Article

First report of morpho-taxonomic study of laboratory reared *Synalpheus thai* Banner and Banner, 1966 (Crustacea: Decapoda: Alpheidae)

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Received 5 November 2024; *Accepted 10 December 2024*; *Published online 25 December 2024*; *Published 1 June 2025*

Abstract
The present information is based on the morpho-taxonomic study of the zoeal stages of *Synalpheus thai* Banner and Banner, 1966. The ovigerous female of *Synalpheus thai* was collected from Nathia Gali (Pacha, Karachi). Larvae were hatched at room temperature 30-32^{o}C, in filtered seawater of a salinity of 35-37 ppt and pH 7.8. All the zoeal stages of *S. thai* are described along with their illustrations, and compared with the available descriptions of its congeners larvae given earlier.

Keywords decapoda; Alpheidae; morpho-taxonomic study; *Synalpheus thai*; Pakistan.

Arthropods
ISSN 2224-4255
URL: http://www.iaees.org/publications/journals/arthropods/online-version.asp
RSS: http://www.iaees.org/publications/journals/arthropods/rss.xml
E-mail: arthropods@iaees.org
Editor-in-Chief: WenJun Zhang
Publisher: International Academy of Ecology and Environmental Sciences

1 Introduction

The genus *Synalpheus* is one of the most species-rich genera of tropical crustaceans and represents a dominant component of coral reef crypto faunas throughout the world (Bruce, 1976; Chace, 1989). Although their abundance and diversity, the systematic relationships and taxonomy of *Synalpheus* remain poorly determined (Gurney, 1938, 1949; Dardeau, 1986; Ríos, 1999, 2007; Anker and Tóth, 2008; Yang, 2009; Anker and Pachelle, 2014; Anker et al., 2012, 2016, 2017; Ashrafi et al., 2020; Santos et al., 2020, 2024).

Approximately 115 currently recognized species of genus *Synalpheus* worldwide. In Pakistani waters is represented by three species: *Synalpheus tumidomanus, S. neptunus* and *S. thai* (Kazmi and Kazmi, 2010). Previously advance developmental stages of *S. tumidomanus* and *S. neptunus* have been reported (Ghory and Siddiqui; 2001; Ghory et al., 2011). In the present study the zoea I-III of *S. thai* are described and illustrated. The larvae of *S. thai* are unknown and consequently this study will be the first on the species.

2 Materials and Methods

2.1 Study area

An ovigerous female of *Synalpheus thai* Banner and Banner, 1966 (Fig. 1) measuring 14 mm was obtained from Nathia Gali (Pacha) (long 66^{o} 43’ 00” E , lat 24^{o} 50’ 54”N). It is the last point on the coastline of Karachi.

2.2 Methodology

The ovigerous female was kept in the laboratory in filtered seawater with a salinity of 35-37‰ and pH 7.9 at room temperature (30°C - 32°C). Newly hatched larvae were segregated and placed, five larvae per beaker (500 ml), containing filtered seawater. *Artemia* nauplii were offered as food. Each beaker was examined daily for exuviae and dead larvae.

2.3 Microscopic observations

Temporary slides were made by using glycerin plus 5% formalin (3:1). The specimens were dissected by using tungsten needle under a binocular microscope (Nikon) with 10x/21 magnifications. The illustrations were made with the help of Olympus BX51 microscope (magnifications WHN10X/22 x10, 20 and 40) with Nomarski interference contrast and camera lucida attachment. Measurements (millimeter = mm) of illustrated specimens were made by using stage micrometer. The total length (TL) was determined from the tip of the rostrum to the mid posterior border of the telson. The spent female and the remaining larvae were deposited in the Marine Reference Collection and Resource Centre, University of Karachi.

Table 1 Time of the first appearance and measurements of each larval stage of *Synalpheus thai* Banner and Banner, 1966.

Stage	**Days elapsed after hatching**	**Total Length TL ± SD (mm)**
Zoea I	6 days	02.00 mm ± 02.05 mm
Zoea II	1 day	02.97 mm ± 03.00 mm
Zoea III	1 day	02.99 mm ± 03.05 mm

Fig. 1 *Synalpheus thai* Banner and Banner, 1966.

3 Results

Description of larvae is as follows:

3.1 Zoea I (Fig. 2A – L)

Diagnostic Features

Carapace (Fig.2A).-Smooth; rostrum basally broad and distally pointed; reaching near the distal end of 1st antennular segment; eyes stalked.

Antennule (Fig.2B).-Biramous; peduncle 4-segmented with 8,7,0 and 5 plumodenticulate setae, respectively; inner ramus (endopod) with 1 spine and 1 simple seta; outer ramus (exopod) with 5 aesthetascs.

Antenna (Fig.2C).-Biramous; peduncle with 1 plumodenticulate seta; endopod with 3 simple setae; exopod (scaphocerite) with 13 setae.

Mandible (Fig.2D).-Well developed.

Maxillule (Fig.2E).-Coxal endite with 4 plumodenticulate setae; basialendite with 4 cuspidate setae; endopod with 2 setae.

Maxilla (Fig.2F).- Coxal and basial endites bilobed with 4 + 3 and 3 + 2 plumodenticulate setae, respectively; endopod with 1 plumodenticulate seta; scaphognathite with 7 setae.

Maxilliped I (Fig.2G).-Coxopod naked; basipod with 4 simple setae and 4 spines; endopod unsegmented with 3 plumodenticulate setae; exopod 2-segmented, distal segment with 4 setae terminally.

Maxilliped II (Fig.2H).-Coxopod broken; basipod naked; endopod 5-segmented with 0,0,0, 1 and 3 plumodenticulate setae, respectively; exopod partially segmented, terminal segment with 2 terminal and 4 subterminal setae.

Maxilliped III (Fig.2I).-Coxopod broken; basipod naked; endopod 5-segmented, segment 2 with 2 plumodenticulate setae; exopod with 2 terminal and 4 subterminal setae.

Pereiopods I-V (Figs.2J-L).-Pereiopod I and II (Figs.2J, K) biramous and rudimentary; pereiopods III-V (Fig.2L) uniramous and rudimentary.

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

Telson (Fig.2A).-Trianular; posterior margin with 8 pairs of setae.

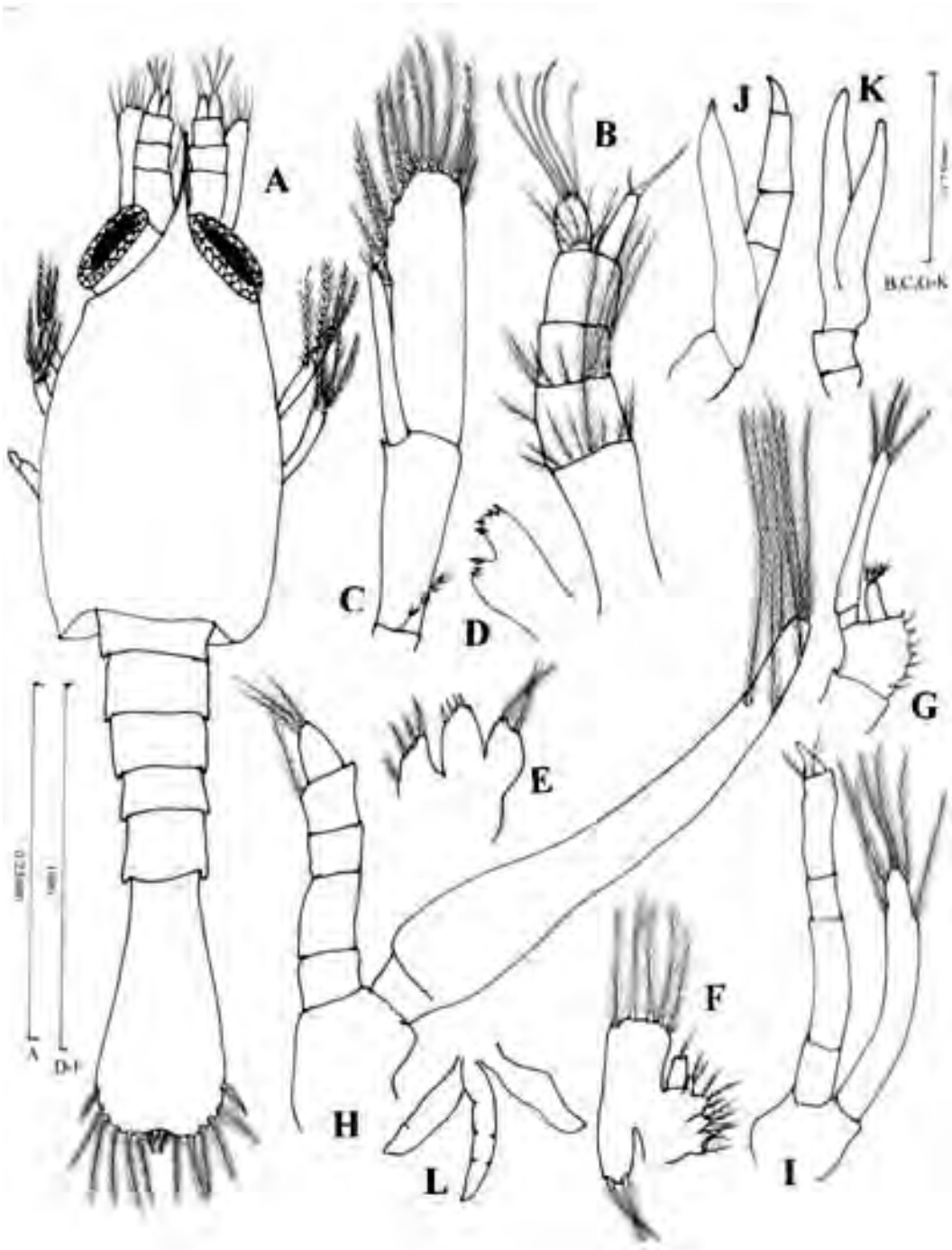

Fig. 2 ***Synalpheus thai*** **Banner & Banner, 1966. Zoea I:** A, entire, dorsal view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla, G-I, maxillipeds I-III; J-L, pereiopods I-V.

3.2 Zoea II (Figs. 3A - 4E)

Diagnostic Features

Carapace (Fig.3A).-With a medio-dorsal hump.

Antennule (Fig.3B).-Peduncle 4-segmented with 1,6,3 and 6 plumodenticulate setae; inner ramus (endopod) with 2 simple setae; outer ramus (exopod) with 3 aesthetascs.

Antenna (Fig.3C).-Endopod with 2 simple setae; scaphocerite with 15 setae.

Mandible (Fig.3D).-Well developed.

Maxillule (Fig.3E).-Coxal endite with 5 plumodenticulate setae; basialendite with 4 cuspidate setae; endopod with 2 setae.

Maxilla (Fig.3F).-Coxal and basial endites bilobed with 4 + 5 and 5+ 2 plumodenticulate setae, respectively; endopod with 3 plumodenticulate setae; scaphognathite with 7 setae.

Maxilliped I (Fig.3G).-Coxopod with 1 seta; basipod with 4 simple setae and 4 spines; endopod 2-segmented with 1 and 2 plumodenticulate setae, respectively; exopod with 2 terminal and 2 subterminal setae terminally.

Maxilliped II (Fig.3H).-Coxopod broken; basipod naked; endopod 5-segmented with 0,0,0,2 and 4 plumodenticulate setae, respectively; exopod with 2 terminal and 4 subterminal setae.

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

Pereiopods I-V (Figs.4A-D).-Pereiopod I (Fig.4A) coxopod broken; basipod with 1 seta; endopod 5-segmented, segment 2 with 1 and terminal segment with 3 plumodenticulate setae; exopod with 2 terminal and 4 subterminal setae; pereiopod II (Fig.4B) coxopod broken; basipod with 1 seta; 5-segmented endopod, segment 2 with 1 and terminal segment with 3 setae; exopod 2-segmented, terminal segment with 2 terminal and 4 subterminal setae; pereiopods III and IV (Fig.4C) rudimentary; pereiopod V (Fig.4D) 5-segmented, terminal segment strong spine like.

Pleopods (Fig.3A).-Rudimentary.

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

Telson (Fig.4E).-Broad; posterior margin with 7 pairs of setae; uropod developed; endopod naked; exopod with 6 setae.

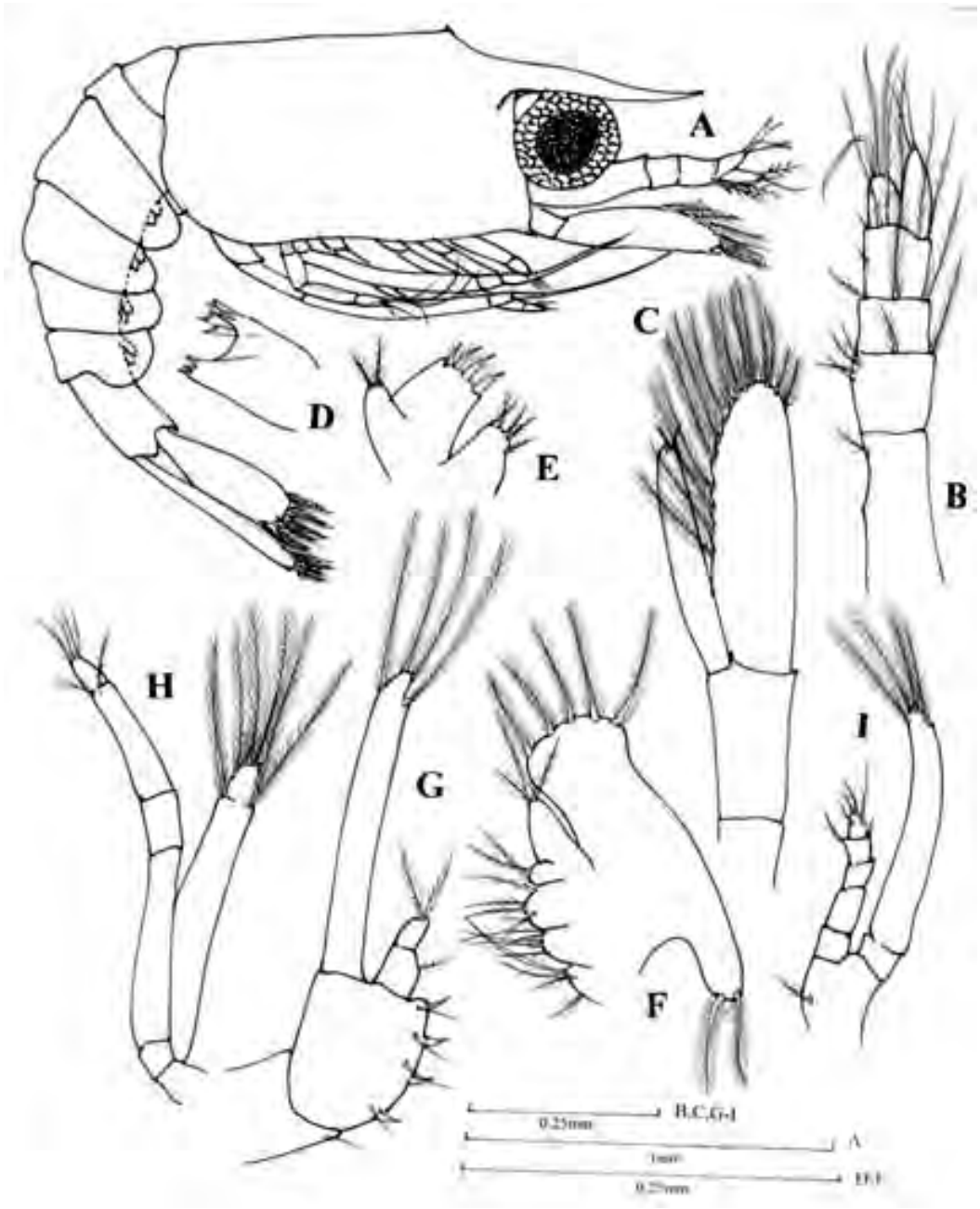

Fig. 3 ***Synalpheus thai*** **Banner & Banner, 1966. Zoea II:** A, entire, lateral view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla, G-I, maxillipeds I–III.

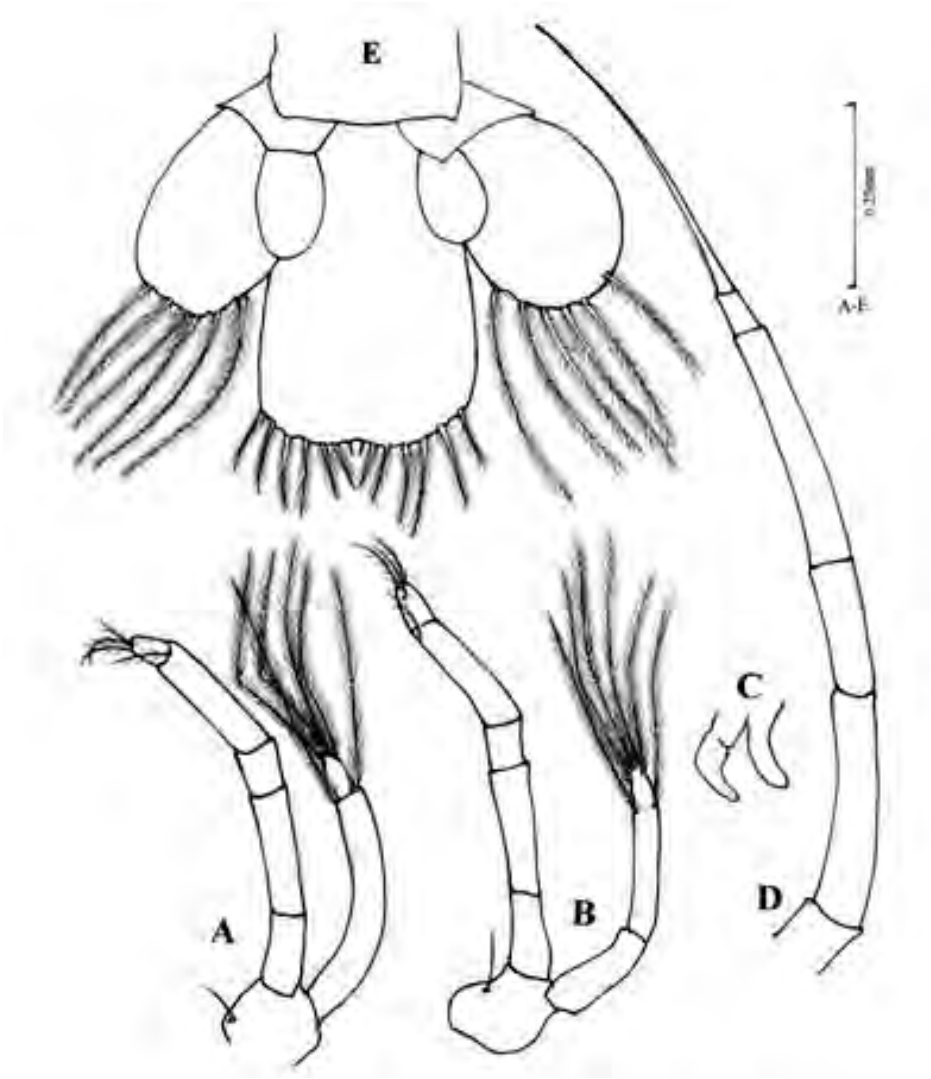

Fig. 4 *Synalpheus thai* Banner & Banner, 1966. Zoea II: A-D, pereiopods I-V; E, telson with uropods dorsal view.

3.3 Zoea III (Figs. 5A - 6F)

Diagnostic Features

Carapace (Fig.5A).-Rostrum small.

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

Antenna (Fig.5C).-Endopod with 2 simple setae; exopod with 12 setae.

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

Maxillule (Fig.5E).-Coxal endite with 4 plumodenticulate setae; basial endite with 4 cuspidate setae; endopod with 2 setae.

Maxilla (Fig.5F).-Coxal and basial endites bilobed with 3 + 2 and 5 + 2 plumodenticulate setae, respectively; endopod with 3 plumodenticulate setae; scaphognathite with 9 setae.

Maxilliped I (Fig.5G).-Coxopod broken; basipod with 4 simple setae and 4 spines; endopod with 3 terminal and 1 subterminal plumodenticulate setae; exopod with 2 terminal and 2 subterminal long plumose natatory setae.

Maxilliped II (Fig.5H).-Coxopod broken; basipod with 2 plumodenticulate setae; segmented endopod, segment 2 with 1 and terminal segment with 4 plumodenticulate setae; exopod with 2 terminal and 4 subterminal plumose natatory setae.

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

Pereiopods I-V (Figs.6A-E).-Pereiopods I-III (Figs.6A-C) well developed; endopod and exopod present; pereiopod IV (Fig.6D) rudimentary; pereiopod V (Fig.6E) 5-segmented, terminal segment strong spine like.

Pleopods (Fig.5J).-Rudimentary.

Abdomen (Fig.5J).-6-somites.

Telson (Fig.6F).-Triangular; posterior margin with 1 pair of spine and 3 pairs of setae; endopod with 10 setae; exopod with 8 setae.

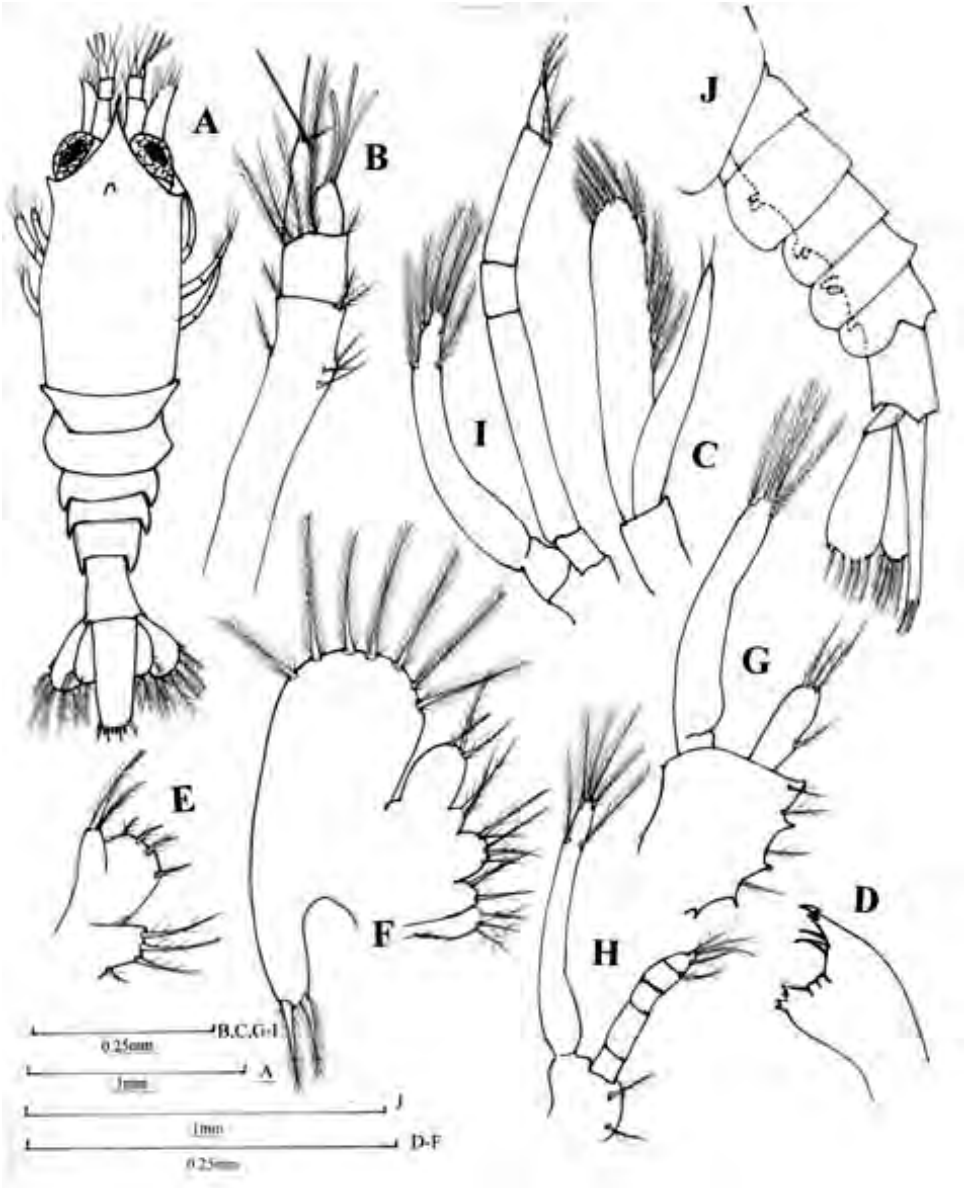

Fig. 5 ***Synalpheus thai*** **Banner & Banner, 1966. Zoea III:** A, entire, dorsal view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla, G-I, maxillipeds I–III; J, abdomen with telson, lateral view.

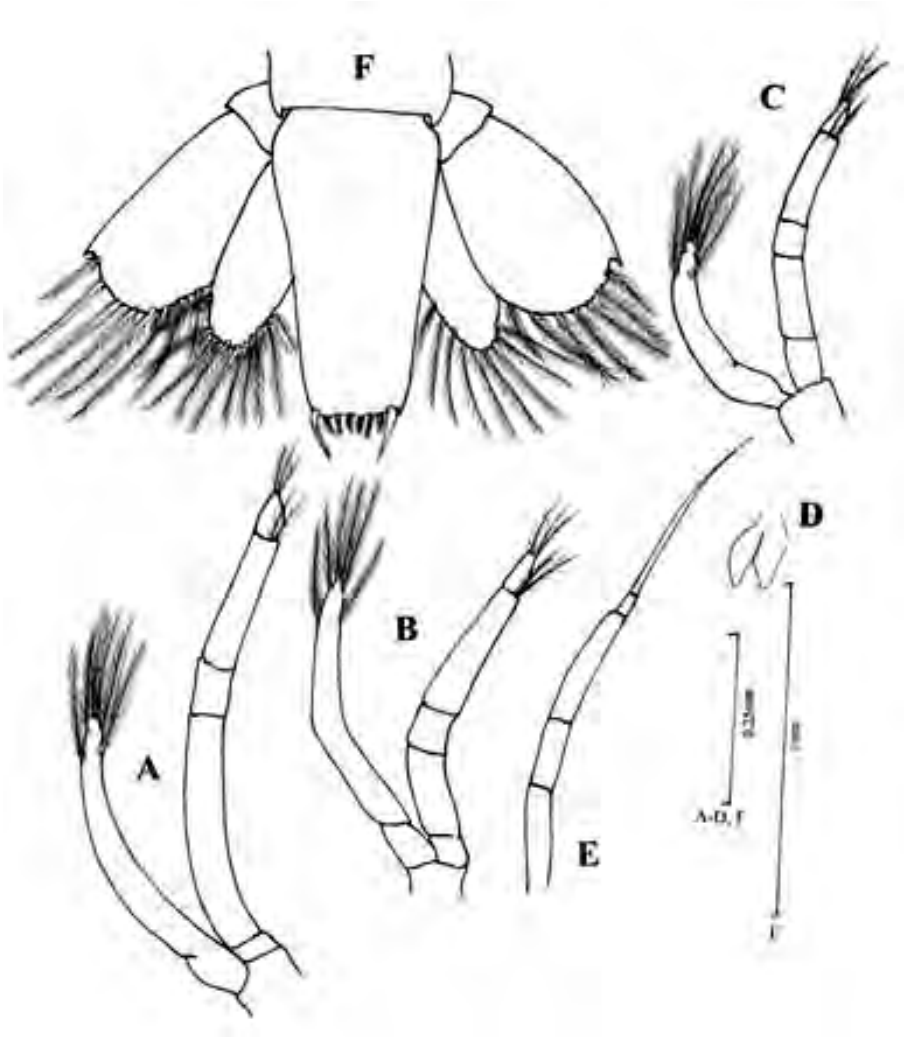

Fig. 6 *Synalpheus thai* Banner & Banner, 1966. Zoea III: A-E, pereiopods I-V; F, telson with uropods dorsal view.

Table 2 The successive changes in morphological characters of *Synalpheus thai* Banner & Banner, 1966 of Zoea I - III.

Characters	**Zoea I**	**Zoea II**	**Zoea III**
Carapace:			
medio-dorsal hump	absent	present	present
rostrum	with pointed tip	no change	no change
Eyes:	stalked	no change	no change
Antennule:			
aesthetascs	5	3	3
setae	1 spine +1 seta	2 setae	3 setae
Antenna:		2 setae	2 setae
endopod	3 setae		
exopod	13 setae	15 setae	12 setae
Mandible:			
palp	Incisor & molar process developed	more developed	well developed

Maxillule:			
coxal endite	4 setae	5 setae	4 setae
basial endite	4 setae	4 setae	4 setae
endopod	2 setae	2 setae	2 setae
Maxilla:			
coxal endite	4 + 3 setae	4 + 5 setae	3 + 2 setae
basial endite	3 + 2 setae	5 +2 setae	5 + 2 setae
endopod	1 seta	3 setae	3 setae
scaphognathite	7 setae	7 setae	9 setae
Maxilliped I:			
coxopod	without setae	1 seta	broken
basis	4 setae+4 spine	4 setae+4 spine	4 setae+4 spine
endopod	3 setae	2-segmented with 1,2 setae	3 setae
exopod	4 setae	4 setae	9 setae
Maxilliped II:			
coxopod	broken	broken	broken
basis	without setae	without setae	2 setae
endopod	5-segmented with 0,0,0, 1,3 setae	5-segmented with 0,0,0,2 ,4 setae	5-segmented with 0,0,0,1 ,4 setae
exopod	partially segmented 2, 4 setae	6 setae	6 setae
Maxilliped III: coxopod	broken	broken	broken
basis	without setae	1 seta	without setae
endopod	5-segmented, segment 2 with 2 setae	5-segmented, segment 2 with 2 setae, terminal segment with 4 setae	5-segmented, segment 2 with 2 and terminal segment with 3 setae
exopod	6 setae	4 setae	6 setae
Pereiopods I-V	rudimentary	biramous, well developed	well developed
Pleopods	absent	rudimentary	rudimentary
Abdomen	5-somites	6-somites	6-somites
Telson			1 pair of spine and 3 pairs
posterior margin	8 pairs of setae	7 pairs of setae	of setae
uropod	absent	developed	developed
endopod	“	without setae	10 setae
exopod	“	6 setae	8 setae

Table 3 Comparison between zoea I - zoea III of *Synalpheus thai* Banner & Banner, 1966 (present study) with previously studied larvae of its congeners *S. triunguiculatus, S. pectiniger, S. minus, S. fritzmuelleri, S. tumidomanus, S. biunguiculatus, S. apioceros* and *S.ubatuba.*

Zoea I

Characters	***S. thai* (Present study)**	***S. triunguiculatus* (Gurney, 1938)**	***S. pectiniger* (Weise,1975)**	***S. minus* (Weise, 1975)**	***S. fritzmuelleri* (Weise, 1975)**	***S. tumidomanus* (Bhuti et al., 1977)**	***S. apioceros* (Santos et al., 2020)**	***S. ubatuba*(Santos et al., 2024)**
Total length mm	02.00 -02.05	-	0.82-0.88	02.6-03.2	02.1-02.3	02.1	2.39- 0.10	1.65 ± 0.25
Carapace: medio-dorsal hump	absent	present	absent	absent	absent	Present	absent	absent
rostrum	with pointed tip	with pointed tip	with pointed tip	with pointed tip	with pointed tip	with pointed tip	with pointed tip	with pointed tip
Eyes:	stalked	stalked	stalked	stalked	stalked	sessile	sessile	sessile
Antennule: aesthetascs	5	not mentioned	4	4	4	4	4	4
setae	1 spine +1 seta	not mentioned	1,1 setae	1 seta	1 seta	1 seta	1 seta	1 seta
Antenna: endopod	3 setae	2 setae	setae absent	2 setae	2 setae	1 seta	2 setae + 1 spine	2 setae
exopod	13 setae	12-13 setae	11 setae	10-11 setae	13 setae	10 setae	12 setae	11 setae
Maxillule: coxal endite	4 setae	3 setae	1 seta	1 seta	not mentioned	3 setae	3 setae	4 setae
basial endite	4 setae	3 setae	2 spines	4 spines	not mentioned	4 spines	2 setae + 1 spine	4 spines
endopod	2 setae	2 setae	1 seta	3 setae	not mentioned	2 setae	3 setae	2 setae
Maxilla: coxal endite	4 + 3 setae	3+4 setae	not mentioned	1 seta	not mentioned	3+4 setae	2+2 setae	4 setae
basial endite	3 + 2 setae	3+1 setae	3 + 2 setae	1 + 3 setae	2 setae	3 setae	2+2 setae	3 +3 setae
endopod	1 seta	2 setae	3 setae	3 setae	3 setae	3+2 setae	3+2 setae	2+3 setae
scaphognathite	7 setae	6 setae	4 setae	3 setae	4 setae	7 setae	5 setae	4 setae
Maxilliped I: basis	4 setae+4 spine	not mentioned	setae absent	not mentioned	2 spines	several setae	5 spines	4spine+2 setae
endopod	3 setae	not mentioned	1 seta	1 seta	2 setae	4 setae	3 setae	4 setae
Maxilliped II: endopod	5-segmented with 0,0,0, 1,3	not mentioned	2-segmented with 1, 1	2-segmented	1 spine	1,1,2 setae	5-segmented with 0,0,0,	4-segmente

	setae		spine + 3 setae	with 1 spine, 2 setae			1,5 setae	d with 0,0, 1,5 setae
exopod	partially segmented 2, 4 setae	not mentioned	partially segmented 1, 4 setae	4-segmented with 4,2 setae	2-segmented with 4,2 setae	4,1 setae	3-segmented with 0,2,4 setae	unsegmented with 6 setae
Maxilliped III: endopod	5-segmented, segment 2 with 2 setae	not mentioned	3 spines, 2 setae	1 seta	2 spines	2-segmented, segment 2 with 1+1+2 setae	5-segmented, segment 2 with 1 seta, seg. 1 with 3 setae	5-segmented with 0,0,0,2,4 setae
exopod	6 setae	not mentioned	4- segmented with 4,2 setae	4-segmented with 2,2 setae	partially segmented 2, 4 setae	4+2 setae	4-segmented with 0,0,2,4 setae	6 setae
Abdomen	5-somites	5-somites	6-somites	6-somites	5-somites	5-somites	5-somites	5-somites
Telson posterior margin	8 pairs of setae	7 pairs of setae	7 pairs of setae	7 pairs of setae	7 pairs of setae	7 pairs of setae	7 pairs of setae	7 pairs of setae
uropod	absent	present	absent	absent	absent	absent	absent	absent
endopod	“	“	“	“	“	“	“	“
exopod	“	“	“	“	“	“	“	“

Zoea II

Characters	***S. thai* (Present study)**	***S. triunguiculatus* (Gurney, 1938)**	***S. biunguiculatus(* Al-Kholy & Mahmoud, 1967)**	***S. pectiniger* (Weise,1975)**	***S. minus* (Weise,1975)**	***S. fritzmuelleri* (Weise,1975)**	***S. tumidomanus* (Bhuti et al., 1977)**
Total length mm	02.97 -03.00	-	-	03.0-03.1	03.1-03.2	02.3-02.4	02.2
Carapace: medio-dorsal hump	present	not mentioned	not mentioned	absent	absent	absent	present
Antennule: aesthetascs	3	not mentioned	2	4	5	4	5
setae	2 setae	not mentioned	1 seta	1 seta	setae absent	6 setae	1 seta
Antenna:		not mentioned					

endopod	2 setae		1 spine+1 seta	3 setae	2 setae	1 seta	1 seta
exopod	15 setae	13 setae	21 setae	12 setae	14 setae	10 setae	11 setae
Maxillule: coxalendite	5 setae	not mentioned	4 setae	3 setae	not mentioned	1 seta	4 setae
basialendite	4 setae	not mentioned	5 setae	4 spines	“	4 spines	4 setae
endopod	2 setae	not mentioned	2 setae	1 seta	“	2 setae	2 setae
Maxilla: coxalendite	4 + 5 setae	3+3 setae	3+4 setae	1 seta	4 + 3 setae	3+3 setae	3+4 setae
basialendite	5 +2 setae	3+2 setae	3 + 3 setae	2 setae	5 +2 setae	3+3 setae	4 +2 setae
endopod	3 setae	3 setae	3 setae	2 setae	3 setae	3 setae	3 setae
scaphognathite	7 setae	5 setae	5 setae	4 setae	6 setae	5 setae	7 setae
Maxilliped I: coxopod	1 seta	not mentioned	not mentioned	not mentioned	not mentioned	not mentioned	1 seta
basis	4 setae+4 spine	not mentioned	not mentioned	4 setae+3 spine	4 setae+4 spine	not mentioned	7 setae
endopod	2-segmented with 1,2 setae	not mentioned	2 setae	2 setae	1 seta	2 setae	1,3 setae
exopod	4 setae	not mentioned	without setae	4 setae	4 setae	4 setae	4 setae
Maxilliped II: basis	without setae	not mentioned	not mentioned	without setae	without setae	without setae	2 setae
endopod	5-segmented with 0,0,0,2 ,4 setae	not mentioned	3-segmented with 1 spine, 1 setae	4-segmented with 1 spine + 2 setae	4-segmented with 1 spine+ 3 setae, 1 seta	4-segmented with 1 spine+ 3 setae, 1 seta	2-segmented with 1,1+2 setae
exopod	6 setae	not mentioned	unsegmented with 5 setae	6 setae	6 setae	6 setae	6 setae
Maxilliped III: basis	1 seta	not mentioned	not mentioned	without setae	without setae	without setae	2 setae
endopod	5-segmented, segment 2 with 2 setae, terminal segment with 4 setae	not mentioned	4-segmented with 1 spine, 1 setae	4-segmented segment 2 with 2 setae, terminal segment with 2 setae	4-segmented, segment 2 with 2 setae, terminal segment with 3 setae + 1 spine	4-segmented with 2 setae+1 spine, 2 setae	2-segmented with 1, 2+1 setae
exopod	4 setae	not mentioned	unsegmented with 5 setae	6 setae	6 setae	4 setae	6 setae

Pleopods	rudimentary	absent	absent	absent	absent	absent	absent
Abdomen	6-somites	5-somites	6-somites	6-somites	6-somites	6-somites	5-somites
Telson posterior margin	7 pairs of setae	6 pairs of setae	7 pairs of setae	7 pairs of setae	7 pairs of setae	7 pairs of setae	8 pairs of setae
uropod	developed	developed	not mentioned	absent	absent	absent	absent

Zoea III

Characters	***S. thai* (Present study)**	***S. biunguiculatus* Al-Kholy & Mahmoud, 1967)**	***S. pectiniger* (Weise,1975)**	***S. minus* (Weise,1975)**	***S. fritzmuelleri* (Weise,1975)**	***S. tumidomanus* (Bhuti et al., 1977)**
Total length mm	02.99- 03.05		03.3-03.5	03.4-03.8	02.6-03.0	02.2
Carapace: medio-dorsal hump rostrum	present no change	not mentioned	absent	absent	absent	present
Antennule: aesthetascs	3	2	4	3	2	4
setae	3 setae	2 setae	2 setae	3 setae	1 seta	3 setae
Antenna: endopod	2 setae	2 setae	3 setae		1 seta	1 seta
exopod	12 setae	13 setae	14 setae	14 setae	12 setae	13 setae
Maxillule: coxalendite	4 setae	5 setae	not mentioned	2 setae+3 spine	3 setae	5 setae
basialendite	4 setae	5 spines	not mentioned	4 spines	2 spine+2setae	4 spines
endopod	2 setae	2 setae	not mentioned	2 setae	3 setae	1 spine, 1 seta
Maxilla: coxalendite	3 + 2 setae	4 setae	2+3 setae	6 setae	3 setae	1,3+4 setae
basialendite	5 + 2 setae	5+5 setae	4+4 setae	3+1 setae	3+2 setae	5+2 setae
endopod	3 setae	2 setae	3 setae	3 setae	3 setae	3 setae
scaphognathite	9 setae	5 setae	4 setae	5 setae	5 setae	7 setae
Maxilliped I: basis	4 setae+4 spine	6 setae	3 setae+4 spine	4 spine	4 setae+4 spine	8 setae
endopod	3 setae	2 setae	1 seta	1 seta	1 seta	1, 3 setae
exopod	9 setae	without setae	4 setae	4 setae	4 setae	4 setae
Maxilliped II: basis	2 setae	not mentioned	not mentioned	not mentioned	not mentioned	not mentioned
endopod	5-segmented	3-segmented	3-segmented	4-segmented	3-segmented	3-segmented

	with 0,0,0,1 ,4 setae	with 0,2,2 setae	with 0,1,1 spine+2 setae	with 1 spine+ 3 setae, 1 seta	with 0,1,1 ,3 setae	with 0,2,1+2 setae
exopod	6 setae	2-segmented with 2, 5 setae	6 setae	4 setae	2-segmented with 5 setae	6 setae
Maxilliped III: basis	without setae	not mentioned	without setae	without setae	without setae	3 setae
endopod	5-segmented, segment 2 with 2 and terminal segment with 3 setae	4-segmented with 0,1,1,3 setae	4-segmented with 0,1,2,3 setae	4-segmented with 1,1,1,3 setae	5-segmented with 1,0,1,2,3 setae	2-segmented with 2+1, 3 setae
Pleopods	rudimentary	absent	absent	absent	absent	absent
Telson posterior margin	1 pair of spine and 3 pairs of setae	6 pair of spines	6 pair of spines and 1 pairs of setae	6 pair of spines and 1 pairs of setae	6 pair of spines	7 pair of spines
uropod	developed	developed	developed	developed	developed	developed
endopod	10 setae	setae absent	setae absent	setae absent	setae absent	setae absent
exopod	8 setae	6 setae	7 setae	7 setae	6 setae	6 setae

4 Discussion

Through literature review of *Synalpheus* larval descriptions, there have been diverse development patterns occur, namely, extended, abbreviated and direct (Dobkin, 1965, 1968; Knowlton, 1973). Morphological comparison (table 3) between zoea I to zoea III of *Synalpheus thai* (present study) with previously studied larvae of *S. pectinige, S. minus, S. fritzmuelleri* (Weise, 1975), *S. tumidomanus* (Bhuti et al., 1977), *S. biunguiculatus* (Al-Kholy and Mahmoud, 1967), *S. triunguiculatus* (Gurney, 1938), *S. apioceros* and *S.ubatuba* (Santos et al., 2020, 2024) have shown that the segmentation of maxilliped I, II and III endopods differs from the other species in the genus. Second and third maxillipeds of *S. thai*, *S. apioceros* and *S.ubatuba* have 5-segmented endopod in zoea I to III. Whereas *S. pectiniger* and *S. minus* have 2-segmented endopod in maxilliped II. However, *S. fritzmuelleri* and *S. tumidomanus* don't have endopodal segmentation. Whereas *S. tumidomanus* has 2-segmented endopod in zoea I. In second zoeal stage of *S. pectiniger, S. minus* and *S. fritzmuelleri* have 4-segmented endopod in maxilliped II and III. Whereas *S.biunguiculatus* and *S. tumidomanus* have 3 and 2-segmented endopod in maxilliped II respectively. In maxilliped III of *S.biunguiculatus* and *S. tumidomanus* have 4 and 2-segmented endopod respectively.

In zoea III of *S. pectiniger, S. fritzmuelleri, S. tumidomanus, S. biunguiculatus* and *S. tumidomanus* have 3-segmented endopod of maxilliped II. However, *S. minus* has 4-segmented endopod of maxilliped II. In maxilliped III of *S. pectiniger, S. minus* and *S. biunguiculatus* have 4-segmented endopod whereas *S. fritzmuelleri* and *S. tumidomanus* have 5 and 2-segmented endopod respectively.

In first zoeal stage of *S. thai* telson has eight pairs of posterior marginal setae whereas other species have seven pairs of posterior marginal setae. In third zoeal stage of *S. thai* telson has 1 pair of spine and 3 pairs of setae whereas *S. pectiniger* and *S. minus* have 6 pairs of spine and 1 pair of setae, *S. fritzmuelleri* and *S. triunguiculatus* have 6 pairs of spine and *S. tumidomanus* has 7 pairs of spine. Third zoeal stage of *S. thai* has

rudimentary pleopods however, it is absent in other species. Moreover, most studies do not present all the morphological characters of the appendages, as well as some details of setae are not described.

The study of larval development in *Synalpheus* is worthy of more extensive investigation, because of the variety of larval forms which exist in this genus and the information which can be obtained concerning the relation between environment and mode of development (Dobkin,1965).

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