

**LARVAL DEVELOPMENT OF *SARON MARMORATUS* (OLIVIER),  
IN THE LABORATORY**

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THE present knowledge of the larval development of *Saron marmoratus* (Olivier) is limited to an early report by Gurney (1937) and to a recent work by Al-Kholy (1961), procuring the material from the Red Sea. Gurney (*op. cit.*) deals with only two larval stages, the first stage from laboratory hatching and the other from plankton. Al-Kholy (*op. cit.*) describes the first four larval stages, obtained by rearing a berried female in the laboratory and points out the differences in the larval characters of the first stage as obtained by him and Gurney. Similarly, a berried female caught off Ratnagiri, was reared in the laboratory and as many as eight stages i.e. from protozoa to fourth post-larva, were obtained, thus enabling us to extend the knowledge of the larval development of this species by four additional stages. Besides, the characteristics of the first four larval stages as described by Al-Kholy show variations in several respects, with the corresponding stages of the local specimen. This makes it necessary to describe in detail each stage once again, since the differences are too many to cite individually.

**MATERIAL AND METHODS**

A live berried specimen of *S. marmoratus* was collected on the 16th November 1959 from one of the rock pools off Ratnagiri. The specimen was kept in an aquarium tank with sea water until the eggs hatched out. The larvae were fed with live microplankton collected every day.

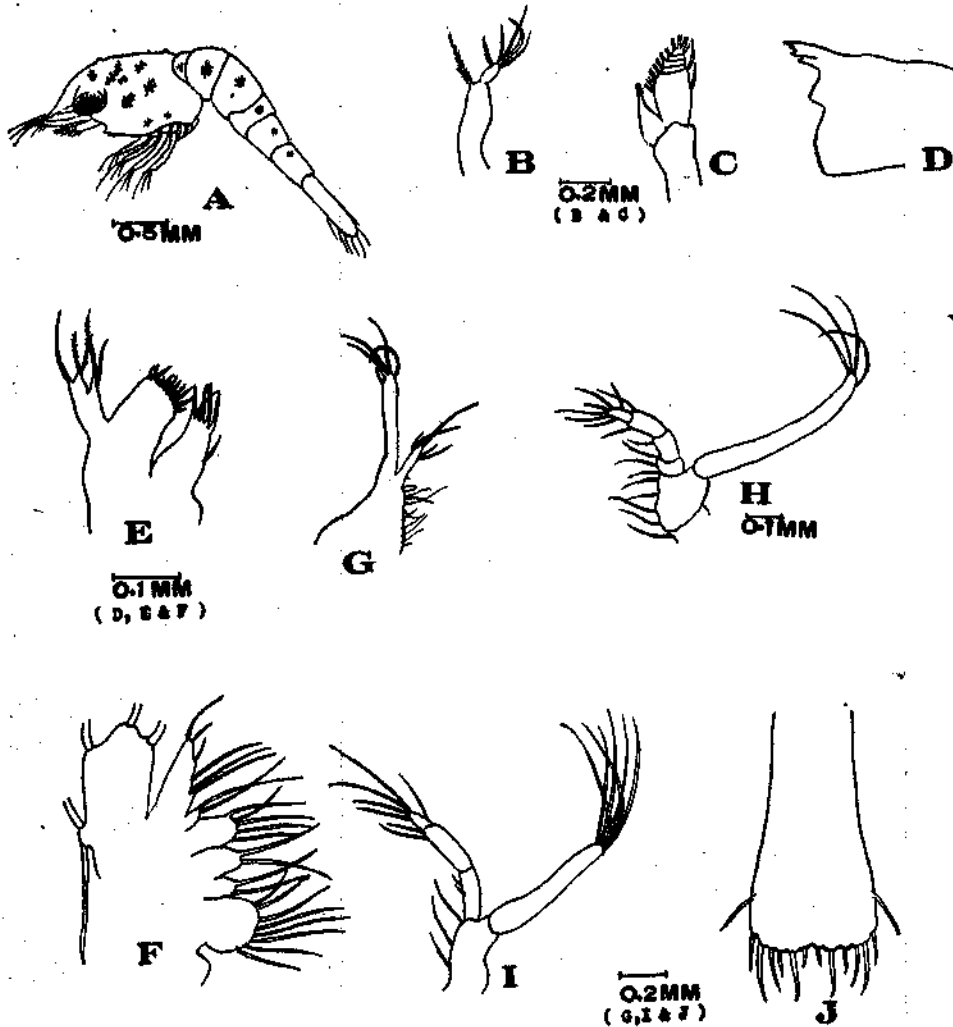
A few larvae were examined, after each moulting, to observe the changes in the chromatophore-pattern, after which they were preserved for detailed morphological studies.

The larvae could not be reared beyond the fourth post-larval stage, as there was a heavy mortality during the second zoeal stage. The remaining few larvae were just sufficient to be reared up to the fourth post-larval stage only. Whenever necessary, a close study was made on the method of locomotion and change of colour of the live larvae. The temperature of the sea water, during the course of the development varied between 26° and 29°C. The terms protozoa, zoea and post-larva are used as followed by Menon (1951).

LARVAL STAGES

Protozoa (Text fig. 1, from A to J).

After 48 hours of introducing the female in the tank, the eggs hatched out into the protozoal stage.



TEXT FIG. 1. *Saron marmoratus* (Olivier), Protozoa. A—Entire larva (side view), B—Antennule, C—Antenna, D—Mandible, E—First Maxilla, F—Second Maxilla, G—First Maxilliped, H—Second Maxilliped, I—Third Maxilliped, J—Telson.

Majority of larvae during this stage, were greenish-yellow and others were orange-red. It was observed, however, that the larvae would suddenly change their colour from greenish-yellow to orange-red, on slight disturbances, such as caused during the simple operation of pipetting, or agitation of water. It is just possible

that Gurney and Al-Kholy did not notice this fact, as the former mentioned the larvae as having red colour and the latter described two types of larvae different in colour, viz. orange and yellow. After the disturbance, the larvae would regain their greenish-yellow colour in about half an hour, when left undisturbed in the tank. Hence, the detailed study of the chromatophores could only be made in the disturbed condition of the larvae i.e. the larvae having orange-red colour. It was also interesting to observe that the protozoecae were swimming upside-down and this posture was observed until the third post-larval stage, when they started swimming like adults.

Length of larva = 3.703 mm., Length of rostrum = 0.207 mm.

The larvae are of fairly stout-built. The carapace has a pterygostomian spine, two small anterior marginal teeth and one small posterior marginal tooth. Anterior and posterior papillae are present on the carapace and the ventral margin of the carapace is sinuate. The rostrum is small, slightly down-turned and does not reach the distal ends of antennule and the antennal scale. The eyes are sessile and not large. The pleural plates of the last four abdominal segments are pointed. The telson is narrow with 7 + 7 unequal and long spines.

Antennule is unsegmented. The exopodite has 4 aesthetes of which one has a narrow hyaline margin and one comparatively short feathered seta on the inner side, whereas in Al-Kholy's larva there are 3 aesthetes and 1 feathered seta. The endopodite is represented by a single feathered seta.

Antennal scale is terminally four-segmented, short and abroad with two outer, ten inner and one terminal setae and not 12 setae as described by Al-Kholy. The endopodite is broad at the base and narrows distally to a spine-like process which bears a few minute spines on either margin.

Mandible consists of only masticatory portion and is without a palp, molar process having several minute teeth and incisor with four teeth.

First maxilla has two endites—the proximal with six setae and the distal with a number of stumpy bristles. The endopodite is unsegmented and has five long setae.

Second maxilla has two bilobed setose endites, a faintly segmented palp with two terminal setae and a scaphognathite with five marginal setae.

Endopodites of the second and the third maxillipeds are four and three jointed respectively and their exopodites bear four and six terminal setae respectively. The endopodite of the third maxilliped is five-segmented as described by Al-Kholy in the Red Sea larva. The endopodite of the first is faintly segmented and its exopodite bears five terminal setae.

Three pairs of pereopods are present as small rudimentary buds.

Sixth abdominal segment is fused with telson. The telson is longer than broad and is roughly parallel-sided, narrowing anteriorly. The central shallow cleft divides the posterior margin into two convex halves each of which bears six unequal spines. Besides, there is one spine on each lateral side near the posterior margin. The first, third and sixth spines are smaller than the remaining ones.

Stellate red chromatophores are profusely distributed over the entire dorsal region of the carapace. Two such chromatophores but smaller in size are present near the ventral margin of the carapace and on either side along the mid-dorsal line of the abdomen. The area between the eyes is covered with red and yellow stellate chromatophores. On the lateral side of the abdomen and on either extremities of the posterior margin of the telson, there are greenish yellow chromatophores. In the larva described by Al-Kholy, the telson is transparent. The last abdominal segment has a patch of yellow chromatophores.

#### First Zoea (Text fig. 2 ; from A to C).

The protozoa, after about 48 hours, moulted into the first zoeal stage. The presence of well-developed movable stalked eyes free from the carapace and development of one spine on either side of the central notch of the posterior margin of the telson marked the changes over the protozoal stage.

Antennule is faintly segmented, whereas it is two-segmented in the Red Sea larva and both the inner and outer rami have increased in size. The inner ramus has four setae nearabout its base and outer ramus distally bears four aesthetes.

The antennal peduncle has a small ventral spine and the segmentation of the scale becomes indistinct.

Mandible, first maxilla, second maxilla, first and second maxillipeds do not show any appreciable change from the previous stage. In the third maxilliped, the endopodite is now segmented.

Amongst the five pairs of biramus pereopods, only the first pair has its endopodites segmented. The last two pairs are rudimentary.

Five pairs of pleopods are present as small buds.

Telson is similar to the previous stage except for an addition of one spine on either side of the central notch of the posterior margin, as in the Red Sea larva.

The larva has a number of orange-red stellate chromatophores ; two on the eye stalk, one towards the distal end of the rostrum, three or four in the cardiac region, three situated obliquely near the lateral side of the carapace and a few minute ones on either side of each of abdominal segments. Ventrally at the origin of the antennule and antenna, there are two stellate brownish-red chromatophores.

#### Second Zoea (Text fig. 2 ; from D to K).

After about 72 hours, the first zoea moulted into the second zoeal stage. This stage is characterised by the development of uniramus uropods.

Both the inner and outer rami of the antennule have increased in size but the inner ramus is still incompletely articulated with the peduncle.

Endopodite of the antenna gradually narrows at the distal end.

Mandible still does not bear a palp.

The proximal endite of the first maxilla bears about eight setae, whereas the endopodite bears only four.

In the second maxilla, except for the increase in number of setae on the scaphognathite, there is no other change.

The endopodite of only the third maxilliped is now five-segmented, otherwise all the maxillipeds do not show any change from the previous stage.

Pereiopods and pleopods do not exhibit any change from the previous stage. As per Al-Kholy's description the endopodite of the second leg is now two-segmented.

Telson becomes more parallel-sided and the number of spines is reduced to 7 + 7. The uropods are uniramus, but in the zoea tending to reach the next stage, the bud of the inner ramus can be seen inside the telson. In the Red Sea larva both the rami are partially free from the telson.

#### Third Zoea (Text fig. 2 ; from L to P).

It took nearly 72 hours for the larva in the second zoeal stage to moult into third zoeal stage. Rostrum just extends beyond the antennular peduncle and antennal scale. The pterygostomian and anterior marginal teeth are well developed and the posterior marginal tooth becomes blunt. The uropods are biramus.

The antennular peduncle is distinctly three-segmented. The inner ramus becomes elongated and is still incompletely articulated with the peduncle. The outer ramus increases in size and has five distal aesthetes.

The scale and endopodite of the antenna are comparatively narrower than in the previous stage. The endopodite is two-segmented and its spine-like distal process is much reduced.

Mandible and maxillae do not show any change from the previous stage.

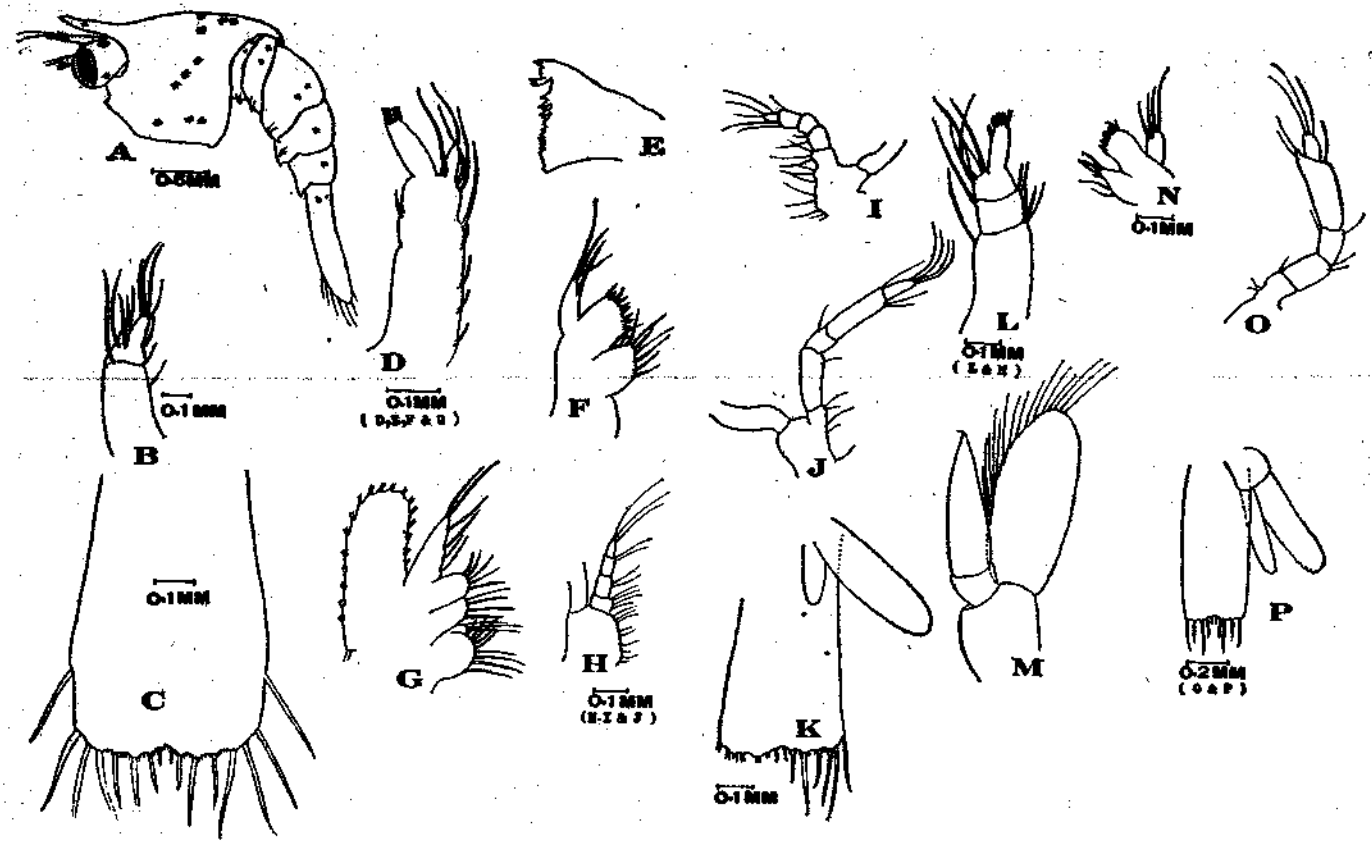
Exopodites of the three maxillipeds respectively bear six, six and five distal setae.

The first two pairs of pereiopods have the prolongation of the propodus over the dactylus showing the beginning of the formation of the chela and the remaining pairs have their endopodites distinctly segmented. In the Red Sea larva of this stage, the third and fourth legs are biramus, more developed than the previous stage and the fifth leg is still rudimentary.

First, second and third segments of the abdomen have their pleural plates rounded.

Pleopods are present as five biramus pairs.

Telson is parallel-sided and the spine-formula is reduced to 5 + 5, out of which the third one is the longest. The spine-formula of the larva from the Red Sea is 6 + 6. Uropods are biramus and both the rami are functional as in the Red Sea larva.



TEXT FIG. 2. *Saron marmoratus* (Olivier), First Zoea (A to C). A—Side view of larva (legs etc. not shown), B—Antennule, C—Telson.  
 Second Zoea (D to K)  
 D—Antennule, E—Mandible, F—First Maxilla, G—Second Maxilla, H—First Maxilliped, I—Second Maxilliped, J—Third Maxilliped, K—Telson.  
 Third Zoea (L to P)  
 L—Antennule, M—Antenna, N—First Maxilla, O—First pereopod, P—Telson.

The chromatophore pattern does not change much from the previous stage. Antennule and antenna have two brownish red pigments distally. Eye stalks have developed one more stellate orange-red chromatophore on the inner side in addition to the two chromatophores of the previous stage. On either side of the gastric region, there are three stellate chromatophores. The last abdominal segment has reddish-brown pigment near the articulation of the uropods. The external ramus of the uropod has one and the posterior margin of the telson has two chromatophores. The basal segments of the maxillipeds have orange-red chromatophores.

First post-larva (Text fig. 3 ; from A to I).

After 120 hours, the larva in the third zoeal stage moulted into first post-larva. Rostrum just touches the distal end of antennular peduncle and is flattened laterally. The tip is pointed and bears one tooth on the dorsal side and two on the ventral. On the carapace, the sub-orbital spine has started developing. The pleura of the sixth abdominal segment terminates in a spine.

The inner ramus of the antennule becomes more slender and the peduncle has, at its base, a strong spine-like tooth on the outer side.

The endopodite of the antenna is sabre-like, two segmented and is now longer than the scale.

Mandible, maxillae and maxillipeds do not exhibit much change from the previous stage. The dactylus of the endopodite of the third maxilliped at its distal end bears three spines.

The first two pairs of pereopods are distinctly chelate but the first pair is more massive than the second. Carpus of the second pair is two-segmented. The dactylus of third and fourth pairs bears two spine-like teeth and that of fifth pair bears a single spine-like tooth on the posterior margin. The dactylus assumes a claw-like appearance.

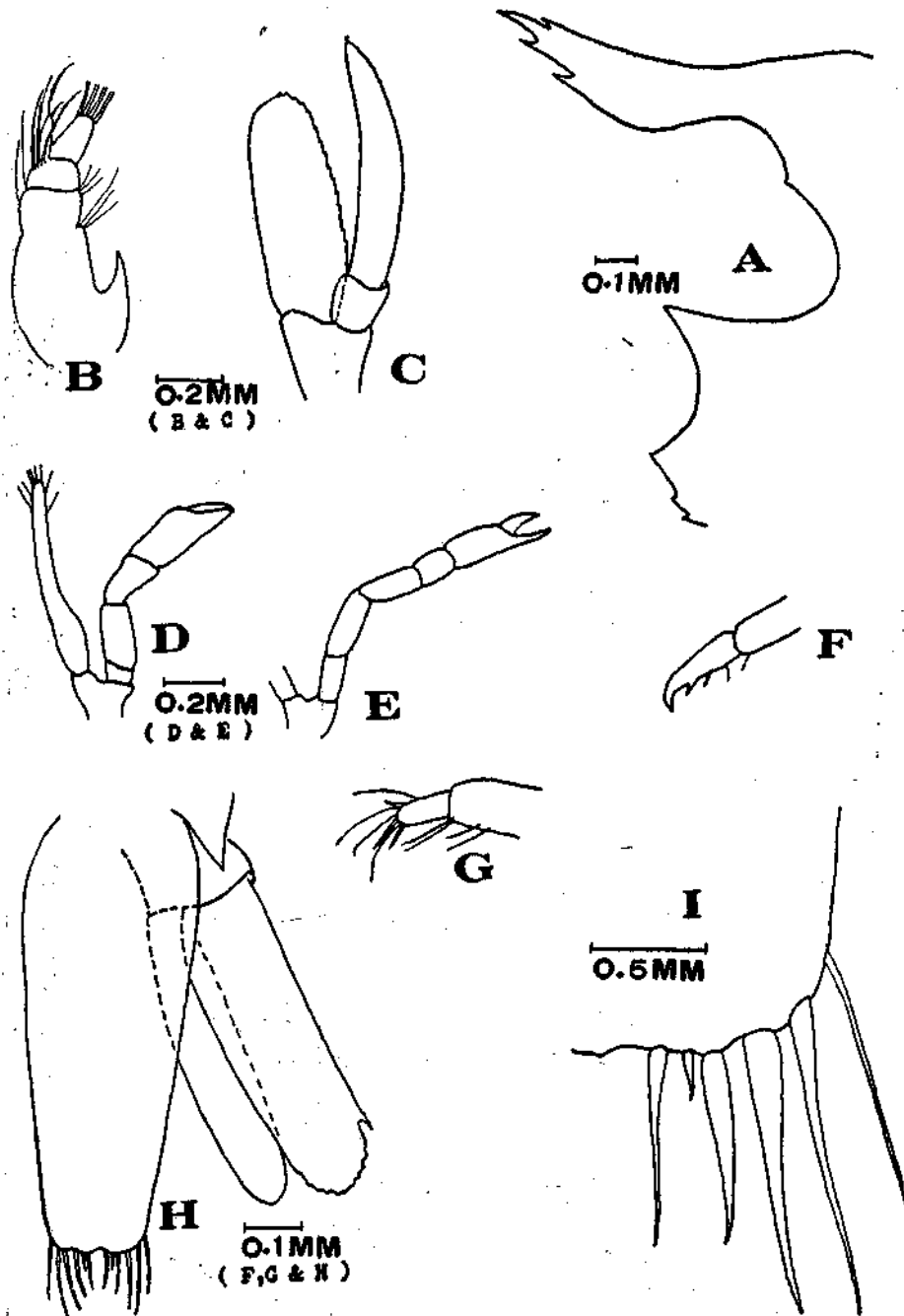
The spine-formula of the telson is  $6 + 6$ , including one on each side of the outer margin. Both the endo- and exo-podites of the uropods are setose but only the exopodites bear a posterior spine-like tooth on the outer margin.

Second post-larva (Text-fig. 4 ; from A to P).

Approximately 96 hours were necessary for the larva to moult into the second post-larva, which stage comprises a striking change resulting in the larva having the shape of the adult prawn. The rostrum is slightly upturned and bears four ventral teeth and five dorsal of which two are on the carapace. The longitudinal rib has started setting in on the lateral side of the rostrum. There are three or four tufts of plumose hairs on the carapace and four tufts on the abdomen.

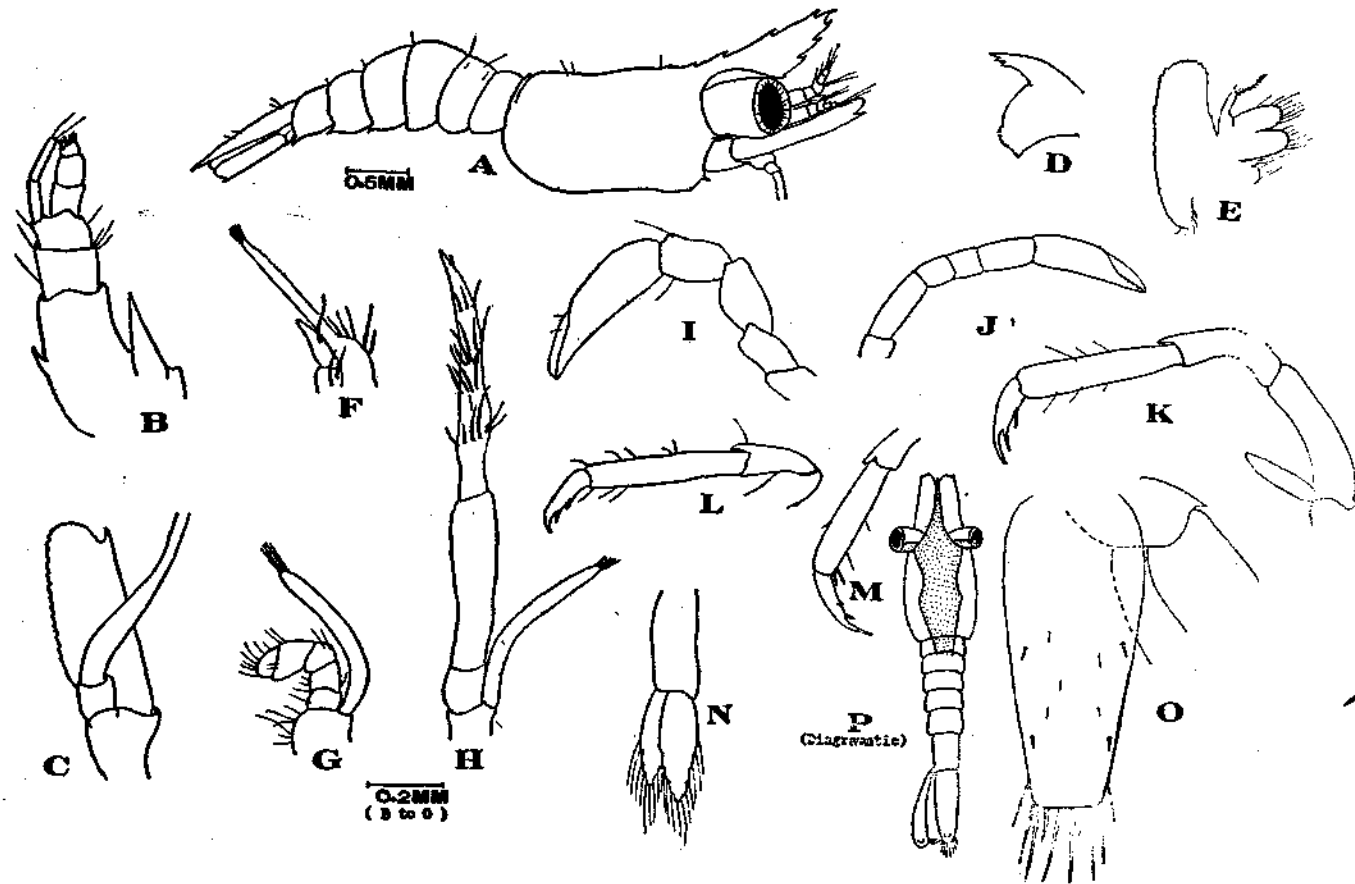
Inner ramus of the antennule is elongated and two jointed, whereas the outer ramus is three-segmented with about five aesthetes. The peduncle is three-segmented and has one small spine on the middle of the inner side, in addition to the outer spine which just falls short of reaching the distal end of the basal segment.

The endopodite of the antenna is three-segmented and the scale bears distally one spine.



TEXT FIG. 3. *Saron marmoratus* (Olivier), First post-larva. A—Part of carapace (side view), B—Antennule, C—Antenna, D—First pereopod, E—Second pereopod, F—Distal portion of third pereopod, G—Distal portion of third maxilliped, H—Telson with uropods, I—Telson.





TEXT FIG. 4. *Saron marmoratus* (Olivier), Second post-larva. A—Side view of larva (legs, etc., not shown), B—Antennule, C—Antenna, D—Mandible, E—Second Maxilla, F—First Maxilliped, G—Second Maxilliped, H—Third Maxilliped, I—First pereiopod, J—Second pereiopod, K—Third pereiopod, L—Portion of fourth pereiopod, M—Portion of fifth pereiopod, N—Pleopod, O—Telson, P—Dorsal view showing colour pattern of larva.

Mandible does not show much difference from the previous stage.

Palp of the first maxilla has two setae.

Scaphognathite of the second maxilla is well-developed and the proximal endite is much reduced. The endopodite has one plumose seta near its distal end.

First maxilliped differs a little from that of the previous stage.

In the second maxilliped there is a beginning of the dactylus being articulated as a strip to the distal portion of the propodus.

Exopodite of the third maxilliped is much reduced in length. The setae on the endopodite are arranged in segmental pattern and the distal end bears a small spine on the outer margin.

In the pereiopods, the first two pairs are distinctly chelate and without exopodites. The second pair has four-segmented carpus. The exopodites of the remaining three pairs are in much reduced condition. The claw-like dactylus, and propodus have two spines on the posterior margin. The lobe-like prolongation of the carpus over the propodus is distinct.

There are five pairs of functional pleopods, each pleopod with a stout basal stalk.

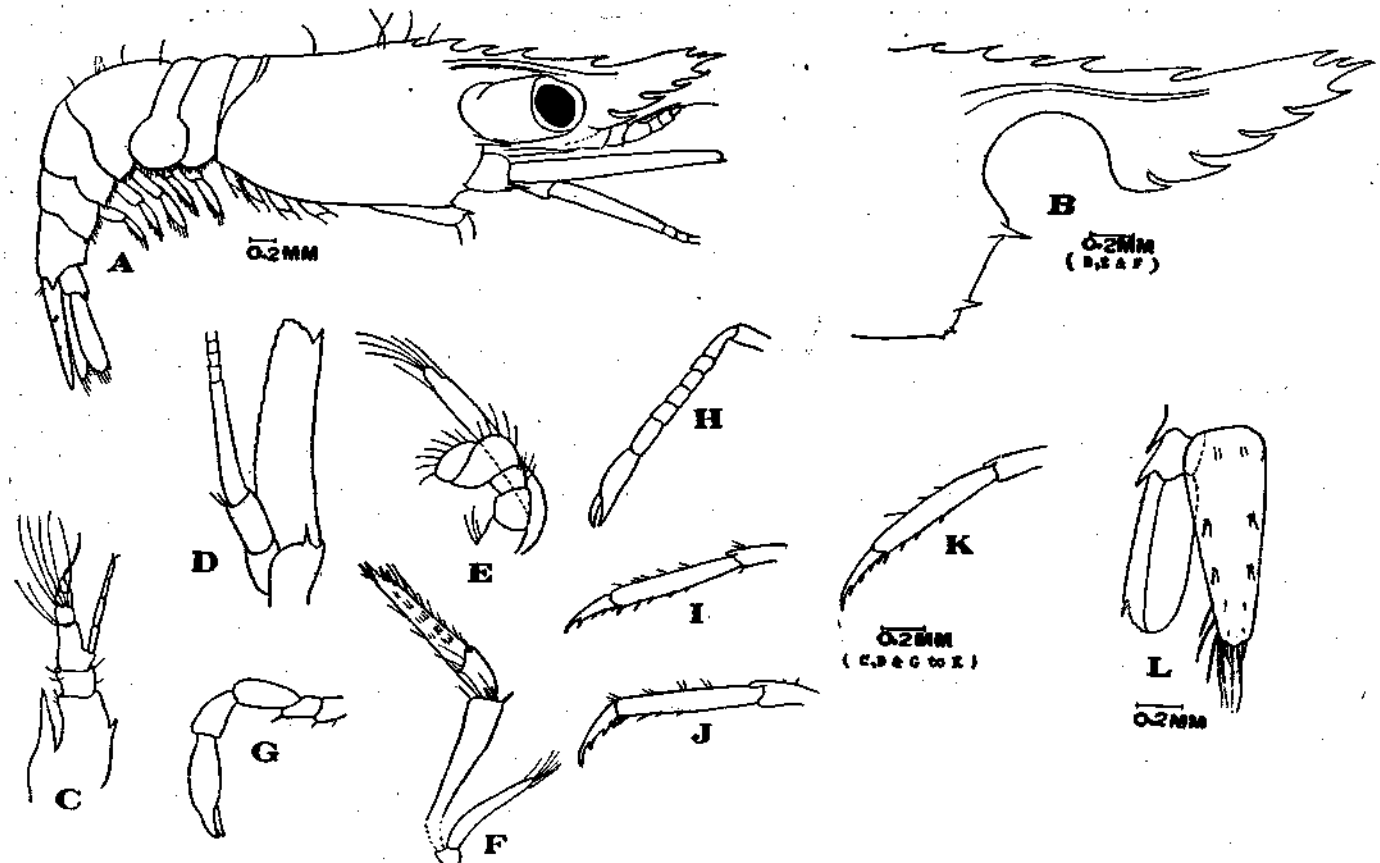
Telson narrows more at the posterior end. Spine-formula is  $5 + 5$ , of which one on each side being on the outer margin. The second spine is smaller and stouter than the rest. There are two spines and a few setae on either side of the dorsal surface. The stalk of uropod has one spine at the distal end of outer margin.

The general colouration now tends towards greenish-brown. There is a 'Shark-skull'-shaped bright yellow area on the dorsal side of the carapace. Antennal scale is greenish-brown and the flagellum is annulated with yellowish iridescent spots on each segment. Last three pairs of legs have bright yellow iridescent spots on their distal segments. On the posterior margin of the telson and uropods, there are patches of bright yellow colour.

Third post-larva (Text fig. 5 ; from A to L).

About 120 hours were required for the larva in the second post-larval stage to moult into the third post-larval stage. Now the rostrum has a distinct crest at its beginning and bears seven dorsal teeth, including the two on the carapace, and five ventral teeth. Rib is quite prominent. The antennal, pterygostomial spines are well-developed. There are four or five tufts of plumose hairs on the mid-dorsal line of the carapace. The first two abdominal pleurites are round and especially the second has taken the shape of that of the adult. The pleural spine of the sixth segment is much prolonged. The tufts of plumose hairs have increased in number and the lower margin of the pleurites is fringed with delicate hairs.

The inner ramus of the antennule is well articulated with the peduncle and is four-segmented. The outer spine of the peduncle reaches well beyond the distal end of the basal segment of the peduncle.



TEXT FIG. 5. *Saron marmoratus* (Olivier), Third Post-larva. A—Side view, B—Portion of carapace, C—Antennule, D—Antenna, E—Second Maxilliped, F—Third Maxilliped, G—First pereiopod, H—Portion of second pereiopod, I—Portion of third pereiopod, J—Portion of fourth pereiopod, K—Portion of fifth pereiopod, L—Telson with uropods.

The basal segment of the antennal peduncle has a spine on its distal margin. The spine at the distal end of the scale is more prominent. The endopodite is distinctly segmented and thus forming a flagellum.

Mandible has a rudimentary palp-like structure.

First and second maxillae and first maxilliped do not show much morphological differences from the previous stage.

In the second maxilliped the articulation of the dactylus as a strip to the distal portion of the propodus is well marked.

Endopodite of the third maxilliped distally bears about five spines. The carpus has one spine on the distal end of the outer margin and the merus has two spines on the distal margin. The exopodite is much reduced.

The ischium of the first pair of legs has distally one spine and the carpus of the second pair is six-segmented. The dactylus of the last three pairs has four spines on the posterior margin. Distally the propodus has two spines and the number of spines on the posterior margin is four, three, and three on the third, fourth and fifth pairs respectively.

The spine-formula of the telson is  $7 + 7$ , of which three on each side being on the outer margin. There are two spines on the outer margin of the exopodite of the uropods.

Fourth post-larva (Text fig. 6; from A to M).

After 96 hours, the larva in the third post-larval stage passed into the fourth stage. Rostrum is shorter and more flattened than in the previous stage. There are seven dorsal teeth including the three on the carapace, and five ventral teeth. The longitudinal rib is more prominent. The carapace has more tufts of plumose hairs on the mid-dorsal line and a few tufts on the ocular peduncle.

Inner ramus of the antennule is seven-segmented and the outer is four-segmented. The spine on the outer margin of the basal segment of the peduncle just reaches the distal portion of the penultimate segment.

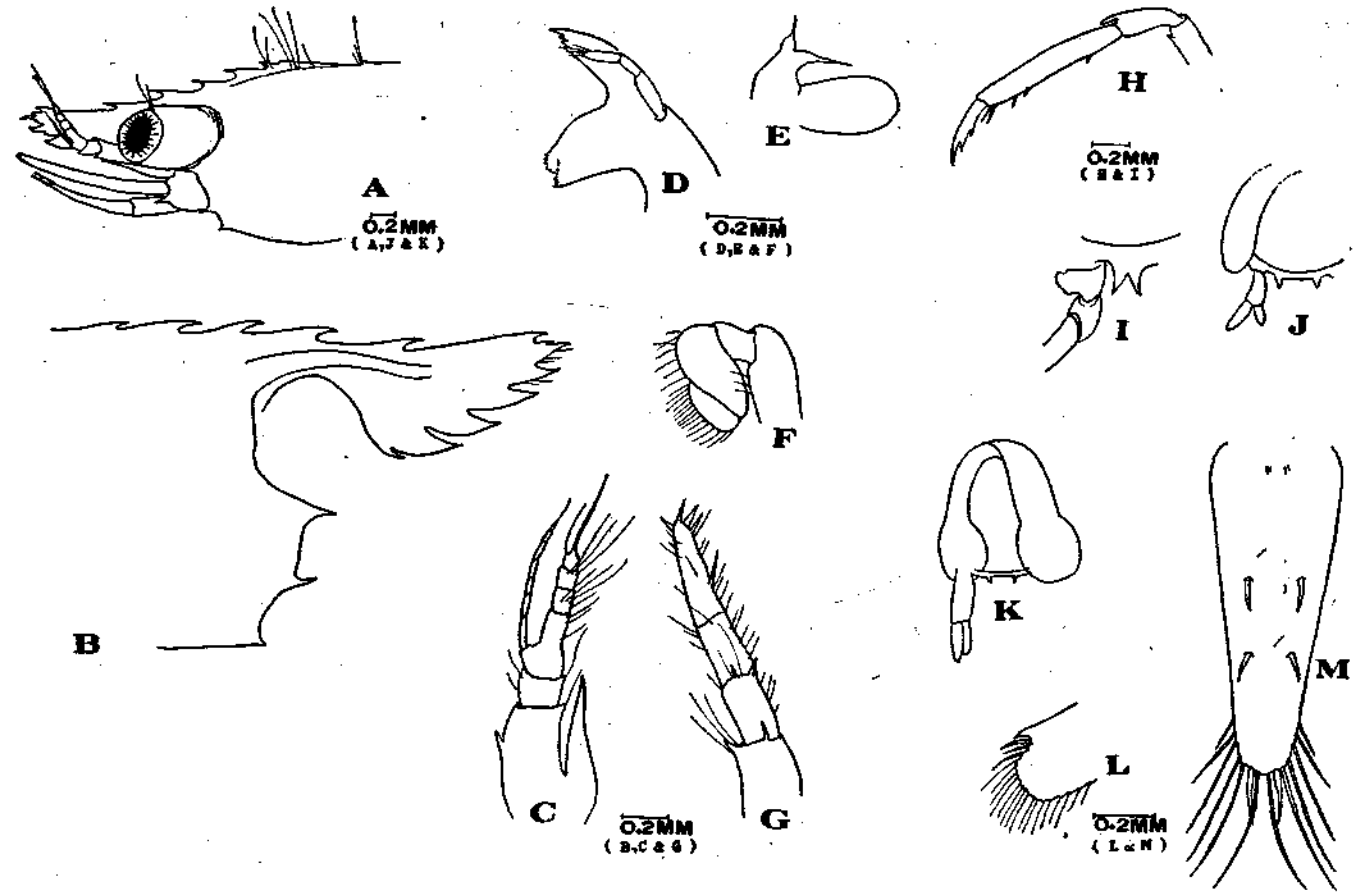
Antenna is similar to that of the previous stage, except for the increase in number of segments of the flagellum.

The three-segmented palp of the mandible is distinctly formed and the incisor and molar processes are well developed.

First and second maxillae and first maxilliped differ a little from the corresponding appendages of the previous stage.

Dactylus of the second maxilliped is attached as a strip to the propodus as in the adult.

In the third maxilliped, the endopodite is well formed with the dactylus bearing about five spines at the distal end. The carpus and merus have two spines distally. The exopodite is much reduced.



TEXT FIG. 6. *Saron marmoratus* (Olivier), Fourth Post-larva. A—Portion of larva, B—Portion of carapace, C—Antennule, D—Mandible, E—First Maxilla, F—Portion of second maxilliped, G—Portion of third maxilliped, H—Portion of third pereiopod, I—Sternal portion of fifth thoracic segment. J—First abdominal segment showing pleuron and sternum, K—Second abdominal segment showing pleuron and sternum, L—Distal portion of external ramus of uropod, M—Telson.

First two pairs of the pereiopods are similar to the previous stage, and the third pair has on the posterior margin a distal spine on its carpus. The fourth and fifth pairs do not differ much from the previous stage except for the sternal plates, which ventrally bear two spine-like protuberances in the middle.

Each tergum of the abdomen bears a single tuft of hair on either side of the mid-dorsal line. The sternal piece of each of the first four abdominal segments bears one spine-like protuberance on either side of the mid-ventral line.

In the pleopods, except for the increase in size, there is no morphological difference from the previous stage.

Telson narrows much at the posterior end. The spine-formula remains the same, but now the last four spines on each side being situated on the outer margins. The spine on the postero-external margin of the outer ramus of the uropods is much developed.

The 'Shark-skull'-shaped area still persists but the general colouration on the lateral portion of the carapace and the abdomen is now towards that of the adult.

#### DISCUSSION

The first four larval stages of *S. marmoratus*, while agreeing in general, differ in detail in each of the corresponding stages of the same species as described by Al-Kholy (1961) from the Red Sea. In both the instances, the larval material is obtained from the laboratory hatchings. Comparing the descriptions, it may be remarked here that the local larvae possess such advanced features in the development, over the Red Sea larvae, as the appearance of pereiopods, their segmentation, appearance of pleopods and reduction in spine-formula of the telson. The advanced features of the local larvae against those of the Red Sea larvae are given below stagewise :—

Larval Stage	Local specimen	Red Sea specimen (As per Al-Kholy)
I	Nil.	Nil.
II	Five pairs of biramus legs, endopodites of first three legs segmented.	Endopodite of first leg only is four-segmented.
III	As in second stage.	Endopodite of second leg now becomes two-segmented.
IV	First two pairs of legs show the beginning of formation of chela and remaining pairs have their endopodites segmented.	Third and fourth legs are biramus, more developed and the fifth leg rudimentary.
	Telson : Spine-formula 5 + 5	Telson : Spine-formula 6 + 6

It is not altogether unusual to find the larvae of such a widely distributed species as *S. marmoratus*, differ on hatching in different parts of the range of distribution (personal communication with Dr. I. Gordon of the British Museum, London). Pike and Williamson (1960) have found differences in the first larva of certain Pagurids in different places. In *Diogenes pugilator*, they find local variations in the larvae. The different ecological conditions may probably be one of the causes for variations in the larval characters of the species as described above.

#### SUMMARY

1. Laboratory hatchings of the eggs, from the protozoa upto the fourth post-larval stage of *Saron marmoratus* (Olivier) are described.
2. Advanced features of the local larvae against the first four larval stages of the Red Sea larvae as described by Al-Kholy (*op. cit.*) are also given.
3. The characteristics of each stage are given below :
  - Protozoa : Sessile eyes ; spine-formula of telson 7 + 7.
  - First zoea : Stalked eyes ; spine-formula of telson 8 + 8.
  - Second zoea : Uniramus uropods.
  - Third zoea : Biramus uropods ; spine-formula of telson 5 + 5.
  - First post-larva : One dorsal tooth on the rostrum ; first two pairs of pereopods chelate.
  - Second post-larva : Uprturned rostrum ; with five dorsal teeth.
  - Third post-larva : Second abdominal pleurite like that of the adult.
  - Fourth post-larva : Much flattened rostrum with seven dorsal teeth ; few tufts of hairs on eye stalks.

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