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ON A COLLECTION OF DECAPOD LARVAE FROM THE GULF OF AQABA OFF THE JORDANIAN COAST, I. THALASSINIDEA AND ANOMURA

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ABSTRACT

Descriptions of some decapod crustacean larvae of a plankton collection from the Gulf of Aqaba deal with Thalassinidea (Laomediidae, Upogebiidae, and Callianassidae) and Anomura (Galatheidae and Diogenidae). Discussion on generic larval characters is made particularly in Callianassidae and Diogenidae. Comparison of Laomediidae and Galatheidae larvae is summarized in tables I and II. The different arrangement of spines on some abdominal somites in Upogebiidae larvae is not a generic character but can be used, viz., in the form of distinctive larval species features. Because of confusion among the adult callianassid genera and the lack of knowledge in larval development, a definite generic identification is not possible. A key to the identification of Coenobitoidea larvae is provided. Larvae of the Coenobitidae and *Calcinus* are distinguished.

RÉSUMÉ

La description de quelques larves de crustacés décapodes d'une collection de plancton du Golfe d'Aqaba, est donnée, concernant plus particulièrement des Thalassinidea (Laomediidae, Upogebiidae and Callianassidae) et des Anomura (Galatheidae et Diogenidae). Les caractères larvaires au niveau générique sont discutés, en particulier chez les Callianassidae et les Diogenidae. La comparaison des larves de Laomediides et de Galatheides est résumée dans les tableaux I et II. L'arrangement différent des épines sur les somites abdominaux des larves d'Upogebiides n'est pas un caractère générique mais peut être utilisé comme un caractère distinctif des espèces de larves. En raison de la confusion existant parmi les genres de Callianassides adultes et le manque de connaissances sur leur développement larvaire, une identification générique définitive n'est pas possible. Une clé d'identification des larves de Coenobitoidae est fournie. Les larves de Coenobitidae et de *Calcinus* sont distinguées.

INTRODUCTION

Most descriptions of Red Sea crustacean decapod larvae have been made on the basis of plankton collections from El-Ghardaqa, Egypt (Al-Kholy, 1960; Al-Kholy & Fikry Mahmoud, 1967a, b; Gohar & Al-Kholy, 1957; Gurney (1927a, b, 1937a, b, 1938) and from the West Coast of the Gulf of Aqaba (Sinai Peninsula) (Williamson, 1970).

Previous papers (Seridji, 1986, 1987) have dealt with the occurrence and distribution of decapod crustacean larvae from a collection of 38 surface plankton samples which contained 126 larval forms. It has been pointed out

that our limited knowledge of the larvae of the decapod fauna of the Red Sea is most obvious at the species level (and indicates our ignorance of the decapod larval fauna of the region), which contrasts with the Mediterranean where almost all the species can be named.

MATERIAL AND METHOD

The surface plankton samples were collected from 10 sampling stations situated between Aqaba and the Jordan-Saudia border in October, 1978 (Seguin & Vaissière, 1981). Five stations (A, B, C, D, and E) were over very shallow water and the other five (A′, B′, C′, D′, and E′) were over deep water (200 m to 850 m), and located near the centre of the Gulf.

The present work describes Thalassinidea and Anomura larvae. It is shown that none of these larvae (except one, *Callichirus laurae*) can be linked with certainty to any known adult. They are described under specific numbers.

DESCRIPTIONS AND DISCUSSIONS

Thalassinidea Latreille, 1831

Most zoologists have recognized this group, but many of them do not agree either on the number of families or on its systematic position. Based on larval characters and on those of the adults, Gurney (1938) recognized seven families: Axianassidae, Axiidae, Callianassidae, Callianideidae, Laomediidae, Thalassinidae, and Upogebiidae. On the other hand, Balss (1957) discerns four families: Callianassidae, Laomediidae, Thalassinidae, and Upogebiidae. De Man (1928) puts the genus *Axianassa* Schmitt, 1924 in the Laomediidae, and De Saint-Laurent (1979) places together Axiidae, Callianideidae, and Callianassidae in the superfamily Axioidea.

In the present collection, three families are present: Laomediidae, Callianassidae, and Upogebiidae.

Laomediidae Borradaile, 1903

For Chace (1939) there are two subfamilies: the Laomediinae with two genera: *Jaxea* Nardo, 1847 and *Laomedia* De Haan, 1841, and the Naushoniinae with one genus, *Naushonia* Kingsley, 1897.

Larval descriptions are known for *Jaxea* (cf. Claus, 1884; Cano, 1891; Bouvier, 1914; Caroli, 1924; Gurney, 1924, 1938; Tattersall, 1938; Dakin & Colefax, 1940; and Wear & Yaldwyn, 1966), for *Laomedia* (cf. Sakai & Miyake, 1964; Yaldwyn & Wear, 1972), and for *Naushonia* (cf. Gurney, 1938; Gurney & Lebour, 1939; Dakin & Colefax, 1940; Goy & Provenzano, 1978).

Naushonia sp. Aqaba 2 (fig. 1a-b)

This specimen, in stage V, is characterized by a short rostrum, double-curved upwards at the tip. It bears considerable resemblance to the specimen from Great Barrier Reef described by Gurney (1938): antennular exopod and endopod not segmented; antennal scale without spine at its external angle, and endopod about twice the length of the antennal scale. Pereiopod 1-4 with exopod. Pleopods not developed and without setae on abdominal somites 2-5. A pair of inwardly-curved postero-lateral processes on the fifth abdominal somite. Parallel-sided telson (fig. 1b) with ten setae on the posterior edge. Developed uropod present.

Discussion. — As suggested by Gurney & Lebour (1939), most specimens of larvae described from the Great Barrier Reef and Samoa had been referred to *Naushonia perrieri* Nobili, 1904, originally described from two adult specimens from the Somali coast. It seems quite likely that *Naushonia* sp. Aqaba 2, which shows a great resemblance to the larvae from the Great Barrier Reef, also belongs to *N. perrieri*.

In table I, we have summarized a number of larval features which allow some distinction between various genera of the Laomediidae.

Callianassidae Dana, 1852

From the point of view of adult taxonomy, the study of the European and Mediterranean species seems to be clearer since the works of De Saint-Laurent (1974, 1979) and De Saint-Laurent & Bozic (1976); Le Loeuf & Intès (1974) and De Saint-Laurent & Le Loeuf (1979) describe some species from the west coast of Africa (Gulf of Guinea). However, the systematic position of *Callianassa* Leach, 1814, *Callichirus* Stimpson, 1866, and *Glypturus* Stimpson, 1866, is not accepted by some workers. Manning & Felder (1986) redefined *Callichirus* and distinguished it from other genera, particularly *Callianassa*, and Manning (1987) recognized *Glypturus* as a separate genus, although it had previously been widely regarded as a synonym of *Callianassa*. The controversy over adult systematics can add to the difficulty of naming larval specimens, but larval studies may just as well clarify the taxonomy of the group and elucidate such questions.

Callichirus laurae De Saint-Laurent, 1984 (figs. 2a-b, 3i)

Zoeae obtained in the laboratory in Aqaba marine station aquarium from an ovigerous female (which could therefore be identified with certainty) by Vaugelas (1989) have been sent to me.

Zoea I, 1.5 mm (from tip of rostrum to posterior edge of carapace). Carapace (fig. 2a), with a long, thin, and distally serrated rostrum (fig. 3a) reaching beyond the antenna. Antero-lateral carapace margins with denticulations. Eyes sessile. Abdomen (fig. 2a) with five free somites, the sixth still being fused to the

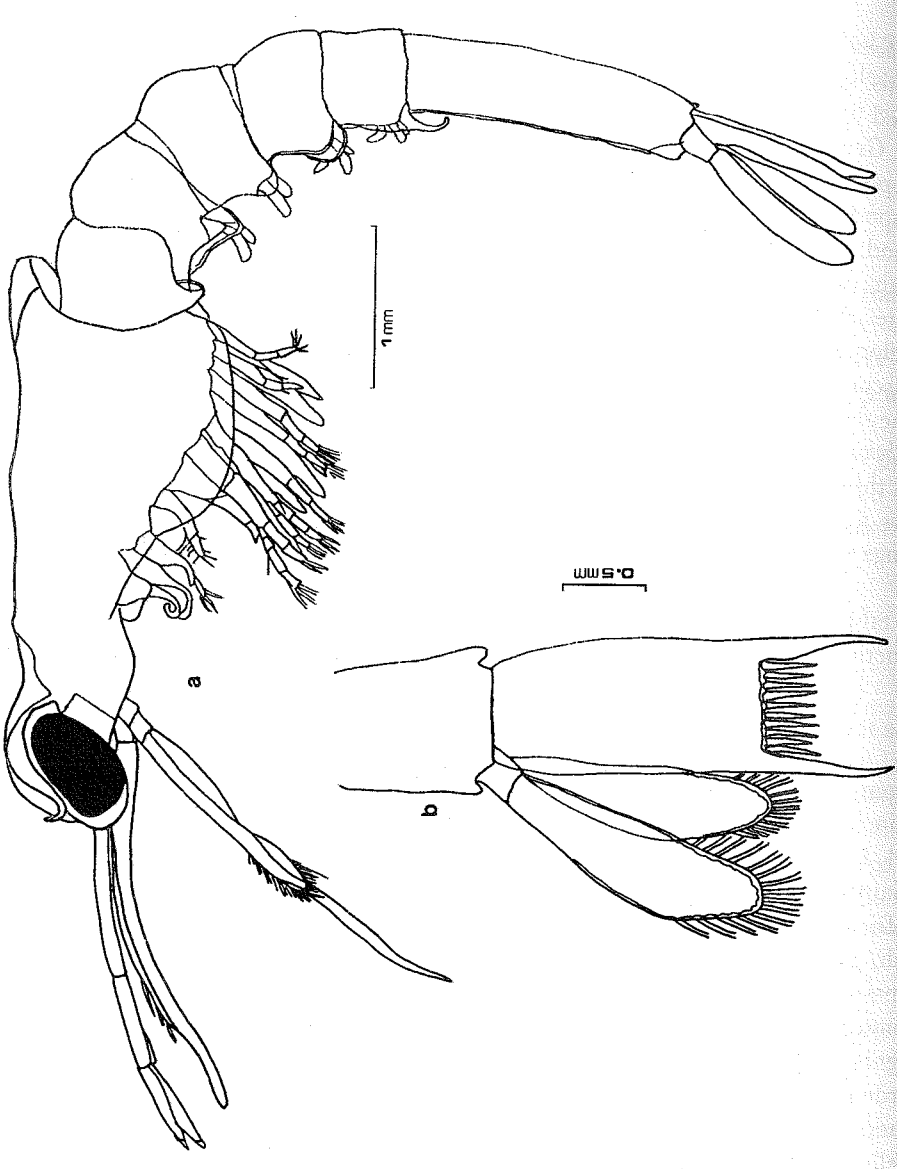

Fig. 1. *Naushonia* sp. Aqaba 2, zoea V. a, lateral view; b, telson and uropods in dorsal view.

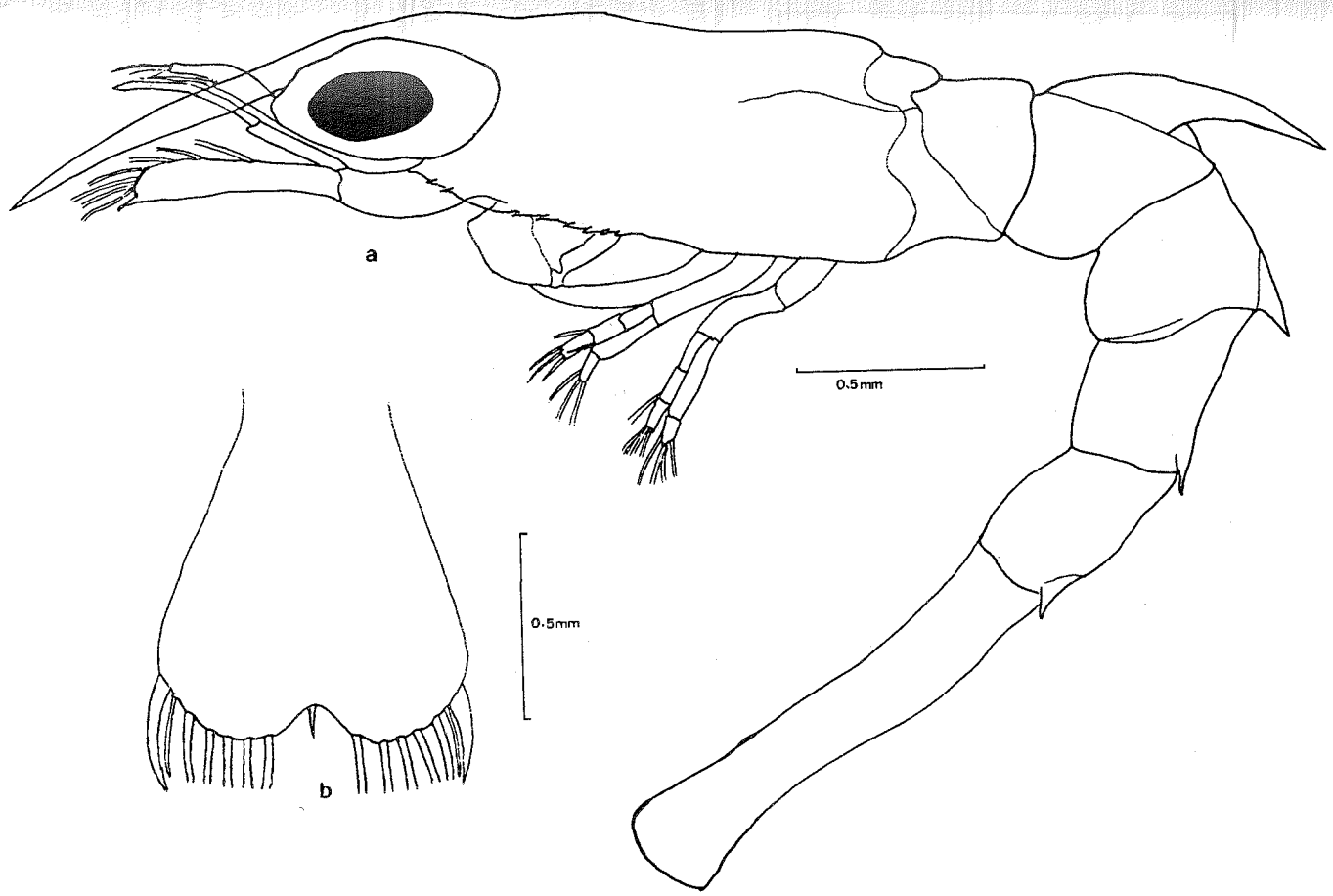

Fig. 2. *Callichirus laurae* De Saint-Laurent, 1984, zoea I. a, lateral view; b, telson.

TABLE I

Distinct characters of different Laomediidae genera

Genera Characters	*Jaxea* Nardo	*Naushonia* Kingsley	*Laomedia* de Haan
Number of larval stages	6	5 or 6	4 ?
Neck region	Long	very short	Absent
Rostrum	Straight, short not beyond eyes	Short, double-curved	Long,straight,beyond eyes
Abdominal pleura	Somites 1-5 with distally curved papillate projections	Somites 2-5 or somites 1-5 or somite 5 with distally curved papillate processes	Papillate processes absent in stage I but often present in the following stages
Telson	Very deep notch with two slender forks in stage I	Notch triangular	Without notch,plate-like with a straight posterior edge
Endopod of Mx1	unsegmented	unsegmented	Three-segmented
Endopod of Mx2	Very short	Short	Well developed

telson. The second somite bears a large spine dorsally overlapping about half the length of the 3rd somite. Somites 3-5 each with a postero-dorsal spine. Telson (fig. 2b) plate-like. Posterior edge rounded with a notch and a median short spine and a total of 7 + 1 + 7 telson processes as follows: the outermost acute spines, the second ones hair-like, and 5 + 5 setae medially.

Antennule (fig. 3c) conical and unsegmented, with three long aesthetascs, two long terminal and one submarginal seta.

Antenna (fig. 3d), scale (= exopod) slightly concave on the external side, with one outer, apical spine and seven long, plumose setae plus one thin seta on the inner and distal margins. Endopod slightly shorter than half the length of the scale, and with three long, terminal setae. One short spine at the distal portion of the basipod.

Maxillule (fig. 3e), coxal endite with seven setae; basal endite with two stout, serrated spines, one marginal and two submarginal setae. Endopod three-segmented; each segment with a long apical seta and, successively, also with, respectively, two latero-proximal setae, one median, marginal seta, and another distal seta.

Maxilla (fig. 3f), undivided coxal endite with 6 + 1 setae; basal endite bilobed with 3 + 3 setae. Endopod with four lobes: large distal lobe with 5 setae; the others smaller, with 3 + 2 + 2 setae. Scaphognathite with 1 long posterior and 3 long apical setae.

Maxilliped 1 (fig. 3g), coxa with 5 marginal setae; basis with 2 + 3 + 2 + 2 setae. Endopod four-segmented with 2 + 1 + 1 + 4 setae, respectively. Exopod partly segmented with 4 long terminal setae.

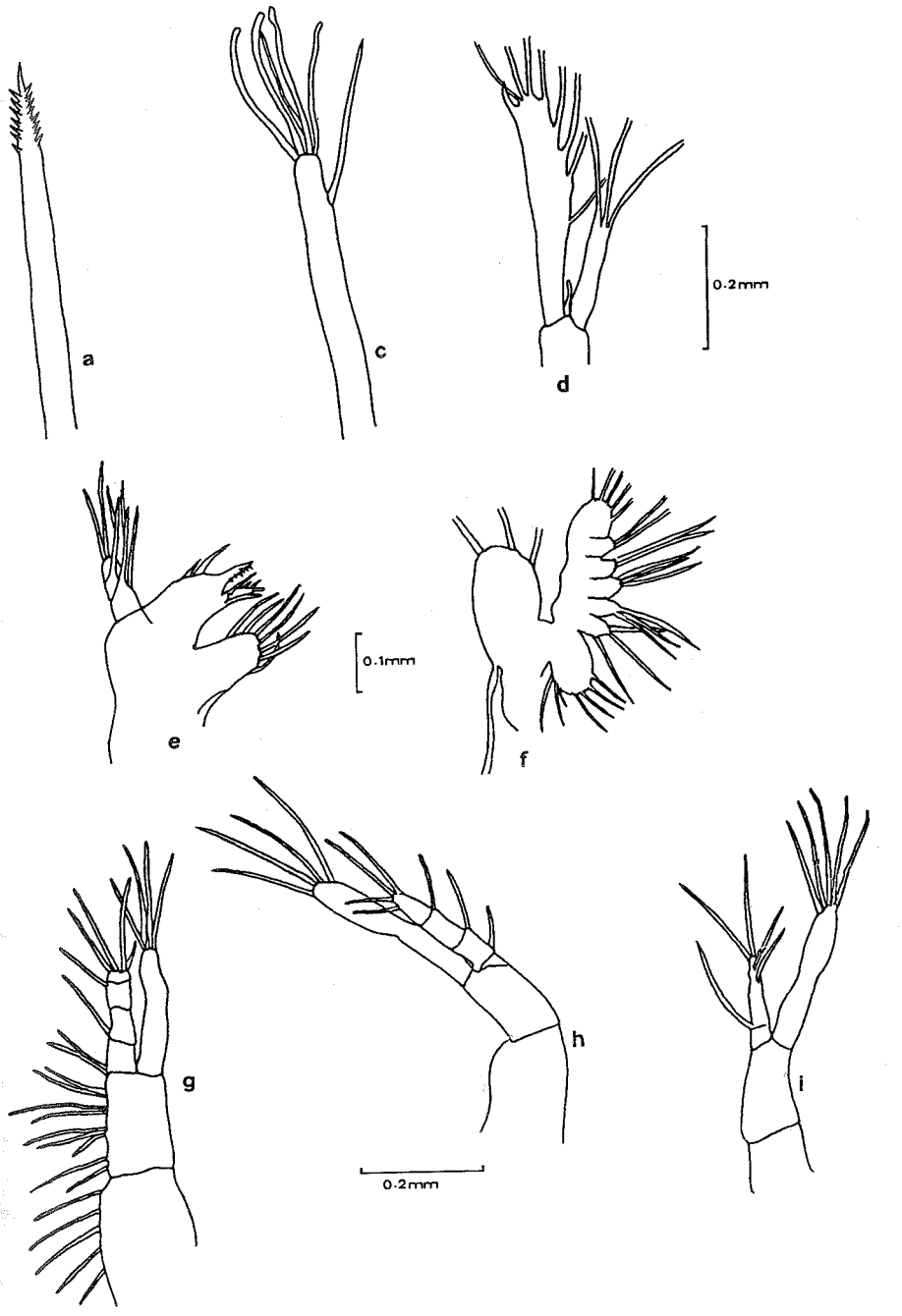

Fig. 3. *Callichirus laurae* De Saint-Laurent, 1984, zoea I. a rostrum; c, antennule; d, antenna; e, maxillule; f, maxilla; g, maxilliped 1; h, maxilliped 2; i, maxilliped 3.

Maxilliped 2 (fig. 3h), exopod partly segmented with 4 long terminal setae. Endopod of four segments with, successively, 1 + 1 + 1 + 4 and 2 marginal setae (these last ones not shown in fig. 3h).

Maxilliped 3 (fig. 3i), coxa and basis without setae. Exopod partly segmented with 5 terminal plumose setae. Endopod two-segmented: proximal segment with one marginal seta; distal segment with 2 + 2 submarginal setae.

Callianassa sp. Aqaba 3 (fig. 4a-e)

Zoea I, 2.80 mm. Carapace (fig. 4a), long and flattened rostrum with denticulations anteriorly on each side (fig. 4b), two stout and four fine carapace denticles behind pterygostomial spine. Eyes sessile. Abdomen (fig. 4a), with five somites and telson; somite 6 still fused to the telson. Telson (fig. 4c) triangular; posterior edge with deep notch, without median spines; a total of 7 + 7 telson processes: the outermost movable spines, the second ones hair-like, and 5 + 5 setae.

Antennule (fig. 4d), long, unsegmented peduncle bearing two distal aesthetascs, one long and three short setae, and a long setulose seta on the inner margin.

Antenna (fig. 4e), with endopod ending in two long plumose setae. Exopod shaped as a scale with an external apical spine and 7 + 1 plumose setae on the inner and distal margins. A long spine arises from the basis, located between antennal scale and endopod.

Callianassa sp. Aqaba 4 (fig. 5a-e)

Zoea I, 2.80 mm. Carapace (fig. 5a), with long and slightly flattened rostrum with stout denticulations anteriorly on each side (fig. 5b), 16 small carapace denticles behind pterygostomial spine. Eyes sessile. Abdomen (fig. 5a), with five free somites and telson; somite 6 still fused with telson. Somites 3-5 each with a pair of dorso-lateral spines, successively increasing in size. Telson (fig. 5c) with two short anterior carinae; posterior edge with deep notch and a median spine. A total of 7 + 1 + 7 telson processes, as follows: the outermost ones movable spines, the second ones hair-like, and 5 + 5 setae with setules.

Antennule (fig. 5e), long, unsegmented peduncle with conical exopod bearing three aesthetascs and three setae distally, and a long seta with setules on the inner margin.

Antenna (fig. 5d), with endopod ending in three long setae. Antennal scale (= exopod) with apical spine and 8 long, plumose setae on the inner and distal margins. A short spine arises from the antennal peduncle, located between antennal scale and endopod.

Callianassa sp. Aqaba 5 (fig. 6a-b)

Zoea I, 2.70 mm. The main features of this zoea are a pterygostomial spine and 8 antero-lateral carapace denticles (fig. 6a). Abdomen (fig. 6b), with five

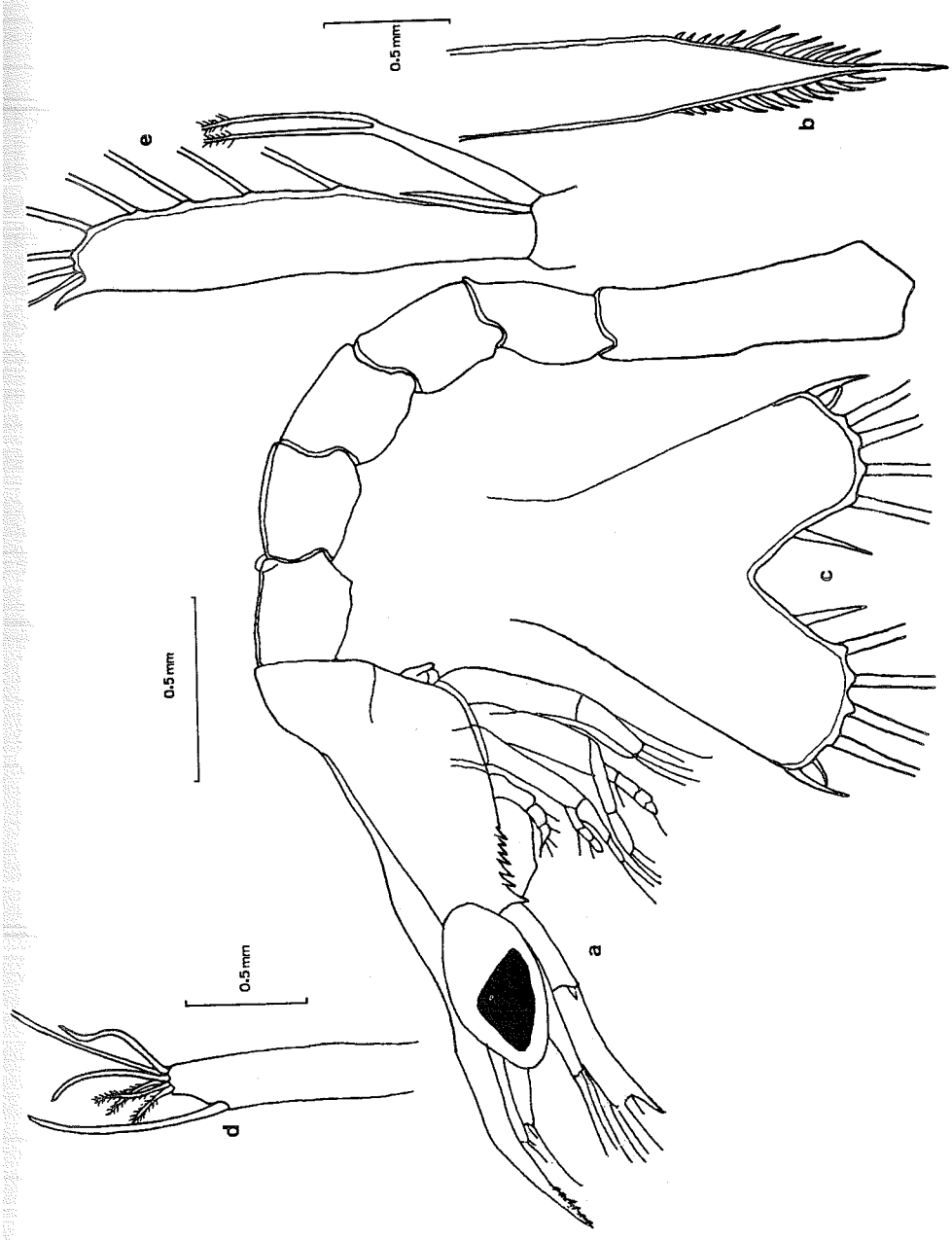

Fig. 4. *Callianassa* sp. Aqaba 3, zoea I. a, lateral view; b, rostrum; c, telson; d, antennule; e, antenna.

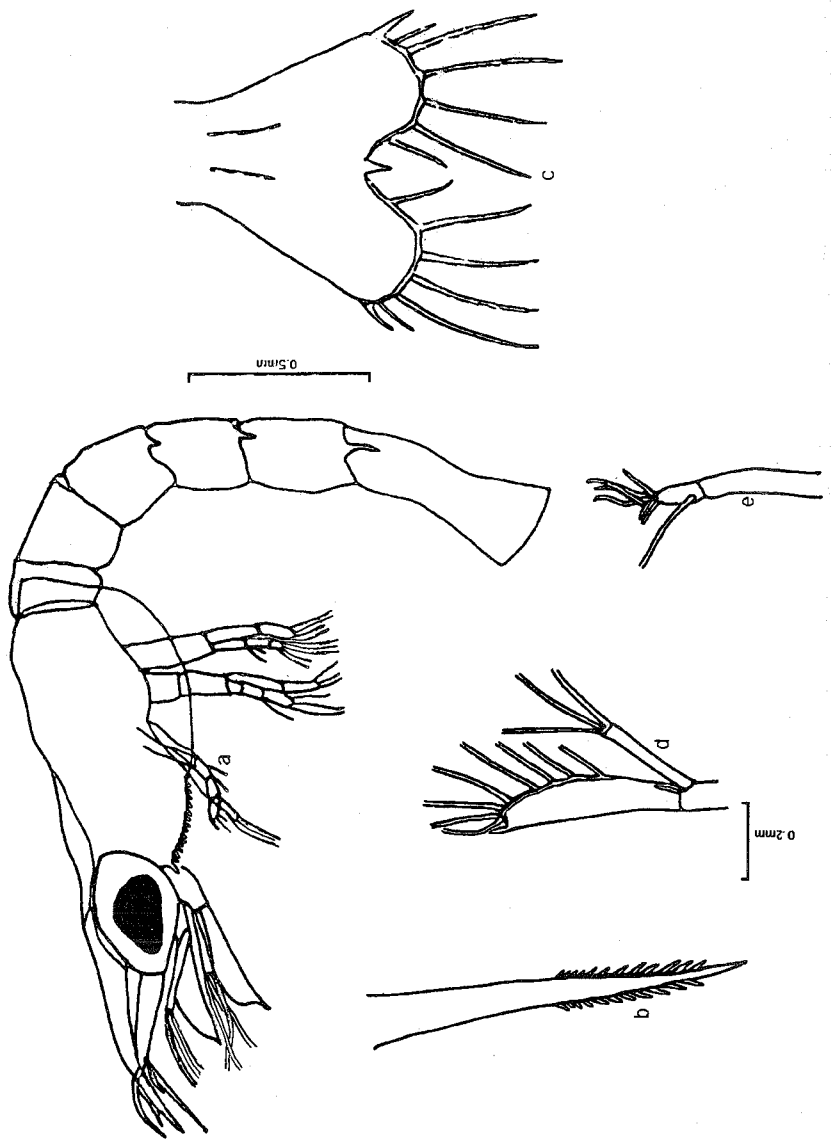

Fig. 5. *Callianassa* sp. Aqaba 4, zoea I. a, lateral view; b, rostrum; c, telson; d, antennule; e, antenna.

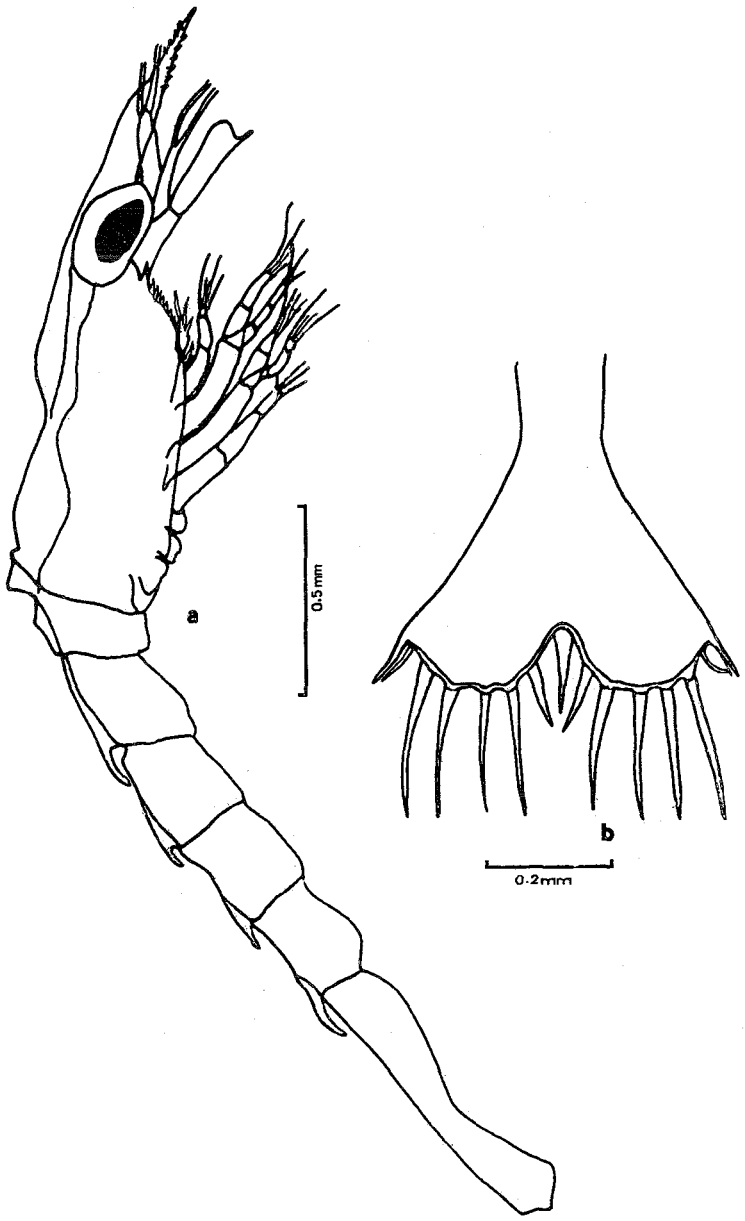

Fig. 6. *Callianassa* sp. Aqaba 5, zoea I. a, lateral view; b, telson.

somites and a telson; somite 2-5 with short dorsal spine; that of fifth somite relatively longer. Telson (fig. 6b) triangular; posterior edge with deep notch and fairly long median spine. A total of 7 + 1 + 7 telson processes: the outermost ones bifid spines, second ones hair-like, and 5 + 5 stout setae.

Callianassa sp. Aqaba 6 (fig. 7a-e)

Zoea I, 2.80 mm. Carapace (fig. 7a), with long, flattened rostrum, slightly wider than that of the previous species, and with denticulations distally on each side (fig. 7b). A pterygostomial spine and 16 antero-lateral carapace denticles are present. Abdomen (fig. 7a, c), with five free somites and telson; somite 6 still fused with telson. Somites 2-5 with a large dorsal spine; that of somite 2 longer and overlapping somite 3 and 2/3 the length of somite 4. Telson (fig. 7c) broad and convex, with two short anterior carinae; posterior edge with a notch and a short median spine. A total of 7 + 1 + 7 telson processes: outermost ones are spines, second ones hair-like, and 5+ 5 setae.

Antennule (fig. 7d), long and unsegmented peduncle with conical exopod, tipped with two aesthetascs and three setae. Endopod present as a long seta with setules.

Antenna (fig. 7e), endopod about half length of scale, tipped with two long setae. Scale (= exopod) with apical spine and 8 long, plumose setae on the inner and distal margins. One short spine arising from antennal peduncle.

Callianassa sp. Aqaba 7 (fig. 8a-e)

Penultimate zoeal stage, 4.20 mm. Carapace (fig. 8a), with long, flattened and serrated rostrum (fig. 8a'); pterygostomial spine and 6 antero-lateral carapace denticles. Abdomen (fig. 8a), with six somites and telson. No dorsal spines on abdominal somites 1-5. Somite 6 with mid-dorsal spine posteriorly and mid-ventral (anal) spine of similar length. Telson (fig. 8b) rectangular, with prominent median spine included in a total of 8 + 1 + 8 processes: outermost ones lateral spines, arising at 2/3 the length of the telson; 2nd-4th also spine-like: 2nd short, 3rd and 4th of increasing length, 3rd at angle, 4th on posterior margin; 5th-8th in the form of stiff setae.

Antennule (fig. 8c), two-segmented peduncle: proximal segment long and bearing 4 short and 2 thin setae on the inner and distal margins, and one long seta on the outer side distally. Distal segment short with two inner marginal setae. Endopod short with two short and one long setae. Exopod conical, tipped with three aesthetascs and three setae.

Antenna (fig. 8d), with short endopod, about half the length of the scale; scale (= exopod) with strong inner, curved apical spine and 10 long plumose setae on the inner and distal margins. A strong spine, 2/3 the length of the endopod, arising from the antennal peduncle.

Pereiopods present but not developed.

Pleopods present as large buds.

Uropods (fig. 8e), well developed: exopod with stout outermost spine and 10 marginal setae; endopod with 8 marginal setae.

Discussion Callianassidae

Since Gurney (1942) the knowledge of the larval stages has been very little advanced. Gurney (1937, 1942) distinguished two types: type I represented by *Callianassa subterranea* (Montagu, 1808) (very long and flattened rostrum with

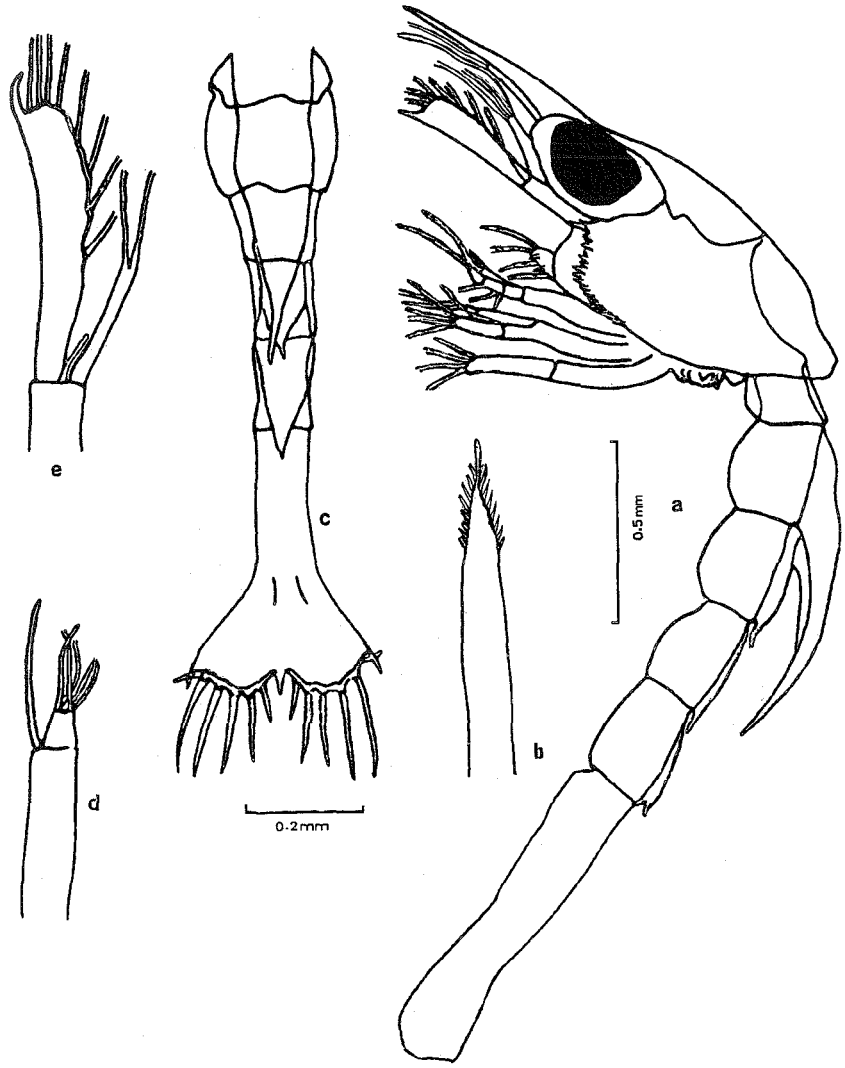

Fig. 7. *Callianassa* sp. Aqaba 6, zoea I. a, lateral view; b, rostrum; c, abdomen and telson; d, antennule; e, antenna.

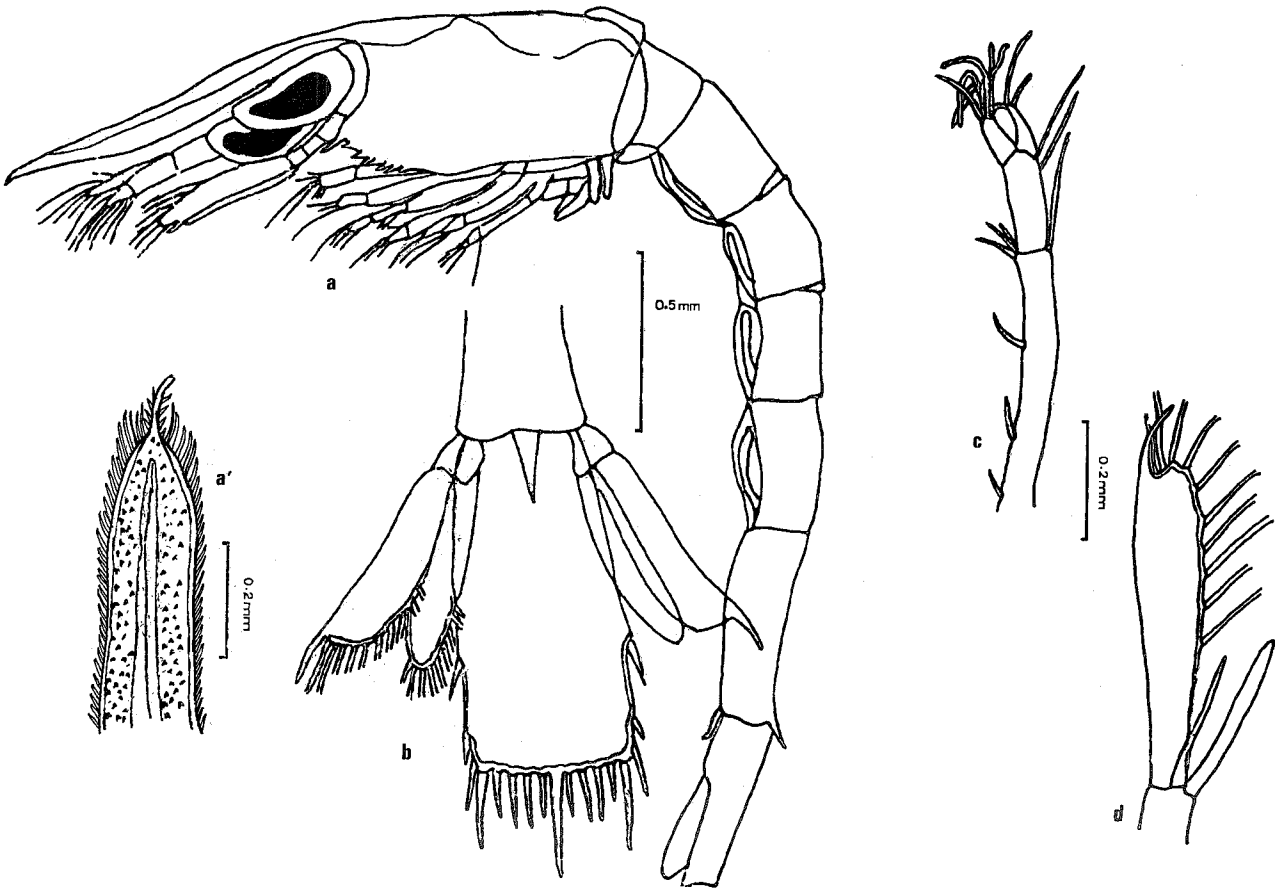

Fig. 8. *Callianassa* sp. Aqaba 7, penultimate zoeal stage. a, lateral view; a', rostrum; b, telson; c, antennule; d, antenna.

lateral denticulations; 2nd abdominal somite with a large dorsal spine; third, fourth and fifth abdominal somites with dorsal denticulate ridge; a triangular telson shape with a large median spine on the posterior edge). Type II as *Callianassa laticauda* Otto, 1828 (= *C. stebbingi* Borradaile, 1903 = *C. tyrrhena* (Petagna, 1792)) (long, flattened, and serrated rostrum; abdominal somites 2-4 with dorsal spines; very broad and convex telson with a total of 14 + 14 telson processes and a short median spine on the posterior edge). Most of the larvae referred to type I seem to be close to the genera *Callianassa, Callichirus* and *Calliax* De Saint Laurent, 1974. Williamson (1982) attributed Claus's larva, described by Claus (1876) as *Callianassa subterranea* and by Gurney (1942, fig. 98I, K) as *Callichirus* sp., to another taxon, viz., *Calliax* sp.

In a previous paper, Vaugelas et al. (1986) described Zoea I of *Callichirus armatus* (A. Milne Edwards, 1870) obtained from laboratory rearing in French Polynesia. Comparison of larvae of *C. armatus* and *C. laurae* De Saint Laurent, 1984 shows some small differences: the telson of *C. armatus* is distinctly triangular with an acute median spine on the posterior edge, while that of *C. laurae* is more rounded and plate-like, with a very marked notch and a reduced median spine. Basing himself on adult taxonomy Manning (1987) concluded that *Callichirus armatus* and *C. laurae* are the same species and both are identical with *Glypturus acanthochirus* Stimpson, 1866. But, for De Saint-Laurent (in litt.) these two species are closely related but distinct (cf. Vaugelas, 1990, after pers. comm. by De Saint-Laurent in 1987). However, as has been shown above, the zoeal stage I of these two species (i.e., *C. armatus* and *C. laurae* sensu De Saint-Laurent, 1973) have a clearly different telson shapes, which would support separation as suggested by De Saint-Laurent (1973).

Almost all the calianassid larvae described in this paper are very different from each other. There is still much confusion about the taxonomy of the callianassid adult genera and as the larval descriptions are very poor, the distinction between the type I and type II larval features of genera as stated by Gurney (1942) seems to be obsolete. It is thus very difficult to assign a generic name to any larval stage. Furthermore, comparison of the zoeal I larval stage described here as *Callianassa* sp. Aqaba 5, with the corresponding stage of *Callichirus* sp. aff. *jousseaumei* (Nobili, 1904) as obtained from rearing in laboratory conditions (Vaugelas, unpublished data), suggest that these are the same species.

We conclude, that definitive generic identification of these callianassid larval stages is not possible.

Upogebiidae Borradaile, 1903

Upogebia sp. Aqaba 8 (fig. 9a-c)

Zoea II, 2.88 mm. Carapace (fig. 9a) longer than broad; rostrum almost as long as antennular peduncle. Abdomen (fig. 9a) with five somites and telson;

somite 5 with a pair of small dorso-lateral projections and two dorsal spines. Telson (fig. 9a) broader than long; posterior edge with short median spine and a total of 8 + 8 telson processes: the outermost ones small spines, the second ones hair-like, and 6 + 6 setae.

Antennule (fig. 9b), a long unsegmented peduncle with two inner marginal setae and two terminal short setae on outer margin. Exopod conical, ending in 4 aesthetascs and 3 setae. Short endopod tipped with one long seta.

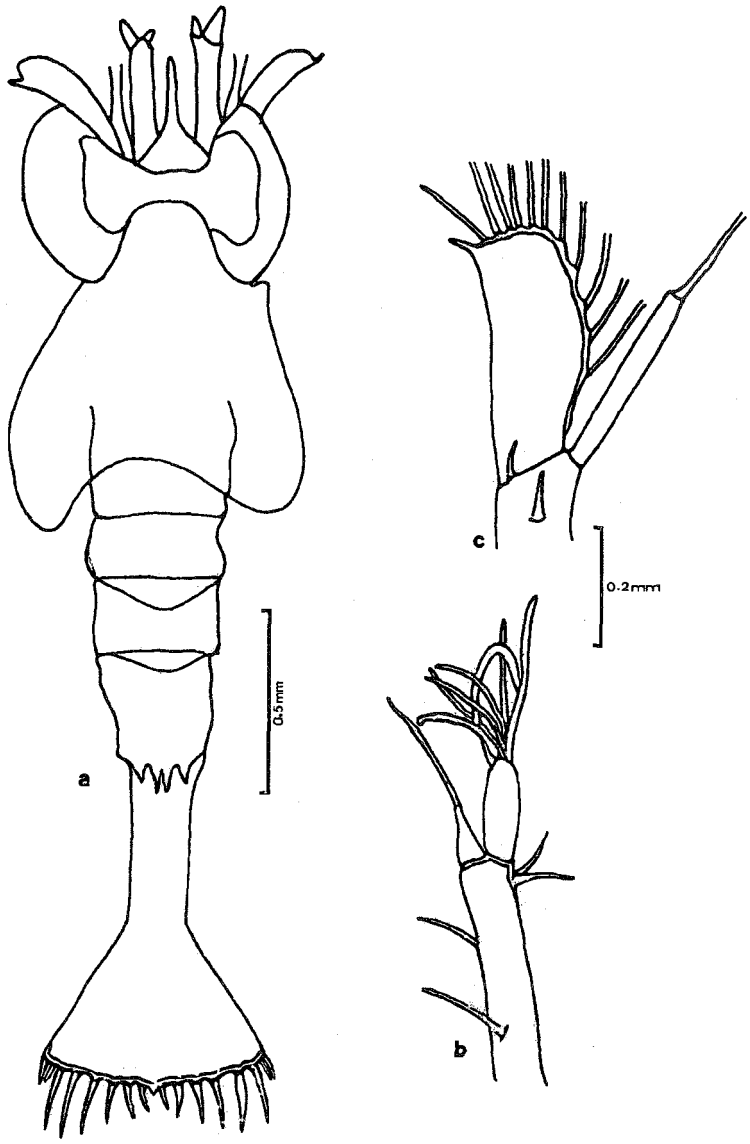

Fig. 9. *Upogebia* sp. Aqaba 8, zoea II. a, dorsal view; b, antennule; c, antenna.

Antenna (fig. 9c), basis with one submarginal and one terminal small spine. Endopod about 2/3 the length of the scale, ending in one long seta. Scale (= exopod) with one outer apical spine, one smooth and 10 plumose setae on inner and distal margins.

Upogebia sp. Aqaba 9 (fig. 10a-c)

Zoea III, 2.72 mm. Carapace (fig. 10a) longer than broad; rostrum slightly shorter than antennular peduncle. Abdomen (fig. 10a) with six somites and telson. Somites 4-6 each with a pair of dorso-lateral projections; those of fifth somite slightly longer than the others. Telson (fig. 10a) longer than broad; posterior edge straight with a median short spine included in a total of 7 + 1 + 7 telson processes: two short outer marginal spines, one immovable and fairly large spine, and 4 + 4 short setae.

Antennule (fig. 10b) with long peduncle with 4 long setulose setae on the inner margin and a bunch of 3 setae in the middle of the outer margin. Endopod with pointed tip. Exopod conical, ending in one aesthetasc and three setae.

Antenna (fig. 10c), endopod slightly longer than exopod, without setae. Scale (= exopod) with one external apical spine and one smooth and 11 long plumose setae on inner and distal margins.

Uropods biramous, not articulated; no endopodal setae.

Undetermined Thalassinidea

Some larval specimens in stages I and II belonging to the same larval form and named Thalassinidea Aqaba 10, and others in stage IV named Thalassinidea Aqaba 11, are described.

Thalassinidea sp. Aqaba 10 (fig. 11a-c)

Zoea II, 3.00 mm. Carapace (fig. 11a) longer than broad, with fairly long rostrum. Short stalked eyes. Abdomen (fig. 11a) with five free somites and telson; somite 6 still fused to the telson. Somites 2-5 each with a pair of lateral projections. Telson triangular with short median spine making up a total of 8 + 1 + 8 processes on posterior edge: the outermost ones short spines, the second ones hair-like, and 6 + 6 setae.

Antennule (fig. 11b), long antennular peduncle with 3 terminal and 3 mid-outer setae. Endopod as one long, plumose seta. Exopod conical, tipped with 4 aesthetascs.

Antenna (fig. 11c), endopod 2/3 the length of the scale, ending in 3 long plumose setae. Scale (= exopod) with one external apical spine, one smooth and 12 long plumose setae on inner and distal margins.

Thalassinidea sp. Aqaba 11 (fig. 12a-d)

Zoea IV, 3.56 mm. Carapace (fig. 12a) longer than broad, with rostrum as long as antennule and antenna; short-stalked eyes. Abdomen (fig. 12a) with six

somites and telson. Somites 3-6 each with a pair of ventrolateral projections; somite 6 bears one dorsal and one ventral spine. Telson (fig. 12b) broader than long, rectangular, with a short median spine and a total of 8 + 1 + 8 marginal processes: 1st-3rd short lateral spines, 4th a long, fused spine, 5th-8th stiff setae.

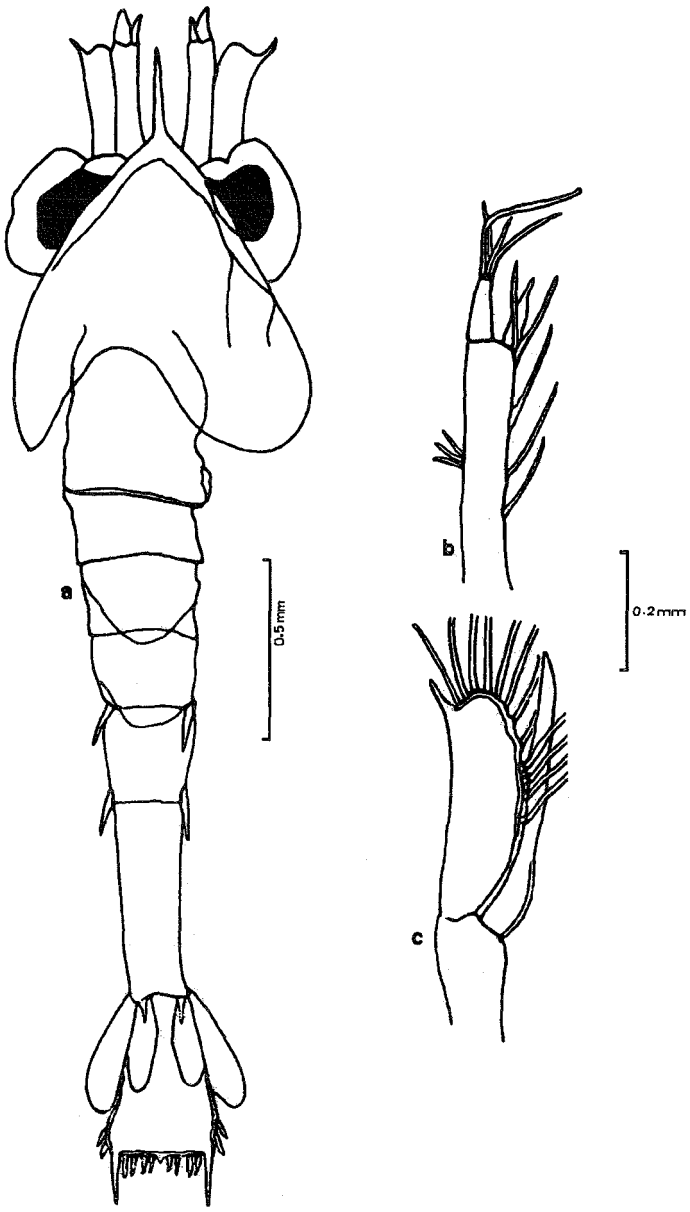

Fig. 10. *Upogebia* sp. Aqaba 9, zoea III. a, dorsal view; b, antennule; c, antenna.

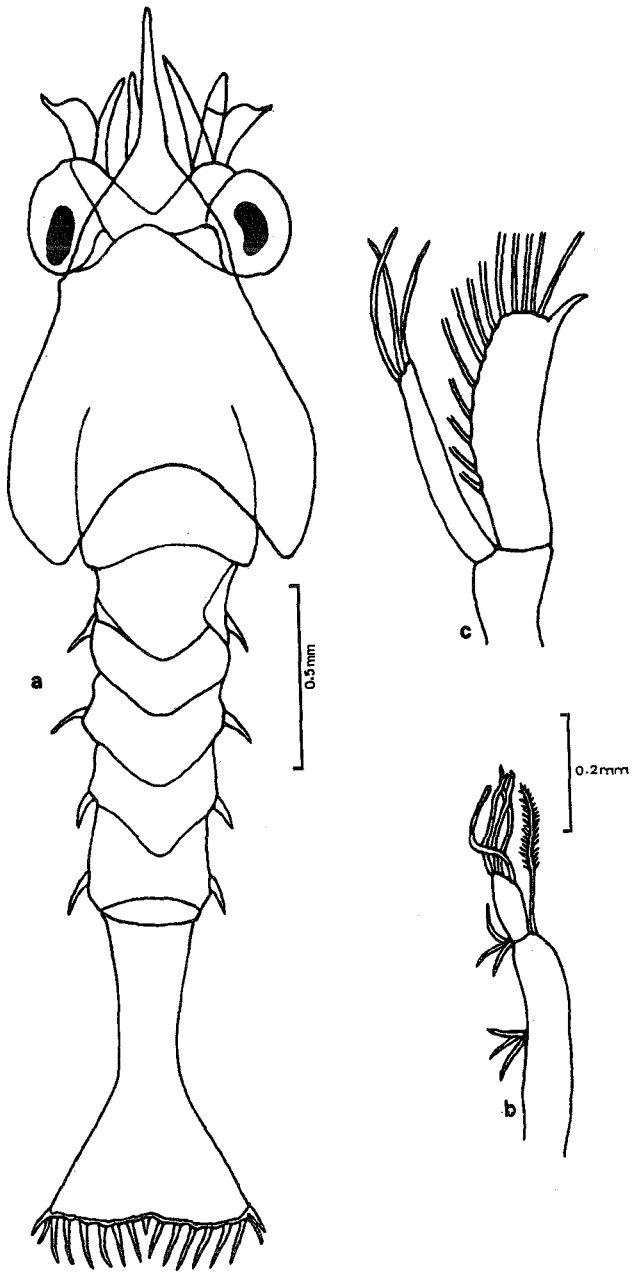

Fig. 11. Thalassinidea Aqaba 10, zoea II. a, dorsal view; b, antennule; c, antenna.

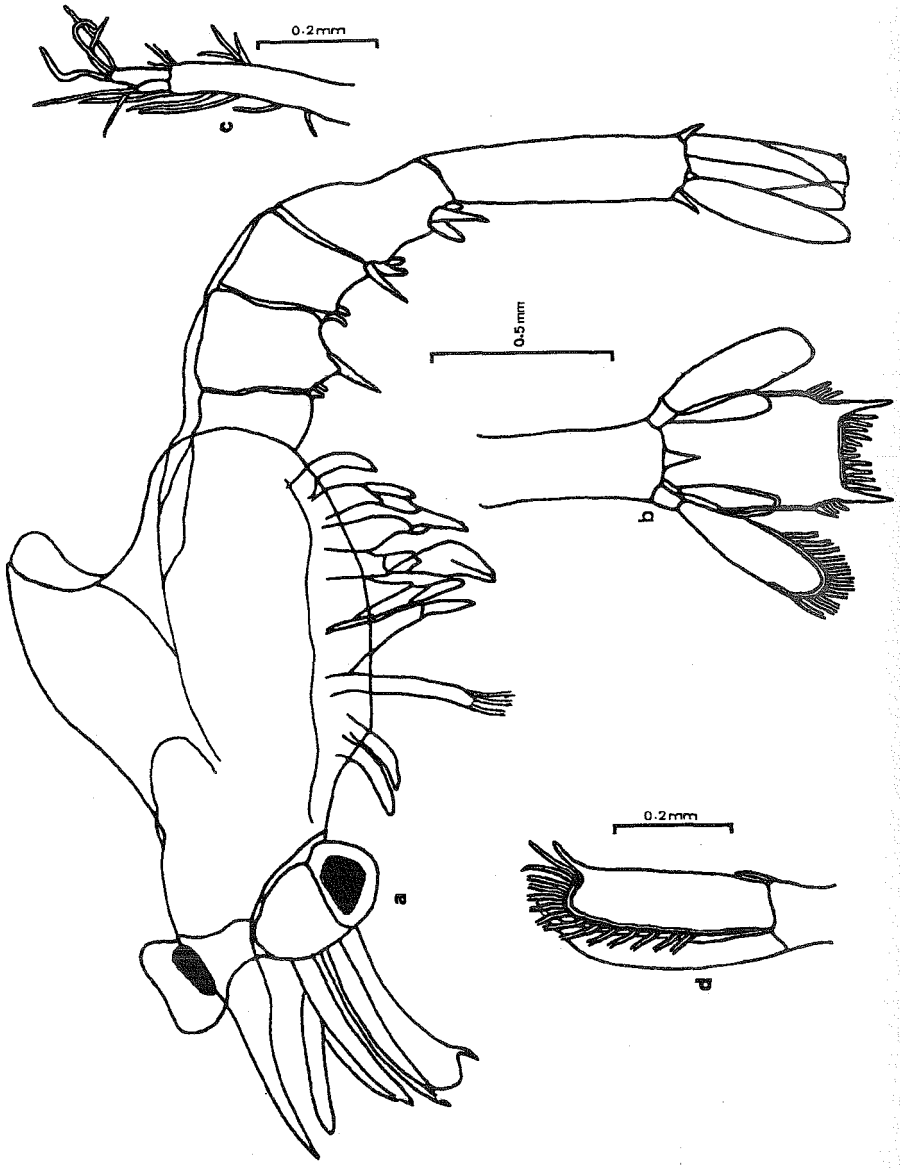

Fig. 12. Thalassinidea Aqaba 11, zoea IV. a, lateral view; b, telson and uropods; c, antennule; d, antenna.

Antennule (fig. 12c), long peduncle with 3 distal and 3 medial setae on outer margin and two short proximal, two long medial, and one long distal setae on inner margin. Exopod conical, tipped with 4 aesthetascs and one inner seta. Endopod smaller, conical, ending in one long seta with setules.

Antenna (fig. 12d), endopod slightly longer than scale (= exopod) tipped with one short spine. Scale with one external apical spine, one smooth and 13 long plumose setae. One short outer spine arising from antennal peduncle.

Pleopods present as buds.

Uropods biramous (fig. 12b), protopod present but undeveloped. Exopod with 12 plumose setae. Endopod without setae.

Discussion undetermined Thalassinidea

Besides the common features of a great number of upogebiid larvae (Gurney, 1942), the main features of the upogebiid larvae described in this paper are the presence of spines on different abdominal somites. These features have been seen in *Upogebia affinis* (Say, 1818) (cf. Sandifer, 1973) which has a pair of lateral spines on the fifth abdominal somite and a pair of small medio-dorsal spines on the sixth somite, in thalassinid larva N°5 (*Upogebia* sp?) (cf. Dakin & Colefax, 1940) with a pair of dorso-lateral spines on the fifth abdominal somite, in *Upogebia* BR II (cf. Gurney, 1938), and in *Upogebia* EA8 (cf. Seridji, 1989, and unpublished data).

These characters do not seem to constitute diagnostic features of upogebiid larvae but are of use rather as distinctive "larval species" characters. Thalassinidea Aqaba 10 and Thalassinidea Aqaba 11 have some resemblance with laomediid DI described by Gurney (1938, fig. 38). The latter thalassinid larva has pleopods as buds while an undeveloped protopod of the uropods suggests that the number of larval stages is more than six.

The presence of exopods on pereiopods 1-4 is a distinctive feature of the Laomediidae. The presence of a long rostrum, wider at the base, a short neck, an apical antennal scale spine, and a median spine on the telson's posterior edge, place these larval Thalassinidea specimens very close to Laomediidae of the "second group" Ngoc-Ho (1981). However, the larvae described here differ from identified larvae of the Upogebiidae and from Ngoc-Ho's "second group" Laomediidae in having lateral spines on most abdominal somites. Thalassinidea Aqaba 10 and Thalassinidea Aqaba 11 appear to be intermediate between the Laomediidae and the Upogebiidae in morphology.

Anomura MacLeay, 1838

From the point of view of larval morphology, MacDonald, Pike & Williamson (1957) separated Diogeninae and Pagurinae and considered them as two main independant lines: Coenobitoidea with Coenobitidae, Diogenidae... and

Paguroidea with Lithodidae, Paguridae... This view has been accepted by Bowman & Abele (1982), and it is used in this paper.

Larval descriptions are presented on Galatheidae and Diogenidae.

Galatheidae Samouelle, 1819

According to Lewinsohn (1969), thirteen species of the genus *Galathea* Fabricius, 1793 and three of the genus *Munida* Leach, 1820 occur in the Red Sea. But the larval development of this group is virtually unknown, except for *Galathea longimana* Paulson, 1875 which has been described by Gurney (1938).

Galathea sp. Aqaba 12 (fig. 13a-b)

Zoea IV, 4.20 mm. Carapace (fig. 13a) with a long, broad, and tapered rostrum, armed on each side. Posteriorly directed spines on postero-lateral carapace margin on each side, reaching third abdominal somite. Carapace margin with small denticulations becoming more acute on the postero-lateral side. Abdomen (fig. 13a) with six somites and telson. Fourth somite with a pair of lateral projections. Fifth with three sharp dorsal spines and a pair of lateral projections reaching to 1/3 the length of somite 6. Sixth somite with one medio-dorsal spine. Telson longer than broad, with a total of 8 + 8 telson processes: the outermost ones acute spines, the second ones hair-like, the third ones longer, the fourth ones immovable spines, and 4 + 4 setae.

Antennule (fig. 13b) with long peduncle bearing two short setae on the mid-outer side and one other on inner distal portion. Exopod conical, tipped with 4 aesthetascs and 5 thin setae on inner margin. Endopod a glabrous segment, about 2/3 the length of the exopod. One long seta arising from antennular peduncle, located between exopod and endopod.

Antenna (fig. 13a) slender scale (= exopod), tapering to acute tip, with two short denticles on outer margin and 14 long plumose setae on inner margin. Endopod 2/3 the length of the scale, tipped with one seta and one short spine.

Galathea sp. Aqaba 13 (fig. 14)

Zoea III, 3.20 mm. Carapace (fig. 13), rostrum conical at base, with large spinules, ending in long spine. Lateral carapace denticles and posteriorly directed spine on postero-lateral carapace margin on each side. A conspicuous posterior fold with thin lateral denticles and seven smooth spines on posterior edge.

Abdomen (fig. 14) with six somites and telson. Pairs of acute lateral projections on fourth and fifth somites, those of fifth somite slightly longer. Telson longer than broad, with a total of 8 + 8 telson processes: the outermost ones acute spines, the second ones hair-like, the fourth ones longer, immovable spines, and 5 + 5 setae.

Antenna (fig. 14), scale (= exopod) tapering distally to a curved spine, with 15 inner long plumose setae and numerous spinules dorsally. Endopod 2/3 the length of the scale, tipped with a minute, rounded spine.

Uropods biramous, endopod glabrous and undeveloped. Exopod slender, tapering distally as a curved spine with 10 inner long plumose setae.

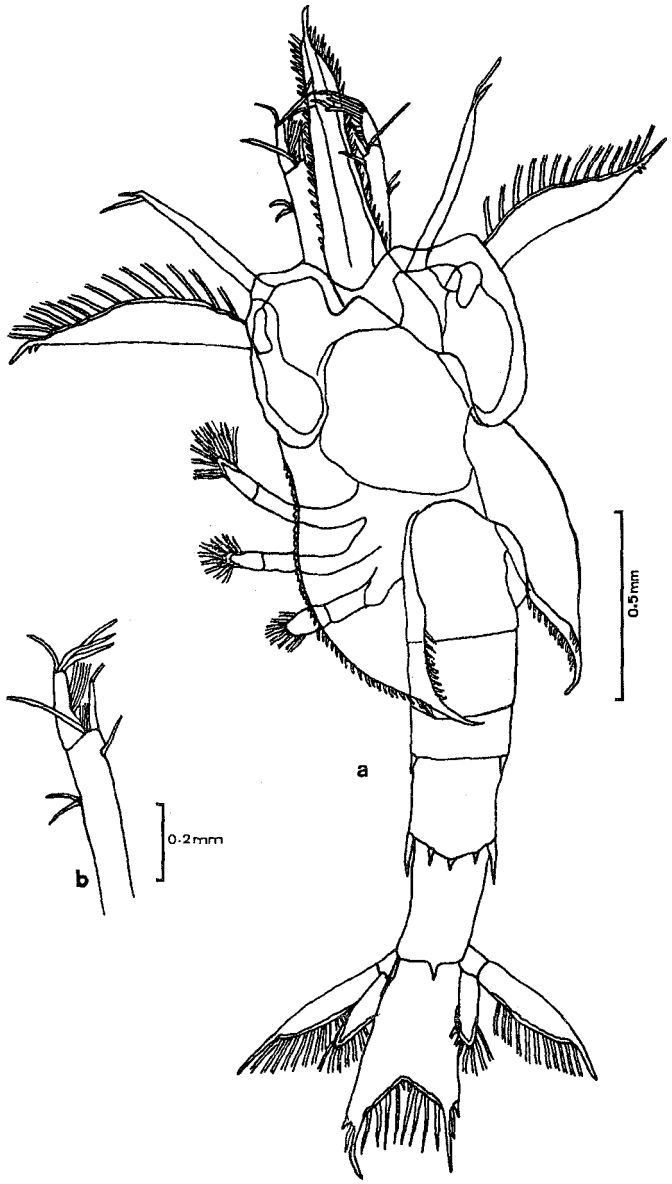

Fig. 13. *Galathea* sp. Aqaba 12, zoea IV. a, dorsal view; b, antenna.

Discussion Galatheidae

The main features of these larvae are those of Galatheidae as established by Gurney (1942). Otherwise, the rostrum shape and the carapace characteristics make us hesitate to include them in the genus *Galathea*. Larval descriptions are known for the following genera: *Galathea* Fabricius, 1793 (cf. Sars, 1889; Lebour, 1930, 1931; Pike & Williamson, 1972; Gore, 1979; Christiansen 1990); *Munida* Leach, 1820 (cf. Sars, 1889; Lebour, 1930, 1931; Rayner, 1935; Pike &

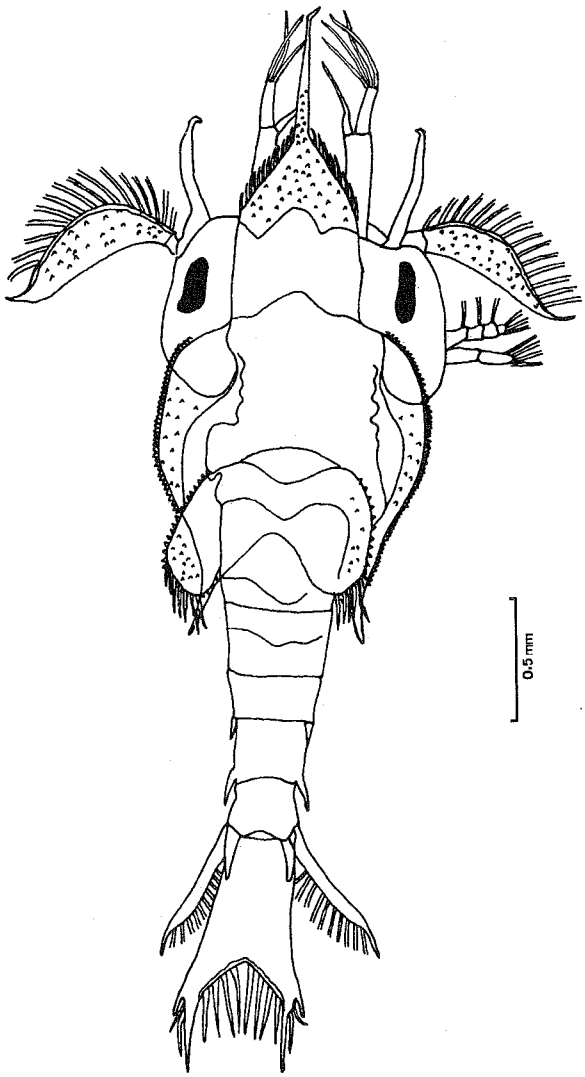

Fig. 14. *Galathea* sp. Aqaba 13, zoea III. dorsal view.

Williamson, 1972; Roberts, 1973); *Munidopsis* Whiteaves, 1874 (cf. Sars, 1889; Samuelsen, 1972; Pike & Williamson, 1972), *Cervimunida* Porter, 1903 (cf. Fagetti, 1960); and *Pleuroncodes* H. Milne Edwards, 1837 (cf. Fagetti & Campodonico, 1971).

The larvae of species of all these genera share several features that indicate close relationships. However, larvae of *Munidopsis* seem to be distinctive by the form of rostrum, carapace, and telson. Those of *Cervimunida* are more spinose and have some resemblance to those of *Pleuroncodes* and *Munida.* Galatheidae larvae described in this paper are different from all known described larvae and may belong to an unknown genus. As *Bathymunida* Balss, 1914 occurs in the Red Sea and its larvae are unknown, one of these larvae might belong to this genus. These larvae have been caught in the surface plankton over deep water (200-850 m) in the centre of the Gulf of Aqaba.

Differences in some larval species of different genera are given in table II.

Diogenidae Ortmann, 1892

All genera of this family occur in the Red Sea: *Diogenes* Dana, 1851, *Calcinus* Dana, 1851, *Clibanarius* Dana, 1852, *Dardanus* Paulson, 1875, and *Paguristes* Dana, 1851. Larval development is known for all the Mediterranean species of these genera but this is not the case for the Red Sea species; so, it is still difficult to link larvae to adults.

Diogenes Dana, 1851

Only two larval species have been caught, one in stages I, II, and III, the second one in stages I-IV.

Diogenes sp. Aqaba 14

Stages I-III are not figured, but the main features of these larvae are the absence of dorsal spines on abdominal somites 3-4. The fifth somite bears one short medio-dorsal and two lateral spines. These specimens resemble *Diogenes* sp. 1 Menon from the Madras plankton (Menon, 1937).

Diogenes sp. Aqaba 15

Larval stages I-V are not illustrated. Nevertheless, they are distinguished from the above zoeal stages by prominent lateral and dorsal spines on the fifth abdominal somite.

Calcinus Dana, 1851

Calcinus sp. Aqaba 16 (fig. 15a-d)

Zoea IV, 3.32 mm. Carapace (fig. 15a) longer than broad, with a long, carinated rostrum, reaching beyong the antenna. Two posteriorly directed

TABLE II

Comparison of zoea larval stage I of some species of different galatheid genera

SPECIES Characters	*G alathea intermedia* (Christiansen & Anger,1990)	*Munida subrugosa* (Roberts,1973)	*Pleuroncodes monodon* (Fagetti & Campodonico, 1971)	*Cervimunida johni* (Fagetti, 1950)	*Munidopsis tridentata* (Samuelsen, 1972)
Carapace					forwardly directed spine on antero lateral margin.
Posterior spines	not reaching as far as anterior margin of 3rd abdominal somite	prominent spines	reaching distal margin of 4th abdominal somite	extremely elongate reaching 5th abdominal somite	absent
Posterolateral denticulations	approximately 10-12 denticles each side	30-35 outside denticles and 18-20 inside spinules each posterior spine	inside denticles each posterior side	posterolateral and posterior margins denticulate each side	denticles on posterior and lateral margins each side
Rostrum	well developed	elongate	well developed	elongate	broad,flattened,near ly spatulate with a tooth like process distally numerous denticles on lateral margins
proximal portion	unarmed	smooth	strongly serrated	armed	
distal portion	unarmed	serrated	strongly denticulate	armed	
Abdominal spines	small lateral spines on somite 5 ; small paired setae dorsally on somites 2-5	somite 1:row of small dorsal spines;somites 2-3:2 pairs of dorsal spines separated by small one.Somites 4-5:2 pairs of dorsal and 1 pair of lateral spines	somite 1 :denticulations on posterior margin. Somites 2-5:1 median and 2 pairs of dorsal spines. Somites 4-5:1 pair of lateral spines	somites 1-5 :dorsal denticulations somites 4-5:1 pair of lateral spines	somite 5 with pair of postero-lateral spines. somites 2-5:posterior margin with plumose setules on each dorso-lateral side
Telson	Triangular shape with U shaped median cleft; outermost process immovable spine	Narrow at basis and widening to the sharp and spinulose outer telson process	Narrow at basis and widening to the sharp and strongly denticulate outer processes	Deeply bifurcate and heavily armed outer processes	Broadly spatulate posterior margin with a small median cleft; outermost process immovable spine
Antennal	Tip produced into long spine	Tip produced into long spinulose spine	Tip produced into long spinous spine and serrated along whole outer margin	Elongate,acicul ate and spinned along outer margin	Tip produced into a slightly curved spinous spine

spines on posterior margin. Abdomen (fig. 15a) with six somites and telson. Somites 4-6 with a pair of small lateral projections. The fifth somite bears one acute medio-dorsal down-curved spine. Sixth one longer, with one medio-dorsal short spine. Telson (fig. 15b) longer than broad with a total of 9 + 9 posterior processes: the outermost ones fused spines, the second ones hair-like,

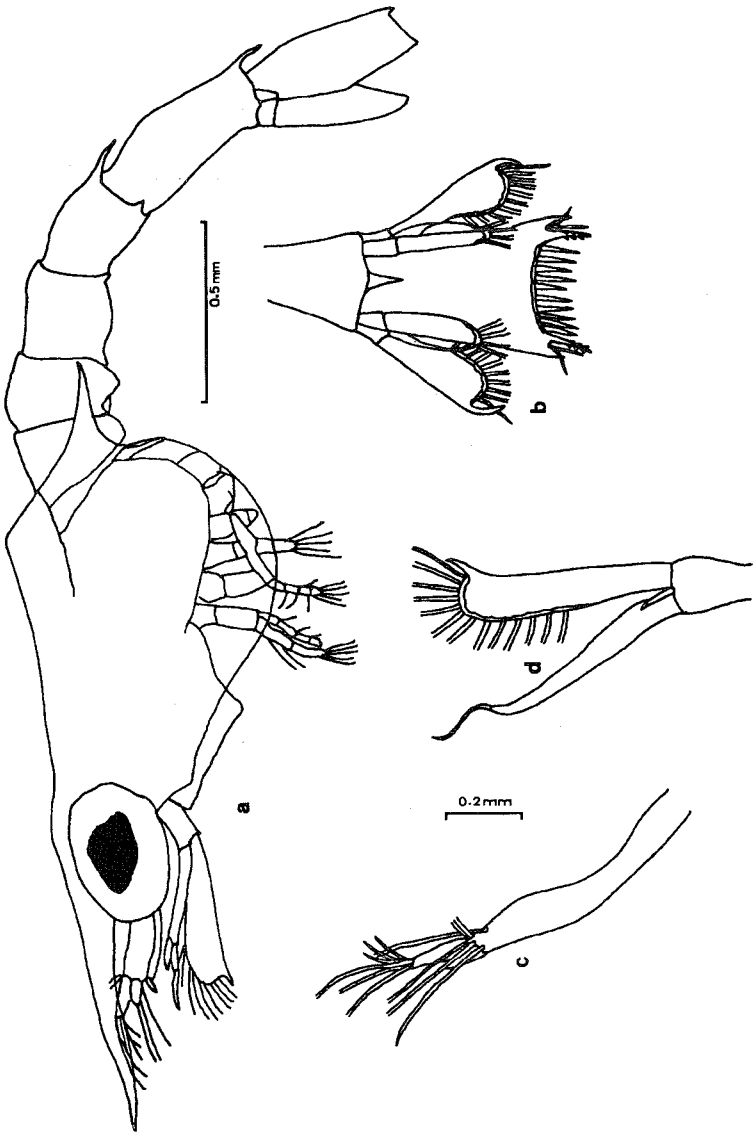

Fig. 15. *Calcinus* sp. Aqaba 16, zoea IV. a, lateral view; b, telson and uropods; c, antennule; d, antenna.

third ones thin setae, fourth ones long, fused spines, with spinules, and 5 + 5 setae.

Antennule (fig. 15c), long peduncle bearing distally a long submarginal seta. Short exopod with three fine setae located basally, and three long and three short terminal aesthetascs. Endopod a bud with three long setae on basis.

Antenna (fig. 15d), scale (= exopod) with one apical outer spine and 13 long plumose setae. The long endopod terminates in single seta. One acute spine located medially on distal end of antennal peduncle.

Maxilliped 1 not drawn, but with endopod of five segments with 5 terminal setae. Exopod bears 6 long setae.

Maxilliped 2 not figured; endopod of 4 segments; exopod ending in 6 long setae.

Maxilliped 3 uniramous with 5 setae (not represented here).

Discussion. — This zoea has the main features of the genus: two carapace spines directed posteriorly on the posterior edge; one medio-dorsal and two lateral spines on the fifth abdominal somite. Pike & Williamson (1960) illustrated five larval stages and one megalopa of *Calcinus ornatus* (Roux, 1830) (= *Calcinus tubularis* (L., 1767)). Provenzano (1962) described six larval zoeal stages and one megalopa of *C. tibicen* (Herbst, 1791), and he noted that under laboratory conditions the number of zoeal stages could reach eight. The *Calcinus* sp. Aqaba 16 larva in stage IV is more related to *C. tibicen* than to *C. ornatus*.

Diogenidae sp. Aqaba 17 (fig. 16a-d)

Zoea IV, CL: 2 mm; AL: 1.88 mm (CL = carapace length; AL = abdomen length). Carapace (fig. 16a) with long, carinate rostrum; two posteriorly directed spines on posterior carapace edge. Abdomen (fig. 16a) with six somites and telson, sixth somite longer; medio-dorsal spines increasing in size on somites 3-6. Fifth and sixth somites bear a pair of acute lateral spines. Telson (fig. 16d) longer than broad with a total of 10 + 10 telson processes: outermost ones fused spines, second ones hair-like, third ones thin setae; fourth ones fused spines, and 6 + 6 setae.

Antennule (fig. 16c), long peduncle bearing distally a long submarginal seta and two short inner setae. One short seta on medio-anterior inner margin. Endopod tipped with three aesthetascs and two short setae. Exopod a bud with three long aesthetascs at the base.

Antenna (fig. 16d), scale (= exopod) with one apical outer spine and 13 long plumose and one thin setae on inner and distal margins. Endopod a long segment ending in a long seta. Short spine between endopod and exopod.

Uropods (fig. 16b): protopod without spines. Exopod rather more than half as long as telson with a stout down-curved outermost spine and 11 long plumose setae. Endopod about half the length of the telson, with six long plumose setae.

Pleopods present as buds.

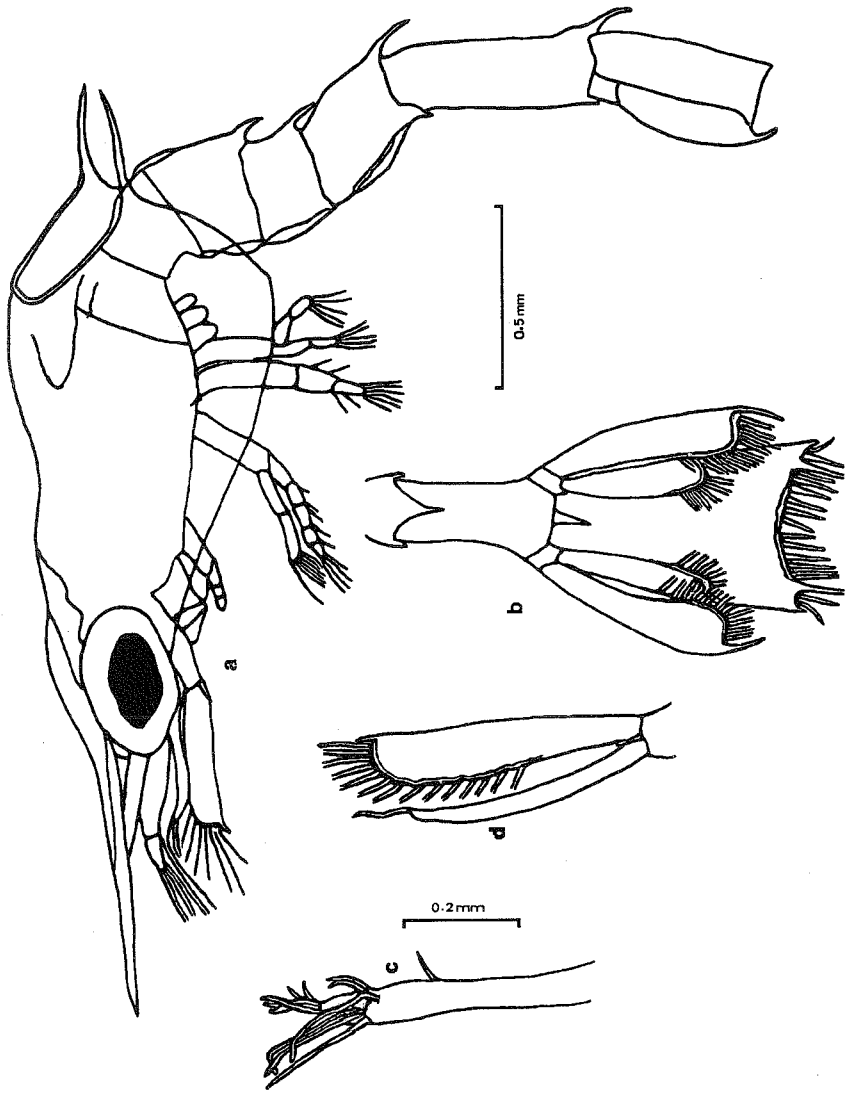

Fig. 16. Diogenidae sp. Aqaba 17, zoea IV. a, lateral view; b, telson and uropods; c, antennule; d, antenna.

Diogenidae sp. Aqaba 18 (fig. 17a-d)

Zoea III, CL: 1.40 mm; AL: 1.80 mm. Carapace (fig. 17a) identical to that of the previous specimens. Abdomen (fig. 17a) with six somites and telson. Somites 4-6 each with one medio-dorsal spine increasing in size on successive somites. Fifth somite with a pair of blunt lateral spines; sixth one with one ventral spine. Telson (fig. 17b) slightly longer than broad. Posterior margin almost straight, with a total of 9 + 9 telson processes: the outermost ones fused spines, second ones hair-like, third ones thin setae, fourth ones immovable spines, and 5 + 5 setae.

Antennule (fig. 17c), long peduncle with two setae on terminal outer margin and one submarginal and one lateral setae on distal inner margin. Short endopod with one long seta. Exopod about twice the length of the endopod, with one long and four short aesthetascs.

Antenna (fig. 17d), scale (= exopod) with one apical outer spine and 12 inner plumose setae. Endopod half the length of the exopod, with one long terminal seta. A strong spine on the protopod, located between exopod and endopod.

Uropods (fig. 17b) biramous: endopod unarmed, about half the length of the exopod. Exopod with 7 natatory plumose setae.

The absence of pleopods suggests that the number of larval stages is about five.

Discussion *Calcinus*

These two larval specimens have a combination of Coenobitidae and *Calcinus* characters: from the Coenobitidae they have the medio-dorsal spines on abdominal somites 3-5 or 2-5, which seems to be the rule in the genus *Coenobita* and allied forms. From *Calcinus* they have the two posteriorly directed spines on the posterior carapace edge, as well as a pair of lateral and medio-dorsal spines on somite 5 which are the main features of *Calcinus*. The larval development is known in *Coenobita clypeatus* (Herbst, 1791) (cf. Provenzano, 1962), in *C. rugosus* H. Milne Edwards, 1837, and *C. cavipes* Stimpson, 1858 (cf. Shokita & Yamashiro, 1986), and in *C. scaevola* (Forskål, 1775) (cf. Al Aidaroos & Williamson, 1989). All Coenobitidae larvae (including *Birgus latro* (L., 1767)) have the posterior carapace edge rounded and have from the zoeal stage III on one median spine on the posterior telson edge. Then, these two diogenid larvae (Diogenidae sp. Aqaba 17 and Diogenidae sp. Aqaba 18) should be the larvae of two other species of *Calcinus*. This allows us to recognize, including *Calcinus* sp. Aqaba 16, three larval species from the Gulf of Aqaba plankton. Lewinsohn (1969), who reviewed the Red Sea anomuran species, gives only two species: *Calcinus latens* (Randall, 1840) and *C. rosaceus* Heller, 1861. Most adults live in coral reefs, which makes it very difficult to catch them, probably one of the reasons why they are still unknown.

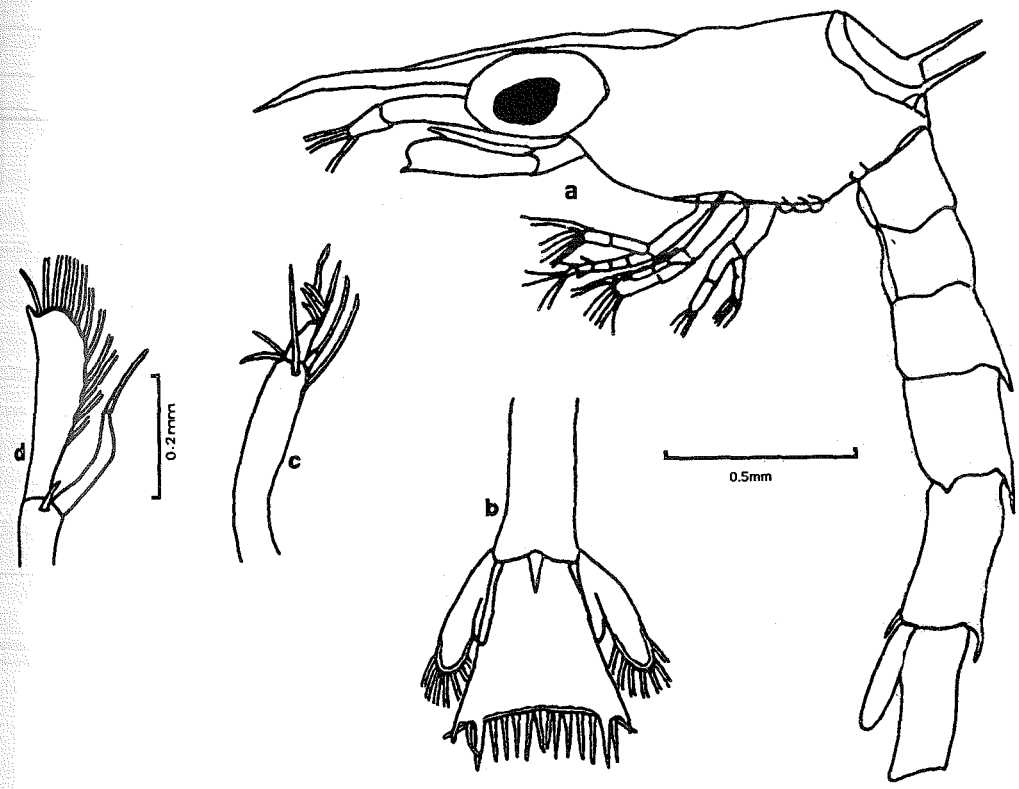

Fig. 17. Diogenidae sp. Aqaba 18, zoea III. a, lateral view; b, telson and uropods; c, antennule; d, antenna.

Clibanarius Dana, 1852

Clibanarius sp. Aqaba 19 (fig. 18a-d)

Zoea II, 2.6 mm (from tip of rostrum to posterior border of telson). Carapace (fig. 18a) with broad rostrum extending a little beyond both antennule and antenna. Posterior carapace edge rounded and smooth. Short stalked eyes. Some spicules on surface of rostrum and carapace. Abdomen (fig. 18b) with five globular somites and telson. Somites 3-6 with minute rounded lateral spines. Telson (fig. 18b) longer than broad, with a deep median notch and longitudinal ridge on either side. A total of 8 + 8 telson processes on posterior edge: the outermost ones short blunt spines, second ones hair-like, and 6 + 6 setae.

Antennule (fig. 18c) two-segmented: proximal segment with one inner and two outer lateral, terminal plumose setae; distal segment with four long and two short terminal aesthetascs.

Antenna (fig. 18d), scale (= exopod) without apical spine and bearing 11 long plumose setae on the inner and terminal margins. Endopod about half the

length of the scale, with two long and one short terminal setae. A strong spine on the protopod, located between scale and endopod.

Discussion *Clibanarius*

In its general aspect this larva resembles the mediterranean species *Clibanarius erythropus* (Latreille, 1818) (cf. Issel, 1910; Boraschi, 1921; Carayon, 1942; Dechancé & Forest, 1958; Pike & Williamson, 1960; Bourdillon-

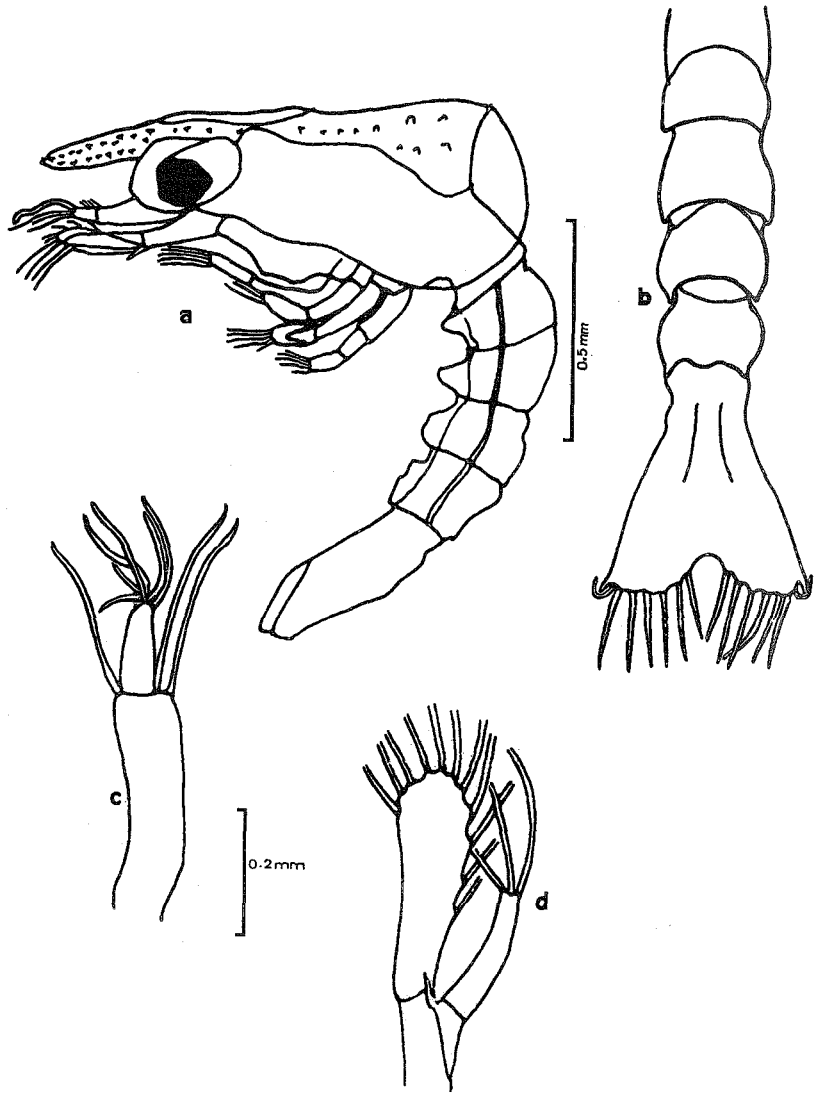

Fig. 18. *Clibanarius* sp. Aqaba 19. zoea II. a, lateral view; b, abdomen and telson; c, antennule; d, antenna.

Casanova, 1960) as well as *C. vittatus* (Bosc, 1802) (cf. Lang & Young, 1977), a common species of the south-eastern coast of the United States.

The comparison of this zoeal stage II to that of its congener *C. vittatus*, shows some common characteristics: broad rostrum with spinules, globular abdominal somites with minute lateral rounded spines, telson with a longitudinal ridge on each side. It differs from zoea II of *C. erythropus* in having somite 6 still fused to the telson. But, as there is no larval description available from this region of the Red Sea, where many species of *Clibanarius* are present, it is impossible to link this larval species to any adult.

Dardanus Paulson, 1875

Dardanus sp. Aqaba

These larvae are characterized by the absence of two lateral spines on the fifth abdominal somite. This character is shared by larval species described by Dechancé (1962) from the Red Sea. Larval development is known for *Dardanus arrosor* (Herbst, 1796) (cf. Kurata, 1968), also stage I of *Dardanus setifer* (H. Milne Edwards, 1836) has been described (cf. Nayak & Kakati, 1977). The zoeal stage V of the latter species has the following details: no scale-like structure on the surface of the cuticle; antennule with three aesthetascs and three setae; maxillule with an unsegmented palp and with two setae. This larva, like *D. arrosor*, has a basipodial lobe on maxilliped 1. Dechancé (1962) summarized the common features which seem to be characters of the *Dardanus arrosor* group: presence of basipodial lobe ending in a short spine; absence of coxopodial lobe of maxilliped 1, and loss of outer apical spine of antennal scale.

Paguristes Dana, 1851

Paguristes sp. Aqaba 20 (fig. 19a-d)

Zoea I, 2 mm (from tip of rostrum to posterior border of telson). Carapace (fig. 19a) with a long rostrum reaching beyond both antennule and antenna. Posterior carapace edge rounded and smooth. A stout pterygostomial spine on antero-lateral carapace margin. Sessile eyes. Abdomen (fig. 19a) with five somites and telson. A medio-dorsal spine, successively decreasing in size, on somites 2-5. The fifth somite bears a pair of strong lateral spines. Telson (fig. 19b) triangular, with a longitudinal ridge on either side and a total of 7 + 7 posterior telson processes: outermost ones fused spines, second ones hair-like, and 5 + 5 setae.

Antennule (fig. 19c) with endopod a long single seta and exopod with three aesthetascs and two setae on distal margin.

Antenna (fig. 19d), scale (= exopod) arched on outer side, with one apical external spine and 10 long plumose setae on inner margin. Endopod with two long and one short setae on distal margin. A stout spine arising from distal margin of peduncle.

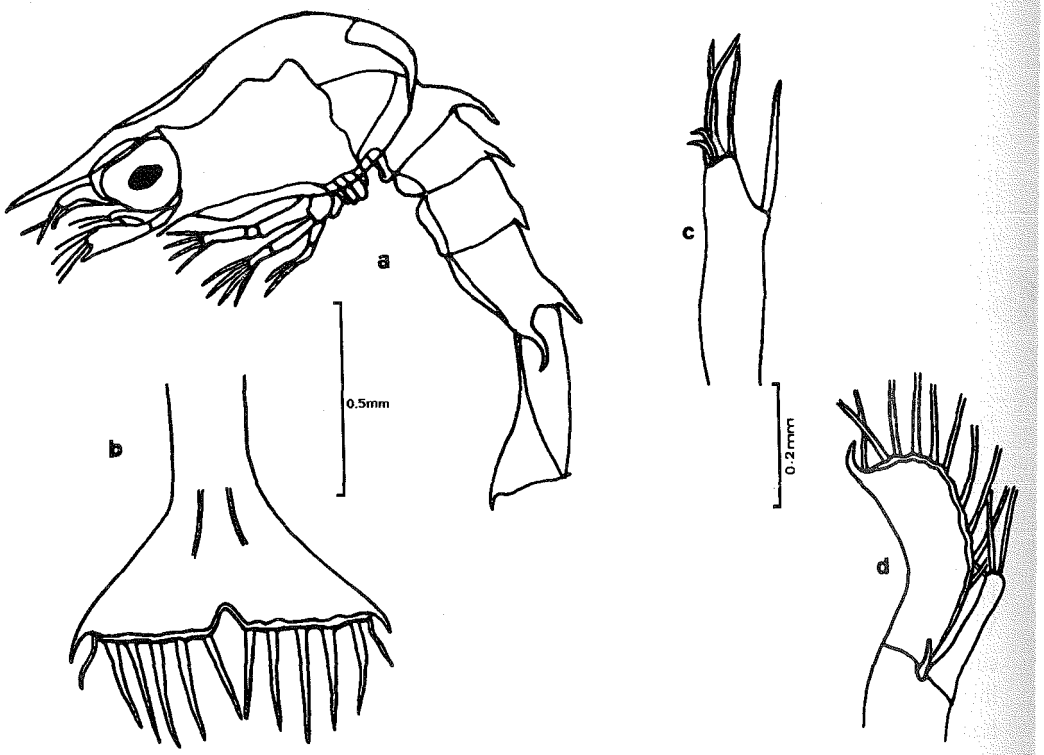

Fig. 19. *Paguristes* sp. Aqaba 20, zoea I. a, lateral view; b, telson; c, antennule; d, antenna.

Paguristes sp. Aqaba 21 (fig. 20a-d)

Zoea III, 3.40 mm (from tip of rostrum to posterior border of telson). Carapace (fig. 20a) with rostrum as long as antennule and antenna. A stout pterygostomial spine on external angle of carapace. Posterior carapace edge rounded and smooth. Abdomen (fig. 20a) with six somites and telson. Somites 3-5 with two short and acute dorsal spines. The sixth somite bears one short dorsal spine. Somites 2-4 with a pair of small lateral spines, those of fifth somite stronger. Telson (fig. 20b) long and broad, with a median thin seta on posterior border and a total of 8 + 8 posterior telson processes: outermost ones fused spines, second ones hair-like, third ones thin setae, fourth ones short, fused spines, and 4 + 4 other processes.

Antennule (fig. 20c) with peduncle bearing one inner, one median long, and two outer short setae on distal margin. Endopod with one terminal and one submarginal setae.

Antenna (fig. 20d) with scale (= exopod) slightly arched on outer side, one apical outer spine, and 11 long plumose setae on inner and terminal margins.

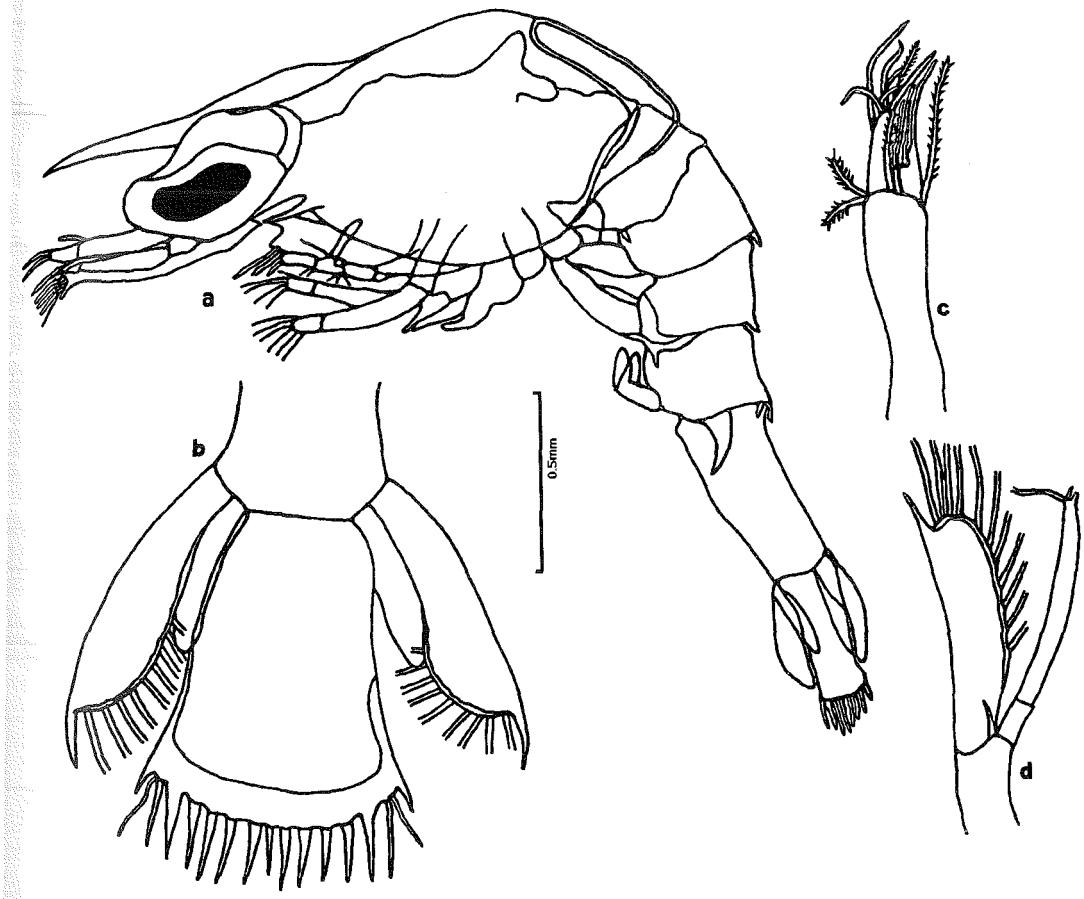

Fig. 20. *Paguristes* sp. Aqaba 21, zoea III. a, lateral view; b, telson; c, antennule; d, antenna.

Endopod two-segmented: distal segment longer with two short spines and one long seta on distal margin.

Pleopods present but not functional.

Uropods (fig. 20b) biramous but not articulated. Exopod about as long as telson with 9 plumose setae on the inner margin and one inwardly-curved spine at the external angle. Endopod half the length of the exopod, without setae.

Discussion *Paguristes*

Among numerous species of the genus *Paguristes* (more than 100, cf. Chace, 1951) widely distributed in the tropical marine waters, the larval development is known only for 7 species, namely: *Paguristes oculatus* (Fabricius, 1775) (= *P. eremita* (L., 1767)) (cf. Issel, 1910; Bourdillon-Casanova, 1960; Pike & Williamson, 1960), *P. turgidus* Stimpson, 1856 (cf. Hart, 1937), *P. sericeus* A. Milne

Edwards, 1880 (cf. Rice & Provenzano, 1965), *P. digitalis* Stimpson, 1858 (cf. Kurata, 1968), *P. abbreviatus* Dechancé, 1963 (cf. Dechancé, 1963), and *P. frontalis* (H. Milne Edwards, 1836) (cf. Morgan, 1987).

The main character of these species is to pass through a short larval planktonic life which never lasts more than a week. Most of them have three zoeal stages and one megalopa, except for *P. sericeus* (two zoeal stages) and *P. abbreviatus* and *P. frontalis* (without larval stages). Rice & Provenzano (1965) have compared the zoeal stages of different species of *Paguristes* and to facilitate the identification of planktonic larvae, they tentatively established some specific differences and some common generic features. For these authors the main generic features are the stout pterygostomial spine on the antero-lateral carapace margin and a pair of postero-lateral projections on the 5th abdominal somite. Although some characters are different among the descriptions of larval species, which could facilitate the determination, because of the great number of species of which the larvae are still unknown, an adequate comparison and consequently proper identification at the specific level are not possible until more detailed descriptions will have become available.

To facilitate the identification of Coenobitoidea larvae a key is given for some of the genera:

Key of identification of some Coenobitoidea genera

1. Posterior carapace margin with conspicuous backwardly directed spines ..... *Calcinus*
– Posterior carapace margin rounded and smooth 2
2. Broad, blunt rostrum reaching a little beyond antennal scale; antennal scale without apical and outer spine; abdominal somites without spines ..... *Clibanarius*
– Abdominal somites with postero-lateral spines 3
3. Antennal scale without apical and outer spine ..... *Dardanus*
– Antennal scale with terminal outer spine 4
4. Sharply pointed rostrum reaching tip of antennal scale; prominent pterygostomial spine; somite 5 with pair of postero-lateral spines ..... *Paguristes*
– No pterygostomial spine 5
5. Long rostrum; a pair of postero-lateral spines on fifth abdominal somite plus one medio-dorsal spine ..... *Diogenes*
– Rostrum broad at base; medio-dorsal spines on abdominal somites 2-5 or 3-5; a pair of postero-lateral spines on abdominal somite 5; a small median spine on posterior telson margin from zoea III ..... *Coenobita*

CONCLUSIONS

This collection of larval Decapoda shows that there are still many gaps in our knowledge of the fauna of the Gulf of Aqaba, and of the Red Sea in general, even regarding such comparatively large animals as the Thalassinidea and Anomura.

However, these larval descriptions show that the identification to subfamily or genus, or even species level, is not very difficult for most decapod crustacean larvae, but only laboratory rearing can assure correct understanding of larval-

adult relationships: Nevertheless, some interesting larval features have been pointed out in Upogebiidae as distinctive larval species characters. Thalassinidea Aqaba 10 and Aqaba 11 which share some features with the 2nd group of Laomediidae (Ngoc-Ho, 1981) on the one hand, and with Upogebiidae on the other, are in fact intermediate between these two families. Because we have very little knowledge about development of Callianassidae, a definite generic identification is not possible and a division of larval characters into Type I and Type II as stated by Gurney (1942) seems to be obsolete. Galatheidae larvae described in this paper are different from all known described larvae of *Galathea, Munida, Munidopsis, Cervimunida* and *Pleuroncodes*, but share several features and indicate close relationships among them. Among Anomura, Coenobitidae could be distinguished from Diogenidae by the presence of a median telson spine from the 3rd zoeal larval stage onward. In Diogenidae, some common features seem to be generic characters of the *Dardanus arrosor* group (Dechancé, 1962): presence of a basipodial lobe ending in a short spine, absence of a coxopodial lobe of maxilliped 1, and the loss of the outer apical spine of the antennal scale. In the genus *Paguristes* we agree with Rice & Provenzano (1965) that a stout pterygostomial spine on the antero-lateral carapace margin and a pair of strong postero-lateral projections on the fifth abdominal somite have generic significance. It is hoped that further studies both of the adult and larval Decapoda of different areas of the Red Sea will continue to take place.

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REFERENCES

Al Aidaroos, A. & D.I. Williamson, 1989. Larval development of the land hermit crab *Coenobita scaevola* (Forskål, 1775) (Crustacea: Anomura: Coenobitidae) reared in the laboratory. Journ. nat. Hist., London, **23**: 111-128.

Al Kholy, A.A., 1960. The larvae of some macruran Crustacea from the Red Sea. Publ. mar. biol. Sta. Ghardaqa, **11**: 73-86, pls. 1-7.

Al Kholy, A.A. & M.M. Fikry, 1967a. Some larval stages of *Callianassa* sp. and *Hippolyte* sp. Publ. mar. biol. Sta. Ghardaqa, **14**: 55-76, pls. 1-9.

—— & ——, 1967b. Some larval stages of *Sergestes* sp. and *Synalpheus biunguiculatus* (Stimpson). Publ. mar. biol. Sta. Ghardaqa, **14**.

Balss, H., 1957. Decapoda. VIII. Systematik. Bronn's Kl. Ordn. Tierreichs (ed. 2), **5**(1)(7)(12): 1505-1672.

Boraschi, L., 1921. Osservazione sulle larve dei crostacei brachiuri e anomuri. Mem. R. Talassogr. Italia, **87**: 1-32.

BOURDILLON-CASANOVA, L., 1960. Le méroplancton du Golfe de Marseille: les larves de Crustacés Décapodes. (Thèse Doct. d'Etat, N° 85, Univ. Marseille).

BOUVIER, E.L., 1914. Observations nouvelles sur les Trachelifers, larves luciféri formes de *Jaxea nocturna*. Journ. mar. biol. Ass., U.K., **10**(2): 194-206.

BOWMAN, T.E. & L.G. ABELE, 1982. Classification of the recent Crustacea: In: L.G. ABELE, (ed.), The biology of Crustacea, **1**. (Academic Press).

CANO, G., 1891. Sviluppo postembrionalle della *Gebia*, *Axius*, *Callianassa* e *Calliaxis*: morfologie dei Thalassinidi. Boll. Soc. nat. Napoli, (1)**5**: 5-30.

CARAYON, J., 1942. Sur le stade glaucothoe du genre *Clibanarius misanthropus* et sur l'établissement de la dissymetrie chez les pagures. Comparaison avec *Glaucothoe grimaldii*. C. r. Acad. Sci., Paris, **214**: 387-389.

CAROLI, E., 1924. Sviluppo larvale e primo stadio post larvale della *Jaxea nocturna* Nardo. Pubbl. Staz. zool. Napoli, **5**: 153-197.

CHACE, F.A., Jr., 1939. On the systematic status of the crustacean genera *Naushonia*, *Homoriscus*, and *Coralliocrangon*. Ann. Mag. nat. Hist., (11)**3**: 524-530.

——, 1951. The number of species of decapod and stomatopod Crustacea. Journ. Washington Acad. Sci., **41**: 370-372.

CHRISTIANSEN, M.E., 1990. Complete larval development of *Galathea intermedia* Lilljeborg reared in laboratory culture (Anomura: Galatheidae). Journ. crust. Biol., **10**(1): 87-11.

CLAUS, C., 1876. Untersuchungen zur Erforschung der genealogischen Grundlage des Crustaceen-system: 1-124 pls., 19, text-figs. 1-25.

——, 1884. Zur Kenntniss der Kreislaufsorgane der Schizopoden und Decapoden. Arb. zool. Inst. Univ. Wien, **5**(3): 271-318.

DAKIN, W.J. & A.N. COLEFAX, 1940. The plankton of the Australian coastal waters off New South-Wales, 1. Publ. Univ. Sydney, (Zool.) **1**: 1-215.

DECHANCÉ, M., 1962. Remarques sur les premiers stades larvaires de plusieurs espèces indo-pacifiques du genre *Dardanus* (Crustacés Décapodes Paguridae). Bull. Mus. natl. Hist. nat. Paris, (2)**34**(1): 82-94.

——, 1963. Développement direct chez un Paguride, *Paguristes abbreviatus* Dechancé et remarques sur le développement des *Paguristes*. Bull. Mus. natl. Hist. nat., Paris, (2)**35**: 488-495, figs. 1-13.

DECHANGÉ, M. & J. FOREST, 1958. Les glaucothoes de *Catapagurus timidus* (Roux) et de *Clibanarius erythropus* (Latreille). Remarque sur le stade post larvaire des Pagurides. Bull. Soc. zool. France, **83**(2/3): 274-293.

FAGETTI, E.G., 1960. Huevos y el primer estadio larval del langostino *Cervimunida johni* (Porter, 1903). Rev. Chilena Hist. nat., **55**: 33-42.

FAGETTI, E.G. & I. CAMPODONICO, 1971. Larval development of the red crab *Pleuroncodes monodon* (Decapoda Anomura: Galatheidae) under laboratory conditions. Mar. Biol., Berlin, **8**(1): 70-81.

GOHAR, H.A.F. & AL KHOLY, A.A., 1957. The larvae of decapod Crustacea. Publ. mar. Biol. Sta. Ghardaqa, **9**: 177-202.

GORE, R.H., 1979. Larval development of *Galathea rostrata* under laboratory conditions with discussion of larval development in the Galatheidae (Crustacea Anomura). Fish. Bull., U.S., **76**(4): 781-806.

GOY, J.W. & A.J. PROVENZANO, Jr., 1978. Larval development of the rare burrowing mud shrimp *Naushonia crangonoides* Kingsley (Decapoda: Thalassinidae: Laomediidae). Biol. Bull., Woods Hole, **154**: 241-261.

GURNEY, R., 1924. Decapod larvae. Nat. Hist. Rep. "Terra Nova" Exped. (Zool.) **8**, Crustacea: 37-202, figs. 1-78.

——, 1927a. Zoological results of the Cambridge expedition to Suez canal. Report on the larvae of the Crustacea Decapoda. Trans. zool. Soc. London, **22**: 391-397.

——, 1927b. Zoological results of the Cambridge expedition to Suez canal, 1924. Report on the species of *Hippolyte*. Trans. zool. Soc. London, **22**: 391-397.

——, 1937a. Notes on some decapod Crustacea from the Red Sea. I, The genus *Processa*. II, The larvae of *Upogebia savignyi* Strahl. Proc. zool. Soc. London, (B)**107**: 85-101, pls. 1-6.

——, 1937b. Notes on some decapod and stomatopod Crustacea from the Red Sea. IV, The larvae of *Callianassa*. Proc. zool. Soc. London, (B)**107**: 319-336, pls. 1-8.

——, 1938. Notes on some decapod Crustacea from the Red Sea. VIII, Brachyura, *Porcellana inaequalis, Galathea longimana*. Proc. zool. Soc. London, (B)**108**: 73-84.
——, 1942. Larvae of decapod Crustacea: i-vi, 1-306. (Ray Society, London).
GURNEY, R. & M.V. LEBOUR, 1939. The larvae of the decapod genus *Naushonia*. Ann. Mag. nat. Hist., (11)**3**: 609-614.
HART, J.F.L., 1937. Larval and adult stages of British Columbia Anomura. Canadian Journ. Res., **15**: 179-220.
ISSEL, R., 1910. Ricerche interno alla biologia ed alla morfologia dei crostacei decapodi. I: studi sui Paguridi. Arch. Zool. (ita.) Napoli, **4**: 335-397.
KURATA, H., 1968. Larvae of decapod Anomura of Arasaki, Sagami Bay, II. *Dardanus arrosor* (Herbst) (Diogenidae). Bull. Tokai Reg. Fish. Res. Lab., **56**: 173-180.
LANG, W.H. & A.M. YOUNG, 1977. The larval development of *Clibanarius vittatus* (Bosc) (Crustacea, Decapoda, Diogenidae) reared in the laboratory. Biol. Bull. Woods Hole, **152**(1): 84-104.
LEBOUR, M.V., 1930. The stages of the Plymouth Galatheidae *Munida bamffica, Galathea strigosa* and *Galathea dispersa*. Journ. mar. biol. Ass. U.K., **17**(1): 175-187.
——, 1931. The larval stages of the Plymouth Galatheidae, *Galathea squamifera* and *Galathea intermedia*. Journ. mar. biol. Ass. U.K., **17**(2): 385-390.
LE LOEUF, P. & A. INTÈS, 1974. Les Thalassinidea (Crustacea, Decapoda) du golfe de Guinée: systématique, écologie. Cah. ORSTOM, (Oceanogr.) **12**(1): 17-69.
LEWINSOHN, CH., 1969. Die Anomuren des Roten Meeres, Crustacea Decapoda: Paguridea-Galatheidea-Hippidea. Zool. Verhand., Leiden, **104**: 1-213, pl. 1.
MACDONALD J.D., R.B. PIKE & D.I. WILLIAMSON, 1957. Larvae of the British species of *Diogenes, Pagurus, Anapagurus* and *Lithodes* (Crustacea, Decapoda). Proc. zool. Soc. London, **128**(2): 209-257.
MAN, J.G. DE, 1928. The Thalassinidae and Callianassidae collected by the Siboga Expedition with some remarks on the Laomediidae. Siboga Exped. Monogr., **39**(a6): 1-187.
MANNING, R.B., 1987. Notes on western Atlantic Callianassidae (Crustacea: Decapoda: Thalassinidea). Proc. biol. Soc. Washington, **100**(2): 386-401.
MANNING, R.B. & D.L. FELDER, 1986. The status of the Callinanassid genus *Callichirus* Stimpson, 1866 (Crustacea: Decapoda: Thalassinidea). Proc. biol. Soc. Washington, **99**(3): 437-443.
MENON, M.K., 1937. Decapod larvae from the Madras plankton. Bull. Madras Gvt. Mus. nat. Hist., **3**(5): 1-56.
MORGAN, G.J., 1987. Abbreviated development in *Paguristes frontalis* (Milne Edwards, 1836) (Anomura: Diogenidae) from Southern Australia. Journ. crust. Biol., **7**(3): 536-540.
NAYAK, V.N. & V.S. KAKATI, 1977. Occurrence of the hermit crab *Dardanus setiger* (H. Milne Edwards) (Decapoda Anomura) at Kawar with a description of the first zoeal stage. Journ. Bombay nat. Hist. Soc., **75**(2): 286-291.
NGOC-HO, N., 1981. A taxonomic study of the larvae of four Thalassinid species (Decapoda, Thalassinidae) from the Gulf of Mexico. Bull. British Mus. (nat. Hist.), (Zool.), **40**(5): 237-273.
NOBILI, G., 1904. Diagnoses préliminaires de vingt-huit espèces de Stomatopodes et Décapodes Macroures de la Mer Rouge. Bull. Mus. natl. Hist. nat., Paris, **10**(5): 228-238.
PIKE, R.B. & D.I. WILLIAMSON, 1960. Larvae of decapod Crustacea of the families Diogenidae and Paguridae from the Bay of Naples. Pubbl. Staz. zool. Napoli, **21**(3): 493-552.
—— & ——, 1972. Crustacea Decapoda: Larvae X, Galatheidae. Fiches Ident. Zoopl., Cons. perm. intern. Explor. Mer, Copenhagen, **139**: 1-5.
PROVENZANO, A.J., JR., 1962. The larval development of the tropical land hermit crab *Coenobita clypeatus* (Herbst) in the laboratory. Crustaceana, **4**(3): 207-228.
——, 1962. The larval development of *Calcinus tibicen* (Herbst) (Crustacea, Anomura) in the laboratory. Biol. Bull., Woods Hole, **123**(1): 179-202.
——, 1978. Larval development of the hermit crab *Paguristes spinipes* Milne Edwards, 1880 (Decapoda, Diogenidae) reared in the laboratory. Bull. mar. Sci., **28**(3): 512-526.
RAYNER, G.W., 1935. The Falkland species of the crustacean genus *Munida*. Discovery Reports, **10**: 209-245.
RICE, A.L. & A.J. PROVENZANO, JR., 1965. The zoeal stages and the glaucothoe of *Paguristes sericeus* A. Milne Edwards (Anomura, Diogenidae). Crustaceana, **8**(3): 239-254.

ROBERTS, P.E., 1973. Larvae of *Munida subrugosa* (White, 1847), from Perseverance Harbour, Campbell Island. Journ. Royal Soc. New Zealand, **3**: 393-408.

SAINT-LAURENT, M. DE, 1974. Sur la systématique et la phylogénie des Thalassinidea: Définition des familles des Callianassidae et des Upogebiidae et diagnose de 5 genres nouveaux (Crustacea, Decapoda). C. r. Acad. Sci., Paris, (D) **277**: 513-516.

——, 1979. Sur la classification et la phylogénie des Thalassinides: Définition de la superfamille des Axioidea, de la sous famille de Thomassiniinae et de 2 genres nouveaux (Crustacea, Decapoda). C. r. Acad. Sci., Paris, (D)**288**: 1395-1397.

SAINT-LAURENT, M. DE & B. BOZIC, 1976. Diagnose et tableau de détermination des Callianasses de l'Atlantique Nord Oriental et de la Méditerranée (Crustacea, Decapoda Callianassidae). Thalassia Jugoslavica, **8**(1): 15-40, figs. 1-35.

SAINT-LAURENT, M. DE & P. LE LOEUF, 1979. Crustacés Décapodes: Thalassinidea-I, Upogebiidae et Callianassidae. Résultats scientifiques des Campagnes de la Calypso au large des côtes atlantiques africaines (1956 et 1959), **11**(22). Ann. Inst. océanogr. Monaco, **55** (Suppl.): 20-101.

SAKAI, K. & S. MIYAKE, 1964. Description of the first zoea of *Laomedia astacina* (De Haan) (Decapod, Crustacea). Scient. Bull. Faculty of Agriculture Kyushu Univ., **21**(1).

SAMUELSEN, T.J., 1972. Larvae of *Munidopsis tridentata* (Esmark) (Decapoda, Anomura) reared in the laboratory. Sarsia, **48**: 91-98.

SANDIFER, P.A., 1973. Larvae of the burrowing shrimp *Upogebia affinis* (Crustacea Decapoda, Upogebiidae) from Virginia plankton. Chesapeake Sci., **14**(2): 98-104.

SARS, G.O., 1889. Bidrag til kundskaben on decapoderne forvandlinger, II. *Lithodes-Eupagurus-Spiropagurus-Galathodes-Galathea-Munida-Porcellana-Nephrops*. Arch. for Mathematik og Naturviderskab., **13**: 133-201.

SEGUIN, G. & R. VAISSIÈRE, 1981. Preliminary note on the zooplankton of the superficial waters surrounding the coral reefs of the coast of Jordan in the Gulf of Aqaba (Red Sea). Coral Reef Symposium, Manilla.

SERIDJI,. R., 1986. Larves de crustacés décapodes des eaux jordaniennes du golfe d'Aqaba. Note préliminaire. Vie Marine, **7**: 1-13.

——, 1987. Some considerations on the geographical distribution of larvae of Crustacea Decapoda from the Red Sea. Vie Marine, **8**: 57-59.

——, 1989. Étude des larves de Crustacés Décapodes: aspects taxonomique, écologique et biogéographique: 1-568 (Thèse Doctorat des Sciences, USTHB, Alger).

SHOKITA, S. & A. YAMASHIRO, 1986. Larval development of the land hermit crab, *Coenobita rugosus* H. Milne Edwards and *Coenobita cavipes* Stimpson reared in the laboratory. Galaxea, **5**: 267-282.

TATTERSALL, W.M., 1938. A note on the trachelifer larva of *Jaxea nocturna* (Chiereghin) and its

VAUGELAS, J. DE, 1990. Écologie des Callianasses (Crustacea, Decapoda, Thalassinidea) en milieu récifal indo-pacifique. (Thèse d'habilitation à diriger des recherches en sciences, Univ. Nice).

VAUGELAS, J. DE, B. DELESALLE & C. MONIER, 1986. Aspects of the biology of *Callichirus armatus* (A. Milne Edwards, 1870) (Decapoda, Thalassinidea) from French Polynesia. Crustaceana, **50**(2): 204-216.

WEAR, R.G. & J.C. YALDWYN, 1966. Studies on thalassinid Crustacea (Decapoda, Macrura, Reptantia) with a description of a new *Jaxea* from New Zealand and an account of its larval development. Zool. Publ. from Victoria Univ. of Wellington, **41**: 1-27.

WILLIAMSON, D.I., 1970. On a collection of planktonic Decapoda and Stomatopoda (Crustacea) from the east coast of the Sinai Peninsula, northern Red Sea. Bull. Sea Fish. Res. Sta. Haifa, **56**: 1-48.

——, 1972. Larval morphology and diversity. In: L.G. ABELE (ed.), the biology of Crustacea, **2**: 43-110. (New York, Academic Press).

YALDWYN, J.C. & R.G. WEAR, 1972. The eastern Australian burrowing mud-shrimp *Laomedia healy* (Crustacea, Macrura, Reptantia, Laomediidae) with notes on larvae of the genus *Laomedia*. Australian Zool., **17**(2): 126-141.