Article

Morphological description of the larval stages of *Alpheus lobidens* De Haan, 1850 (Crustacea: Decapoda: Caridea: Alpheidae) reared under laboratory conditions

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Abstract
The *Alpheus lobidens* is a widely distributed snapping shrimp that lives on soft and hard bottoms in warm coastal environments (Hamdy and Dorgham, 2018). The berried female of *Alpheus lobidens* De Haan, 1850 was collected from Buleji (Karachi, Pakistan) and kept in the laboratory. The larvae hatched after 2 days and existed within 7 days at room temperature 23°C - 28°C in filtered seawater with a salinity of 37 - 40 parts per thousand and a pH of 7.5 - 7.8. *Artemia* nauplii were used to feed the larvae. Two zoeal stages are described, illustrated and compared with those of its congener's larvae known previously.

Keywords Crustacea; Caridea; Alpheidae; *Alpheus lobidens* larvae.

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1 Introduction

In coastal tropical and subtropical regions, snapping shrimps of the genus *Alpheus* Fabricius, 1798 inhabit soft and hard bottoms within variable depths in estuaries, mangroves, and coral reefs (Anker et al., 2006). Different types of benthic animals were associated with some *Alpheus* species (e.g. Anker et al., 2008; Purohit et al., 2014). The global distribution of *A lobidens* indicates that it can live in diverse ecological environments, including changes in temperature, salinity, water flow, food availability, and other factors (Hamdy and Dorgham, 2018). Its representative exhibits lessepsian migration (Burukovsky et al., 2021).

Many inshore marine meroplankton larvae are of the Alpheidae family, but little is known about the larvae. The larvae of alpheid shrimp are poorly studied in Pakistan and its neighbouring waters, despite the fact that many species have been recorded here (Kazmi and Kazmi, 2012). We describe and illustrate in detail the zoeal stages of *A. lobidens* here. Furthermore, we compare these stages with those of other congeneric species.

2 Materials and Methods

2.1 Study area

An ovigerous female of *Alpheus lobidens* De Haan, 1850 was collected from Buleji near Karachi (Long. 66º49'E, Lat. 24º59'N). It is a rocky ledge located 30 kilometers away from Karachi (Fig. 1).

A planktonic sample was taken from Manora Channel (Long. 66°59'E, Lat. 24° 48'N) on 1995 (Fig. 2). Two stations, A and B, 5 kilometers apart were sampled. The samples included four 10 minute tows using Bango net 300 micron mesh size equipped with a flow meter at shallow depth 15'- 20'.

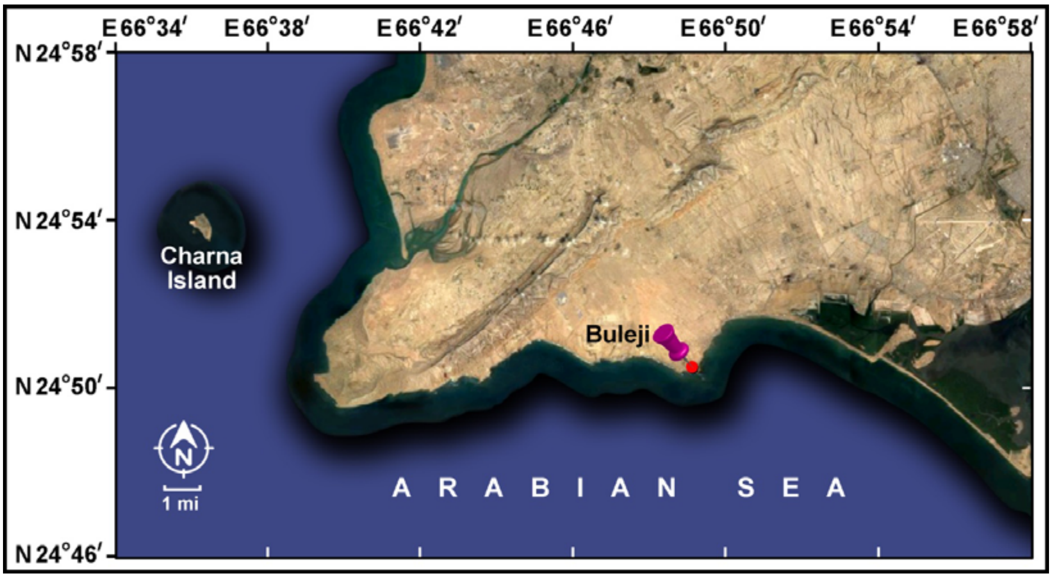

Fig. 1 Map showing collection site of Buleji.

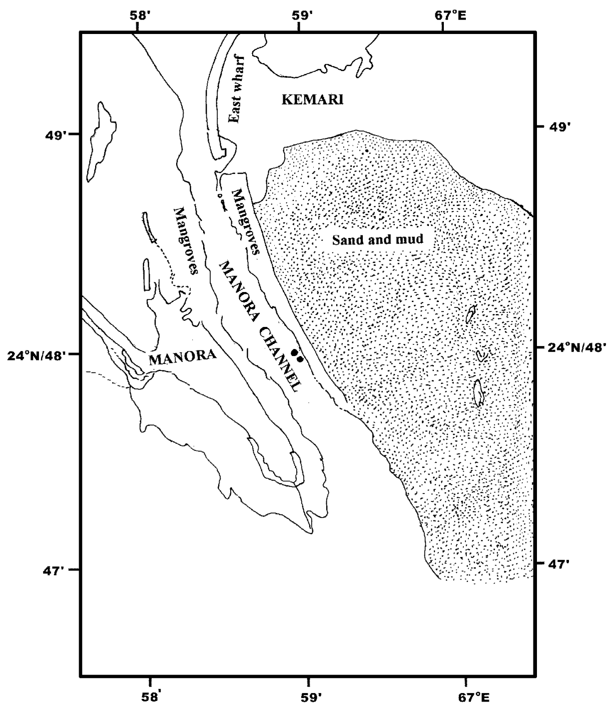

Fig. 2 Map showing sampling sites (solid circles) of plankton samples.

2.2 Methodology

Meteorological parameters, air and water temperature (^{o}C), salinity (o%) , dissolved oxygen (ml/1), pH and tide (m) were noted. We kept the ovigerous female in unfiltered seawater containing 37 - 40 ppt salinity under laboratory conditions at room temperature between 23^{o}C and 28^{o}C until hatching occurred.

A total of five beakers were used to separate and divide the newly hatched larvae (ten in each beaker, 500 ml) filled by filtered seawater of the alike salinity and temperature. The mortality rate and next developmental stage of each beaker were assessed daily. The exuviae were preserved and the live larvae were transferred to clean beakers filled with freshly filtered seawater, and at the same time offered newly hatched *Artemia* nauplii as food.

2.3 Fixation and preservation of material

Temporary slides of each stage were made using glycerin and 5% formalin (3 : 1). Measurements of each stage were made with the aid of a micrometer. The total length (TL) was determined by adding the carapace length (CL) (measured from the tip of the rostral spine to the midposterior margin of the telson). Measurements are in millimeter (mm).

2.4 Microscopic observations

The specimens were dissected through tungsten needle by using a Nikon binocular microscope (4 x 10/ 21 magnification). Olympus BH2 microscope (1.25 x 10, 20 and 40 magnifications) with Nomarski Differential Interference Contrast (D/C) and camera lucida attachment.

The spent female and the remaining larvae were deposited in the Marine Reference Collection and Resource Centre, University of Karachi.

Fig. 3 *Alpheus lobidens* De Haan, 1850.

2.5 Synopsis

Alpheus lobidens Tufail and Hashmi (1965) (Zoea I): 278-281 (as *Alpheus crassimanus*); Jang et al. (1999): 205; Yang et al. (2003) (early zoeas): 15-24.

Table 1 Analyses of *Alpheus lobidens* De Haan, 1850, larval stages and appearance times.

Stage	**Days Elapsed After Hatching**	**Total Length TL ± SD (mm)**
Zoea I	2 days	2.59 mm ± 2.89 mm
Zoea II	1 day	2.78 mm ± 2.88 mm
Zoea III	1 day	2.53 mm ± 2.75 mm
Zoea IV	1 day	2.62 mm ± 2.87 mm
Zoea V	2 days	2.43 mm± 2.50 mm

2.6 Systematics
Class: Malacostraca
Order: Decapoda
Infraorder: Caridea Dana, 1825
Family: Alpheidae Rafinesque, 1815
Genus: *Alpheus* Weber, 1795
Alpheus lobidens De Haan, 1850 (Fig. 3)

2.7 Synonymised names
Alpheus lobidens De Haan, 1849: 179; Banner & Banner, 1985: 19; Chace, 1988: 34; Hayashi, 1998: 394; Naderloo & Türkay, 2012: 10; Anker & De Grave, 2016: 364.
Alpheus lobidens lobidens Banner & Banner, 1974: 430; Banner & Banner, 1978: 223; Banner & Banner, 1982: 252.
Alpheus lobidens polynesica Banner & Banner, 1974: 429; Banner & Banner, 1982: 256.
Alpheus crassimanus Heller, 1862: 526; 1865: 170; Bate, 1888: 554; de Man, 1902: 880; Kemp, 1915: 299; Barnard, 1950: 756; Johnson, 1962: 53; Banner & Banner, 1966: 138; Johnson, 1979: 36.

2.8 Distribution
Eastern and Central Mediterranean and entire Indo-Pacific: Red Sea to Hawaii, Gulf of Oman and Arabian Sea.

2.9 Habitat
Typically found in the intertidal and shallow sub tidal areas, usually under rocks and large pieces of coral rubble, muddy intertidal, estuaries and mangroves areas.

3 Results
3.1 Description of the larvae
3.1.1 Zoea I (Fig. 4A – K)
Diagnostic Features

Carapace (Fig. 4A). - Smooth with a medio-dorsal hump; rostrum broad and distally pointed; eyes stalked.

Antennule (Fig. 4B). - Peduncle 2-segmented with 4 and 4 plumodenticulate setae, respectively; endopod present in a form of long plumose seta on distal segment; outer ramus (exopod) with 5 aesthetascs and 1 seta.

Antenna (Fig. 4C). - Biramous, peduncle with a distal spine on inner margin; endopod with 2 plumose setae and 1 spine; scaphocerite (exopod) 5-segmented with 2, 3, 1, 1 and 3 setae.

Mandible (Fig. 4D). - Well developed.

Maxillule (Fig. 4E). - Coxal endite with 2 cuspidate and 1 plumodenticulate seta; basial endite with 2 cuspidate and 1 plumodenticulate seta; endopod with 1 plumodenticulate seta.

Maxilla (Fig. 4F). - Coxal endite with 2 plumodenticulate setae; basial endite bilobed with 3 + 5 plumodenticulate setae; endopod with 2 plumodenticulate setae; scaphognathite with 4 setae.

Maxilliped I (Fig. 4G). - Coxopod naked; basipod with 5 setae; endopod 3-segmented, distal segment with 3 plumodenticulate setae; exopod with 2 terminal and 4 subterminal plumose natatory setae.

Maxilliped II (Fig. 4H). - Coxopod naked; basipod with 2 setae; endopd 4-segmented with 1, 0, 0 and 5 (4 setae + 1 spine); exopod with 2 terminal and 4 subterminal plumose natatory setae.

Maxilliped III (Fig. 4I). - Coxopod broken; basipod naked; endopod 4-segmented, distal segment with 1 long strong spine with 5 simple setae; exopod 2-segmented with 2 and 4 (2 terminal and 2 subterminal) plumose natatory setae.

Pereiopods I-V (Fig. 4J). - Rudimentary.

Abdomen (Fig. 4A). - 6-somites.

Telson (Fig. 4K). - Triangular, posterior margin with 8 pairs of long plumose setae, uropod rudimentary.

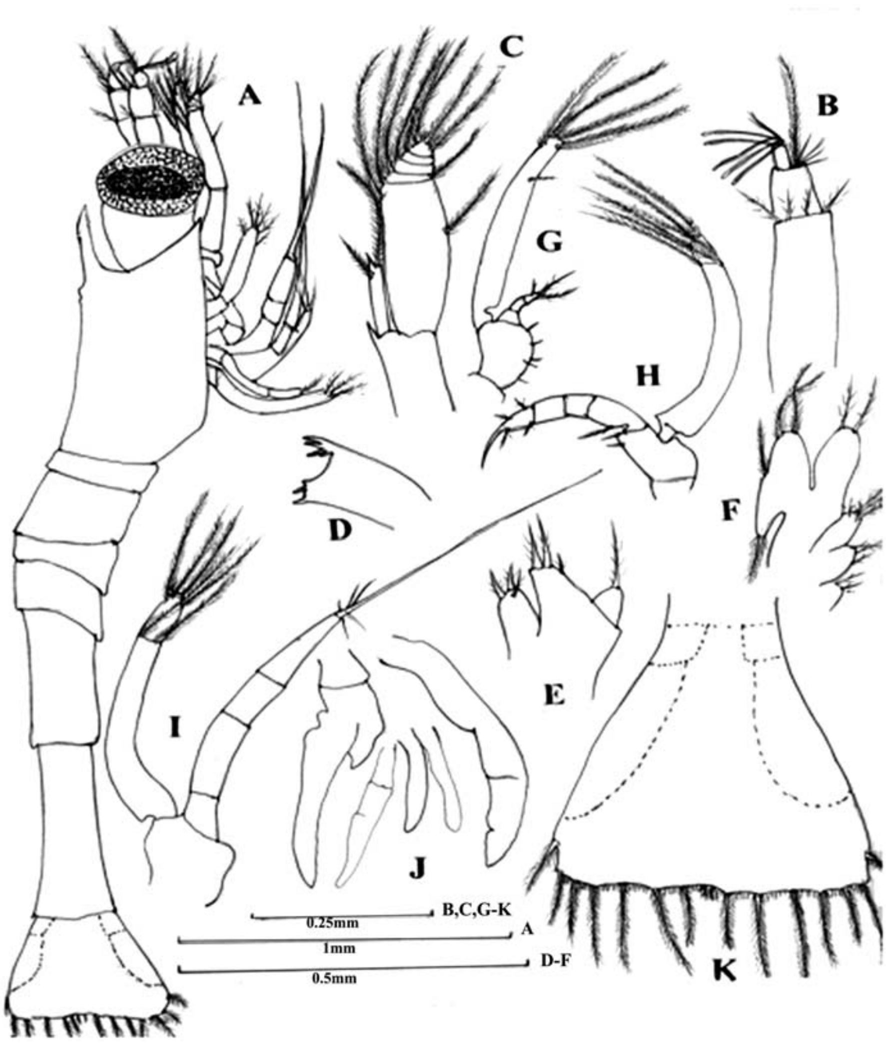

Fig. 4 *Alpheus lobidens* De Haan, 1850. Zoea I: A, entire, lateral view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla, G - I, maxillipeds I - III; J, pereiopods I - V; K, telson.

3.1.2 Zoea II (Figs. 5A – 6D)

Diagnostic Features

Carapace (Fig. 5A). - Smooth, rostrum small in size; eyes stalked.

Antennule (Fig. 5B). - Peduncle 2-segmented with 3 and 8 plumodenticulate setae, respectively; inner ramus (endopod) with 1 seta; outer ramus (exopod) with 4 aesthetascs and 1 seta.

Antenna (Fig. 5C). - Endopod with 2 plumose setae; scaphocerite with 10 setae.

Mandible (Fig. 5D). - Well developed.

Maxillule (Fig. 5E). - Coxal endite with 1 cuspidate and 3 plumodenticulate setae; basial endite with 2 cuspidate spines; endopod with 1 plumodenticulate seta.

Maxilla (Fig.5F). - Coxal endite with 2 plumodenticulate setae; basial endite bilobed with 3 + 3 plumodenticulate setae; endopod with 2 plumodenticulate setae; scaphognathite with 5 setae.

Maxilliped I (Fig. 5G). - Coxopod broken; basipod with 6 setae; endopod 3-segmented with 1, 0, and 3 plumodenticulate setae, respectively; exopod with 2 terminal and 3 subterminal setae.

Maxilliped II (Fig. 5H). - Coxopod broken; basipod with 1 seta; endopd 5-segmented with 1, 0, 0, 1 and 4 (3 setae + 1 spine) plumodenticulate setae, respectively; exopod with 2 terminal and 5 subterminal setae.

Maxilliped III (Fig. 5I). - Coxopod broken; basipod with 1 setae; endopod 5-segmented with 1, 0, 0, 0 and 4 (3 setae + 1 spine) plumodenticulate setae, respectively; exopod 2-segmented with 3 and 4 (2 terminal and 5 subterminal) plumose natatory setae.

Pereiopods I-V (Figs. 6A-C). - Biramous; pereiopod I (Fig. 6A) with rudimentary endopod; exopod with 2 terminal and 4 subterminal plumose natatory setae; pereiopods II-IV (Fig. 6B) rudimentary; pereiopod V (Fig. 6C) 5-segmented terminal segment ending in long strong spine with serrated tip.

Abdomen (Fig. 5A). - 5-somites.

Telson (Fig. 6D). - Triangular, posterior margin with 8 pairs of long plumose setae, uropod biramous; endopod naked; exopod with 6 long plumose setae.

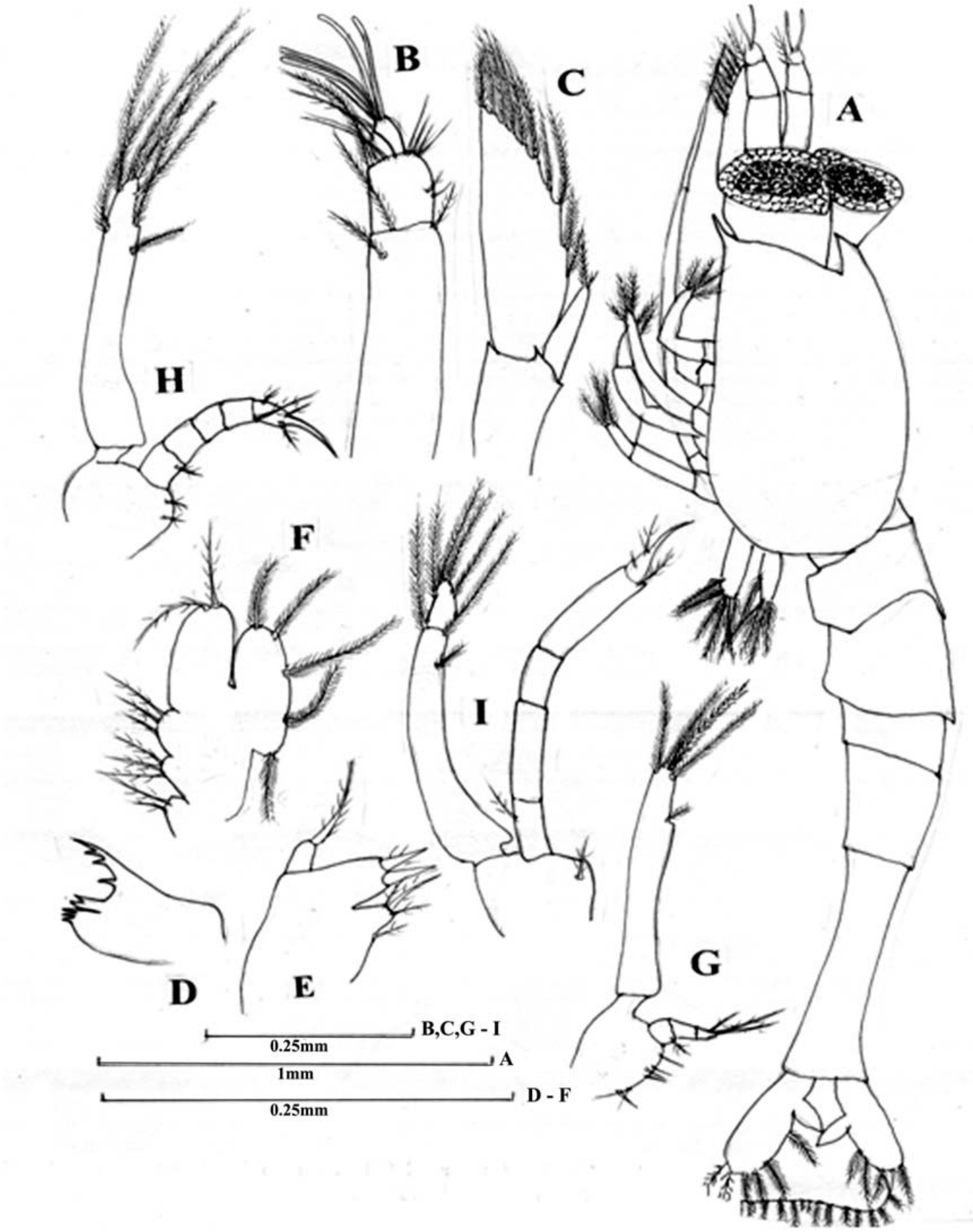

Fig. 5 *Alpheus lobidens* De Haan, 1850. Zoea II: A, entire, lateral view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla, G - I, maxillipeds I - III.

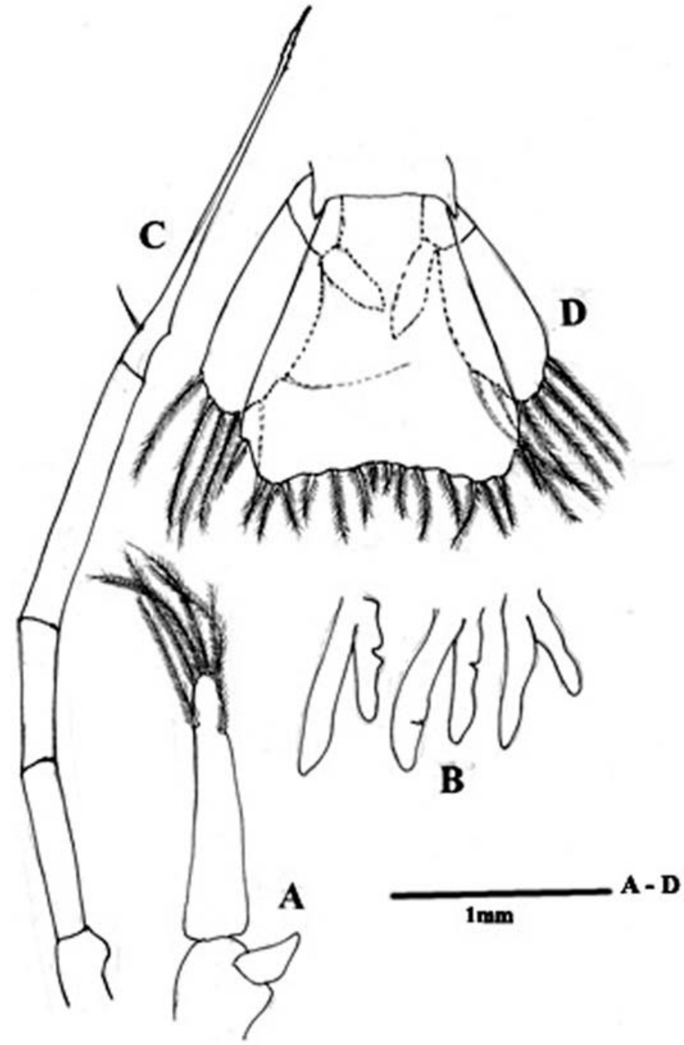

Fig. 6 *Alpheus lobidens* De Haan, 1850 . Zoea II: A - C pereiopods I - V; D, telson with uropods.

3.1.3 Zoea III (Figs. 7A – 8D)

Diagnostic Features

Carapace (Fig. 7A). - Smooth, rostrum small in size; eyes stalked.

Antennule (Fig. 7B). - Peduncle 2-segmented with 5 and 7 plumodenticulate setae, respectively; inner ramus (endopod) with 1 plumodenticulate setae; outer ramus (exopod) with 3 aesthetascs and plumodenticulate seta.

Antenna (Fig. 7C). - Endopod with 2 plumose setae; scaphocerite with 11 setae.

Mandible (Fig.7D). - Well developed.

Maxillule (Fig.7E). - Coxal endite with 4 plumodenticulate setae; basial endite with 2 cuspidate spines; endopod with 1 plumodenticulate seta.

Maxilla (Fig. 7F). - Coxal endite with 2 plumodenticulate setae; basial endite with 3 + 3 plumodenticulate setae; endopod with 3 plumodenticulate setae; scaphognathite with 5 setae.

Maxilliped I (Fig. 7G). - Coxopod with 2 and basipod with 5 plumodenticulate setae; endopod 3-segmented with 1, 0 and 3 plumodenticulate setae, respectively; exopod with 2 terminal and 2 subterminal plumose setae.

Maxilliped II (Fig. 7H). - Coxopod broken; basipod with 3 plumodenticulate setae; endopd 5-segmented with 1, 0, 0, 1 and 4 (3 setae + 1 spine) plumodenticulate setae, respectively; exopod with 2 terminal and 5 subterminal setae.

Maxilliped III (Fig. 7I). - Coxopod broken; basipod naked; endopod 5-segmented with 0, 0, 0, 2 and 3 (2 setae + 1 spine) plumodenticulate setae, respectively; exopod with 2 terminal and 4 subterminal plumose setae.

Pereiopods I-V (Figs. 8A-C). - Biramous; pereiopod I (Fig. 8A) with rudimentary endopod; exopod with 2 terminal and 4 subterminal plumose natatory setae; pereiopods II-IV (Fig. 8B) rudimentary; pereiopod V (Fig. 8C) 5-segmented terminal segment ending in long strong spine with serrated tip.

Abdomen (Fig. 7A). - 5-somites.

Telson (Fig. 8D). - Triangular, posterior margin with 1 pairs of spine and 7 pairs of long plumose setae, uropod biramous; endopod with 2 setae; exopod with 6 setae.

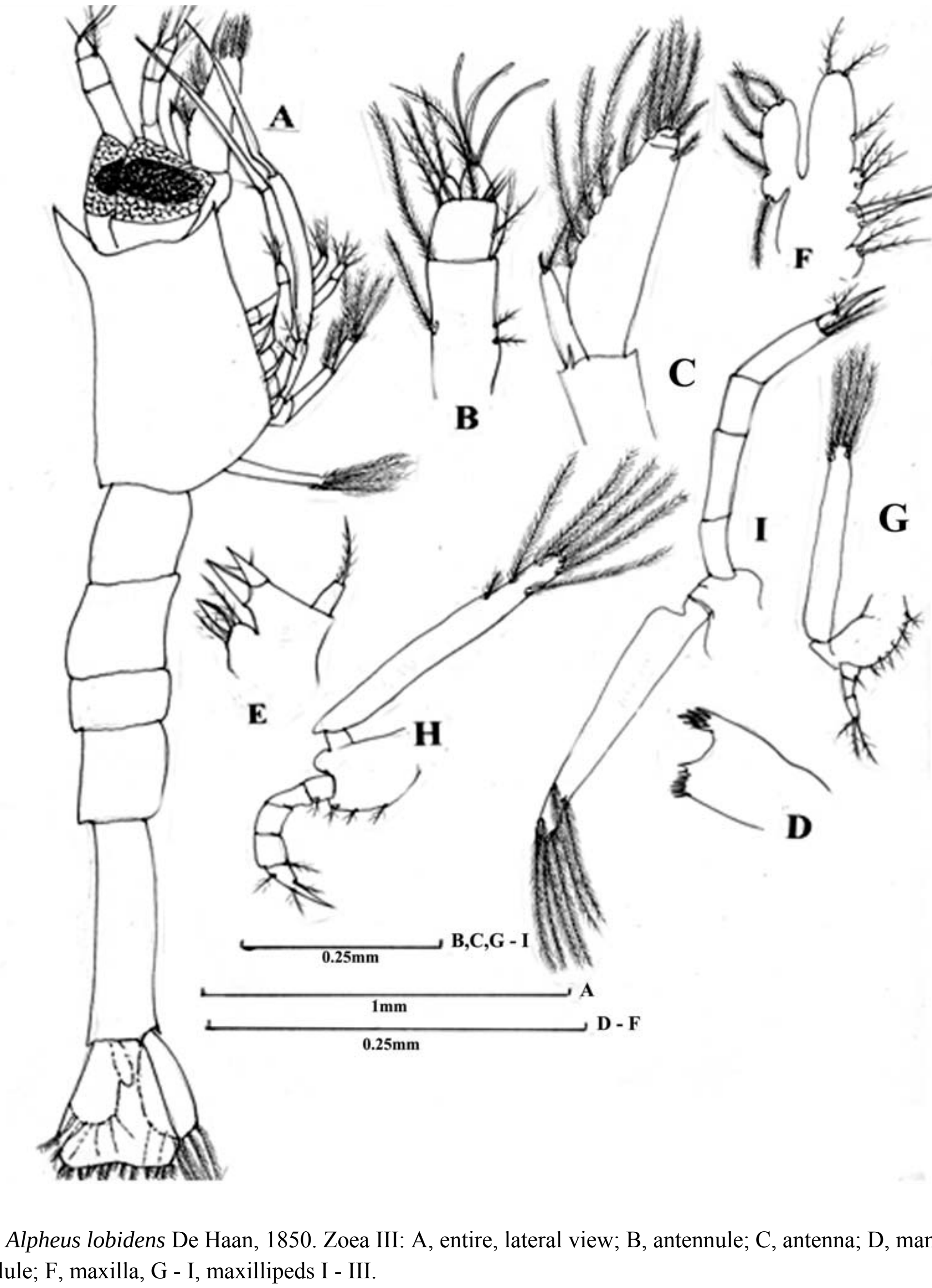

Fig. 7 *Alpheus lobidens* De Haan, 1850. Zoea III: A, entire, lateral view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla, G - I, maxillipeds I - III.

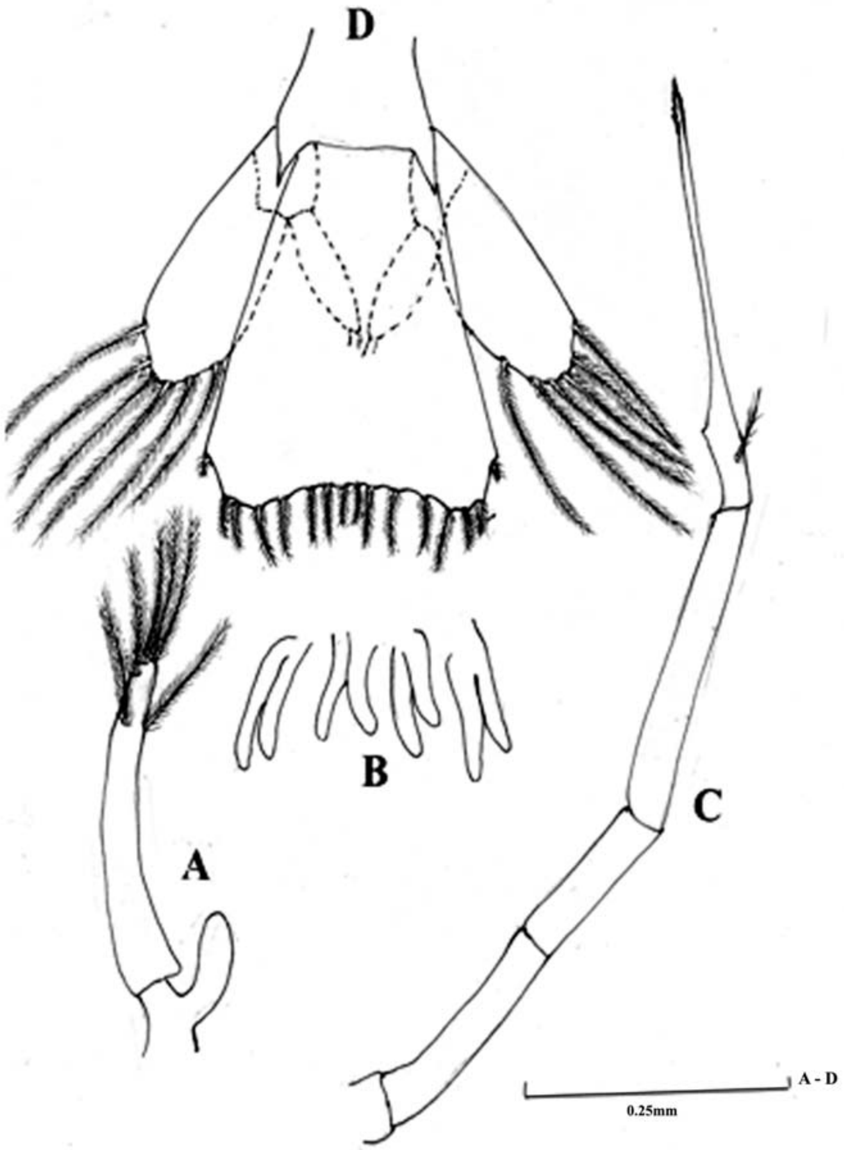

Fig. 8 *Alpheus lobidens* De Haan, 1850. Zoea III: A - C pereiopods I - V; D, telson with uropods.

3.1.4 Zoea IV (Figs. 9A – 10D)

Diagnostic Features

Carapace (Fig. 9A). - Smooth, rostrum small in size; eyes stalked.

Antennule (Fig. 9B). - Peduncle 2-segmented with 5 and 5 plumodenticulate setae, respectively; inner ramus (endopod) with 1 plumodenticulate setae; outer ramus (exopod) with 1 aesthetascs and 2 plumodenticulate seta.

Antenna (Fig. 9C). - Endopod with 2 plumose setae; scaphocerite with 13 setae.

Mandible (Fig. 9D). - More developed.

Maxillule (Fig. 9E). - Coxal endite with 5 plumodenticulate setae; basial endite with 2 cuspidate spines; endopod with 1 plumodenticulate seta.

Maxilla (Fig. 9F). - Coxal endite with 2 plumodenticulate setae; basial endite bilobed with 3 + 4 plumodenticulate setae; endopod with 1 plumodenticulate seta; scaphognathite with 6 setae.

Maxilliped I (Fig. 9G). - Basipod with 5 plumodenticulate setae; endopod 3-segmented with 1, 0 and 3 plumodenticulate setae, respectively; exopod with 2 terminal and 2 subterminal setae.

Maxilliped II (Fig. 9H). - Coxopod broken; basipod with 3 plumodenticulate setae; endopd 5-segmented with 1, 0, 0, 2, 3 and 4 (3 setae + 1 spine) plumodenticulate setae, respectively; exopod with 2 terminal and 3 subterminal setae.

Maxilliped III (Fig. 9I). - Coxopod broken; basipod with 1 seta; endopod 5-segmented with 0, 0, 0, 2 and 3 (2 setae + 1spine) plumodenticulate setae, respectively; exopod with 2 terminal and 4 subterminal setae.

Pereiopods I-V (Figs. 10A-C). - Biramous; pereiopod I (Fig. 10A) with rudimentary endopod; exopod with 2 terminal and 4 subterminal plumose natatory setae; pereiopods II-IV (Fig. 10B) rudimentary; pereiopod V (Fig. 10C) 5-segmented, terminal segment ending in long strong spine with serrated tip.

Abdomen (Fig. 9A). - 5- somites.

Telson (Fig. 10D). - Posterior margin with 1 pairs of spines and 5 pairs of plumose setae; endopod and exopod with 7-8 setae, respectively.

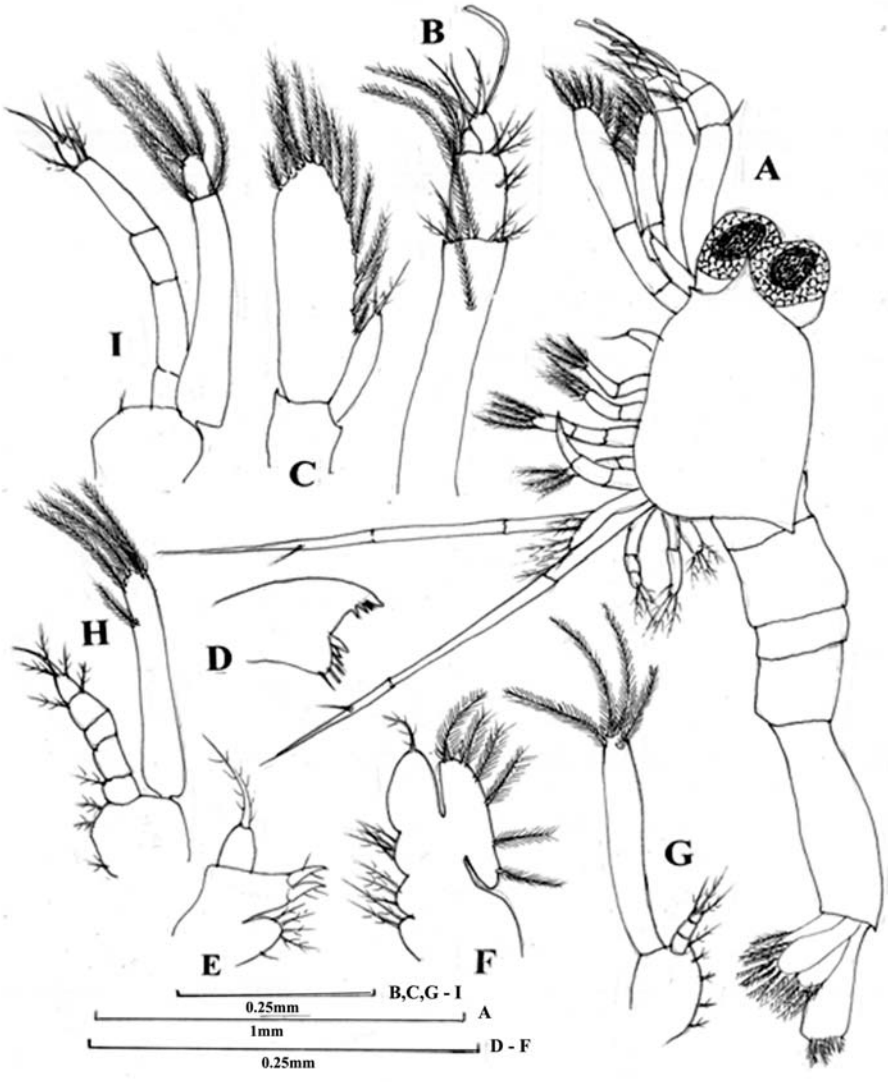

Fig. 9 *Alpheus lobidens* De Haan, 1850 . Zoea IV: A, entire, lateral view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla, G - I, maxillipeds I - III.

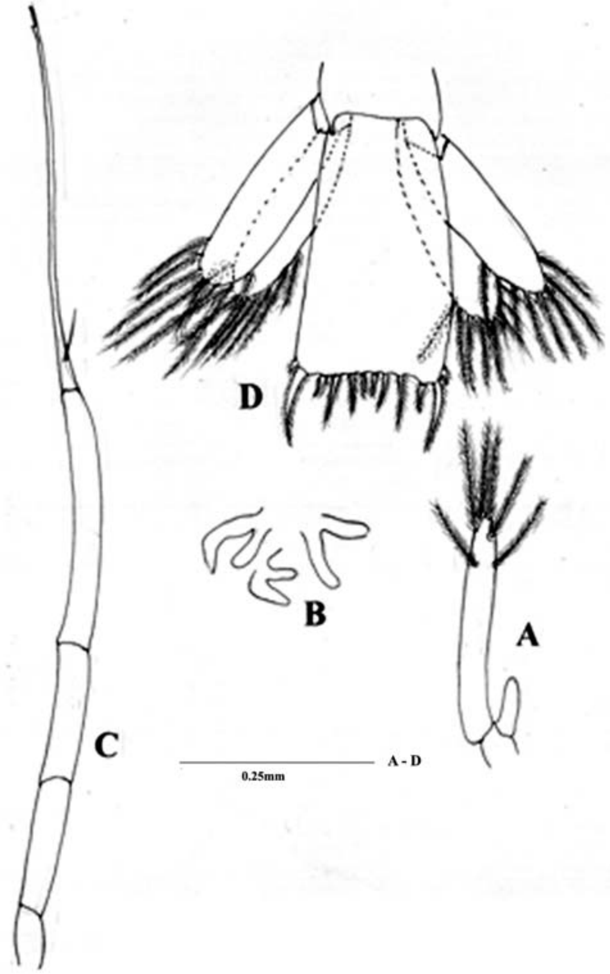

Fig. 10 *Alpheus lobidens* De Haan, 1850. Zoea IV: A - C pereiopods I - V; D, telson with uropods.

3.1.5 Zoea V (Figs. 11A – 12E)

Diagnostic Features

Carapace (Fig. 11A). - Smooth, rostrum small in size with pointed tip; eyes stalked.

Antennule (Fig. 11B). - Peduncle 2-segmented with 5 and 8 plumodenticulate setae, respectively; inner ramus (endopod) with 1 plumodenticulate setae; outer ramus (exopod) with 2 aesthetascs and 1 seta.

Antenna (Fig. 11C). - Endopod with 2 plumose setae; scaphocerite with 8 setae.

Mandible (Fig. 11D). - More developed.

Maxillule (Fig. 11E). - Coxal endite with 4 plumodenticulate setae; basial endite with 2 cuspidate and 1 seta; endopod with 1 plumodenticulate seta.

Maxilla (Fig. 11F). - Coxal endite with 2 plumodenticulate setae; basial endite bilobed with 4 + 4 plumodenticulate setae; endopod with 2 plumodenticulate setae; scaphognathite with 6 setae.

Maxilliped I (Fig. 11G). - Coxopod broken; basipod with 5 plumodenticulate setae; endopd 3-segmented with 1,0 and 3 plumodenticulate setae, respectively; exopod with 2 terminal and 2 subterminal plumose natatory setae.

Maxilliped II (Fig. 11H). - Coxopod broken; basipod with 4 plumodenticulate setae;

endopd 5-segmented with 1, 0, 0, 2 and 4 (3 setae + 1 spine) plumodenticulate setae, respectively; exopod with 4 terminal plumose natatory setae.

Maxilliped III (Fig. 11I). - Coxopod broken; basipod with 1 seta; endopod 5-segmented with 0, 0, 0, 2 and 3 (2 setae + 1 spine) plumodenticulate setae, respectively; exopod with 2 terminal and 4 subterminal plumose natatory setae.

Pereiopods I-V (Figs. 12A-C). - pereiopod I (Fig. 12A) with rudimentary endopod; exopod with 2 terminal and 4 subterminal setae; pereiopod II (Fig. 12B) with rudimentary endopod and exopod with 8 setae pereiopods III & IV (Fig. 12B) rudimentary; pereiopod V (Fig. 12C) 5-segmented, terminal segment ending in long strong spine with serrated tip.

Abdomen (Fig. 11A). - 5-somites.

Telson (Fig. 12E). - Posterior margin with 1 pairs of spine and 4 pairs of setae; endopod and exopod both with 8 setae.

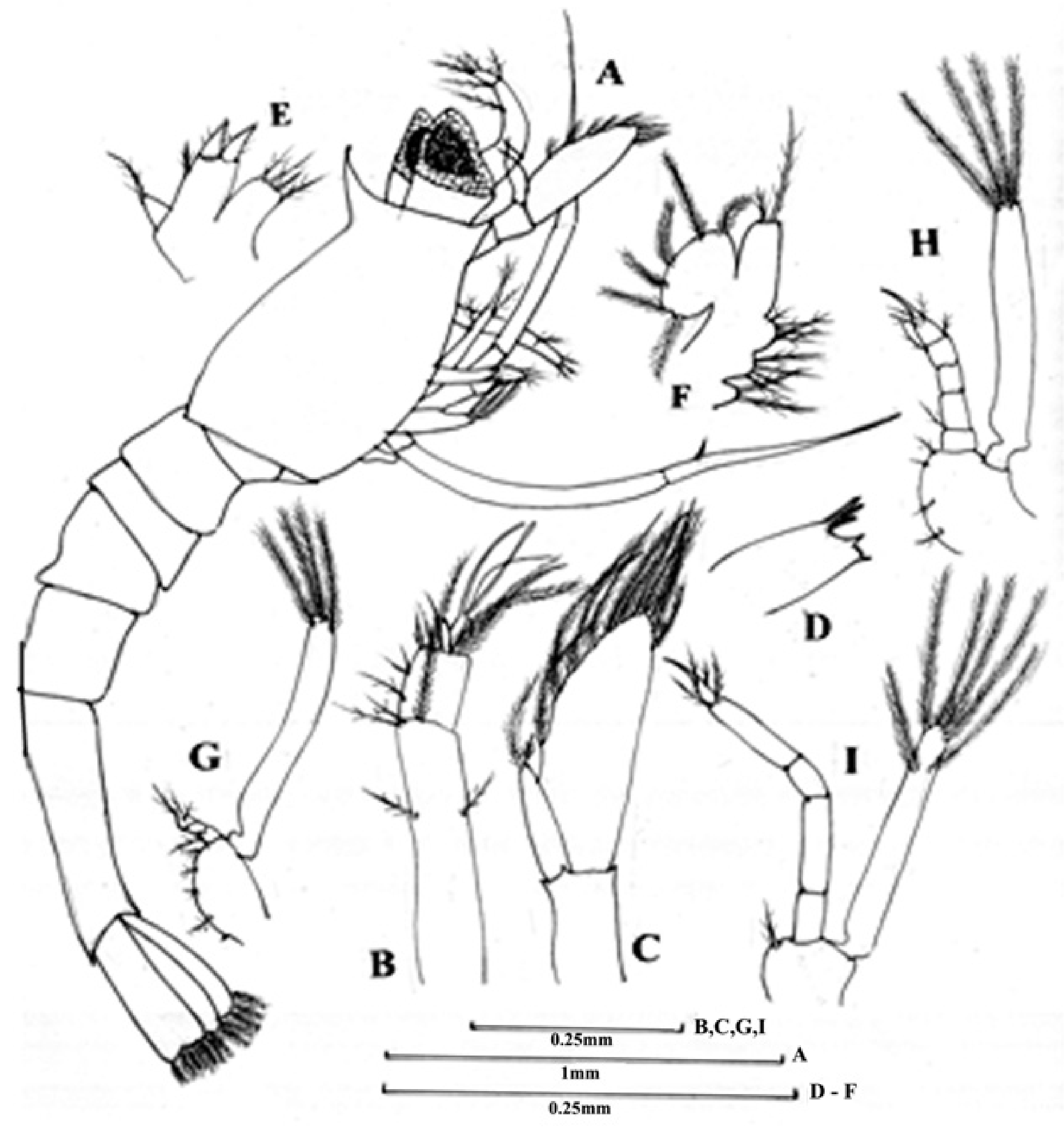

Fig. 11 *Alpheus lobidens* De Haan, 1850. Zoea V: A, entire, lateral view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla, G - I, maxillipeds I - III.

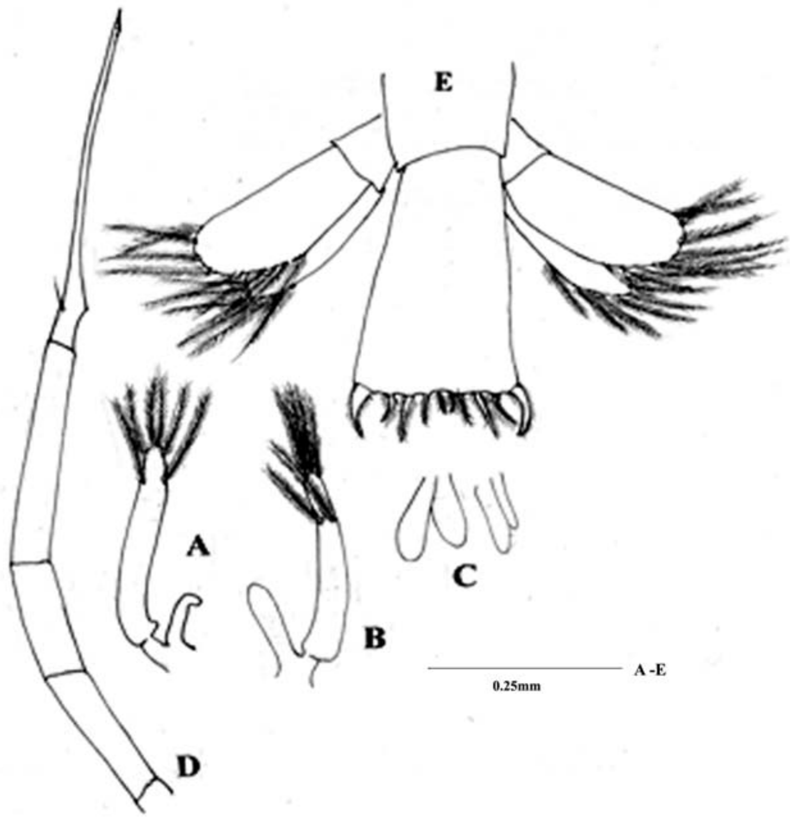

Fig. 12 *Alpheus lobidens* De Haan, 1850. Zoea V: A - D pereiopods I - V; E, telson with uropods.

4 Discussion

Alpheus sp. exhibit prolonged larval development. While some species of Alpheidae shows abbreviated development. Conspecific individual livings under different environmental conditions produce larvae with vastly different developmental modes (Knowlton, 1973). Brooks and Herrick (1892) claimed that the same species in different localities may produce different types of larvae.

Lebour, 1932 and Knowlton, 1973 have been described complete larval development of *Alpheus macrocheles* and *A. heterochaelis* respectively, another 23 species (*A. normanni* by Brooks and Herrick, 1892; *A. laevis* by Coutiĕre, 1899; *A. pacificus* and *A. lottini* by Gurney, 1938; Gohar and Al-Kholy, 1957; *A. rapacida and A. strenuous* by Prasad and Tampi, 1957, *A. rapax* and *A. ventrosus* by Al-Kholy, 1960, *A. lobidens* by Tufail and Hashmi, 1965 as = *Alpheus crassimanus*; Jang et al., 1999; *A. dentipes* by Fernández-Muñoz, 1987; *A. euphorsyne richardsoni* by Yang and Kim 1996, *A. brevicristatus* by Yang and Kim, 1998; *A. heeia* by Yang and Kim, 1999; Yang et al., 2003, *A. sudara* by Yang et al., 2003, *A. armillatus* by Mossolin et al., 2006, *A. albatrossaie* by Yang and Kim, 2006; *A. estuariensis* Pires et al., 2008; *Alpheus brasileiro* by Pescinelli et al., 2017; *Alpheus formosus* and *Alpheus malleator* 2020; *A. japonicas*, *A. digitalis* by Yang and Kim, 2022; *A. edwardsii* by Ghory, 2023) failed to develop in culture attempts and so descriptions of their larval stages are incomplete.

The rostrum is present in the *A. lobidens* (present study) and *A. edwardsii,* while absent in all other species. The number of setae on the maxillule coxal endite is also diversable: *A. estuariensis, A. euphorosyne richardsoni, A. heeia, A. digitalis, A. japonicus* and *A. brevicristatus, A.albatrossae, A.edwardsii,* and *A. lobidens* (present study), all have three, whereas in *A. sudara, A. lobidens* and *A. heterochaelis* they vary from

1 - 5. As well all *A. estuariensis, A. brevicristatus, A. heterochaelis, A. heeia* and *A.edwardsii* have the similar number of spines on the maxillule basal endite and be deficient in setae, although in *A. lobidens, A. japonicus, A. digitalis, A. euphorsyne richardsoni* and *A. sudara* have one or two supplementary setae are present.

A morphological comparison shows that the first zoeal stage of *A. lobidens* larvae is similar to that of other *Alpheus* species (Table 4). Due to this similarity, specific identification may be difficult. In spite of this, there are some differences that could be useful for identification. Larvae caught from plankton are difficult to identify. Comparing larvae reared in laboratory conditions and accompanied by illustrations is the only way to accurately identify such material.

Table 2 Comparison between laboratory reared zoea I of *Alpheus lobidens* (present study) with previously reared zoea I of same species: Zoea I.

Characters	*A. lobidens* Present study	*A. lobidens* Tufail & Hashmi (1965)	*A. lobidens* Yang & Kim (2002)	*A. lobidens* Yang et al. (2003)
Rostrum	present	present	absent	absent
Antennule: peduncle	2-segmented	not mentioned	unsegmented	unsegmented
endopod	present in a form of long plumose seta	lobe like endopod present	not mentioned	present in a form of long plumose seta
exopod	5 aesthetascs + 1 seta	2 setae	3 aesthetascs	3 aesthetascs
Antenna: endopod	Unsegmented with 2 setae + 1 spine	2-segmented with 2 setae	not mentioned	unsegmented with 1 seta and 1 spine
exopod	5-segmented with 10 setae	unsegmented with 8 setae	6-segmented with 11 setae	6-segmented with 11 setae
Maxillule: setae coxalendite	3 setae	not mentioned	2 setae	4 setae
basialendite	2 spines + 1 seta	not mentioned	2 setae + 2 spines	4 setae
Maxilla: setae scaphognathite	4 setae	12 setae	3 - 5 setae	5 setae
Maxilliped I: setae coxopod	without setae	not mentioned	not mentioned	1 seta
Basipod	5 setae	3 setae	not mentioned	7 setae
Endopod	3 setae	4 setae	not mentioned	4 setae
Maxilliped II: setae endopod	5-segmented with 1, 0, 0 and 5 setae	not mentioned	4-segmented	5-segmented with 1, 0, 1, 3 setae
Maxilliped III:	developed	underdeveloped	not mentioned	developed

setae basipod	without setae	not mentioned	not mentioned	1 seta
endopod	4-segmented with 0, 0, 0, 6 setae	not mentioned	not mentioned	4-segmented with 0, 0, 2, 2 setae
Telson: setae posterior margin	8 pairs	8 pairs	7 pairs	7 pairs

Table 3 Comparison between laboratory reared zoea II – IV and planktonic caught zoea II of *Alpheus lobidens.*

Zoea II.

Characters	*A. lobidens* Present study, lab. reared	*A. lobidens* Present study, planktonic	*A. lobidens* Yang et al. (2003)
Antennule: setae peduncle	2-segmented with 3, 8 setae	2-segmented with 3, 5 setae	2-segmented with 3, 5 setae
exopod	4 aesthetascs + 1 seta	2 aesthetascs + 1 seta	not mentioned
Maxillule: setae basial endite	2 setae	2 setae	3 setae
Maxilla: setae endopod	2 setae	1 + 2 setae	3 setae
Maxilliped I: setae endopod	3-segmented with 1, 0, 3 setae	3-segmented with 0 ,0, 3 setae	unsegmented with 3 setae
exopod	4 setae	5 setae	4 setae
Maxilliped II: setae endopod	5-segmented with 1, 0, 0, 1, 4 setae	3-segmented with 0, 2, 3 setae	5-segmented with 1, 0, 0, 1, 3 setae
exopod	7 setae	4 setae	not mentioned
Maxilliped III: setae basipod	1 seta	setae absent	not mentioned
endopod	5-segmented with 1, 0, 0, 0, 4 setae	5-segmented with 1, 0, 0, 1, 3 setae	5-segmented with 0, 0, 0, 2, 2 setae
Telson: uropod	developed	developed	underdeveloped

Zoea III:

Characters	*A. lobidens* Present study, lab. reared	*A. lobidens* Yang et al. (2003)
Antennule: setae peduncle	2-segmented with 5, 7 setae	2-segmented with 6, 7 setae
Maxillule: setae coxal endite	4 setae	6 setae
Basial endite	2 setae	4 setae
Maxilla: setae basial endites	3 + 3 setae	4 + 5 setae
scaphognathite	5 setae	7 setae
Maxilliped I: setae coxopod	2 setae	1 seta
basipod	5 setae	7 setae
endopod	3-segmented with 1, 0, 3 setae	unsegmented with 3 setae
exopod	4 setae	4 setae
Maxilliped III: setae basipod	without setae	1 seta
endopod	5-segmented with 1, 0, 0, 0, 4 setae	5-segmented with 0, 0, 0, 2, 2 setae
Telson: posterior margin	8 pairs setae	7 pairs setae
Uropod: endopod	2 setae	without setae

Zoea IV:

Characters	*A. lobidens* present study, lab. reared	*A. lobidens* Yang et al. (2003)
Antennule: setae peduncle	2-segmented with 5, 5 setae	2-segmented with 6, 10 setae
Maxillule: setae coxal endite	5 setae	6 setae
basial endite	2 setae	4 setae
Maxilla: setae basial endite	3 + 4 setae	5 + 5 setae
endopod	1 seta	3 setae
scaphognathite	6 setae	7 setae
Maxilliped I: setae coxopod	2 setae	1 seta
basipod	5 setae	8 setae
endopod	3-segmented with 1, 0, 3 setae	unsegmented with 4 setae
Maxilliped II: setae basipod	3 setae	4 setae
Maxilliped III: setae basipod	without setae	1 seta
Telson: setae uropod endopod and exopod	7 - 8 setae	11 - 12 setae

Table 4 Comparison of morphological features of first zoeal stage of 11 species belonging to the Alpheidae species (after Ghory, 2023): Zoea I.

Characters	*A.lobidens* , 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.obidens* Yang *et al.* (2003)	*A.sudara* Yang et al. (2003)	*A.albatrossae* Yang & Kim (2006)	*A.estuariensis* Pires et al. (2008)	*A.edwardsii,* Ghory, (2023)
Rostrum	present	absent	absent	absent	Absent	absent	absent	absent	absent	absent	absent	present
Antennule Peduncle segment	2-segmented	unsegmented	unsegmented	unsegmented	Unsegmented	Unsegmented	unsegmented	unsegmented	unsegmented	unsegmented	unsegmented	3-segmented
Outer flagellum	5 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	1 aesthetascs + 1 seta
Antenna Distal segment	4	5	4	3	5	5	4	6	6	5	4	unsegmented
Exopodite	10 setae	11 setae	11 setae	11 setae	11 setae	11 setae	11 setae	11 setae	11 setae	11 setae	11 setae	11 setae
MaxilluleEndopodite	1 seta	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 + 1 seta	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	2 spines
Coxalendite	3 setae	1 seta	3 + 1 seta	3 setae	5 setae	3 setae	3 setae	2 setae	4 setae	3 setae	3 setae	3 setae
Maxilla Scaphognathite	4 setae	8-10 setae	5 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	5-segmented
Telson	8 pairs	7 pairs	7 pairs	7 pairs	7 pairs	7 pairs	7 pairs	7 pairs	7 pairs	7 pairs	7 pairs	7 pairs

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