Studies on Larvae of Decapod Crustacea from the Central Red Sea.

Thesis submitted in accordance with requirements of the University of Liverpool for the degree of Doctor in Philosophy

by

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October 1988

To my father, in the memory of
my mother, wife and childern

Abstract

Plankton samples were taken at fortnightly intervals from January 1986 to June 1987 at six stations 20-50 km north of Jeddah, Saudia Arabia : three in a mangrove area (Zahban village) , two outside the mangrove area (Thuwal village) and one off Obhor Creek . Larvae of decapod Crustacea (excluding the Brachyura) were identified as far as possible and descriptions are given of the anomuran larvae encountered . Studies were made on seasonal variations in the numbers of larvae and on differences in occurrence and abundance between the stations .

Eighty nine species of *Alpheus* larvae were distinguished , largely using differences in chromatophore pattern . Only two species of adult *Alpheus* are recorded from the central Red Sea . Thirty seven unnamed species of Anomura were distinguished on morphological characters and these are described and figured . The anomuran larvae belong to the following families : Upogebiidae (4 species) , Callianassidae (7 species) , Laomediidae (2 species) , Galatheidae (7 species) , Porcellanidae (6 species) , Paguridae (4 species) , Diogenidae (7 species) , and the Diogenidae are made up of the following genera : *Diogenes* (2 species) , *Calcinus* (2 species) , *Dardanus* (2 species) , *Clibanarius* (1 species) . Ten genera of Macrura , belonging to seven families , are also listed .

Descriptions are given of the complete larval development of *Coenobita scaevola* (Forskål) (Coenobitidae) and *Dardanus tinctor* (Forskål) (Diogenidae) , based on laboratory rearing . Comparisons are made with the larvae of related species . The presence of a central telson spine in zoea III and all subsequent zoeal stages is a feature of all known coenobitid larvae , although it does not occur in other larvae of the Anomura (*sensu stricto*) (i. e. excluding the Thalassinidae) .

The concentration of decapod larvae over the 18 months at the different stations was fairly similar , averaging about 1190/1000 m^3 . The most common anomuran larvae were those of the Diogenidae , with *Diogenes avarus* Heller the most common in the mangrove area and the unnamed species *Calcinus* A the most common off Obhor Creek . Larvae of *Alpheus* spp. and *Harpilius* spp. made up a large percentage of the decapod larvae , especially at the stations outside the mangrove area and off Obhor Creek . Larvae of Galatheidae , Paguridae and Callianassidae were conspicuously more abundant in the night samples than in the day samples .

During the eighteen months of sampling at the six stations , decapod larvae tended to be more common in summer , particularly in June . More sampling would be required to establish whether this is a regular annual feature .

Acknowledgements

In the beginning thanks to God for my success in carrying out this work . I wish to express my deep gratitude and cordial thanks to Dr. D. I. Williamson for suggesting the topic in the first place , for his constructive criticism during the preparation of the manuscript , and his deep concern when I was doing my field work in Jeddah , Saudi Arabia . It is in fact my honor to work under his supervision , during which I learned from him many things on the identification of decapod larvae .

I would like to thank Dr. R. G. Hartnoll for his comments on the manuscript , also Prof. T. A. Norton for his kind treatment during my stay in the Isle of Man , and Mr. C. D. Bridge for the preparation of the photographs .

I am also very much obliged to all the staff members and the boat men in the department of Marine Biology , Faculty of Marine Science , King Abdulaziz University , who helped and gave me so much valuable assistance during the field work . I wish to express my sincere thanks to Prof. S. M. Saifulla for his valuble advice and encouragement during this study . I have never forgotten the advice of Dr. A. S. Mandura for his encouragement to continue my Ph.D degree immediately after I obtained my M.Sc degree .

Especial thanks to Dr. S. Y. Hong for his constant advice , particulary in the rearing of decapod larvae during my preliminary work . It is my pleasure to thank all my collegues especially , Clemente Graziano , Simi Steingrimsson , Adnan Salama and Hishamuddin Omar , for their help in various ways during this study .

Finally , I would like to express my deep thanks to my father for his constant praying during this study , and I am very grateful to my wife for her moral support in making this work possible .

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CHAPTER 1

GENERAL INTRODUCTION

The Red Sea is a long narrow basin , dividing Asia and Africa , extending north-west to south-east between 30° and 12° north , 34° and 43° east (Fig. 1) . The name of the Red Sea is usually attributed to the existence of a planktonic unicellar flagellate called *Trichodesmium erythraeum* Ehrenb. , which has a red pigment, and in some seasons , in some regions , can became sufficiently dense to colour the water red . There are , however , other possible reasons for the name . One is the existence of coral reefs of red colour ; another claims that at one time the Red Sea was a lake bordering Eritrea , and Eritrea means red land (Behairy et al. , 1982) .

The total length of the Red Sea is 1932 km . The average width is 280 km , greatest towards the south , between Mousoa and Jizan , at 340 km and least in the southern entrance to the Bab-Al-Mandab , at 27 km . In the north of the Red Sea there are two branches , the Gulf of Suez and the Gulf of Al-Aqaba . The total length of the Gulf of Suez is 250 km , the average width 32 km , and the depth 55 - 80 m . The Gulf of Al-Aqaba is 150 km in length , and the average width is 16 km . It is a deep basin , up to 1300 m in the north , separated from the Red Sea by a barrier of 250 - 300 m (Behairy et al. 1982) .

In the period from May to Septemper , the prevailing wind is from the north-north-west along the entire basin . From October to April the north-north-west wind stops in the region 20 - 22° N and to the south of latitude 20° N the prevaling wind is south-south-east . The surface currents follow the direction of the prevailing winds (Morcos, 1970).

The surface temperature of the water ranges from 25 - 32° C in the south , and 21.3 - 27.9° C in the north (Halim , 1969) . The intermediate layers , down to 300 m , are homothermal , with a temperature of about 21.7° C . The deep water of the Red Sea is at about 21.5° C , which is warmer than in any other marine basin (Morcos , 1970) .

The Red Sea is one of the most saline marine environments in the world . The salinity ranges from 39.2 - 41 ppt. , decreasing gradually from north to south . A layer of minimum oxygen is present at 300 - 600 m , with very low values of 0.4 - 0.6 ml O_2/L^{-1} (Morcos , 1970) .

The Red Sea has an uneven bottom , with many sea mounts , some rising to near surface , and many islands . Corals grow well in the Red Sea and reefs are scattered along the coastal zone . This is attributed largely to the high and fairly even temperature (Behairy et al. , 1982) .

Decapod larvae are one of the most important groups in the zooplankton community , because they are usually sufficiently numerous to form an important link in the food chain and many are the larvae of commercial species . Identification of this group is necessary to give a complete understanding of the area investigated . For this reason any addition to our knowledge of the decapod larvae is very important , whether it concerns identification of the species or temporal and spatial variations in density .

The first aim of the present work was to provide a record of the larvae of Decapoda present in the central Red Sea , identifying them as far as possible . Some specimens from the plankton samples can be identified directly to species and others to genera , but many can be identified only to families or larger groups . During the work , some species were hatched or reared in captivity to describe the larvae and to follow the life history of the species , including the number and duration of stages . In a few selected genera , including some very rich in species , the number of species was determined from the larvae for comparision with records of adults from the same area . The second aim of this study was to investigate seasonal differences in the occurrence and density of decapod larvae and to compare records from different ecological areas .

Regular samples were therefore taken at several stations along the open coast , mostly over corals , and also from a shallow mangrove area , partly cut off from the open sea and with a muddy bottom .

The importance of this study lies in the fact that no detailed work on the identification of the decapod larvae from this area has been done before . The identifications and records provided by the present study will form a good basis for monitoring possible future changes in the fauna of the mangrove area and will provide a basis for comparision with other areas of the Red Sea .

Historical Review

The Red Sea has attracted the attention of scientists since the early 18 th century , and expeditions have been devoted to the study of this area . The Danish Expedition under the leadership of P. Forskål (1775) was the first to collect specimens from this area . It was followed by other expeditions , such as the ' Pola ' (1895 - 96 ; 1897-98) , ' Valadivia ' (1898 - 99) , ' Ammiraglio Magnaghi ' (1923 - 24), the ' Cambridge Expedition ' (1933 - 34) , but in all these works the plankton received little attention .

The main contribution to the study of the decapod larvae of the Red Sea is due to individual scientists . Santucci (1927 , 1929) worked chiefly on material collected from the ' Ammiraglio Magnagni ' in various parts of the Red Sea .Gurney(1927,1936,1937a,b,1938a,b,c) studied material from the Gulf of Suez and from Al-Ghardaqa , Egypt . Gohar & Al-Kholy (1957) , Al-kholy (1959 ,1961 , 1963) , Al-kholy & Fikry Mahmoud (1967 a,b) and Al-kholy & El-Hawary (1970) also worked from Al-Ghardaqa . Williamson (1970) and Seridji (1986) reported on collections from the Gulf of Al-Aqaba , although descriptions of larvae listed in Seridji's paper have not yet been published . A few other publications, primarily concerned with larvae from other areas , include some species from the Red Sea . All these publications include accounts of larvae from plankton collections , and in some cases the identifications are uncertain . References to descriptions of identified larvae (other than Brachyura) covered by these reports are listed in Table 1 .

Table 1 . Identified decapod larvae (other than Brachyura) from the Red Sea described in previous publications .

Penaeidea

Metapenaeus sp. , *Lucifer hanseni* .... Gurney , 1927

Metapenaeus stebbingi .... Gurney , 1927 ; Al-Kholy & El-Hawary , 1970

Sergestes sp. .... Al-Kholy & Fikry Mahmoud , 1967b

Penaeus trisulcatus , *P. japonicus*

P. semisulcatus , *Metapenaeus philippii* .... Al-kholy & El-Hawary , 1970

Caridea

Palaemon elegans .... Gurney , 1927

Chlorotocella sp. , *Processa aequimana* ,

Processa sp. , *Nikoides dana* .... Gurney , 1937a

Alpheus audouini .... Gurney , 1927, 1938c

Alpheus pacificus .... Gohor & Al-Kholy , 1957

Saron marmoratus .... Al-Kholy , 1961

Alpheus rapax .... Al-Kholy , 1961

Alpheus ventrosus .... Al-Kholy , 1961; Gurney , 1938c

Alpheus microstylus .... Al-Kholy ,1963

Periclimenes (Harpilius) spp. .... Al-Kholy ,1963 ; Williamson ,1970

Hippolyte sp. .... Al-Kholy & Fikry Mahmoud , 1967a

Synalpheus biunguiculatus .... Al-Kholy & Fikry Mahmoud , 1967b

Rhynchocinetes spp. , *Eretmocaris* sp. , *Hippolyte* sp. , *Processa* sp. , *Palaemon* sp. , *Saron* sp. , *Alpheus* spp. .... Williamson , 1970

Thalassocaris crinita, *T. obscura* .... Williamson , 1970 ; Menon & Williamson, 1971

Anomura

Diogenes pugilator .... Gurney ,1927

Upogebia savignyi .... Gurney ,1937a

Callianassa spp. ..... Gurney , 1937b ; Al- kholy & Fikry Mahmoud 1967a ; Williamson , 1970

Galathea longimana .... Gurney , 1938a

Porcellana inaequalis, *Petrolisthes* sp. .... Gurney , 1938a

Petrolisthes rufescens .... Gohor & Al-Kholy , 1957

Galathea sp. .... Al-kholy , 1959

Hippa adactyla, *Dromia* sp. .... Al-Kholy ,1959

? Pachycheles sp. .... Williamson , 1970

Stenopodidea

Stenopus hispidus, Stenopodidae .... Gurney , 1936 ; Williamson ,1970 ,1976

Palinura *

Palinuridae (P1) , Palinuridae (P2) ,

Scillaridae (S1) , *Thenus orientalis* .... Santucci , 1927

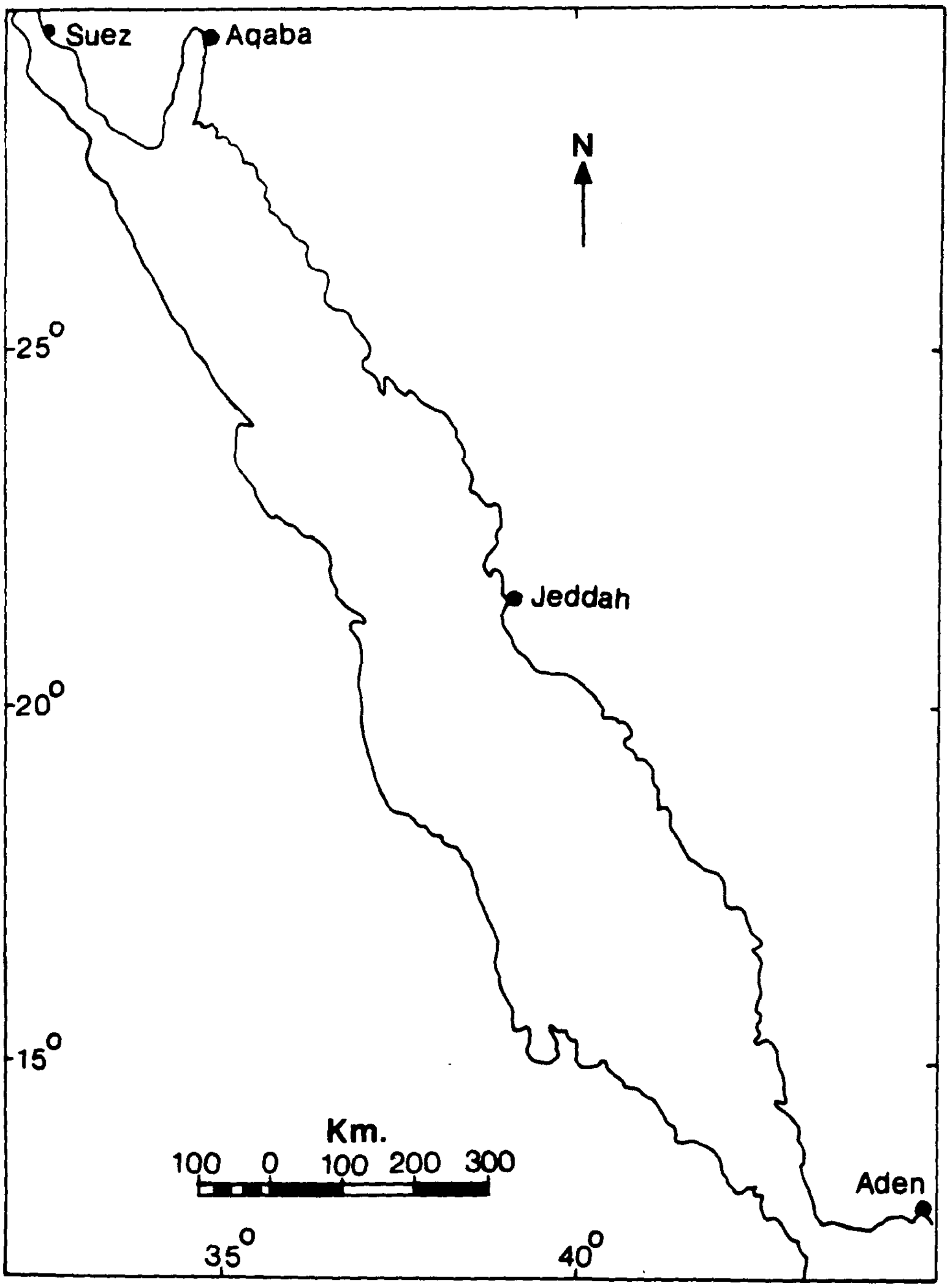
Scyllarides latus .... Santucci , 1929

Panulirus penicillatus ,

Scyllarus thiorioux i .... Al-Kholy , 1961

* Williamson (1988) has recently suggested that the Palinura should be removed from the Decapoda .

Figure 1 . Map of the Red Sea , showing the location of Jeddah , Saudia Arabia .


Suez
Aqaba
N
25°
Jeddah
20°
15°
Km.
100 0 100 200 300
Aden
35°
40°

CHAPTER 2

LARVAL DEVELOPMENT OF THE LAND HERMIT CRAB COENOBITA SCAEVOLA (FORSKÅL , 1775) (CRUSTACEA : ANOMURA : COENOBITIDAE), REARED IN THE LABORATORY.

(This chapter in press in Journal of Natural History , 1988 ,

INTRODUCTION

The hermit crabs of family Coenobitidae are among the most conspicuous and characteristic elements of the terrestrial fauna of tropical marine beaches and atolls . The members of this family have become adapted for life on land , but the larvae are liberated into the sea (Provenzano , 1962) . Many species live in burrows or rest in shaded areas among coastal vegetation during the daytime and then scatter along the coast at night .

There are few previous descriptions of coenobitid larvae . There is only a brief account of the stage 1 zoea of *Coenobita perlatus* H. Milne Edwards from the Maldive and Laccadives (Borradaile , 1903) , and Yamaguchi (1938) described the first stage and megalopa of *C. rugosus* H. Milne Edwards from Kikai Island , southern Japan . Provenzano (1962) followed all the larval development of the Caribbean species *C. clypeatus* (Herbst) in the laboratory , and Reese & Kinzie (1968) described all the larval development of the Indo-Pacific species *Birgus latro* (L.) . Shokita and Yamashiro (1986) described all the larval stages of *C. rugosus* and *C. cavipes* Stimpson from Ryukyu Island , southern Japan .

C. scaevola (Forskål , 1775) is the only species represented in the Red Sea , and is abundant in the Jeddah region (Lewinsohn,1969) . The purpose of the present study is to provide a description of the complete larval development of *C. scaevola* based on laboratory rearing .

MATERIALS AND METHODS

An ovigerous female was collected at night on 17 April 1987 from the shore in Jeddah, Saudi Arabia. It was kept in an aquarium in the laboratory, provided with sand at one end and water at the other to allow the female to shed her larvae in the water. The first zoeas were obtained on 21 April 1987 and reared at a temperature of 25° C, salinity 38-39 ppt. Individual larvae were placed in 70 glass beakers of about 100 ml capacity containing filtered sea water (Millipore 0.45 µm). A further 200 larvae were reared in mass culture in a glass beaker of about 2 L capacity.

Newly hatched *Artemia* nauplii were added as food. Larvae were examined daily for exuviae and dead specimens, and living specimens were transferred to freshly filtered sea water to which were added newly hatched *Artemia* nauplii. Larvae and exuviae were preserved in 5% sea water formalin. Appendages were dissected and drawn from temporary mounts in this medium.

Drawings were made with the aid of a camera lucida, and measurements by using an ocular micrometer. Total length was measured from the tip of the rostrum to the posterior border of the telson exclusive of the telson processes. Length of carapace was measured from rostral tip to the posterio-lateral margin of the carapace. Lengths are given as average values for each larval stage, based on at least 10 specimens when sufficient material was available. The range is usually ± 10-15% of the mean value.

RESULTS

Development and duration of the larvae .

Coenobita scaevola passed through seven zoeal stages and one megalopa before reaching the first crab stage (Table 2) . The number of days required to complete the larval development in the laboratory at 25° C is approximately 47 days .

(Table 2) : Duration of each stage and survival of larvae .

Stages	Duration (mean and ranges) (days)	No. at beginning
Zoea I	11.5 (9 - 14)	70
Zoea II	9.0 (7 - 11)	57
Zoea III	8.5 (7 - 10)	39
Zoea IV	9.5 (7 - 12)	38
Zoea V	9.5 (7 - 12)	30
Zoea VI	9.5 (8 - 11)	18
Zoea VII	9.5 (9 - 10)	3
Megalopa	–	2

Descriptions .

First Zoea

(Figs.2A, 3A,4)

Size- CL: 1.12 mm (average)

TL: 2.40 mm (average)

Colour - Orange-red under both eyes and on posterior margin of carapace , yellow on posterior margin of telson .

Carapace (Figs.2A, 3A) - Rostrum broad at base , curved slightly downward distally . Posterio-lateral margins of carapace smooth and devoid of spines .

Eyes (Fig. 2A, 3A) - Immobile .

Antennule (Fig. 4A) - Uniramous , with 3 terminal aesthetascs of varying size and 3 plumose setae of varying size ; 1 long subterminal plumose seta.

Antenna (Fig. 4B) - Endopod with 2 terminal and 1 subterminal plumose setae , the subterminal about 1/3 length of other two ; exopod with 10 plumose setae on inner and distal margin and strong outer distal spine ; a strong serrated ventral spine on protopod at base of exopod .

Mandible (Fig. 4C) - A simple process with irregular teeth , not differentiated into incisor and molar regions .

Maxillule (Fig. 4D) - Coxal endite with 6 setae ; basial endite with 2 strong spines , each with several denticles , and 2 setae ; endopod 3-segmented , 3rd segment with 3 setae and 2nd with 1 seta.

Maxilla (Fig. 4E) - Proximal lobe of coxal endite with 7 setae , distal lobe with 4 setae ; proximal lobe of basial endite with 5 setae , distal lobe with 4 setae ; outer lobe of endopod with 3 setae (innermost very short) , inner lobe with 2 setae ; scaphognathite with 5 plumose setae .

First Maxilliped (Fig. 4F) - Basis with hooked process at proximal end of inner face and 2, 3, 2 setae more distally on this face; endopod 5-segmented with 2/0, 2/0, 1/0, 2/0, 4/1 inner/outer plumose setae , also fine hairs on segments 2, 3, 4; exopod with 4 natatory plumose setae .

Second Maxilliped (Fig. 4G) - Basis with 1,2 distal setae on inner face ; endopod 4-segmented with 2/0, 2/0, 2/0, 4/1 inner/outer plumose setae , also fine outer hairs on segment 3 ; exopod with 4 natatory plumose setae .

Third Maxilliped (Fig. 4H) - Endopod a small lobe ; exopod a long lobe .

Abdomen (Fig. 2A, 3A) - 6 somites ; 2nd somite with prominent curved medio-dorsal spine , 3rd and 4th somites with much smaller medio-dorsal spines , 5th somite with large medio-dorsal spine and large lateral spines each of similar length to dorsal spine on second somite , 6th somite fused with telson .

Telson (Fig. 4I) - Triangular in form with concave median notch; 7 pairs of marginal processes : outermost a stout spine, 2nd a fine hair and 3rd to 7th plumose setae.

Second Zoea

(Figs. 2B, 3B,5)

Size- CL: 1.53 mm (average)

TL: 2.73 mm (average)

Carapace (Fig. 2B, 3B) - Almost unchanged .

Antennule (Fig.5A) - Peduncle with 3 terminal aesthetascs and 3 plumose setae of variable size , 1 long subterminal seta and 3 small outer plumose setae .

Antenna (Fig.5B) - Similar in form to first stage .

Mandible (Fig.5C) - Corneous teeth present .

Maxillule (Fig.5D) - Coxal endite unchanged in form and setation; basial endite with 4 strong spines , each with several denticles , and 2 setae ; endopod unchanged in form and setation .

Maxilla (Fig. 5E) - Coxal endite , basial endite and endopod unchanged in form and setation ; scaphognathite with 7 plumose setae.

First Maxilliped (Fig.5F) - Basis with 1 small seta near hook and 2, 3,2 larger inner setae ; endopod 5 segmented with 2/1, 2/1, 1/1, 2/0, 4/1 inner/outer plumose setae ; exopod with 6 natatory plumose setae .

Second Maxilliped (Fig.5G) - Basis unchanged in setation ; endopod 4 segmented with 2/0, 2/1, 2/1, 4/1 inner/outer plumose setae ; exopod with 6 natatory plumose setae .

Third Maxilliped (Fig.5H) - Endopod unchanged ; exopod with 5 natatory plumose setae .

Abdomen (Fig.2B, 3B) - Dorsal spine on second abdominal somite somewhat more prominent , that on fifth somite rather shorter .

Telson (Fig.5I) - An inner pair of smaller plumose setae added , to give 8 pairs of posterior marginal processes .

Third zoea

(Fig. 2C, 3C,6)

Size - CL: 1.53 mm (average)

TL: 3.13 mm (average)

Carapace (Fig.2C,3C) - Unchanged .

Antennule (Fig.6A) - Now consisting of peduncle and 2 unsegmented rami , 3 short outer distal plumose setae on peduncle ; 3 plumose setae on short inner ramus ; 3 aesthetascs all of about same length , 1 long and 2 short plumose setae on large (outer) ramus .

Antenna (Fig.6B) - Endopod with 1 terminal aesthetasc ; exopod with 11 plumose setae .

Mandible (Fig.6C) - With additional small teeth .

Maxillule (Fig.6D) - Coxal endite with 7 setae ; basial endite and endopod unchanged in setation .

Maxilla (Fig.6E) - Coxal endite and basial endite unchanged in setation ; endopod with 3 terminal setae and 2 subterminal ; scaphognathite with 8 plumose setae .

First Maxilliped (Fig.6F) - Unchanged in form and setation .

Second Maxilliped (Fig.6G) - Unchanged in form and setation .

Third Maxilliped (Fig.6H) - Endopod unchanged in form ; exopod with 6 natatory plumose setae .

Abdomen (Fig.2C, 3C) - Dorsal abdominal spines more distinct ; 6th abdominal somite now with medio-dorsal spine .

Uropod (Fig.6I) - Unsegmented , endopod unarmed , about half length of exopod ; exopod with 8 natatory plumose setae .

Telson (Fig.6I) - Now with short median plumose seta , to give 8+1+8 processes ; processes 1 to 3 and 5 to 8 unchanged , 4th process a large fused spine .

Fourth Zoea

(Fig.2D,3D,7)

Size- CL: 1.53 mm (average)

TL: 3.80 mm (average)

Carapace (Fig.2D,3D) - Unchanged .

Antennule (Fig.7A) - 4 short outer distal plumose setae on peduncle ; 4 plumose setae on short ramus ; 3 aesthetascs all of about same length , 1 long and 2 short plumose setae on long ramus .

Antenna (Fig.7B) - Endopod unchanged ; exopod with 13 plumose setae .

Mandible (Fig.7C) - With additional small teeth .

Maxillule (Fig.7D) - Coxal endite with 8 setae ; basial endite with 6 strong spines , each with several denticles , and 2 setae ; endopod unchanged .

Maxilla (Fig.7E) - Proximal lobe of coxal endite with 8 plumose setae and distal lobe unchanged ; proximal lobe of basial endite unchanged and distal lobe with 5 setae ; endopod unchanged ; scaphognathite with 12 plumose setae .

First Maxilliped (Fig.7F) - Basis unchanged ; endopod unchanged except for additional inner seta on 1st segment , to give formula 3/1; exopod unchanged .

Second Maxilliped (Fig.7G) - Unchanged in setation .

Third Maxilliped (Fig.7H) - Endopod with small seta , exopod with 7 natatory plumose setae .

Abdomen (Fig.2D, 3D) - Unchanged in form .

Uropod (Fig.7I) - Endopod and exopod articulated with protopod ; endopod longer with 4 or 5 plumose setae ; exopod with 10 plumose setae and strong outer distal spine .

Telson (Fig.7I) - Unchanged in form .

Fifth Zoea
(Figs.2E,3E,8)

Size - CL: 1.98 mm (average)
TL: 4.16 mm (average)

Carapace (Fig.2E,3E) - Unchanged .

Antennule (Fig.8A) - Unchanged except one additional plumose seta on large (outer) ramus .

Antenna (Fig.8B) - Endopod with 1 long and 2 short aesthetascs ; exopod with 15 plumose setae .

Mandible (Fig.8C) - Unchanged in form .

Maxillule (Fig.8D) - Unchanged in setation .

Maxilla (Fig.8E) - Unchanged in setation .

First Maxilliped (Fig.8F) - Unchanged in setation .

Second Maxilliped (Fig.8G) - Basis and endopod unchanged ; exopod now with 7 natatory plumose setae .

Third Maxilliped (Fig.8H) - Endopod unchanged; exopod now with 8 natatory plumose setae .

Abdomen (Fig.2E, 3E) - unchanged in form .

Uropod (Fig.8I) - Endopod with 6 or 7 plumose setae ; exopod with 11 plumose setae .

Telson (Fig.8I) - Unchanged in form except central process now of similar length to processes 5 to 8 .

Sixth Zoea

(Figs.2F,3F,9)

Size - CL: 2.30 mm (average)

TL: 4.64 mm (average)

Carapace (Fig.2F,3F) - Unchanged .

Antennule (Fig.9A) - Unchanged in setation .

Antenna (Fig.9B) - Unchanged in setation .

Mandible (Fig.9C) - Unchanged in form .

Maxillule (Fig.9D) - Unchanged in setation .

Maxilla (Fig.9E) - Unchanged in setation except scaphognathite with 13 plumose setae and now with unarmed posterior projection .

First Maxilliped (Fig.9F) - Unchanged in setation .

Second Maxilliped (Fig.9G) - Basis and endopod unchanged ; exopod now with 8 natatory plumose setae .

Third Maxilliped (Fig.9H) - Unchanged in setation .

Abdomen (Fig.2F, 3F) - Unchanged in form .

Uropod (Fig.9I) - Endopod with 7 plumose setae ; exopod with 13 plumose setae .

Telson (Fig.9I) - Unchanged .

Seventh Zoea

(Figs.2G,3G,10)

Size - CL: 2.34 mm (average)

TL: 5.19 mm (average)

Carapace (Fig.2G,3G) - Unchanged .

Antennule (Fig.10A) - Unchanged except 1 additional plumose seta on the large (outer) ramus .

Antenna (Fig.10B) - Endopod unchanged ; exopod now with 16 plumose setae .

Mandible (Fig.10C) - Unchanged in form .

Maxillule (Fig.10D) - Coxal endite unchanged in setation ; basial endite now with 7 strong spines each with several denticles , and 2 setae ; endopod unchanged .

Maxilla (Fig.10E) - Unchanged in setation except distal lobe of basial endite now with 6 setae .

First Maxilliped (Fig.10F) - Unchanged in setation .

Second Maxilliped (Fig.10G) - Unchanged in setation .

Third Maxilliped (Fig.10H) - Unchanged in setation .

Legs (Fig.2G) - Bud-like ; unsegmented .

Abdomen (Fig.2G,3G) - Medio-dorsal spine on 2nd abdominal somite larger .

Pleopods (Fig.2G) - Small biramous buds on somites 2 to 5 .

Uropod (Fig. 10I) - Endopod with 8 plumose setae ; exopod with 14 plumose setae .

Telson (Fig.10I) - Unchanged in form .

Megalopa

(Fig.11)

Size - CL: 1.44 mm (average)

TL: 3.95 mm (average)

Carapace (Fig.11A) - Shorter than abdomen, with prominent blunt rostrum .

Eyes (Fig.11A) - Length of eyestalks less than twice width , eye reaches to base of ultimate segment of antennular peduncle .

Antennule (Fig.11B) - Peduncle 3-segmented with short setae ; rami still unsegmented: inner with 5 short setae , outer with 7 aesthetascs .

Antenna (Fig.11C) - Flagellum with 7 segments each with a few setae , distal segment with long terminal seta .

Mandible - Damaged during the dissection

Maxillule (Fig.11D) - Coxal endite with 9 setae ; basial endite with many spines and 5 setae ; 3 plumose setae on outer side of basis; endopod terminating in long plumose seta .

Maxilla (Fig.11E) - Proximal lobe of coxal endite with about 18 marginal setae and about 5 submarginal , distal lobe with 7 setae ; proximal lobe of basial endite with 7 setae , distal lobe with 12 setae; endopod unsegmented without setae ; scaphognathite with 49 plumose setae .

First Maxilliped (Fig.11F) - Basis with 2 large setose inner lobes ; endopod unsegmented ; exopod with about 11 lateral plumose setae .

Second Maxilliped (Fig.11G) - Basis with 3,2 setae ; endopod 3-segmented , distal segment with 7 setae , many inner and outer setae on segments ; exopod long , with 7 plumose setae and 3 distal setae .

Third Maxilliped (Fig.11H) - Basis with 2 setae ; endopod 5-segmented with numerous setae ; exopod with 2 small terminal setae .

First leg (Fig.11I) - Right and left equal ; propodus twice as long as broad , with scattered setae .

Second and Third legs (Fig.11J,11K) - Similar , carpus about equal in length to propodus .

Fourth leg (Fig.11L) - Carpus and merus with few setae , propodus with 4 corneous spines and few setae , dactylus short with long seta and a few short setae .

Fifth leg (Fig.11M) - Propodus with a few corneous spines and long curved setae .

Abdomen (Fig.11A) - Somites with 1, 2, 2, 2, 2, 1 median dorsal spines , also pair of dorso-lateral spines on somite 1 .

Pleopods (Fig.11N) - On somites 2 to 5 similar : endopod a simple lobe with 2 curved spines , exopod with 9 natatory plumose setae .

Uropod (Fig.11O) - Endopod with 13 plumose setae and 5 blunt corneous spines ; exopod with 25 plumose setae , 2 small setae and 4 blunt corneous spines .

Telson (Fig.110) - Subquadrangular , somewhat broader than long , with 9 plumose setae on posterior margin , 3 small setae on one side and 2 setae on other in specimen examined , 4, 2, 2, 2, spines on dorsal surface .

DISCUSSION

There has been some argument about the name of the species of *Coenobita* which occur in the Red Sea . The debate was summarised by Lewinsohn (1969) , who gave a full bibliography and demonstrated that adult specimens from the Red Sea show a number of relatively small but consistent differences from *C. rugosus* H. Milne Edwards from the Indian ocean and west Pacific . The present work follows Lewinsohn in the use of the name *Coenobita scaevola* (Forskål , 1775) for the Red Sea species , which was originally described under the name *Cancer scaevola* .

Zoeas of *C. scaevola* differ in minor characters from described larvae of other species of this genus . Those of four species of *Coenobita* have been described , *C. perlatus*, *C. rugosus*, *C. cavipes* and *C. clypeatus*. The description of the newly hatched larva of *C. perlatus* by Borradaile (1903) is too brief to permit detailed comparision . The first stage of *C. scaevola* is very similar in general appearance to the first stage of *C. rugosus* as illustrated by Yamaguchi (1938) , but there are some differences .

In *C. rugosus*, the antennule bears a different number of setae, the antennal scale has an additional seta at the proximal end of the inner margin and the endopod is shown as segmented, although this may be erroneously represented by Yamaguchi. The maxilla and second maxilliped have minor differences in setation from *C. scaevola*. In the megalopa stage the long ramus of the antennule is segmented in *C. rugosus* but unsegmented in *C. scaevola*; the antennal flagellum of *C. rugosus* has 7 segments, compared with 5 in *C. scaevola*. Most of the megalopal appendages of *C. rugosus* are not illustrated by Yamaguchi and therefore no detailed comparision between the two larvae can be made.

Recently Shokita et al (1986) have published full descriptions of the larval development of *C. rugosus* and *C. cavipes* Stimpson. The larvae of these two species are very similar and differences are confined to the appendages, which show minor differences in setation. These authors compared their larvae of *C. rugosus* with those described by Yamaguchi (1938) and pointed out a number of differences. They suggested that the larvae described by Yamaguchi might have belonged to *C. purpureus*, the adults of which have frequently been confused with *C. rugosus*. Confirmation is, however, required of several points in the description of larvae of *C. rugosus* by Shokita et al. In zoea I, the numbers of setae stated to occur on the endopod of the antenna and on the endopods of the first and second maxillipeds differ not only from those given here for *C. scaevola* but also from those of other known coenobitid larvae, and the 3 setae shown on the scaphognathite of the maxilla would be unique among anomuran larvae . In the megalopa , *C. rugosus* has 6 segments in the antennal flagellum , compared with 5 *C. scaevola* , and the two species differ in the number of plumose setae on the exopods of the pleopods . Whichever description is correct , the larvae of *C. rugosus* appear to show minor differences from those of *C. scaevola*.

C. scaevola and *C. clypeatus*(described by Provenzano , 1962) are easily distinguished in the zoeal stages by the medio-dorsal spine on the 5th abdominal somite, which is shorter than the lateral spines in *C. scaevola* but longer in *C. clypeatus*. In all other zoeal stages *C. clypeatus* is distinguished by the presence of a dorsal rostral carina . *C. clypeatus* is longer than *C. scaevola* in all stages , and the appendages show some differences in setation . Provenzano obtained the megalopa of *C. clypeatus* after 5 or 6 stages , but in the present study the megalopa of *C. scaevola* was obtained after 7 stages. It is possible that the different laboratory conditions of temperature and salinity are the reason for the difference in the numbers of stages . Temperature and salinity were 25° C , 38- 39 ppt. in the present study while they were 29° C , 33-36 ppt. for *C. clypeatus* .

The only other genus of the Coenobitidae is *Birgus* . Larvae of *B. latro* , the only species of this genus , have been described by Reese and Kinzie (1968) . This spcies has two submedian spines on the posterior dorsal margin of the fifth abdominal somite and the other somites are without spines . This is the main character which distinguishes *B. latro* from the species of *Coenobita* .

MacDonald , Pike & Williamson (1957) and Pike & Williamson (1960) grouped the Coenobitidae with the Diogenidae in the superfamily Coenobitoidea, while other hermit-crabs were grouped in the superfamily Paguroidea. The early zoeal stages of the known larvae of *Coenobita* resemble those of the Diogenidae rather than the Paguroidea in having three setae on the antennal endopod . The occurrence of median dorsal abdominal spines in the zoeal stages of *Coenobita* is a character shared with many Diogenidae but no known Paguroidea (Paguroidea usually have a small pair of median dorsal spines but not a single median spine) . There are, however, two submedian dorsal spines on the fifth abdominal somites in the zoea larvae of *B. latro*, the only other genus of the Coenobitidae (Reese and Kinzie ,1968) . The presence of a median telson spine in the later zoeal stages of the Coenobitidae seems to distinguish this family from all other known larvae of the Anomura (*sensu stricto*), although it is a common feature of larvae of the Thalassinoidea .

Figure 2 . *Coenobita scaevola* (Forskål) , lateral view of zoeal stages.

A, first stage; B , second stage ; C , third stage ; D , fourth stage ; E , fifth stage ; F , sixth stage ; G , seventh stage . Scale bar = 0.5 mm .

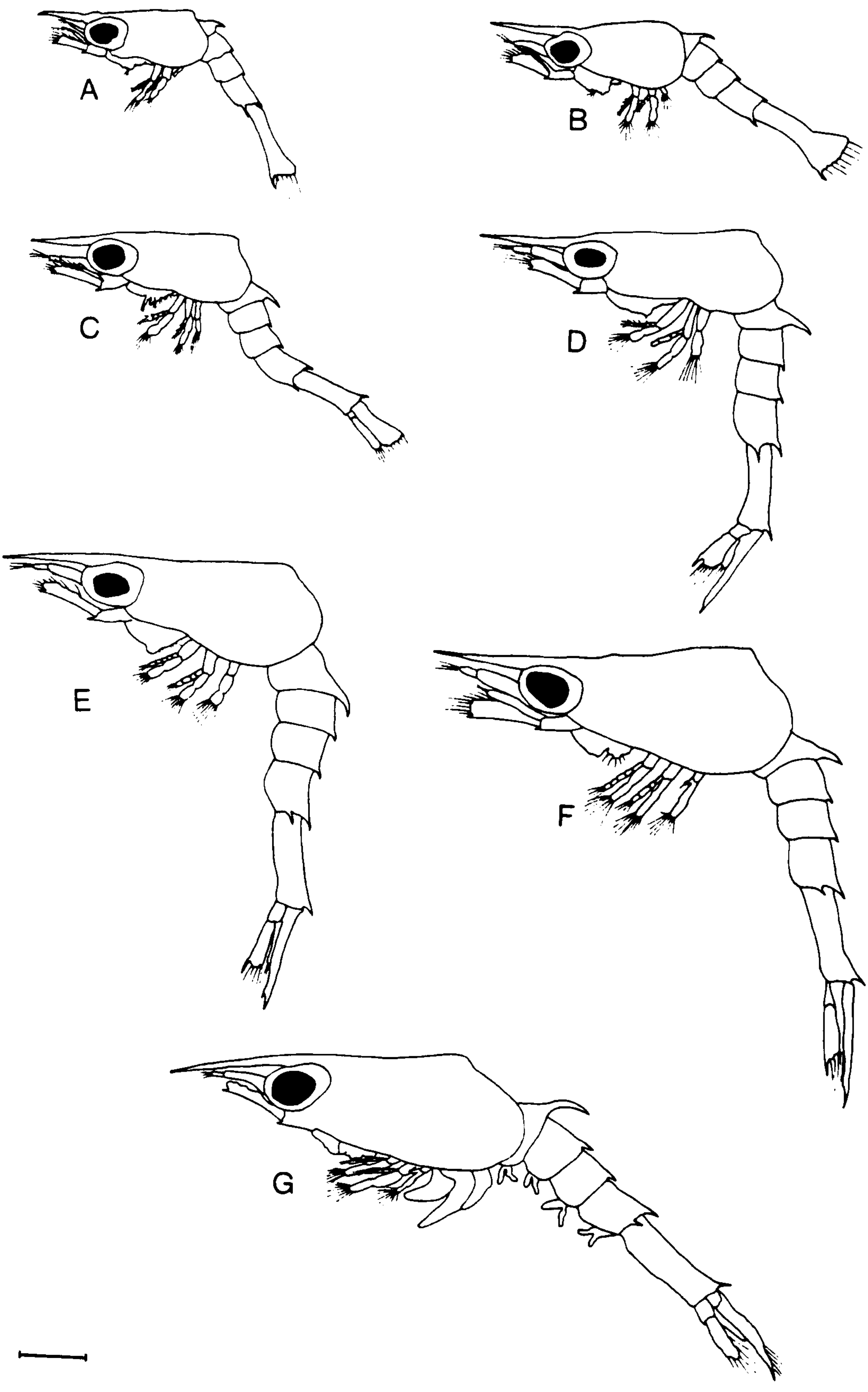

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Figure 3 . *Coenobita scaevola* (Forskål), dorsal view of zoeal stages. A , first stage ; B , second stage ; C , third stage ; D , fourth stage ; E , fifth stage ; F , sixth stage ; G , seventh stage . Scale bar = 0.5 mm .

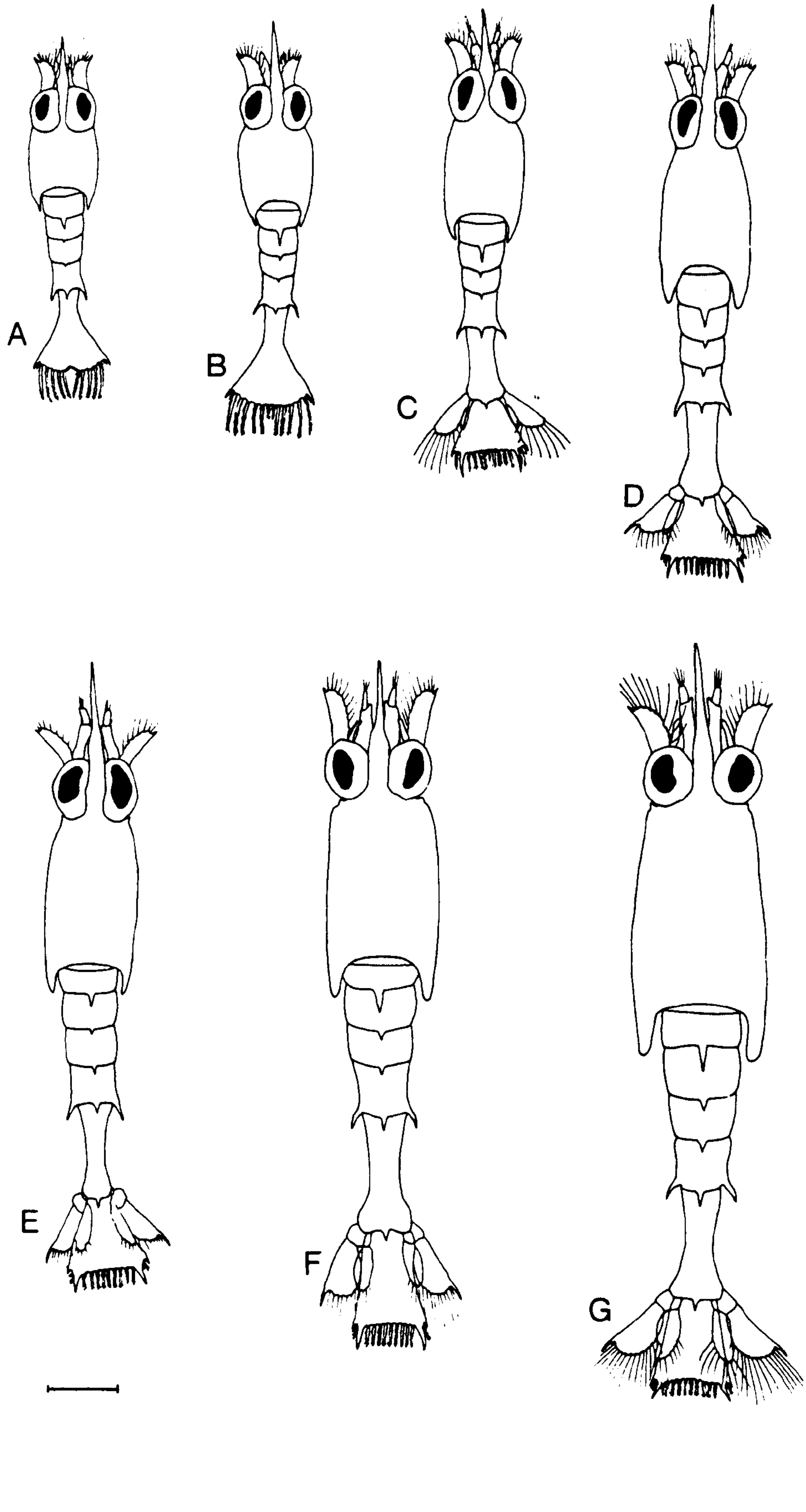
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Figure 4. *Coenobita scaevola* (Forskål), first zoea.

A, antennule ; B, antenna ; C, mandible ; D, maxillule ; e, maxilla ; F, first maxilliped ; G, second maxilliped ; H, third maxilliped ; I, telson. Scale bars (from top) : (1) I = 0.5 mm ; (2) A,B, F,G = 0.2 mm ; (3) C-E, H = 0.2 mm.

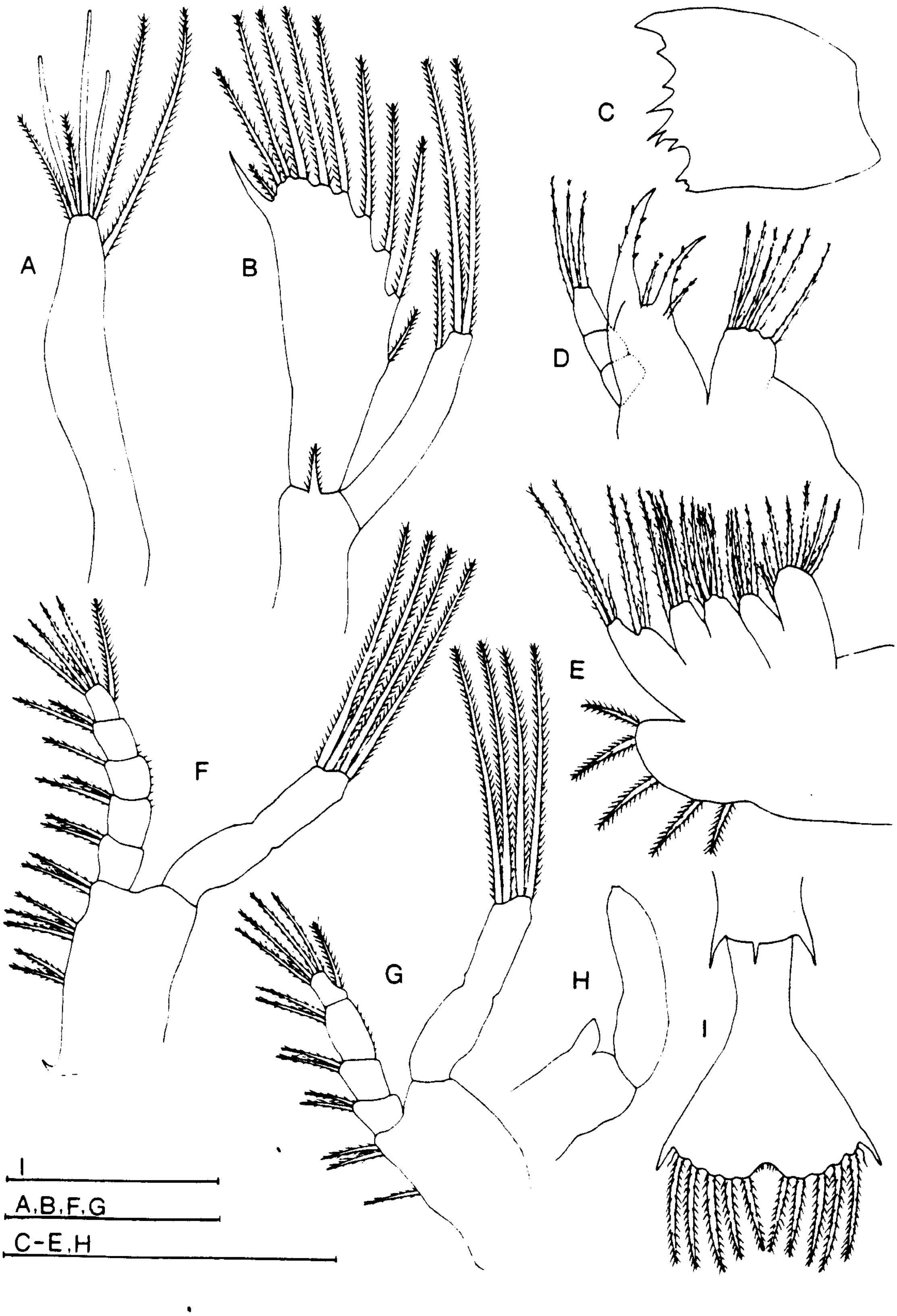
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Figure 5 . *Coenobita scaevola* (Forskål), second zoea .

A , antennule ; B , antenna ; C , mandible ; D , maxillule ; E , maxilla ; F , first maxilliped ; G , second maxilliped ; H , third maxilliped; I , telson . Scale bars (from top) : (1) A, B , F-H= 0.2 mm, I = 0.5 mm ; (2) C-E = 0.2 mm.

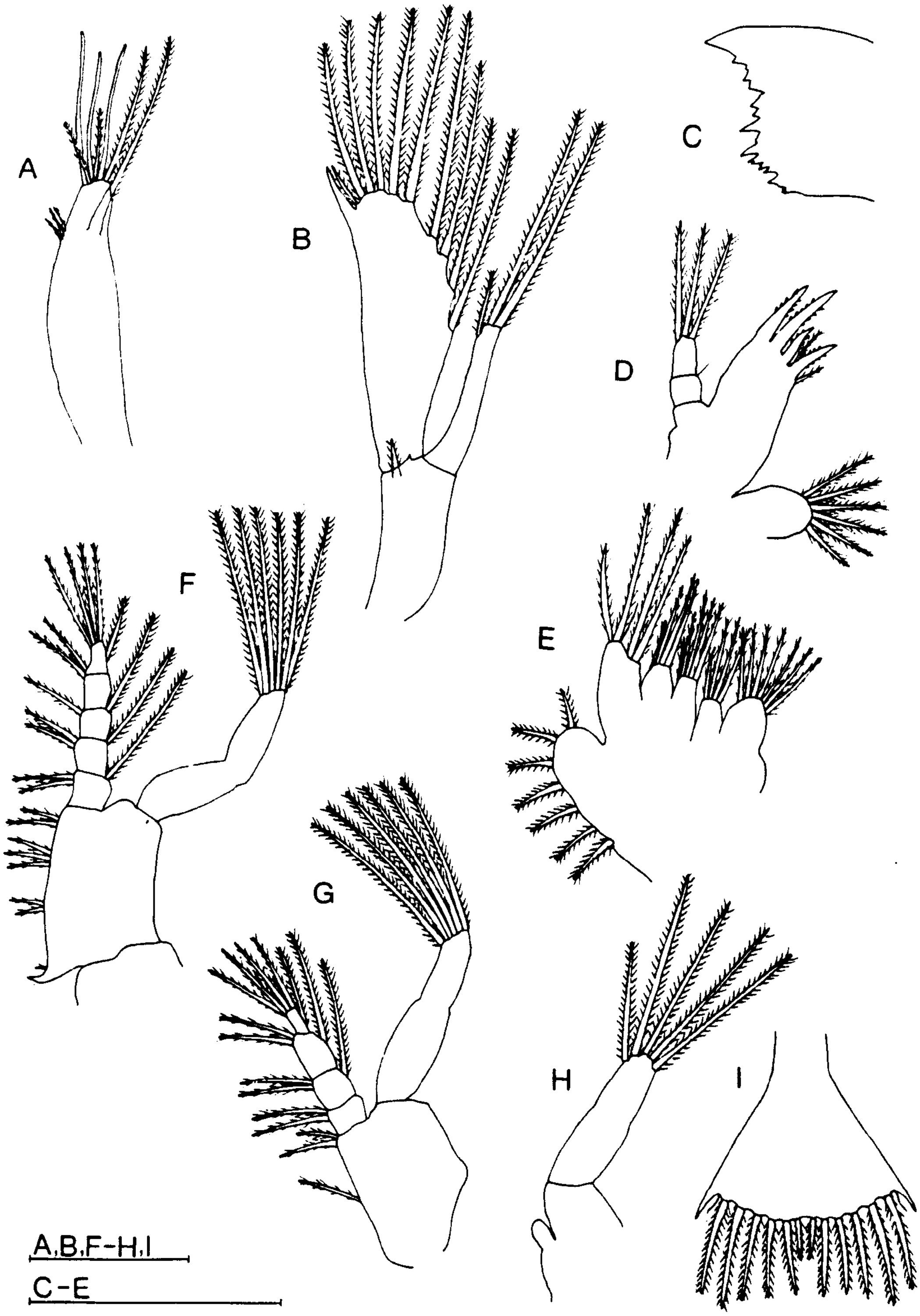
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Figure 6 . *Coenobita scaevola* (Forskål) , third zoea .

A , antennule ; B , antenna ; C , mandible ; E , maxilla ; F , first maxilliped ; G , second maxilliped ; H , third maxilliped; I , uropod and telson . Scale bars (from top) : (1) A, B , F–H= 0.2 mm , I = 0.5 mm ; (2) C–E = 0.2 mm .

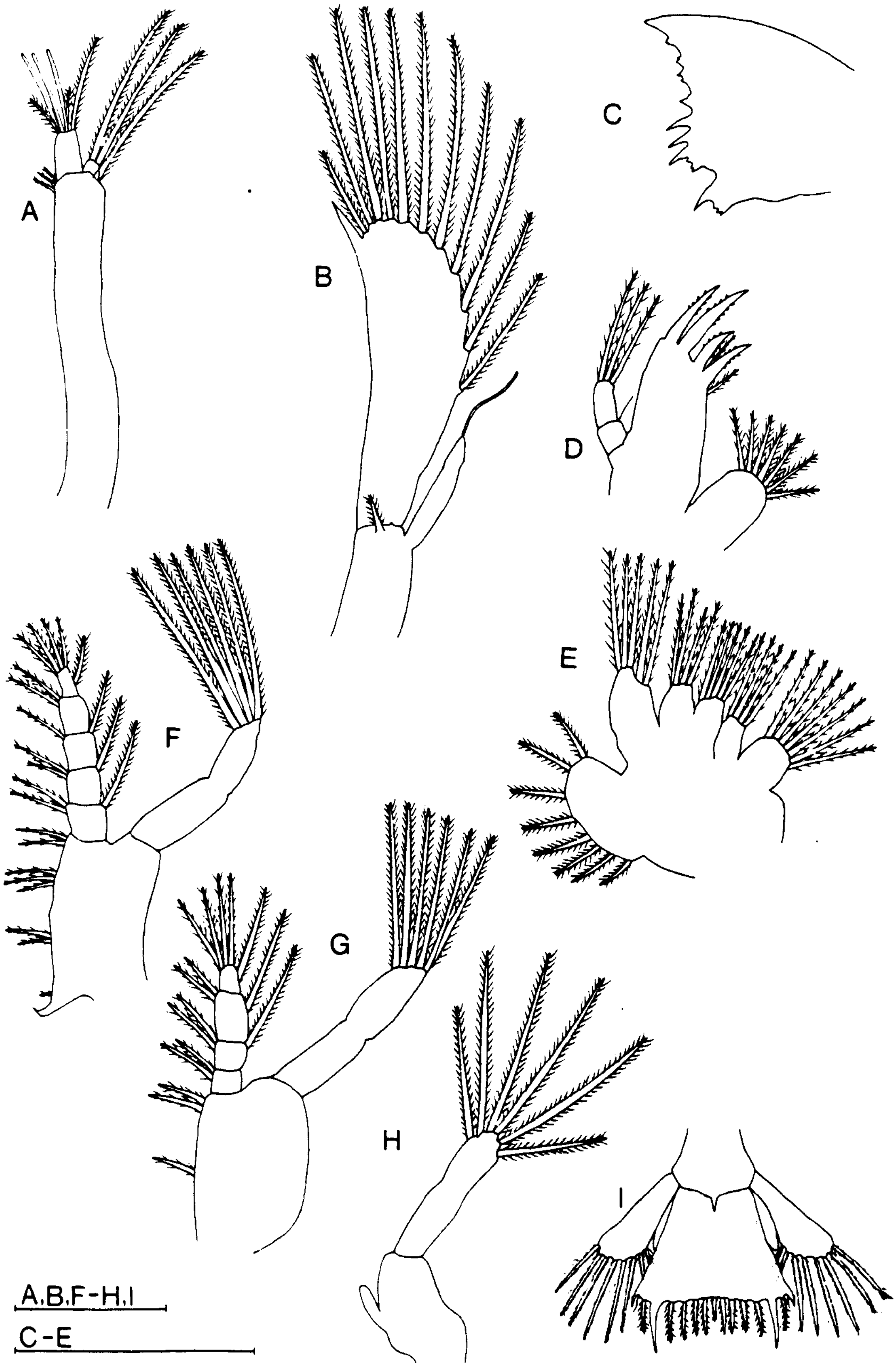
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Figure 7 . *Coenobita scaevola* (Forskål) , fourth zoea .

A , antennule ; B , antenna ; C , mandible ; D , maxillule ; E , maxilla ; F , first maxilliped ; G , second maxilliped ; H , third maxilliped ; I , uropod and telson . Scale bars (from top) : (1) A,B,F–H = 0.2 mm , I = 0.5 mm ; (2) C–E = 0.2 mm .

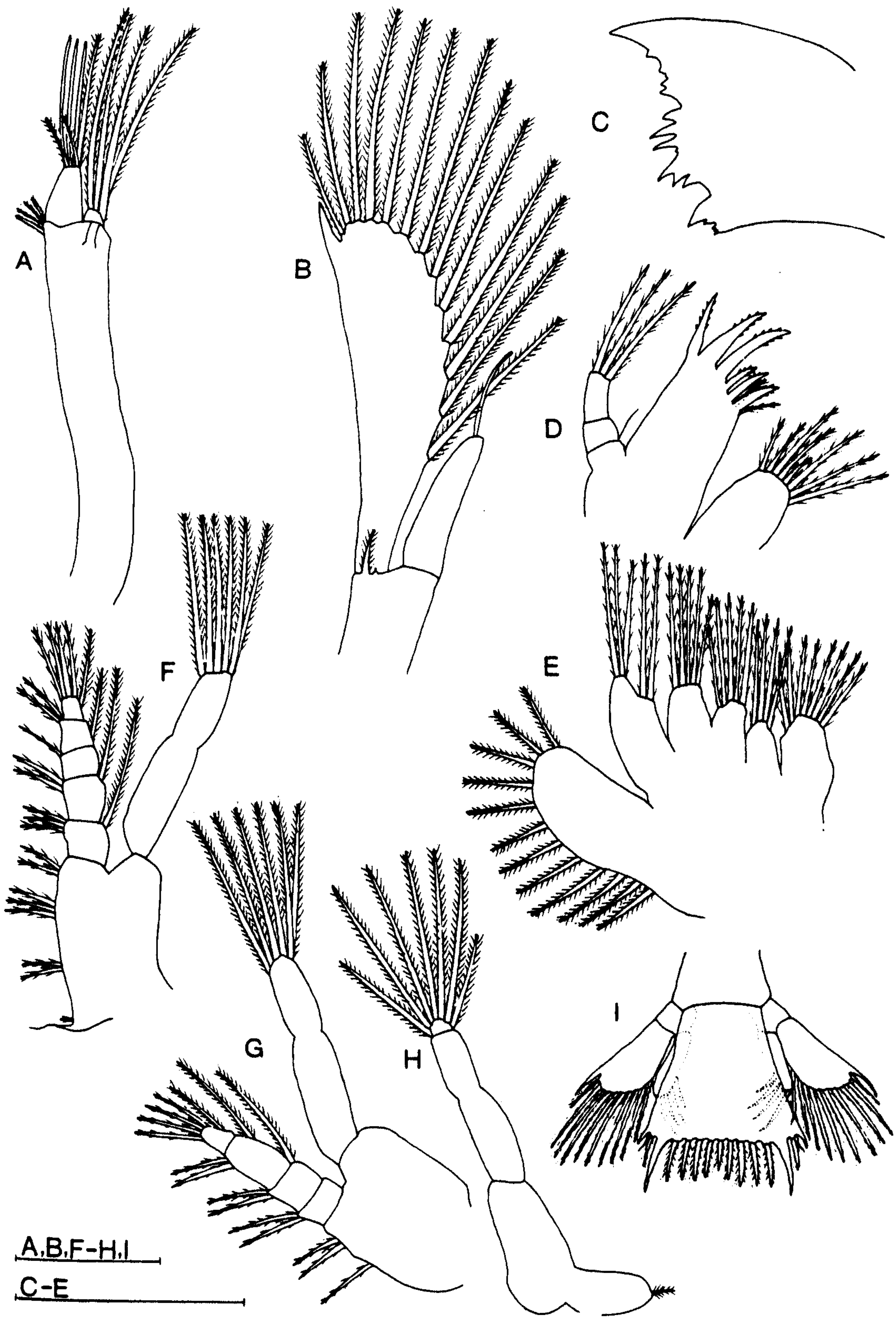
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Figure 8 . *Coenobita scaevola* (Forskål) , fifth zoea .

A , antennule ; B , anttena ; C , mandible ; D , maxillule ; E , maxilla ; F , first maxilliped ; G , second maxilliped ; H , third maxilliped ; I , uropod and telson . Scale bars (from top) : (1) A,B,F-H = 0.2 mm ; (2) C-E = 0.2 mm , I = 0.5 mm .

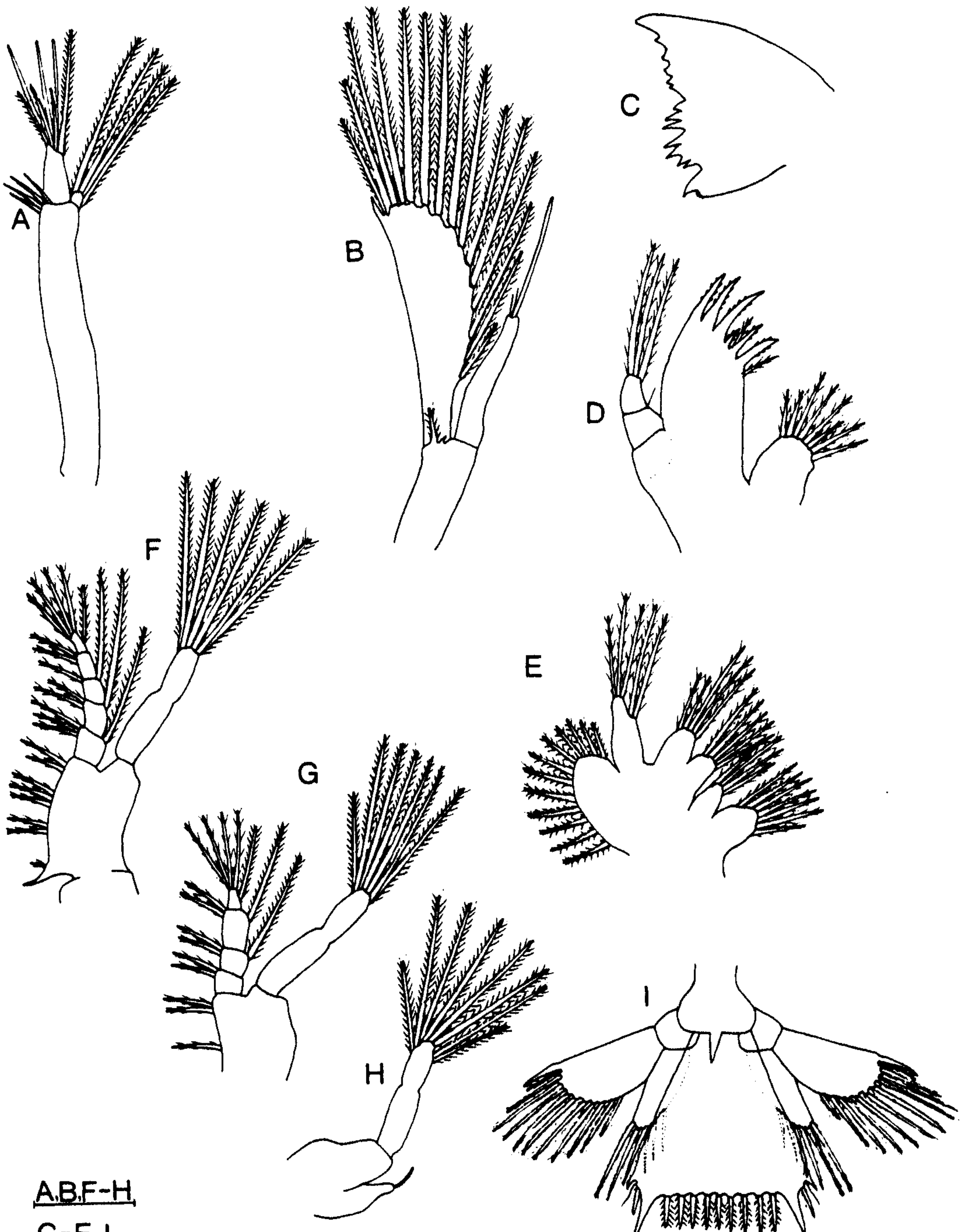
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Figure 9 . *Coenobita scaevola* (Forskål) , sixth zoea .

A , antennule ; B , antenna ; C , mandible ; D , maxillule ; E , maxilla ; F, first maxilliped ; G , second maxilliped ; H , third maxilliped ; I , uropod and telson . Scale bars (from top) : (1) A,B,F-H =0.2 mm ; (2) C-E = 0.2 mm , I = 0.5 mm .

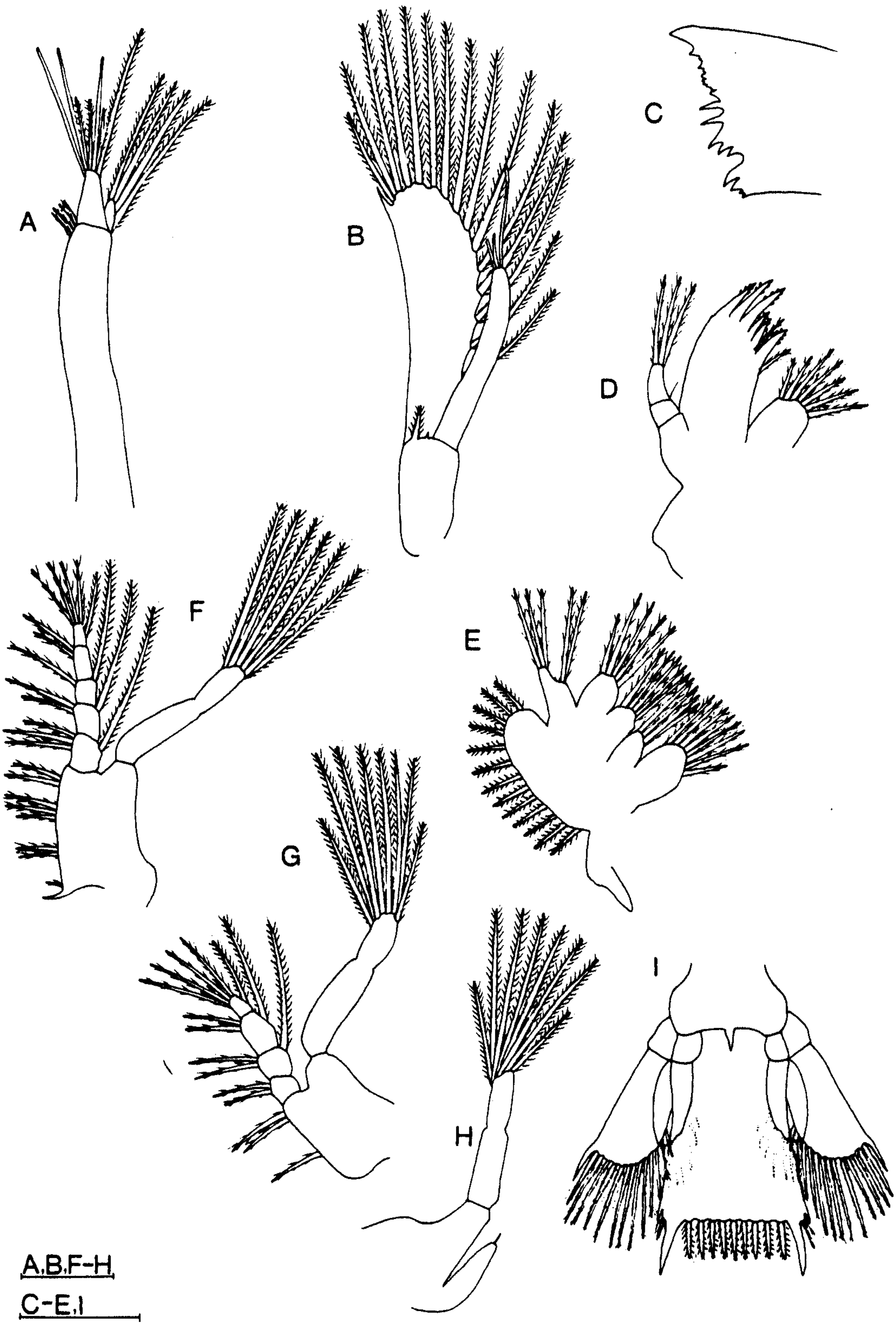
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Figure 10. *Coenobita scaevola* (Forskål), seventh zoea.

A, antennule ; B, antenna ; C, mandible ; D, maxillule ; E, maxilla ; F, first maxilliped ; G, second maxilliped ; H, third maxilliped ; I, uropod and telson. Scale bars (from top) : (1) A,B,F-H = 0.2 mm ; (2) C-E = 0.2 mm, I = 0.5 mm.

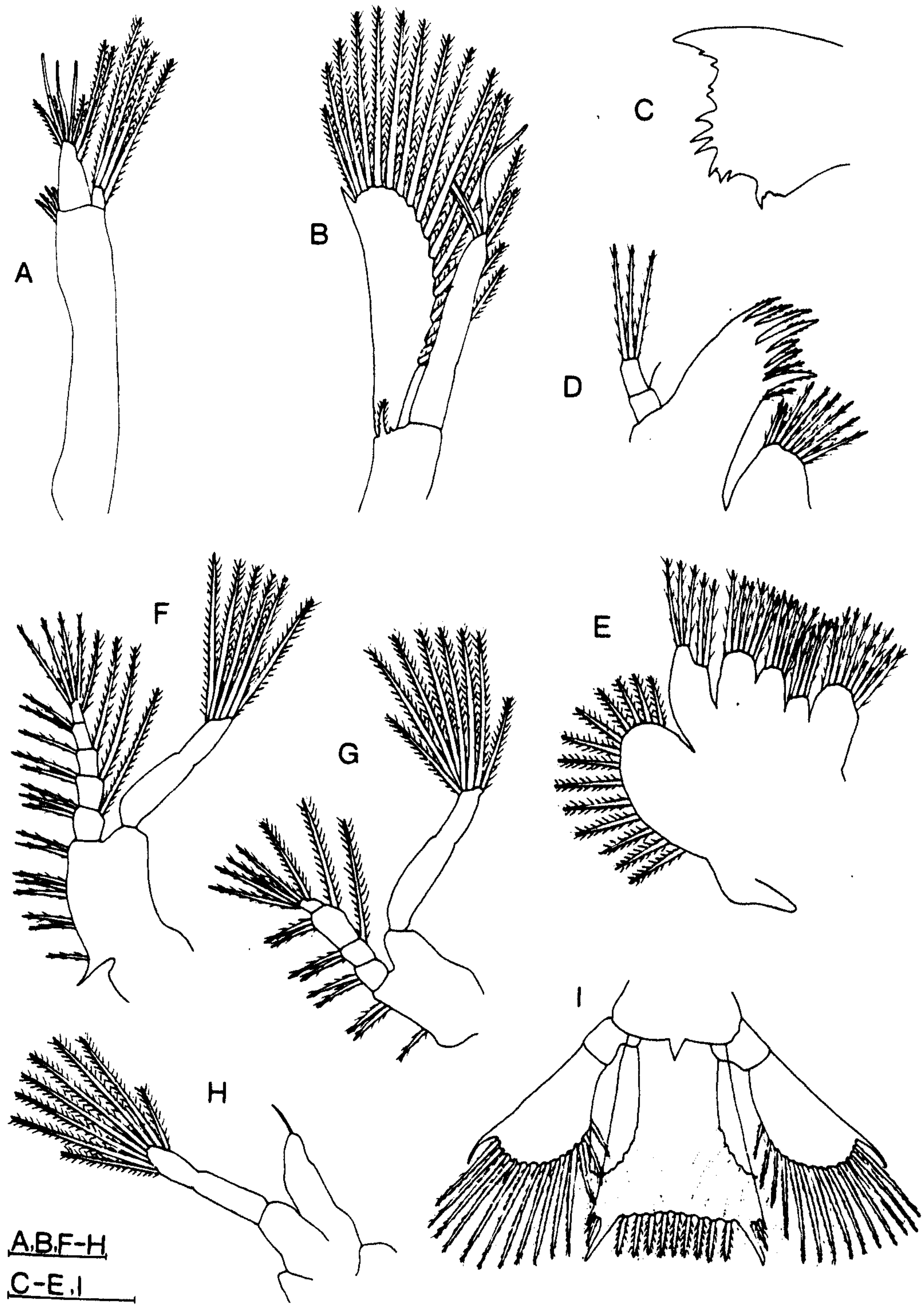

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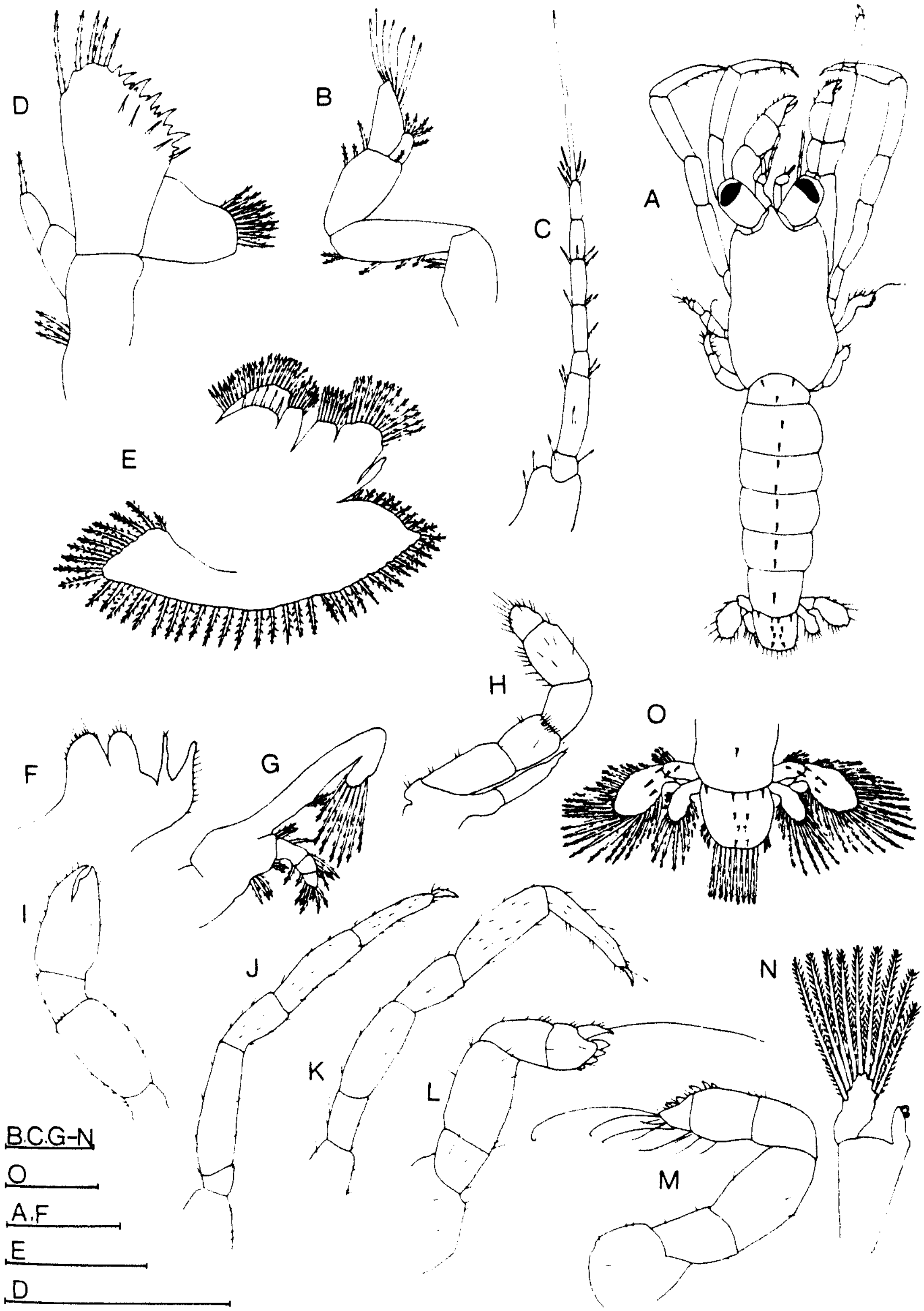
Figure 11 . *Coenobita scaevola* (Forskål), megalopa .

A , dorsal view; B , antennule ; C , antenna ; D , maxillule ; E, maxilla ; F , first maxilliped ; G , second maxilliped ; H , third maxilliped ; I , first leg ; J , second leg ; K , third leg; L , fourth leg ; M , fifth leg ; N , second pleopod ; O , uropod and telson . Scale bars (from top) : (1) B,C,G-N = 0.2 mm ; (2) O = 0.5 mm ; (3) A =1 mm , F = 0.2 mm ; (4) E = 0.2 ; (5) D = 0.2 mm .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CHAPTER 3

LARVAL DEVELOPMENT OF THE HERMIT CRAB DARDANUS TINCTOR (FORSKÅL , 1775) (CRUSTACEA : ANOMURA : DIOGENIDAE) REARED IN THE LABORATORY .

INTRODUCTION

The hermit crab genus *Dardanus* is represented by 3 species in the Jeddah region according to Lewinsohn (1969). From my collection of adults, *D.tinctor* (Forskål, 1775) appears to be more common than the others in this region. It is found among corals and has the habit of encouraging *Calliactis* anemones to settle on its gastropod shell (Vine, 1986).

Although over 40 species of *Dardanus* have been described (Provenzano, 1963) with distributions extending throughout all the warmer seas of the world, there are few previous descriptions of *Dardanus* larvae. Pike and Williamson (1960) described the first zoeal stage of *D. arrosor* (Herbst), and Kurata (1968) reared the same species to the megalopa, but none of these authors described the mouth parts of the larvae. Dechancé (1962) distinguished between different unnamed species of *Dardanus* larvae from the Indo-Pacific, but gave very brief descriptions. Provenzano (1963) described the megalopa stage of *D. venosus* (H. Milne-Edwards), and Nayak and Kakati (1978) described the first zoea stage of *D. setifer* (H. Milne-Edwards).

The purpose of this study is to describe the complete larval stages of *D.tinctor* reared in the laboratory and to compare these with other known *Dardanus* larvae.

MATERIALS AND METHODS

An ovigerous female was collected on 5th April 1987 from a depth of about 5 m by traps . On 13 April larvae hatched , and rearing methods were the same as for *Coenobita scaevola* .

RESULTS

Development and duration of the larvae .

Dardanus tinctor passed through seven stages and one megalopa before reaching the first crab (Table 3) . The number of days required to complete the larval development in the laboratory at 25° C is approximately 41 days .

Table 3 : Duration of each stage and survival of larvae .

Stages	Duration (mean and range) (days)	No. at beginning
Zoea I	8.5 (8 - 9)	70
Zoea II	4.5 (4 - 5)	68
Zoea III	5.0 (4 - 6)	62
Zoea IV	5.0 (4 - 6)	53
Zoea V	5.5 (4 - 7)	44
Zoea VI	6.0 (5 - 7)	37
Zoea VII	8.5 (8 - 9)	18
Megalopa	–	6

Descriptions.

First Zoea

(Fig. 12A,B,13)

Size - CL : 1.24 mm (average)

TL : 2.33 mm (average)

Colour - Orange-red along middle of carapace , all abdomen and part of telson on ventral side .

Carapace (Fig.12A,B) - Rostrum broad at base , narrow at end ; with cuticle scaly .

Eyes (Fig.12A,B) - Immobile .

Antennule (Fig.13A) - Uniramous , with 3 terminal aesthetascs of varying size , 2 short and one long plumose setae ; 1 long subterminal plumose seta .

Antenna (Fig.13B) - Endopod with 2 terminal and 1 subterminal plumose setae , the subterminal seta about 1/3 length of other two ; exopod with 10 plumose setae on inner and distal margin ; a strong serrated ventral spine on protopod at base of exopod ; fine hairs along the outer margin .

Mandible (Fig.13C) - A simple process with irregular teeth , without differentiation into incisor and molar regions .

Maxillule (Fig.13D) - Coxal endite with 6 setae ; basial endite with 2 strong spines , each with several denticles and 2 setae ; endopod with 2 setae .

Maxilla (Fig.13E) - Proximal lobe of coxal endite with 6 setae , distal lobe with 3 setae ; proximal lobe of basial endite with 5 setae , distal lobe with 4 setae ; Outer lobe of endopod with 2 setae , inner lobe with 2 setae ; scaphognathite with 5 plumose setae .

First Maxilliped (Fig.13F) - Basis with hooked process at proximal end of inner face , 1 small seta near hook and 2 , 3 , 2 setae more distally on this face ; endopod 5-segmented with 3/0 , 2/0 , 1/0, 2/0, 4/1 inner / outer plumose setae , also fine outer hairs on segments 1 , 2 , 3 and 4 ; exopod with 4 natatory plumose setae .

Second Maxilliped (Fig.13G) - Basis with 1 , 2 inner setae more distally on this face ; endopod 4-segmented with 2/0 , 2/0 , 2/0 , 4/1 inner / outer setae , also fine outer hairs on segments 2 , 3 ; exopod with 4 natatory plumose setae .

Third Maxilliped (Fig.13H) - A small lobe .

Abdomen (Fig.12A,B) - Surface of cuticle scaly , 5th abdominal somite with short lateral spines .

Telson (Fig.13I) - Triangular in form with concave median notch; 7 pairs of marginal processes : outermost a stout spine , 2nd a fine hair and 3rd to 7th plumose setae ; longitudinal ridges on dorsal surface .

Second Zoea

(Fig.12C,14)

Size - CL : 1.47 mm (average)

TL : 2.72 mm (average)

Carapace (Fig.12C) - Almost unchanged .

Antennule (Fig.14A) - Peduncle with 3 terminal aesthetascs and 2 plumose setae , 2 long subterminal plumose setae and 4 small outer plumose setae .

Antenna (Fig.14B) - Endopod unchanged ; exopod with 12 plumose setae .

Mandible (Fig.14C) - A few more minute corneous teeth .

Maxillule (Fig.14D) - Coxal endite unchanged in setation ; basial endite with 4 strong spines , each with several denticles and 2 setae ; endopod unchanged in setation .

Maxilla (Fig.14E) - Proximal lobe of coxal endite unchanged , distal lobe with 4 setae ; basial endite and endopod unchanged ; schaphognathite with 7 plumose setae .

First maxilliped (Fig.14F) - Basis with 1 small seta near hook and 2, 3 and 3 setae ; endopod with 3/0 , 2/1 , 1/1 , 2/1 , 4/1 inner/outer plumose setae ; exopod with 6 natatory plumose setae .

Second Maxilliped (Fig.14G) - Basis unchanged ; endopod with 2/0 , 2/ 1 , 2/1 , 4/1 inner / outer plumose setae ; exopod with 6 plumose natatory setae .

Third Maxilliped (Fig.14H) - Endopod absent ; exopod a lobe with 5 natatory plumose setae .

Abdomen (Fig.12C) - Unchanged in form .

Telson (Fig.14I) - An inner pair of smaller plumose setae added,to give 8 pairs of posterior marginal processes .

Third Zoea

(Fig.12D,15)

Size - CL : 1.47 mm (average)

TL : 3.40 mm (average)

Carapace (Fig.12D) - Unchanged .

Antennule (Fig.15A) - Now consisting of peduncle and 2 unsegmented rami , 4 short outer distal plumose setae on peduncle ; 4 plumose setae on short inner ramus ; 3 aesthetascs all about same length , 2 long and 2 short plumose setae on large outer ramus .

Antenna (Fig.15B) - Endopod with 1 terminal aesthetasc ; exopod with 14 plumose setae and hairs along outer margin .

Mandible (Fig.15C) - With additional small teeth .

Maxillule (Fig.15D) - Unchanged in setation .

Maxilla (Fig.15E) - Proximal lobe of coxal endite with 7 setae , distal endite unchanged ; basial endite and endopod unchanged ; scaphognathite with 11 plumose setae .

First Maxilliped (Fig.15F) - Unchanged in setation .

Second Maxilliped (Fig.15G) - Unchanged in setation .

Third Maxilliped (Fig.15H) - Endopod a lobe on inner side of basis with short plumose setae ; exopod with 6 natatory plumose setae .

Abdomen (Fig.12D) - Unchanged in form .

Uropod (Fig.15I) - Unsegmented ; endopod unarmed ; exopod with 10 natatory plumose setae .

Telson (Fig.15I) - Slightly wider posterioly than anteriorly ; outer process of stage I and II now completely absent ; original 4th process now a fused spine .

Fourth Zoea
(Fig.12E,16)

Size - CL : 2.04 mm (average)
TL : 4.03 mm (average)

Carapace (Fig.12E) - Unchanged .

Antennule (Fig.16A) - Unchanged in setation with additional short plumose seta on the middle region of the peduncle .

Antenna (Fig.16B) - Endopod unchanged ; exopod with 16 plumose setae

Mandible (Fig.16C) - With additional small teeth .

Maxillule (Fig.16D) - Coxal endite unchanged ; basial endite with 5 strong spines , each with several denticles ; endopod unchanged .

Maxilla (Fig.16E) - Unchanged in setation .

First Maxilliped (Fig.16F) - Unchanged in setation .

Second Maxilliped (Fig.16G) - Endopod unchanged ; exopod with 6 long and 2 short natatory plumose setae .

Third maxilliped (Fig.16H) - Unchanged in setation .

Abdomen (Fig.12E) - Unchanged in form .

Uropod (Fig.16I) - Endopod and exopod articulated with protopod; endopod with 6 plumose setae ; exopod with 12 plumose setae and strong outer distal spine .

Telson (Fig.16I) - Unchanged in form .

Fifth Zoea

(Fig.12F,17)

Size - CL : 2.24 mm (average)

TL : 4.22 mm (average)

Carapace (Fig.12F) - Unchanged .

Antennule (Fig.17A) - Unchanged in setation except one additional plumose seta on large (outer) ramus and one additional short plumose seta on the middle region of the peduncle .

Antenna (Fig.17B) - Endopod with 2 terminal aesthetases ; exopod with 17 plumose setae .

Mandible (Fig.17C) - Unchanged in form .

Maxillule (Fig.17D) - Coxal endite with 7 setae , basial endite and endopod unchanged in setation .

Maxilla (Fig.17E) - Unchanged in setation .

First Maxilliped (Fig.17F) - Unchanged in setation .

Second Maxilliped (Fig.17G) - Endopod unchanged ; exopod now with 8 equal natatory plumose setae .

Third Maxilliped (Fig.17H) - Endopod unchanged ; exopod with 6 long and 1 short natatory plumose setae .

Abdomen (Fig.12F) - Unchanged in form .

Uropod (Fig.17I) - Endopod with 7 - 8 plumose setae ; exopod with 14 plumose setae .

Telson (Fig.17I) - Unchanged in form .

Sixth Zoea
(Fig.12G,18)

Size - CL : 2.52 mm (average)
TL : 4.76 mm (average)

Carapace (Fig.12G) - Unchanged .

Antennule (Fig.18A) - Unchanged in setation except long (outer) ramus now with 4 aesthetases , 3 long and 2 short plumose setae .

Antenna (Fig.18B) - Unchanged in setation .

Mandible (Fig.18C) - With additional small teeth .

Maxillule (Fig.18D) - Unchanged in setation .

Maxilla (Fig.18E) - Proximal lobe of coxal endite with 11 setae , distal lobe unchanged ; proximal lobe of basial endite with 6 setae , distal lobe with 5 setae ; endopod unchanged ; scaphognathite with 12 plumose setae and now with unarmed posterior projection , 4 plumose setae at base of proximal projection.

First Maxilliped (Fig.18F) - Endopod unchanged in setation ; exopod with 7 natatory plumose setae .

Second Maxilliped (Fig.18G) - Unchanged in setation .

Third Maxilliped (Fig.18H) - Endopod unchanged ; exopod now with 7 equal natatory plumose setae .

Abdomen (Fig.12G) - Unchanged in form .

Uropod (Fig.18I) - Endopod with 9 plumose setae ; exopod with 16 plumose setae .

Telson (Fig.18I) - With additional pair of inner plumose setae , to give 9 + 9 processes .

Seventh Zoea

(Fig. 12H,19)

Size - CL : 3.52 mm (average)

TL : 5.85 mm (average)

Carapace (Fig.12H) - Unchanged .

Antennule (Fig.19A) - Small (inner) ramus with 6 plumose setae ; long (outer) ramus with 3 long and 2 short plumose setae and 9 - 10 aesthetascs ; proximal part of peduncle with 2 plumose setae , middle part with 2 plumose setae and basal part with 4 plumose setae.

Antenna (Fig.19B) - Endopod unchanged ; exopod with 18 plumose setae .

Mandible (Fig.18C) - Unchanged in form .

Maxillule (Fig.19D) - Coxal endite with 9 setae ; basial endite and endopod unchanged .

Maxilla (Fig.19E) - Proximal lobe of coxal endite with 13 setae , distal lobe unchanged ; proximal lobe of basial endite with 7 setae and distal lobe with 5 setae ; endopod unchanged ; scaphognathite with 13 plumose setae and 4 plumose setae at base of proximal projection .

First Maxilliped (Fig.19F) - Endopod unchanged ; exopod with 9 natatory plumose setae .

Second Maxilliped (Fig.19G) - Endopod unchanged ; exopod with 9 natatory plumose setae .

Third Maxilliped (Fig.19H) - Endopod with 2 short setae , exopod with 8 natatory plumose setae .

Pleopods (Fig.12H) - Small biramous buds on somites 2 - 5 .

Uropod (Fig.19I) - Endopod with 11 plumose setae ; exopod with 16 plumose setae .

Telson (Fig.19I) - Unchanged in form .

Megalopa

(Fig. 20)

Size - CL : 1.76 mm (average)

TL : 4.96 mm (average)

Carapace (Fig. 20A) - Shorter than abdomen , with prominent blunt rostrum .

Eyes (Fig. 20A) - Length of eyestalks less than twice width .

Antennule (Fig. 20B) - Peduncle 3-segmented with short setae ; rami segmented , inner (shorter) ramus of 4 segments with short setae, outer (longer) ramus of 7 segments with numerous long setae.

Antenna (Fig. 20C) - Flagellum with 14 segments , distal segment with seta ; small vestigial exopod with 2 short setae .

Mandible palp (Fig. 20D) - paddle-like with 12 terminal setae and 2 setae at proximal end .

Maxillule (Fig. 20E) - Coxal endite with 8 spines and 12 setae ; basial endite with 13 spines and 10 setae ; endopod with 1 seta .

Maxilla (Fig. 20F) - Proximal lobe of coxal endite with about 34 setae and distal lobe with 9 setae ; proximal lobe of basial endite with 12 setae and distal lobe with 12 setae ; endopod unsegmented without setae ; scaphognathite with about 49 plumose setae .

First Maxilliped (Fig. 20G) - Endopod unsegmented , with short terminal seta ; exopod with 6 natatory plumose setae ; epipod blade-like with 10 plumose setae .

Second Maxilliped (Fig. 20H) - Endopod of 4 segments with short setae ; exopod with 8 natatory plumose setae .

Third Maxilliped (Fig. 20I) - Endopod of 5 segments with numerous short setae ; exopod with 8 natatory plumose setae .

First Leg (Fig. 20J) - Right and left chelipeds equal ; dactyl about 1/3 length of merus .

Second and third Legs (Fig. 20K,L) - Similar , dactylus shorter than propodus , with some spines .

Fourth and fifth Legs (Fig. 20M,N) - Chelate , with numbers of setae .

Pleopods (Fig. 20O) - On somites 2 - 5 , similar : endopod a simple lobe with 2 curved spines ; exopod with 9 natatory plumose setae .

Uropod (Fig. 20P) - Endopod with 16 long ,1 short plumose setae and 4 blunt corneous spines ; exopod with 21 long , 3 short plumose setae and 9 blunt corneous spines .

Telson (Fig. 20P) - Ovoid , about twice as long as broad , with 12 plumose setae on posterior margin .

DISCUSSION

This is the first description of the larvae of *D. tinctor* (Forskål,1775) and , as noted in the Introduction , it is the first complete account of the larval development of any species of the genus *Dardanus*. Kurata (1968) , however , established the number of zoeal stages in *D.arrosor* and gave figures of the antennule, antenna and telson in each stage . Unpublished figures by Dr . D. I . Williamson of all the appendages of zoeal stages I - V and the megalopa of this species have also been made available to the author , and it is therefore possible to compare the larvae of *D.tinctor* and *D. arrosor* in some detail . Similarities between the larvae of the two species include the number of zoeal stages (*D.arrosor* can pass through either 7 or 8) , the lack of distinct chromatophores and the general shape of the rostrum , carapace and telson .

The larvae of *D. tinctor* are , however , only about 3/4 the length of those of *D. arrosor* in each stage ; in the zoeal stages , the rostrum is shorter , extending beyond the antennal scale by only about half the length of the scale as opposed to the full length ; and there was no dorsal carina at the base of the rostrum . The lateral spines on the 5th abdominal somite are smaller in *D. tinctor* , and the outermost telson process , which becomes reduced to a small spine in *D. arrosor* , disappears entirely in *D. tinctor*. The antennal exopod bears the same number of setae in both species in zoeal stages I and II , but *D. arrosor* bears one more in zoea III , increasing to 5 more in zoea VII .

In those stages which can be compared , *D. arrosor* has one more seta than *D. tinctor* on the coxal endite of the maxillule and also on the distal lobe of the coxal endite of the maxilla ; it also has one more seta on the exopod of maxilliped 3 in stages IV and V . The inner setae on the endopods of maxillipeds 1 and 2 also show specific differences : on maxilliped 1 there are 2 , 2 , 1 , 2 in *D. arrosor* , 3, 2, 1, 2 in *D. tinctor* ; on maxilliped 2 there are 2, 1 , 1 in *D.arrosor* , 2 , 2 , 2 in *D. tinctor* .

Nayak and Kakati (1978) described the first zoea of *D. setifer* and noted that the surface of the cuticle was without scales in the larvae they examined . Seridji (1987) (unpublished data) described *D. callidus* (stage III) , which has a very long rostrum and long lateral spines on the 5th abdominal somite . It also shows differences from *D. tinctor* in the setation of most of the appendages. The megalopa of *D.venosus* was described by Provenzano (1963) , and the features of the three known species in this stage are compared in Table 4 .

Table 4 . Comparision of megalopas of *D. tinctor*, *D. arrosor*, and *D. venosus* .

	D. tinctor	*D. arrosor*	*D. venosus*
Mandible : setae on palp	14	19	18
Maxillule : coxal endite :			
spines + setae	8+12	14+?	15+23
basial endite :			
spines + setae	13+10	26+?	35+8
Maxilla : setae on endites	34,9,12,12	19,4,15,21	19,4,15,21
setae on scaphognathite	about 49	about 115	about 100
First maxilliped :			
setae on exopod	6	19	17
Second maxilliped :			
setae on exopod	8	12	14
Third maxilliped :			
setae on exopod	8	15	15
Pleopods			
hooks on endopod	2	5	3-5
setae on endopod	0	3	3-5
setae on exopod	9	14	12
Telson : terminal setae	12	15	17

Appendage setation is mostly similar in *D. venosus* and *D. arrosor*, but both show great differences from *D. tinctor* .

Figure 12. *Dardanus tinctor* (Forskål), lateral view of zoeal stages. A, first stage; B, dorsal view of first stage ; C, second stage ; D, third stage ; E, fourth stage ; F, fifth stage ; G, sixth stage ; H, seventh stage. Scale bar = 0.5 mm.

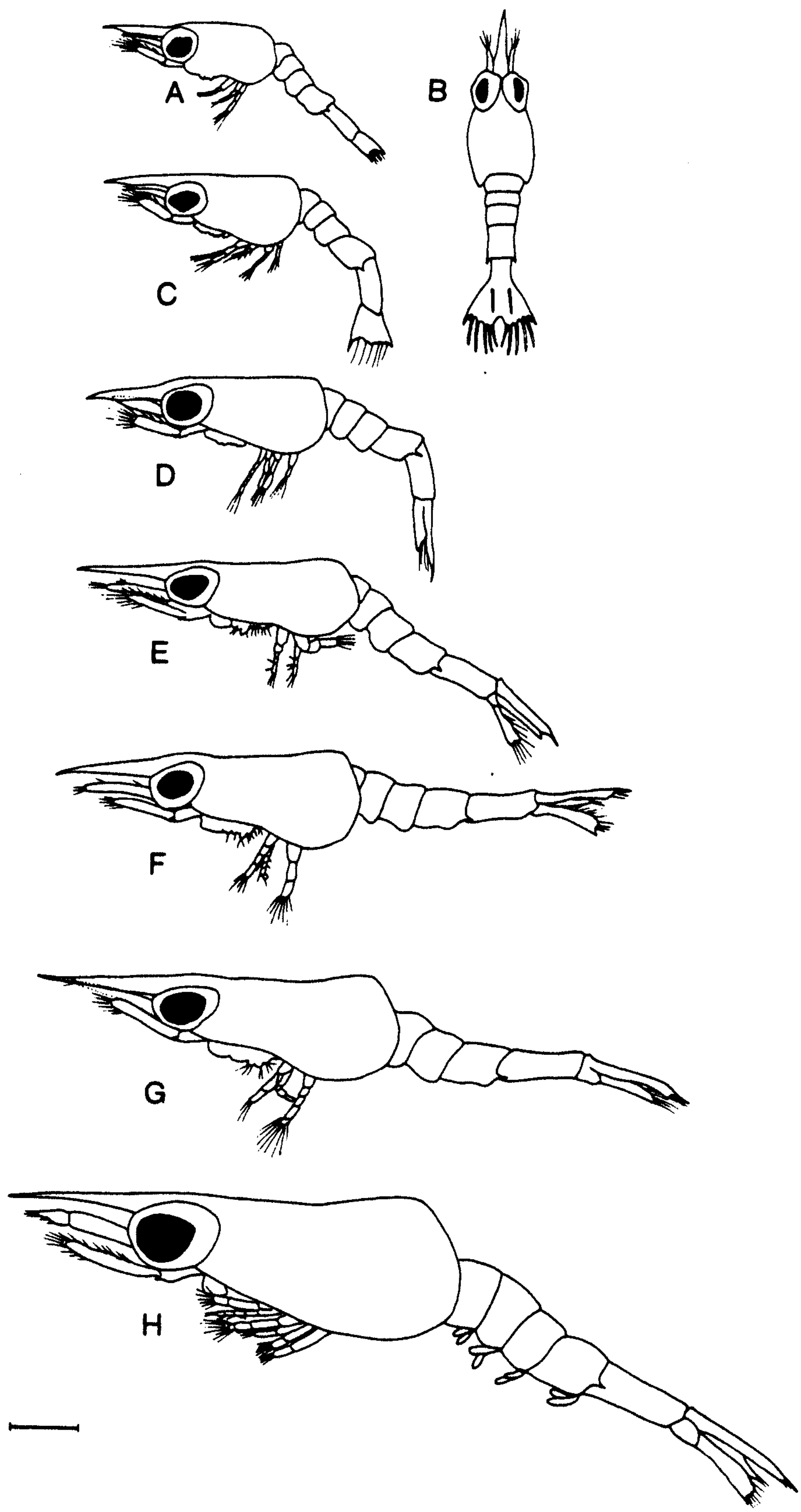
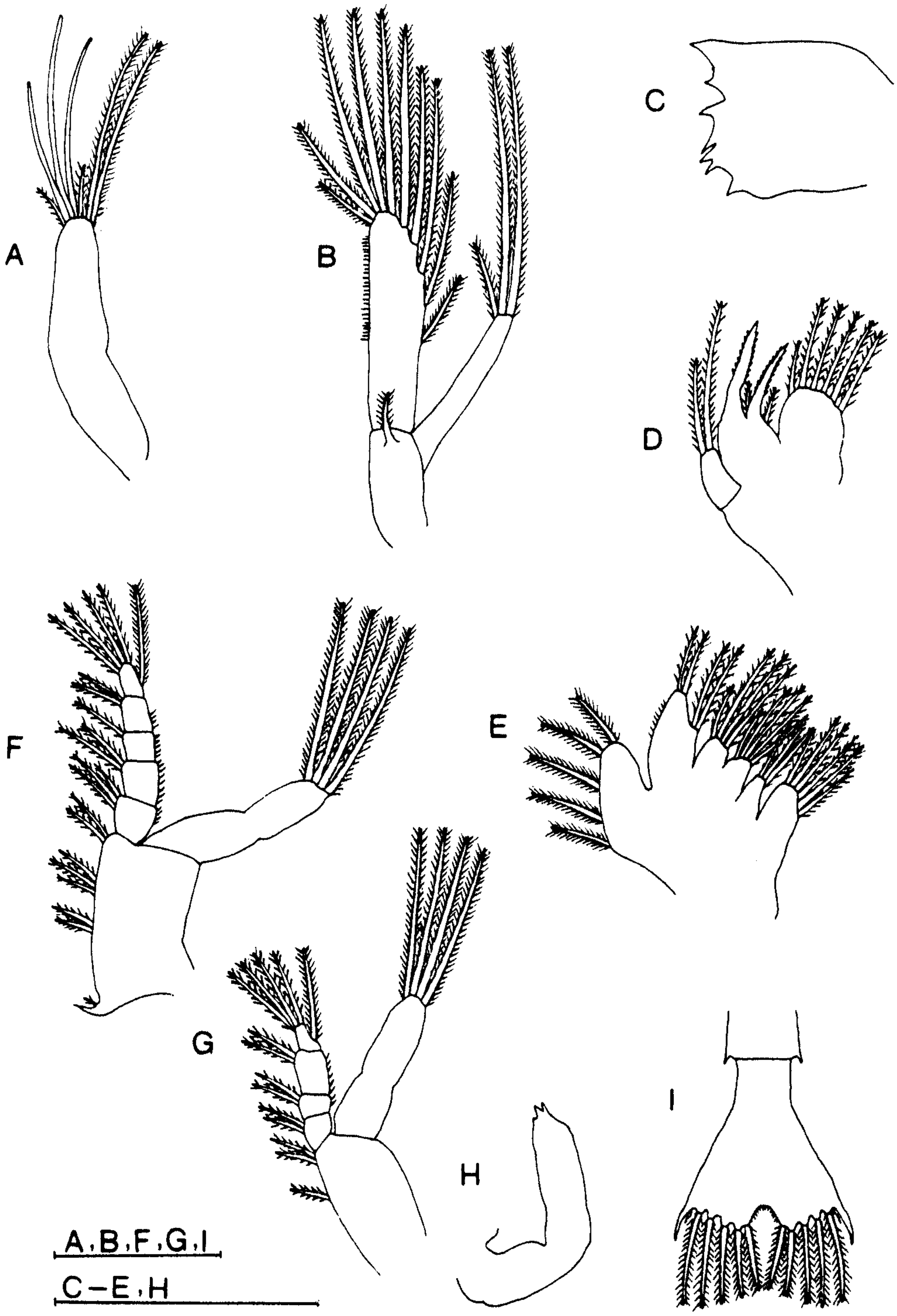

A
B
C
D
E
F
G
H

Figure 13. *Dardanus tinctor* (Forskål), first zoea.

A, antennule ; B , antenna ; C , mandible ; D , maxillule ; e , maxilla ; F , first maxilliped; G, second maxilliped ; H , third maxilliped ; I , telson . Scale bars (from top) : (1) A , B , F, G = 0.2 mm ,I= 0.5 mm ; (2) C - E , H = 0.2 mm .



A
B
C
D
E
F
G
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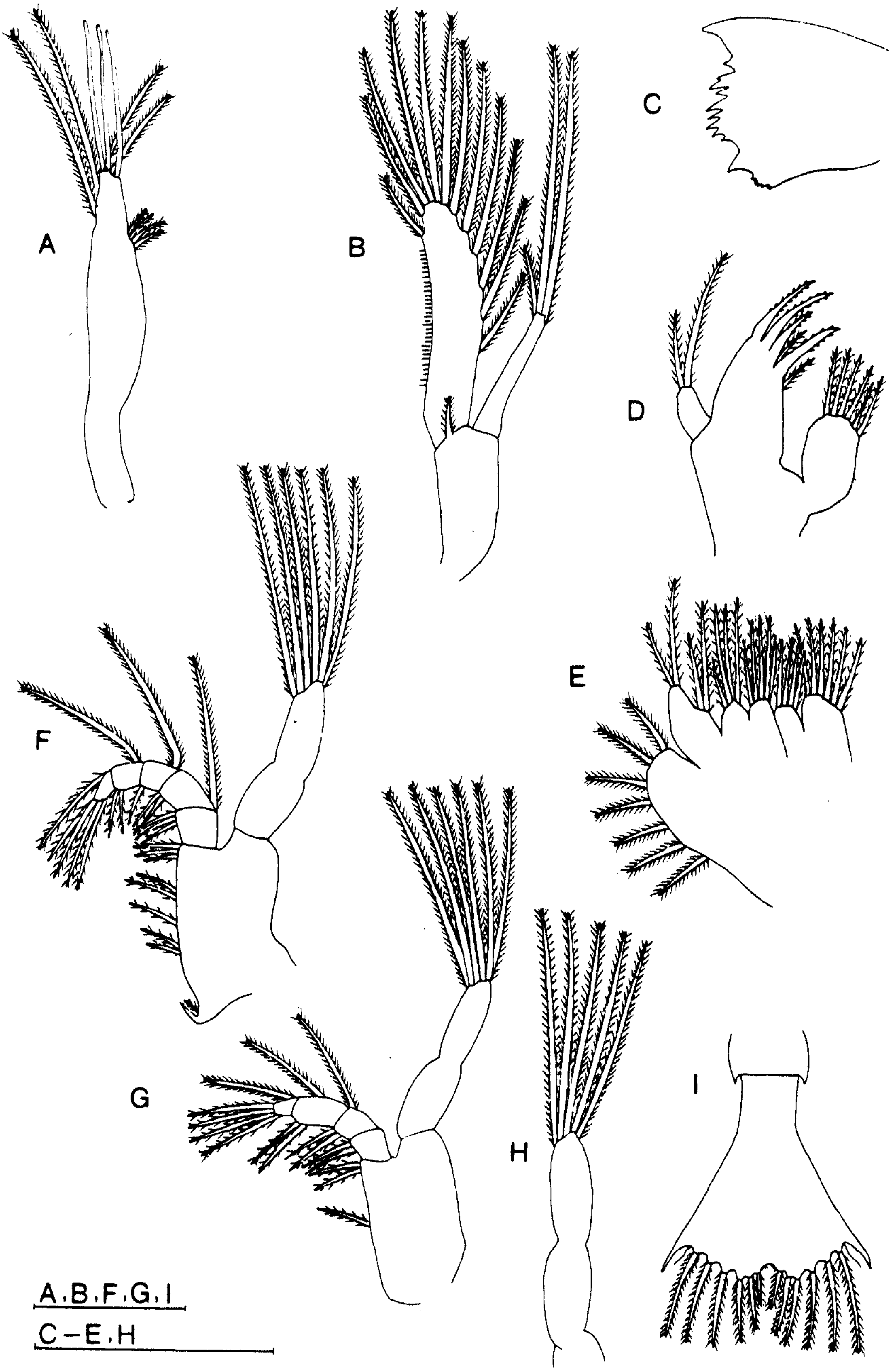
I
A, B, F, G, I
C–E, H

Figure 14. *Dardanus tinctor* (Forskål), second zoea.

A, antennule ; B, antenna ; C, mandible ; D, maxillule ; E, maxilla ; F, first maxilliped ; G, second maxilliped ; H, third maxilliped ; I, telson. Scale bars (from top) : (1) A, B, F, G = 0.2 mm, I = 0.5 mm ; (2) C - E, H = 0.2 mm.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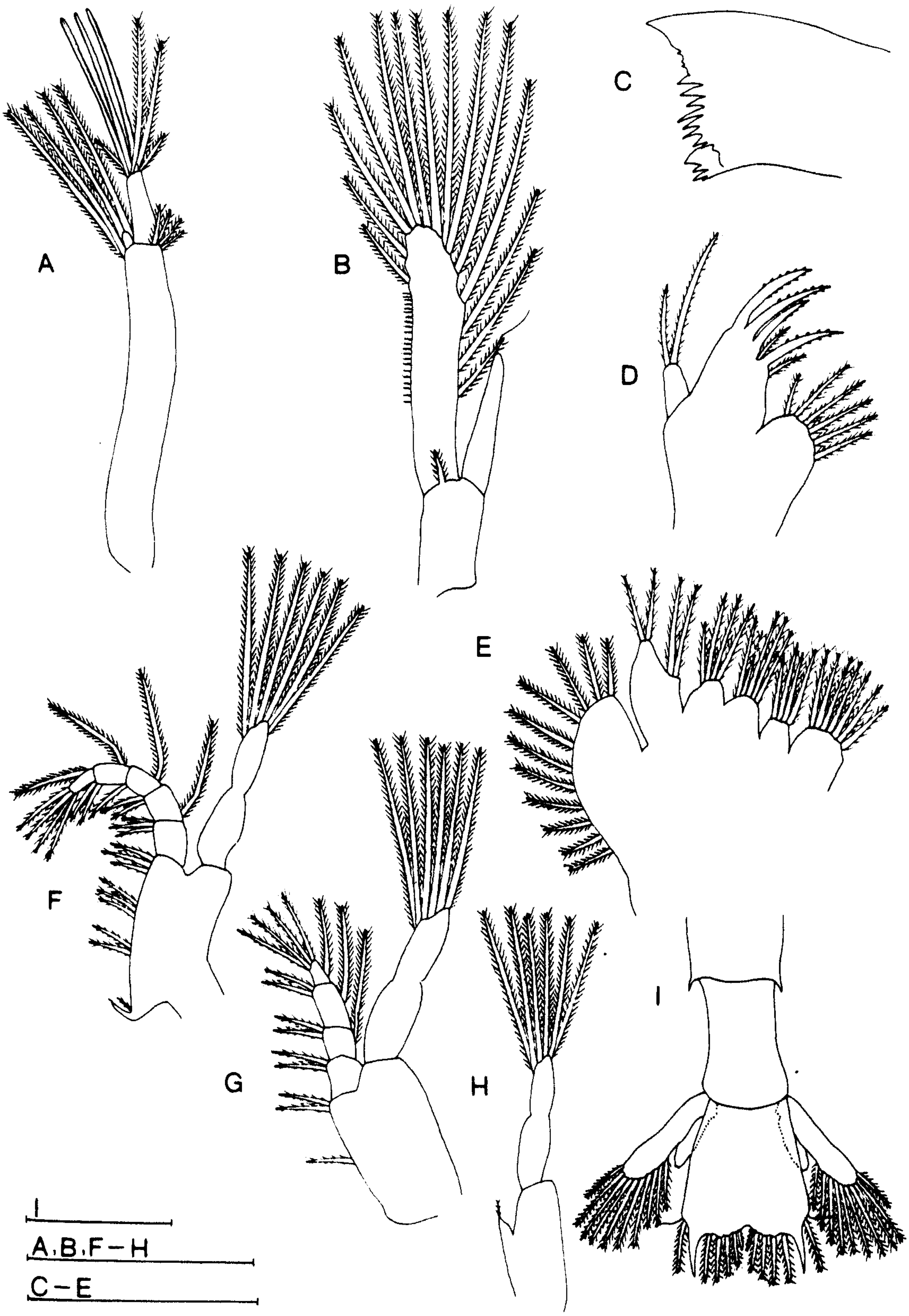
A, B, F, G, I
C–E, H

Figure 15 . *Dardanus tinctor* (Forskål) , third zoea .

A , antennule ; B, antenna ; C , mandible ; D , maxillule ; E , maxilla ; F , first maxilliped ; G , second maxilliped ; H , third maxilliped ; I , uropod and telson . Scale bars (from top) : (1) I = 0.5 mm;(2) A , B , F- H = 0.5 mm ; (3) C - E = 0.2 mm .


A
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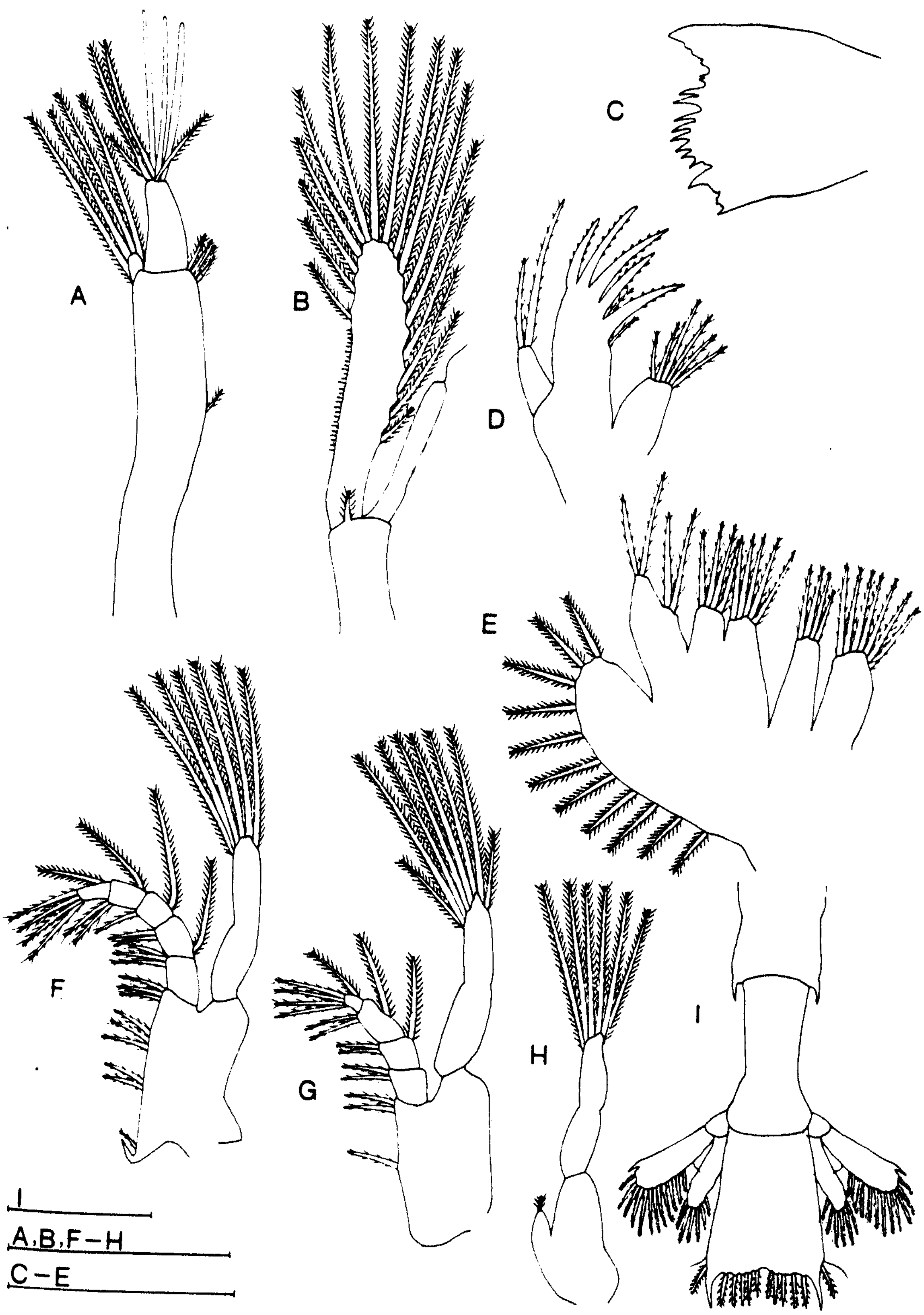
I
A,B,F–H
C–E

Figure 16 . *Dardanus tinctor* (Forskål) , fourth zoea .

A , antennule ; B , antenna ; C , mandible ; D , maxillule ; E , maxilla ; F , first maxilliped ; G, second maxilliped ; H , third maxilliped ; I , uropod and telson . Scale bars (from top) : (1) I = 0.5 mm ; (2) A , B , F- H = 0.5 mm ; (3) C - E = 0.2 mm .


A
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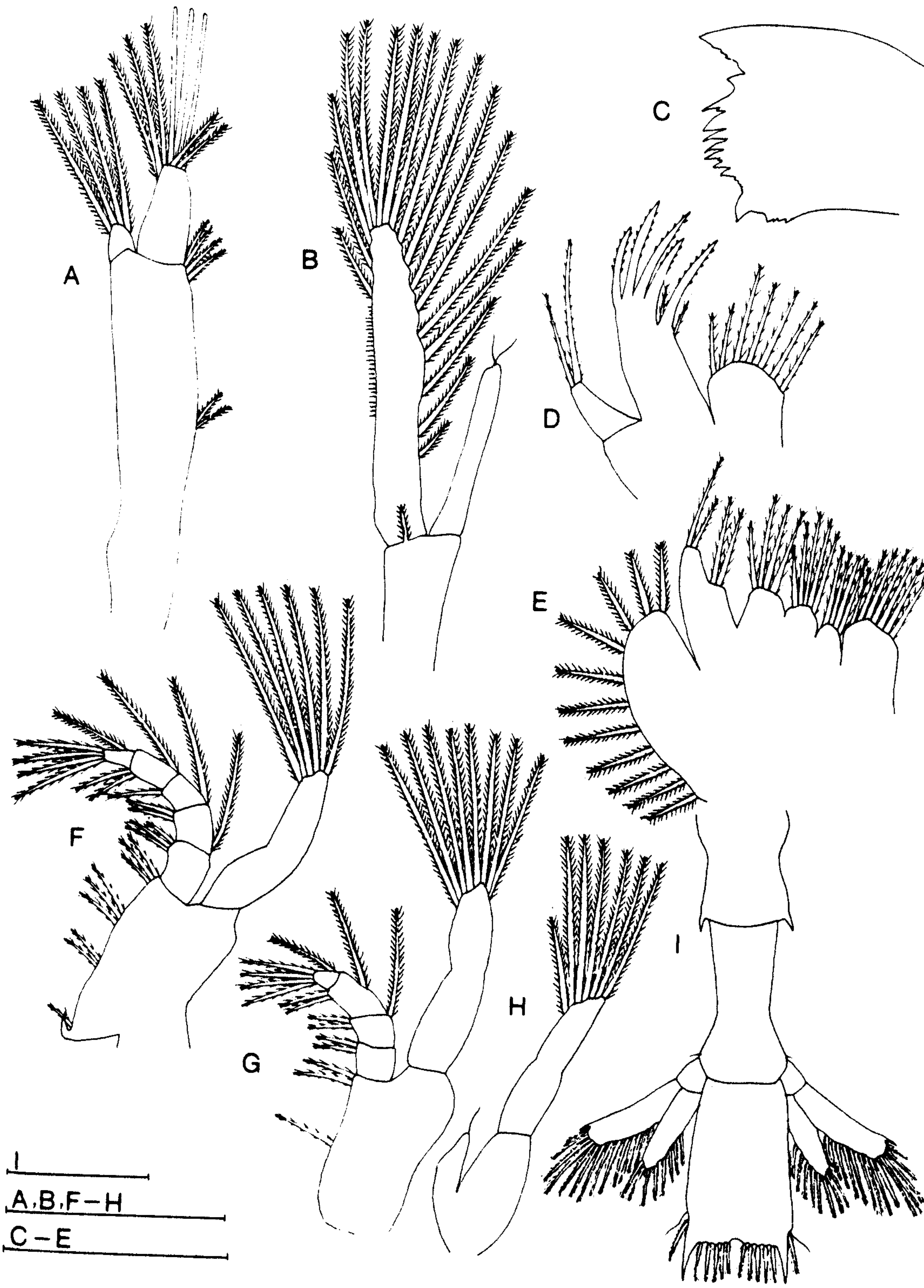
A,B,F–H
C–E

Figure 17 . *Dardanus tinctor* (Forskål), fifth zoea .

A , antennule ; B , antenna ; C , mandible ; D , maxillule ; E , maxilla ; F , first maxilliped ; G, second maxilliped ; H , third maxilliped ; I , uropod and telson . Scale bars (from top) : (1) I = 0.5 mm ; (2) A , B , F- H = 0.5 mm ; (3) C - E = 0.2 mm .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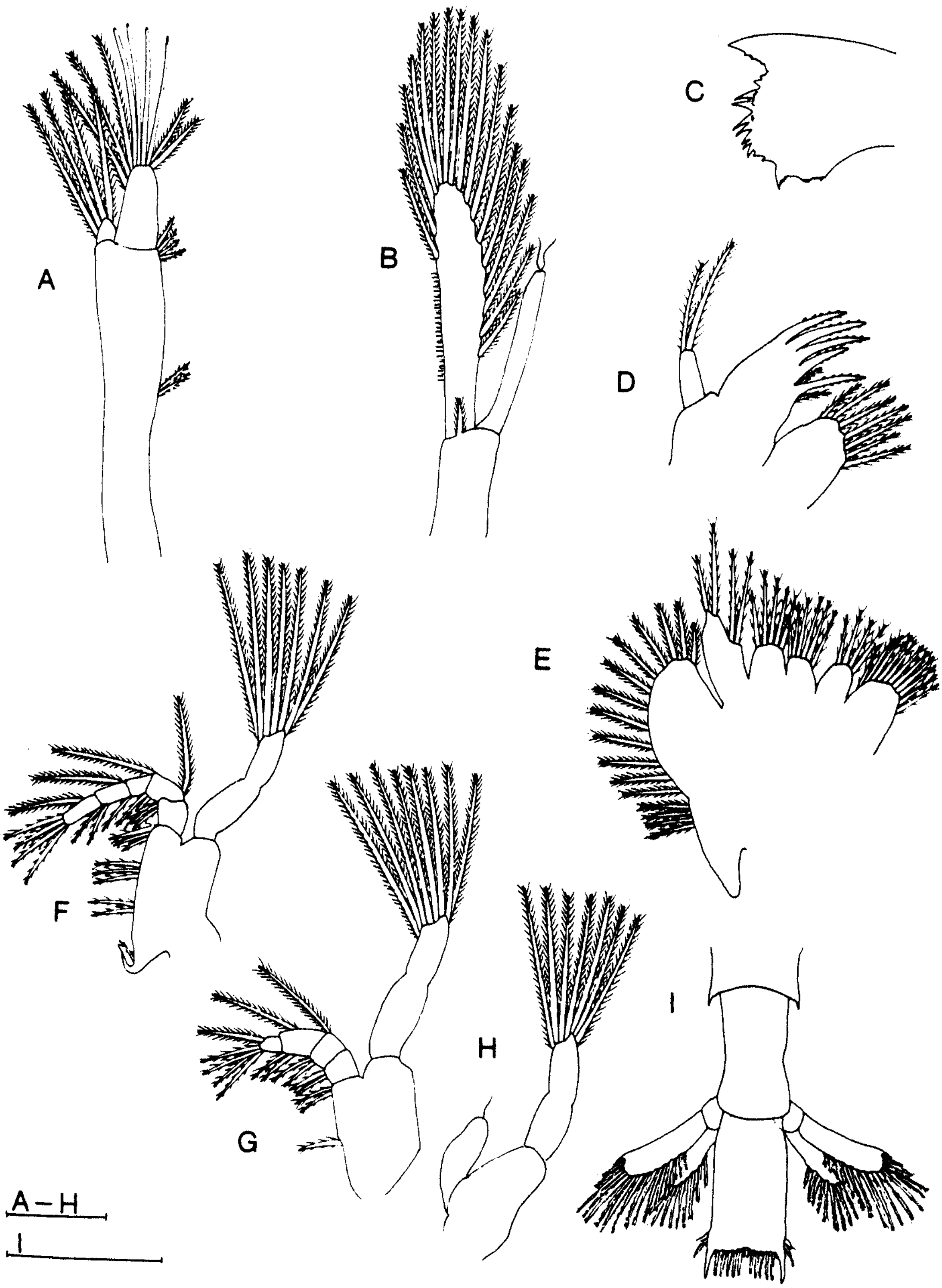
A,B,F–H
C–E

Figure 18. *Dardanus tinctor* (Forskål), sixth zoea.

A, antennule ; B, antenna ; C mandible ; D, maxillule ; E, maxilla ; F, first maxilliped ; G, second maxilliped ; H, third maxilliped ; I, uropod and telson. Scale bars (from top) : (1) A, B, F - H = 0.5 mm, C - E = 0.2 mm ; (2) I = 0.5 mm.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A – H
I

Figure 19. *Dardanus tinctor* (Forskål), seventh zoea.

A, antennule ; B, antenna ; C, mandible ; D, maxillule ; E, maxilla ; F, first maxilliped ; G, second maxilliped ; H, third maxilliped ; I, uropod and telson. Scale bars (from top): (1) A, B, F - H = 0.5 mm, C - E = 0.2 mm ; (2) I = 0.5 mm.

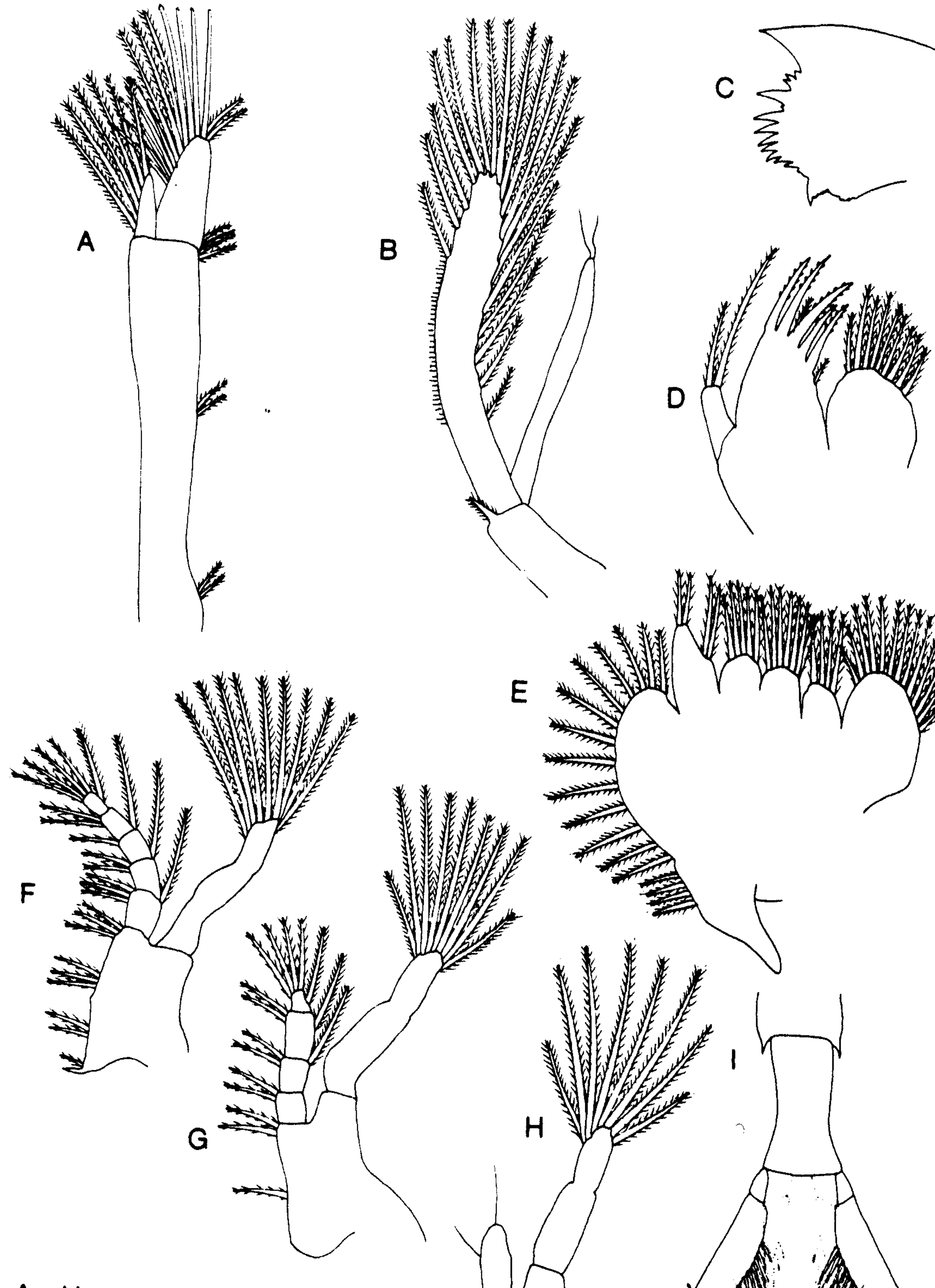
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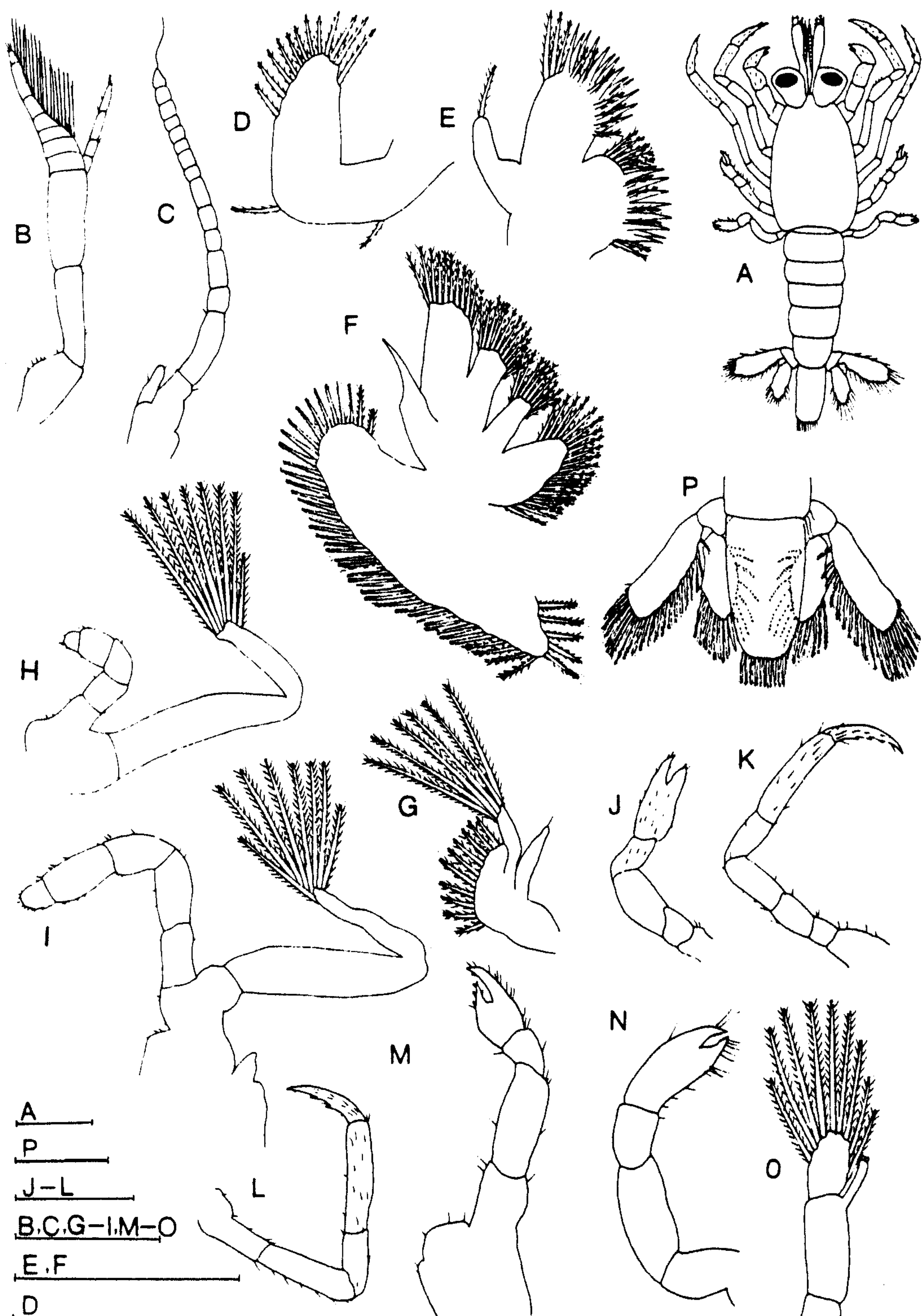
Figure 20. *Dardanus tinctor* (Forskål), megalopa.

A, dorsal view ; B, antennule ; C, antenna ; D, Mandible palp ; E, maxillule ; F, maxilla ; G, first maxilliped ; H, second maxilliped ; I, third maxilliped ; J, first leg; K, second leg ; L, third leg ; M, fourth leg ; N, fifth leg ; O, second pleopod ; P, uropod and telson. Scale bars (from top) : (1) A = 1 mm ; (2) P = 0.5 mm ; (3) J - L = 1 mm ; (4) B, C, G - I, M - O = 0.5 mm ; (5) E, F = 0.5 mm ; (6) D= 0.2 mm.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E,F
D

CHAPTER 4

A DESCRIPTION AND DISCUSSION OF ALPHEID AND ANOMURAN LARVAE FROM PLANKTON SAMPLES IN THE CENTRAL RED SEA.

INTRODUCTION

Comparatively few decapod larvae in collections from the Red Sea can be assigned to named species , but many can be assigned to families or genera , and specific differences between larvae of the same genus are often apparent . The larvae of a number of families and genera in the present collections were sorted to species and specific numbers allocated . In several groups the numbers of species determined from the larvae were very much greater than the numbers previously recorded from the area as adults, but in others the larval records indicate smaller numbers of species than those which have previously been recorded . Examples of both these situations are given in the present chapter , which concerns investigations into the number of species in the genus *Alpheus* (Caridea) and in several families of the Anomura .

Lengths are given as average values for each larvae , based on at least 10 specimens when sufficient material was available . The range is usually ±10-15% of the mean value . The locations of stations, frequencies of sampling and distribution of the commoner species are given in chapter 5 .

Alpheidae (Caridea)

Alpheus spp.

Introduction

Alpheid shrimps have attracted the attention of many scientists from several points of view , including their habit of burrowing in the sea bed , the sound production of males and the fact that some live commensally with different species of gobiid fish (Vine , 1986).

The Red Sea is known to be extremely rich in alpheid species (Gurney , 1938c) . Banner & Banner (1981 , 1983) listed records of 95 species and subspecies of adult Alpheidae , including 49 species of *Alpheus* , from the Red Sea and Gulf of Aden , and 143 species of Alpheidae from the western Indian Ocean including the Red Sea .

Knowlton (1973) summarised available information on modes of development in the Alpheidae . It appears that extended larval development , with about 9 zoeal stages , occurs in most species of *Alpheus*, although two species are known in which larval development is abbreviated to three or less zoeal stages . Extended larval devlopment also occurs in those species of *Athanas* which have been investigated and the small egg size of known species of *Alpheopsis* and *Leptalpheus* is characteristic of extended development . In *Synalpheus*, however , nearly half the known species have abbreviated or direct devlopment .

Lebour (1932) found that , in the laboratory , larvae of *A. glaber* (Olivi) (= *A. ruber* H. Milne-Edwards) hatched with stalked eyes , usually characteristic of stage II and later stages , but with 7+7 telson setae , as in a normal stage I larva . Such larvae moulted to produce forms with the usual characters of stage III larvae . The youngest specimens of this species obtained from the plankton had all the characters of typical stage II caridean larvae . Knowlton (1973) found that , in the laboratory , *A. heterochaelis* Say could hatch either as a typical stage I or stage II larva and that stage I , when it occurred , was of much shorter duration than the subsequent stages .

Larvae of five named species of *Alpheus* have been previously described from the Red Sea . *A. audouini* Coutiere was described from the Suez Canal (Gurney , 1927) and from Al-Ghardaqa (Gurney , 1938c) . The other species , all from Al-Ghardaqa , are *A. ventrosus* Herbst (described by Gurney , 1938c and Al-Kholy , 1961) , *A. pacificus* Dana (by Gurney , 1938c and by Gohar & Al-Kholy , 1957) , *A. rapax* Forsk (by Al-Kholy ,1961) and *A. microstylus* Bate (by Al-Kholy , 1963) . In addition , Williamson (1970) described late larvae of 37 unnamed species from plankton samples from the Gulf of Al-Aqaba , distinguishing them only on external morphological characters as the chromatophores were no longer distinguishable .

Methods

Larvae of *Alpheus* were sorted from plankton samples and preserved in approximately 2% formaldehyde in sea water . In distinguishing species , much use was made of the distribution of chromatophores . As the chromatophores fade in preserved material , larvae had to be examined within 7-10 days of capture . Chromatophore patterns are shown in the results on standardised dorsal views of typical *Alpheus* larvae (Fig. 21-28) . These diagrams do not show other specific morphological characters . The total length of each larva , the ratio of rostral length to eye length and the shape of the eyes was also recorded . Drawings of rostra and eyes are given for only a minority of species . The larvae were given specific numbers , each with the prefix CRS (for Central Red Sea) .

Attempts were made to rear larvae captured by pipette from plankton samples . Some were isolated in small bowls and fed on either Rotifers or *Artemia* nauplii . In addition , about 100 larvae were placed in a 2 litre beaker and fed on *Artemia* nauplii . All rearing experiments were at a controlled temperature of 25° C .

Results

No *Alpheus* larvae were seen with typical characters of a stage I caridean larva (sessile eyes and 7+7 telson setae) . The great majority of the larvae were in stage II and the drawings and measurements all relate to this stage .

The most common chromatophores were red spots , but some larvae (e. g. CRS 52) had diffuse pigment and a number had elongated chromatophores , often on the posterior part of the carapace . A few had very big red chromatophores (e.g. CRS 13) . Yellow chromatophores scattered along the body occurred in CRS 60 and a few other species . All species had a single red spot chromatophore on the distal antennular peduncle and another on the inner side of the eye stalk . Most had a red chromatophore on the anterior part of the telson, but some had none (e.g. CRS 5) and some had two (e.g. CRS 55) . In many species the posterior telson was unpigmented (e.g. CRS 1) , but some had two chromatophores in this region (e.g. CRS 7) , others four (e.g. CRS 2) . A very large chromatophore occurred in the middle of the telson in CRS 21 .

Each larva was assigned to one of four categories depending on the length of the rostrum in relation to that of the eyes (Fig. 29) : (A) rostrum at least 1/2 length of eye (e.g. CRS 20) , (B) about 1/3 length of eye (e.g. CRS 31) , (C) about 1/4 length of eye (e.g. CRS 34) and (D) less than 1/4 length of eye (e.g. CRS 61) . Category 'B' was the most common (Table 5) .

It was found possible to distinguish 10 groups depending on eye shape , assigned to categories E-N (Fig. 30) . For example , the anterodorsal region of the eye was pointed in CRS 12 (E) , produced into a rounded prominence in CRS 20 (H) and into a larger rounded prominence in CRS 13 (N) , while the eye of CRS 41 (K) was almost round . The most common type of larval eye resembled that of CRS 16

(F) and CRS 82 (I) , both of which should a small rounded prominence but the cornea is wider in F (Table 5) .

The total length of *Alpheus* larvae in stage II ranged from 1.76 mm (CRS 78) to 3.36 mm (CRS 50) , with an average of 2.44 mm (Table 5).

Of the 89 species distinguished , CRS 20 was the most common in the mangrove area . It occurred in about 21% of the total samples , was restricted to February and March , when it occurred in all samples , often in very large numbers . CRS 46 was the most common in the Obhor creek . Many species occurred as only a single specimen . CRS 20 is probably the same species as that from the Gulf of Aqaba numbered NRS 28 by Williamson (1970) , although the chromatophore pattern of NRS 28 is not known . None of the larvae can be assigned to a named species with any certainty .

In the rearing experiments all the isolated larvae died within a few days . Of the 100 larvae reared in mass culture , 10 survived for six months , seven died during the seventh month , and the remaining three were killed at the end of the seventh month , having reached a length of approximately 10 mm .

Discussion

The relatively small range of morphlogical characters is consistent with assigning all the 89 species to the same genus , although the possibility that some belong to other alpheid genera cannot be entirely eliminated . Larvae of *Athanas* were encountered and were fairly easily distinguished from those assigned to *Alpheus* .

It has been assumed in this work that the larval chromatophore pattern is consistent for each species . This assumption is supported by the consistent and distinct chromatophore patterns found by Lebour (1932) in the larvae of *A. glaber* and *A. macrocheles* in British waters and by the fact that chromatophores have provided reliable specific characters in the larvae of all decapod groups that have been investigated , including the Brachyura (Lebour , 1928) , Diogenidae and Paguridae (Pike & Williamson , 1960) and Penaeidae (Mair , 1979) . As 89 species have been distinguished as larvae in the present work and only 49 have been recorded from the Red Sea as adults , it must be inferred that there are nearly as many undescribed adults in the area as have been described . This reflects the considerable difficulties encountered in trying to sample small benthic shrimps in a community dominated by corals and the relative ease and efficiency of taking plankton samples in the overlying waters .

Figure 21 . Chromatophores patterns on standardised views of typical *Alpheus* larvae (stage II) CRS 1 - CRS 12 .

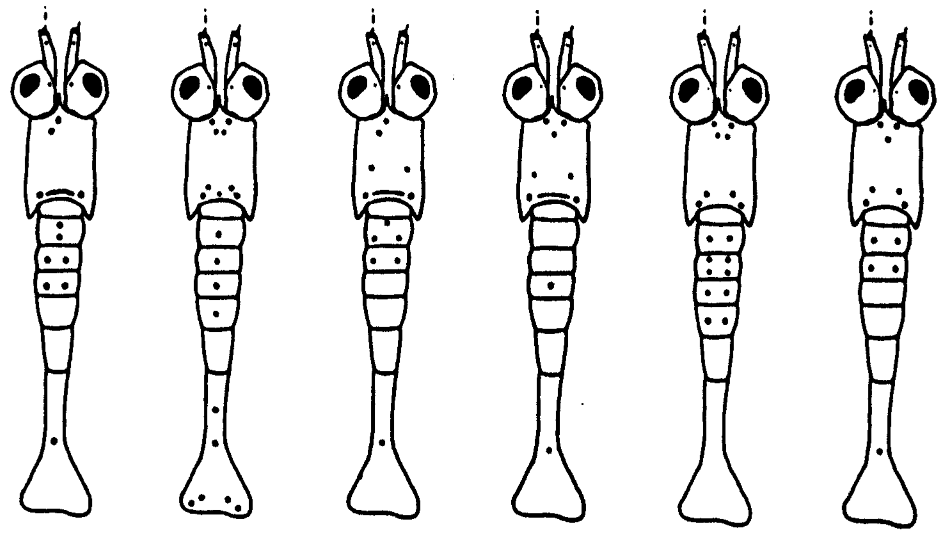
Key to shape and colour of chromatophores in *Alpheus* larvae CRS 1 - CRS 89 .

(•) Red chromatophores .

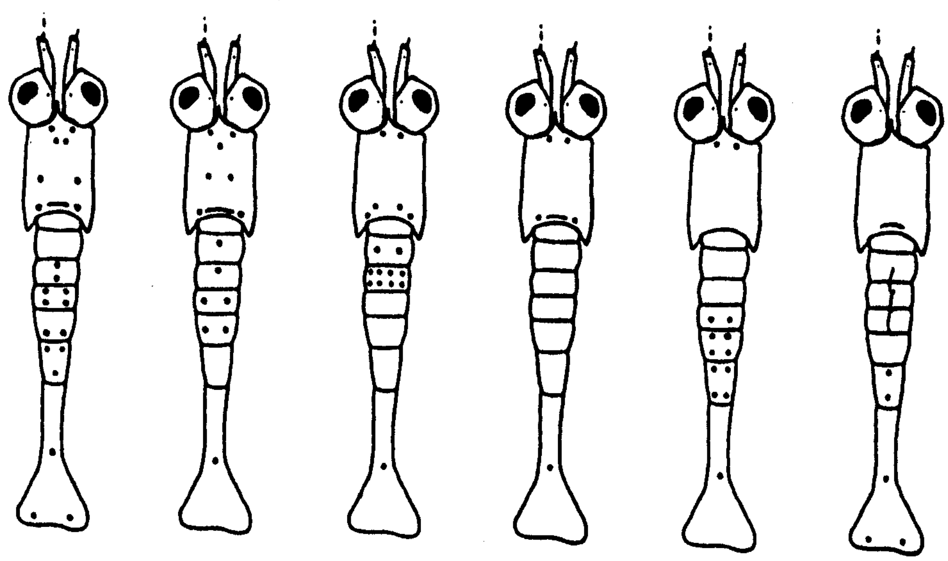
(–) Elongate Red chromatophores .

(*) Diffuse Red chromatophores .

(░) Yellow chromatophores .



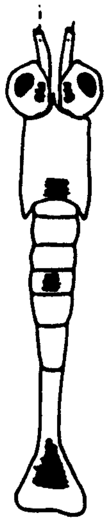
1 2 3 4 5 6



7 8 9 10 11 12

Figure 22 . Chromatophores patterns on standardised views of typical *Alpheus* larvae (stage II) CRS 13 - CRS 24 .

CRS 18 and CRS 24 have the same chromatophore pattern but differ in length of rostrum (see Table 5) .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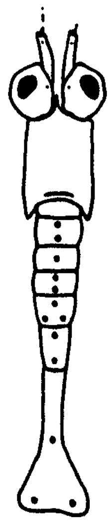
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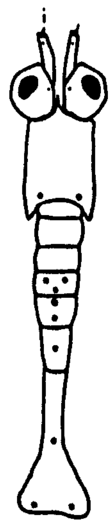
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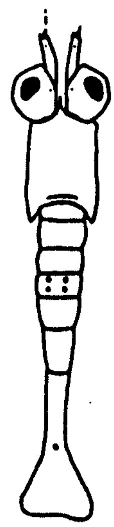
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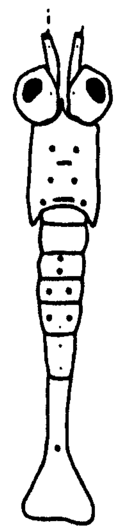
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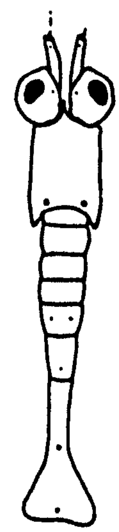
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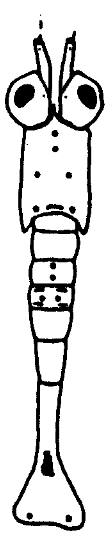
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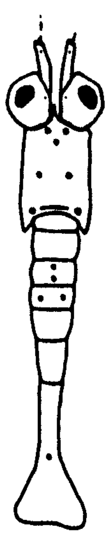
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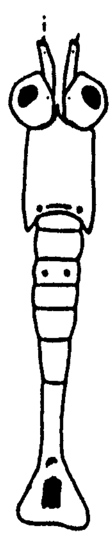
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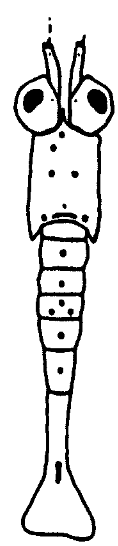
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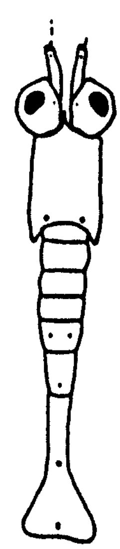
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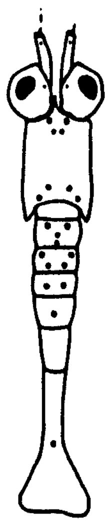
Figure 23 . Chromatophores patterns on standardised views of typical *Alpheus* larvae (stage II) CRS 25 - CRS 36 .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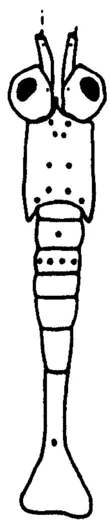
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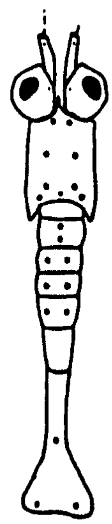
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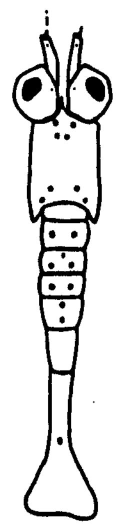
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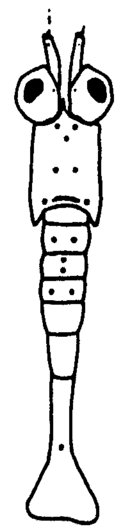
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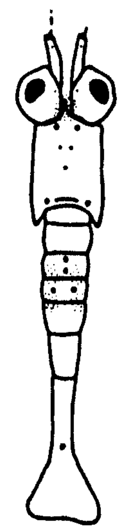
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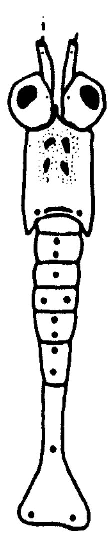
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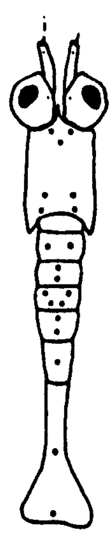
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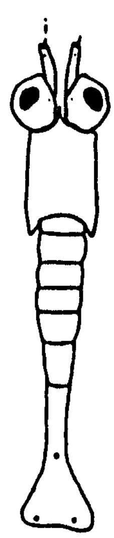
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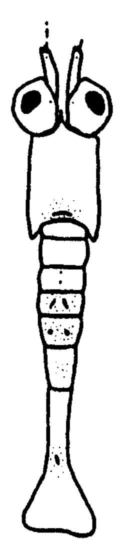
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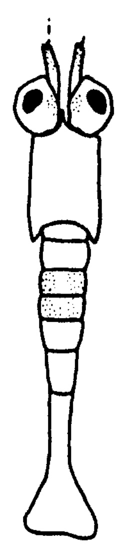
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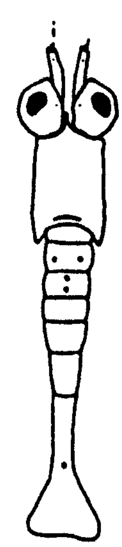
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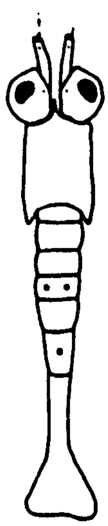
Figure 24. Chromatophores patterns on standardised views of typical *Alpheus* larvae (stage II) CRS 37 - CRS 48 .



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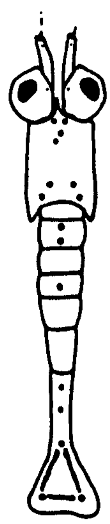

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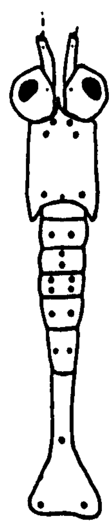

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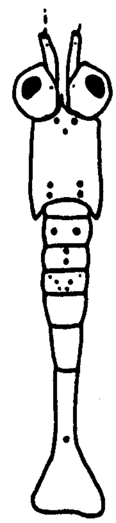

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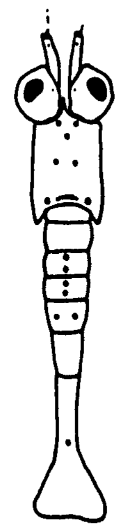

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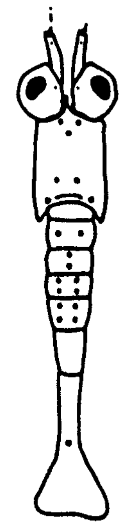

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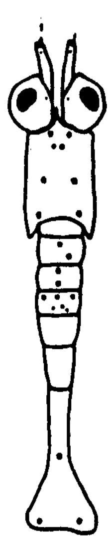

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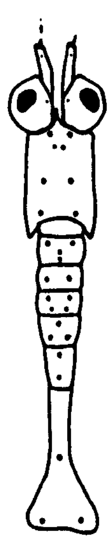

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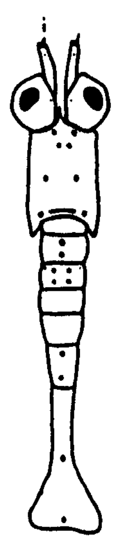

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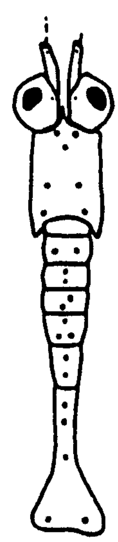

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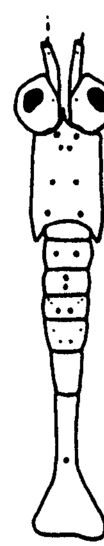

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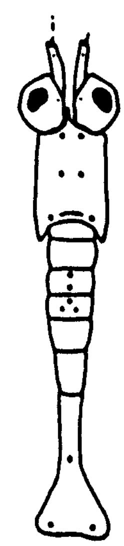

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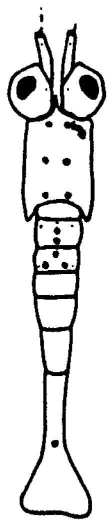
Figure 25 . Chromatophores patterns on standardised views of typical *Alpheus* larvae (stage II) CRS 49 - CRS 60 .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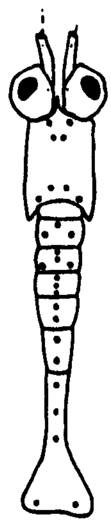
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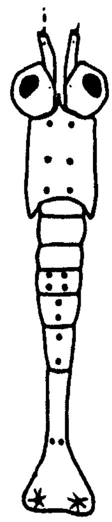
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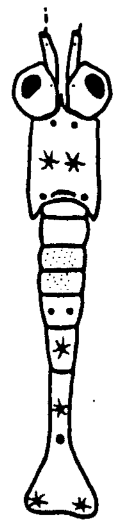
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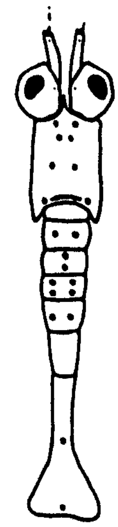
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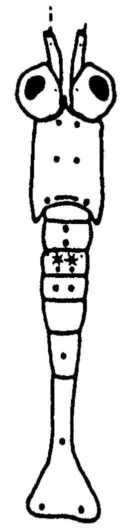
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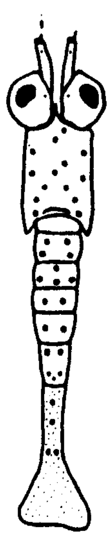
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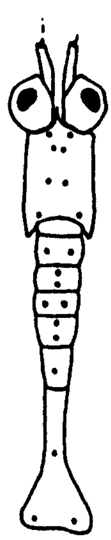
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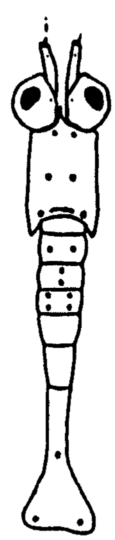
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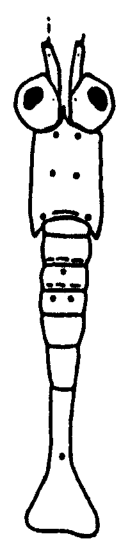
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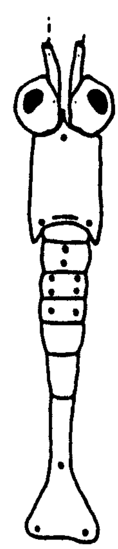
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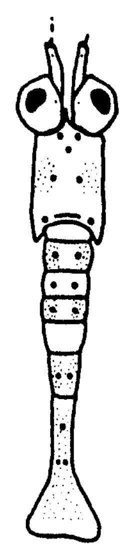
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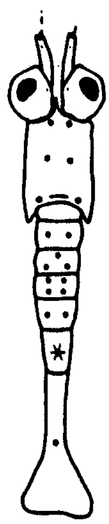
Figure 26 . Chromatophores patterns on standardised views of typical *Alpheus* larvae (stage II) CRS 61 - CRS 72 .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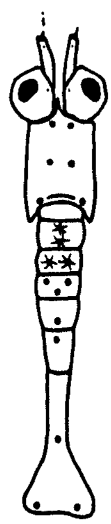
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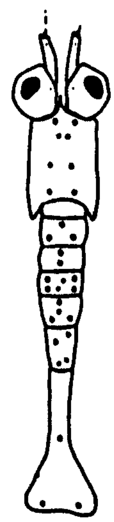
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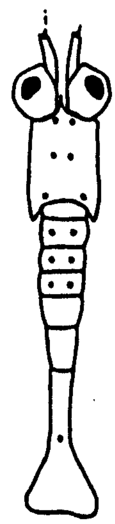
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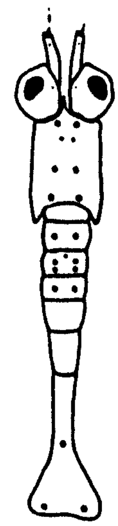
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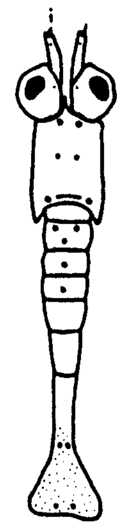
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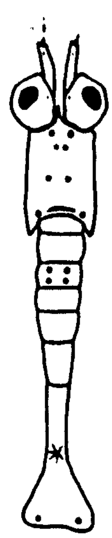
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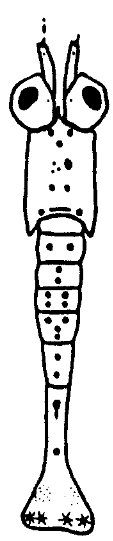
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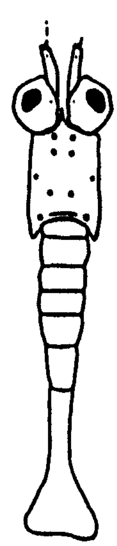
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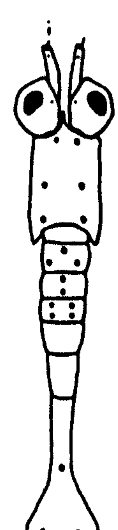
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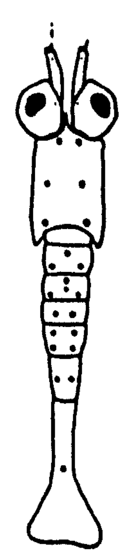
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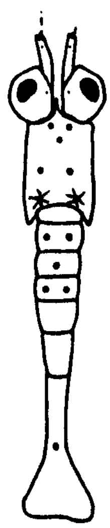
Figure 27 . Chromatophores patterns on standardised views of typical *Alpheus* larvae (stage II) CRS 73 - CRS 84 .



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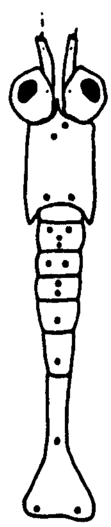

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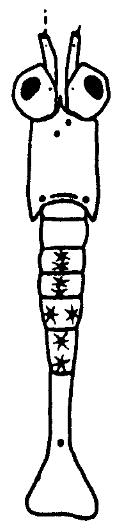

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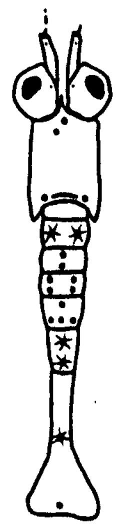

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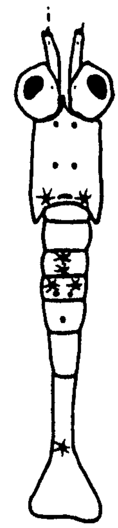

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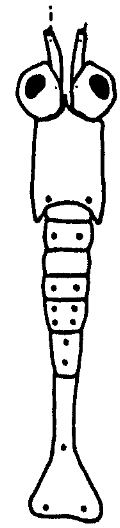

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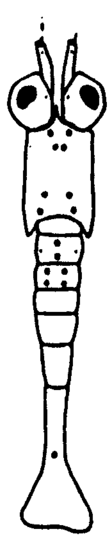

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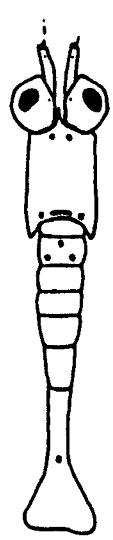

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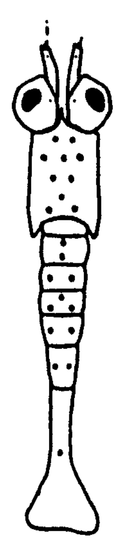

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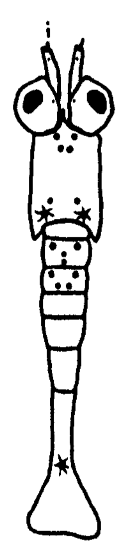

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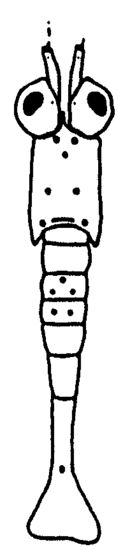

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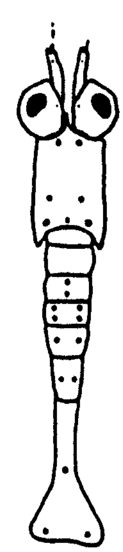
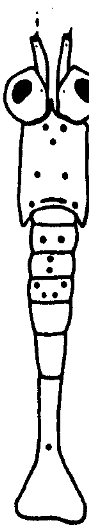


84

Figure 28 . Chromatophores patterns on standardised views of typical *Alpheus* larvae (stage II) CRS 85 – CRS 89 .



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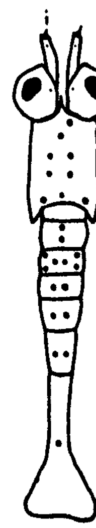
86



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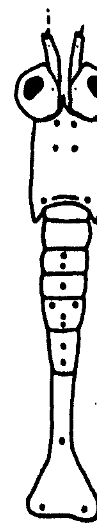

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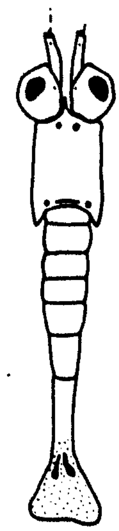

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Figure 29 . Length of rostrum in relation to eyes of *Alpheus* larvae . A , rostrum at least 1/2 length of eye ; B , rostrum about 1/3 length of eye ; C , rostrum about 1/4 length of eye ; D , rostrum less than 1/4 length of eye . Scale bar = 0.5 mm .

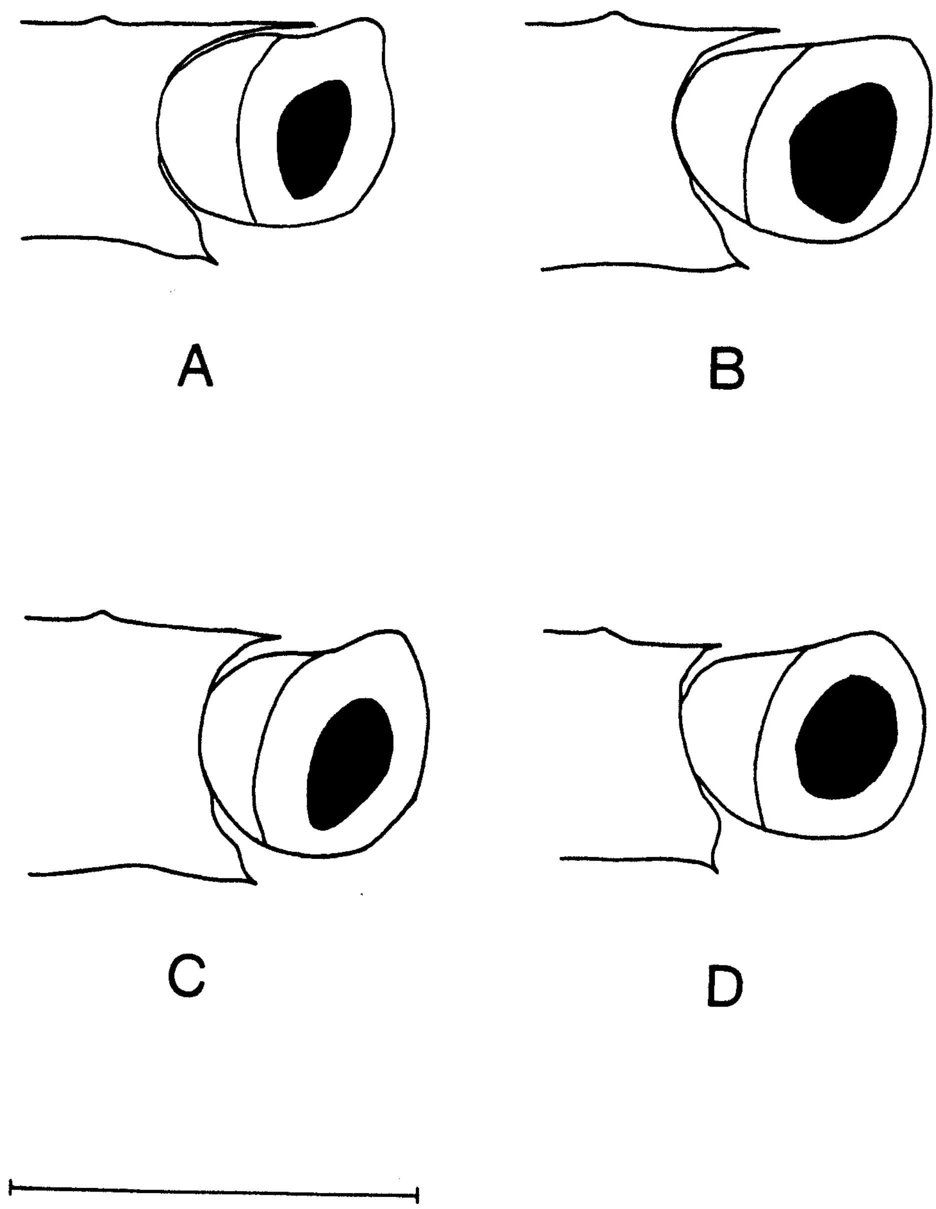

A
B
C
D

Figure 30 . Different eye shapes (E - N) encountered in *Alpheus* larvae . Scale bar = 0.5 mm .

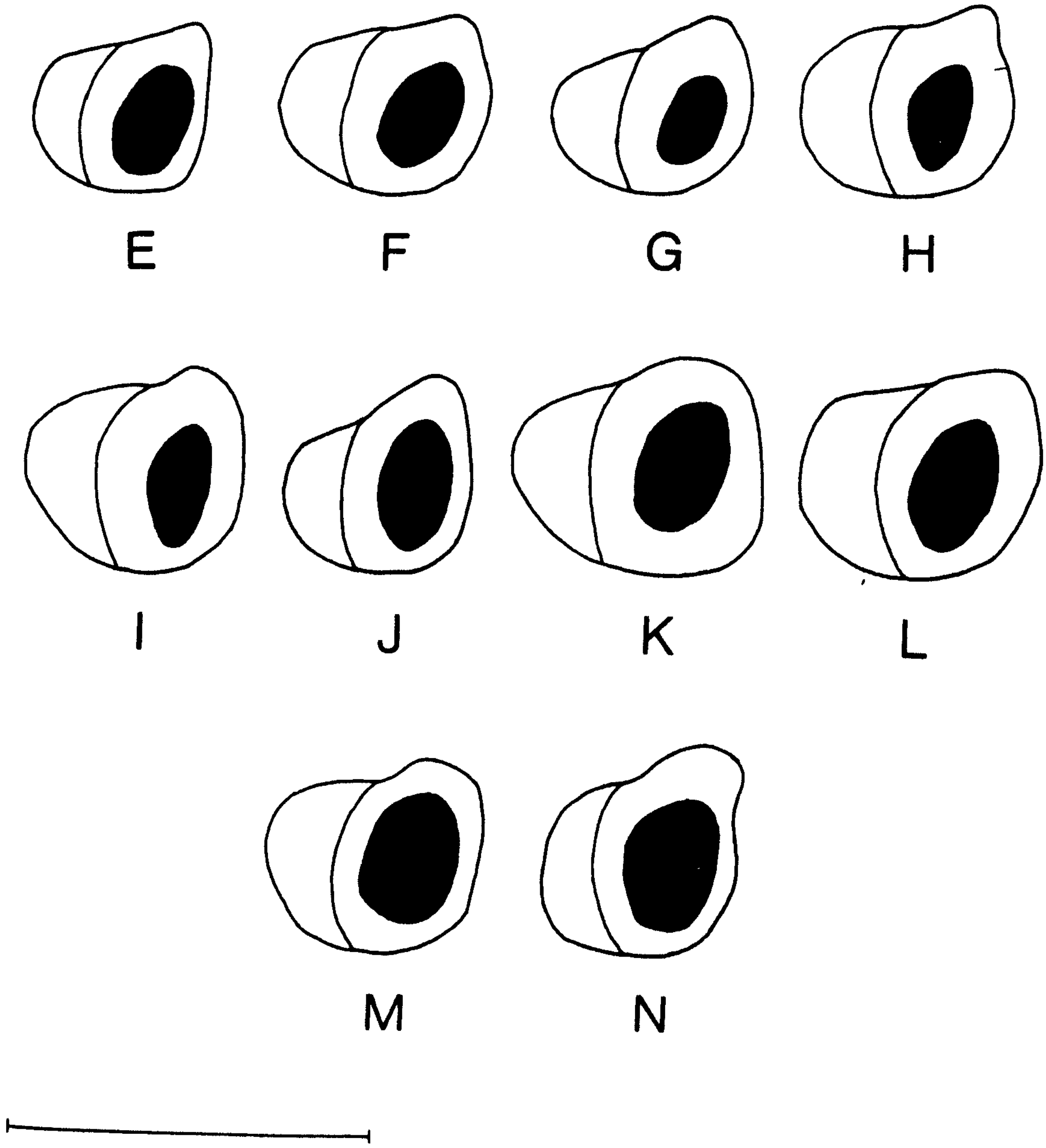

E
F
G
H
I
J
K
L
M
N

Table 5 . *Alpheus* species , CRS 1 - CRS 89 .

Total length , length of rostrum compared with eye length (categories A - D) and eye shape (categories E - N) .

Alpheus	T.L.	Rost./Eye	Eye shape		Alpheus	T.L.	Rost./Eye	Eye shape
CRS 01	2.79	A	I		CRS 46	1.88	C	F
CRS 02	3.07	B	F		CRS 47	2.57	B	I
CRS 03	2.56	B	F		CRS 48	2.16	A	F
CRS 04	2.21	A	G		CRS 49	2.34	D	F
CRS 05	2.51	A	F		CRS 50	3.36	B	I
CRS 06	2.44	B	H		CRS 51	2.4	B	M
CRS 07	2.82	A	F		CRS 52	2.36	D	I
CRS 08	2.48	A	I		CRS 53	2.32	B	K
CRS 09	2.08	A	I		CRS 54	2.27	D	I
CRS 10	2.02	B	F		CRS 55	3.12	A	I
CRS 11	2.03	B	I		CRS 56	2	B	I
CRS 12	2.02	B	E		CRS 57	2.2	B	I
CRS 13	2.32	B	N		CRS 58	2.13	B	I
CRS 14	2.07	C	F		CRS 59	2.19	B	F
CRS 15	2.45	A	G		CRS 60	3.18	B	F
CRS 16	2.25	B	F		CRS 61	2.48	D	L
CRS 17	2.18	B	F		CRS 62	2.28	A	K
CRS 18	2.32	D	I		CRS 63	2.24	B	F
CRS 19	2.14	A	M		CRS 64	2.56	B	J
CRS 20	2.85	A	H		CRS 65	2.49	B	J
CRS 21	2.32	A	I		CRS 66	3.2	A	N
CRS 22	2.45	B	I		CRS 67	3.04	A	F
CRS 23	1.94	A	F		CRS 68	2.16	B	I
CRS 24	2.4	B	I		CRS 69	2.72	B	N
CRS 25	2.81	B	F		CRS 70	2.72	A	J
CRS 26	2.45	A	E		CRS 71	2.86	A	I
CRS 27	2.31	B	F		CRS 72	2.4	B	F
CRS 28	2.43	B	F		CRS 73	3.04	B	L
CRS 29	2.48	B	F		CRS 74	2.4	B	I
CRS 30	2.86	A	I		CRS 75	2.8	B	I
CRS 31	2.27	B	I		CRS 76	2.4	B	I
CRS 32	2.28	B	F		CRS 77	2.4	B	I
CRS 33	2.18	C	G		CRS 78	1.76	B	F
CRS 34	2.25	C	F		CRS 79	2.92	B	F
CRS 35	1.96	C	F		CRS 80	2.88	A	I
CRS 36	2.88	A	F		CRS 81	2.4	D	I
CRS 37	2.36	B	L		CRS 82	2.36	C	I
CRS 38	3	C	L		CRS 83	2.5	B	I
CRS 39	2.31	C	F		CRS 84	2.28	D	I
CRS 40	2.73	C	L		CRS 85	2.53	B	I
CRS 41	2.58	B	K		CRS 86	2.3	D	F
CRS 42	2.8	A	I		CRS 87	2.17	B	J
CRS 43	2.51	B	L		CRS 88	2.21	C	L
CRS 44	2	B	G		CRS 89	2.1	B	F
CRS 45	2.13	C	F					

ANOMURA (INCLUDING THALASSINIDEA)

Thalassinidea

Upogebiidae

Introduction

This family is usually regarded as consisting of the single genus *Upogebia* Leach , although some authors have recognised *Gebicula* Alcock and *Calliadne* Strahl as subgenera of *Upogebia* or as separate genera . Most species of *Upogebia* live in burrows in the substratum , but *U.savigni* Strahl lives inside a sponge in a smooth-walled canal which does not open to the surface . Development of this Red Sea species was described by Gurney (1937a) , but it hatches as a juvenile and there is no planktonic larval phase . No named larvae of *Upogebia* have been described from the Red Sea , but Seridji (1986) recorded the larvae of three unnamed species from the Gulf of Aqaba , northern Red Sea .

Species of Upogebia recorded from the Red Sea as adults are *Upogebia darwini* (Miers) , *U. ancylodactyla* De man , *U. cargadensis* Borradaile, *U. savignyi* (Strahl) , *U. pseudochelata* Tattersall , *U. carinicauda* (Stimpson) (Sakai , 1984) .

European larvae of *Upogebia* have the rostrum shorter than the antennal scale , the telson develops a small median spine in stage II and there are no abdominal spines (Williamson , 1957) . The absence of abdominal spines , however , is not a generic larval character . Gurney (1938b) ascribed to *Upogebia* a larva from the Great Barrier

Reef with dorsal spines on abdominal somites 2-5 , and Ngoc-Ho (1981) described larvae of *U. affinis* (Say) and two other (unnamed) species from the Gulf of Mexico all with a pair of large lateral spines on the 5th abdominal somite and a pair of small dorsal spines on the posterior border of the 6th somite in stage III and later stages . She also mentioned , but did not describe , larvae ascribed to *Upogebia* from the Red Sea with a small median spine on the posterior border of the 6th somite in stage III and later stages . European species for which information is available pass through three or four zoeal stages (Gurney , 1942) , Mexican species through five (Ngoc-Ho, 1981).

Results

Larvae of four species from the present collections are regarded as belonging to *Upogebia* and they have been given the specific letters A-D . They are illustrated in Fig. 31 and the main distinguishing characters are given in Table 6 . Each larva has an anal spine , and larva B , which is in stage III , has a median dorsal spine on the posterior margin of somite 6 and a small median telson spine .

Table 6. Comparision of larvae of *Upogebia* from the present collection.

	A	B	C	D
Total length (average) in mm (stage)	2.85(I)	2.69(III)	2.30(I)	2.73(I)
Length rostrum/A2 scale	1	1/2	3/4	1/2
Dorsal denticles on somites	3,4,5	none	5	none
Lateral spines on somites	3,4,5	none	none	none

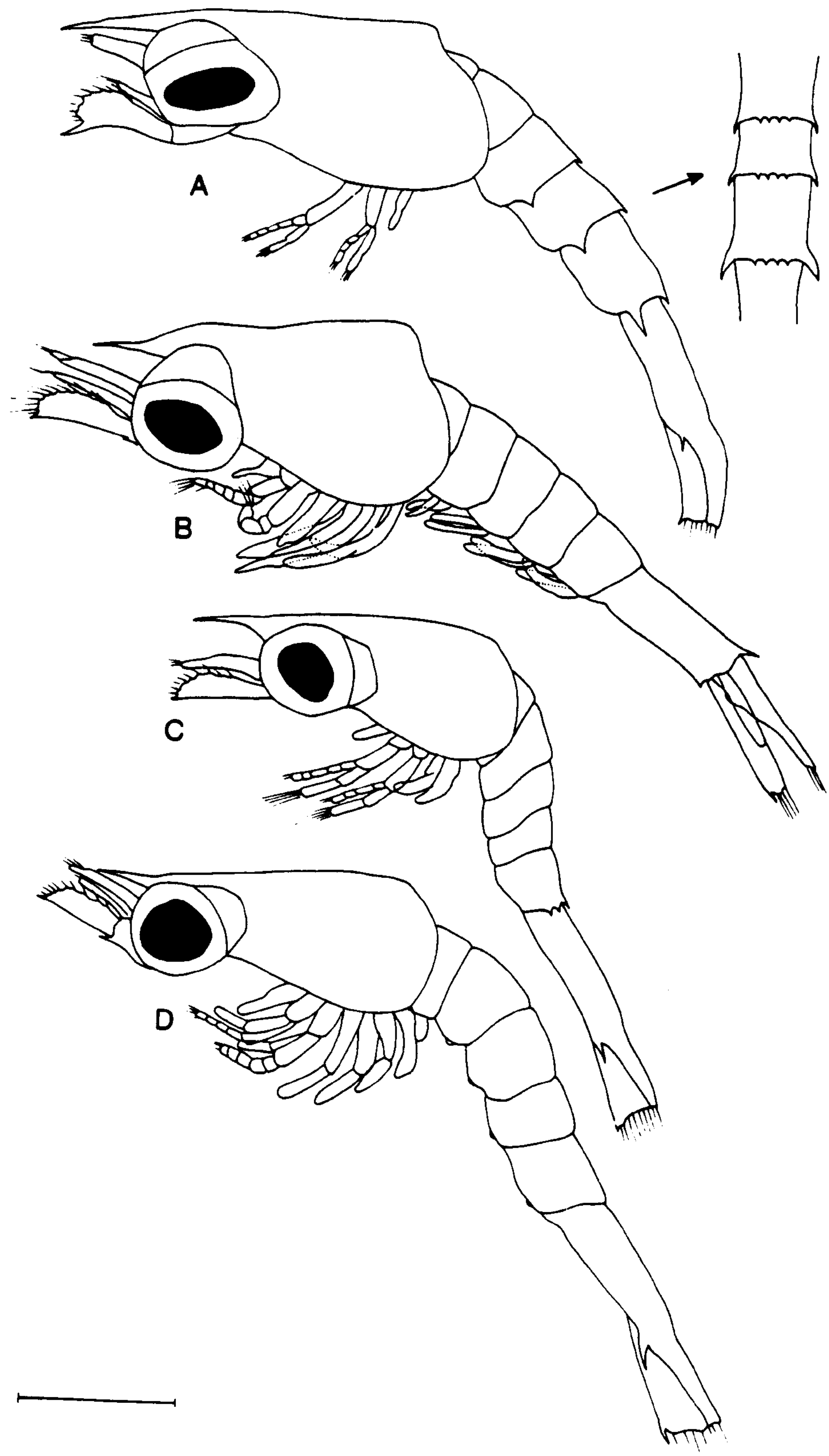
Discussion

Larva A (Fig. 31A) resembles Gurney's (1938b) larva from the Great Barrier Reef in having a relatively long rostrum and lateral spines on abdominal somites 3-5 but it differs in having dorsal denticles on these same abdominal somites.

Larvae B (Fig. 31B) in stage III , is clearly in the last zoeal stage , as shown by the large rudiments of legs and pleopods. Larva D (Fig. 31D) , in stage I , already has large leg rudiments and small pleopod buds . There may be only two zoeal stages in this species . Larvae A and C (Fig. 31C) , both in stage I , show similar development of the thoracic appendages to the stage I larvae of Mexican species , described by Ngoc-Ho (1981) , which pass through five zoeal stages . Ngoc-Ho commented on the similarity of the larvae of the three species of *Upogebia* which she described from the Gulf of Mexico but noted that there did not appear to be any general world-wide tendency for closely related species of *Upogebia* to occur in the same region . This is certainly true of the Red Sea , where the larvae of this genus show a wide range of abdominal armature and different species may show direct development or pass through an estimated two , three or five zoeal stages .

Figure 31 . *Upogebia* larvae , lateral view .

A , *Upogebia* A (stage I) ; B , *Upogebia* B (stage III) ; C, *Upogebia* C (stage I) ; D , *Upogebia* D (stage I) . Scale bar = 0.5 mm .



A
B
C
D

Callianassidae

Introduction

The generic name *Callianassa* Leach is here used in a broad sense to include all the known Callianassidae (excluding Upogebiidae).

Gurney (1937b) arranged the species of *Callianassa* into two types on larval characters . Species of type 1 , represented by the subgenera *Callianassa* , *Chearmus* Bate and *Trypaea* Dana , pass through five zoeal stages and have a large dorsal spine on the 2nd abdominal segment . Species of type 2 , represented by the subgenus *Callichirus* Stimpson , pass through only two zoeal stages ; the spine on the second somite is shorter and the telson is very broad and convex with many marginal processes . Gurney (1937b) described larvae of three species of type 2 from the Red Sea and Williamson (1970) described one larva of type 1 , apparently of the subgenus *Callianassa* .

Seridji (1986) recorded the larvae of four unnamed species of *Callianassa* from the Gulf of Aqaba , and Al-Kholy and Fikry Mahmoud (1967a) described the larval stages of one unnamed species of *Callianassa* from Al-Ghardaqa , Egypt . The larva described by Williamson resembles the Al-Kholy and Fikry Mahmoud larvae , but the spine on the 2nd abdominal somite is longer in the latter .

Species of *Callianassa* recorded from the Red Sea as adults are *C. jousseaumei* Nobili , *C. calamani* Nobili , *C. amboinesis* Deman and *C. loouvieri* Nobili (De Man , 1928 ; Holthuis , 1958) . Gurney (1937 , 1942) commented that in some cases it is difficult to decide whether a larva should be assigned to the Callianassidae or the Axiidae. He regarded the presence of an exopod on leg 5 in the late zoeal stages of the Axiidae as the only reliable distinguishing character . Kurata (1965) regarded the presence of a dorsal spine on the second abdominal somite as an essential character of all larvae of *Callianassa* and assigned similar larvae without such a spine to *Axius* .

Results and Discussion

Seven species of larvae from the present collections are ascribed to *Callianassa*, although in some cases it is not possible to rule out the possibility that they may belong to the Axiidae . The larvae , given the specific letters A - G , are illustrated in Figs. 32 and 33 and the main diagnostic characters are listed below .

Larva A (stage I) (Fig. 32A) - CL : 1.34 mm (average) , TL : 3.26 mm (average) . 2nd abdominal somite with long dorsal spine reaching to about posterior margin of 3rd somite . 3rd , 4th and 5th abdominal somites with small dorsal spine . Telson median spine very short (Fig. 33A) .

Larva B (stage I) (Fig. 32B) - CL : 1.92 mm (average) , TL : 4.32 mm (average) . 2nd abdominal somite with long dorsal spine , 3/4 length of 3rd somite . 3rd , 4th and 5th abdominal somites with dorsal spines longer than A . Telson median spine very long (Fig. 33B) .

Larva C (stage I) (Fig. 32C) - CL : 1.66 mm (average) , TL : 3.81 mm (average) . 2nd abdominal somite with long dorsal spine , 1/2 length of 3rd somite . 3rd , 4th and 5th somites with dorsal spines similar to A . Telson median spine very long , as in B (Fig. 33C) .

Larva D (stage I) (Fig. 32D) - CL : 1.92 mm (average) , TL : 4.16 mm (average) . 2nd abdominal somite with long spine , 1/2 length of 3rd somite . 3rd , 4th and 5th somites with dorsal spines a little longer than A . Telson median spine shorter than B (Fig. 33D) .

Larva E (stage I) (Fig. 32E) - CL : 1.44 mm (average) , TL : 3.30 mm (average) . 2nd , 3rd, 4th and 5th abdominal somites with equal spines . Telson median spine short , as in A (Fig. 33E) .

Larva F (stage I) (Fig. 32F) - CL : 2.40 mm (average) , TL : 5.28 mm (average) . 2nd abdominal somite without spine . 3rd and 4th abdominal somites with dorsal spines and the 5th with long lateral spines . Telson median spine long, as in B (Fig. 33F) .

Larva G (stage II) (Fig. 32G) - CL : 1.92 mm (average) , TL : 4.16 mm (average) . 2nd abdominal somite without spine . 4th and 5th abdominal somites with lateral spines . Telson median spine long , as in B (Fig. 33G) .

The telsons of all these larvae resemble that of Gurney's type I (Gurney , 1937b) , but , if the distinction employed by Kurata (1965) is correct , species F and G should belong to the family Axiidae . As the larvae are all in the early zoeal stages it is impossible to say whether an exopod would eventually develop on leg 5 .

Figure 32. Callianassidae larvae, lateral view.

A, Larva A (stage I); B, Larva B (stage I); C, Larva C (stage I); D, Larva D (stage I); E, Larva E (stage I); F, Larva F (stage I); G, Larva G (stage II). Scale bar = 0.5 mm.

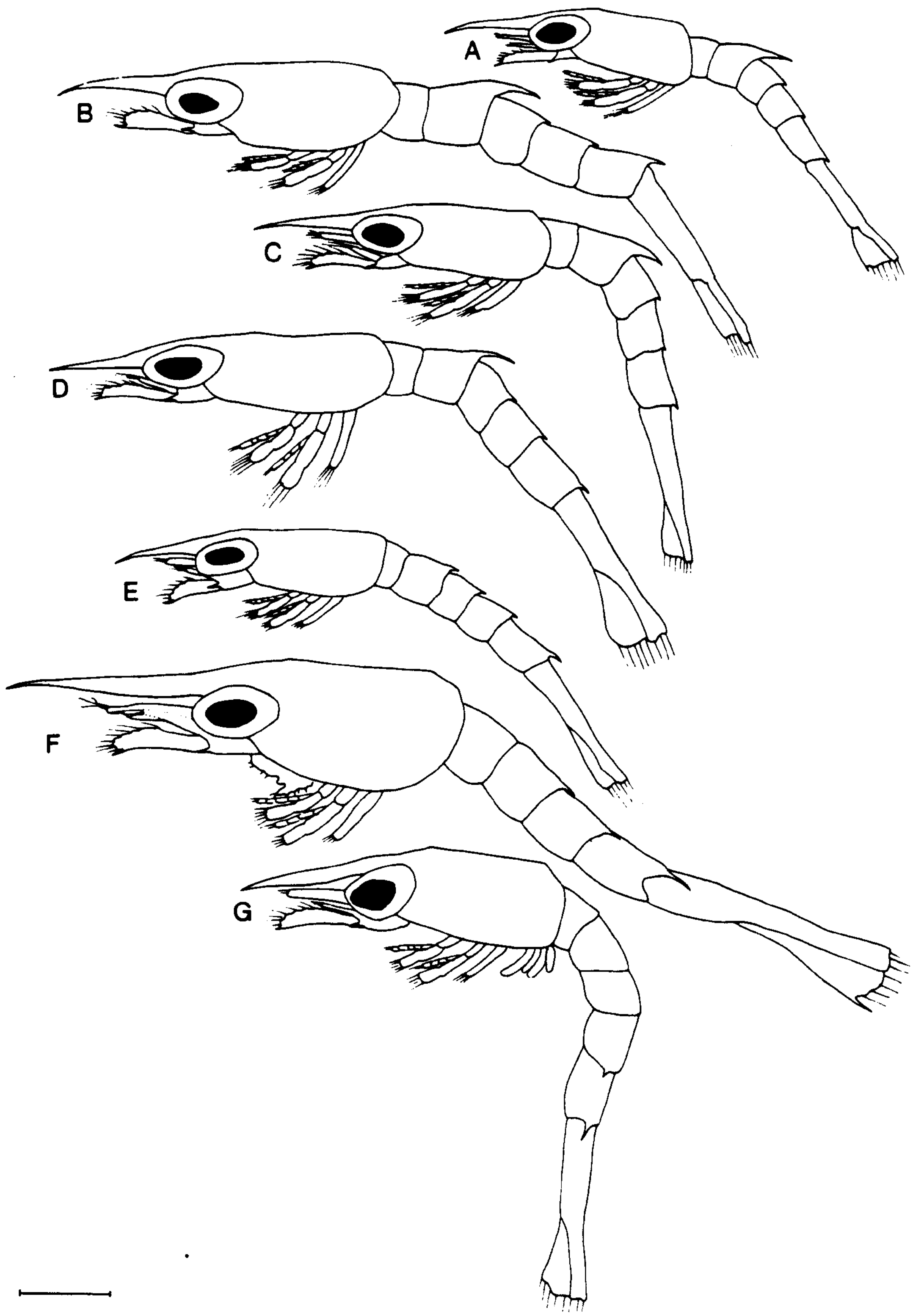
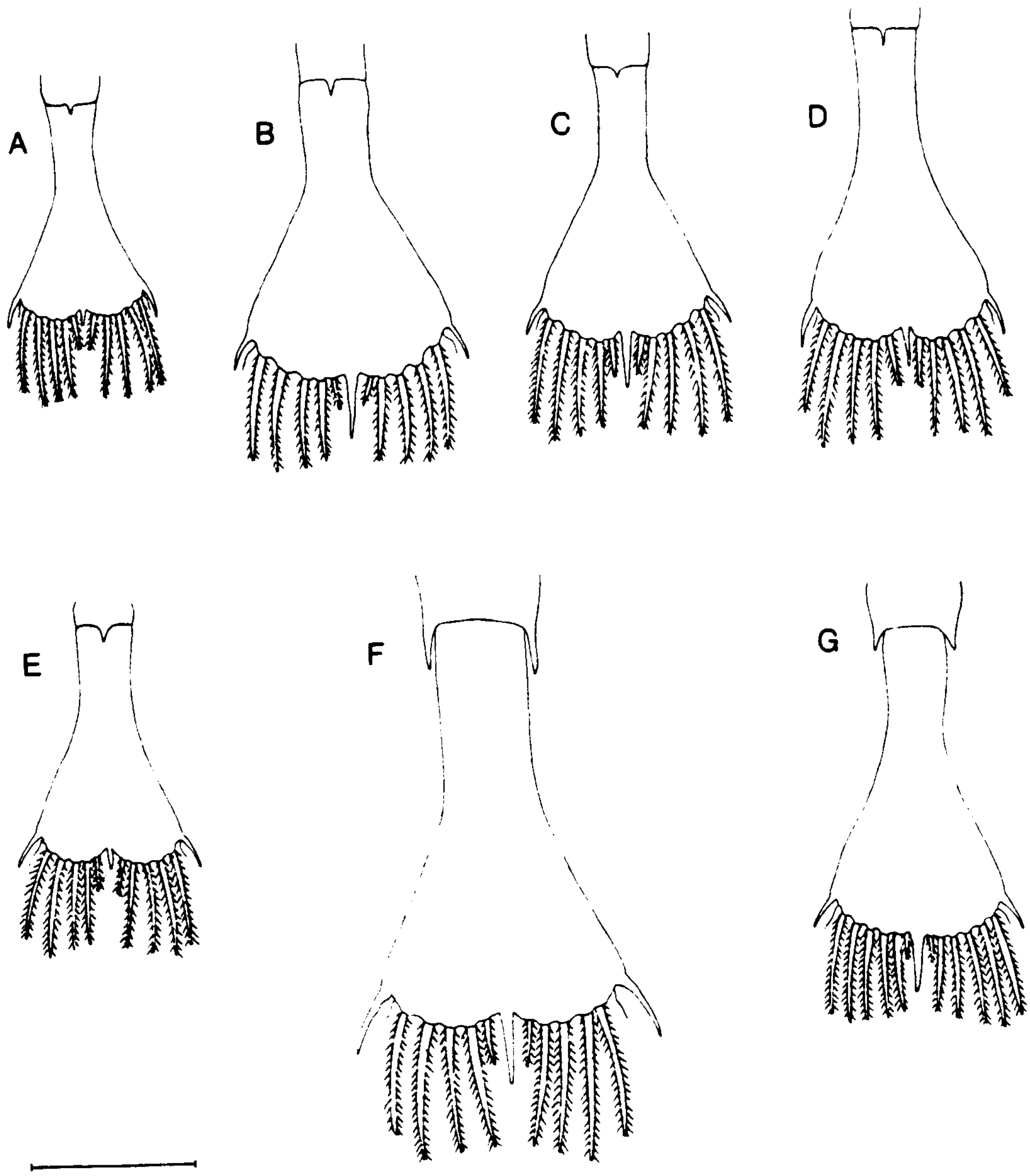

A
B
C
D
E
F
G

Figure 33. Callianassidae larvae, telsons.

A, Larva A (stage I); B, Larva B (stage I); C, Larva C (stage I); D, Larva D (stage I); E, Larva E (stage I); F, Larva F (stage I); G, Larva G (stage II). Scale bar = 0.5 mm.


A
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Laomediidae

Introduction

The Laomediidae are burrowing decapods , macrurous in form (Wear & Yaldwyn , 1966) . The known adults of the family make up the genera *Laomedia* de Haan , *Naushonia* Kingsley , *Jaxea* Nardo , *Axianassa* Schmitt and *Laurentiella* LeLoeuff & Intes . Publications on laomediid larvae are listed by Ngoc-Ho (1981) . Larvae of *Laomedia*, *Naushonia* and *Jaxea* are known either from hatching in the laboratory or rearing to identifiable juveniles . Ngoc-Ho (1981) ascribed a series of larval stages from the Gulf of Mexico to *Axianassa*, and other larvae described by Menon (1933) from India may belong to the same genus . No genus has been suggested for larvae, apparently all of the same species , described by Gurney (1938b) from the western Atlantic , the Great Barrier Reef and Samoa . No larvae have been ascribed to *Laurentiella*. There are no previous full descriptions of laomediid larvae from the Red Sea but Seridji (1986) recorded the larvae of one unnamed species of *Naushonia* from the Gulf of Aqaba .

The described larvae of the family all have highly modified mandibles in which the left is drawn out into a long sickle-shaped spine . There is also a tendency for the head to be elongated between the antenna and the mandibles to give the appearance of a ' neck ' . This feature is well marked in larvae of *Laomedia* and *Jaxea*, only slightly developed in *Naushonia* and absent in the larvae ascribed to

Axianassa. There is also a tendency for the telson of the early zoeal stages to be broad and sickle-shaped , a feature most pronounced in larvae of *Jaxea* , rather less developed in larvae of *Laomedia* and *Naushonia* and again absent in the larvae ascribed to *Axianassa* .

Results

Larvae of two species are described in the present study , *Naushonia* sp. and Laomodiidae CRS (Central Red Sea) . The latter could not be identified to any genus of this family . Larvae are illustrated in (Fig. 34) .

Naushonia sp. (TL : 1.81 mm , stage I) (Fig. 34E) . One larva was seen in the plankton collections , and the modification of the mandibles was clear without dissection . Rostrum small , slender , upturned at end . Abdominal somites without pleural spines , but somite 5 with a small papilliform process ventrally on either side . Telson deeply hollowed in middle .

Laomodiidae CRS (TL : 2.12 mm (average) , stage I) (Fig. 34A). Rostrum broad at base narrowing into sharp distal part . Abdominal somites 2- 4 with pleural spines , somite 5 with lateral spines . Mandibles asymmetrical : the left a long curved spine (Fig. 34B) , the right with cutting part pointed and molar part forked (Fig. 34C) .

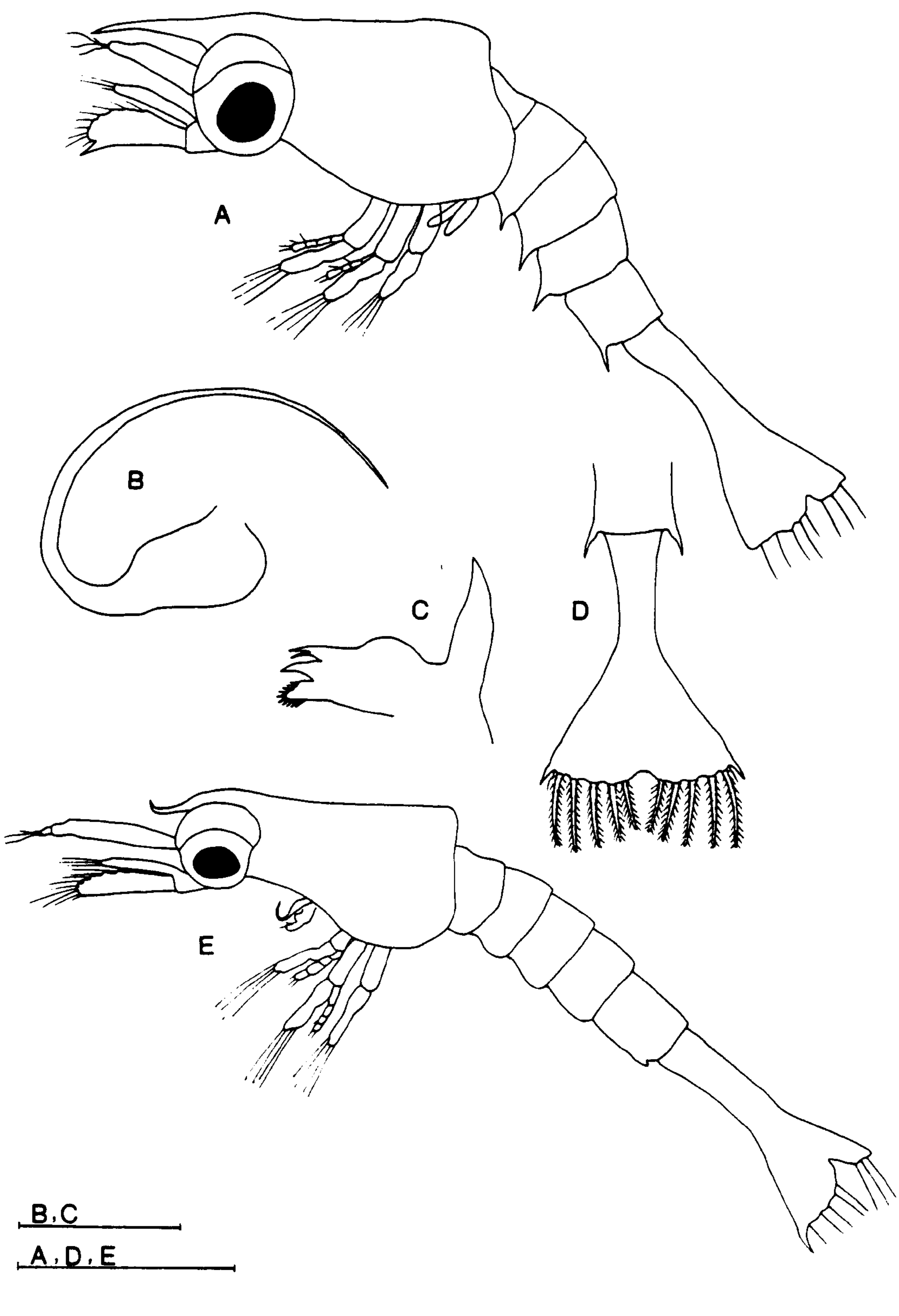
Discussion

The present larva of *Naushonia* sp. (Fig. 34E) closely resembles those described by Gurney (1938b) from Samoa and the Great Barrier Reef and undoubtedly all these larvae belong to the same species ; also Seridji's larva from the Gulf of Aqaba show many similarities . One adult species of *Naushonia* has been recorded from the Somilia coast of the Red Sea ; this is *N. perrieri* Nobili . The larvae probably all belong to this species , as suggested by Gurney & Lebour (1939) .

Laomediidae CRS (Fig. 34A) closely resembles Laomediidae D.I described by Gurney (1938b) from the western Pacific , the Great Barrier Reef and Samoa , although Gurney's larva is rather larger (2.4 mm in stage I) and the rostrum and pleural spines are shorter . Laomediidae D.I has a very small median telson spine in the late zoeal stages and it is probable that such a spine is also present in the late zoeal stages of Laomediidae CRS . Both larvae probably belong to the same genus , although it is still not possible to suggest what this genus might be . The form of the mandibles and pleural spines leaves no doubt that they belong to the Laomediidae . Larvae from the Gulf of Mexico , resembling Laomediidae CRS in most respects but lacking pleural spines , were ascribed to *Axianassa* by Ngoc-Ho (1981) . Larvae from India , originally ascribed to the Upogebiinae by Menon (1933), probably belong to the same genus as Ngoc-Ho's larva , although the presence of appendices internae on the pleopods of the postlarvae does not agree with the suggestion that they belong to '*Axianassa*. Laomediidae CRS seems likely to be the larva of an undescribed species of the Laomediidae , but it is not yet possible to say whether or not it belongs to a named genus .

Figure 34. Laomediidae, lateral view.

A, Laomediidae CRS (Central Red Sea); B, left mandible of Laomediidae CRS; C, right mandible of Laomediidae CRS; D, telson of Laomediidae CRS; E, *Naushonia* sp.. Scale bars (from top): (1) B,C = 0.1 mm; (2) A,D,E = 0.5 mm.


A
B
C
D
E
B,C
A,D,E

(Anomura s. s.)

Galatheidae

Intoduction

Several species of this family are confined to deep water , and some are commensal with different organisms (Vine , 1986) . Lewinsohn (1969) gave descriptions of 15 species of adult Galatheidae from the Red Sea , belonging to the genera *Galathea* (11 species) , *Munida* (3 species) and *Bathymunida* (1 species) .

Seridji (1986) recorded from the northern Red Sea (Gulf of Aqaba) larvae of five unnamed species of Galathea and one unnamed specis of *Munida* , but descriptions of these larvae are not yet published . Only two *Galathea* larvae have previously been described from the Red Sea , both from Al-Ghardaqa , Egypt . These are *G. longimana* Paulson , described by Gurney (1938a) and *Galathea* sp. by Al-Kholy (1959) .

The following distinguishing features of *Galathea* and *Munida* are from Gore (1979) .

Galathea spp.

1- Rostrum acute , expanded proximally often from stage II .

2- Carapace postero-lateral margin usually spinulate .

3- Antennal scaphocerite broad or flattened .

4- Telson triangular , not deeply bifurcate in early stages , becoming more elongate in later stages .

Munida spp.

1- Rostrum elongate , needle-like , spinulate on distolateral margin and tip in early stages , but may be unarmed in late stages .
2- A serrated postero-lateral carapace margin with noticeable posterior spine .
3- Antennal scaphocerite elongate , thin or even noticeably aciculate , often spined , basal segment with a single ventral spine in first stage.
4- Telson originally deeply bifurcate in early stages of development . Also Williamson (1957) mentioned that larva of the family Galatheidae are distinguished by having the postero-lateral margins of carapace denticulate and usually with a spine .

Results

Larvae of seven species were recorded in the present study and given the specific letters A - G . The larvae are illustrated in Fig. 35, and the main distinguishing features are listed below . In each case the length and breadth of the rostrum refer to the part which extends beyond the eyes . All species have a pair of lateral spines on the posterior margins of both the 4th and 5th abdominal somites .

Larva A (Fig. 35A) . Zoea I , TL : 2.35 mm (average) . Dorsal posterior margins of somites 4 and 5 each with a continuous row of denticles between lateral spines . Rostrum smooth , about 5 times as long as broad . Dorsal part of posterior margin of carapace without spinules . Length of spine on antennal scale only about 1/4 width of scale .

Larva B (Fig. 35B) . Zoea II , TL : 1.75 mm (average) . Dorsal posterior margins of somites 4 and 5 each with a pair of small spines. Rostrum with lateral serrations ; length less than twice breadth . Short length of dorsal posterior margin of carapace without spinules . Length of spine on antennal scale about half width of scale . In all the remaining species the dorsal posterior margins of somites 4 and 5 are smooth .

Larva C (Fig. 35C) . Zoea III , TL : 3.17 mm (average) . Rostrum with lateral serrations , about 4 times as long as broad . Only about 4 dorsal spinules at base of each posterior carapace spine , remainder of margin between spines smooth . Length of spine on antennal scale about equal to width of scale .

Larva D (Fig. 35D) . Zoea I , TL : 2.00 mm (average) . Rostrum smooth , about 6 times as long as broad . Continuous row of spinules on dorsal posterior margine of carapace . Spine on antennal scale much longer than width of scale . Lateral spines on 4th abdominal somite small . Outermost telson spine long .

Larva E (Fig. 35E) . Zoea I , TL : 2.00 mm (average) . Rostrum smooth , about 8 times as long as broad . Only 4 or 5 dorsal spinules at base of each posterior carapace spine , remainder of margin between spines smooth . Spine on antennal scale slightly longer than width of scale .

Larva F (Fig. 35F) . Zoea I , TL : 1.82 mm (average) . Rostrum smooth , about 5 times as long as broad . Only short length of dorsal posterior margin of carapace without spinules . Spine on antennal scale much longer than width of scale . Eyes very large : length of eye greater than distance from posterior eye to tip of carapace spine .

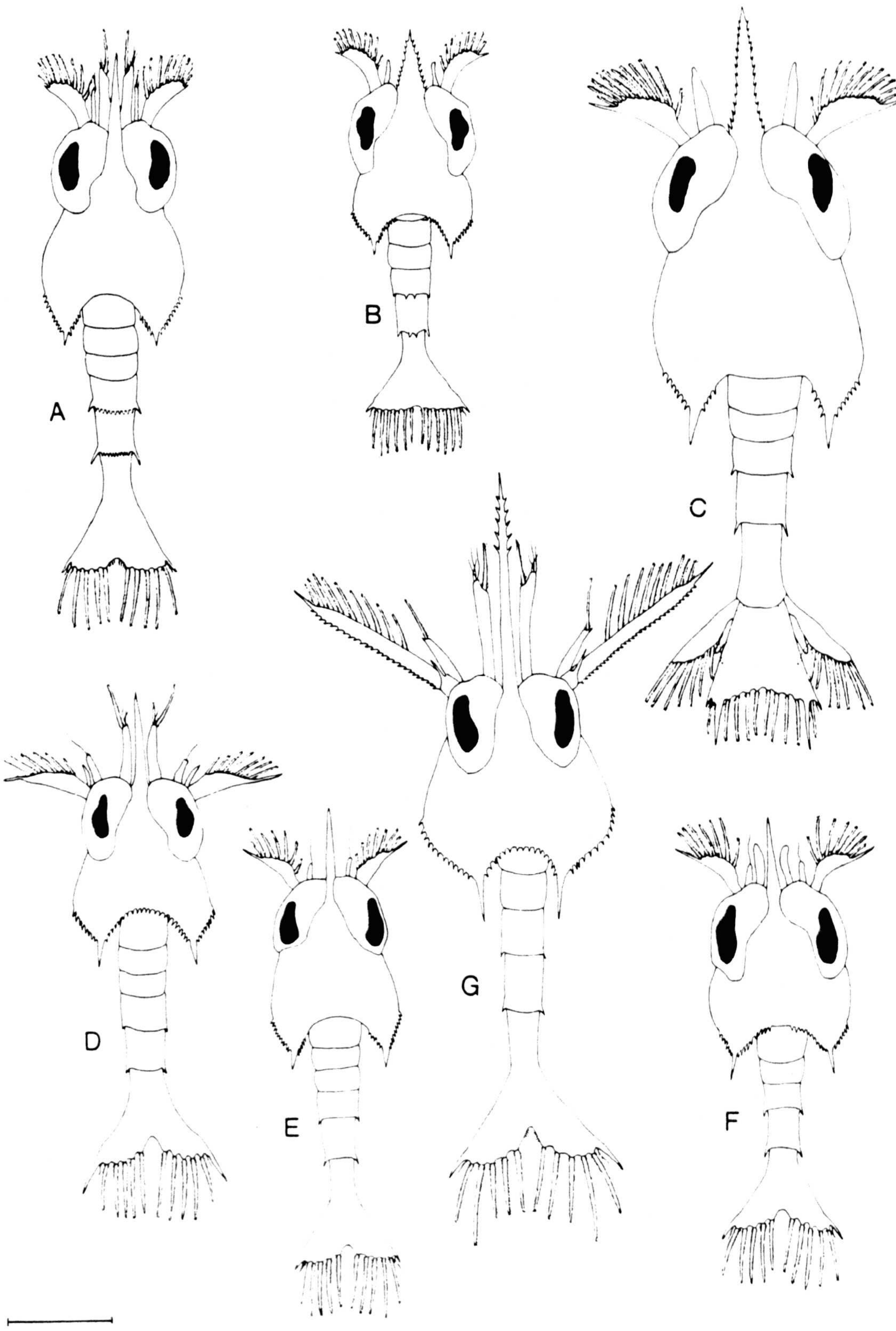
Larva G (Fig. 35G) . Zoea I , TL : 3.00 mm (average) . Rostrum with lateral spinules on anterior third , remainder smooth ; about 14 times as long as broad . continuous row of spinules on dorsal posterior margin of carapace . Antennal scale parallel-sided for most of length; setae on distal 3/4 of inner margin , spinules along entire length of outer margin ; terminal spine longer than width of scale .

Discussion

None of the larvae correspond to previously published descriptions. Larvae A - F almost certainly belong to different species of *Galathea* but G belongs to a different genus (Fig. 35) . G resembles larvae of *Munida* in having spinules on the anterior part of the rostrum , and larvae of some species of *Munida* have spinules on the distal part of the outer margin of the antennal scale . The shape of the antennal scale of G is , however , unlike that of any previously described galatheid larva , and no other described larva has spinules along the entire outer margin of the scale . The carapace spines and outermost telson spines of G are similar to those of some species of *Galathea* and much less developed than in *Munida* larvae . G seems likely to belong to a genus of the Galatheidae for which no larva has previously been described . It is suggested that it may well belong to *Bathymunida* , which is known to be represented in the Red Sea by *B. polae* Balss (Lewinsohn , 1969).

Figure 35 . Galatheidae , dorsal view .

A , Larva A (stage I) ; B , Larva B (stage II) ; C , Larva C (stage III); D , Larva D (stage I) ; E , Larva E (stage I) ; F, Larva F (stage I) ; G, Larva G (stage I) . Scale bar = 0.5 mm .


A
B
C
D
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F
G

Porcellanidae

Introduction

Larvae of the Porcellanidae are very distinctive , having the rostrum much longer than the body , long posterior carapace spines extending beyond the telson and the telson tending towards an ovoid shape (Williamson , 1957 ; Wear , 1964) . Greenwood (1965) gave a table to distinguish the larvae of *Petrolisthes* , *Porcellana* and *Pisidia* , but larvae have also been described from species of *Polyonyx*, *Pachycheles* , *Petrocheles* *Euceramus* , *Neopisosoma* and *Megalobrachium* .

Lewinsohn (1969) gave descriptions of 13 species of adult Porcellanidae from the Red Sea , belonging to the genera *Petrolisthes* (8 species) , *Pachycheles* (1 species) , *Pisidia* (1 species) and *Polyonyx* (3 species) . Seridji (1986) recorded 4 larvae of Porcellanidae from Gulf of Aqaba , northern Red Sea : these are *Pisidia inaequalis* (Heller), *Pachycheles* sp. , *Polyonyx* sp. and *Petrolisthes* sp. . Larvae ascribed to *Petrolisthes* sp. and identified larvae of *Pisidia inaequalis* described by Gurney (1938a) (the latter as *Porcellana inaequalis*) from northern Red Sea , *Petrolisthes rufescens* (Heller) described by Gohar and Al-Kholy (1957) from Al-Ghardaqa , northern Red Sea , and a larva ascribed to the genus *Pachycheles* Stimpson by Williamson (1970) from northern Red Sea are the only other larvae of this family described from the Red Sea .

Results

Larvae of six different species were recorded in the present study and given specific letters A - F (Fig. 36) . They were distinguished by the morphological features , tabulated in Table 7 .

Table 7 . Comparision of larvae of six species of Porcellanidae in stage I .

	A	B	C	D	E	F
Length of rostrum(average)(mm)	2.56	5.92	4.48	4.06	(bro.*)	7.63
Length of carapace(average)(mm)	1.25	1.60	1.44	1.38	1.05	1.80
Length of carapace spines(mm)	0.51	1.37	1.98	1.98	2.59	1.87
Denticles on ventral carapace	-	-	+	-	-	-
Abdominal somites with spines	5	4,5	5	5	5	4,5

* indicates broken rostrum .

Discussion

The characters given in the (Table 7) distinguish all the larvae , but C and D are similar except for the presence of denticles on the ventral carapace margin in the former larva (Fig. 36C,D) . The telson is also of similar form in C and D , but in D it is slightly narrower , the central prominence is more convex and the four short setae on this prominence are more widely spaced (Fig. 37C,D) . C and D appear to be the larvae of two closely related species of the same genus .

In larva F the outermost telson process , normally a simple spine, is replaced by two partly fused spines of unequal length (Fig. 37F) . Such a structure has not previously been described in a porcellanid larva .

Larva A (Fig. 36A) is very simiar to the larvae of *Pisidia inaequalis* described by Gurney (1938a) from Al-Ghardaqa , on the Egyptian coast of the Red Sea . There are , however , some small differences . The 6th abdominal somite is serrated in Gurney's larvae but not in larva A , and the central telson prominence bears 2 setae in Gurney's larvae but 4 in larva A . In spite of these differences , it seems likely that larva A is *P. inaequalis*. This species is known to be common throughout the Red Sea and there are no confirmed records of other species of this genus from the area (Lewinsohn , 1969) .

Although the telson of larva E (Fig. 37E) is less elongated than that of larva A , it is of the same general form . Knight (1966) pointed out that the larvae of *Porcellana*, *Pisidia* and *Polyonyx* show similarities , including a narrow telson , which distinguish them from other known porcellanid larvae . No species of *Porcellana* are known from the Red Sea , but larva E may well belong to one of the three species of *Polyonyx* which have been recorded .

The features of larvae B , C , D and F are consistent with ascribing them to the genus *Petrolisthes*. They do not include *P. rufescens* , whose larval telson lacks a central prominence (Al-Kholy, 1963) , but it is not possible to say which of the seven other species of the genus recorded from the Red Sea are represented in the larval collection.

Figure 36 . Porcellanidae , lateral veiw .

A , Larva A (stage I) ; B , Larva B (stage I) ; C , Larva C (stage I) ; D, Larva D (stage I) ; E ; Larva E (stage I) ; F , Larva F (stage I) ; G, Larva G (stage I) . Scale bar = 0.5 mm .

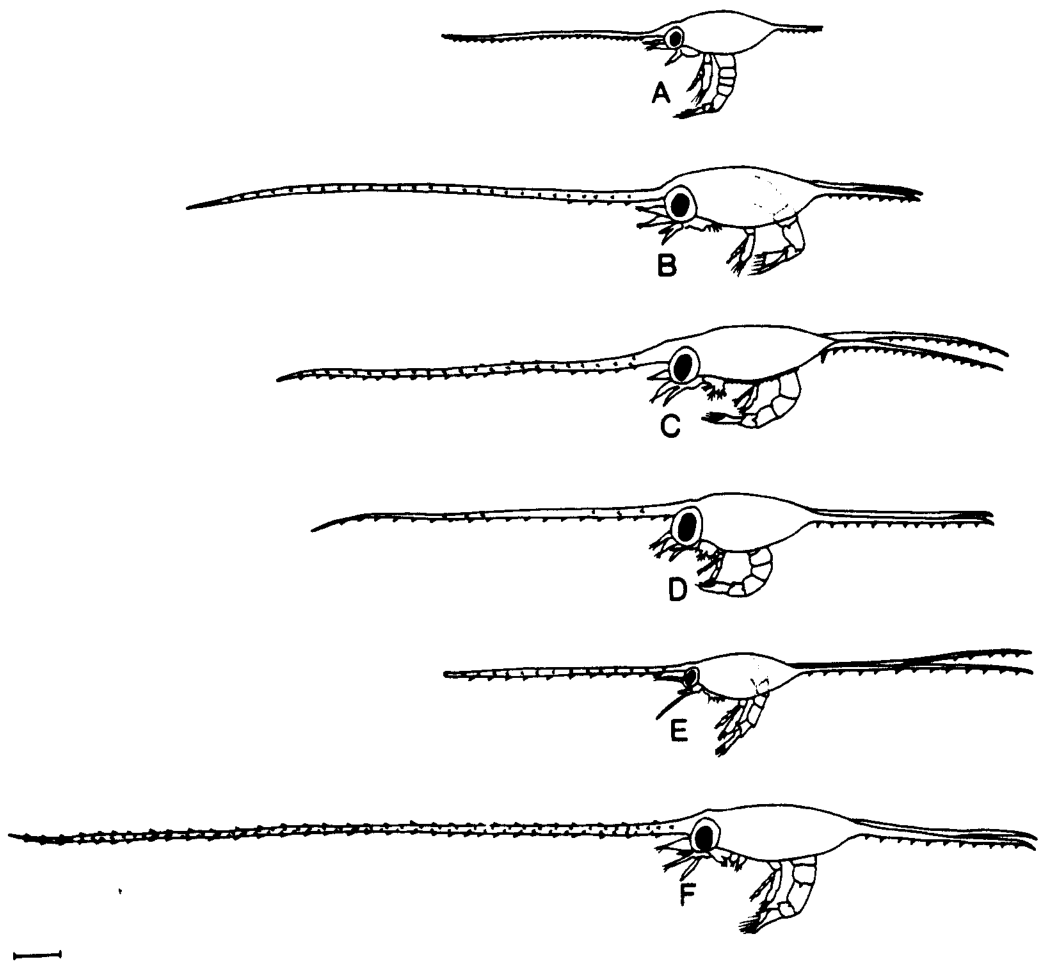
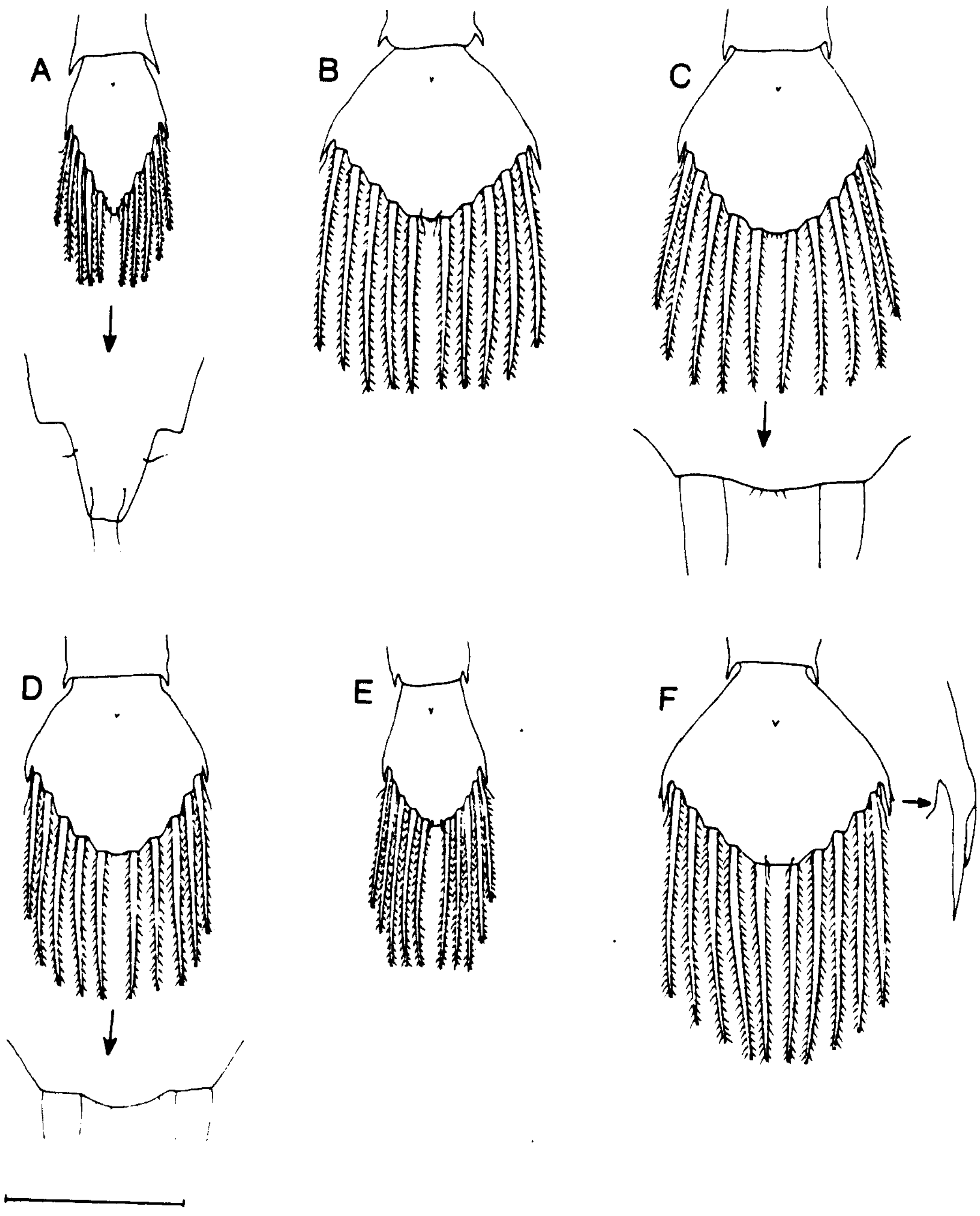

A
B
C
D
E
F

Figure 37. Porcellanidae, telsons.

A, Larva A (stage I); B, Larva B (stage I); C, Larva C (stage I); D, Larva D (stage I); E, Larva E (stage I); F, Larva F (stage I); G, Larva G (stage I). Scale bar = 0.5 mm.


A
B
C
D
E
F

Paguridae

Introduction

In general the pagurids are scavengers and are found in a wide range of habitats , particulary among the corals (Vine , 1986) . Lewinsohn (1969) recorded from the Red Sea waters the following adult pagurids : *Ploypaguropsis* (1 species) , *Pagurus* (4 species) , *Nematopagurus* (3 species) , *Catapagurus* (1 species) , *Cestopagurus* (3 species) and *Anapagurus* (1 species) .

One of the species of *Pagurus* closely resembles *P. prideauxi* Leach from the Mediterranean and northern Europe and is recorded by Lewinsohn (1969) as *Pagurus* cf. *prideauxi* . Larvae have been described for *P. prideauxi* (e. g. MacDonald et al , 1957) but not for the other Red Sea species of paguridae . Larvae have not been described for any species of *Ploypaguropsis* , *Nematopagurus* , *Catapagurus* or *Cestopagurus*. Seridji (1986) recorded from the Gulf of Aqaba , northern Red Sea , four larval species of *Pagurus* and one of *Anapagurus* , but these are not identified to named species .

The larval stages of the family Paguridae are well-known from different regions of the world , and many authors have described different species belonging to this family . For instance , MacDonald , Pike and Williamson (1957) described the larvae of eight species of Paguridae from British waters with morphological keys for identification , also Pike and Williamson (1960) described nine species of Paguridae , in addition to three unknown species , from the Bay of Naples , again with a key to species .

General morphological characters of the family Paguridae , from Pike and Williamson (1960) , are as follows :

1- Rostrum smooth , narrow and tapering .

2- Carapace with a pair of posterior spines (but it is now known that these spines are absent in at least one species) .

3- The 5th abdominal somite usually with a pair of lateral spines , somites 2 - 5 usually each with a pair of small dorsal spines .

4- From stage III the 4th telson process becomes broad and fused to the telson .

The zoeal stages of *Anapagurus* have the same general form as these of *Pagurus*, but differ in that the posterior margin of the 5th abdominal somite has only very small lateral spines or none . The 5th abdominal somite , and in some species the 4th somite also , is without pleopods in stage IV .

Results

Larvae of four species of Paguridae were collected in the present study and they were given the specific letters A - D . The larvae are illustrated in (Fig. 38) and the main points of distinction are listed in Table 8 .

Table 8. Comparision of larvae of Paguridae from present collection.

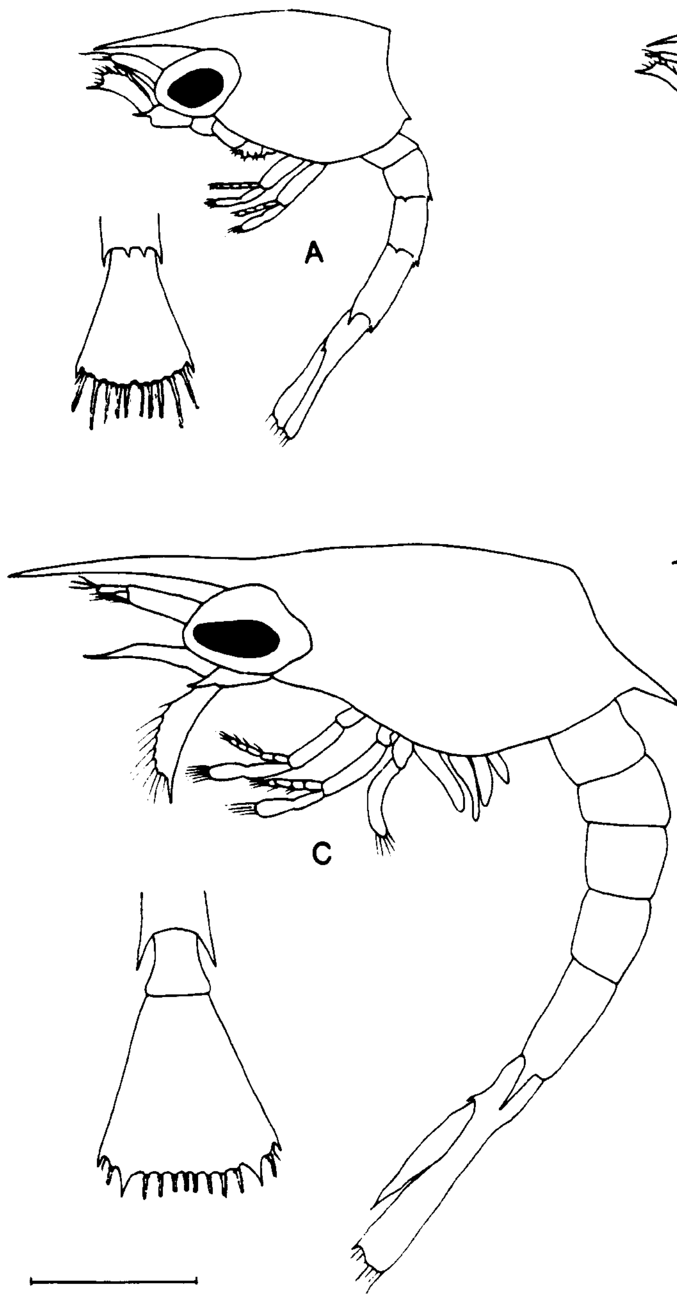
	A	B	C	D
Total length in mm(average)(stage)	1.89(I)	1.77(II)	3.57(III)	1.91(I)
Post-carapace spine /rostrum	1/20	1/7	1/4	1/6
Dorsal abd. spines on somites	3,4,5	4,5	none	3,4,5
Lateral abd. spines on somites	3,4,5	4,5	5	3,4,5
Sizes of lateral spines	5>4	5>4	5 long	5=4

Discussion

Larvae A and B (Fig. 38A,B) are fairly typical of the genus *Pagurus*. Larva C (Fig. 38C) is less typical of this genus in having no abdominal spines other than the large laterals on somite 5 , but similar armature occur in the larvae of the Brazilian species *Pagurus criniticornis* (Dana) described by Hebling & Brossi-Garcia (1981). Lateral spines on the 5th somite are common in larvae of *Pagurus* but not large as shown in larva C . Larva C may , therefore , belong to another species of *Pagurus* or to a species of *Nematopagurus* , *Catapagurus* or *Cestopagurus* . Larva D (Fig. 38D) is fairly typical of the genus *Anapagurus* .

Figure 38. Paguridae, lateral veiw and telsons.

A, Larva A (stage I); B, Larva B (stage II); C, Larva C (stage III); D, Larva D (stage I). Scale bar = 0.5 mm.


A
B
C
D

Diogenidae

Diogenes spp.

Introduction

Diogenes avarus Heller lives in sandy areas of the eulittoral . This species burrows into the sand when the tide ebbs and becomes active when the tide floods back . Many of these crabs use the shell of the gastropod *Nassa arcularia* for their protection (Vine , 1986) . Lewinsohn (1969) gave descriptions of 4 species of adult *Diogenes* from the Red Sea , *D. avarus* , *D. costatus* Henderson , *D. gardineri* Alcock and *D. denticulatus* Chevreux & Bouvier .

Seridji (1986) recorded from the northern Red Sea (Gulf of Aqaba) larvae of two unnamed species of *Diogenes* . The larvae of *D. pugilator* (Roux) have been described by many authors from different regions , Gurney (1927) from the northern Red Sea (Suez Canal) ; Menon (1937) from Madras ; MacDonald , Pike and Williamson (1957) from British waters ; Pike and Williamson (1960) from the Mediterranean Sea (Bay of Naples) . Lewinsohn (1969) , however , has questioned the records of *D. pugilator* from Red Sea and Indian Ocean .

Sarojini and Nagabushanam (1968) described the zoeal larval stages of *D. bicristimanus* from India . Sankolli and Shenoy (1975) described the larval development of *D. avarus* also from India . Nayak and Kakati (1977) studied the metamorphsis of *D. diogenes* (Herbst) from Japan , and Baba and Fukuda (1985) studied the larval development of *D. nitidimanus* Terao , also from Japan . Larvae of this genus are distinguished by having three setae on the endopod of the antenna , and one of these setae is very minute and subterminal . Also these larvae are very small compared with other genera in the same family .

Results

Larvae of two species of *Diogenes* were collected in the present study and they were given the specific letters A (Fig. 39) and B (Fig. 41) . Some specimens of species A were reared in the laboratory from stage 3 to the megalopa (Fig. 40) .

Diogenes A (Fig. 39) , stage I

Size - TL : 1.27 mm (average) .

Carapace (Fig. 39A) - Rostrum upturned at the end , posterior margin rounded .

Antennule (Fig. 39B) - Uniramous , with one long subterminal plumose seta , 3 terminal aesthetascs and 2 plumose setae .

Antenna (Fig. 39C) - Endopod with 3 plumose setae , 3rd very minute ; exopod with 10 plumose setae and strong outer distal spine ; a strong ventral spine on protopod at base of exopod .

Maxillule (Fig. 39D) - Coxal endite with 6 setae ; basial endite with 2 strong spines , each with several rows of denticles , and one seta ; endopod of 2 segments : proximal segment fused to basis , with one inner seta ; distal segment with 2 terminal setae .

Maxilla (Fig. 39E) - Proximal lobe of coxal endite with 5 setae , distal lobe with 4 setae ; proximal lobe of basial endite with 4 setae , distal lobe with 3 setae ; endopod unsegmented , with 2 setae . Scaphognathite with 5 plumose setae .

First Maxilliped (Fig. 39F) - Basis with 1 , 3 , 2 setae ; endopod 5-segmented with 3/0 , 2/0 , 1/0 , 2/0 and 4/1 inner / outer plumose setae ; exopod with 4 natatory plumose setae .

Second Maxilliped (Fig. 39G) - Basis with 1 , 1 setae ; endopod 4-segmented with 2/0 , 2/0 , 2/0 and 4/1 inner / outer plumose setae; exopod with 4 natatory plumose setae .

Third Maxilliped (Fig. 39H) - One rudimentary ramus , denticulate at end .

Abdomen (Fig. 39A) - 3rd , 4th and 5th somites with medio-dorsal spines , 5th somite with pair lateral spines slightly longer than medio-dorsal spine .

Telson (Fig. 39I) - Traingular with medain posterior notch , processes 7 + 7 , 5th process longest .

Diogenes B (Fig. 41), stage I

Generally similar to *Diogenes* A , but total length 1.45 mm (average) and medio-dorsal abdominal spines confined to somite 5 .

Discussion

Diogenes avarus Heller and *D. pugilator* Roux are two closely related species which have often been confused in the past . Lewinsohn (1969) made a detailed comparision between adults of *D. avarus* from the Red Sea and *D. pugilator* from the Mediterranean . He showed that *D. avarus* is very common throughout the Red Sea but there are no authenticated records of *D. pugilator* from this region . *Diogenes* A (Fig. 39A) is regarded as being the larva of *D. avarus* because it is common in the coastal regions north of Jeddah where adults of *D. avarus* are common and because the larvae show a close general resemblance to larvae of *D. pugilator* , as described by MacDonald et al (1957) from the Irish Sea and Pike & Williamson (1960) from Naples . *Diogenes* A differs from the larvae of *D. pugilator* in having only 2 setae on the endopod of each uropod (as opposed to 3 or 4) in the last zoeal stage and in having no spines on the chelipeds in the megalopa . It should be noted , however , that megalopas from Naples had more and larger spines on the chelipeds than megalopas from the Irish Sea . In both these characters , the larvae from the Suez Canal which Gurney (1927) ascribed to *D. pugilator* agree with larvae from the Jeddah region rather than those from Naples or northern Europe but they differ from *Diogenes* A in having only a shallow central notch in the telson . It seems likely , however , that Gurney's specimens were realy *D. avarus* rather than *D. pugilator* . *D. pugilator* from the Irish Sea was reported to pass through five zoeal stages , but the same species from Naples passed through only four , as did *Diogenes* A when reared in the laboratory in the present work .

The larvae from Madras , southern India , which Menon (1937) ascribed to *D. pugilator* apparently did not have spines on the chelipeds of the megalopa , as would be expected in this species . The identification of the Indian larvae which Sankolli & Shenoy (1975) described under the name *D. avarus* must also be questioned because they differ from *Diogenes* A in the setation of several of the appendages , particularly the maxilla .

It was noted by MacDonald et al (1957) that , while the majority of larvae of *D. pugilator* had medio-dorsal abdominal spines on somites 3 - 5 , a few lacked spines on somites 3 and 4 . The lack of spines on somites 3 and 4 is given above as the main character separating *Diogenes* B (Fig. 41) from the much commoner *Diogenes* A , and it may be argued that , in view of the observations on *D. pugilator* , this may not be a specific difference . *Diogenes* B is , however , slightly larger than *Diogenes* A in stage I and the eye is larger , and it is therefore regarded as belonging to a distinct species. From the records of adults given by Lewinsohn (1969) . *Diogenes* B seems most likely to belong to *D. gardineri* Alcock , but Lewinsohn also records *D. costatus* Henderson from the southern Red Sea and mentions doubtful records of *D. denticulatus* Chevreux & Bouvier from Aden and the Perim Islands , at the southern entrance to the Red Sea .

Figure 39. *Diogenes* A = *avarus* Heller.

A, lateral view; B, antennule; C, antenna; D, maxillule; E, maxilla; F, first maxilliped; G, second maxilliped; H, third maxilliped; I, telson. Scale bars (from top): (1) A, I = 0.5 mm; (2) B - H = 0.2 mm.

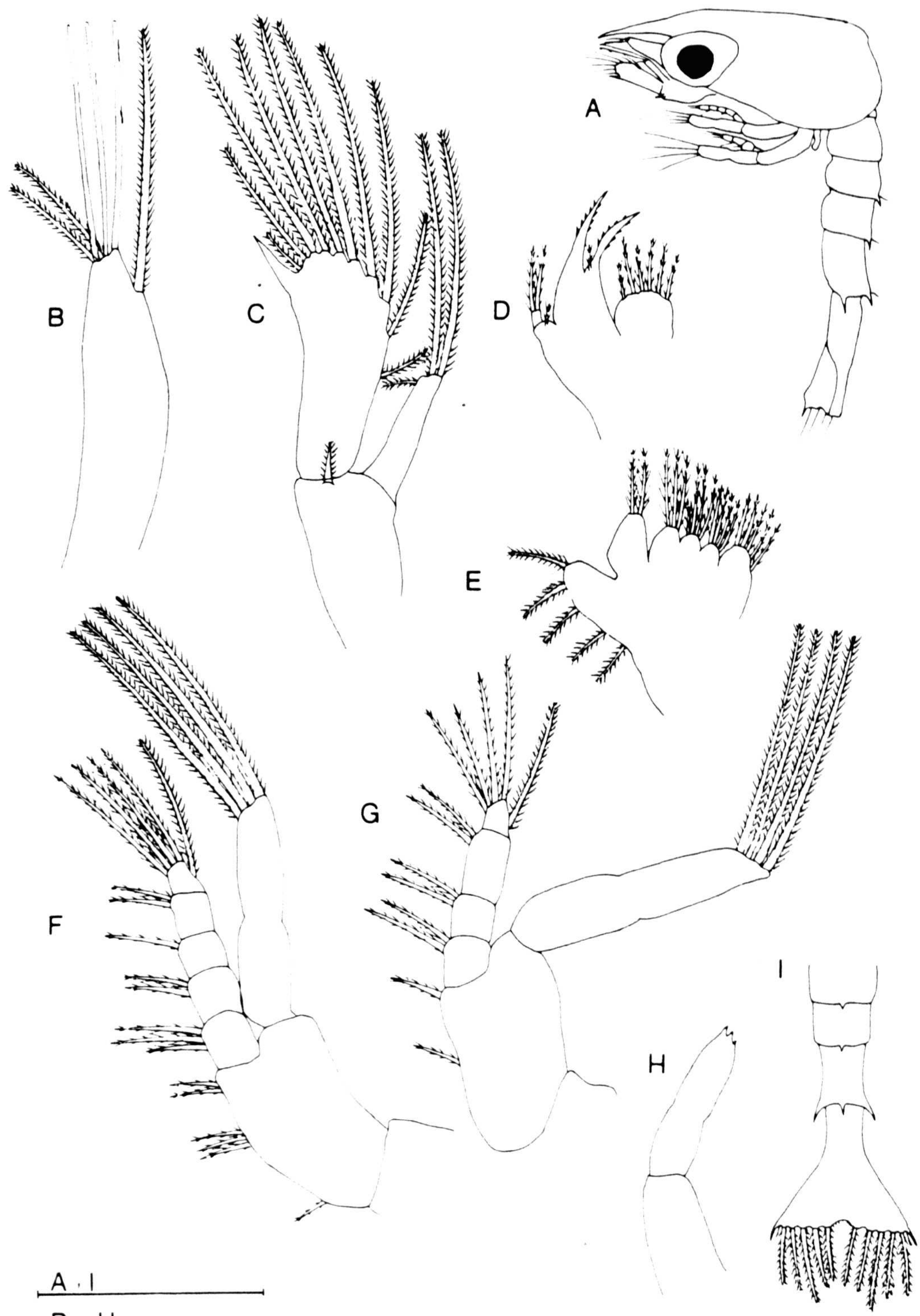
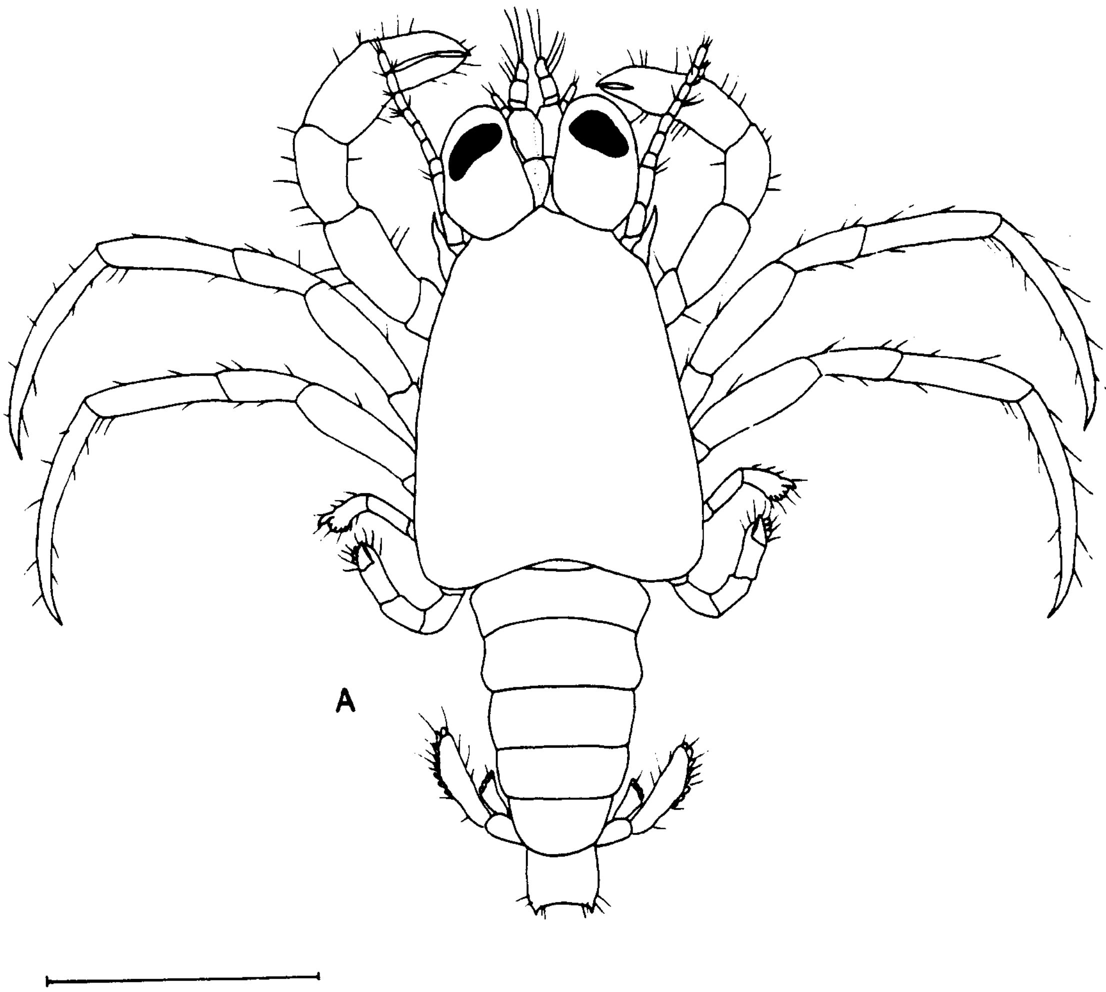

A
B
C
D
E
F
G
H
I
A, I
B – H

Figure 40. *Diogenes* A = *avarus* Heller.

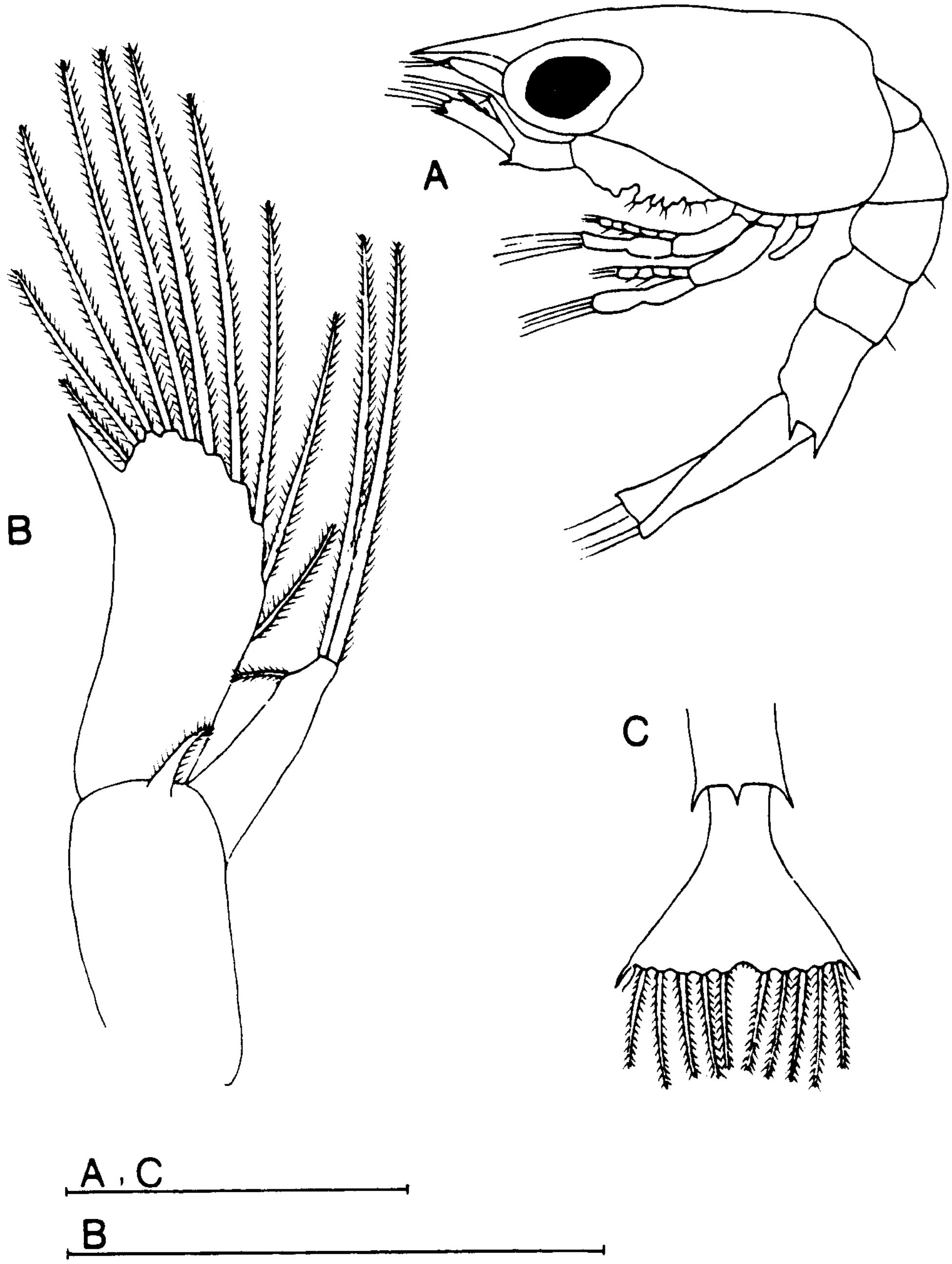
Megalopa stage. Scale bar = 0.5 mm.



A

Figure 41 . *Diogenes* B .

A , lateral view (stage I) ; B , antenna ; C , telson . Scale bars (from top) : A , C = 0.5 mm ; B = 0.2 mm .


A
B
C
A, C
B

Calcinus spp.

Introduction

Lewinsohn (1969) gave descrpitions of 2 species of adult *Calcinus* from the Red Sea , *C. latens* (Randall) and *C. rosaceus* Heller ; the former species has been recorded from the Jeddah region and other parts along the Saudia Arabian coast . Pike and Williamson (1960) described the larvae of *C. ornatus* from the Mediterranean Sea (Bay of Naples) . Provenzano (1962) gave descriptions of the larval stages of *C. tibicen* from the western Atlantic ocean . Only one unnamed species of larva has previously been recorded from the northern Red Sea (Gulf of Aqaba) by Seridji (1986) , but a full description of this larva is not yet published .

The generic features of *Calcinus* larvae are as follows : Antenna with 3 setae , one shorter than the others , which is a feature of all larvae of the Diogenidae . A pair of prominent submarginal postero-lateral spines on the carapace , which is unknown in other genera of the Diogenidae . A medio-dorsal and pair of lateral spines on the fifth abdominal somite .

Results

Larvae of two species in stage I were recorded in the present study and given the specific letters A and B . Both have a TL : 1.93 mm (average) , and both are very similar in most features . The only difference found was in the medio-dorsal spines on the abdominal somites , larva A having dorsal spines on the 5th abdominal somite only , whereas larva B has dorsal spines on the 3rd , 4th and 5th abdominal somites . The spine on the 3rd segment is very small . The larvae are illustrated in (Fig. 42) , but the appendages were not dissected .

Discussion

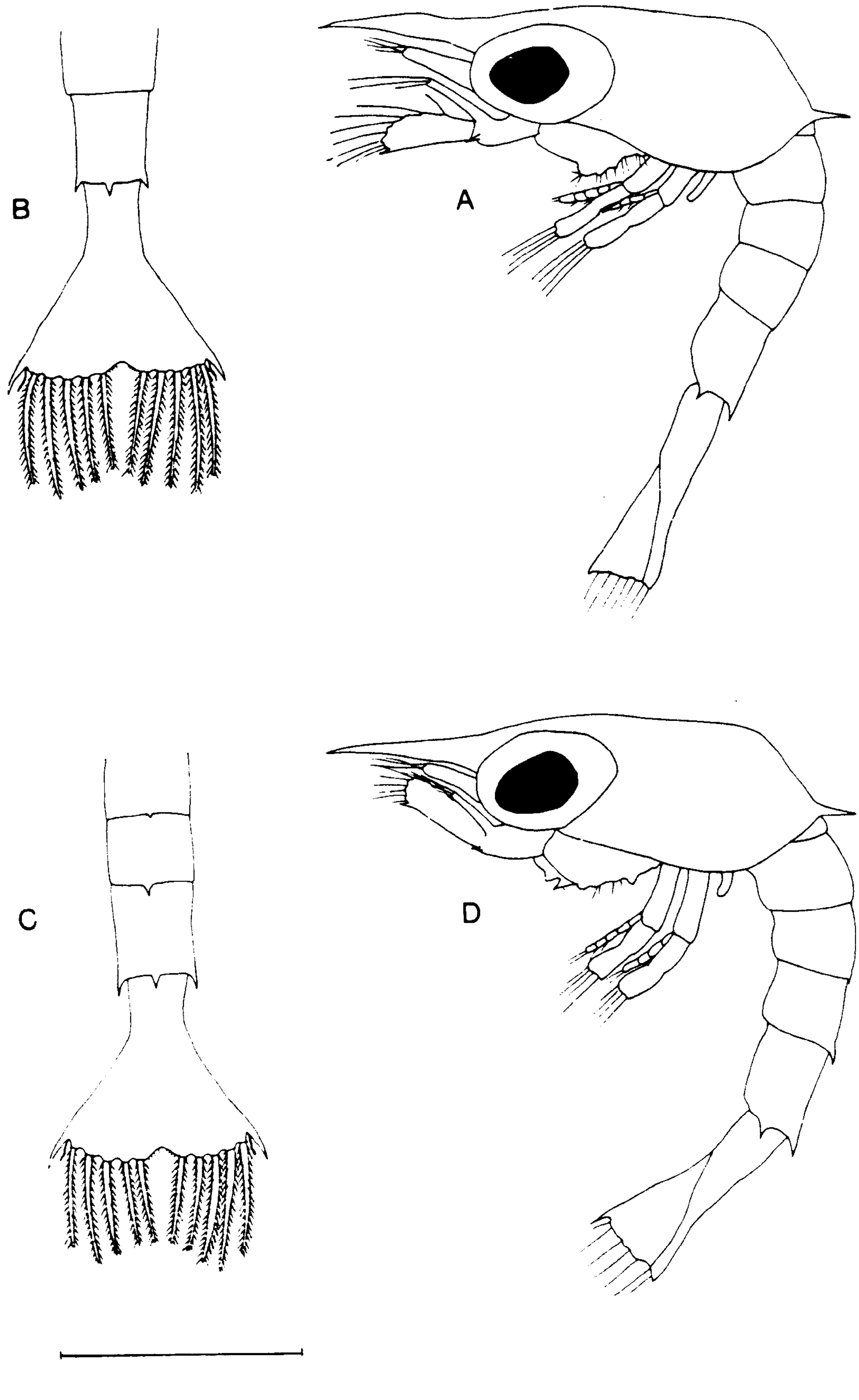
Seridji mentioned in her description of the *Calcinus* sp. that the larva from the northern Red Sea is very similar to the larva of *C. tibicen* rather than *C. ornatus* .

Larvae A and B (Fig. 42A,C) have the medio-dorsal spine on the 5th somite similar in length to the pair of lateral spines . In *C. tibicen* the medio-dorsal spine is longer than the pair of lateral spines , whereas in *C. ornatus* the medio-dorsal spine is shorter than the laterals .

Larvae A was the more common of the two species , and was very common in some samples . This larva may be *C. latens* , which is known to occur in the Jeddah region from Lewinsohn's records . Larva B may then be tentatively referred to *C. rosaceus* .

Figure 42 . *Calcinus* spp. .

A , Larva A , lateral view (stage I) ; B , telson of larva A;
C , telson of larva B ; D , Larva B , lateral view (stage I).
Scale bar = 0.5 mm .


B
A
C
D

Dardanus spp.

Introduction

Lewinsohn (1969) described adults of three species of *Dardanus* from the Red Sea : *D. tinctor* (Forskål), *D. lagopodes* (Forskål) and *D. woodmasoni* (Alcock). Larvae have not previously been described for any of these species , but larvae of *D. tinctor* were reared in the laboratory during the present work and are described in Chapter 3 . Two larval unnamed species of *Dardanus* were recorded from the northern Red Sea (Gulf of Aqaba) by Seridji (1986) . Zoea larvae have been described for *D. arrosor* (Herbst) , from the Mediterranean (Pike & Williamson , 1960) and Japan (Kurata , 1968) , and for *D. setifer* from India (Nayak & Kakati , 1978) , and unnamed larvae have been ascribed to this genus by Dechancé (1961) .

Results and discussion

The Known larvae of *Dardanus* and those ascribed to the genus all have a longitudinal ridge on either side of the medio-dorsal line of the telson and all except *D. setifer* have a scaly cuticle . Both these characters occur in the larvae of the two species of *Dardanus* encountered in the present study . These were originally given the specific letters A and B , but species A is now known to be *D. tinctor*.

Dardanus B in stage I is illustrated in (Fig. 43A) , and the more important differences between it and *D. tinctor* (Fig. 12A,B) are as follows :

· 1- Size - *D. tinctor* has TL : 2.33 mm (average) in stage I whereas *Dardanus* B has TL : 2.63 mm (average) in stage I .

2- Antenna - Antennal scale in *D. tinctor* without terminal spine and with fine hairs on outer margin (similar to that described by Dechancé , 1962 , Fig. 3d) . Antennal scale of *Dardanus* B (Fig. 43B) with small terminal spine and without fine hairs on outer margin (similar to that described by Dechancé , 1962 , Fig. 3c) .

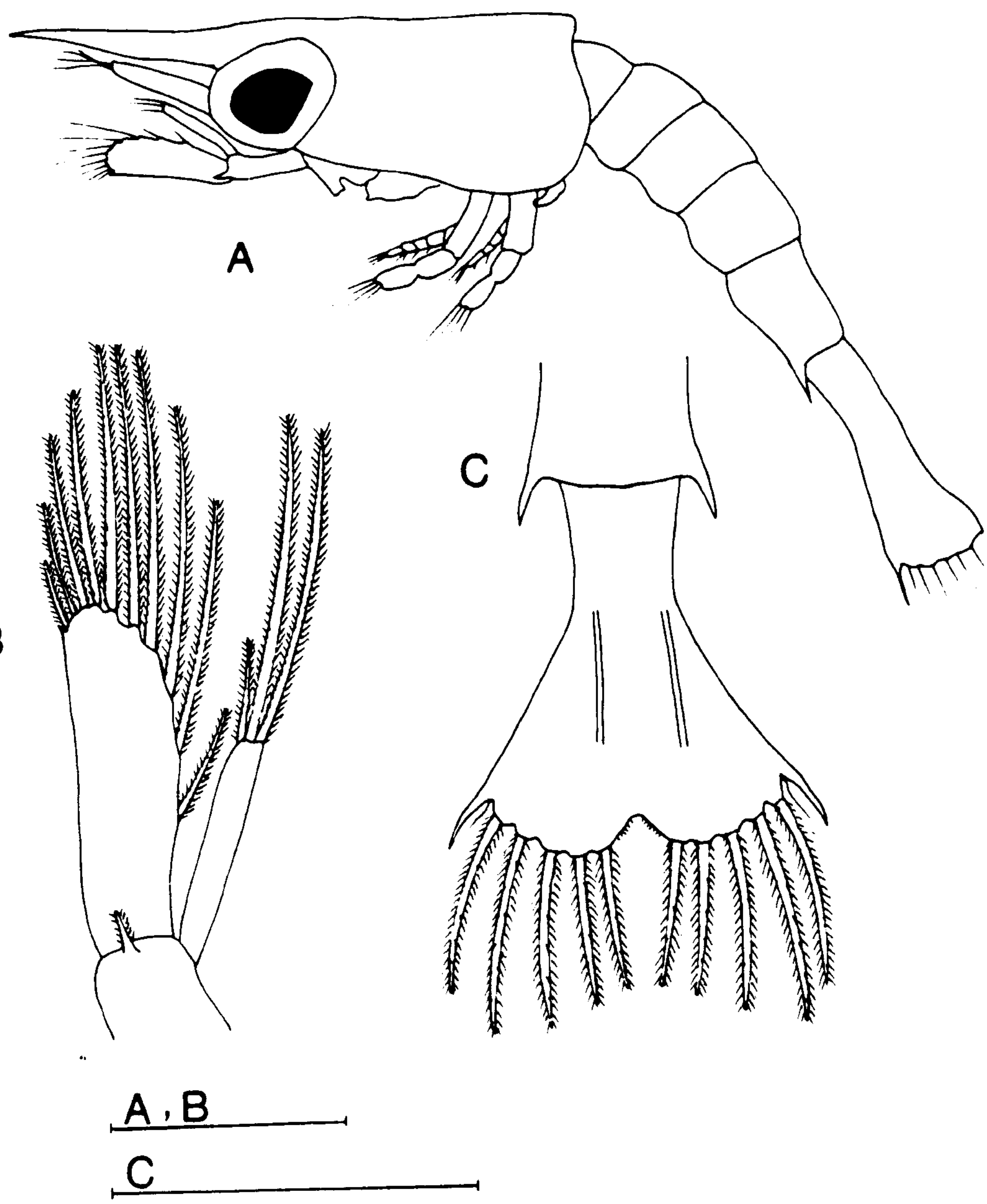
3- Lateral spines on 5th abdominal somite much longer in *Dardanus* B (Fig. 43C) than in *D. tinctor* .

Dardanus B could belong to either *D. lagopodes* or *D. woodmasoni.*

Figure 43. *Dardanus* B. (stage I).

A, *Dardanus* B, lateral view; B, antenna; C, telson.

Scale bars (from top): (1) A = 0.5 mm, B = 0.2 mm; (2) B = 0.5 mm.


A
B
C
A, B
C

Clibanarius sp.

Introduction

Five species of this genus have been recorded from the Red Sea by Lewinsohn (1969) : *C. longitarsus* (de Haan) , *C. striolatus* Dana, *C. signatus* Heller , *C. carnifex* Heller and *C. virescens* (Krauss) . Of these *C. signatus* and *C. carnifex* are much more common than the others . One larval unnamed species of *Clibanarius* was recorded from the northern Red Sea (Gulf of Aqaba) by Seridji (1986) .

The larval stages of several species have been studied . From Indian waters , for instance , larvae of *C. longitarsus* were described by Khan and Natarajan (1981a) , *C. signatus* and *C. virescens* by Tirmizi and Siddiqui (1979) , *C. clibinarius* by Khan et al (1981) , *C. olivaceus* by Khan and Natarajan (1981b) and *C. infraspinatus* by Shenoy and Sankolli (1977) . Pike and Williamson (1960) described *C. erythropus* from the Mediterranean Sea (Bay of Naples) . Brossi-Garcia and Hebling (1983) studied the larval stages of *C. antillensis* from Brazil .

The main generic features of *Clibanarius* , from Shenoy and Sankolli (1977) , are as follows :

1- Rostrum broad and blunt , may be acute at tip only in some , and reaching beyond the antennule and antenna .
2- Antennale scale without a terminal spine , endopod with 3 setae .

3- Telson broad and triangular with a deep median notch edged with fine hairs on the posterior margin . The 1st telson process is generally blunt , finger-like and situated slightly laterally .

Results

Larvae of one species of *Clibanarius* were collected in the present study . This larva closely resembles that of *C. signatus*. It is illustrated in (Fig. 44) .

Size - TL : 1.96 mm (average) (stage I) .

Carapace (Fig. 44A,D) - Rostrum broad and rounded at tip .

Antennule (Fig. 44B) - With 4 terminal aesthetascs and 2 short plumose setae , one subterminal plumose seta .

Antenna (Fig. 44C) - Endopod with 3 plumose setae , 3rd about 1/2 length of others ; exopod with 11 plumose setae and without terminal spine ; a strong ventral spine on protopod at base of exopod .

Mandible (Fig. 44E) - Many spines of varying size on distal margin .

Maxillule (Fig. 44F) - Coxal endite with 6 setae and one simple seta ; basial endite with 2 strong spines and 2 setae ; endopod 2-segmented with 2 terminal setae and 2 inner setae on segment 1 and 2 .

Maxilla (Fig. 44G) - Proximal lobe of coxal endite with 6 setae , distal lobe with 3 setae ; proximal lobe of basial endite with 3 setae , distal lobe with 4 setae ; endopod with 2 terminal setae and 2 subterminal setae ; scaphognathite with 5 plumose setae .

First Maxilliped (Fig. 44H) - Basis with 1 , 2 , 2 , 2 setae ; endopod 5- segmented with 1/0 , 2/0 , 1/0 , 2/0 ,4/1 outer / inner plumose setae ; exopod with 4 plumose setae .

Second Maxilliped (Fig. 44I) - Basis with 1 , 2 setae ; endopod 4-segmented with 2/0 , 2/0 , 2/0 , 4/1 outer / inner plumose setae ; exopod with 4 plumose setae .

Third Maxilliped (Fig. 44J) - Uniramous , lobe-like .

Abdomen (Fig. 44A) - Without dorsal and lateral spines .

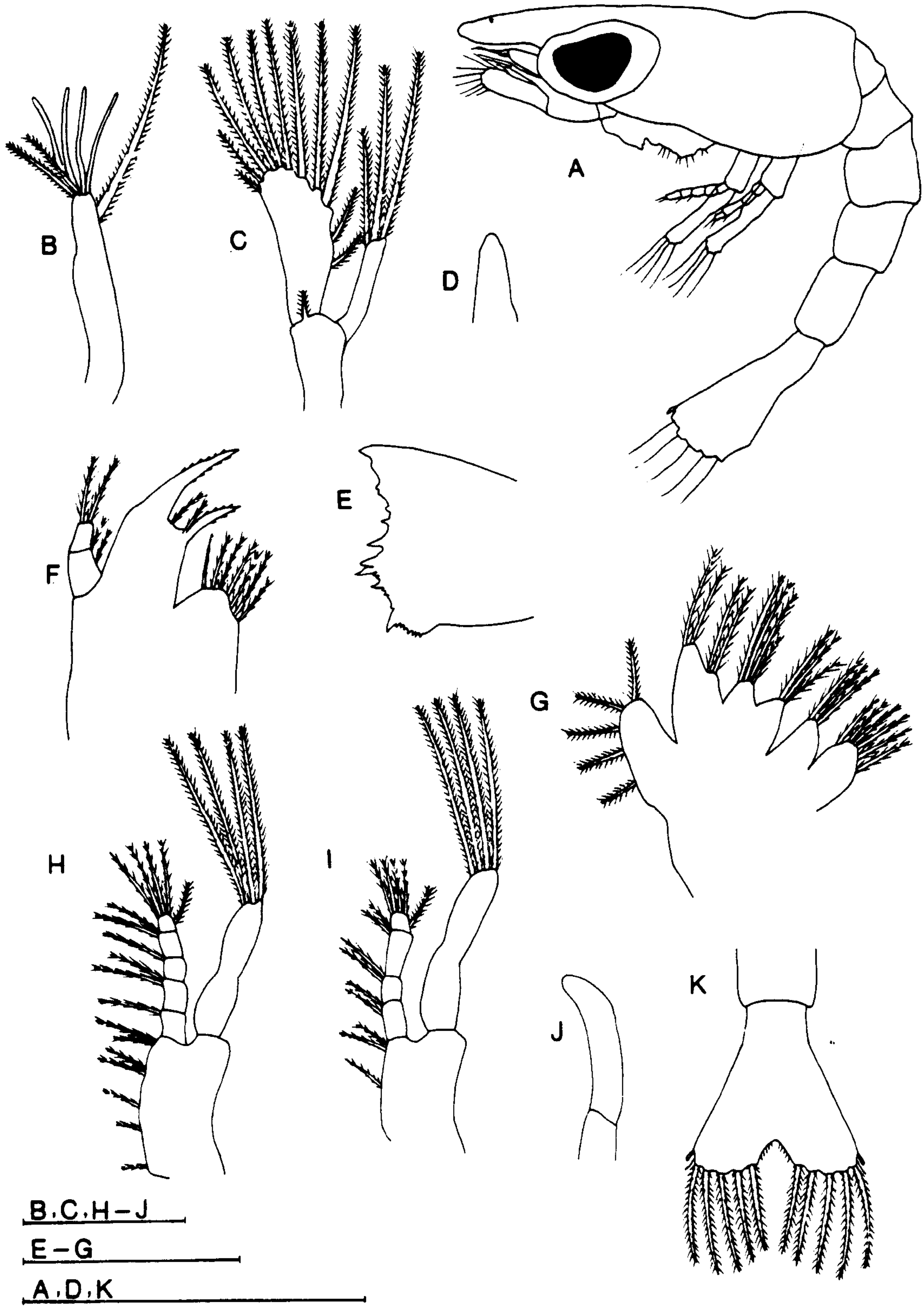
Telson (Fig. 44K) - Triangular in form , with a deep notch on median posterior margin and with fine hairs . The 1st telson process finger-like and situated laterally .

Discussion

Of the 5 *Clibanarius* species recorded by Lewinsohn from the Red Sea , larval descriptions of *Clibanarius signatus* and *C. longitarsus* are already known . Larvae of *C. longitarsus* , with the rostrum pointed at the end , differ from the present larvae (Fig. 44), whereas larvae of *C. signatus*, described by Tirmizi and Siddiqui (1979) from Pakistan , agree in many features with the present larvae and show only minor differences in setation . It is possible that the larva described here belongs to *C. signatus* and that species shows minor regional variations .

Figure 44. *Clibanarius* sp. (stage I).

A, lateral view ; B, antennule ; C, antenna ; D, rostrum; E, mandible ; F, maxillule ; G, maxilla ; H, first maxilliped; I, second maxilliped ; J, third maxilliped ; K, telson . Scale bars (from top) : (1) B,C, H - J = 0.2 mm ; (2) E-G= 0.2 mm ; (3) A,D,K = 0.5 mm .


A
B
C
D
E
F
G
H
I
J
K
B, C, H–J
E–G
A, D, K

List of macruran larvae identified from the plankton samples , from central Red Sea .

(Macrura - Natantia)

(Penaeidea)

Family : Penaeidae

(Protozoea , Mysis larvae and postlarvae)

Family : Sergestidae

Sergestes sp.

(Caridea)

Family : Alpheidae

Alpheus spp.

Athanas sp.

Family : Palaemonidae

Harpilius spp.

Palaemon sp.

Family : Hippolytidae

Saron sp.

Lysmata sp.

Family : Pasiphaeidae

Leptochela sp.

Family : Processidae

Processa aequimana

Family : Pandalidae

Family : Oplophoridae

(Macrura - Reptantia)

Family : Scyllaridae

Family : Stenopodidae

Stenopus hispidus

Family : Nephropidae

General Discussion

The checklist of species of Alpheidae reported from the Red Sea (Banner & Banner , 1981) was based mostly on collections made by Tel Aviv University and Hebrew University of Jerusalem in the Gulf of Aqaba and the southern Red Sea . The 95 species of Alpheidae listed include 49 species of *Alpheus*, of which the geographical distribution is as follows : Gulf of Aqaba , 26 ; Gulf of Suez , 5 ; northern Red Sea , 2 ; central Red Sea , 2 ; southern Red Sea , 14 . These figures might be taken to indicate that the richest area for species of *Alpheus* is the Gulf of Aqaba , followed by the southern Red Sea , but they would probably be more correctly interpreted as reflecting the relative intensities of collection in the different areas. Very litle collection has taken place in the central Red Sea , between 17° and 23° N .

The 89 species or subspecies of *Alpheus* (Table 9) , distinguished in the present work by the distribution of larval chromatophores , is in most marked contrast to the 2 species of adults recorded from the same region , but it emphasises the inadequacy of the collection of adults . Williamson (1970) , working with preserved material and therefore unable to use chromatophore patterns , identified 37 species of *Alpheus* larvae from 14 plankton samples from the Gulf of Aqaba . This figure compared with the 26 species of adults taken in many samples from the same region , again illustrates that the planktonic larvae of this genus are very much easier to sample than the adults , most of which live in association with corals .

The number of some species of Thalassinidea distinguished as larvae in the present work is also greater than the number of species distinguished as adults by different workers in the Red Sea (Table 9), although there is no review of records of adult Thalassinidea from the Red Sea comparable to that of Alpheidae (above) and Anomura (below). Adults of this group tend to burrow into the substratum and are therefore difficult to collect , particularly among corals .

The number of species of anomuran larvae collected (Table 9) is only about half the number of species of adults from the Red Sea listed by Lewinsohn (1969) . In the case of *Calcinus* , the numbers derived from larvae and adults are the same , but more species have been recorded as adults in all the other genera and families investigated . These results are not unexpected for groups in which the adults can be caught in conventional nets , dredges and traps and for which the adult records relate to the collections of different workers over many years covering much of the Red Sea while the larval records are all from one person working in one area for 18 months . As an adult , *Calcinus* protects its abdomen in crevices in rocks and corals and is therefore less mobile and more difficult to collect than most anomurans . Further collections of adults and larvae may well reveal more species of this genus in the Red Sea .

In contrast to the Red Sea , there is almost complete agreement in the numbers of decapod species recorded as adults and larvae in the Irish Sea and fairly close agreement in the Mediterranean (D. I. Williamson , personal communication) . This is partly to be explained as the result of more people working on adult and larval Decapoda in both the Irish Sea and the Mediterranean compared with the Red Sea, but it also reflects the fact that, in most families, the Red Sea is richer in species than either of these other regions.

Table 9. Numbers of species recorded as adults (previous records for the Red Sea) and larvae (present work for region north of Jeddah).

Family or genus	species as adults	species as larvae
Alpheidae		
Alpheus spp.	49	89
Upogebiidae	6	4
Callianassidae	4	7
Laomediidae	1	2
Galatheidae	13	7
Porcellanidae	13	6
Paguridae	13	4
Diogenidae		
Diogenes	4	2
Calcinus	2	2
Dardanus	3	2
Clibanarius	5	1

CHAPTER 5

THE SEASONAL OCCURRENCE OF DECAPOD LARVAE IN VARIOUS HABITATS IN THE CENTRAL RED SEA COASTAL AREA OF SAUDI ARABIA.

Introduction

Several studies have been made on the variation and vertical distribution of the general zooplankton in the Red Sea . Most of this previous work on the decapod larvae has been taxonomic or morphological in character and does not provide any information on the seasonal occurrence or ecology of these larvae (Halim , 1969) . Near (1980) gave some general information on the variation in percentage composition of decapod larvae on the coast of Sudan , central Red Sea .

In the present work it was possible to study not only the variation in total number of decapod larvae , but also the variation in number of several species or groups at six stations . Several of the stations were located in a mangrove area , which , although not extensive , is important as a nursery area for fish and appears to be rich in larvae of Crustacea and other invertebrates .

Materials and Methods

Fortnightly samples were taken at six stations . Stations 1 - 3 were in the region of Zahban village (Fig. 45) , about 50 km north of Jeddah . These three stations adjoin a mangrove area , about 5 km long , with station 1 (water depth 3 m) at the inner (blind) end of the Creek, station 2 (water depth 3 m) near the densest concentration of mangroves in the middle of the patch , and station 3 (water depth 5 m) at its outer end . In the mangrove area the average monthly temperature ranged from 22.1 to 33.6° C and salinity was between 38 and 40.8 ppt. (parts per thousand) (Table 10). Stations 4 and 5 were in the region of Thuwal village (Fig.45), with station 4 (water depth about 18 m) about 6 km west of station 3, outside the mangrove area, and station 5 (water depth about 18 m) a further 1 km west, exposed to the open sea . The average temperature at stations out of the mangrove area was 22.2 to 32.5° C and the salinity was between 38.2 and 40.5 ppt. (Table 10). Station 6 (water depth about 55 m) was in the open sea just off Obhor Creek, about 20 km north of Jeddah and 30 km south of stations 1 - 5 (Fig. 45). The monthly temperature ranged from 23.5 to 31° C and salinity was between 38 and 40 ppt. (Table 10). The bottom at station 2 was sandy mud, at stations 1 and 3 there was more sand, and at stations 4 - 6 there was coarser sand with clay. Scattered corals occurred near all sampling stations.

Plankton samples were taken with nets of mouth-diameter 0.5 m, mesh 300 µm, towed at a depth of approximately 1 m for 15 minutes. The quantitative representation of the organisms recorded are expressed in numbers per thousand cubic meters, calculated from tows of approximately 643 m . Material was preserved in 5% formalin (2% formaldehyde) . Surface salinities were taken with a hand refractometer, and surface temperatures were also recorded. Samples were taken between 0700 - 1200 h, with an additional sample on each occasion from station 6 at midnight. Sampling was continued over the 18 months January 1986 to June 1987.

In the laboratory, samples were divided with a Folsom plankton splitter into 1/2, 1/4, 1/8 or 1/16 of the original sample, and the decapod larvae from the whole sample or from one of these fractions were separated for identification and counting under a stereoscopic microscope . *Lucifer* and larvae of Brachyura were not included . Larvae were assigned to families .or smaller taxa , and particular attention was paid to anomuran larvae .

An analysis by nonparametric multiple comparision using the Tukey-test (Zar , 1984) was performed to test if the abundances were significantly different between different sampling stations .

Figure 45 . Location of sampling stations (1 - 6) .

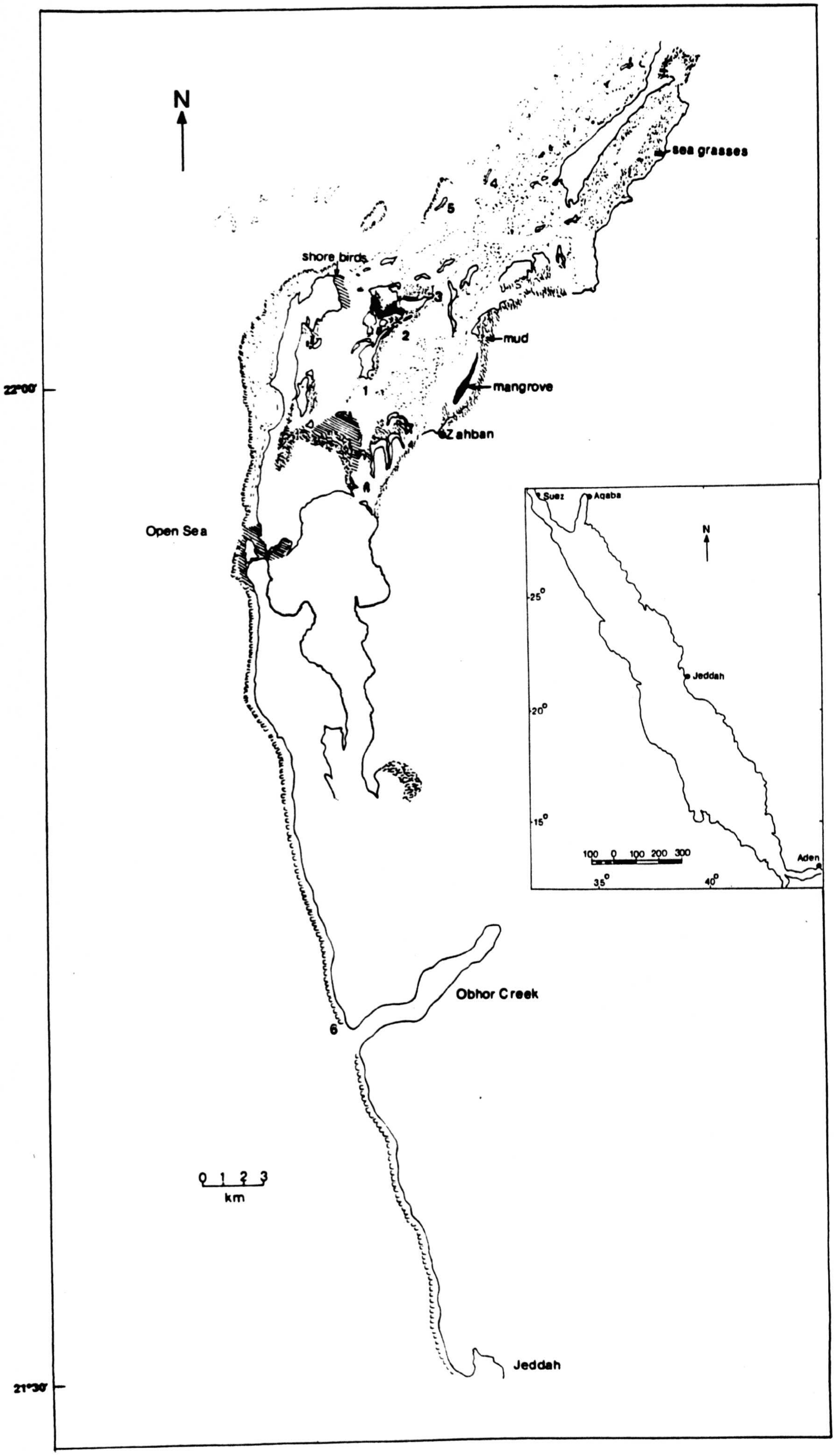

N
sea grasses
4
5
shore birds
3
2
mud
1
mangrove
22°00'
Zahban
Open Sea
Suez
Aqaba
N
25°
Jeddah
20°
15°
100 0 100 200 300
Aden
35°
40°
Obhor Creek
6
0 1 2 3
km
Jeddah
21°30'

Table 10 . Mean monthly surface water temperature (T°C) and salinity (ppt.= parts per thousand) at the study stations , from January 1986 to June 1987 .

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
Teperature																		
Station 1	23	25	28	29.5	28	32	34	33	30	30.5	26	22	23	25.5	27	27	30	30.5
Station 2	23.5	24.5	27	28	28	31.5	33	33	32.5	31	26.5	21.5	23	25.5	24.5	26.5	28.5	30.5
Station 3	24	25	27	28.5	29	31.5	34	33	32	30.5	26.5	23	24	25.5	23	24	28.5	30
Station 4	25.5	26	27	28	29	31.5	33	30	30	31	27	24	24.5	25.5	22	26.5	28	30
Station 5	25	25	27	28.5	28.5	31.5	32	32	30	31	26.5	24.5	24.5	25.5	22.5	26	28	30
Station 6	26	25.5	26.5	28	27.5	29.5	30	31	29	29.5	25	24.5	25	25.5	23.5	26.5	26	28
Salinity																		
Station 1	38	39.5	40.5	39	41	41	40	38	40	41.5	42	40.5	40.5	40.5	39.5	40.5	41	40.5
Station 2	38	39	40	38.5	41	40.5	39	39	40	40.5	41	40.5	40.5	40.5	39	39.5	41	40.5
Station 3	38	38.5	40	39	40	40	38	40	40	40	40	40	39.5	40	39	39.5	40.5	40.5
Station 4	38.5	38.5	39.5	38.5	39	40	38	40	39	39.5	39.5	40	40	40	39.5	39	39.5	40
Station 5	39.5	38	39	38.5	39	40	38.5	39	39	39	40.5	41	40.5	40	39.5	39.5	39.5	40
Station 6	39.5	38	40	39.5	40	40	40	40	40	40	40	40	39	38	40	39.5	39	39.5

Results

Staion 1

Peaks in total decapod larvae occurred in June , September and November 1986 and a much bigger peak in February and March 1987 (Fig. 46) . The three peaks in 1986 were mostly due to *Diogenes avarus* , which made up 68, 62 and 43 % , respectively , of the total decapod larvae and reached a maximum abundance of 1232 /1000 m^3 in June (Table 18) . *Alpheus* spp. (26 %) (Fig. 47) and *Harpilius* spp. (21%)(Fig. 48) also made appreciable contributions to the third peak , in November 1986 . The large peak in February 1987 consisted mostly of *Alpheus* spp. , which made up 90 % of the total decapods and reached 5184 /1000 m^3 (Fig. 47) (Table 18) . By the following month (March 1987) the numbers of the total decapod larvae had decreased only slightly , but *Diogenes avarus* had now become the most common species , accounting for 55 % of the total , with 2720 / 1000 m^3 (Table 18) .

Diogenidae were the most common anomuran larvae (Table 11) , represented by *Diogenes avarus* in high density , which occurred at this station in all months (Fig. 49) . Minimal concentrations of Laomediidae occurred in most months , while *Upogebia* E , the only representative of the Upogebiidae recorded at this station , was restricted to the months of January , February and March in both years (Fig. 49) .

Table 11 : Differences in abundance between anomuran families at station 1 (Nonparametric multiple comparison using Tukey test).

R= Mean ranks ; SE= Standard error ; Q= Studentized range .

Comparison	Difference R1-R2	SE	Q	Q table	Conclusion
Diogenidae vs Upogebiidae	40.5-17.2=23.3	5.01	4.65	2.394	Significant difference
Diogenidae vs Laomediidae	40.5-24.8=15.7	5.01	3.13	2.394	Significant difference

- Diogenidae more abundant than Upogebiidae and Laomediidae .

Station 2

Peaks in total decapod larvae occurred in June and October 1986 and January 1987 (Fig. 46) . The two peaks in 1986 were mostly due to *Harpilius* spp. which made up 28 and 52 % , respectively , of the total decapod larvae and reached a maximum abundance of 1968 / 1000 m^3 in October (Fig. 48 , Table 19) . Hippolytidae (28 %) and Penaeidae (20%) also made appreciable contributions to the peak in June 1986 and *Alpheus* spp. (31%) in October 1986 (Fig. 47) . The peak in January 1987 consisted mostly of Hippolytidae , which made up 53% of the total decapod larvae and reached 1344 / 1000 m^3 (Table 19) .

Diogenidae were the most common anomuran larvae at this station (Table 12) , represented by *Diogenes avarus* , which occurred in all months except February and March 1986 and February 1987 . In addition to *Diogenes avarus* , small numbers of *Calcinus* A and *Dardanus tinctor* occurred in March 1986 and May 1987 (Fig. 50) . Small numbers of Laomediidae occurred at this station , with peaks in March and October 1986 ; while *Upogebia* D , the only representative of the Upogebiidae recorded at this station , had peaks in February and October 1986 and January 1987 (Fig. 50) .

Table12 : Differences in abundance between anomuran families at station 2 (Nonparametric multiple comparison using Tukey test) .

Comparison	Difference R1-R2	SE	Q	Qtable	Concolusion
Diogenidae vs Upogebiidae	38.2-22.7=15.5	5.05	3.07	2.394	Significant difference
Diogenidae vs Laomediidae	38.2-21.5=16.7	5.05	3.31	2.394	Significant difference

- Diogenidae more abundant than Upogebiidae and Laomediidae .

Station 3

Peaks in total decapod larvae occurred in June , September and December 1986 and in February and April 1987 (Fig. 46) . The two peaks in June and December 1986 were mostly due to *Harpilius* spp. , which made up 48% and 43% , respectively , of the total decapod larvae (Fig. 48) and reached a maximum abundance of 752 / 1000 m^3 in June (Table 20) . The peak in September 1986 was mostly due to *Alpheus* spp. , which made up 67% of the total decapod larvae (Fig. 47) . *Alpheus* spp. (34%) also made appreciable contributions to the peak in December 1986 . The peaks in February and April 1987 were mostly due to *Alpheus* spp. , which made up 93% and 57% , respectively , of the total decapod larvae (Fig. 47) .

There were no significant differences between the abundance of the Diogenidae and Upogebiidae at this station (Table 13) ; on the other hand , Laomediidae were less abundant . *Diogenes avarus* was the most common species among the Diogenidae and occurred in all months with the exception of February , March and September 1986 and February 1987 (Fig. 51) ; small numbers of *Dardanus tinctor* and *Calcinus* A occurred in April and May 1986 . *Upogebia* C and D , the two species representing the Upogebiidae , occurred in small numbers in some months , and also small numbers of the Laomediidae occurred in some months (Fig. 51) (Table 20) .

Table 13 : Differences in abundance between anomuran family at station 3 (Nonparametric multiple comparison using Tukey test).

Comparison	Difference R1-R2	SE	Q	Qtable	Conclusion
Diogenidae vs Upogebiidae	37.3-28.1=9.2	4.98	1.85	2.394	No significant difference
Diogenidae vs Laomediidae	37.3-17.5=19.8	4.98	3.97	2.394	Significant difference

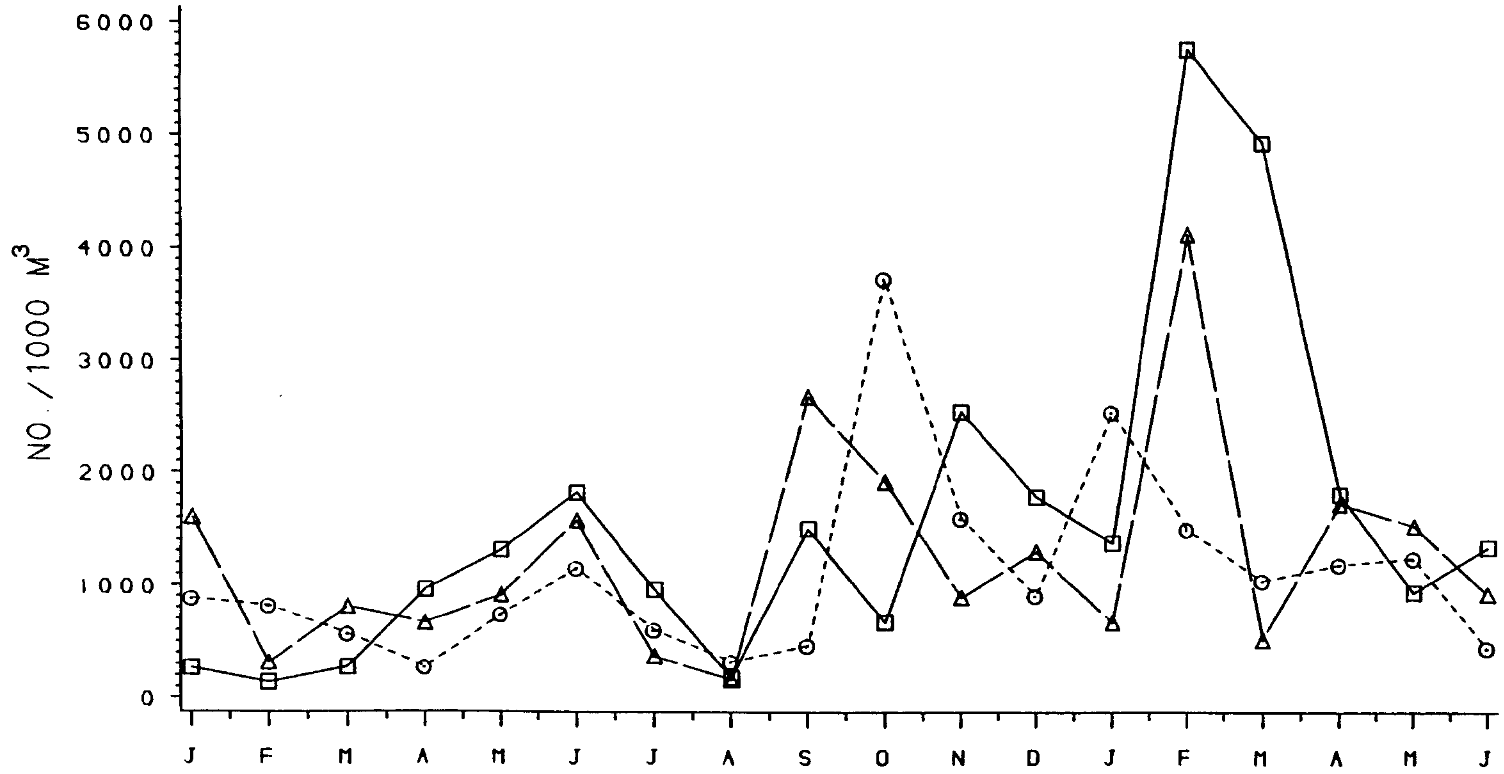
- Laomediidae significantly less abundant than Upogebiidae and Diogenidae .

Figure 46 . Density variation (monthly means) of decapod larvae per 1000 m^3 at stations 1 , 2 and 3 , from January 1986 to June 1987 .

□———□ Station 1 .

○--------○ Station 2 .

△— — —△ Station 3 .


NO. /1000 M3
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5000
4000
3000
2000
1000
0
J F M A M J J A S O N D J F M A M J

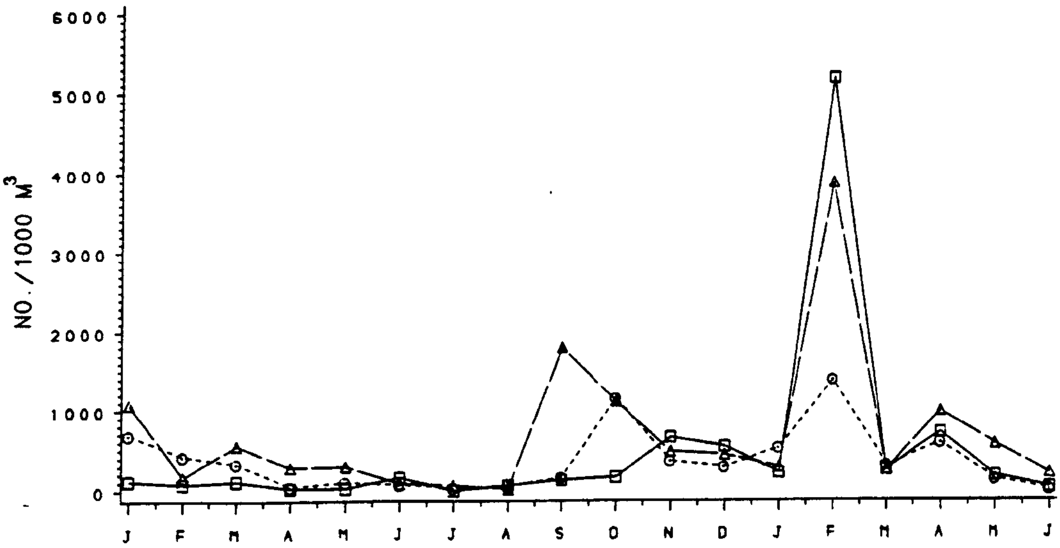
Figure 47 . Density variation (monthly means) of *Alpheus* larvae per 1000 m^3 at stations 1 , 2 and 3 , from January 1986 to June 1987 .

Figure 48 . Density variation (monthly means) of *Harpilius* larvae per 1000 m^3 at stations 1 , 2 and 3 , from January 1986 to June 1987 .

□———□ Station 1.

○--------○ Station 2 .

△— — —△ Station 3 .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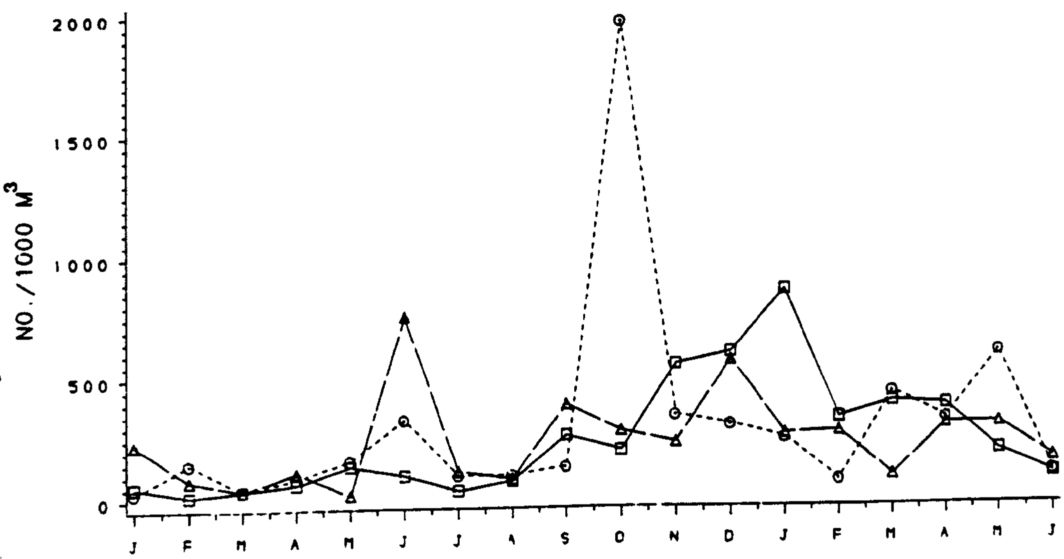
J F M A M J J A S O N D J F M A M J


2000
1500
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NO./1000 M^3
J F M A M J J A S O N D J F M A M J

Figure 49 . Density variation (monthly means) of the most common anomuran families per 1000 m^3 at stations 1, from January 1986 to June 1987 .

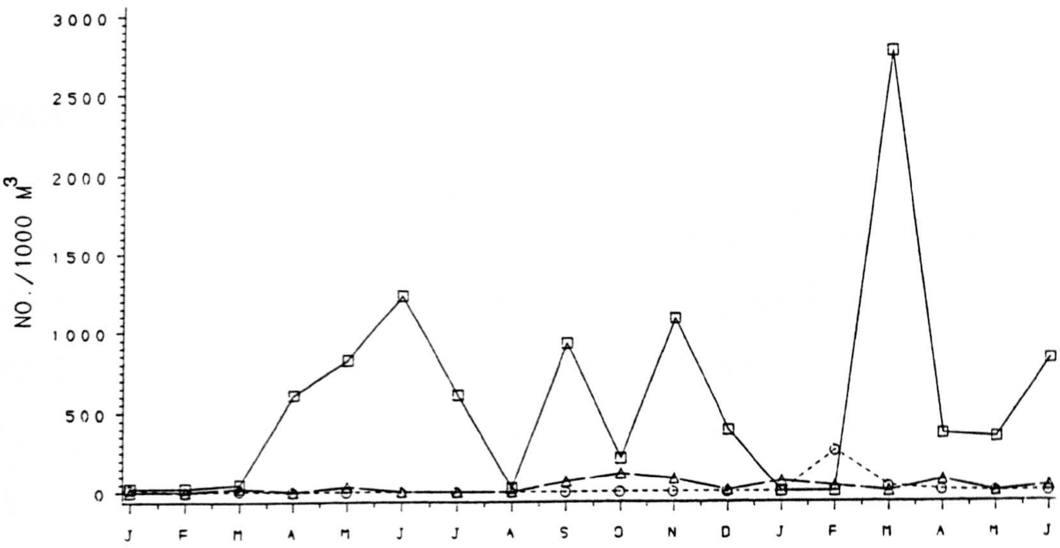
Figure 50 . Density variation (monthly means) of the most common anomuran families per 1000 m^3 at stations 2 , from January 1986 to June 1987 .

Figure 51 . Density variation (monthly means) of the most common anomuran families per 1000 m^3 at stations 3 , from January 1986 to June 1987 .

Diogenidae .

Upogebiidae .

Laomediidae


3000
2500
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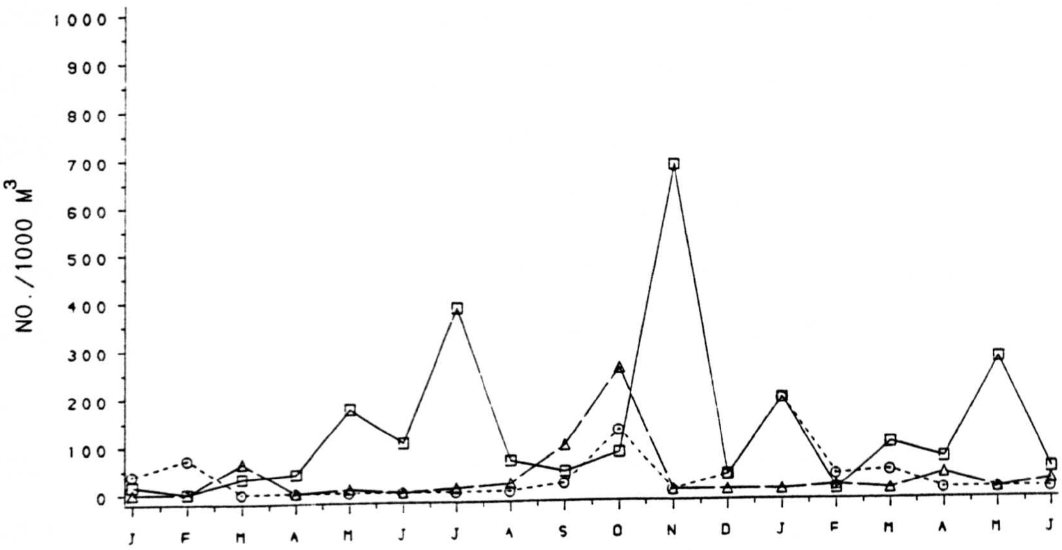
NO./1000 M3
J F M A M J J A S O N D J F M A M J


1000
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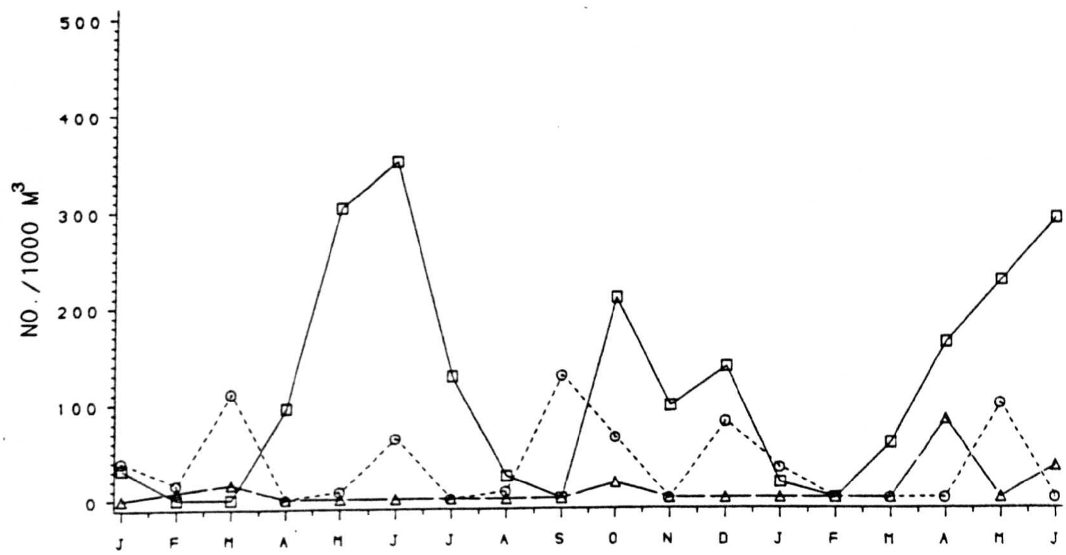
100
0
NO./1000 M3
J F M A M J J A S O N D J F M A M J


500
400
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100
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NO./1000 M3
J F M A M J J A S O N D J F M A M J

Stations 4 and 5

The monthly abundances of decapod larvae were significantly different at stations 4 and 5 (Table 14) , being more abundant at station 5 with an average value over the 18 months of 1421/1000 m^3 (Table 22) compared with 576/1000 m^3 at station 4 (Table 21) . Peaks in total decapod larvae occurred in March , June and August 1986 and February and May 1987 at both stations (Fig. 52) . All these peaks were due mainly to the appearance of a high numbers of *Alpheus* spp. and *Harpilius* spp. . The *Alpheus* spp. at station 4 in March , June and August 1986 made up 41 , 23 and 59% , respectively , of the total decapod larvae (Fig. 53) , while *Harpilius* spp. made up 23, 41 and 24%, respectively (Fig. 54) . *Alpheus* spp. at station 5 made up 54 , 46 and 43%, respectively , of the total decapod larvae (Fig. 53) ; while *Harpilius* spp. made up 28 , 34 and 50% , respectively (Fig. 54) .

Diogenidae were the most common anomuran larvae at both stations (Table 15) (Fig. 55 , 56) , represented by *Diogenes avarus*, *Calcinus* A and *Dardanus tinctor* . The average concentrations over the 18 months of the three species at station 4 were 34/1000 m^3 , 11/1000 m^3 and 4/1000 m^3, respectively , and at station 5 they were 39/1000 m^3 , 65/1000 m^3 and 17/1000 m^3 , respectively . Porcellanidae were represented by *Pisidia inaequalis* in station 5 , with average concentrations over the 18 months of 21/1000 m^3 (Fig. 56) . The highest concentration of *Pisidia inaequalis* was in June , and smaller numbers occurred in most months . Callianassidae were represented by *Callianassa* A at station 5 , with average numbers over the 18 months of 20/1000 m^3 (Fig. 56) . The highest densities of *Callianassa* A at station 5 were in June and August .

Table 14 : Differences in abundance between decapod larvae at stations 4 and 5 (Nonparametric multiple comparison using Tukey test) .

(Number in brackets indicates number of station) .

Comparison	Difference R1-R2	SE	Q	Qtable	Coclusion
Decapod larvae (5) vs Decapod larvae (4)	413-253=160	44.69	3.58	2.772	Significant difference

- Decapod larvae more abundant at station 5 than at station 4 .

Table15 : Difference in abundance between anomuran families at station 4 and 5 (Nonparametric multiple comparison using Tukey test).

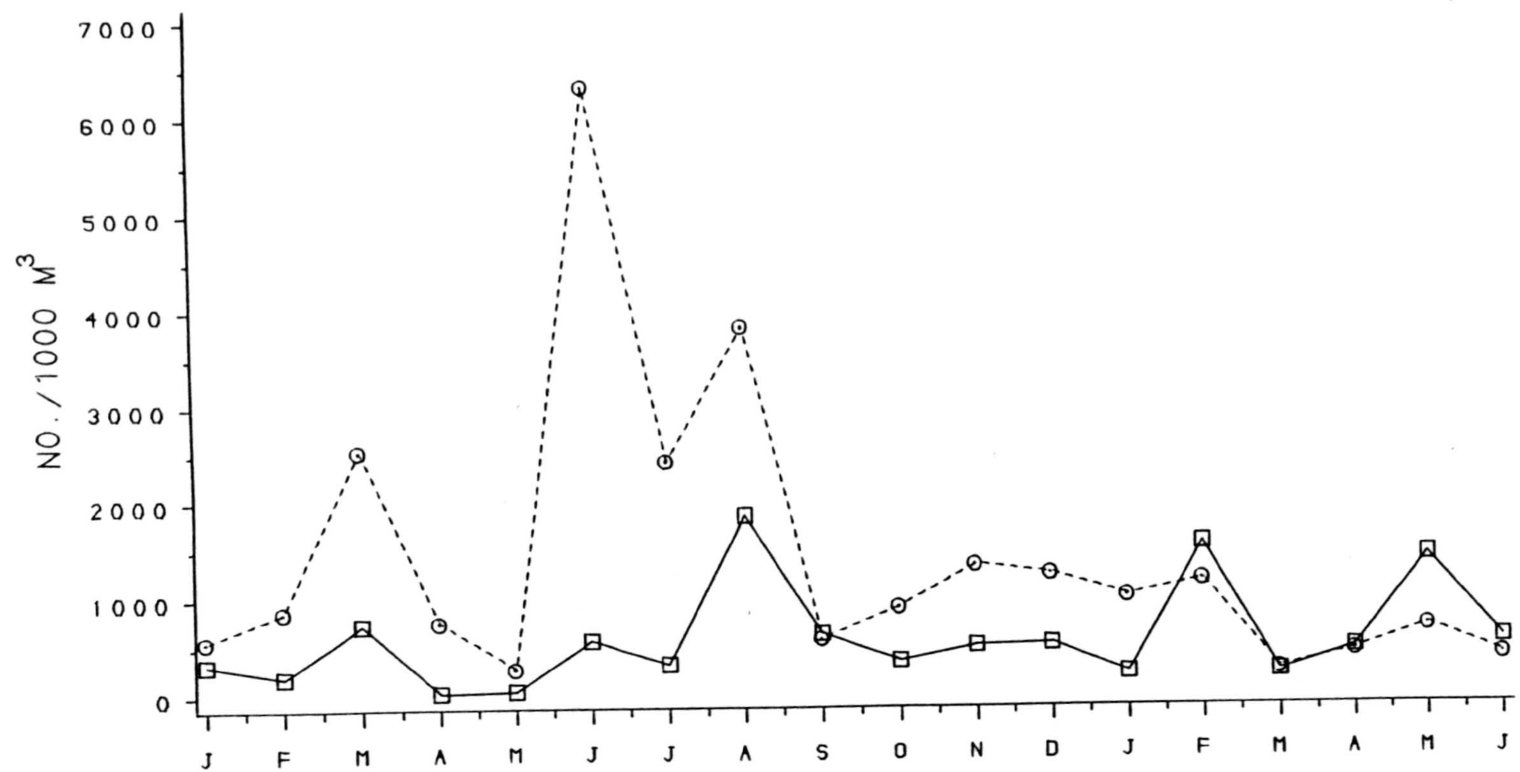
Comparison	Difference R1-R2	SE	Q	Qtable	Conclusion
Diogenidae (4) vs Upogebiidae (4)	38.3-24.3=14	4.87	2.87	2.394	Significant difference
Diogenidae (4) vs Laomediidae (4)	38.3-19.9=18.4	4.87	3.78	2.394	Significant difference
Diogenidae (5) vs Callinassidae (5)	42.9-18.9=24	5.16	4.65	2.394	Significant difference
Diogenidae (5) vs Porcellanidae (5)	42.9-20.7=22.2	5.16	4.30	2.394	Significant difference

- Diogenidae was most common family at both stations 4 and 5 .

Figure 52 . Density variation (monthly means) of decapod larvae per 1000 m^3 at stations 4 and 5 , from January 1986 to June 1987 .

□——□ Station 4 .

○- - - -○ Station 5 .



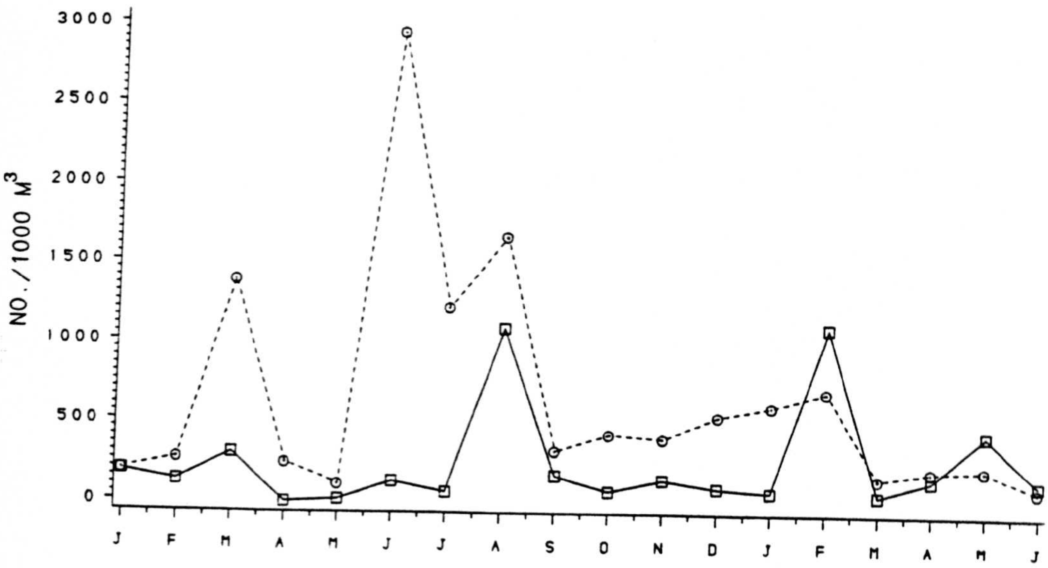
NO./1000 M3
7000
6000
5000
4000
3000
2000
1000
0
J F M A M J J A S O N D J F M A M J

Figure 53 . Density variation (monthly means) of *Alpheus* larvae per 1000 m^3 at stations 4 and 5 , from January 1986 to June 1987 .

Figure 54 . Density variation (monthly means) of *Harpilius* larvae per 1000 m^3 at stations 4 and 5 , from January 1986 to June 1987 .

□——□ Station 4 .

○--------○ Station 5 .



3000
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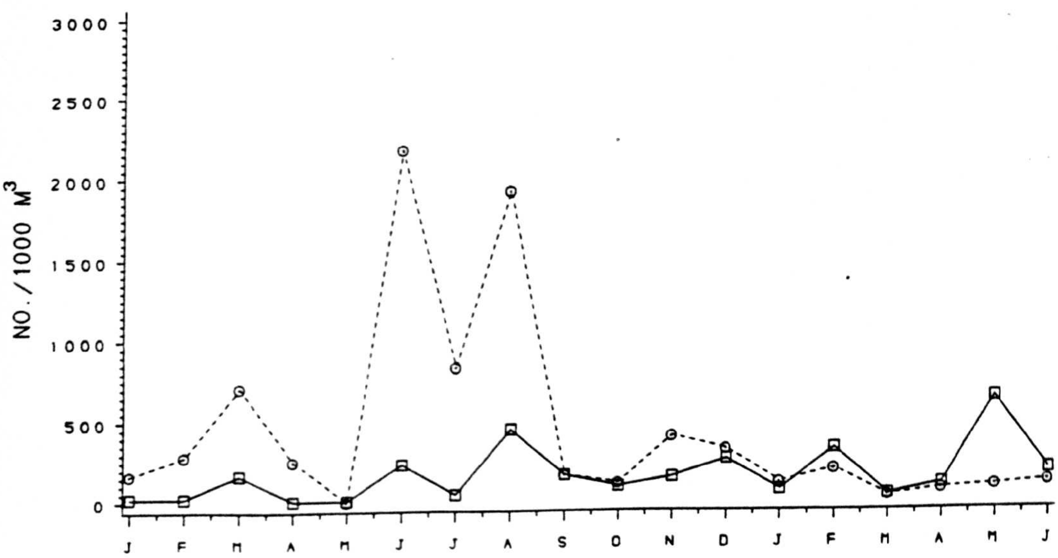
NO./1000 M3
J F M A M J J A S O N D J F M A M J



3000
2500
2000
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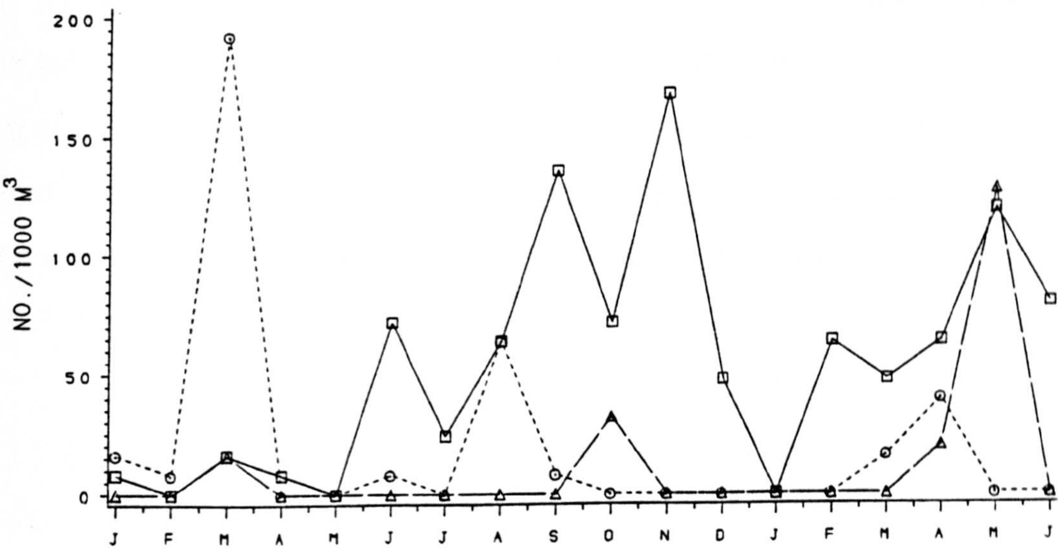
1000
500
0
NO./1000 M3
J F M A M J J A S O N D J F M A M J

Figure 55 . Density variation (monthly means) of the most common anomuran families per 1000 m^3 at stations 4 , from January 1986 to June 1987 .

- Diogenidae .
- Upogebiidae .
- Laomediidae .

Figure 56 . Density variation (monthly means) of the most common anomuran families per 1000 m^3 at stations 5 , from January 1986 to June 1987 .

- Diogenidae .
- Porcellanidae .
- Callianassidae .



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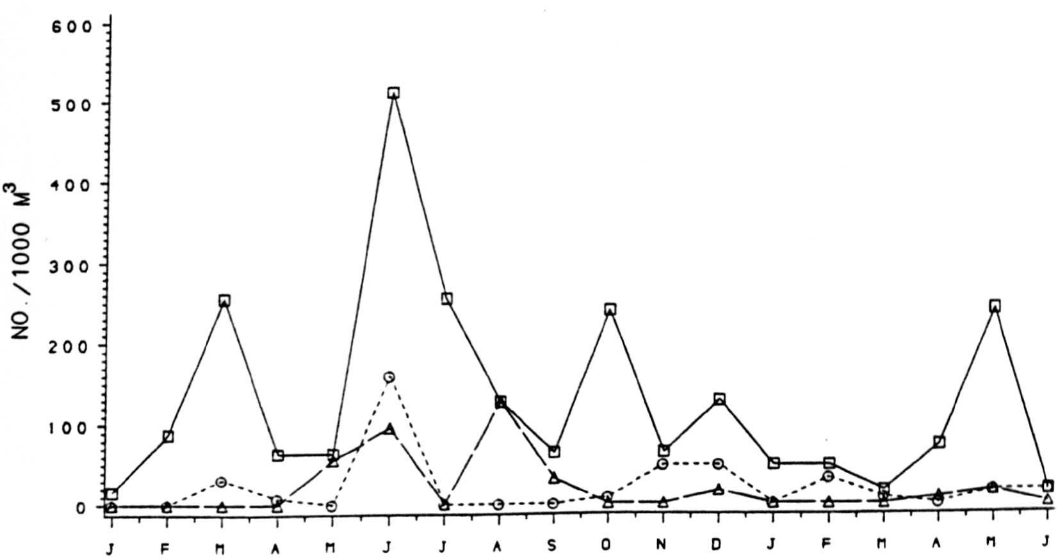
100
50
0
NO./1000 M^3
J F M A M J J A S O N D J F M A M J



600
500
400
300
200
100
0
NO./1000 M^3
J F M A M J J A S O N D J F M A M J

Station 6

decapod larvae showed peaks in abundance in February and May 1986 and a much bigger peak in June 1987 (Fig. 57) . The peaks were due mainly to the appearance of a high numbers of *Alpheus* spp. (27% of total) (Fig. 58) , *Calcinus* A (25% of total) and *Harpilius* spp. (20% of total) (Fig. 59) . These genera were usually present in any collection at this station throughout the year , in contrast to other genera (Table 23) .

Diogenidae were the most common anomuran larvae (Table 16) (Fig. 60) with an average of 362/1000 m^3 , of which *Calcinus* A made up the majority (average 287/1000 m^3) . *Diogenes* B , *Dardanus* B and *Clibanarius* sp. occurred at this station in small numbers . Porcellanidae appeared in all months (average 78/1000 m^3) , and Callinassidae (average 41/1000 m^3) in some months (Fig. 60) (Table 23) .

Some anomuran larvae were more abundant in the midnight samples than during the day time , for instance Galatheidae , Paguridae and Callianassidae (Table 16) (Table 24) .

Table 16 : Differences in abundance between anomuran larvae at station 6 (Nonparametric multiple comparison using Tukey test).

- (6mn) indicates mid-night sample at station 6

Comparison	Difference R1-R2	SE	Q	Qtable	Conclusion
Diogenidae (6) vs Porcellanidae (6)	40.2-22.4=17.8	5.14	3.46	2.394	Signifficant difference
Diogenidae (6) vs Callianassidae (6)	40.2-19.9=20.3	5.14	3.95	2.394	Significant difference
Calcinus A (6) vs *Dardanus tinctor* (6)	39.0-21.4=17.7	4.91	3.60	2.394	Significant difference
Calcinus A (6) vs *Diogenes avarus* (6)	39.0-21.4=17.6	4.91	3.58	2.394	Significant difference
Galtheidae (6mn) vs Galatheidae (6)	23.4-12.3=11.1	3.45	3.22	1.960	Significant difference
Paguridae (6mn) vs Paguridae (6)	21.8-15.2=6.6	3.00	2.20	1.960	Significant difference
Callinassidae(6mn) vs Callinassidae (6)	20.9-13.7=7.2	3.34	2.16	1.960	Significant difference

- Diogenidae more common than Porcellanidae and Callinassidae .
- *Calcinus* A more common than *Dardanus tinctor* and *Diogenes avarus*
- Galatheidae , Paguridae and Callianassidae more abundant in the mid-night samples than daytime samples .

Figure 57 . Density variation (monthly means) of decapod larvae per 1000 m^3 at station 6 , from January 1986 to June 1987 .

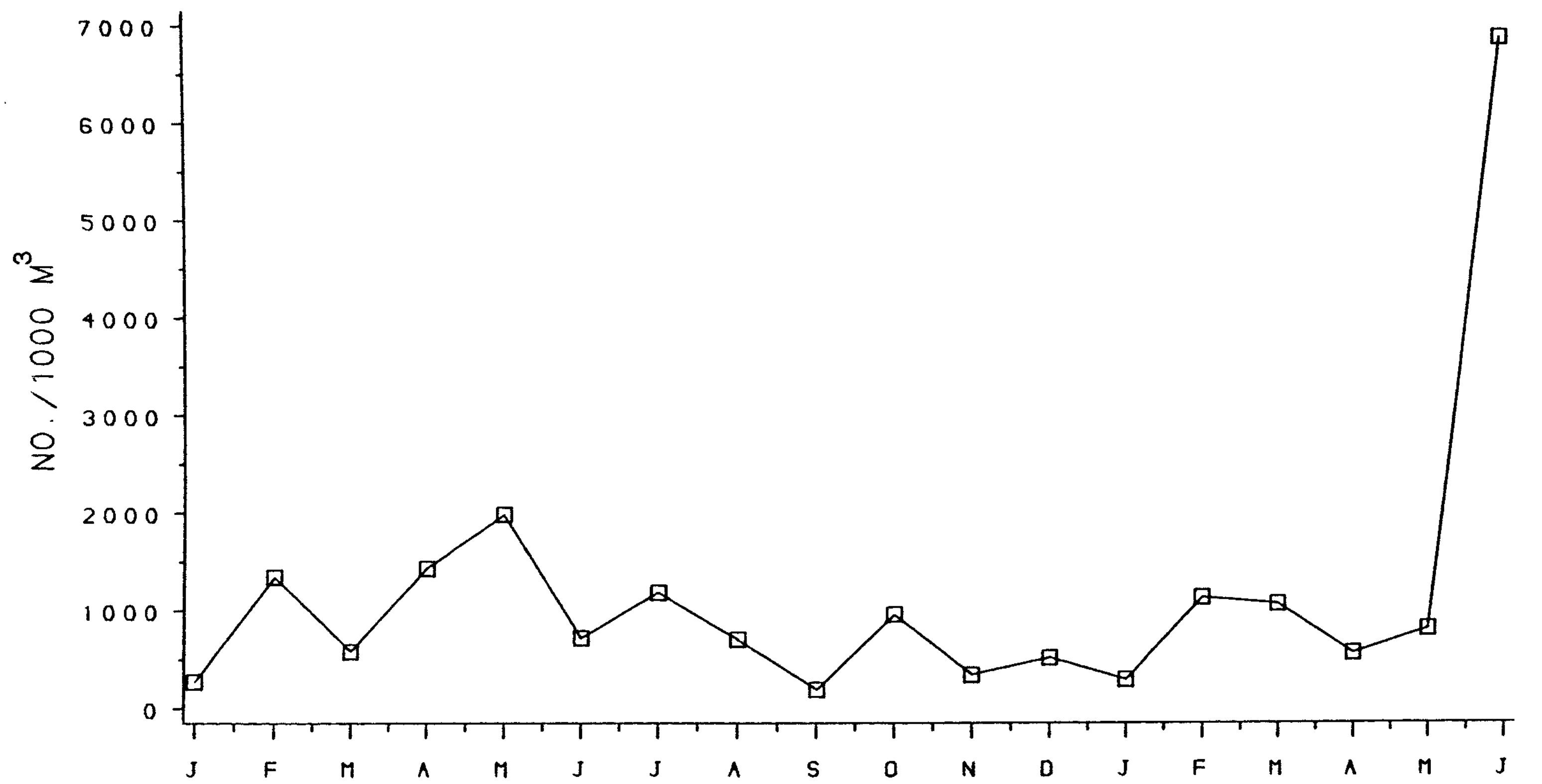

NO./1000 M3
7000
6000
5000
4000
3000
2000
1000
0
J F M A M J J A S O N D J F M A M J

Figure 58 . Density variation (monthly means) of *Alpheus* larvae per 1000 m^3 at station 6 , from January 1986 to June 1987 .

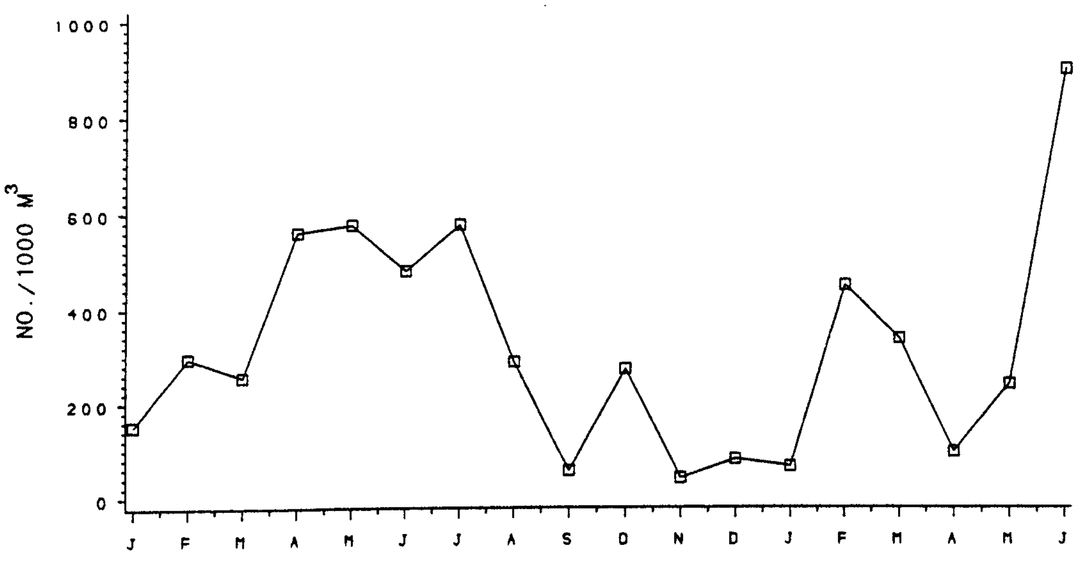
Figure 59 . Density variation (monthly means) of *Harpilius* larvae per 1000 m^3 at station 6 , from January 1986 to June 1987 .

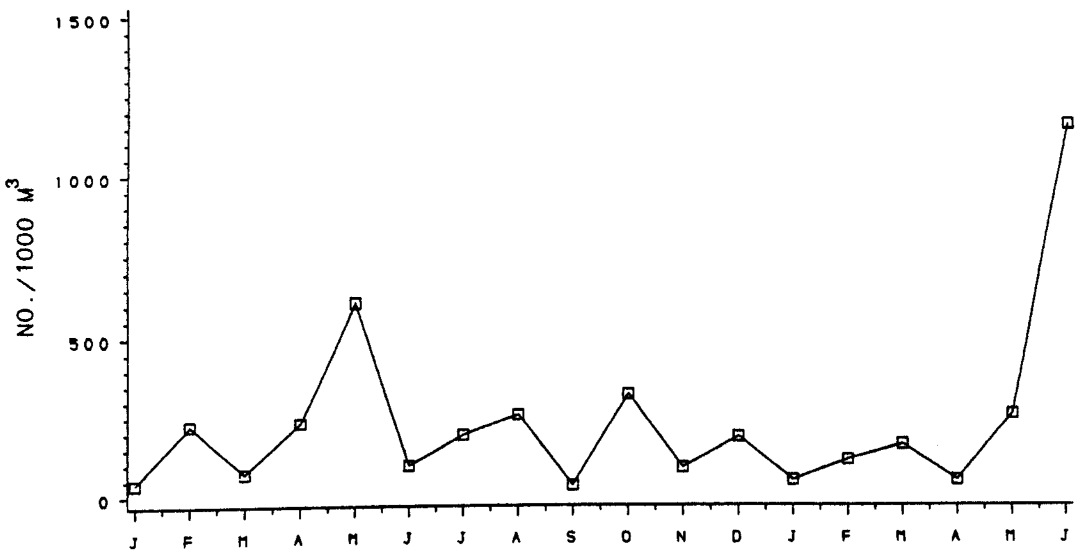
Figure 60 . Density variation (monthly means) of the most common anomuran families per 1000 m^3 at station 6 , from January 1986 to June 1987 .

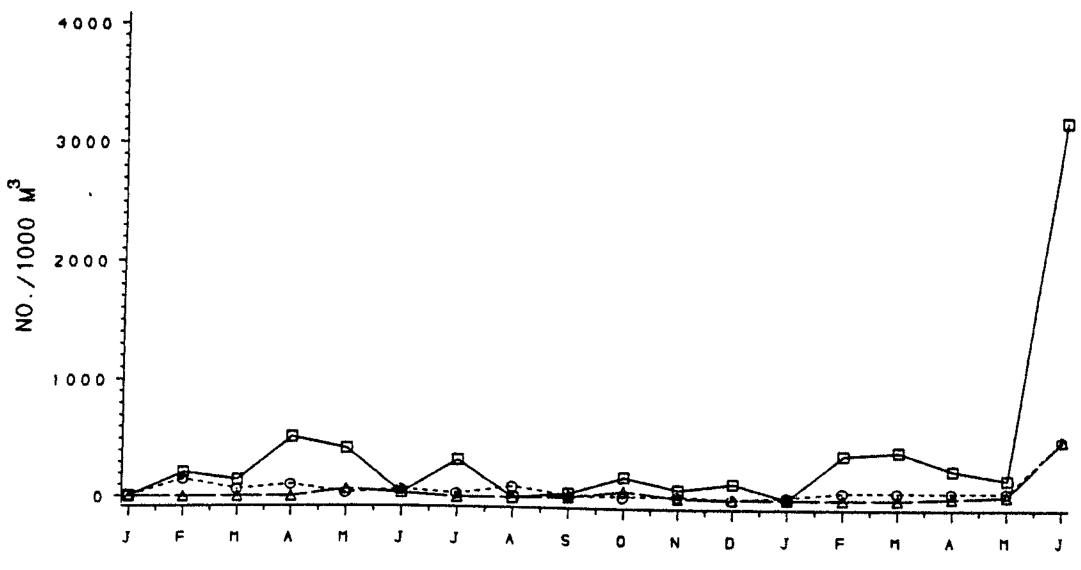
□——□ Diogenidae .

⊙------⊙ Porcellanidae .

△— — —△ Callianassidae


NO./1000 M3
0
200
400
600
800
1000
J F M A M J J A S O N D J F M A M J


NO./1000 M3
0
500
1000
1500
J F M A M J J A S O N D J F M A M J


NO./1000 M3
0
1000
2000
3000
4000
J F M A M J J A S O N D J F M A M J

Discussion

Results from stations 1 - 5 all agreed in showing peaks in abundance of decapod larvae in June 1986 which were not repeated in June 1987 . At station 6 there was no peak in June 1986 , although there was one in the previous month , and there was a large peak in June 1987 .

Studies in other years at station 6 (off Obhor Creek) have shown a major peak of phytoplankton in December-February and a smaller peak in June -August (Skaikh et al. , 1986) . During December-February the surface water cools and overturns resulting in nutrients becoming available to permit a bloom of diatoms . In June-August the water is stratified and diatoms numbers are low but blue green algae , including *Trichodesmium* , are able to utilize atmospheric nitrogen and the excretory products released by them become available to dinoflagellates which then produce a secondary bloom in summer (Weikert , 1987) .

Peaks of Copepoda in May and July-August (Al-Aidaroos , 1984) and peaks in abundance in June by various groups of Red Sea zooplankton have been noted by several workers, including Near (1980 : decapod larvae in the Dongonab , Sudan Coast) . Al-Aidaroos (1984 : larvae of bottom invertebrates in Obhor Creek , near Jeddah) and Al-Ghamrawy (1982 : zooplankton off the Jeddah Coast) , while Ponomareva (1968) stated that water originating from the upper layers of the Red Sea could be recognised by its high plankton content in June . The two hermit crabs reared in the present work were both carrying eggs in April and May , and other workers in the same region have also noted large numbers of ovigerous crabs and shrimps in the same months (personal communications) , which would tend to produce peaks of larvae in June .

Although there are variations from year to year , the summer period seems to be generally the most productive for zooplankton in the Red Sea . The results in this present work of decapod larvae showed considerable variation from month to month . The density tended to increase and reached a maximum in June in most stations , but high densities were also noted in some winter months . These winter peaks were largely due to single species of *Alpheus* or *Harpilius* .

Workers in the Red Sea (Near , 1980 ; Halim , 1969) and in other tropical areas (Moore , 1949 ; Wickstead , 1958) have noted that different groups of zooplankton tend to have their peaks of abundance in different months , and this is also true for the present results , in spite of the tendency for an overall peak to occur in June . Thus , *Alpheus* spp. showed high concentrations at most of the stations in February 1987 , although no other group showed a peak at this time , and *Alpheus* CRS 20 was taken only in February and March of both 1986 and 1987 .

The average numbers of decapod larvae at the different stations were not significantly different , except at station 4 , where there were fewer larvae . However marked differences in the composition of the samples at the different stations frequently occurred .Thus the most common species of *Alpheus* in the mangrove area in February and March of both years was CRS 20 , while CRS 46 was more common in Obhọr Creek . Larvae of *Diogenes avarus* were also more common in the mangrove area , while *Calcinus* A , Porcellanidae , Galatheidae and Callianassidae were more abundant in Obhor Creek . These differences no doubt reflect differences in the distribution of the corresponding adults . There were similarities in the patterns of decapod larvae at the three stations in the mangrove area , but even within this restricted area samples from station 2 often showed considerable differences from those taken at stations 1 and 3 on the same morning .

It is interesting to note that , while *Coenobita scaevola* is one of the most common species of decapod along the coasts in the Jeddah region , only two larvae of this species were taken during the whole 18 months of sampling . This case appears to be comparable to that of *Palaemon elegans* , one of the most common intertidal prawns in the Isle of Man , whose larvae have not been found in coastal plankton from that region (Salman , 1981) .

Table 17 : Differences in abundance between anomuran larvae at different stations . (Nonparametric multiple comparison using Tukey test) .

Comparison	Difference R1-R2	SE	Q	Qtable	Conclusion
Diogenes avarus(1) vs *Diogenes avarus*(5)	39.1-20.4=18.7	5.06	3.70	2.394	Significant difference
Diogenes avarus(1) vs *Diogenes avarus*(6)	39.1-23.1=16	5.06	3.16	2.394	Significant difference
Calcinus A (6) vs *Calcinus* A (5)	36.3-30.5=5.8	5.07	1.14	2.394	No significant difference
Calcinus A (6) vs *Calcinus* A (1)	36.3-15.7=20.6	5.07	4.06	2.394	Significant difference
Calcinus(5) vs *Calcinus*(1)	30.5-15.7=14.8	5.07	2.92	2.394	Significant difference
Porcellanidae (6) vs Porcellanidae (5)	41.6-26.9=14.7	4.87	3.02	2.394	Significant difference
Porcellanidae (6) vs Porcellanidae (1)	41.6-14.0=27.6	4.87	5.67	2.394	Significant difference
Porcellanidae (5) vs Porcellanidae (1)	26.9-14.0=12.9	4.87	2.65	2.394	Significant difference
Galatheidae (6) vs Galatheidae (5)	34.3-30.0=4.3	4.87	0.88	2.394	No significat difference
Galatheidae (6) vs Galatheidae (1)	34.3-20.1=14.2	4.87	2.92	2.394	Significant difference
Galatheidae (5) vs Galatheidae (1)	30.0-20.1=9.9	4.87	2.03	2.394	No significant difference

continue

Callianassidae (6) vs Callianassidae (5)	31.5-30.1=1.4	4.21	0.33	2.394	No significant difference
Callianassidae (6) vs Callianassidae (1)	31.5-20.8=10.7	4.21	2.54	2.394	Significant difference
Callianassidae (5) vs Callianassidae (1)	30.1-20.8=9.3	4.21	2.21	2.394	No significant difference

- *Diogenes avarus* more common at station 1 than at stations 5 and 6 .
- *Calcinus* A more common at stations 5 and 6 than at station 1 .
- Porcellanidae more common at station 6 than at stations 5 and 1 .
- Galatheidae and Callianassidae more common at station 6 than at station 1 .

Monthly mean numbers of all the families of decapod larvae studied in this present work are recorded for all stations in Tables 18- 24 , to summarise the density variations of these larvae .

Table 18 . Numbers (monthly means) per 1000 m^3 of macruran and anomuran families at station 1 , from January 1986 to June 1987 .

* Abbreviations used in tables 18 - 24 .

Pr. = Protozoea ; M. = Mysis ; Al. = *Alpheus*; At. = *Athanas*;
H.= *Harpilius*; P. = *Palaemon*; Di. = *Diogenes*; Da. = *Dardanus*;
Cl. = *Clibanarius*; Ca. = *Calcinus* .

** Unidentified larvae . (me = megalopa) .

Family	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Average
Penaeidae*Pr.	-	-	24	-	8	80	64	8	32	-	-	-	-	-	-	-	-	32	14
Penaeidae*M.	8	-	-	-	-	-	32	-	48	-	64	-	-	-	-	-	-	-	8
Sergestidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alpheidae*Al.	120	80	120	32	32	160	-	64	128	160	656	544	216	5184	256	720	176	32	482
Alpheidae*At.	-	-	-	-	40	-	-	-	16	-	-	-	-	-	-	-	-	-	3
Palaemonidae*H	56	16	40	64	136	96	32	72	256	192	544	592	848	320	384	368	176	80	237
Palaemonidae*P	8	16	-	-	-	-	-	-	-	-	-	192	-	-	-	-	-	-	12
Hippolytidae	16	-	8	-	80	112	128	8	-	-	-	72	128	-	320	-	128	-	56
Pasiphaeidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Processidae	8	-	-	256	160	144	96	-	32	-	-	-	128	-	1056	288	96	224	138
Pandalidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	96	-	-	96	11
Oplophoridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Thalassinidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Upogebiidae	16	-	8	-	-	-	-	-	-	-	-	-	-	256	32	8	-	-	18
Callianassidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	-	1
Laomediidae	-	-	24	-	32	-	-	-	64	112	80	8	64	32	-	72	-	32	29
Galatheidae	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Porcellanidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paguridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diogenidae*Di.	24	24	40	608	816	1232	608	24	928	192	1088	384	-	-	2720	360	336	768	564
Diogenidae*Da.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32	-	-	-	2
Diogenidae*Cl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diogenidae*Ca.	-	-	8	-	8	-	-	-	-	16	-	-	-	-	32	-	-	64	7
Coenobitidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Anomura me.	-	-	-	-	-	-	-	-	-	-	128	-	-	-	-	-	16	16	9
Scyllaridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32	-	-	-	2
Stenopodiae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nephropidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dromidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	264	136	272	960	1312	1824	960	176	1504	672	2560	1792	1384	5792	4960	1816	944	1344	1593

Table 19 . Numbers (monthly means) per 1000 m^3 of macruran and anomuran families at station 2 , from January 1986 to June 1987 .

Family	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Average
Penaeidae*Pr.	8	112	24	8	24	40	16	-	16	80	64	64	-	-	-	-	-	208	37
Penaeidae*M.	-	32	-	40	24	192	32	64	8	64	8	32	-	-	-	-	-	32	29
Sergestidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alpheidae*Al.	688	424	336	56	104	72	32	48	160	1152	360	288	528	1384	312	592	136	8	371
Alpheidae*At.	-	-	-	8	56	64	-	-	-	-	8	-	-	-	-	-	-	-	8
Palaemonidae*H	32	152	40	88	160	328	96	96	128	1968	336	296	240	64	424	312	584	88	303
Palaemonidae*P	48	8	24	-	16	-	-	-	-	-	64	8	-	8	48	-	64	-	16
Hippolytidae	8	8	48	24	40	328	16	32	-	-	8	96	1344	-	32	-	128	-	117
Pasiphaeidae	-	8	-	8	-	-	-	-	-	-	-	-	-	-	32	-	64	8	7
Processidae	-	-	-	-	128	16	16	-	-	-	64	64	64	-	32	192	-	32	34
Pandalidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32	-	-	-	2
Oplophoridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Thalassinidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Upogebiidae	40	72	-	-	-	-	-	-	16	128	-	32	192	32	40	-	-	-	31
Callianassidae	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	8	1
Laomediidae	-	-	64	-	8	-	8	16	96	256	-	-	-	8	-	32	-	16	28
Galatheidae	24	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	2
Porcellanidae	16	-	-	-	-	8	-	-	-	16	-	-	-	-	-	-	-	8	3
Paguridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diogenidae*Di.	16	-	-	40	176	104	384	64	40	80	680	32	192	-	96	64	200	24	122
Diogenidae*Da.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-
Diogenidae*Cl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diogenidae*Ca.	-	-	32	-	-	-	-	-	-	-	-	-	-	-	-	-	64	16	6
Coenobitidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Anomura me.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scyllaridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenopodiae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nephropidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dromidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	880	816	568	272	736	1152	600	320	464	3744	1600	912	2560	1504	1048	1192	1248	448	1115

Table 20 . Numbers (monthly means) per 1000 m^3 of macruran and anomuran families at station 3 , from January 1986 to June 1987 .

Family	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Average
Penaeidae*Pr.	16	32	-	-	8	16	16	16	-	160	-	-	-	-	-	-	-	-	15
Penaeidae*M.	32	-	-	64	8	64	16	16	-	-	-	-	-	-	-	-	-	-	11
Sergestidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alpheidae*Al.	1072	168	560	288	296	88	64	16	1792	1112	480	440	288	3872	248	992	576	208	698
Alpheidae*At.	32	-	-	-	64	64	-	-	256	-	-	-	-	-	-	-	-	-	23
Palaemonidae*H	232	80	40	112	16	752	112	80	384	272	224	560	256	264	80	288	288	144	232
Palaemonidae*P	-	-	48	24	-	-	-	-	-	-	-	-	-	8	32	-	-	16	7
Hippolytidae	88	8	32	16	56	72	16	-	128	80	96	8	48	-	16	-	96	16	43
Pasiphaeidae	-	-	-	-	-	-	-	-	-	-	-	16	-	-	16	-	16	32	4
Processidae	40	-	-	64	152	104	-	-	-	-	-	-	32	-	48	64	16	192	40
Pandalidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	80	64	-	8
Oplophoridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* * Thalassinidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Upogebiidae	40	16	112	-	8	64	-	8	128	64	-	80	32	-	-	-	96	-	36
Callianassidae	8	-	-	-	-	-	16	-	-	-	-	64	-	-	-	64	128	-	16
Laomediidae	-	8	16	-	-	-	-	-	-	16	-	-	-	-	-	80	-	32	8
Galatheidae	8	-	-	-	-	-	-	-	-	-	-	-	-	-	16	-	- .	-	1
Porcellanidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paguridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32	-	2
Diogenidae*Di.	32	-	-	80	280	352	128	24	-	208	96	136	16	-	56	160	224	288	116
Diogenidae*Da.	-	-	-	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Diogenidae*Cl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diogenidae*Ca.	-	-	-	-	24	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Coenobitidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* * Anomura me.	-	-	-	-	-	-	-	-	-	16	-	-	-	-	-	-	-	-	1
Scyllaridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenopodiae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nephropidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dromidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1600	312	808	664	912	1576	368	160	2688	1928	896	1304	672	4144	520	1728	1536	928	1264

Table 21 . Numbers (monthly means) per 1000 m^3 of macruran and anomuran families at station 4 , from January 1986 to June 1987 .

Family	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Average
Penaeidae*Pr.	16	-	-	-	-	40	64	64	16	32	8	-	-	-	8	-	-	16	15
Penaeidae*M.	-	-	-	-	-	-	8	-	-	8	16	-	-	-	-	-	-	16	3
Sergestidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alpheidae*Al.	184	128	296	-	16	128	64	1088	168	72	144	96	72	1104	56	152	440	136	241
Alpheidae*At.	-	-	16	-	8	8	16	-	8	-	-	-	-	-	-	-	-	-	3
Palaemonidae*H	24	24	168	8	8	232	40	448	160	88	144	256	64	320	32	96	624	176	162
Palaemonidae*P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-
Hippolytidae	32	8	16	-	-	40	64	64	56	-	16	96	48	-	24	32	72	80	36
Pasiphaeidae	-	8	-	-	-	16	-	-	-	-	-	16	8	-	-	-	-	-	3
Processidae	8	-	-	-	-	-	32	-	-	-	-	-	-	-	8	32	-	16	5
Pandalidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	24	-	2
Oplophoridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Thalassinidae	-	8	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Upogebiidae	16	8	192	-	-	8	-	64	8	-	-	-	-	-	16	40	-	-	20
Callianassidae	8	8	-	8	8	8	-	-	-	-	-	-	8	-	-	-	-	16	4
Laomediidae	-	-	16	-	-	-	-	-	-	32	-	-	-	-	-	20	128	-	11
Galatheidae	16	-	-	-	-	8	-	-	-	-	-	-	-	64	-	-	-	-	5
Porcellanidae	8	-	-	-	-	-	-	64	8	32	-	-	-	-	8	8	-	-	7
Paguridae	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diogenidae*Di.	8	-	8	8	-	56	16	-	128	72	168	32	-	-	16	40	24	80	36
Diogenidae*Da.	-	-	-	-	-	8	-	-	-	-	-	-	-	64	-	-	-	-	4
Diogenidae*Cl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diogenidae*Ca.	-	-	8	-	-	8	8	64	8	-	-	16	-	-	32	24	96	-	15
Coenobitidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Anomura me.	-	-	-	-	-	-	-	-	64	-	-	-	-	-	-	-	-	-	4
Scyllaridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenopodiae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nephropidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dromidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	328	192	728	24	40	560	312	1856	624	336	496	512	200	1552	208	452	1408	536	576

Table 22 . Numbers (monthly means) per 1000 m^3 of macruran and anomuran families at station 5 , from January 1986 to June 1987 .

Family	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Average
Penaeidae*Pr.	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-
Penaeidae*M.	-	-	-	-	8	32	-	-	-	8	96	-	-	-	-	-	-	-	8
Sergestidae	-	-	-	-	-	-	-	-	-	-	-	-	-	16	-	-	-	-	1
Alpheidae*Al.	192	264	1384	240	112	2944	1216	1664	320	424	400	544	608	704	160	212	224	96	650
Alpheidae*At.	24	64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
Palaemonidae*H	168	288	712	256	-	2176	832	1920	160	112	400	320	112	192	24	64	80	104	440
Palaemonidae*P	-	8	-	8	-	-	-	-	-	-	32	-	16	-	-	-	-	-	4
Hippolytidae	136	64	-	40	-	192	64	-	-	64	64	80	48	56	-	16	32	40	50
Pasiphaeidae	-	-	48	32	-	224	-	-	-	-	32	-	96	16	-	16	-	16	27
Processidae	-	-	-	-	24	-	-	-	-	-	-	-	-	-	-	8	-	-	2
Pandalidae	8	-	-	-	-	-	-	-	-	-	-	-	-	16	-	-	16	48	5
Oplophoridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Thalassinidae	-	-	32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Upogebiidae	-	8	-	96	-	-	-	-	-	8	16	-	-	96	-	8	-	8	13
Callianassidae	-	-	-	-	56	96	-	128	32	-	-	16	-	-	-	8	16	-	20
Laomediidae	-	32	-	-	-	-	-	-	-	32	32	48	48	-	24	8	32	-	14
Galatheidae	8	48	72	8	-	-	64	-	-	-	-	-	-	-	-	-	16	16	13
Porcellanidae	-	-	32	8	-	160	-	-	-	8	48	48	-	32	8	-	16	16	21
Paguridae	8	-	-	-	-	-	-	-	-	-	-	16	32	-	-	-	-	-	3
Diogenidae*Di.	-	16	-	-	16	416	64	-	32	72	64	16	16	16	-	8	32	-	43
Diogenidae*Da.	8	-	-	-	24	96	192	-	32	-	-	16	-	-	-	-	-	8	21
Diogenidae*Cl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diogenidae*Ca.	8	72	256	64	24	-	-	128	-	168	-	96	32	32	16	64	208	8	65
Coenobitidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Anomura me.	-	-	8	-	8	-	-	-	-	8	160	48	-	-	-	-	-	-	13
Scyllaridae	-	8	-	-	-	-	-	-	-	-	-	-	-	-	8	8	-	-	1
Stenopodiae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nephropidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dromidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	568	872	2544	752	272	6336	2432	3840	576	904	1344	1248	1008	1176	240	420	672	368	1421

Table 23 . Numbers (monthly means) per 1000 m^3 of macruran and anomuran families at station 6 , from January 1986 to June 1987 .

Family	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Average
Penaeidae*Pr.	-	-	-	-	-	-	-	-	-	8	8	-	-	-	-	-	-	-	1
Penaeidae*M.	8	-	-	-	-	-	-	-	-	8	8	16	-	-	-	-	-	-	2
Sergestidae	-	-	16	-	-	-	-	-	-	8	16	-	104	-	-	16	-	-	9
Alpheidae*Al.	152	296	256	560	576	480	576	288	56	272	40	80	64	448	336	96	240	896	317
Alpheidae*At.	-	8	-	-	-	-	32	-	-	-	8	-	-	-	-	-	-	-	3
Palaemonidae*H	40	224	72	232	608	96	192	256	32	320	88	184	48	112	160	48	256	1152	229
Palaemonidae*P	8	32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Hippolytidae	32	400	8	-	64	-	-	64	8	8	56	48	16	48	48	32	32	-	48
Pasiphaeidae	-	8	-	8	-	16	-	-	-	-	-	8	8	-	-	16	-	-	4
Processidae	-	8	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	1
Pandalidae	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	8	-	128	8
Oplophoridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
**Thalassinidae	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	128	8
Upogebiidae	-	-	-	-	64	-	-	-	-	-	-	-	-	-	-	-	16	-	4
Callianassidae	-	-	-	-	64	32	-	-	8	64	8	-	-	-	-	16	32	512	41
Laomediidae	-	8	-	-	-	-	-	-	-	64	-	-	-	32	-	-	-	384	27
Galatheidae	-	-	8	8	128	-	32	-	16	8	-	40	-	32	48	16	-	-	19
Porcellanidae	8	152	64	104	32	64	32	96	24	16	24	-	24	64	64	64	64	512	78
Paguridae	16	-	-	-	-	-	-	-	8	-	-	8	8	-	-	-	-	-	2
Diogenidae*Di.	-	8	-	-	-	16	-	-	8	160	72	128	-	-	48	16	96	-	31
Diogenidae*Da.	-	64	-	16	96	-	32	-	-	-	-	-	-	-	-	24	-	512	41
Diogenidae*Cl.	-	-	8	-	32	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Diogenidae*Ca.	8	136	136	496	288	16	288	-	32	24	8	8	-	384	368	216	80	2688	288
Coenobitidae	-	-	-	-	32	-	-	-	-	-	-	-	-	-	-	-	-	-	2
**Anomura me.	-	-	8	-	-	-	-	-	-	-	8	-	-	16	-	-	-	-	2
Scyllaridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenopodiae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nephropidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dromidae	-	-	8	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Total	272	1344	584	1432	1984	720	1184	704	192	960	344	520	296	1136	1072	568	816	6912	1169

Table 24 . Numbers (monthly means) per 1000 m^3 of macruran and anomuran families at station 6 night-time , from January 1986 to June 1987 .

Family	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Average
Penaeidae*Pr.	-	-	-	-	-	-	-	-	-	64	-	-	8	-	-	-	-	-	4
Penaeidae*M.	-	-	-	-	128	-	256	-	-	-	64	-	-	-	-	-	-	-	25
Sergestidae	64	-	16	-	-	-	-	256	-	-	16	-	-	-	-	-	-	-	20
Alpheidae*Al.	224	288	152	1624	1952	1312	3584	768	1408	1088	512	416	144	1024	2112	1792	5632	8704	1819
Alpheidae*At.	-	32	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Palaemonidae*H	144	272	88	592	640	1760	1280	1024	384	352	240	352	88	384	576	384	1600	1280	636
Palaemonidae*P	80	16	-	32	-	-	-	-	-	-	-	-	-	32	-	-	-	-	9
Hippolytidae	16	256	-	240	128	320	768	128	128	144	80	128	24	-	-	-	256	-	145
Pasiphaeidae	16	928	8	136	-	-	-	-	-	-	-	384	32	288	256	-	64	-	117
Processidae	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-
Pandalidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	256	14
Oplophoridae	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-
**Thalassinidae	-	16	16	128	-	256	-	-	-	-	-	-	-	-	-	-	-	-	23
Upogebiidae	-	-	-	-	-	-	-	-	-	64	-	-	-	-	-	128	-	-	11
Callianassidae	-	-	8	192	1024	5568	1280	256	-	64	-	-	8	-	192	320	4864	8704	1249
Laomediidae	-	-	-	8	-	-	-	-	256	48	-	-	16	-	-	256	896	512	111
Galatheidae	16	80	40	488	896	320	1280	256	-	-	32	32	16	384	896	384	1216	2304	480
Porcellanidae	16	16	8	32	-	-	-	-	-	80	-	-	-	-	128	-	-	-	16
Paguridae	-	-	16	96	128	-	-	-	-	-	-	32	8	-	128	256	256	768	94
Diogenidae*Di.	-	160	-	-	256	-	256	256	128	128	336	192	24	-	192	512	128	-	143
Diogenidae*Da.	-	16	-	64	64	160	-	-	-	-	-	-	-	-	-	-	-	768	60
Diogenidae*Cl.	-	-	-	64	32	-	-	-	-	-	-	-	8	-	-	-	128	-	13
Diogenidae*Ca.	-	240	184	1056	736	1056	2048	-	384	128	128	-	40	1280	1792	1280	6784	6400	1308
Coenobitidae	-	-	-	-	64	-	-	-	-	-	-	-	-	-	-	-	-	-	4
**Anomura me.	-	-	16	200	-	-	-	-	-	128	80	32	-	32	128	256	256	-	63
Scyllaridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenopodiae	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	256	-	-	15
Nephropidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dromidae	-	-	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Total	576	2320	584	4952	6048	10752	10752	2944	2688	2288	1488	1568	440	3424	6400	5824	22080	29696	6379

Chapter 6

General Discussion and Conclusions

Larval identification is important not only for taxonomy but also for all those branches of biology which taxonomy subserves ; for instance , the results of quantitative ecological research would be incomplete if larval forms had to be neglected because they could not be identified (Gordon , 1955) . A number of decapods are important as commercial species , and effective management of the fishery for such species is impossible without a thorough knowledge of the larval life-history . Other species are important , either as adults or larvae , as the food of fish , and again it is very desirable that the larvae should be identified and their distribution known .

Larvae of decapod crustaceans have been the subject of a great deal of work in different parts of the world , and in some regions , such as the Irish Sea and the English Channel , practically all decapod larvae which are encountered can be linked with named adults . In the central Red Sea , on the other hand , larvae of decapod Crustacea have received very little attention and the fauna of adult decapods is very imperfectly known . The present study is a first attempt to provide records of decapod larvae from the central Red Sea . It was undertaken with the realisation that one man , in the time available , could not hope to provide a complete record or cover all groups of decapods , but it provides a basis for further studies by any workers with the opportunity and an interest in the subject . The work has concentrated on larvae of the caridean genus *Alpheus* , which are particularly abundant in the area , and on larvae of the Anomura . In most cases it has not been possible to link the larvae with named species of adults , but within these groups , it has usually been possible to identify to genera and to study the number of species in each genus occurring as planktonic larvae in the area .

Usually the only way to obtain firm identifications of the larvae is to hatch them from identified ovigerous females in the laboratory or to rear planktonic larvae through metamorphosis to the adult phase. It is not realistic to contemplate doing this for all the decapods of the central Red Sea , but in selected cases hatching or rearing can be invaluable in establishing specific identifications and in determining the larval characters of genera or families . Larvae of the hermit crabs *Coenobita scaevola* and *Dardanus tinctor* , obtained from ovigerous females and reared through all their larval stages in the present work, provide examples of successful rearing experiments, and it is hoped that more will be added in the future . With full and accurate descriptions obtained in this way , it is then possible to identify planktonic larval material with assurance and study the natural distribution and breeding periods of the species (Costlow et al , 1970).

In distinguishing the many species of *Alpheus* larvae encountered in the present work , great use was made of the distribution of chromatophores in fresh material . In the past , the method has been used by a number of other workers studying the larvae of several different groups and has proved extremely effective in cases where the morphological differences between larvae of different species is not well marked . It was also shown in the present work that it is possible to rear in the laboratory *Alpheus* larvae taken from plankton samples , with high survival in the later larval and juvenile stages . This means that in selected cases it should be possible to rear larvae of known chromatophore pattern to identifiable adults .

The results showed considerable variation from month to month in the numbers of decapod larvae , but in many cases it is not yet possible to say how much of this variation is a regular seasonal feature . There are indications of two main seasons : summer , from March to October , and winter , from November to February . The summer season , with its higher water temperatures , was generally the more productive for decapod larvae , but high densities were also noted in some winter months in 1987 . These winter peaks were largely due to single species of *Alpheus* or *Harpilus* , and these larvae may have been carried by the wind driven circulation from other areas.

The records of some larvae showed clear and consistent differences between stations , probably reflecting the distributions of the corresponding adults . *Diogenes avarus* larvae were much more common in the mangrove area and larvae of *Calcinus* A were more common at the station off Obhor Creek , suggesting that the adults could be collected in these respective regions to provide material for laboratory rearing . Most of the species of decapod larvae were more common in the night samples than by day , suggesting that they carry out regular vertical migrations . Particularly clear evidence of such vertical migration was provided by larvae of the anomuran familes

Galatheidae , Paguridae and Callianassidae , and by larvae of the Sergestidae (Penaeidea) and of the caridean genus *Leptochaela* .

In the present study the larvae of the Thalassinidea have been included in the Anomura , although there is no general agreement among workers on decapod Crustacea whether they should be included or excluded . They were , for example , included in the Anomura by McLaughlin (1980) , who considered mainly adult characters , but excluded by Gurney (1942) , who considered chiefly larval characters. The larvae of the two groups are linked by having the second telson process reduced to a fine hair , a character which occurs elsewhere only in the Stenopodidea .

Until quite recently it could be claimed that the presence of a central telson spine in the larvae of many families of the Thalassinidea provided a clear distinction from larvae of the Anomura, which are usually stated to have no central telson spine . It now emerges , however, that all known larvae of the anomuran family Coenobitidae , including that described in the present work , have a central telson spine in zoea III and all subsequent zoeal stages (Al-Aidaroos and Williamson , in press) . This is comparable to the occurrence of a central telson spine in zoea II and all subsequent zoeal stages in the thalassinid family Upogebiidae .

The only other larval character separating the Thalassinidea and the Anomura is the occurrence of exopods on some of the legs in most larvae of the former group but in none of the second . Exopods do , however , occur on some of the legs in larvae of some genera of the Dromiidae . The affinities of this family , in which the adults are clearly brachyuran but the larvae clearly anomuran , are discussed by Williamson (1988) . In conclusion , however , it may be said that the better understanding of coenobitid larvae , to which this work has contributed , makes it more difficult to separate the Thalassinidea and the Anomura on larval characters .

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