ON THE BREEDING HABITS AND LARVAL STAGES OF SOME CRABS OF BOMBAY

By

B. F. CHHAPGAR

Research Student, Taraporevala Marine Biological Research Station, Bombay

INTRODUCTION

Extensive studies have been carried out on the larval stages of British and American Brachyura by Lebour (1927-1947), Churchill (1917-18, 1942), and others. However, hardly any studies on this aspect of the problem have been made in India. A few notable exceptions are the works of Menon (1933 ; 1937 ; 1953), Naidu (1951), and Prasad and Tampi (1953). The early developmental stages of *Scylla serrata*, the commonest Indian crab, have also been studied by Arriola (1940) in the Philippines. Barring these sketchy observations, no account of the larval stages of our crabs is available. The present work, therefore, is an effort to increase our knowledge of these stages as they occur in Bombay.

MATERIAL AND METHODS

The zoeae and megalopae were secured by the use of townets operated from the stern of two forty-foot power-boats, the "Vicky" and "Mysis", belonging to the Taraporevala Aquarium. A circular plankton net with a ring diameter of 20 inches and made of fine Swiss organdy cloth was used, a large bottle being tied at the tip of the net. Towings were made just below the surface and varied from 8-15 minutes. Runs were made, weather and tide permitting, from opposite the Taraporevala Aquarium west to Malabar Hill and beyond. A smaller plankton net with a ring diameter of 10 inches and made of bolting silk was also used for making collections along the shore at Marine Drive, Apollo Bunder and Sassoon Dock. The contents of the bottle were immediately transferred to a larger, shallow jar, and the samples were examined alive in the laboratory and sorted out. They were then kept in aerated dishes or finger-bowls, and fed with diatoms and mollusc larvae. The zoeae were examined with the aid of a binocular microscope, in watch glasses and cavity slides. Appendages were cut off with a pair of entomological needles No. 20 mounted in holders. This was necessary especially in examining the details and making counts of the hairs on the various appendages.

Drawings were made with the aid of a camera lucida. The dimensions of the zoeae were obtained by the use of ocular and stage micrometers on the specimens themselves, and checked by projecting with the camera lucida the markings of the stage micrometer on the drawings made at the same magnification.

Breeding Habits

The study of the breeding habits of crabs presents considerable difficulties because of limitations of underwater observations. Consequently, a knowledge of the breeding habits of Indian crabs has been very limited, except for the recent publication by Menon (1952).

A suitable method for observing their breeding habits is to keep a pair of crabs in a tank. This, even in the most suitable environments is, after all, an artificial method which may cause deviation from the normal habits of an animal. However, in the absence of more convenient methods, observations in a large tank in which the environment is made as natural as possible, are quite accurate, and this is what has been done in the present case. Another difficulty in the way of their observation is the readiness with which copulating crabs will separate on the slightet disturbance. Observations on mating habit had, therefore, to be limited to opportunities available at the Taraporevala Aquarium, where luckily a spacious tank 10′ × 4′ × 4′ was set aside for this purpose.

Mating habits.—A number of specimens of both sexes of *Scylla serrata*, *Neptunus* (*Neptunus*) *pelagicus* and *Neptunus* (*Neptunus*) *sanguinolentus* were released in large aquarium tank to study their mating habits. Out of the three species, the mating habits of *Neptunus* (*Neptunus*) *pelagicus* and *Neptunus* (*Neptunus*) *sanguinolentus* could be studied with a fair degree of accuracy within the artificial conditions of an aquarium. Although the details of the phenomenon in each species may be slightly different, it is presumed that the general procedure will be somewhat similar. The details of these mating habits in case of *Neptunus* (*Neptunus*) *pelagicus* are as follows :—

In the male, the first and second pair of abdominal appendages act as genital organs. The first pair is a tube-like organ, while the second is a jointed rod. The two are usually separate, but the second is capable of being inserted into the first.

The female is in a "soft" state during copulation, *i.e.*, it has just moulted. Before copulation, the male holds the female with the second pair of walking legs. The female at this stage is upright, with its back against the abdomen of the male, and is quite passive. It is not attracted towards any food, but the cleaning operation of the gills by moving the third pair of maxillipedes to and fro takes place.

The male, on the contrary, is very active and drives away any intruder with its chelipeds. If, however, the intruder persists in advancing the male, catching the female in its legs, it swims away. The pair may thus lie in the same position for two or three days.

Sometimes it happens that the female is "hard" (*i.e.*, not recently moulted) when the male catches her. In that case, the male still holds the female which struggles hard, not to get away from the male, but to get rid of its moult.

When copulation begins, the male turns the female so that the latter is now inverted, with its abdomen apposed to that of the male. The male then inserts the second pair of abdominal appendages inside the first, and both together acting as a penis are thrust into the female openings. The first pair is capable of very little motion in this position, but the second pair of appendages can move freely up and down inside the first, very much like the piston of a pump. In fact, it is a pump forcing the sperms into the female. The rate of motion of the penis is, in this crab, about 15-18 times a minute, while Williamson (1904) observed this motion to take place about once every two seconds in the case of *Carcinus maenas*. Copulation may last for three to four hours, after which the crabs separate.

The abdomen of the male during copulation is shut against the sternum, only the penis protruding, and the abdomen of the female is opened only just sufficiently for the penis to move freely. If the crabs are disturbed during copulation, the act ceases and the crabs readily separate, so that it is difficult to observe complete copulation. Sometimes, during copulation, two or more males will fight for the possession of the female, and in trying to snatch away the female, will tear it to pieces, since at this time it is soft and helpless.

BREEDING SEASON

Determination of the breeding season in crabs is comparatively easy, as instead of liberating the eggs loose into the sea like some of the fishes, they have the eggs attached to the pleopods of the female crabs. Thus, the occurrence of "berried" crabs clearly indicates the breeding period. Various authors (Lebour, 1927-1947; Menon, 1933-1937; Churchill, 1917-1942, etc.) have used this method to determine the breeding season, and have been successful in elucidating the results. In the present study, observations on breeding season and surmises thereabout had to be made on the basis of collection of berried crabs during different periods of the year. In the following table, the days when berried crabs of different species were collected have been furnished as the months in which these crabs were found can roughly be taken to indicate the breeding season of the respective crabs.

TABLE 1

Name of crab	Day of collection	Diameter of egg in millimetres
Matuta lunaris	12-2-1952, 17-11-1952, 22-11-1952	0·266
Philyra globosa	7-12-1952, 9-1-1953, 3-3-1953	0·233
Doclea gracilipes	12-2-1952	0·566
Scylla serrata	24-4-1954	—
Neptunus (Neptunus) sanguinolentus	27-10-1951, 2-11-1951, 11-12-1951, 22-1-1952, 15-4-1952, 15-7-1952, 20-11-1952	0·233
Neptunus (Neptunus) pelagicus	24-10-1951, 17-12-1951, 22-1-1952, 12-2-1952, 11-7-1952, 25-11-1952	0·233
Charybdis (Goniosoma) cruciata	17-12-1951	0·250
Charybdis (Goniosoma) annulata	27-11-1951, 7-12-1951, 24-1-1952	0·233
Charybdis (Goniosoma) callianassa	3-10-1951	0·266
Charybdis (Goniosoma) orientalis	11-12-1951, 14-12-1951	0·300
Thalamita crenata	3-11-1951	0·266
Leptodius exaratus	20-3-1953, 29-3-1953	0·300
Leptodius crassimnus	12-11-1951, 19-11-1951	0·300
Myomenippe hardwickii	—	0·500

TABLE 1—*contd.*

Name of crab	Day of collection	Diameter of egg in millimetres
Ozius rugulosus	29-11-1951, 10-12-1951, 30-6-1952	0·333
Pilumnus vespertilio	29-11-1951	0·366
Euryacarcinus orientalis	8-11-1952, 21-11-1952	0·300
Litocheria angustifrons	29-11-1951, 20-3-1952	0·333
Eucrate crenata dentata	27-11-1951, 7-12-1952	0·333
Pinnotheres placunae	——	0·300
Gelasimus annulipes	20-3-1953, 31-3-1953	0·266
Metopograpsus messor	20-3-1953	0·350
Psudograpsus intermedius	17-3-1953, 3-4-1953	0·288

From the above table it will be seen that the majority of crabs of Bombay State breed from November to March, but a few such as *Neptunus* (*Neptunus*) *sanguinolentus* and *Neptunus* (*Neptunus*) *pelagicus* breed irregularly at different periods throughout the year.

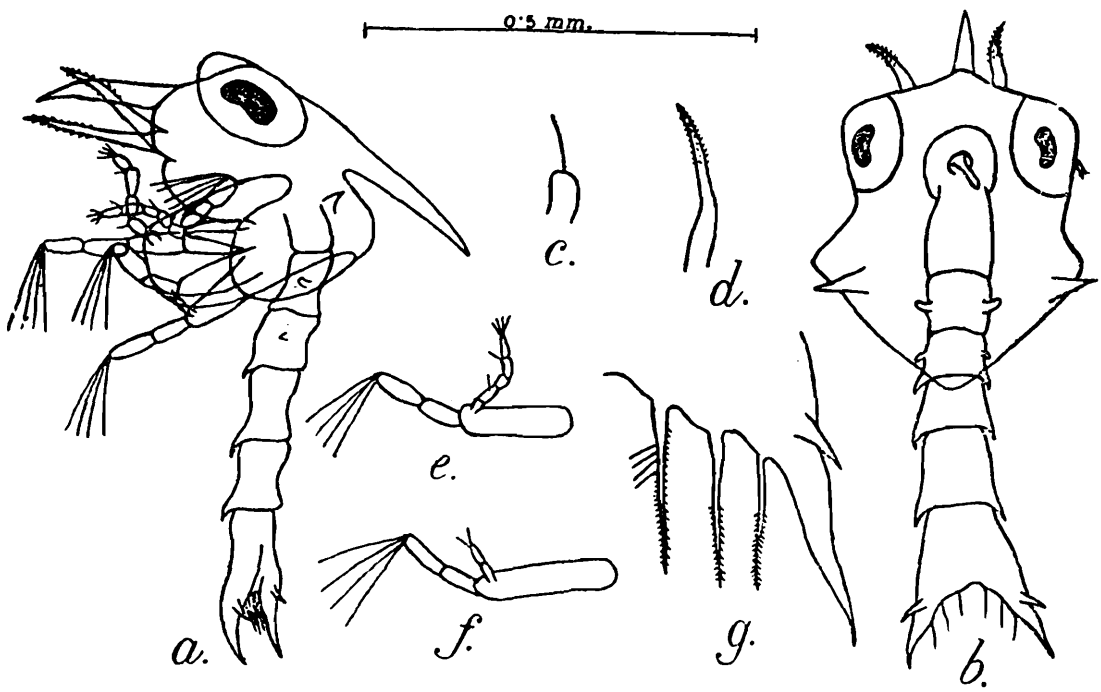
1. First zoea of *Neptunus* (*Neptunus*) *sanguinolentus* (Text-fig. 1)

Measurements in mm. : Body length 0·533 ; body width, between (and including) the eyes 0·266 ; body width between bases of lateral spines 0·360 ; dorsal spine 0·233 ; rostral spine 0·214 ; lateral spine 0·060 ; antenna 0·214.

The carapace is rounded. The dorsal spine is hardly longer than the rostral spine, while the lateral spines are very short. The antennule is an unjointed appendage with a single aesthete. The antenna is much longer than the antennule, it is unjointed and bears spines on its distal half. The first maxillipede consists of a stout basipodite, a two jointed exopodite bearing four hairs at the tip, and an endopodite of five segments with four setae at the tip and others along the joints. The second maxillipede is similar to the first except that the endopodite consists of two joints only, with two hairs at the tip. The abdomen consists of five joints and a telson. The second and third joints bear a pair of lateral hooks, the anterior pair being slightly larger and anteriorly directed, while the second pair is posteriorly directed. The telson is

regularly forked. Inside the fork are three pairs of setae. The innermost pair of setae bears four minute hairs on the inside and a row of spinules on the outer surface. The other setae bear spinules on both their surfaces. There are, in addition, two spines on the dorsal surface of the base of the forks of the telson.

The first zoea of *Neptunus* (*Neptunus*) *sanguinolentus* is very similar to that of *Neptunus* (*Neptunus*) *pelagicus*, but it can be distinguished from the latter in being much smaller and in having only four hairs on the inner border of the innermost setae in the fork of the telson.



TEXT-FIG. 1.—*Neptunus* (*Neptunus*) *sanguinolentus* (Herbst), 1st Zoea.

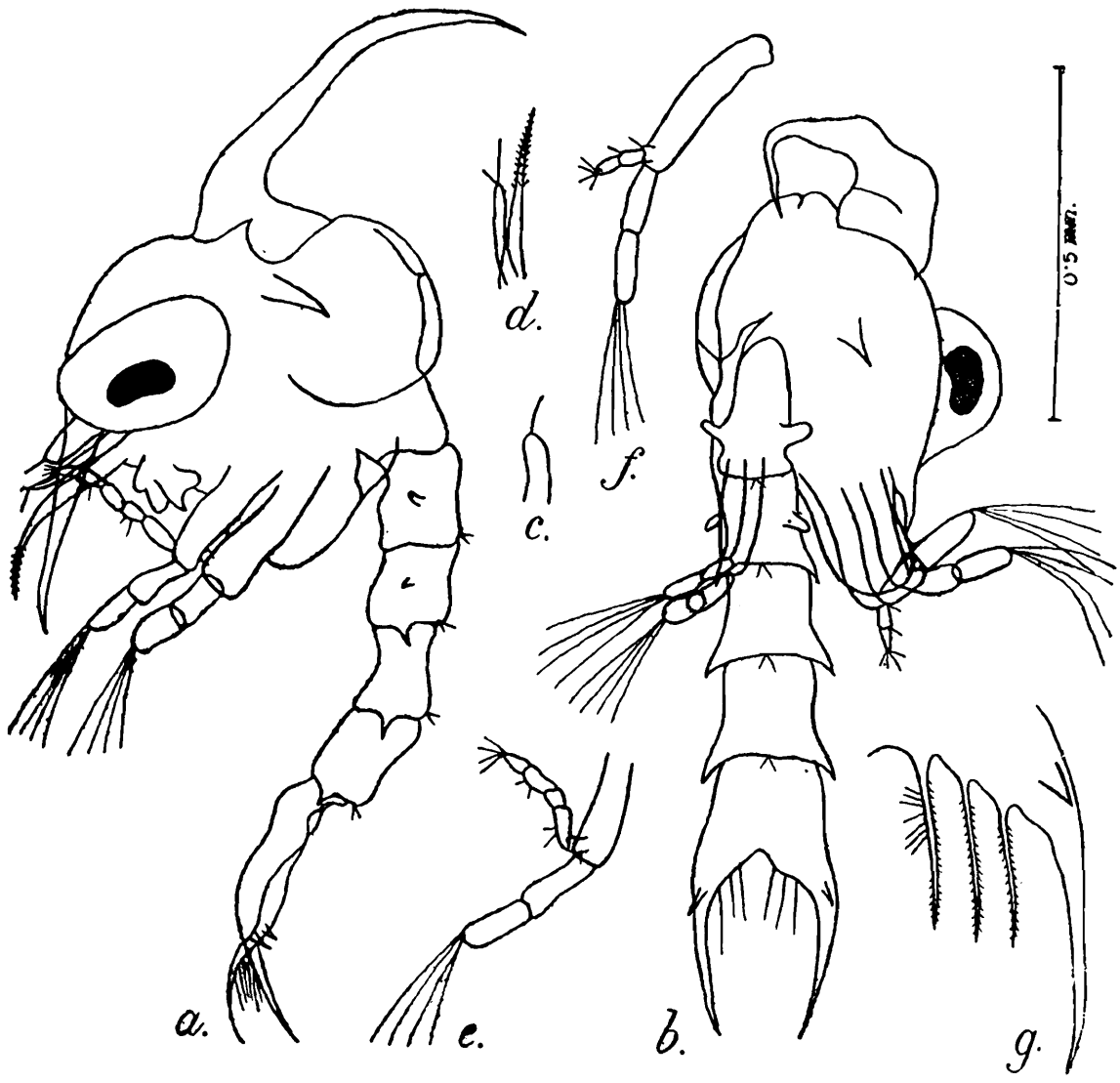
a. Side view ; *b*. Dorsal view ; *c*. Antennule ; *d*. Antenna ; *e*. 1st maxillipede ; *f*. 2nd maxillipede: *g*. Telson (right half, enlarged).

2. First zoea of *Neptunus* (*Neptunus*) *pelagicus* (Text-fig. 2)

Measurements in mm. : Body length 1·173 ; body width between the eyes 0·366 ; body width between bases of lateral spines 0·500; dorsal spine 0·533 ; rostral spine 0·333 ; lateral spine 0·133 ; antenna 0·293.

Though a detailed description of this zoea has been given by Prasad and Tampi (*op. cit.*), the following points noted by the author may be mentioned.

Prasad and Tampi have noted three aesthetes on the tip of the, antennule. Only one aesthete has been noted in the present specimens. Moreover, the endopodite of the second maxillipedes in the present specimens consists of three segments, the first being very short. Prasad and Tampi have mentioned only two segments. On the fork of the telson there are only two spines, as opposed to four given by Prasad and Tampi.



TEXT-FIG. 2.—*Neptunus* (*Neptunus*) *pelagicus* (Linnaeus), 1st Zoea.

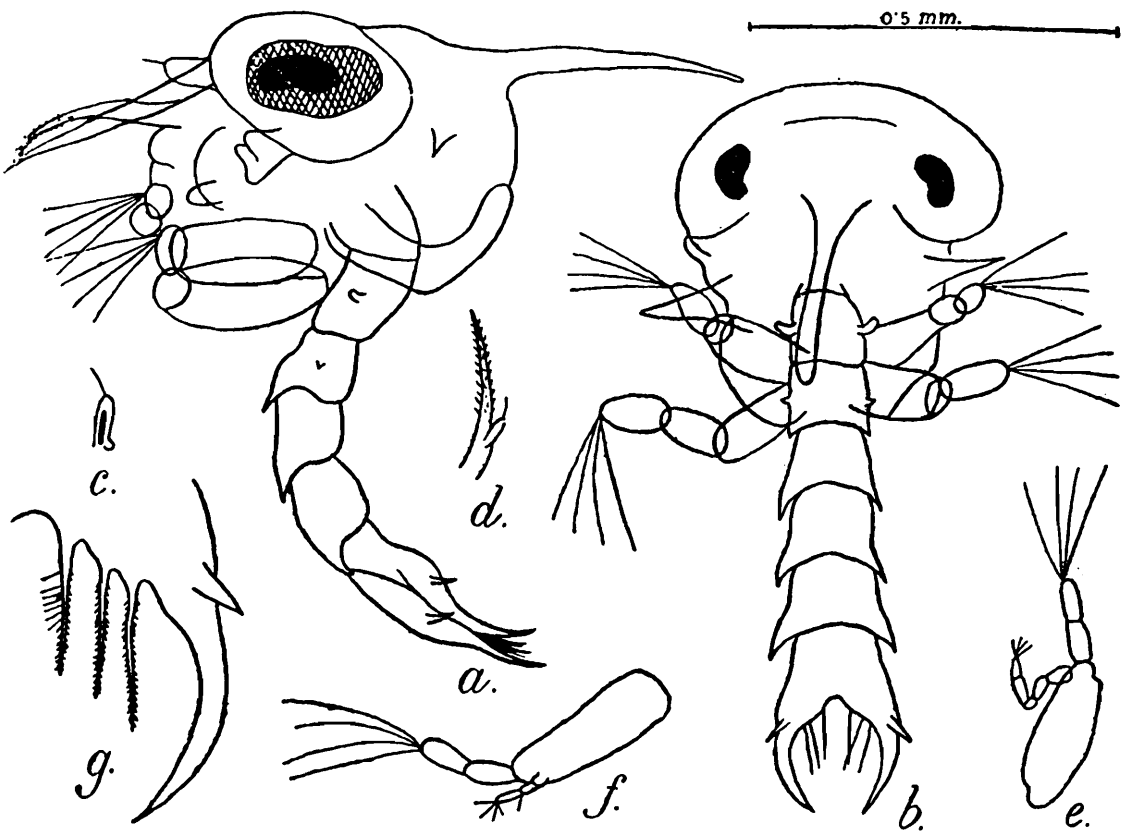
a. Side view ; *b*. Dorsal view ; *c*. Antennule ; *d*. Antenna ; *e*. 1st maxillipede ; *f*. 2nd maxilliped ; *g*. Telson (right half, enlarged).

3. First zoea of *Charybdis* (*Goniosoma*) *orientalis* (Text-fig. 3)

Measurements in mm. : Body length 0·733 ; body width between the eyes 0·288 ; body width between bases of lateral spines 0·420 ; dorsal spine 0·288 ; rostral spine 0·233 ; lateral spine 0·066 ; antenna 0·166.

The carapace is rounded. The dorsal spine is regularly curved and is slightly longer than the straight rostrum. The antennule is a short unjointed pigmented process with a single aesthete. The antenna consists of a well-developed spiniform process which is nearly as long as the rostrum and a small exopodite bearing a setae. The first maxillipede has the usual stout basipodite, an exopodite of two segments with four setae at the tip, and a five-jointed endopodite with four setae at the tip. In the second maxillipede, the endopodite consists of three joints. The abdomen consists of five segments and a telson. The second and third segments have the usual lateral hooks, while the third, fourth and fifth segments have a pair of long downwardly directed spines from the postero-lateral border. The forks of the telson are curiously inbent posteriorly in a regular curve, and bear two spines. There are

seven hairs on the inner border of the innermost pair of setae in the fork of the telson, followed by a few spinules. The outer surface of



TEXT-FIG. 3.—*Charybdis* (*Goniosoma*) *orientalis* (Dana), 1st Zoea.

a. Side view ; *b*. Dorsal view ; *c*. Antennule ; *d*. Antenna ; *e*. 1st maxillipede ; *f*. 2nd maxillipede ; *g*. Telson (right half, enlarged).

these setae and both the borders of the other setae are spinulate.

4. First zoea of *Thalamita crenata* (Text-fig. 4)

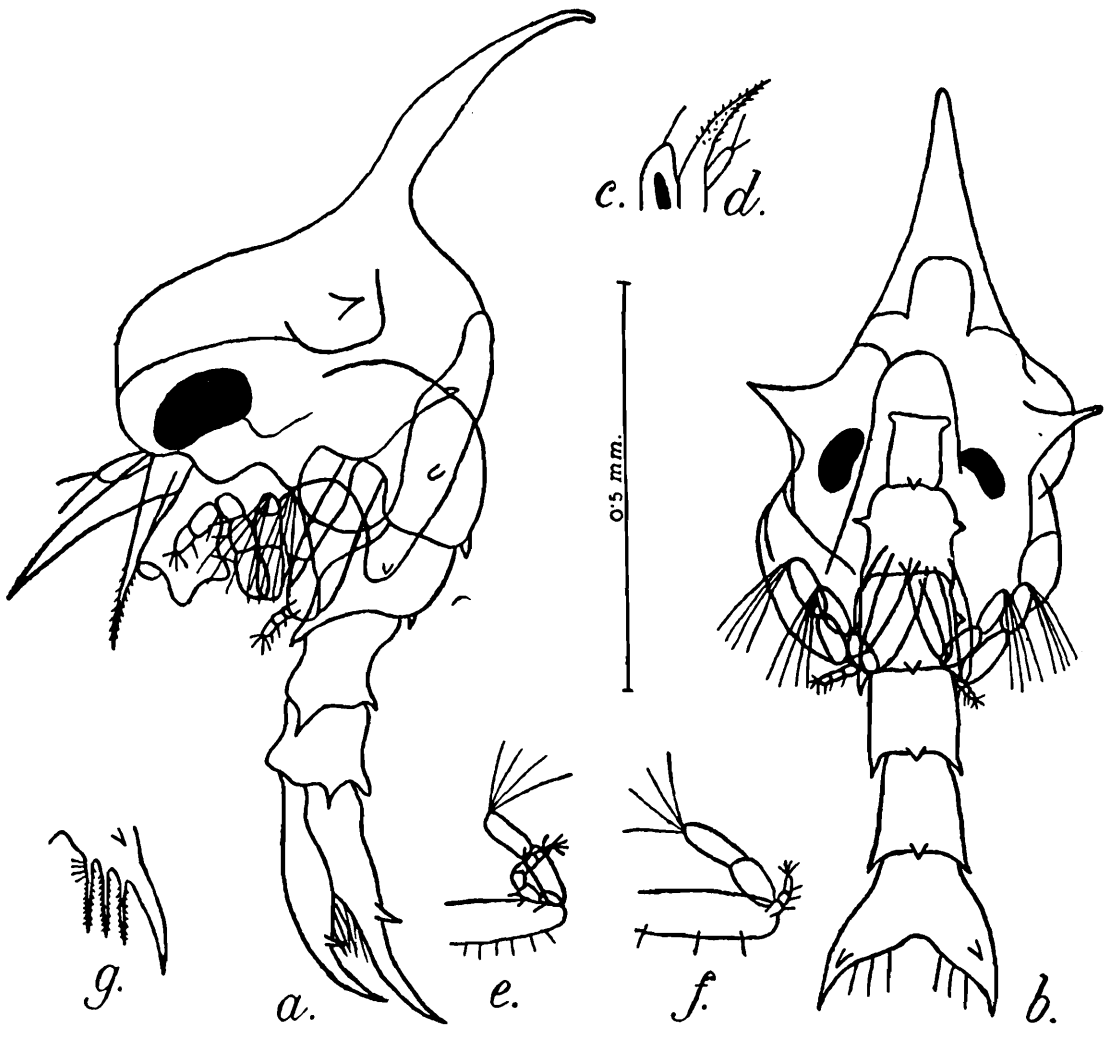
Measurements in mm. : Body length 0·744 ; body width between the eyes 0·300 ; body width between bases of lateral spines 0·212 ; dorsal spine 0·238 ; rostral spine 0·188 ; lateral spine 0.088 ; antennule 0·073 ; antenna 0·177

A description of this zoea has been given by Prasad and Tampi. They have failed to observe a spine on each of the abdominal segments in the middle of the posterior border. The author has noted only one aesthete on the antennule, instead of three, and only two spines at the base of the telson instead of four as described by previous authors. Moreover, there are only four hairs on the inner border of the innermost pair of setae in the fork of the telson.

5. First zoea of *Leptodius exaratus* (Text-fig. 5)

Measurements in mm. : Body length 1·00 ; body width between the eyes 0·40 ; body width between bases of lateral spines 0·33 ; dorsal spine 0·40 ; rostral spine 0·33 ; lateral spine 0·11.

The carapace is peculiar in that its posterior dorsal border has two lobes. All four spines are present. The antennule is a short process with two aesthetes. The antenna is long and smooth. The first maxillipede has the usual basipodite, two-jointed exopodite with four setae at the tip, and five-jointed endopodite. The second maxillipede has its endopodite of three joints. The abdomen consists of five segments and a telson. The second and third segments bear lateral hooks, while the third and fourth joints have downwardly directed spines on the postero-lateral border. The forks of the telson are broad in their basal part and become narrow distally. The innermost pair of



TEXT-FIG. 4.—*Thalamita crenata* Milne-Edwards, 1st Zoea.

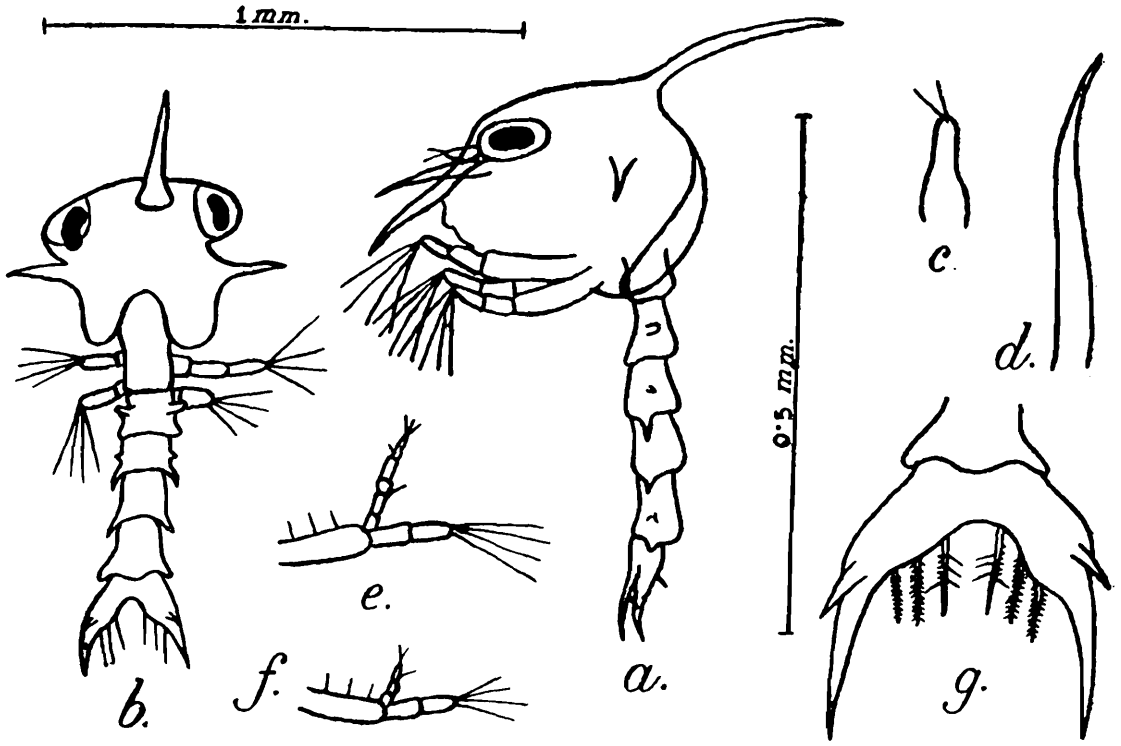
a. Side view ; *b*. Dorsal view ; *c*. Antennule ; *d*. Antenna ; *e*. 1st maxillipede ; *f*. 2nd maxillipede ; *g*. Telson (right half, enlarged).

setae in the fork of the telson bear four hairs on their inner border and a hair and some spinules on the outer border. The other setae bear spinules. The usual pair of spines at the base of the telson is present.

6. First zoea of *Ozius rugulosus* (Text-fig. 6)

Measurements in mm. : Body length 0·900 ; body width between the eyes 0·400 ; body width between bases of lateral spines 0·700 ; dorsal spine 0·433 ; rostral spine 0·400 ; lateral spine 0·166 ; antenna 0·233.

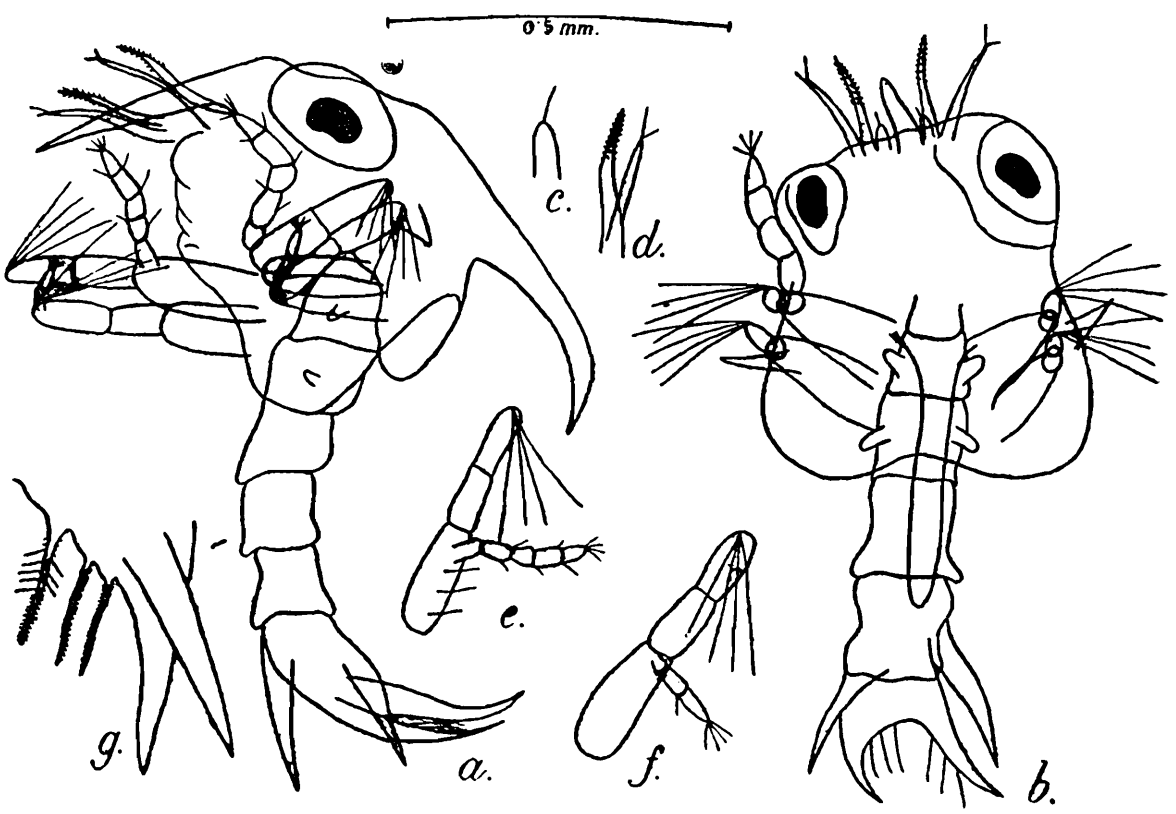
The dorsal spine is curved throughout its length. The lateral spines are very short. The antennule is an unjointed process with



TEXT-FIG. 5.—*Leptodius exaratus* Milne-Edwards, 1st Zoea.

a. Side view ; *b*. Dorsal view ; *c*. Antennule ; *d*. Antenna; *e*. 1st maxillipede ; *f*. 2nd maxillipede ; *g*. Telson (right half, enlarged).

a single aesthete. The antenna consists of a well developed spiniform process, and a long exopodite bearing two setae. The first and second



TEXT-FIG. 6.—*Ozius rugulosus* Stimpson, 1st Zoea.

a. Side view ; *b*. Dorsal view ; *c*. Antennule ; *d*. Antenna ; *e*. 1st maxillipede ; *f*. 2nd maxillipede ; *g*. Telson (right half, enlarged).

maxillipeds have the usual structure. The abdomen consists of five segments and telson. The lateral hooks on the second and third segments of the abdomen are present. The spines on the base of the telson are very long in this zoea, indeed as long as the fork of the telson. The innermost setae in the fork of the telson bear five hairs and some spinules on the inner border, and there are hairs and some spinules on the outer border. The second pair of setae bear spinules only on their outer border, and the outermost pair only on the inner border.

7. First zoea of *Eucrate crenata dentata* (Text-fig. 7)

Measurements in mm.: Body length 0·933 ; body width between the eyes 0·275 ; body width between bases of lateral spines 0·589 ; dorsal spine 0·566 ; rostral spine 0·366 ; lateral spine 0·589.

The carapace is small and rounded. The dorsal spine is a huge process much like a dunce's cap and is more than half the length of the zoea. The rostrum is also comparatively long, and the lateral spines are directed forward like the horns of a bull. The antennule is thin and club-shaped, and bears a single aesthete. The antenna consists of a long spiniform process, and a smooth exopodite which is longer than the spinous process. The first maxillipede consists of a narrow basipodite, a two-jointed exopodite bearing four setae at the tip, and a five-jointed endopodite with four setae at the tip and others along its length. The second maxillipede is similar to the first, except that its endopodite consists of three segments. The abdomen consists of five segments and a telson. The lateral knobs on the third segment are very minute, almost invisible. The innermost setae in the fork of the telson bear numerous minute hairs on their outer border, but are smooth on the inner border. The middle setae bear hairs on the basal half of their inner border and spinules on their outer border. The outermost setae bear hairs throughout their inner border and spinules on their outer border. The usual spines on the base of the telson are present.

8. First zoea of *Gelasimus annulipes* (Text-fig. 8)

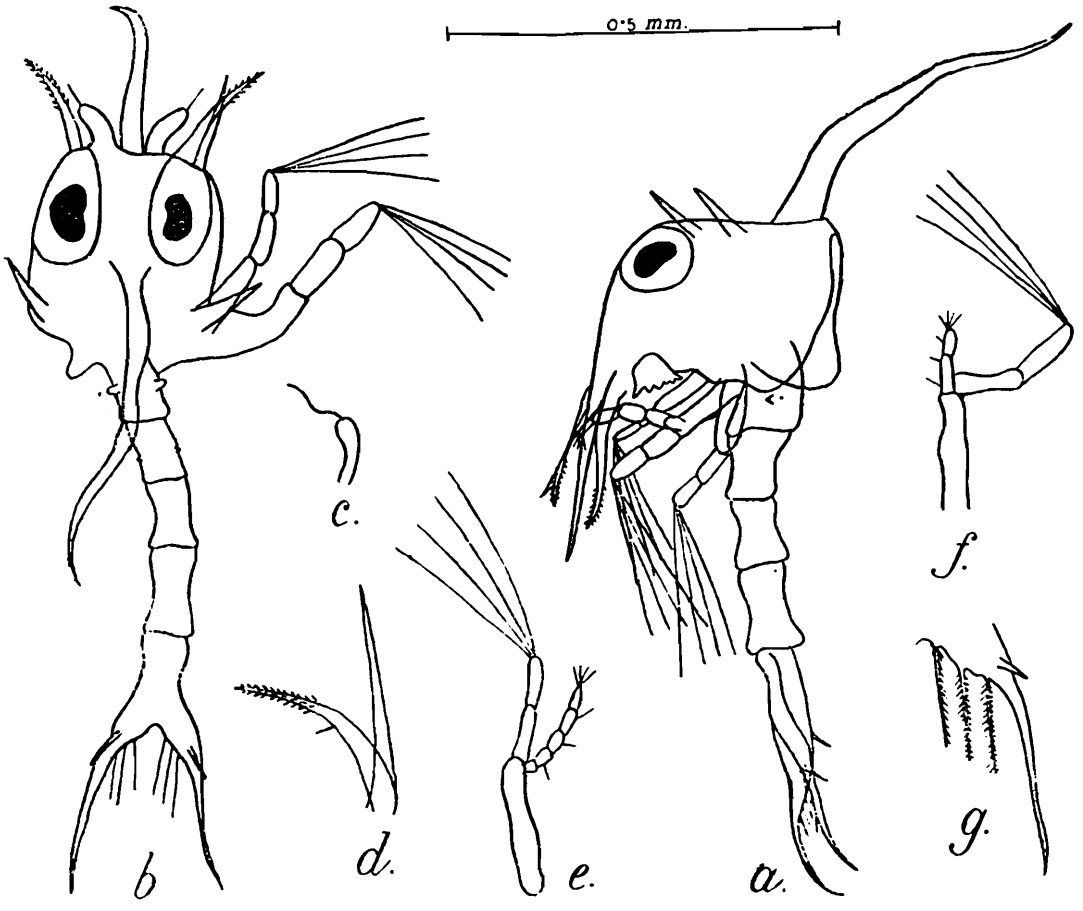
Measurements in mm. : Body length 0·74 ; body width between the eyes 0·25 ; body width 0·18 ; dorsal spine 0·092 ; rostral spine 0·13.

The lateral spines are absent in this zoea, not even indicated by any protuberance. The dorsal spine is shorter than the rostrum. A pair of oval chromatophores are present at the base of the dorsal spine. The antennule is a stout unjointed process bearing two aesthetes. The antenna is a spinous process not much longer than the antennule. The first and second maxillipedes have the usual structure. The abdomen consists of five joints and a telson. The fourth joint is much broader than the others and the next joint is embedded in its posterior border.

9. First zoea of *Metopograpsus messor* (Text-fig. 9)

Measurements in mm. : Body length 1·07 ; body width between the eyes 0·33 ; body width between lateral prominences 0·32 ; dorsal spine 0·33 ; rostral spine 0·26.

The carapace is rounded. The dorsal and rostral spines are well developed. There are no lateral spines, but indications can be seen as lateral protuberances. The antennule is a stout unjointed process with



TEXT- FIG. 7.—*Eucrate crenata dentata* (Stimpson), 1st Zoea.

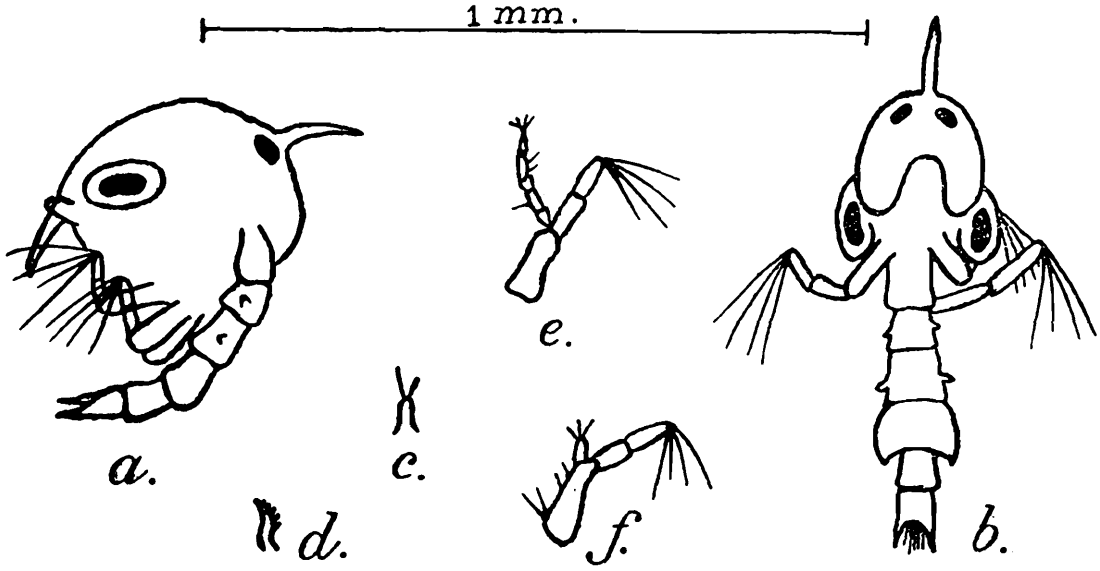
a. Side view ; *b*. Dorsal view ; *c*. Antennule ; *d*. Antenna ; *e*. 1st maxillipede ; *of*. 2nd maxillipede ; *g*. Telson (right half, enlarged).

three aesthetes. The antenna is a bent process with spinules near the tip. The first maxillipede consists of a stout base, a two-jointed exopodite bearing four plumose hairs at the tip, and an endopodite of five joints. The endopodite of the second maxillipede consists of four joints. The abdomen is composed of five segments and a telson. Lateral hooks are present on the second and third segments, while the fifth segment has peculiar fan-like projections on its postero-lateral borders. The innermost setae on the fork of the telson bear spinules along their outer border, while the other setae bear spinules along both the borders.

10. First zoea of *Pseudograpsus intermedius* (Text-fig. 10)

Measurements in mm.: Body length 0·85 ; body width between the eyes 0·35 ; body width between lateral protuberances 0·29 ; dorsal spine 0·16 ; rostral spine 0·11.

The carapace is rounded. The dorsal and rostral spines are well developed but the lateral spines are rudimentary and seen only as small prominences. The antennule is a short unjointed process with two aesthetes. The antenna is short and smooth. The maxillipedes have the usual structure. The abdomen consists of five segments and a telson. The telson is long and slightly paddle-like. The innermost setae in the fork of the telson bear six hairs on their inner border, while the middle pair bears eight. Both these pairs are smooth along their outer border, as also are both borders of the outermost pair. Two spines are present at the base of the telson.



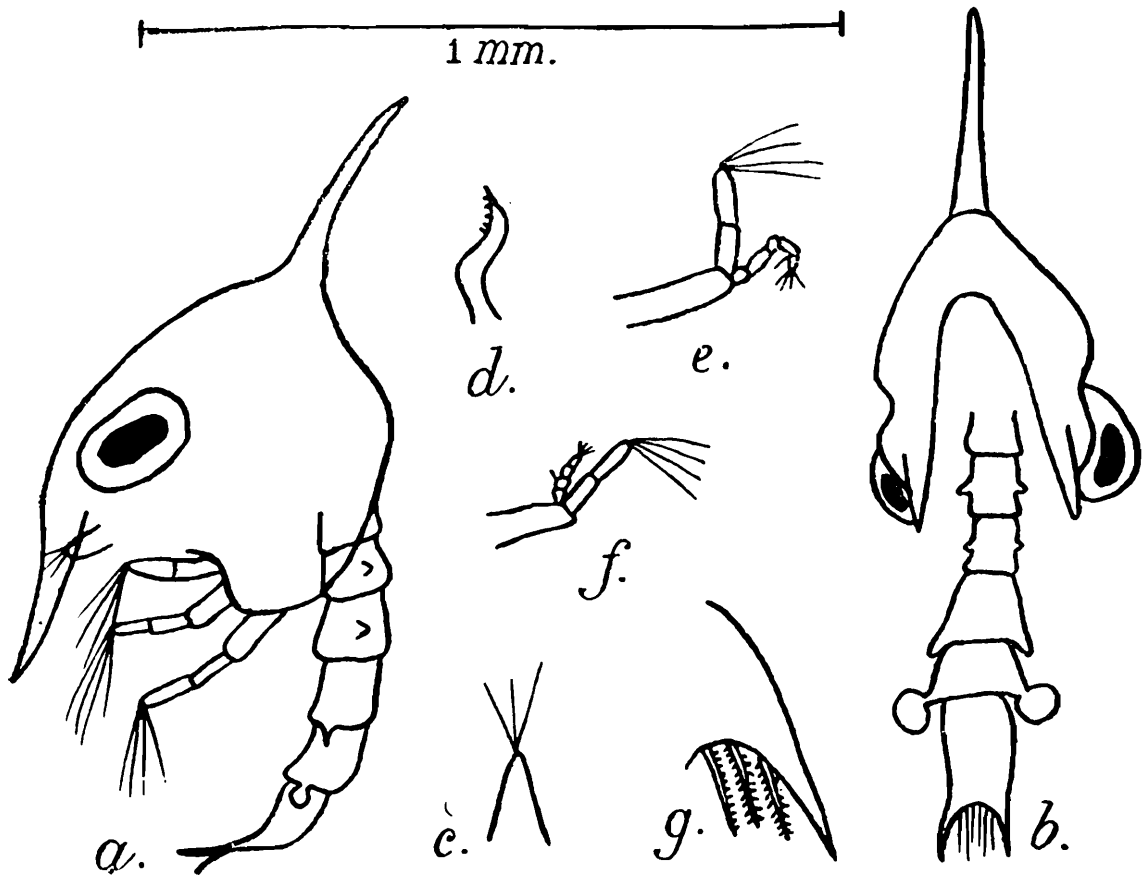
TEXT-FIG. 8.—*Gelasimus annulipes* Latreille, 1st Zoea.

a. Side view ; *b*. Dorsal view ; *c*. Antennule ; *d*. Antenna ; *e*. 1st maxillipede ; *f*. 2nd maxillipede.

In the absence of sufficiently extensive material of the zoeae of different species of crabs, previous authors had not furnished keys for the identification of larval Brachyura. The present material, however, is large enough for a comparative study of the external characters of different larvae collected so far and has made it possible to formulate an artificial key to the identification of many of the zoeae of Bombay waters as given under :—

Key of the zoea of Bombay crabs

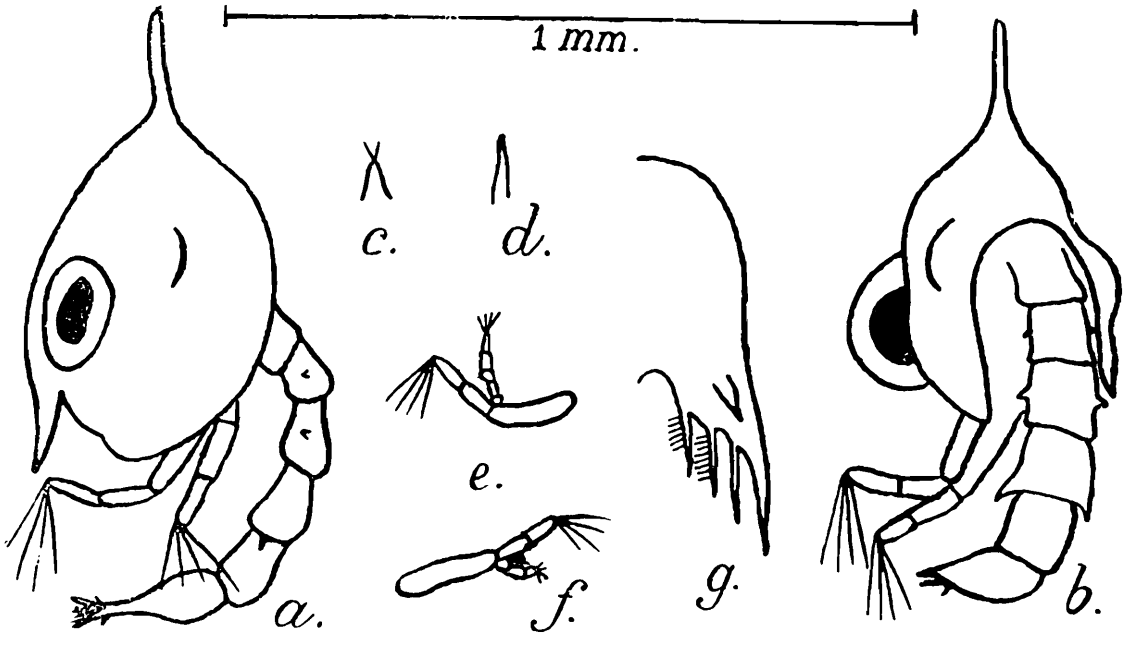
1.	Lateral spines on the carapace well-developed .	2
	Lateral spines on the carapace absent or rudimentary .	8
2.	Dorsal spine shorter or, at the most, as long as carapace . . .	3
	Dorsal spine much longer than carapace .	*Eucrate crenata dentata*
3.	Spines on the dorsal surface of telson much smaller than the forks of the telson	4
	Spines on the dorsal surface of telson almost as long as the forks of the telson . .	*Ozius rugulosus.*



TEXT-FIG. 9.—*Metopograpsus messor* (Forskal), 1st Zoea.

a. Side view ; *b*. Dorsal view ; *c*. Antennule ; *d*. Antenna ; *e*. 1st maxillipede ; *f*. 2nd maxillipede ; *g*. Telson (right half, enlarged).

4. Arms of fork of telson pointing straight or outward	5
Arms of fork of telson curving inward	*Charibdis* (*Goniosoma*) *orientalis*
5. No spines on the middle of the dorsal surface of the abdominal segments .	6
Spines on the middle of the dorsal surface of the abdominal segments present	*Thalamita crenata*



TEXT-FIG. 10.—*Pseudograpsus intermedius*, 1st Zoea.

a. Side view ; *b*. Dorsal view ; *c*. Antennule ; *d*. Antenna ; *e*. 1st maxillipede ; *f*. 2nd maxillipede , *p*. Telson (right half, enlarged).

6.	Posterior border of carapace simply curved dorsally	7
	Posterior border of carapace dorsally divided into two lobes	*Leptodius exaratus*
7.	Four hairs on the inner side of the innermost pair of hairs in the fork of the telson	*Neptunus (Neptunus) sanguinlentus.*
	Seven hairs on the inner side of the innermost pair of hairs in the fork of the telson	*Neptunus (Neptunus) pelagicus*
8.	Telson forked	9
	Telson plate-like . . .	*Philyra globosa*
9.	Lateral spines rudimentary but clearly visible as swellings on the carapace .	10
	No trace of lateral spines .	*Gelasimus annulipes*
10.	Lateral borders of last abdominal segment normal	*Pseudograpsus intermedius*
	Lateral borders of last abdominal segment with fan-like projections	*Metopograpsus messor*

Key to the megalopae of Bombay crabs

1	Dorsal spines on carapace present, no feelers on last joint of last leg . .	2
	No dorsal spines on carapace, feelers on last joint of last leg present	4
2.	Rostrum with two horns, ventral cornua absent	*Doclea gracilipes*
	Rostrum three-horned, extremely long ventral cornua.	*Philyra globosa*
4.	Sides of rostrum pointed, but without accessory spinules. . . .	*Charybdis (Goniosoma) callianassa*
	Sides of rostrum rounded, with two minute spines .	*Neptunus (Neptunus) pelagicus*

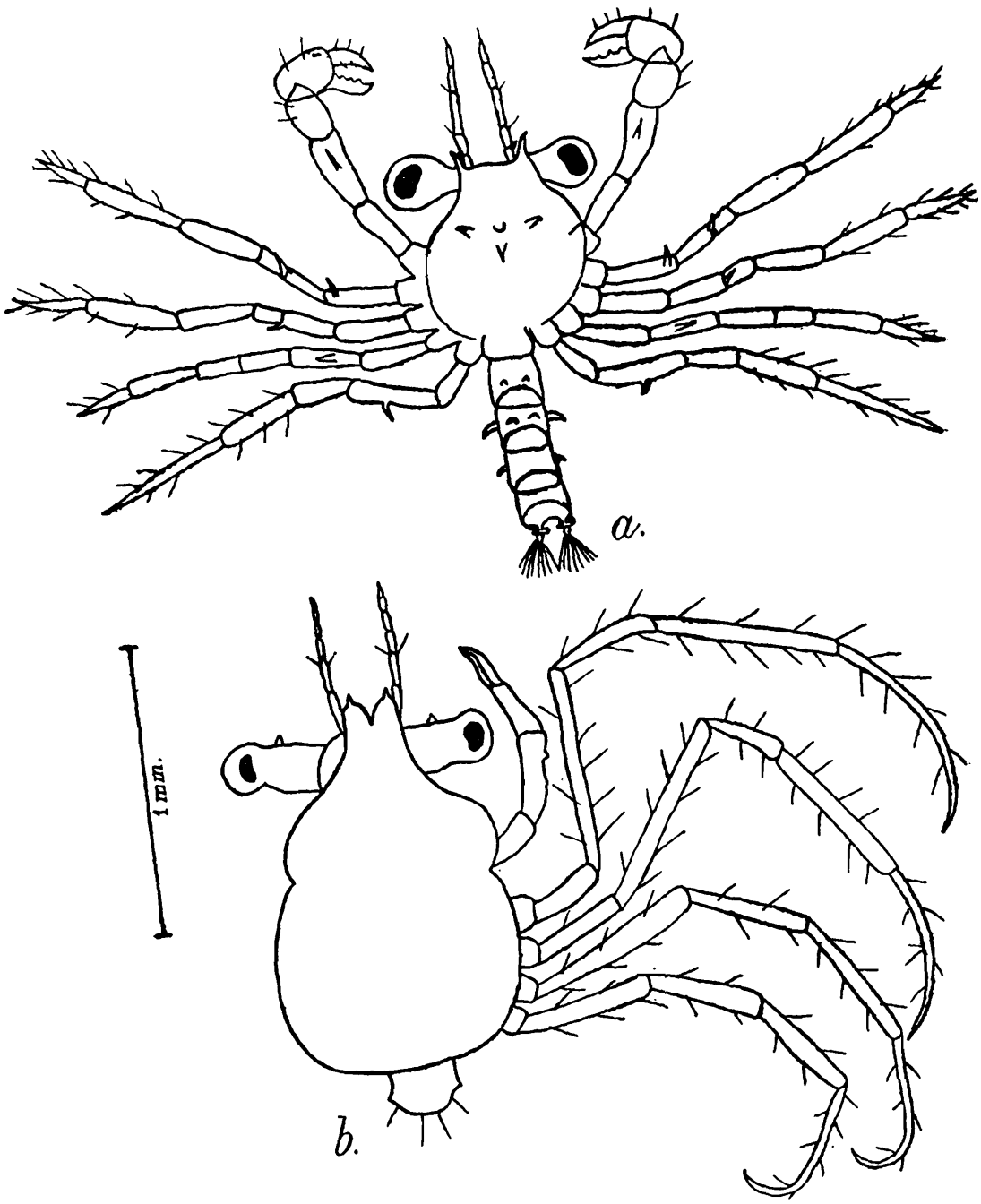
1. Megalopa of *Doclea gracilipes* (Text-fig. 11)

A megalopa was obtained on 7th July, 1952 and metamorphosed on 10th July into the first postlarval instar.

The megalopa is 1·5 mm long. The carapace is rounded, and on the dorsal surface are four spines arranged in the form of a triangle with its base forward and apex pointing backward. The rostrum consists of two horns at the extremity with a transverse border between them. The chelipeds and pereiopods are fully developed and are long. There is a spine in the middle of the meri of the chelipeds and walking legs, and the merus joint is incompletely divided into joints at this place. There is also a spine on the ischium of the first pair of walking legs. There are no feelers on the last joint of the last pair of legs in the shape of coarse curved setae. The abdomen consists of five segments and a telson.

On the dorsal surface of the second and third abdominal segments are two spinules placed side by side, while there are lateral hooks on the third and fourth abdominal segments. The pleopods of the last abdominal segment have eight setae each.

The characters for distinguishing megalopae of different genera and species are :—form of rostrum or front of carapace ; presence or absence



TEXT-FIG. 11.—*Doclea gracilipes* Stimpson. *a*. Megalopa ; *b*. 1st instar.

of median dorsal spine, or other spines or prominences, on the carapace ; presence or absence of feelers on the last legs ; number of setae on the last pleopods ; number of hooks on the legs. The megalopa of *Doclea gracilipes* can be distinguished by the presence of four spines on the carapace, two-horned rostrum, and spines on the meri of the pereiopods.

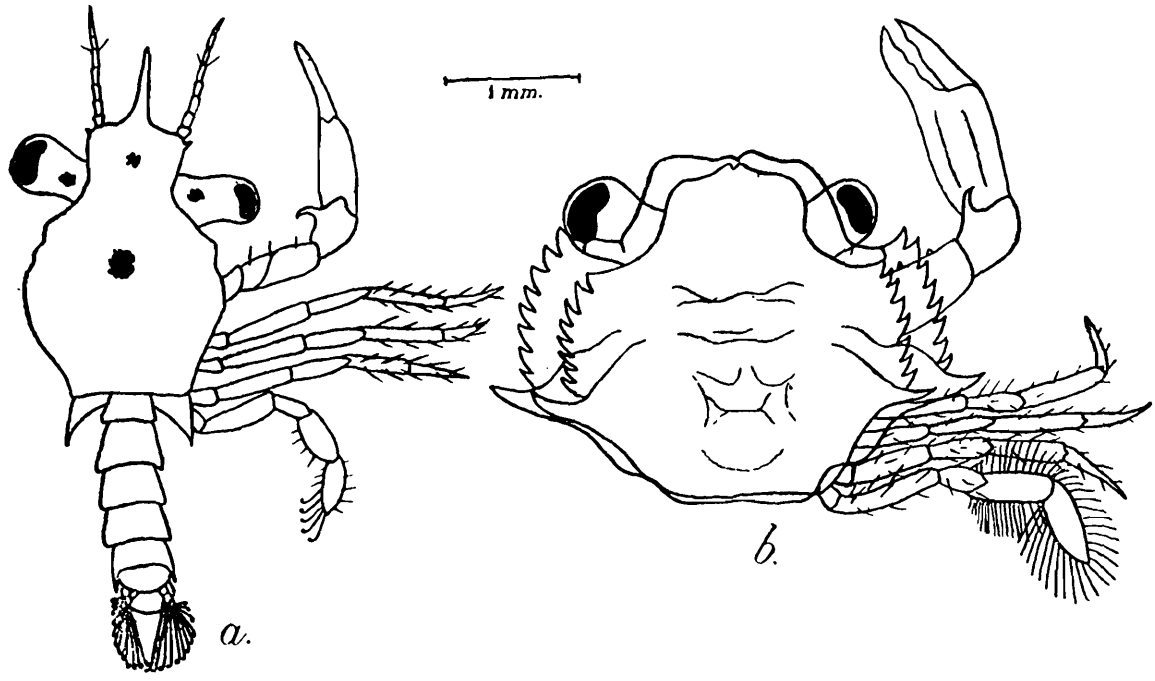
The first postlarval instar has the general proportions of the adult crab, the carapace being rounded, and the legs extremely long. The

rostrum now resembles that of the adult in being deeply cleft, without secondary spinules. The spines on the carapace have not yet developed. The eye stalks bear a minute spinule in their middle.

2. Megalopa of *Neptunus* (*Neptunus*) *pelagicus* (Text-fig. 12)

The megalopa has been described by Prasad and Tampi (*op. cit.*). The following new points may, however, be noted :—

Two minute spinules are present at the outer extremities of the rostrum. There are five coarse, curved setae on the last joint of the last pair of legs. The pleopods on the sixth abdominal segment bear only 12 setae each (Prasad and Tampi have mentioned 20 setae on all the pleopods).



TEXT-FIG. 12.—*Neptunus* (*Neptunus*) *pelagicus* (Linnaeus)

a. Megalopa ; *b*. 1st instar (with border of carapace of 2nd instar superimposed)

The megalopa was caught on January 2, 1952, and metamorphosed into the first postlarval instar on January 4. This again moulted into the second postlarval instar on January 6. Thus the period for the first postlarval instar before metamorphosing into the second was only two days. (Prasad and Tampi have recorded a uniform period of 6-10 days.) This period, however, varies with the availability of proper food, starved megalopae and crabs taking a much longer interval to moult.

3. Megalopa of *Charybdis* (*Goniosoma*) *callianassa* (Text-fig. 13)

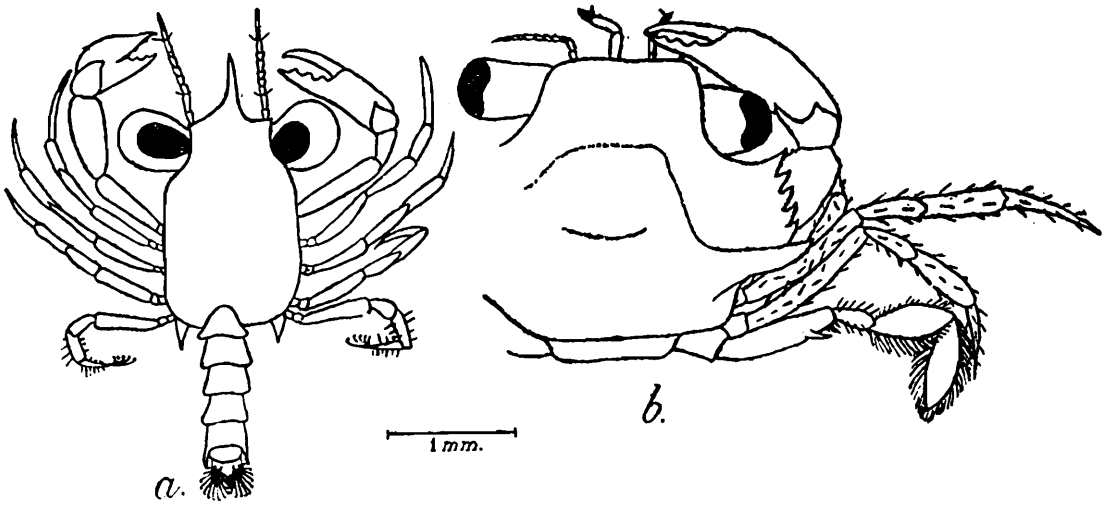
A megalopa was caught on May 23, 1952, and metamorphosed into the first postlarval instar on May 25.

The megalopa is 3·4 mm long. The carapace is elongate ; a rostrum in present and consists of a single long spine. The sides are angular.

A pair of ventral cornua (prolongations of the external plate of the last thoracic segment) is present.

The chelipeds and pereiopods are fully developed. The last joint of the last pair of legs is flattened and bears along its inner border five coarse setae with curved tips and three straight setae. The other legs almost resemble those of the crab. The abdomen consists of six segments and a telson. The first segment is comparatively shorter than the rest and bears no pleopods. The postero-lateral borders of the fifth pleon-segment are developed into long spines. The pleopods on the last abdominal segment have 12 setae each.

The first postlarval instar resembles the adult crab. The carapace has widened, and the six serrulate spines on the antero-lateral borders have developed. The last of these is much longer than the rest. The rostral spine of the megalopa has disappeared and the front is a simple transverse curve. The branchio-cardiac groove and the grooves from the last spines on the antero-lateral borders are present. The last pair of legs is adapted into swimming paddles. The abdomen is permanently flexed.



TEXT FIG. 13.—*Charybdis* (*Goniosoma*) *callianassa* (Herbst.)
a. Megalopa ; *b*. 1st instar.

The crab at this stage, is 2·23 mm broad and 2·03 mm long, the distance between the tips of the outstretched legs being 8 mm. Its colour varies from dirty white to a very faint grey, the eyes being yellowish pink and the cornea black.

REFERENCES

ARRIOLA, F J. 1940. A preliminary study of the life-history of *Scylla serrata* (Forskal).—*Philipp. J Sci.*, Manila, **78**, pp. 437-455, pls. 1-3, 1 text-fig.

CHACKO, P. I. & THYAGARAJAN, S. 1952. On the development and parental care in the Potamonid crab, *Paratelphusa* (*Barytelphusa*) *jacquemontii* (Rathbun).—*J Bombay nat. Hist. Soc.*, Bombay, (1) **51**, pp. 289-291, 4 text-figs.

CHURCHILL, E. P. 1917-1918. Life history of the Blue crab.—*Bull. U S. Bur. Fish.*, **36,** pp. 91-128, pls. 47-55, 2 text-figs.

———1942. The zoaeal stages of the Blue crab, *Callinectes sapidus* Rathbun.—*Publ. Bd. nat. Resources*, State of Maryland, no. **49,** pp. 1-26, pls. 1-4.

CRANE, J. 1941. Eastern Pacific Expeditions of the New York Zoological Society. XXIX. On the growth and ecology of Brachyuran crabs of the genus *Ocypoda*.—*Zoological*, N. Y., **26,** pp. 297-310, pls. 1-2, 7 text-figs.

CUNNINGHAM, J T. 1898. On the early post-larval stages of the common crab (*Cancer pagurus*), and on the affinity of that species with *Atelecyclus heterodon*.—*Proc. zool. Soc. Lond.*, pp. 204-209, pl. 21.

DELSMAN, H. C. & de MAN, J G. 1925. On the " Radjungans " of the Bay of Batavia.—*Treubia*, Batavia, **6,** pp. 308-323, pls. 10-15, 8 text-figs.

GURNEY, R. 1938. Notes on some Decapod Crustacea from the Red Sea. VI-VIII.—*Proc. zool. Soc. Lond.*, **108,** pp. 73-84, pls. 1-4.

HOPKINS, S. H. 1943. The external morphology of the 1st and 2nd zoaeal stages of the Blue crab, *Callinectes sapidus* Rathbun.—*Trans. Amer. micr. Soc.*, (1) **62,** pp. 85-90, pls. 1-2.

———1944. The external morphology of the 3rd and 4th zoaeal stages of the Blue crab, *Callinectes sapidus* Rathbun.—*Biol. Bull.*, **87**, pp. 145-152.

LABOUR, M. V 1927 Studies of the Plymouth Brachyura. I. The rearing of crabs in captivity, with a description of the larval stages of *Inachus dorsettensis*, *Macropodia longirostris* and *Maia squinado*.—*J. Mar. biol. Ass. U. K.*, **14,** pp. 759-814, pls. 1-4.

———1928. Ibid. II. The larval stages of *Ebalia* and *Pinnotheres*.—*J Mar. biol. Ass. U.K.*, **15,** pp. 109-118, pls. 1-2, 1 text-fig.

———1928*a*. The larval stages of the Plymouth Brachyura.—*Proc. zool. Soc. Lond.*, pp. 473-560, pls. 1-16, 5 text-figs.

———1944. The larval stages of *Portunus* (Crustacea Brachyura) with notes on some other genera.—*J Mar. biol. Ass. U K.*, **26,** pp. 7-15, 5 text-figs.

———1947 Notes on the inshore plankton of Plymouth.—*J Mar. biol. Ass. U K.*, **26,** pp. 527-536.

MENON, M. K. 1933. The life-histories of Decapod Crustacea from Madras.—*Bull. Madras Govt. Mus.* (nat. hist.), (N.S.), (3) **3,** pp. 1-45, pls. 1-10.

———1937 Decapod larvae from the Madras plankton.—*Bull. Madras Govt. Mus.* (nat. hist.), N.S., (5), **3,** pp. 1-56, pls. 1-9.

———1952. A note on the bionemics and fishery of the swimming crab *Neptunus sanguinolentus* (Herbst.) on the Malabar Coast.—*J. Zool. Soc. India*, **4,** pp. 177-184, 3 text-figs.

NAIDU, K. G. RAJA BAI. 1951. Some stages in the development and bionomics of *Ocypoda platytarsis*.—*Proc. Indian Acad. Sci.*, Bangalore, (B), **33**, pp. 32-40, pls. 1-3, 13 text-figs.

PRASAD, R. R., & TAMPI, P. R. S. 1953. A contribution to the biology of the blue swimming crab, *Neptunus pelagicus* (Linnaeus), with a note on the zoaea of *Thalamita crenata* Latreille. *J. Bombay nat. Hist. Soc.* Bombay, (3) , **51**, pp. 674-689, pl. 1, 58 text-figs.

SANDOZ, M. and ROGERS, R. 1944. The effect of environmental factors on hatching, moulting and survival of zoea larva of the blue crab, *Callinectes sapidus* Rathbun.—*Ecology*, (2), **25**, pp. 216-228, 7 text-figs.

SHEN, CHIA-JUI. 1935. An investigation of the post-larval development of the shore-crab *Carcinas meanas*, with special reference to the external secondary sexual characters.—*Proc. zool. Soc. Lond.*, pt. 1, pp. 1-33, 20 text-figs.

WILLIAMSON, H. C. 1904. Contributions to the life-histories of the edible crab (*Cancer pagurus*) and of other Decapod Crustacea—impregnation : spawning : casting : distribution : rate of growth.—*22nd Annual Rep. Fish. Bd. Scot.*, **22**, pt. 3, pp. 100-140, pls. 1-5.

YONGE, C. M. 1937. The nature and significance of the membranes surrounding the developing eggs of *Homarus vulgaris* and other Decapoda.—*Proc. zool. Soc. Lond.*, **107**, pp 499-517, pl. 1, 7 text-figs.