Article

Morphological study of laboratory reared first and second zoeal stages of *Alpheus edwarsii* (Audouim, 1826) (Crustacea: Decapoda: Caridea: Alpheidae)

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Abstract
The ovigerous female of *Alpheus edwarsii* (Audouim, 1826) was collected from Buleji, Karachi, Pakistan, and retained in the laboratory. The larvae hatched after 4 days and subsisted within 3 days at room temperature 28°C-30°C in filtered seawater with a salinity of 35-37 parts per thousand and a pH of 7.6-7.8. In order to feed the larvae, *Artemia* nauplii was used. Two zoeal stages are described, illustrated and compared with those of its congener's larvae known previously.

Keywords crustacea; Caridea; Alpheidae; *Alpheus edwarsii* larvae.

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1 Introduction

The alphaheidae family of caridean snapping shrimp is characterized by their asymmetrical claws, the larger of which usually produces a loud snapping sound. There is a wide range of diversity within the family, and it is distributed throughout the world. Alpheidae comprises 45 genera and over 620 species. A total of 283 species are found in the genus *Alpheus* (Grave et al., 2009). Coutiere (1897) divided the genus into five groups and then into three subgroups of Crinitus to simplify this cumbersome and large taxonomic unit. A group rank was given to these subgroups by Banner and Banner (1966). It was revised by Crosnier and Forest (1966). Based on Banner and Banner (1982), seven groups are now recognized: Brevirostris group, Crinitus group, Diadema group, Edwardsi group, Macrocheles group, Obesomanus group and Sulcatus group. Chace (1988) has not clearly accepted these groups. These groups clearly do not share a monophyletic relationship.

In Pakistan, the following species are represented by the genus, *Alpheus albertii*, *Alpheus* cf. *Barbatus*, *Alpheus bisincisus*, *Alpheus chiragriucus*, *Alpheus edwardsii*, *Alpheus isodactylus*, *Alpheus lobidens*, *Alpheus manorensis*, *Alpheus pacificus*, *Alpheus pseudoedwardsii*, *Alpheus cf. rapax*, *Alpheus splendidus*, *Alpheus strenuous strenuous* and *Alpheus zulfaquiri* (Kazmi and Kazmi, 2010).

In the present account larvae of *Alpheus edwarsii* are described in terms of their taxonomical characteristics.

1.1 Taxonomy

Class: Malacostraca

Order: Decapoda

Infraorder: Caridea Dana, 1825

Family: Alpheidae Rafinesque, 1815

Genus: *Alpheus* Weber, 1795

Alpheus edwardsii (Audouin, 1826) (Fig. 1)

1.2 Synonymised names

Athanas edwardsii Audouin, 1826: 91. *Alpheus edwardsii* Banner and Banner, 1973: 1141; Banner and Banner, 1978: 222; Banner and Banner, 1982: 270; Banner and Banner, 1985: 16; Chace, 1988: 25. Naderloo and Türkay, 2012: 9; Anker and De Grave, 2016: 352.

2 Materials and Methods

2.1 Study area

Alpheus edwarsii (Audouim, 1826) ovigerous female obtained from Buleji (long 66°49' 12" E, lat 24°50' 12" N). It is located 30 km away from Karachi on a sandy cum rocky ledge.

2.2 Methodology

The following meteorological parameters were recorded: air and water temperatures (Celsius), salinity (^{o}%), dissolved oxygen (ml/1), pH, and tide (m). Filtered seawater with a salinity of 35-37^{o}%, pH of 7.5-7.9 at room temperature (29^{o}C-30^{o}C) was maintained to keep the ovigerous female during the study period. To isolate newly hatched larvae, we divided them into five groups and placed them in a 500 ml beaker of filtered seawater. As food, *Artemia* nauplii were used. The dead larvae and exuviae in each beaker were examined daily (Table 1).

2.3 Fixation and preservation of material

In order to prepare temporary slides, glycerin and formalin (3:1) were used. A stage micrometer was used to measure the illustrated specimens (millimeter = mm). From the tip of the rostrum to the mid posterior border of the telson, we measured the total length (TL).

2.4 Microscopic observations

Under a binocular microscope (Nikon) with 10x/21 magnifications, specimens were dissected with tungsten needle. Olympus BX51 microscope (magnifications WHN10X/22 x10, 20 and 40) with Nomarski interference contrast and *camera lucida* attachment was used to make the illustrations. A spent female and the rest of the larvae were fixed in formalin and stored at the Marine Reference Collection and Resource Centre, University of Karachi (Fig. 1).

Fig. 1 *Alpheus edwarsii* (Audouim, 1826), ovigerous female.

Table 1 Analyses of *Alpheus edwarsii* (Audouim, 1826) larval stages and appearance times.

Stage	**Days elapsed after hatching**	**Total Length TL ± SD (mm)**
Zoea I	1 day	1.63 mm ± 2.24 mm
Zoea II	1 day	1.90 mm ± 2.27 mm

2.5 Distribution

Western Indian Ocean; Gulf of Mannar; Piearl Banks in Ceylon; Indonesia; New Caledonia and Sandwich Islands; Indo-West Pacific from South Africa and Red Sea to Japan and Australia, New Zealand and Hawaii.

2.6 Habitat

Found in tropical and temperate coastal and marine waters. Most snapping shrimp dig burrows and are common inhabitants of rocky/sandy intertidal and shallow sub tidal zone.

3 Results

3.1 Zoea I

Carapace (Fig. 2A).- Carapace smooth; rostrum basally broad and distally pointed; eye stalked.

Antennule (Fig. 2B).- Peduncle 3-segmented with 0,2,0, plumodenticulate setae from proximal to distal segments respectively; endopod in a form of 1 long plumose seta; outer ramous (exopod) with 1 aesthetascs and 2 setae.

Antenna (Fig. 2C).- Biramous, endopod with 1 long plumose seta; scaphocerite (exopod)with 11 long plumose setae.

Mandible (Fig. 2D).- Incisor and molar processes developed.

Maxillule (Fig. 2E).- Coxal endite with 3 plumodenticulate setae; basial endite with 2 cuspidate setae; endopod with 1 plumose seta.

Maxilla (Fig. 2F).- Endites with 2,2 and 2 plumodenticulate setae respectively; endopod with 2 setae; scaphognathite with 5 long plumose setae.

Maxilliped I (Fig. 2G).- Coxopod broken; basipod with 3 spines; endopod unsegmented with 2 simple setae; exopod with 2 terminal and 2 subterminal plumose natatory setae.

Maxilliped II (Fig. 2H).- Coxopod broken; basipod without setae; endopd 5-segmented terminal segment with

2 simple setae; exopod with 2 terminal and 2 subterminal plumose natatory setae.

Maxilliped III (Fig. 2I).- Coxopod broken; basipod without setae; endopod 5-segmented; exopod simple without setae.

Pereiopod I-V (Figs. 2J-N).- Pereiopods I-V biramous.

Abdomen (Fig. 2A).- 5-segmented.

Telson (Fig. 2O).- Triangular, posterior margin with 7 pair of long plumose setae.

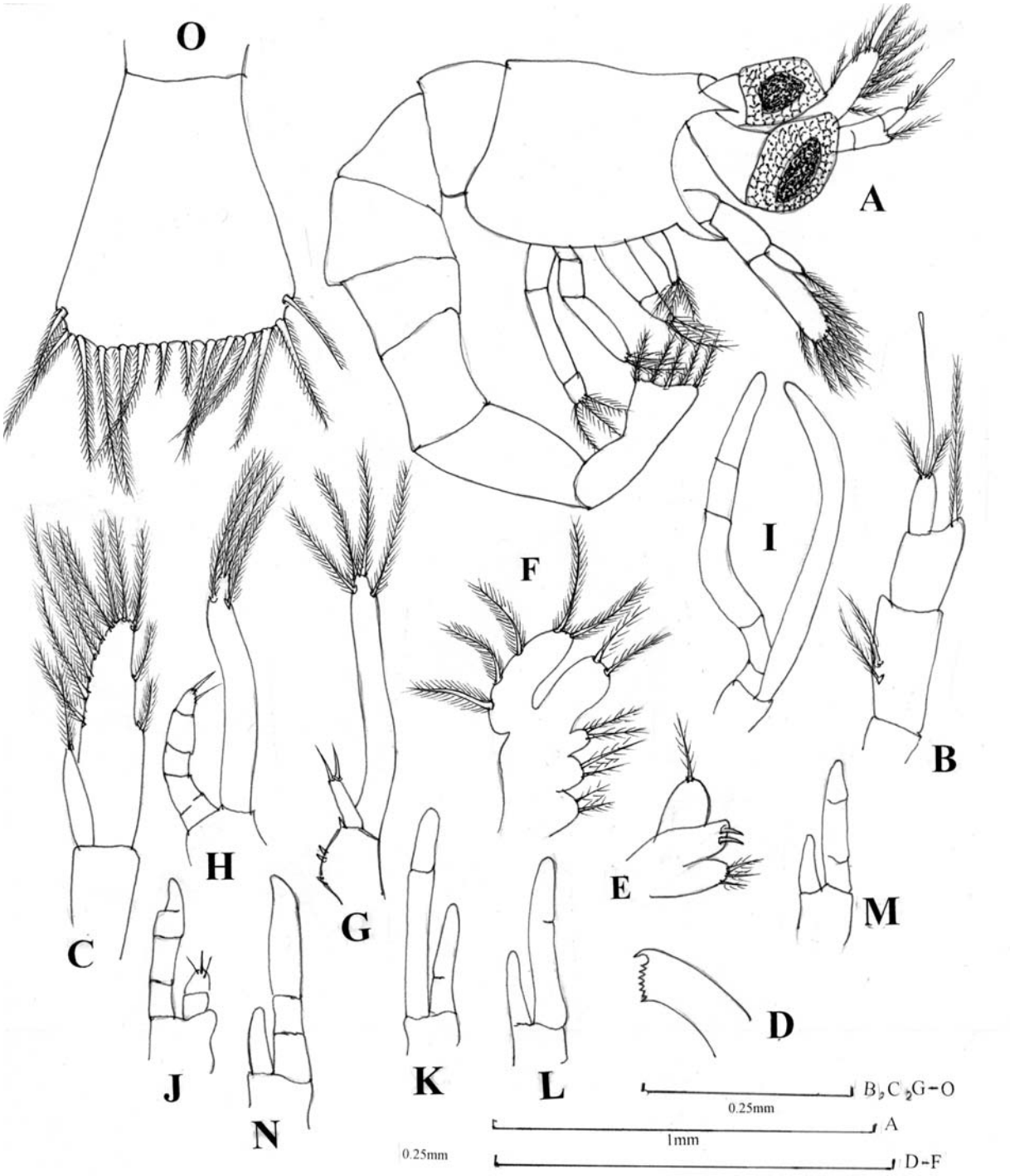

Fig. 2 *Alpheus edwarsii* (Audouim, 1826) . Zoea I: A, dorsal view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla, G - I, maxillipeds I - III; J - N, pereiopods I-V, O, telson with uropods.

3.2 Zoea II

Carapace (Fig. 3A).- Unchanged.

Antennule (Fig. 3B).- Peduncle 3-segmented with 0, 5 and 1 setae respectively; inner ramous (endopod) with 1 long plumose seta; outer ramous (exopod) with 1 plumodenticulate seta and 2 aesthetscs.

Antenna (Fig. 3C).- Unchanged.

Mandible (Fig. 3D).- Incior and molar processes well developed.

Maxillule (Fig. 3E).- Coxal endite with 2 plumodenticulate setae; basial endite with 2 cuspidate setae; endopod unchanged.

Maxilla (Fig. 3F).- Endites with 2,4 and 2 plumodenticulate setae respectively; endopod and scaphognathite unchanged.

Maxilliped I (Fig. 3G).- Coxopod without setae; basipod with 4 simple setae; endopod and exopod unchanged.

Maxilliped II (Fig. 3H).- Coxopod broken; basipod with 2 simple setae; endopod 5-segmented with 1,0,0,2 and 4 plumodenticulate setae from proximal to distal segments respectively; exopod unchanged.

Maxilliped III (Fig. 3I).- Coxopod without setae; basipod with 1 seta; endopod 3-segmented with 2,2 and 4 plumodenticulate setae from proximal to distal segments respectively; exopod unchanged.

Pereiopod I-V (Figs. 4A - D).- Pereiopods I- IV biramous, endopod and exopod developed (Fig. 4E); pereiopod V uniramous, 5-segmented ending in a strong spine, segment 3 and 5 with a simple seta.

Abdomen (Fig. 3A).- Unchanged.

Telson (Fig. 4F).- Uropod developed; endopod without setae; exopod with 6 long plumose setae.

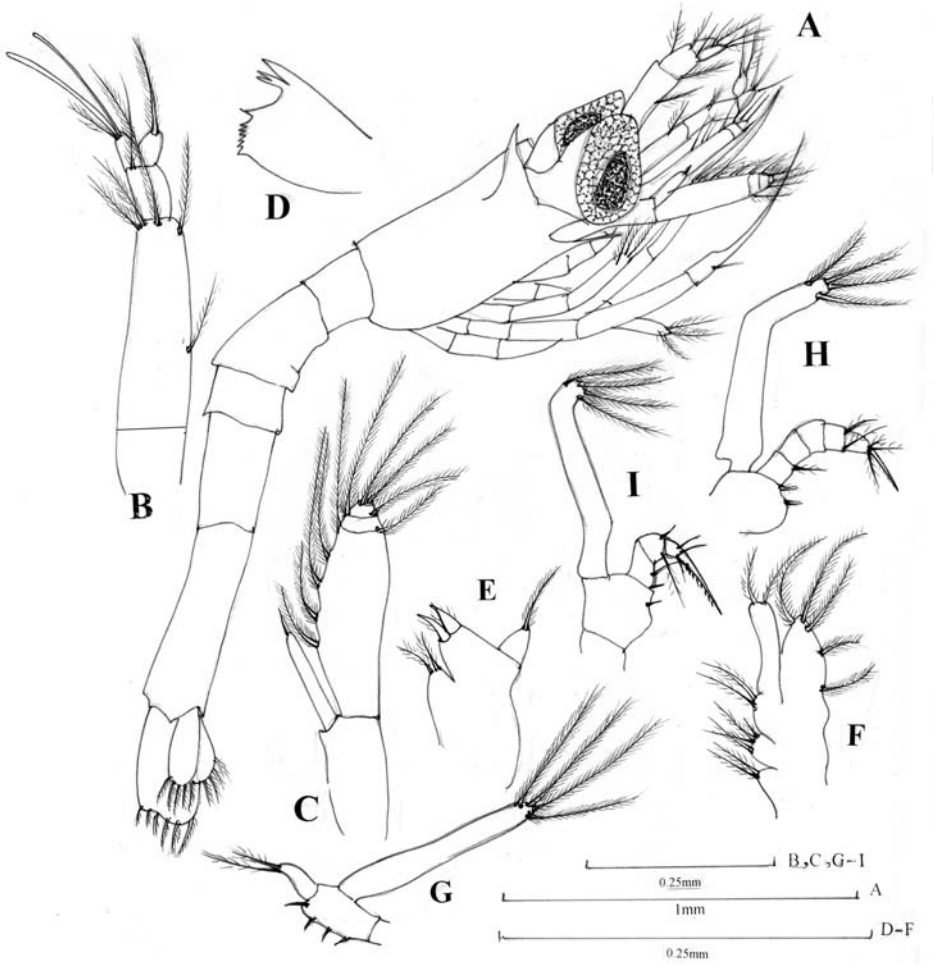

Fig. 3 *Alpheus edwarsii* (Audouim, 1826). Zoea II: A, dorsal view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla; G - I, maxillipeds I-III.

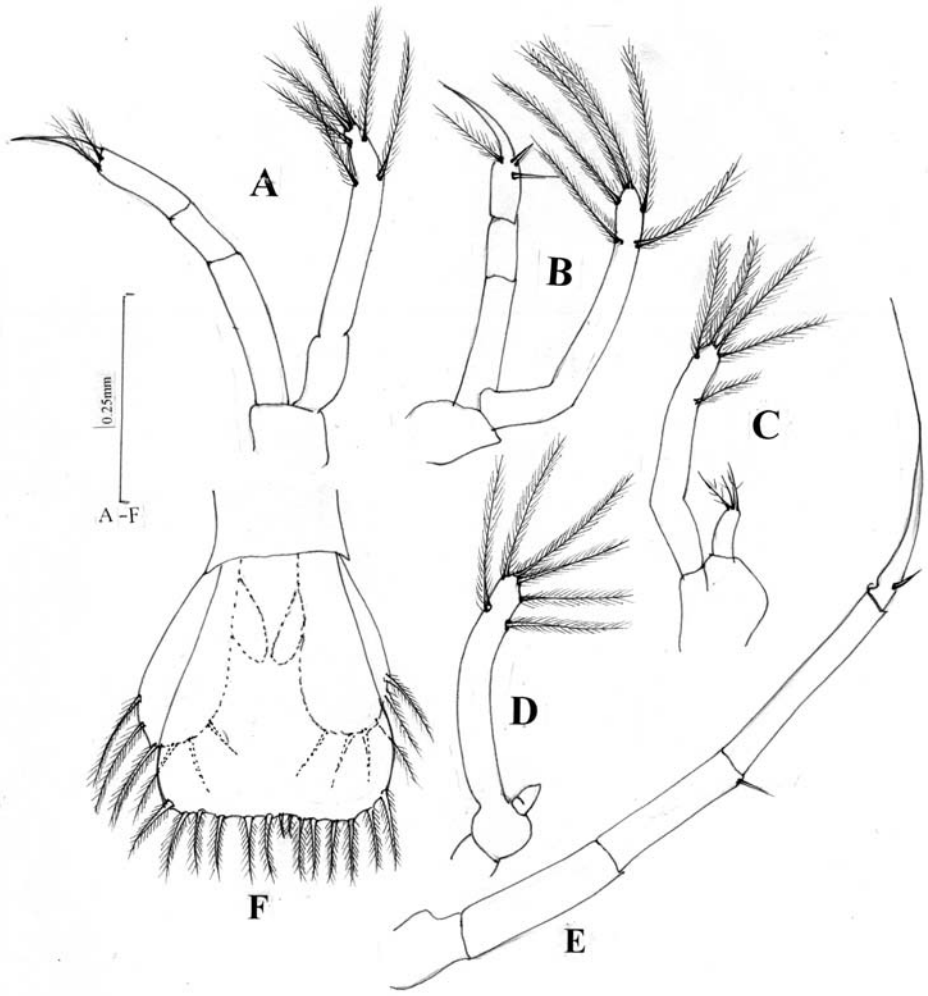

Fig. 4 *Alpheus edwarsii* (Audouim, 1826) . Zoea II: A - E, pereiopods I-V; F, telson with uropods.

4 Discussion

Meroplankton of the inshore zone is usually dominated by larvae of the Alphaheidae family, but larval descriptions with the family are scarce. The larval stages of some species have been described based on plankton-captured individuals or egg-hatched individuals; however, complete postembryonic developmental sequences have rarely been described (see Knowlton (1970) for an overview of historical studies about alpheid development). Larvae hatching from large eggs are likely to have advanced structural development and to have fewer larval instars than larvae hatching from smaller eggs (Knowlton, 1973). Many carideans, including *Alpheus*, exhibit the extended pattern as their normal pattern (Lebour, 1932a, b; Gurney, 1942, p. 33). Brooks and Herrick (1892) it has been suggested that the same species can produce different types of larvae depending on the locality. Researchers believed that conspecific larvae produced by different environmental conditions would develop in vastly different ways, calling the phenomenon "poecilogony" (Knowlton, 1973).

Despite Pakistan's large number of species recorded from its waters, little is known about alpheid shrimp larvae (Kazmi and Kazmi, 2010). There has been limited success in rearing alpheid larvae in the laboratory.

A morphological comparison shows that the first zoeal stage of *A. edwardsii* larvae is similar to that of other *Alpheus* species (Table 2). As a result, specific identification may be difficult due to the similarity. Even so, there are some differences that could be useful for identifying the organisms.

Table 2 Comparison of morphological features of zoea I of 10 species belonging to the genus *Alpheus*.

Characters	***A.edwardsii* present study**	**A. *heterochaelis* Knowlton (1973)**	***A. euphosyne richardsoni* Yang & Kim (1996)**	***A.brevicristatus* Yang & Kim (1998)**	***A.digitalis* Yang & Kim (1998)**	***A.heeia* Yang & Kim (1999)**	***A.japonicus* Yang & Kim (2002)**	***A.lobidens* Yang *et al. (*2003)**	***A.sudara* Yang *et al. (*2003)**	***A.albatrossae* Yang & Kim (2006)**	***A.estuariensis* Pires, *et al*., (2008)**
Rostrum:	present	absent	absent	absent	absent	absent	absent	absent	absent	absent	absent
Antennule :peduncle segment	3-segmented	unsegmented	unsegmented	unsegmented	unsegmented	unsegmented	unsegmented	unsegmented	unsegmented	unsegmented	unsegmented
outer flagellum	1 aesthetascs + 1 seta	3 aesthetascs	3 aesthetascs	3 aesthetascs	3 aesthetascs	3 aesthetascs	3 aesthetascs	3 aesthetascs	3 aesthetascs	4 aesthetascs + 1 seta	4 aesthetascs
Antenna: distal segments	unsegmented	5	4	3	5	5	4	6	6	5	4
exopod	11 setae	11 setae	11 setae	11 setae	11 setae	11 setae	11 setae	11 setae	11 setae	11 setae	11 setae
Maxillule endopod	1 seta	1 seta	1 seta	1 seta	1 seta	1 seta	1 seta	1 seta	1 seta	1 seta	1 seta
basal endite	2 spines	2 spines	2 spines + 1 seta	2 spines	2 spines + 1 seta	2 spines	2 spines + 2 setae	2 spines + 2 setae	1 spine + 2 setae	2 spines + 2 setae	2 spines
coxal endite	3 setae	1 seta	3+ 1 seta	3 setae	5 setae	3 setae	3 setae	2 setae	4 setae	3 setae	3 setae
Maxilla: Scaphognathite	5 setae	8-10 setae	5 setae	5 setae	5 setae	5 setae	5 setae	5 setae	5 setae	5 setae	5 setae
Maxilliped II:endopod segment	5-segmented	4-segmented	4-segmented	Incomplete 3 segments	4-segmented	4-segmented	3-segmented	4-segmented	4-segmented	3-segmented	4-segmented
Telson:posterior margin setae	7 pairs	7 pairs	7 pairs	7 pairs	7 pairs	7 pairs	7 pairs	7 pairs	7 pairs	7 pairs	7 pairs

The rostrum is present in *Alpheus edwardsii* (present species*)* as absent in all other species. The number of setae on the maxillule coxal endite is also variable: *A. estuariensis*, *A. euphorosyne richardsoni* (now two separate species), *A. heeia*, *A. digitalis*, *A. japonicus* and *A. brevicristatus*, *A.albatrossae*, *A.edwardsii*, and *A. lobidens* (present study), all have three, as in *A. sudara*, *A. lobidens* and *A. heterochaelis* they differ from 1 - 5. Also all *A. estuariensis*, *A. brevicristatus*, *A. heterochaelis*, *A. heeia* and *A.edwardsii* have the similar number of spines on the maxillule basal endite and lack setae, whereas in *A. lobidens*, *A. japonicus*, *A. digitalis*, *A. euphorsyne richardsoni* and *A. sudara* have one or two additional setae are present.

It is fairly accurate to predict degree of epimorphosis based on the size of larva at hatching among species in the same genus. As the family is characterized by a variety of developmental patterns, it is nearly impossible to define alpheid larvae uniformly.

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