal seta 9
7. Endopod of second maxilliped with 1, 1, 6 setae *Pilodius nigrocrinitus*
 - Endopod of second maxilliped with 1, 1, 5 setae 8
8. Lateral carapace spine spinulate *Calvactaea tumida*
 - Lateral carapace spine not spinulate *Cycloxanthops truncatus*
9. Endopod of second maxilliped with 1, 1, 6 setae 10
 - Endopod of second maxilliped with 1, 1, 5 setae *Atergatus reticulatus*
10. Abdominal somites 2 and 3 with lateral processes *Gaillardiellus orientalis*
 - Abdominal somites 2 to 5 with lateral processes *Novactaea pulchella*

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옴부채계 (갑각강, 십각목, 부채계과)의 조에아 유생기 및 한국 부채계과 종의 조에아 유생 검색표

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요 약

옴부채계를 제 1 조에아 유생에서 제 1 어린 계시기까지, 실험실내 25°C에서 발생시키고 제 1기와 2기 조에아 유생에 대해 상세히 기재 및 도시하였다. 본 연구에서 옴부채계의 제 1 조에아 유생은 갑각, 제 1 촉각, 제 1 악지의 저절, 제 1 복부 절에 강모들이 존재함으로 Terada (1987)의 연구와 약간의 차이를 보였다. 옴부채계의 조에아 유생은 제 1 촉각 외지가 한 개의 강모이거나 혹은 흔적적인 상태에서 한 개의 강모를 가지고 있어 다른 부채계과 조에아 유생들과 분명하게 식별되었다. 그리고 한국근해의 부채계과 종에 대한 조에아 유생검색표가 제공되었다.