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SUPPLEMENT 2

STUDIES ON DECAPOD LARVAL DEVELOPMENT

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A COMPARISON OF THE LARVAL DEVELOPMENT OF *METASESARMA RUBRIPES* (RATHBUN) AND *SESARMA RICORDI* H. MILNE EDWARDS (BRACHYURA, GRAPSIDAE) REARED UNDER SIMILAR LABORATORY CONDITIONS

BY

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Metasesarma rubripes (Rathbun) and *Sesarma ricordi* H. Milne Edwards are common species of grapsoid crabs found in several localities of the Maracaibo estuary where the chlorinity ranges from 2 to $9^0/_{00}$. Ovigerous females of both species have been found throughout the year near the water line, among the moist root of palm trees and beach grasses and pieces of driftwood.

The purpose of this contribution is to determine the differences that may occur between the larval development of both species.

Larval descriptions of six species of *Sesarma* and one of *Metasesarma* appear in the literature: *S. cinereum* Say (Costlow & Bookhout, 1960), *S. reticulatum* (Bosc) (Costlow & Bookhout, 1962), *S. haematocheir* De Haan and *S. dehaani* H. Milne Edwards (Yatsuzuka, 1962), *S. tetragonum* (Fabricius) and *M. rousseauxii* H. Milne Edwards (Rajabai, 1962), *S. bidentatum* Benedict (Hartnoll, 1963). However, no description is available of those species found in Venezuela.

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MATERIALS AND METHODS

Ovigerous females of *Metasesarma rubripes* (Rathbun) and *Sesarma ricordi* H. Milne Edwards were captured in various localities in the Maracaibo estuary. They were maintained in squat one-gallon glass jars containing a small amount of diluted sea water ($19^0/_{00}$ S.). As the larvae hatched, those showing the greater activity were placed in compartments of clear plastic boxes. This technique has been recently used in the successful rearing of brachyuran crabs (Costlow & Bookhout, 1960), pagurid crabs (Provenzano 1962), caridean shrimps (Dobkin, 1963), stomatopods (Manning & Provenzano, 1963), penaeid shrimps (Ewald, 1965) and many others. The larvae were changed to freshly filtered water in

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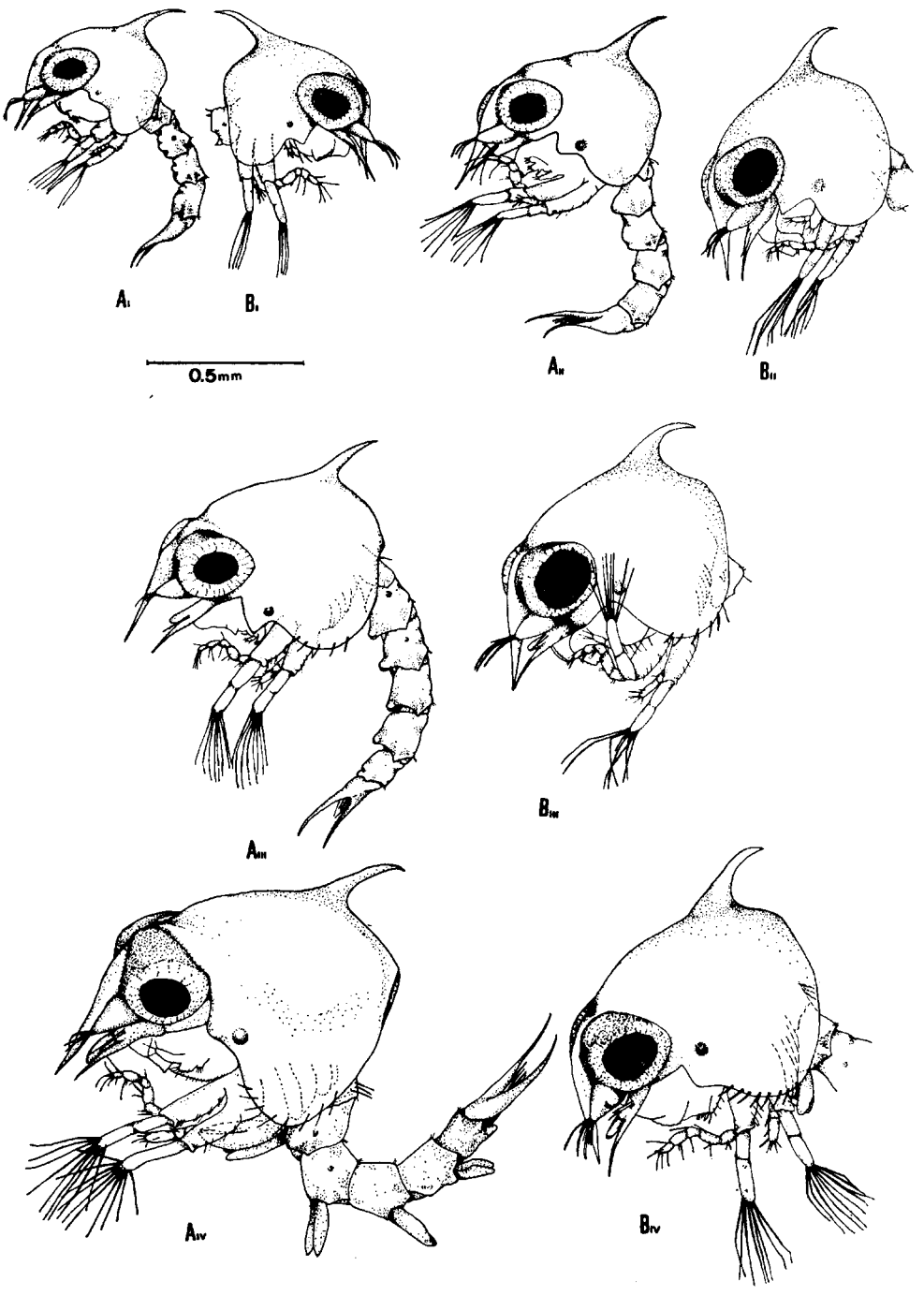

Fig. 1. *Metasesarma rubripes* (Rathbun). AI-AIV, lateral view of zoeal stages I to IV. *Sesarma ricordi* Milne Edwards. BI-BIV, lateral view of zoeal stages I to IV.

clean boxes and the boxes were examined daily for exuviae. Larvae were fed throughout their development on recently hatched nauplii of *Artemia salina* (L.). Temperature of the laboratory was maintained at 27 ± 1°C., salinity was adjusted to 19 ± 1‰ by using either distilled water or river water. Illumination was supplied by fluorescent lamps for periods of nine to twelve hours per day.

The larvae of twelve *Metasesarma rubripes* females and seven *Sesarma ricordi* females were reared according to the procedure explained above. Some samples of live larvae and their exuviae were preserved in 10% formaline buffered with hexamethylenamine and others were preserved in 70% ethylene glycol. Examples of preserved specimens and molts were dissected in polyvinyl-lactofenol or ethylene glycol using a stereo-microscope. The appendices were then placed in polyvinyl-lactophenol tinted with ordinary fountain pen ink and drawings were made with the help of a camera lucida. Setation was frequently checked using oil immersion (800 ×). No fewer than fifty larvae of each stage were examined for variations. Where variation occurred, the most common form was illustrated. In the illustrations the secondary setation is frequently omitted for clarity. Setation counts run from basal to distal segments.

Parent females were identified by Rathbun's (1918) and Rodriguez's (M.S.) keys. Samples have also been sent to the U.S. National Museum for confirmation. The original parent females have been deposited in the Biological Museum of the Faculty of Science at the Universidad Central de Venezuela in Caracas.

RESULTS

There are four zoeal stages and one megalopa stage in the complete larval development of both *Metasesarma rubripes* and *Sesarma ricordi*. The following includes a detailed description of the larvae of *M. rubripes* and a shorter description of the differences encountered by the authors in their comparison of the larvae of *S. ricordi* with these.

Gross morphology of the zoeal stages (fig. 1)

First zoea

M. rubripes. — The cephalothorax has a short tapering dorsal spine which curves caudally. The rostral spine is approximately equal in length to the antennae. The eyes are not stalked. The abdomen consists of five segments plus the telson. The first abdominal segment is partially or totally covered by the cephalothorax. The second segment bears a pair of small lateral spines and the third bears a smaller pair of lateral spines or knobs. The posterior lateral margin of abdominal segments 2 to 5 terminates dorsally in a short blunt point which overlaps the following segment, while the postero-dorsal border of each segment bears two fine, short hairs. The telson is bifurcated in two long processes, each of which bears three serrated spines in its terminal border. Duration of this stage is from three to five days.

S. ricordi. — Similar to the first stage of *M. rubripes* but proportionately larger in all respects. Duration of this stage is from four to seven days.

Second zoea

M. rubripes. — In the frontal area of the cephalothorax, between the rostral and dorsal spines, prominent undulations appear on each side. Behind the eyes appears a protruding knob. The inferior border of the carapace is zig-zag. The eyes are now pedunculated. Duration of this stage is from two to four days.

S. ricordi. — Slightly larger than *M. rubripes* in size. Dorsal spine and its base, much wider. Duration of this stage is from four to seven days.

Third zoea

M. rubripes. — Rudimentary thoracic appendages appear in this stage. Six abdominal segments are present, each bearing small bulbous projections which correspond to the pleopods in later stages. The postero-lateral margin of the carapace bears five plumose setae. Undulations are more prominent in the inter-orbital area. Lateral protuberances are present. Duration of this stage is from two to three days.

S. ricordi. — Slightly larger than *M. rubripes* in size and with the dorsal spine shorter and wider. Rudimentary thoracic appendages evident. Duration of this stage is from three to seven days.

Fourth zoea

M. rubripes. — The carapace has almost doubled in size since the first zoea but keeps the general aspects of previous stages. The eyes are large and the ocular peduncles well developed. The rostral and dorsal spines of the carapace, as well as the lateral protuberances, are still present. The postero-lateral border of the carapace bears eight plumose setae. The thoracic appendages are better developed, but still not functional. Dorsally, the first abdominal segment bears three rigid setae, in addition to the short fine setae that are present in the other segments. The second abdominal segment possesses a pair of robust lateral spines, and the third a pair of less pronounced protuberances. The sixth segment bears ventro-lateral buds in place of pleopods. Pleopods now appear on four of the six segments (2-5). The duration of this stage is from three to four days.

S. ricordi. — The base of the dorsal spine is wider. In most respects this stage is similar to that in *M. rubripes.* Duration of this stage is from three to eight days.

Cephalothoracic appendages of the zoeal stage

Antennule (fig. 2)

M. rubripes. — The antennule is conic in form, non-segmented and terminates in a group of setae and aesthetascs. The antennule of the first zoeal stage has three aesthetascs and one seta, the second zoea possesses four aesthetascs and one

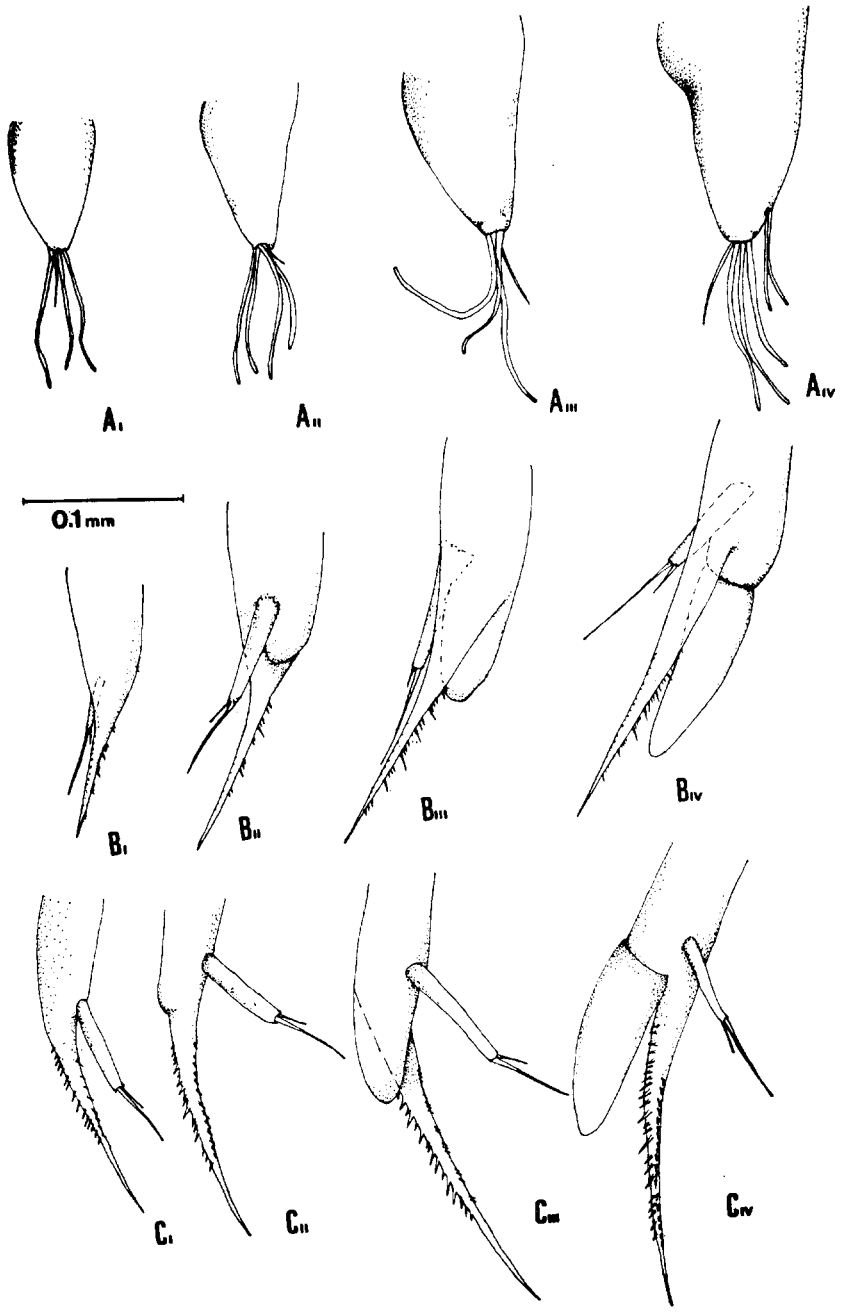

Fig. 2. *Metasesarma rubripes* (Rathbun). AI-AIV, antennula; BI-BIV, antenna of zoeal stages I to IV. *Sesarma ricordi* H. Milne Edwards. CI-CIV, antenna of zoeal stages I to IV.

seta, the third zoea possesses two large aesthetascs and a small one in addition to a small fine seta. The base of the antennule in the fourth zoeal stage is inflated and bears three terminal aesthetascs and one seta plus two sub-terminal aesthetascs.

S. ricordi. — The antennule is non-segmented, similar to that of *M. rubripes.* The first zoeal stage bears three aesthetascs and two setae, the second zoea has four aesthetascs and one seta, the third zoea bears three aesthetascs and one seta, and the fourth bears three additional sub-terminal aesthetascs and one seta.

Antenna (fig. 2)

M. rubripes. — The antenna of the first zoea consists of a protopodite which tapers gradually to a point and which bears a long row of small sharp teeth on its border and another row of less conspicuous ones. The exopodite consists of one segment approximately one-third of the protopodite's length and terminates in two unevenly sized setae. In the second zoea there appears a rounded protuberance, the endopodite bud; the number and distribution of the spines has changed, and the exopodite now consists of one segment and terminates in two unequal setae. In the third zoea the endopodite bud is now approximately the size of the exopodite and the size of the exopodite is approximately one-half that of the protopodite. The antenna of the terminal zoea is larger and bears a segmented endopodite.

S. ricordi. — The antennal protopodite is longer in all stages and bears two long and conspicuous rows of sharp teeth.

Mandible (fig. 3)

M. rubripes. — In the zoeal stages the mandible consists of both incisor and molar processes. As development advances the dentation of these processes increases in complexity. In the first zoea the incisor process consists of one large and several small flat teeth. In the second zoea the mandible is slightly larger, and an additional tooth is found between the large tooth of the incisor process and the molar plate. These teeth increase in size as development proceeds and constitute the most conspicuous character in the zoeal development of the mandible. No mandibular palp is present in the zoea.

S. ricordi. — Except for a slightly larger size, no distinguishing differences were observed between the zoeal mandible of *S. ricordi* and *M. rubripes.*

Maxillule (fig. 3)

M. rubripes. — The general morphology of the maxillule remains constant throughout development. It consists of a two-segmented endopodite and basal and coxal endites. In the first zoea the distal segment of the endopodite bears five plumose setae and the penultimate segment, one seta. As the larva passes through additional zoeal stages the number of setae does not change, although the size of the appendages increases. In the first zoea, the basal endite possesses

five serrated spines, in the second zoea seven, in the third eight, and in the fourth eleven. Coxal setation counts from first to terminal zoea are 5-6-6-7. One long seta appears at the base of the protopodite in stage two and is accompanied by another one in the third and fourth zoeae.

S. ricordi. — Except for a slightly larger size no distinguishing differences were observed between the zoeal maxillule of *S. ricordi* and *M. rubripes.*

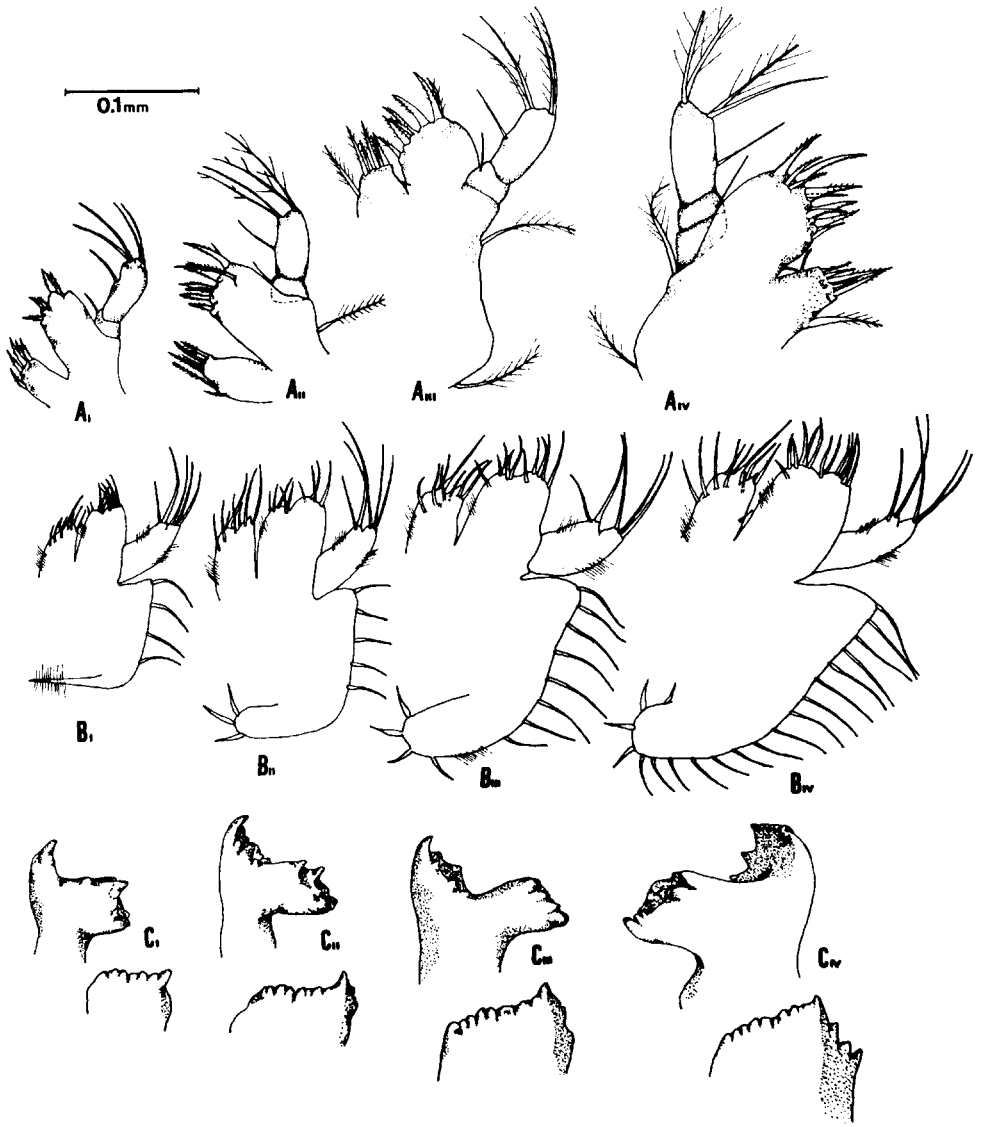

Fig. 3. *Metasesarma rubripes* (Rathbun). AI-AIV, maxillule; BI-BIV, maxilla; CI-CIV, mandible of zoeal stage I to IV.

Maxilla (fig. 3)

M. rubripes. — The maxilla throughout larval development is composed of an endopodite, two endites, and a scaphognathite. In the first zoeal stage the endopodite is bifurcated, with the distal lobe bearing three plumose setae and the other, two. This character remains constant in all four zoeal stages. Fine hairs are present on the endites and endopodite. The basal endite is weakly bifurcated and possesses from nine to ten spines in the first three stages and twelve in the terminal zoea. The coxal endite bears eight spines distributed over two lobes in the first three stages and eleven in the terminal zoea.

The scaphognathite in the first zoea bears four plumose setae and terminates dorsally in a long plumose point. In the succeeding stages the dorsal terminus bears three strong setae with wide bases. Fringing setation of the scaphognathite increases through succeeding stages in the following manner: 5,7-8, 15-17.

S. ricordi. — The maxilla of the zoeae of *S. ricordi* also bears numerous, fine hairs on the endites and endopodite. Setation, through the four zoeal stages of the basal endite (9, 9, 10, 12), coxal endite (8, 8, 8, 11) and scaphognathite (4, 5, 9-10) is very similar to that found in *M. rubripes.*

First maxilliped (fig. 4)

M. rubripes. — The first and second maxillipeds are composed of three parts, a protopodite that supports two branches, the endopodite and the exopodite. Throughout larval development the endopodite consists of five segments and the exopodite is slightly constricted in its middle. In the first zoea the endopodite bears the characteristic setation of 2, 2, 1, 2, 5. The exopodite ends in four natatory setae and the protopodite bears nine plumose setae. The endopodite of the second zoea bears the setation 2, 2, 1, 2, 5, the exopodite now ends in six natatory setae and the protopodite now bears ten plumose setae. In the third zoea the endopodite has a setation of 2, 2, 2, 2, 5, the exopodite shows marked segmentation and terminates in eight plumose natatory setae, and the protopodite bears ten plumose setae. The setation of the five segments of the endopodite in the fourth zoeal stage is 2, 2, 2, 2, 6. The exopodite is divided into two segments and ends in nine natatory setae. The protopodite bears ten plumose setae.

S. ricordi. — Except for slight (and probably insignificant) differences in setation counts, no character was found that could be used to distinguish the first maxilliped of the two species.

Second maxilliped (fig. 4)

M. rubripes. — As was the case with the first maxilliped, no fundamental changes occur throughout zoeal development. The endopodite always consists of three segments. In all four zoeal stages it bears a setation of 0, 1, 6. The exopodite is slightly constricted in its middle and in the first zoeal stage bears four long plumose setae, in the second zoeal stage six natatory setae, in the third eight and

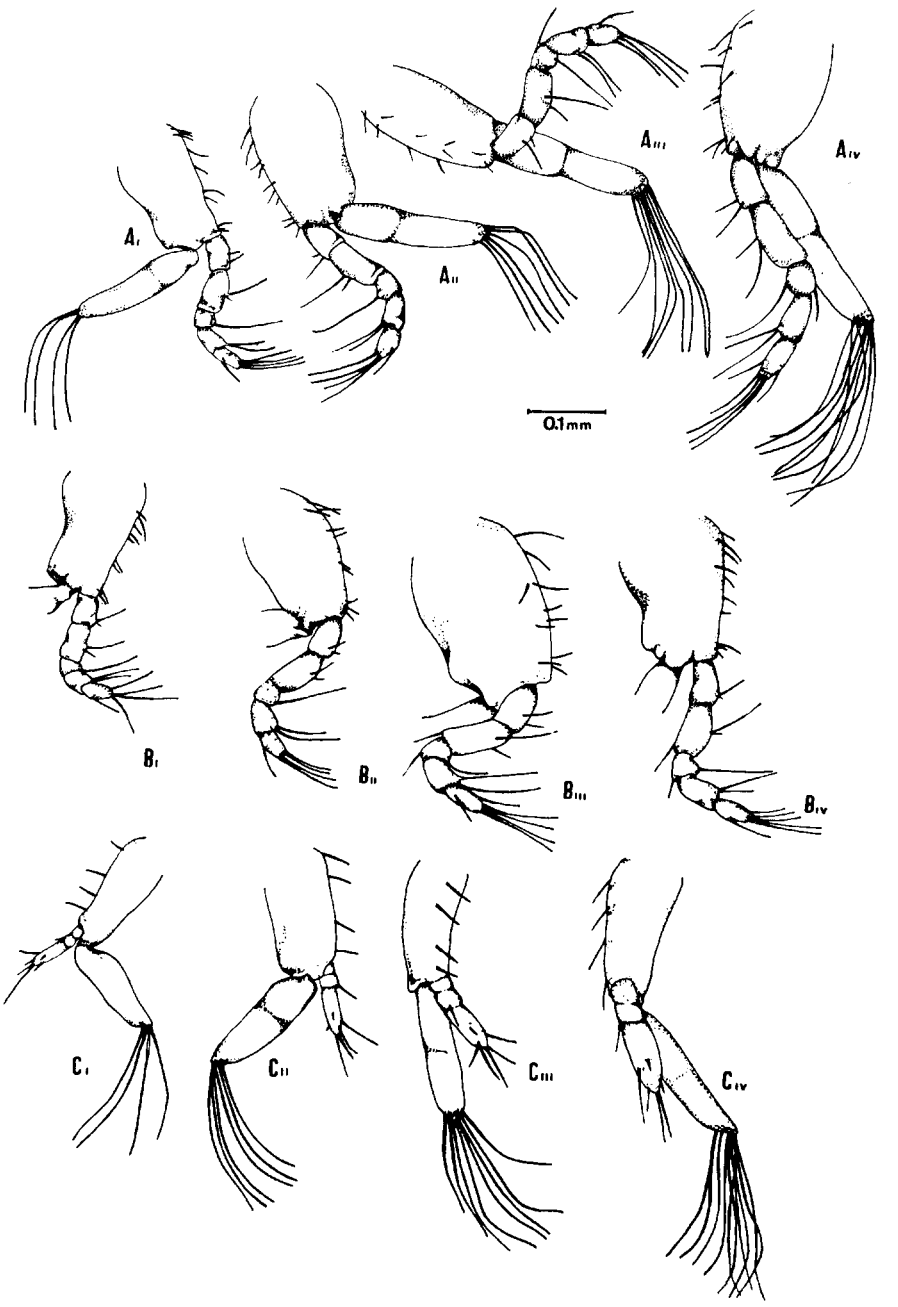

Fig. 4. *Metasesarma rubripes* (Rathbun). AI-AIV, first maxilliped; CI-CIV second maxilliped of zoeal stages I to IV. *Sesarma ricordi* H. Milne Edwards. BI-BIV, first maxilliped of zoeal stages I to IV.

in the last zoeal stage ten. The protopodite of all four zoeal stages bears four plumose setae.

S. ricordi. — The setation count of the protopodite (4) and of the endopodite (0, 1, 6) remains constant in all four zoeal stages. The exopodite setation is similar in both species.

Third maxilliped

M. rubripes. — The third maxilliped remains poorly developed in the first, second and third zoeal stages, and the fourth zoea is characterized by having three branches with five, two and no segments. No setae are present.

S. ricordi. — No differences were observed.

The gross morphology of the megalopa (fig. 5)

M. rubripes. — The cephalothorax of the megalopa is quadrangular and possesses prominent undulations in the epibranchial area. The entire area of the carapace bears numerous small hairs. The center of the very short rostrum is depressed. The pereiopods are well developed and functional. The eyes are located in sockets. The abdomen consists of six segments plus the telson and all except the first and sixth bear well developed pleopods. The setation of the five pleopods is 13, 13, 13, 11, 7 and no variation from this is observed. No setae are present on the endopodite of the pleopods but two small hooks are located on the inner surface of all. The uropods are bisegmented and without endopodites. The dactylus of the fifth pair of pereiopods bears three long setae and its distal portion is curved inwards and serrated. The duration of the megalopa stages is from seven to nine days. There is a marked variability in the telson and rostrum. In the megalopa of the first twelve series of rearing the rostral spine was always absent. The telson was round and with a single plumose hair on the central posterior margin, and two small lateral spines. In four additional rearings the rostral spine was either absent or present, and the telson displayed a great amount of variability in the setation and number of lateral spines.

S. ricordi. — Similar to *M. rubripes.* Carapace longer and front slightly wider and pointed. Lateral borders of the gastric and epibranchial area well defined. The telson bears two sets of three small spines each on the posterior extremity, in addition to the pair of small lateral spines observed in *M. rubripes.* Pleopod setation is 13, 13, 13, 11, 8. The duration of the megalopa stage is from ten to fifteen days.

Cephalothoracic appendages of the megalopa

M. rubripes. — The antennula and the antenna occur in pairs and are separated by the undulation created by the depression of the rostrum. The antennula has a globose basal somite and three short, more distal segments. The first two segments bear one seta each; the third, none; and the penultimate and terminal

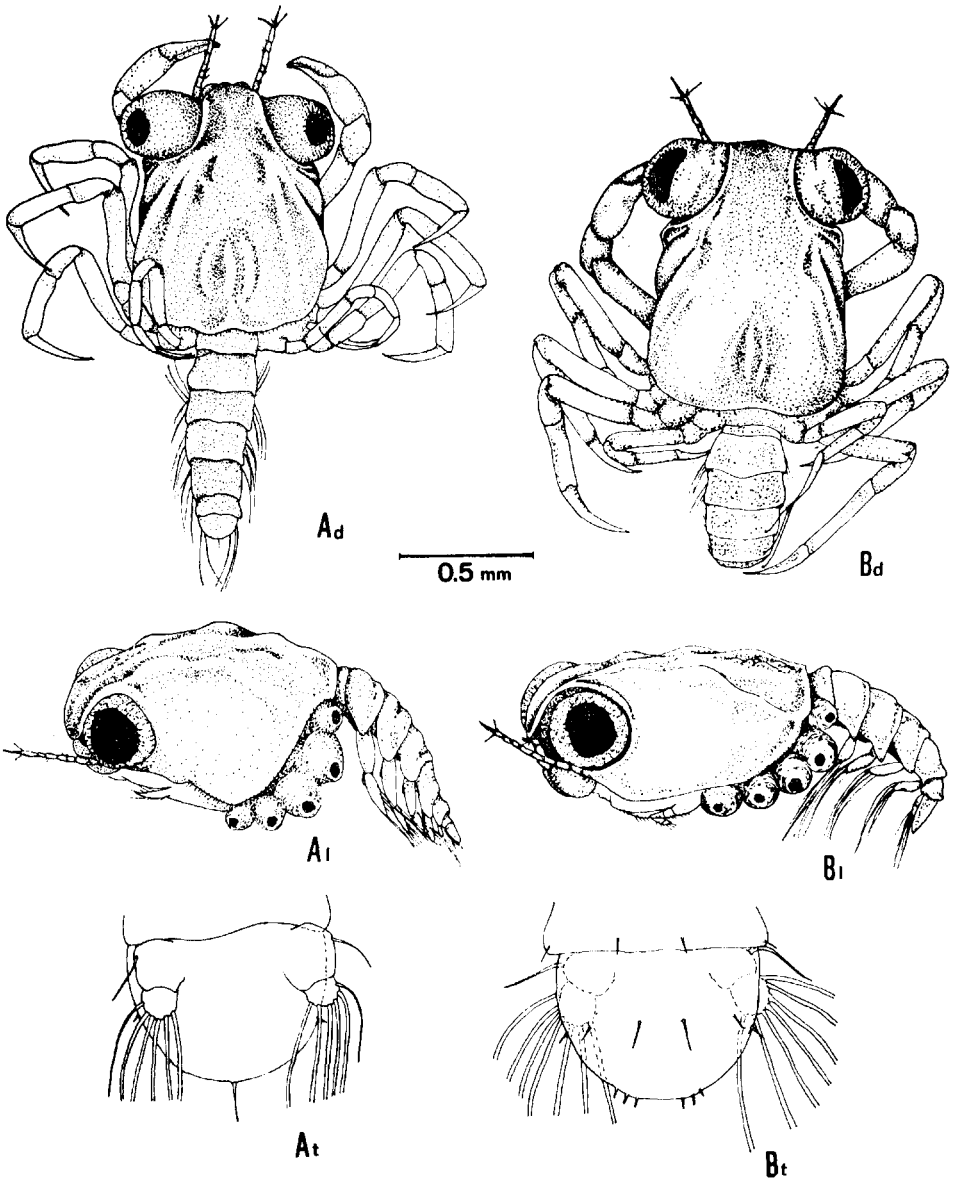

Fig. 5. *Metasesarma rubripes* (Rathbun). Ad, dorsal view; Al, lateral view; At, telson of megalopa stage. *Sesarma ricordi* H. Milne Edwards. Bd, dorsal view; Bl, lateral view; Bt, telson of megalopa stage.

segments bear numerous setae and aesthetascs. The antenna is composed of nine segments with a setation of 2, 1, 1, 0, 2, 1, 4, 1, 3 (fig. 6).

The mandible has lost much of its incisor process and now consists of a sharp cutting edge which projects to the ventral side. The molar processes are well developed. The mandible now bears a bisegmented palp which terminates in four

strong setae. The endopodite of the maxillule bears four setae on the terminal segment and two on the basal segment. The basal endite bears seventeen spines, the coxal eleven. In the maxilla the endopodite is without setation and the basal and coxal endites possess twelve and fourteen spines respectively. The marginal border of the scaphognathite bears approximately 35 long, weak and plumose setae (fig. 7).

The first maxilliped has been considerably modified and no longer serves a swimming function. The exopodite is bisegmented and bears three setae on its basal segment and four on its terminal segment. The endopodite bears two terminal spines. The protopodite is bilobed, the basal endite possessing nine spines and the coxal endite, six. The epipodite is triangular in shape and bears three setae proximaly and four terminally (fig. 8).

The second maxilliped consists of a bisegmented exopodite, bearing five distal plumose setae, its basal segment bears one spine and a four-segmented endopodite, bearing a strong spine on the last three segments (0, 1, 3, 6). The third maxilliped is now well-developed. Its exopodite is bisegmented and terminates in five setae and its basal segment bears one spine. The endopodite is composed of five segments, all of which bear numerous rigid spines (8, 8-9, 3-4, 6-7). The epipodite bears twelve spines on its base and eighteen non-plumose hairs on the distal part (fig. 8).

S. ricordi. — The endopodite of the maxillule bears four setae on the terminal segment and two on the basal segment, more spines are present on the basal and coxal endite (18 and 11). Twelve and fifteen spines are present on the basal and coxal endites of the maxilla and more soft plumose hairs ($\pm$ 45) are present on the marginal border of the scaphognathite.

The terminal segment of the exopodite of the first maxilliped is longer and narrower. The protopodite is bilobed and bears an additional spine on both basal and coxal endites (11 and 8). The second maxilliped is similar to that described for *M. rubripes.* The terminal segment of the exopodite of the third maxilliped bears four setae. The epipodite of the third maxilliped bears ten spines on its base and 15 non-plumose hairs on the distal part (fig. 8).

Gross morphology of the first juvenile (fig. 9)

M. rubripes. — The carapace of the first juvenile is quadrangular, increasing in width posteriorly, and the dorsal surface is covered with many fine hairs. The postero-lateral margin of the ocular fossa bears two undulations. The front is clearly depressed. The antennule arises from cavities below the rostrum, adjacent to the antennae. These cavities bear a septum that separates the two pairs of sensory appendages. The orbital hiatus does not yet possess the tooth which is of taxonomic importance in the adult. The abdomen is bent under the thorax and consists of seven segments. The pleopods do not bear setae and the pereiopods are flat.

S. ricordi. — Very similar to *M. rubripes.* A distinct spine is present on the

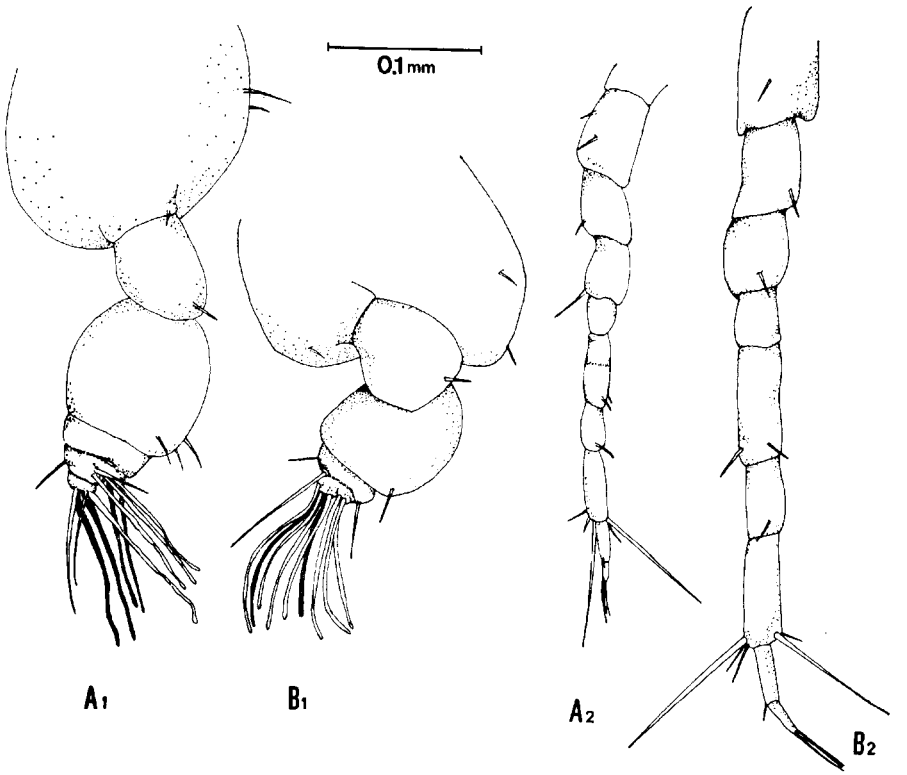

Fig. 6. *Metasesarma rubripes* (Rathbun). A1, antennula; A2, antenna of megalopa stage. *Sesarma ricordi* H. Milne Edwards. B1, antennula; B2, antenna of megalopa stage.

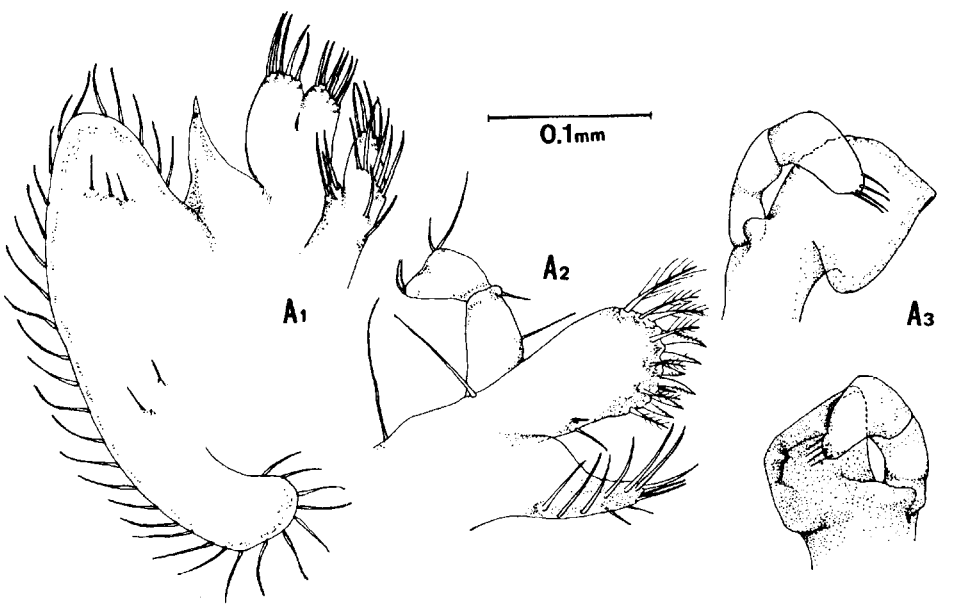

Fig. 7. *Metasesarma rubripes* (Rathbun). A1, maxilla; A2, maxillule; A3, mandible of megalopa stage.

postero-lateral margin of the ocular fossa, in addition, two undulations posteriorly.

The width of carapace is constant. The post-frontal lobes of carapace are not divided by a groove as in *M. rubripes*. Gastric areas are well defined. Each abdominal segment bears more setae than in *M. rubripes*.

Cephalothoracic appendages of the first juvenile

M. rubripes. — The antennula is composed of a large basal segment which bears ten short setae, and a peduncule of three segments, the middle of which bears one setae and terminates in four aesthetascs and one seta. The antenna consists of eight segments which bear a setation of 2, 1, 1, 0, 2, 1, 5, 3. The penultimate segment bears one very long seta with a length almost half of the antenna (fig. 10).

The mandible is similar in morphology to that of the megalopa with increased development in the molar surface and the palp. The two-segmented palp ends in five small spines, with one spine on the basal segment. The endopodite of the maxillule consists of two segments, the first bears two setae and the second bears four setae. The basal endite bears seventeen spines and the coxal endite, eleven. The endopodite of the maxilla is smooth, the basal endite is slightly lobulated, bearing thirteen spines, and the coxal endite has fourteen spines. The marginal border of the scaphognathite bears approximately 50 long delicate and plumose setae (fig. 11).

The exopodite of the first maxilliped consists of a terminal segment bearing four smooth setae and a basal segment bearing one spine. The endopodite has three spines and two setae, the basal endite of the protopodite has thirteen spines, and the coxal endite twelve. The epipodite is triangular in shape and bears three setae on its basal and eight on its distal area (fig. 12).

The second maxilliped consists of a bisegmented exopodite, the terminal segment bearing four setae and a basal segment bearing six spines and two setae. The endopodite has four segments, the first of which bears two setae and the others, many strong spines (1, 5, 9) (fig. 12).

The exopodite of the third maxilliped bears seven spines and two setae on its basal segment and five terminal setae on its second segment. The endopodite is composed of five segments each possessing numerous spines (18, 12, 5, 6, 6), and the epipodite now bears sixteen non-plumose hairs in the distal part and $\pm$ 30 spines on its base (fig. 12).

S. ricordi. — The antennula and the antenna are slightly different in setation. A similar situation occurs in the maxillule and maxilla.

The terminal segment of the exopodite of the first maxilliped bears three setae, its basal segment bears four spines. The unsegmented endopodite has five spines. The basal endite of the protopodite has 18 to 20 spines and the coxal endite 10 or 11. The exopodite of the second maxilliped has four setae on its terminal segment, five spines and three setae on the basal segment. The terminal

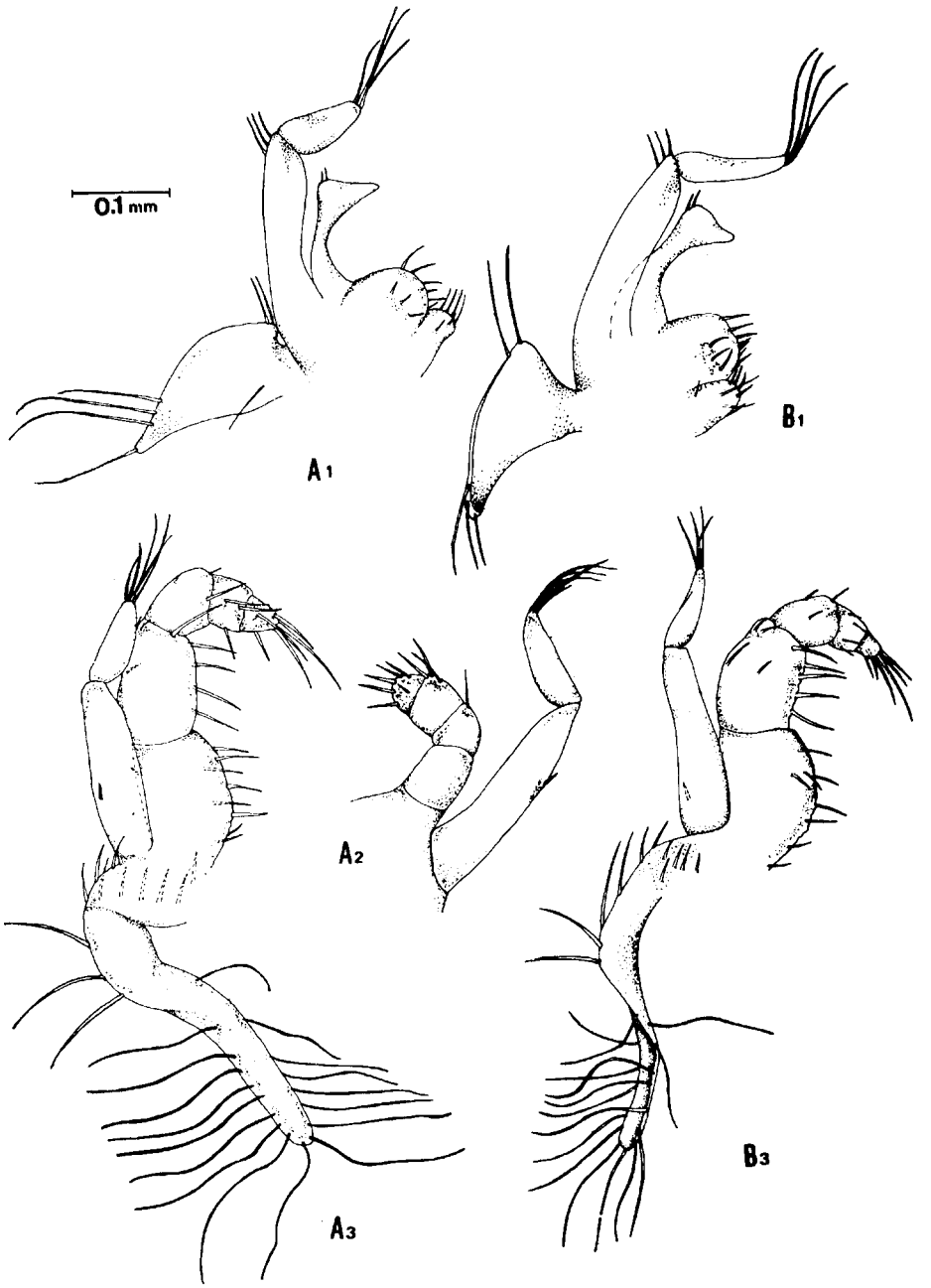

Fig. 8. *Metasesarma rubripes* (Rathbun). A1, first maxilliped; A2, second maxilliped; A3, third maxilliped of megalopa stages. *Sesarma ricordi* H. Milne Edwards. B1, first maxilliped; B3, third maxilliped of megalopa stage.

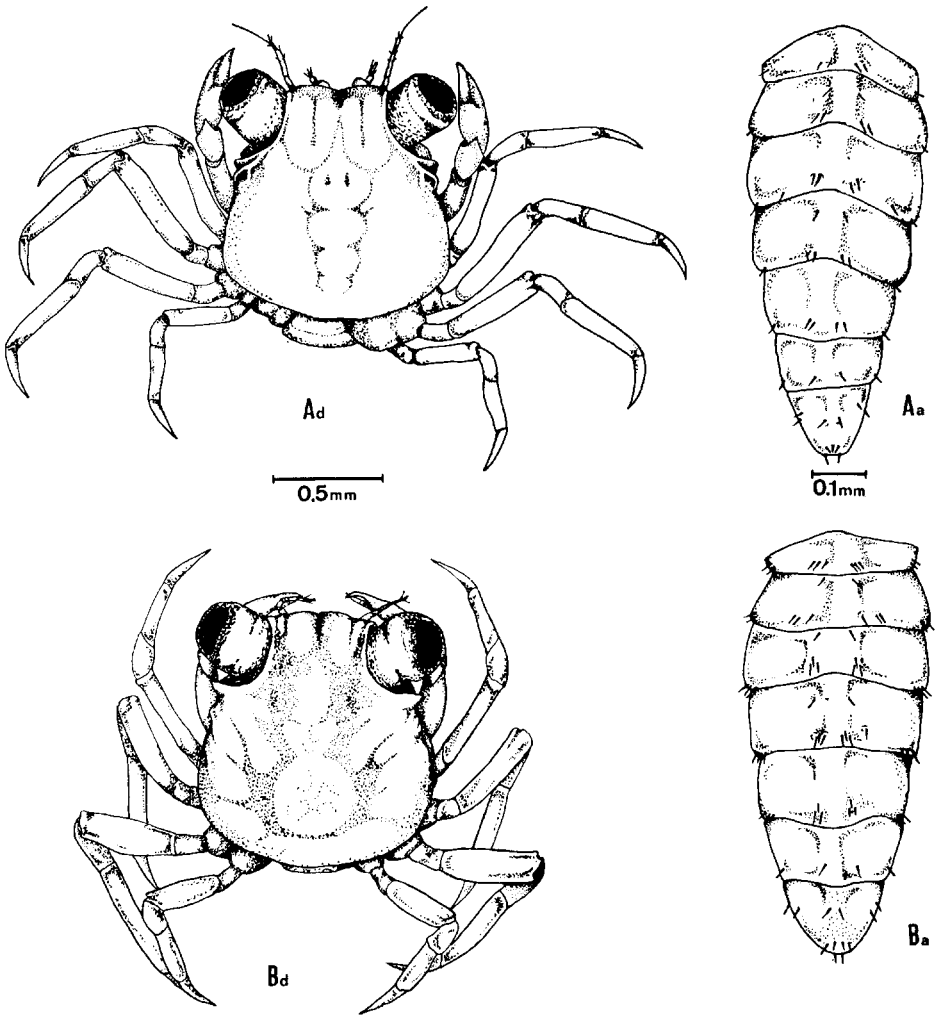

Fig. 9. *Metasesarma rubripes* (Rathbun). Ad, dorsal view; Aa abdomen of the first juvenile. *Sesarma ricordi* H. Milne Edwards. Bd, dorsal view; Ba, abdomen of the first juvenile.

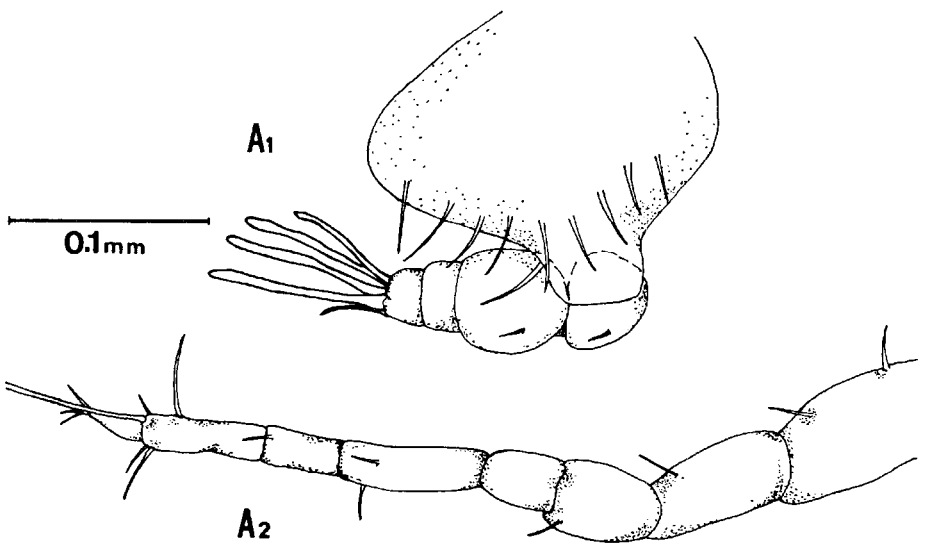

Fig. 10. *Metasesarma rubripes* (Rathbun). A1, antennula; A2 antenna of the first juvenile.

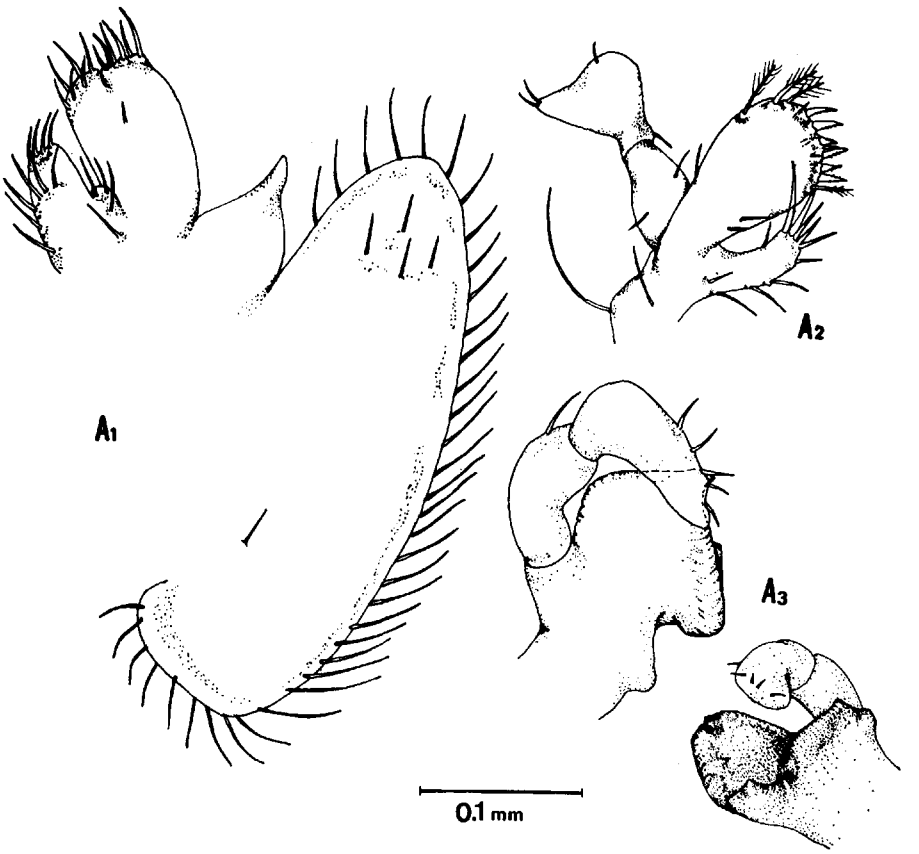

Fig. 11. *Metasesarma rubripes* (Rathbun). A1, maxilla; A2, maxillule; A3 mandible of the first juvenile.

segment of the exopodite of the third maxilliped has three setae. The endopodite bears numerous spines (18, 14, 4, 6, 5) (fig. 12).

DISCUSSION

The larval development of several species of estuarine Brachyura has been shown to be affected by changes in the salinity (Costlow et al., 1960; Costlow & Fagetti, 1967). Accordingly throughout our rearing experiments, the salinity was maintained as close as possible to that found in the natural habitat of the organisms, 19 $\pm$ $1^0/_{00}$.

Larval development of both *M. rubripes* and *S. ricordi* consists of four zoeal stages and one megalopa and therefore, comparisons are justified. The zoeal stages are very similar in both species, except that the base of the dorsal spine is much wider in *S. ricordi* in advanced zoeal stages; the setation of the endopodite of

the first maxilliped of the third and fourth zoeal stages is different; and the antennal protopodite of *S. ricordi* is longer and bears two long and conspicuous rows of sharp teeth in all zoeal stages. This last character may be used to distinguish between the two species.

The telson of the megalopa in *M. rubripes* bears a single plumose hair on the central portion of the posterior margin and two small lateral spines. In *S. ricordi* there are two sets of three small spines each on the posterior margin, in addition to the pair of small lateral spines observed in *M. rubripes*. However, there is a marked variability in the telson and rostrum of *M. rubripes*.

The first juvenile of *S. ricordi* has a small sharp spine located at the tip of the protuberance of the postero-orbital, lateral margin of the carapace. This is replaced by a less prominent protuberance in *M. rubripes*.

The postfrontal lobes of the carapace of the first juvenile stage of *M. rubripes* are divided into two parts by a narrow and shallow longitudinal depression. In *S. ricordi* the lobes are not divided and are separated from the orbital margin by a wide and shallow depression.

The number and distribution of the setae on the terminal abdominal segment in the first juvenile of the two species is different. *S. ricordi* has twelve setae, distributed in a 6, 2, 2, 2 pattern and *M. rubripes* has eleven, distributed in a 5, 2, 2, 2 pattern. Greater setation exists on all abdominal segments in *S. ricordi* than in *M. rubripes*. Other, perhaps less significant characters are mentioned in the text, under descriptions for each form.

A comparison of the larval development of the two species described in this paper with the development of other *Sesarma,* can be made through the descriptions published by Costlow & Bookhout (1960, 1962) on the larval forms of *S. cinereum* and *S. reticulatum* (Appendix). Yatsuzuka (1962) observed four zoeal stages in the larval development of *S. dehaanii*. Hartnoll (1963) reported that in the first zoea of *S. bidentatum* the dorsal and lateral spines are absent, but does not indicate the total number of larval stages of this species.

The unsegmented flagellum on the peduncle of the antenna of the megalopa, described for other Grapsidae, is replaced by a single seta in *M. rubripes,* and *S. ricordi.*

In *S. reticulatum* there is a rostral spine (Costlow & Bookhout, 1962). This spine is lacking in *S. cinereum* (cf. Costlow & Bookhout, 1960) and in *S. ricordi.* However, in *M. rubripes* this spine could be present or absent, and therefore the constancy of this character in other species might be questioned. On the other hand, the authors have found considerable variation in the telson of *M. rubripes,* while in the other species the characters of this appendage seem to be fairly constant.

Fig. 12. *Metasesarma rubripes* (Rathbun). A1, first maxilliped; A2, second maxilliped; A3, third maxilliped of the first juvenile. *Sesarma ricordi* H. Milne Edwards. B1, first maxilliped; B2, second maxilliped; B3, third maxilliped of the first juvenile.

APPENDIX

Distinctive characters of the different stages in the larval development of *Sesarma cinereum* (Bosc) (cf. Costlow & Bookhout, 1960); *Sesarma reticulatum* Say (cf. Costlow & Bookhout, 1962); *Sesarma ricordi* H. Milne Edwards and *Metasesarma rubripes* (Rathbun)

Stage and structure	*S. cinereum*	*S. reticulatum*	*S. ricordi*	*M. rubripes*
FIRST ZOEA				
Antennula	3 aesthetascs + 2 setae	4 aesthetascs + 1 seta	3 aesthetascs + 2 setae	3 aesthetascs + 1 seta
Antenna	2 rows teeth (*)	1 row teeth (*)	2 rows teeth	1 row teeth
Maxillule				
Endopodite	Bisegmented 1 + 5 spines	Bisegmented 1 + 5 spines	Bisegmented 1 + 5 plumose setae	Bisegmented 1 + 5 plumose setae
Basal endite	5 spines	5 spines	5 spines	5 spines
Coxal endite	5 spines	5 spines	5 spines	5 spines
Maxilla				
Endopodite	5 spines	5 setae	5 plumose setae	5 plumose setae
Basal endite	9 spines	9 spines	9 spines	9 spines
Coxal endite	7 spines	7 spines	8 spines	8 spines
Scaphognathite	4 soft plumose hairs, pointed and plumose tip	4 soft plumose hairs, pointed and plumose tip	4 soft plumose hairs, pointed and plumose tip	4 soft plumose hairs, pointed and plumose tip
First maxilliped				
Exopodite	4 natatory setae	4 natatory setae	4 natatory setae	4 natatory setae
Endopodite	1, 1, 1, 2, 4 setae	2, 2, 1, 2, 5 setae	2, 2, 1, 2, 5 setae	2, 2, 1, 2, 5 setae
Protopodite	—	10 setae (*)	10 setae	9-10 setae
Second maxilliped				
Exopodite	4 natatory setae	4 natatory setae	4 natatory setae	4 natatory setae
Endopodite	0, 1, 5 setae	0, 1, 5 setae	0, 1, 6 setae	0, 1, 6 setae
Protopodite	—	3 setae (*)	4 setae	4 setae
SECOND ZOEA				
Antennula	3 aesthetascs + 2 setae	4 aesthetascs + 2 setae	4 aesthetascs + 1 setae	4 aesthetascs + 1 setae
Antenna	Same as *M. rubripes*	Unsegmented endopodite bud equal in length to exopodite	Same as *M. rubripes*	Protopodite with a bud

Stage and structure	*S. cinereum*	*S. reticulatum*	*S. ricordi*	*M. rubripes*
Maxillule				
Basal endite	7 spines	5 spines	7 spines	7 spines
Coxal endite	6 spines	5 spines	6 spines	6 spines
Maxilla				
Basal endite	10 spines	7 spines	9 spines	9 spines
Coxal endite	8 spines	5 spines	8 spines	8 spines
Scaphognathite	5 distal soft hairs + 3 terminal hairs	7 lateral hairs + 3 terminal hairs	5 plumose hairs + 3 hard plumose hairs	5 soft plumose hairs + 3 hard plumose hairs
First maxilliped				
Exopodite	6 natatory setae	6 natatory setae	6 natatory setae	6 natatory setae
Endopodite	2, 2, 1, 2, 5 setae	2, 2, 1, 2, 5 setae	2, 2, 1, 2, 5 setae	2, 2, 1, 2, 5 setae
Protopodite	—	11 setae (*)	10 setae	10 setae
Second maxilliped				
Exopodite	6 natatory setae	6 natatory setae	6 natatory setae	6 natatory setae
Endopodite	0, 1, 6 setae	0, 1, 6 setae	0, 1, 6 setae	0, 1, 6 setae
Protopodite	—	3 setae (*)	4 setae	4 setae
THIRD ZOEA				
Antennula	4 aesthetascs + 1 seta	4 aesthetascs + 2 setae	3 aesthetascs + 1 seta	3 aesthetascs + 1 seta
Antenna	Same as *M. rubripes*	Endopodite larger and partially segmented	Same as *M. rubripes*	Unsegmented endopodite bud equal in length to exopodite
Maxillule				
Basal endite	8 spines	8 spines	8 spines	8 spines
Coxal endite	6 spines	6 spines	6 spines	6 spines
Maxilla				
Basal endite	10 spines	7 spines	10 spines	10 spines
Coxal endite	9 spines	5 spines	8 spines	8 spines
Scaphognathite	8 distal soft hairs + 4 hairs on the apical tip	19 hairs on the border	9-10 soft plumose hairs + 3 hard plumose hairs	8-10 soft plumose hairs + 4 hard plumose hairs
First maxilliped				
Exopodite	8 natatory setae	8 natatory setae	8 natatory setae	8 natatory setae
Endopodite	2, 2, 1, 2, 5 setae	2, 3, 2, 2, 6 setae	2, 3, 2, 2, 5 setae	2, 2, 2, 2, 5 setae
Protopodite	—	—	10 setae	10 setae
Second maxilliped				
Exopodite	8 natatory setae	8 natatory setae	8 natatory setae	8 natatory setae
Endopodite	0, 1, 6 setae	0, 1, 6 setae	0, 1, 6 setae	0, 1, 6 setae

Stage and structure	*S. cinereum*	*S. reticulatum*	*S. ricordi*	*M. rubripes*
Second maxilliped *(Continued)*				
Protopodite	—	—	4 setae	4 setae
FOURTH ZOEA				
Antennula	6 aesthetascs + 1 seta	—	6 aesthetascs + 1 seta	5 aesthetascs + 1 seta
Antenna	Endopodite is equal in length to the protopodite, terminates in one short non plumose spine and is partially segmented	—	Equal to *M. rubripes*	5 aesthetascs + 1 seta bisegmented endopodite is twice longer than exopodite
Mandible	Palp present	—	Palp absent	Palp absent
Maxillule				
Basal endite	11 spines	—	11 spines	11 spines
Coxal endite	7 spines	—	7 spines	7 spines
Maxilla				
Basal endite	12 spines	—	12 spines	12 spines
Coxal endite	12 spines	—	11 spines	11 spines
Scaphognathite	23 soft plumose hairs	—	16-18 soft plumose hairs + 4 hard plumose hairs	15-17 soft plumose hairs + 4 hard plumose hairs
First maxilliped				
Exopodite	9 natatory setae	—	9 natatory setae	9 natatory setae
Endopodite	2, 3, 1, 2, 6 setae	—	2, 3, 2, 2, 6 setae	2, 2, 2, 2, 6 setae
Protopodite	—	—	10 setae	10 setae
Second maxilliped				
Exopodite	10 natatory setae	—	10 natatory setae	10 natatory setae
Endopodite	0, 1, 6 setae	—	0, 1, 6 setae	0, 1, 6 setae
Protopodite	—	—	4 setae	4 setae
MEGALOPA				
Rostral spine	Absent	Present	Absent	Absent
Antennula	Enlarged base and peduncle with a flagellum of 3 short segments bearing a terminal tier of 5 aesthetascs and a subterminal tier of 6 aesthetascs	Enlarged base bearing 3 setae and peduncle with flagellum bearing terminal tier of 5 aesthetascs, a subterminal tier of 4 aesthetascs and 2 spines	Enlarged base bearing 3 setae and 3 segments bearing terminal tier of 6 aesthetascs a subterminal tier of 3 aesthetascs and 3 setae	Same as *S. ricordi*, terminal tier of 5 aesthetascs, a subterminal tier of 3 aesthetascs

Stage and structure	*S. cinereum*	*S. reticulatum*	*S. ricordi*	*M. rubripes*
Antenna	0, 0, 1, 0, 2, 1, 2, 1, 2 setae	1, 1, 1, 0, 1, 4, 4 setae	1, 1, 1, 0, 2, 1, 5, 1, 3 setae	2, 1, 1, 0, 2, 1, 4, 1, 3 setae
Maxillule				
Endopodite	Bisegmented, 2 + 4 plumose setae	Bisegmented, 1 + 5 plumose setae	Bisegmented, 2 + 4 plumose setae	Bisegmented, 2 + 4 plumose setae
Basal endite	12 spines	15 spines	18 spines	17 spines
Coxal endite	9 spines	10 spines	11 spines	11 spines
Maxilla				
Endopodite	5 setae	4 setae	No setae are present	No setae are present
Basal endite	14 spines	15 spines	12 spines	12 spines
Coxal endite	13 spines	12 spines	15 spines	14 spines
Scaphognathite	± 30 soft plumose hairs	± 30 soft plumose hairs	± 45 soft plumose hairs	± 40 soft plumose hairs
First maxilliped				
Exopodite	Bisegmented, 3 + 5 setae	Bisegmented, 1 + 8 setae	Bisegmented, 3 + 4 setae	Bisegmented, 3 + 4 setae
Endopodite	Unsegmented, 6 + 4 setae	4 segments, 3 + 2 + 2 + 5 setae (*)	Unsegmented, 2 setae	Unsegmented, 2 setae
Protopodite	8 + 5 spines	14 + 5 spines	11 + 8 spines	9 + 6 spines
Epipodite	2 setae + 3 hairs	1 seta + 3 hairs (*)	3 setae + 3 hairs	2 setae + 3 hairs
Second maxilliped				
Exopodite	5 setae	7 setae (*)	1 spine + 5 setae	1 spine + 5 setae
Endopodite	0, 1, 3, 6 spines (*)	1, 1, 4, 8 spines (*)	0, 1, 3, 6 spines	0, 1, 3, 6 spines
Third maxilliped				
Exopodite	0, 5 setae (*)	0, 5 setae (*)	1 spine + 4 setae	2 spines + 5 setae
Endopodite	7, 6, 3, 2, 5 spines (*)	9, 6, 2, 4, 6 spines (*)	8, 8-9, 4, 3, 6 spines	8, 8-9, 3, 4, 6-7 spines
Epipodite	15 basal spines (*) + 8 terminal hairs	7 basal spines (*) + 10 terminal hairs	10 basal spines + 15 terminal hairs	12 basal spines + 18 terminal hairs
Setation of pleopods	13, 13, 13, 11, 8 setae	14, 13, 12, 11, 6 setae	13, 13, 13, 11, 8 setae	13, 13, 13, 11, 7 setae
Telson	8 short setae	6 spines	2 sets of 3 posterior spines + 2 lateral spines	1 central plumose seta + 2 lateral spines

(*) According to Costlow & Bookhout (1960, 1962) illustrations.

RÉSUMÉ

On a déterminé la différence entre le développement larvaire de *Metasesarma rubripes* (Rathbun) et celui de quelques espèces du genre *Sesarma,* qui vivent dans des conditions écologiques comparables.

Le développement larvaire de *M. rubripes* et celui de *Sesarma ricordi* H. Milne Edwards ont été observés dans le laboratoire depuis l'éclosion jusqu'au premier stade juvenile.

Mille cinq cent larves de douze femelles porteuses d'oeufs de *M. rubripes* et neuf cent provenant de sept femelles porteuses d'oeufs de *S. ricordi* ont été maintenues dans des conditions constantes de température et de salinité (27 ± 1°C, 19 ± 1‰ S.), éclairées pendant des périodes de neuf à douze heures et alimentées avec des nauplies de *Artemia salina.*

Quatre stades de zoé et un de mégalope ont été trouvés chez les deux espèces. Les stades de zoé de *S. ricordi* montrent dans le protopodite de l'antenne deux rangées de dents bien développées qui sont moins évidentes chez *M. rubripes.* Entre la mégalope et le premier stade de crabe de *M. rubripes* on a observé les différences les plus marquées. Dans quatre cultures additionelles de *M. rubripes* on a trouvé de notables variations dans le telson et le rostre de la mégalope.

Les différences entre *M. rubripes* et *S. ricordi* dans les premiers stades de développement ne sont pas plus importantes que celles entre *S. ricordi* et d'autres espèces du genre *Sesarma.*

LITERATURE CITED

COSTLOW, J. D., Jr. & C. G. BOOKHOUT, 1960a. A method for developing brachyuran eggs in vitro. Limnol. Oceanog., **5**: 212-215.

—— & ——, 1960b. The complete larval development of Sesarma cinereum (Bosc) reared in the laboratory. Biol. Bull. Woods Hole, **118** (2): 203-214.

—— & ——, 1962. The larval development of Sesarma reticulatum Say reared in the laboratory. Crustaceana, **4**: 281-294.

COSTLOW, J. D., Jr., C. G. BOOKHOUT & R. MONROE, 1960. The effect of salinity and temperature on larval development of Sesarma cinereum (Bosc) reared in the laboratory. Biol. Bull. Woods Hole, **118** (2): 183-202.

COSTLOW, J. D., Jr. & E. FAGETTI, 1967. The larval development of the crab, Cyclograpsus cinereus Dana, under laboratory conditions. Pacific Sci., **21** (2): 166-177.

DOBKIN, S., 1963. The larval development of Palaemonetes paludosus (Gibbes, 1850) (Decapoda, Palaemonidae), reared in the laboratory. Crustaceana, **6** (1): 41-61.

EWALD, J. J., 1965. The laboratory rearing of pink shrimp, Penaeus duorarum Burkenroad. Bull. mar. Sci., **15** (2): 436-449.

HARTNOLL, R. G., 1964. The freshwater grapsoid crabs of Jamaica. Proc. Linnean Soc. London, **175** (2): 145-169.

MANNING, R. B. & A. J. PROVENZANO, Jr., 1963. Studies on development of stomatopod Crustacea, 1. Early larval stage of Gonodactylus oerstedii Hansen. Bull. mar. Sci. Gulf Carib., **13** (3): 467-487.

PROVENZANO, A. J., 1962. The larval development of Calcinus tibicen (Herbst), (Crustacea, Anomura) in the laboratory. Biol. Bull. Woods Hole, **123** (1): 179-202.

RAJABAI, K. G., 1962. Studies on the larval development of Brachyura. Early development of Metopograpsus messor (Forskål), Plagusia depressa squamosa (Herbst), Metasesarma rousseauxii A. Milne Edwards, Sesarma tetragonon (Fabricius). J. zool. Soc. India, **13** (2): 154-165.

RATHBUN, M. J., 1918. The grapsoid crabs of America. Bull. U. S. nation. Mus., **97**: i-xxii, 1-461, textfigs. 1-172, pls. 1-161.

RODRIGUEZ, G., unpublished. Monografía de los crustáceos (Decapoda) de Venezuela.

YATSUZUKA, K., 1962. Studies on the artificial rearing of the larval brachyuran specially of the larval blue crab Neptunus pelagicus Linn. Rep. Usa mar. biol. Sta., Kochi Univ. Japan, **9** (1): 1-88.

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