J. mar. biol. Ass. India, 1973, **15** (1): 359 - 385

LARVAL HISTORY OF *MACROBRACHIUM IDELLA* (HILGENDORF) REARED IN THE LABORATORY*

N. N. PILLAI AND K. H. MOHAMED
Central Marine Fisheries Research Institute, Cochin

ABSTRACT

Complete larval history of *Macrobrachium idella* (Hilgendorf) is traced by rearing them in the laboratory. They pass through 10 well defined zoeal stages before metamorphosing into the first post-larva in an average period of 42 days. Behaviour of larvae in different physical and chemical conditions of water and the rearing and feeding techniques followed are described. Better rearing conditions are observed in water having salinity between 12‰ to 18‰ when temperature is between 23°C and 28°C.

INTRODUCTION

SUCCESSFUL rearing of larval stages of *Macrobrachium rosenbergii* by Ling and Merican (1961) is to be considered as a pioneering work which indicated the possibility of commercial culture of this species and that of several other fresh and brackish water prawns in confined waters. Since then, several workers have studied various aspects of rearing of a number of species of *Macrobrachium* from different parts of the world (Ling, 1964, 1969; Lewis and Ward, 1965; Uno and Kwon, 1969; Kwon and Uno, 1969; Fielder, 1970; Choudhury, 1970, 1971; Kewalramani *et al.,* 1971). Commercial culture of *M. rosenbergii* is now being practised in Malaysia and Hawaii and attempts are being made to popularise the culture of this species in other parts of Asia. In addition to *M. rosenbergii,* there are several other species of the same genus in India which are suitable for culture. The larval history of one of the species namely, *M. malcolmsoni* has been worked out recently by Kewalramani *et al.* (1971) by rearing them in the laboratory.

M. idella (Hilgendorf) is an endemic species of prawn of the Kerala backwaters and it supports a commercial fishery of considerable magnitude. The larval history of this species has been completely worked out in the laboratory and the present communication gives the description of the larval stages, rearing techniques, moulting and larval mortality. Experiments carried out in the laboratory have shown that this species is quite suitable for commercial culture in the backwaters.

The authors are grateful to Dr. S. Z. Qasim, Dr. E. G. Silas and Dr. P. Vedavyasa Rao for the constant help and encouragement they have rendered during the course of this work. They wish to express their thanks to S/Shri M. Aravindakshan and P. Dhandapani for providing *Artemia* eggs for rearing experiments and for helping with the photography respectively.

MATERIAL AND METHODS

Cast net operations were undertaken at Thevara (Cochin) in the canal systems adjoining the Cochin Backwater and healthy specimens of *M. idella* were sorted out and kept in polythene buckets containing water from the same area.

* Presented at the 'symposium on Indian Ocean and Adjacent Seas – Their Origin, Science and Resources' held by the Marine Biological Association of India at Cochin from January 12 to 18, 1971.

They were brought to the laboratory and placed in aquarium tanks containing freshly collected water from the same area. Berried females with advanced stages of berry (with dull white eggs having clearly visible eye spots of the developing embryo) were isolated and kept singly in 6 litre glass troughs containing brackish water of salinity 12‰ to 18‰. They were fed on chopped prawn meat twice a day. Extra food was removed half an hour after it was offered so as to avoid spoilage of water. As soon as the hatching was completed, the female was removed from the trough and placed in another aquarium.

Rearing of the larvae was carried out in one litre glass jars containing about 800 ml of water. About 50 to 75 larvae were introduced into the jars which were properly labelled. They were kept in a serial order and covered with a fine cloth, to prevent settling of the dust. No aeration was provided. The larvae, on hatching, were picked out individually and transferred to these jars. In one series four sets of larvae were kept for rearing. To observe the moulting and growth, some larvae were individually kept in separate 250 ml jars containing water and observations were made on individual larva.

For the experiments, sea water was collected and brought to the laboratory in large plastic containers. It was allowed to stand for the settlement of fine suspended particles, at least for two days. This was an essential operation as the larvae could not survive in water containing fine suspended particles, which got adhered to the setae of the appendages and increased the mortality. The medium of required salinity was prepared from the sea water by adding tapwater devoid of chlorine. The salinity of the medium was maintained between 12‰ and 18‰. No effort was made to control the temperature of the water medium in which rearing was carried out. Normally the daily variation in temperature of the water never exceeded 2.0°C. The impurities accumulated at the bottom of the jars, extra food material, dead larvae and moults were removed every day by siphoning them out with a rubber tube. The water in the jar was changed only on days when the larvae were found to have moulted; even then only 75% of the water was siphoned off, and then freshly prepared water was added to restore the original quantity.

Measurements were taken from preserved material, using a microscope with ocular micrometer. Total length was taken from the tip of the rostrum to the tip of the tail fold (excluding terminal spine) in the earlier stages and to the tip of telson in subsequent stages. Carapace length was measured from its anterior margin of the orbital region to the posterior margin of the mid dorsal region. Appendages were carefully dissected out from specimens preserved in neutral formalin and mounted on slides for making camera lucida drawings.

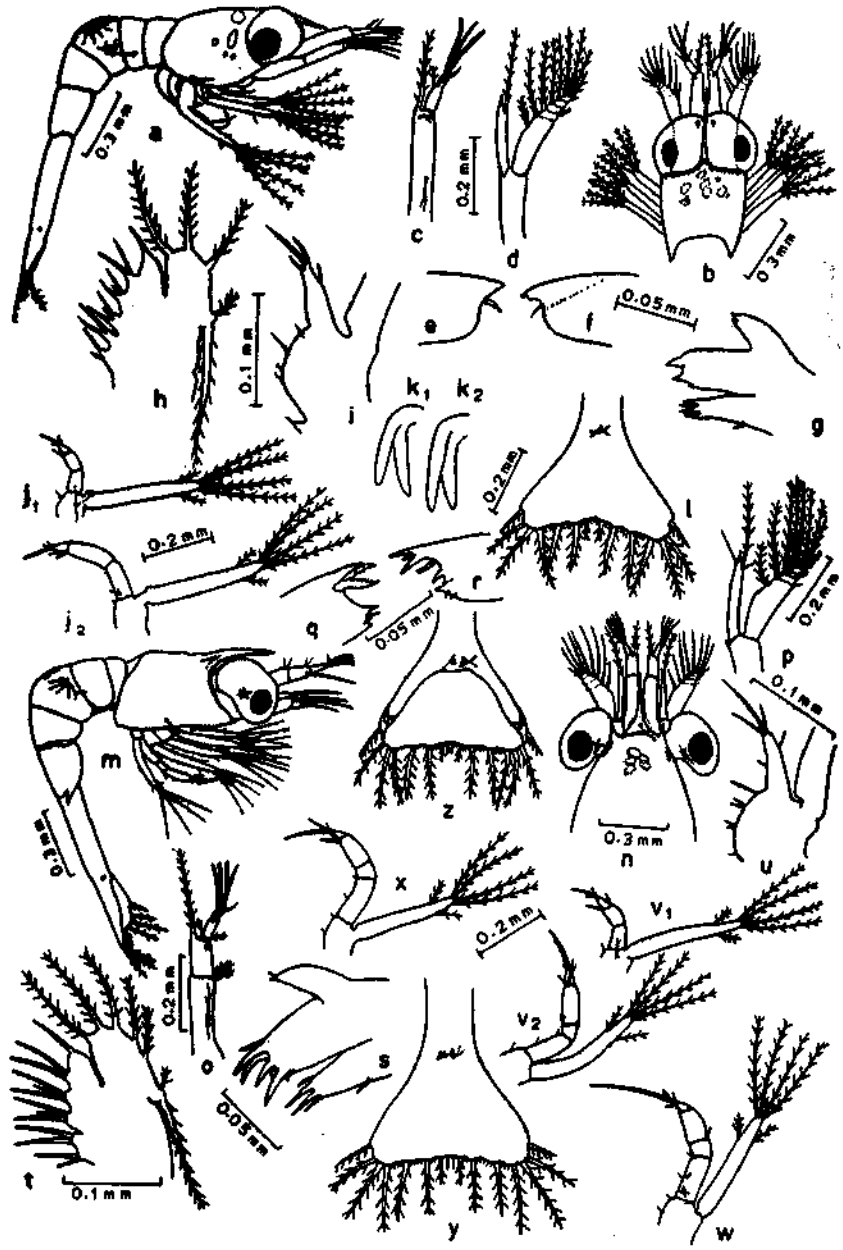
DESCRIPTION OF LARVAL STAGES

Zoea I (Fig. 1 a–l) TL 1.92 to 2.10 mm.

Carapace smooth, anterolateral edge produced into small pterygostomial spine; rostrum slender, pointed and reaching more than half antennular peduncle; eyes large, sessile; antennule, antenna and mouth parts developed; first and second pereiopods appear as biramous buds; abdomen 6-segmented; telson not separated from 6th segment.

Larva transparent, distal margin of antennular peduncle with light bluish and orange red chromatophore; dorsal aspect of eye with a branching yellow chromatophore; junction of eye with carapace deep bluish; 3rd abdominal segment

with orange red and a bluish branching chromatophore dorsally; an orange red chromatophore each on lateral aspect of 3rd abdominal segment and base of telson.



1. *M. idella:* a-zoea I lateral view, b-cephalothorax, c-antennule, d-antenna, e-right mandible, f-left mandible, g-maxillule, h-maxilla, i-maxilliped I, j1-maxilliped II, j2-maxilliped III, k1-buds of pereiopod I, k2-buds of pereipod II, l-telson, m-zoea II lateral view, n-cephalothorax, o-antennule, p-antenna, q-left mandible, r-right mandible, s-maxillule, t-maxilla, u-maxilliped I, v1-maxilliped II, v2-maxilliped III, w-pereiopod I, x-pereiopod II, y-telson, and z-telson of advanced zoea II.

Antennular peduncle long, slender and unsegmented carrying 2 flagella, inner one slender and plumose, outer stumpy bearing 3 aesthetes and 2 setae, inner seta short and plumose; antennal peduncle unsegmented, bearing a slender pointed spine at base of unsegmented flagellum, carrying a long plumose seta and a short spine terminally; exopod with 4 distinct distal joints, inner margin with 9 plumose setae and one short spine at apex, outer margin with a single short plumose seta; upper incisor process of right mandible with 2 teeth, one short and other slender, the left mandible with 3 teeth, molar process smooth on both sides; maxillule uniramous with 3 distinct lobes, endopod with 2 terminal spines, distal lacinia with 2 stout and one small teeth, proximal lacinia with 4 stout terminal and a small marginal setae; exopod of maxilla with 5 plumose setae along its margin, hindermost being considerably long and directed backwards, endopod with a proximal lobe carrying 2 setae and a distal one with a single non-plumose seta; protopod with 3 masticatory processes, of which proximal has 4 and others have 3 non-plumose setae; maxilliped I biramous, coxopod with one seta, basipod slightly protuberant with 4 small setae, endopod unsegmented with 3 setae terminally and one on outer margin, exopod with 4 apical and 2 sub-apical plumose setae; basipod of maxilliped II with one small seta, endopod 3-segmented, inner margin of 2nd segment with one seta, 3rd segment with a claw and 3 small setae, exopod long with 4 apical and 2 sub-apical plumose setae; basipod of maxilliped III with a small seta, endopod 3-segmented, 1st and 2nd segments with 2 setae each, terminal segment with 2 setae and a claw, exopod with 4 apical and 2 sub-apical plumose setae; biramous buds of 1st and 2nd pereiopods developed. Telson not distinct from 6th abdominal segment, broad concave posteriorly carrying 7 setose spines on either side, outer spines bearing setae on their inner margins only.

Zoea II (Fig. 1 m–z) TL 2.14 to 2.36 mm.

Although there was no significant increase in size, the larva has undergone considerable morphological changes. Carapace with prominent supra-orbital and branchiostegal spines, rostrum slightly bent downwards from middle, eyes stalked, 1st and 2nd pereiopods developed, a pair of prominent lateral spines present on 5th abdominal segment; chromatophore more prominent, a yellow branching chromatophore on peduncle of eye, orange red chromatophore on anterior border of carapace and basal segments of maxilliped II and III and pereiopods I and II.

Antennular peduncle 2-segmented, proximal segment bearing 4 short plumose setae terminally, distal segment with 2 flagella, outer flagellum with one seta and 4 aesthetes, 2 plumose setae at base of flagellum; antennal flagellum having 4 terminal setae, margin of exopod with 9 plumose setae and one small spine; incisor process of right mandible with 4 stout teeth and molar with 2 stout and 2 small teeth, incisor and molar process of left mandible carry 4 stout teeth each, one of which on incisor movable and serrated on dorsal side; distal lacinia of maxillule with 7 teeth, and exopod of maxilla with 7 plumose setae; basipod of maxilliped I with 6 setae on its inner margin, endopod with 3 terminal and 2 lateral teeth; second segment of endopod of maxilliped II with 2 setae; endopod of maxilliped III 4-segmented, terminal claw serrated on its inner margin; pereiopods I and II biramous, basipod with 2 setae, endopods 4-segmented, terminal claw of pereiopod I conspicuous, propodus with one and 2 spines respectively in pereiopods I and II, exopod unsegmented with 4 long apical and 2 sub-apical plumose setae; one additional small non-setose spine developed on inner aspect of each side of telson, outermost spine on either side with setae on inner aspect only; outline of developing uropod distinguishable in larvae which are about to moult to next stage.

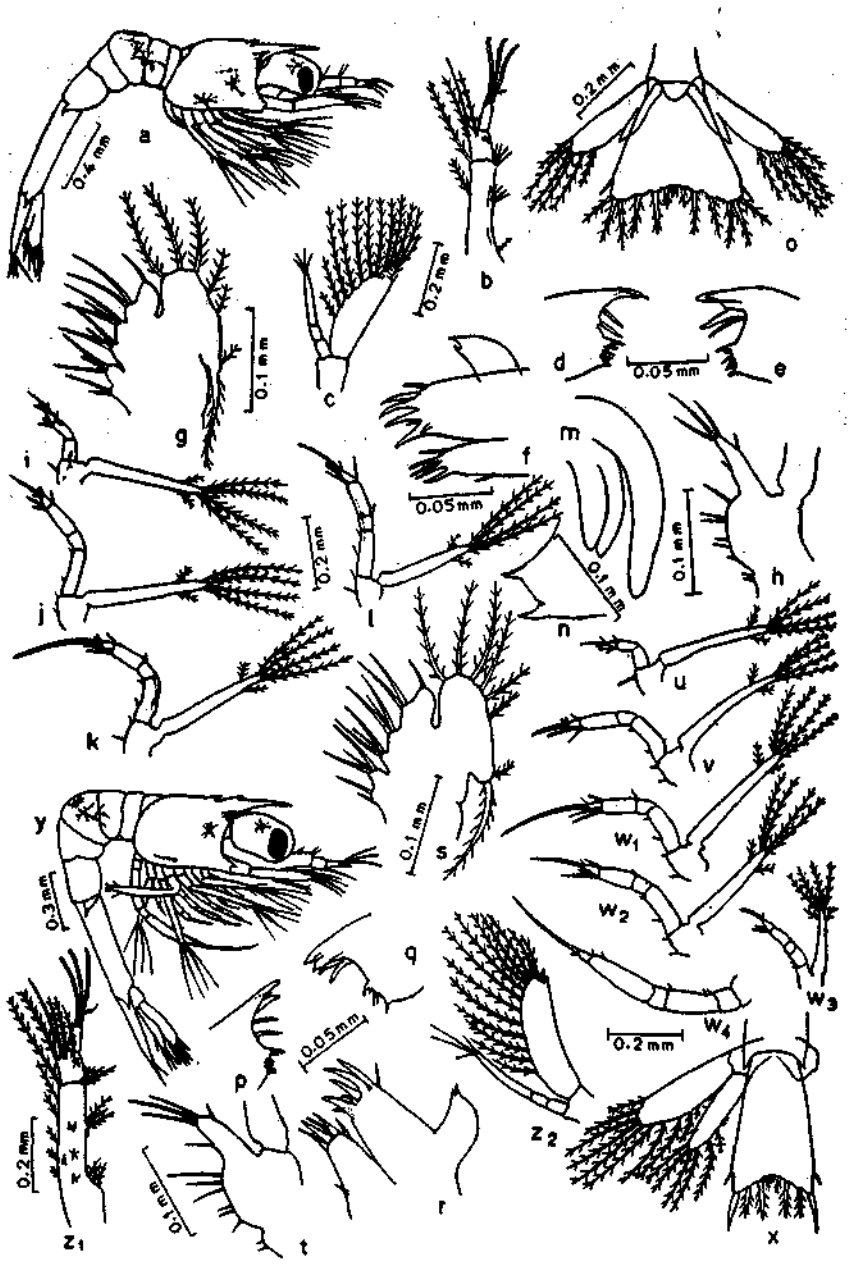


Fig. 2. *M. idella:* a-zoea III lateral view, b-antennule, c-antenna, d-right mandible, e-left mandible, f-maxillule, g-maxilla, h-maxilliped I, i-maxilliped II, j-maxilliped III, k-pereiopod I, l-pereiopod II, m-buds of pereiopod III & V, n-pterygostomial spine, o-telson and uropod, y-zoea IV lateral view, z1-antennule, z2-antenna, p-right mandible q-left mandible, r-maxillule, s-maxilla, t-maxilliped I, u-maxilliped II, v-maxilliped III, w1-pereiopod I, w2-pereiopod II, w3-pereiopod III, w4-pereiopod V, and x-telson and uropod.

Zoea III (Fig. 2 a-o) TL 2.33 to 2.62mm.

Rostrum with epigastric spine, carapace with well defined supra-orbital, branchiostegal and pterygostomial spines, biramous buds of pereiopod III and uniramous buds of pereiopod V developed, articulation of telson with 6th abdominal somite defined, uropods developed; yellow branching chromatophore on lateral aspect of peduncle of eye and hepatic region of carapace, between rostrum and supra-orbital spine conspicuous deep blue colouration from which orange red chromatophores radiate backwards, branching orange red chromatophore on lateral aspect of 3rd abdominal segment extend to 2nd segment.

Terminal segment of antennule with 2 flagella and 5 plumose setae encircling its apex, outer flagellum with 3 aesthetes and one seta, proximal segment carries one long plumose seta on inner side and 4 on outer side terminally, laterally it carries one plumose seta on inner side and 4 on outer side; antennal flagellum 3–segmented, terminal segment with 4 slender apical setae, exopod broad unsegmented, inner margin with 12 plumose setae and one spine, outer margin with a single seta; incisor process of right mandible with 3 teeth on upper and 2 on lower part, molar process with 6 teeth, left mandible with 5 teeth on incisor process, one of which is movable and serrated, molar with 6 teeth; maxillule with an additional tooth on proximal lacinia, maxilliped II with a claw and 3 setae on terminal segment of endopod, 3 setae at junction of propodus and dactylus; basipod of maxilliped III with 2 setae, 3rd segment bears 3 setae; propodus of pereiopod I and II bear 3 spines each; telson less broad and more concave on posterior margin which bears 8 spines on either side; uropod biramous, exopod with 6 long plumose setae and endopod bare.

Zoea IV (Fig. 2 p-z_3) TL 2.35 to 2.70 mm.

Larva with pereiopods III and V developed, rostrum with 2 dorsal teeth,endopod of uropod with plumose setae; peduncle of eye with orange-red branching chromatophores, proximal segment of antennular peduncle with a few orange-red chromatophores.

Base of inner antennular flagellum swollen, distal segment with 7 terminal plumose setae, of which 4 are large and on one side, 6 plumose setae and a stout spine on inner side of proximal segment, several plumose setae on middle portion of outer side, 3 plumose setae at position of stylocerite; curved margin of antennal exopod carries 14 setae and one spine, distolateral tip pointed and spine-like; exopod of maxilla with 8 plumose setae, protopod with 3 masticatory processes having 5, 3 and 3 setae respectively; pereiopod III biramous, relatively small, endopod 4 segmented, pereiopod V uniramous but most conspicuous, 4–segmented terminal segment ending with a claw, propodus with 2 setae on inner side; telson long, broader at posterior margin which is concave, terminal spines reduced to 5 on one side, one small spine on lateral margin; exopod of uropod with one small spine and 10 plumose setae, endopod with 7 plumose setae.

Zoea V (Fig. 3 a-p) TL 2.70 to 2.93 mm.

Rostrum with 2 dorsal teeth, second one being prominent. Colouration more pronounced, merus and propodus of pereiopod V with a branching orange-red chromatophore, dactylus and claw with light reddish tinge.

Terminal segment of antennular peduncle with 10 plumose setae of which 5 longer ones are on one side, inner flagellum smaller, finger-shaped and with 2 non-

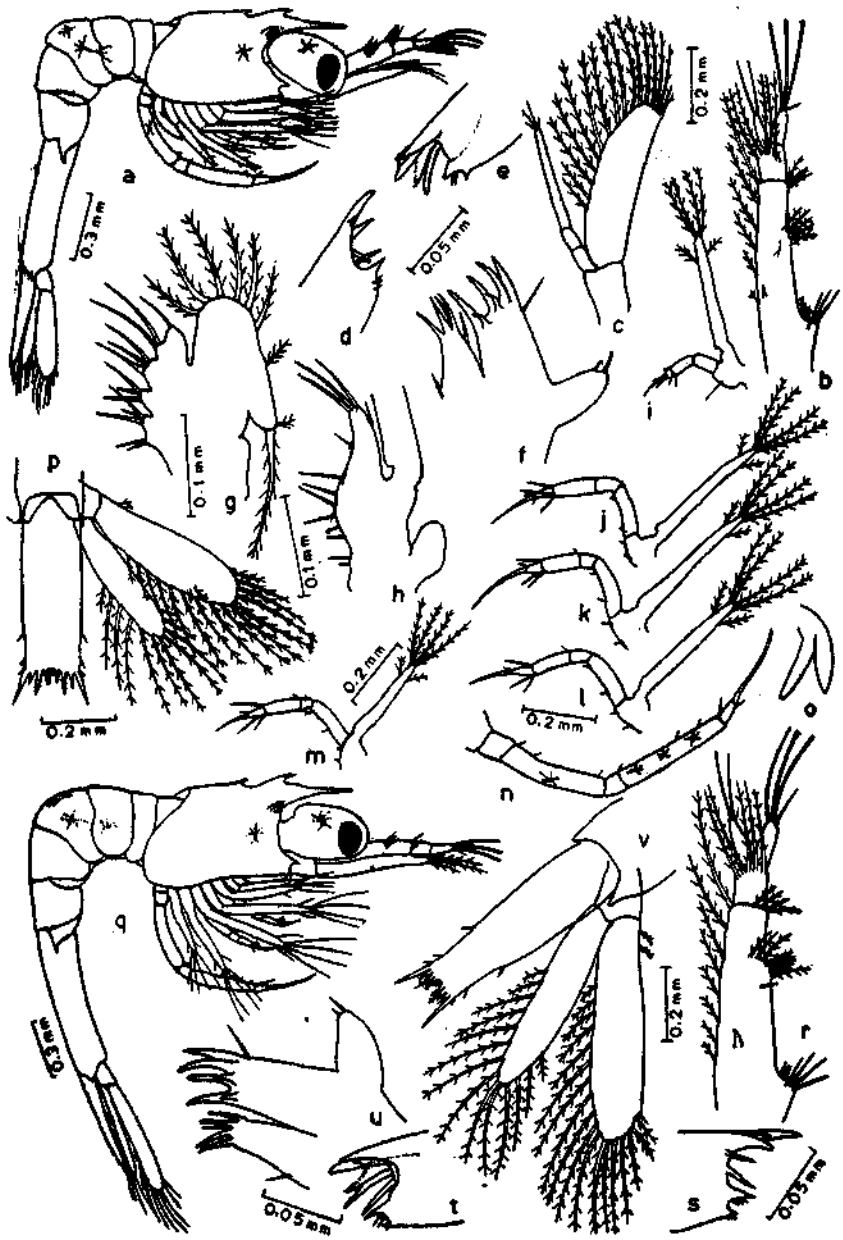


Fig. 3. *M. idella:* a-zoea V lateral view, b-antennule, c-antenna, d-right mandible, e-left mandible, f-maxillule, g-maxilla, h-maxilliped I, i-maxilliped II, j-maxilliped III, k-pereiopod I, l-pereiopod II, m-pereiopod III, n-pereiopod V, o-biramous buds of pereiopod IV, p-telson and uropod, q-zoea VI lateral view, r-antennule, s-right mandible, t-left mandible, u-maxillule, and v-telson and uropod.

plumose setae, proximal segment of peduncle with 6 plumose setae and one stout spine on inner side, with several setae on outer side, protuberance of stylocerite with 6 setae, 3 of which are longer and non-plumose; antennal flagellum3-segmented, 3rd segment longest, exopod with characteristic adult shape having 17 plumose setae and one prominent spine on margin; exopod of maxilla with 9 plumose setae; maxilliped I with a rudimentary bud of epipod; biramous buds of pereiopod IV developed; telson rectangular, posterior margin with 5 spines on either side, distal portion of lateral margin with 3 spines; exopod of uropod with one small spine and 15 plumose setae, endopod with 11 setae, 2 small plumose setae on outer margin of base of exopod.

Zoea VI (Fig. 3 q-v; Fig. 4 a-j) TL 3.12 to 4.08 mm.

Pereipod IV fully developed; telson narrower at posterior end; orange-red branching chromatophores more pronounced and consequently carapace and abdomen as a whole having orange-red tinge. Orange-red tinge also present at joints of uropod and telson with abdomen.

Inner flagellum of antennular peduncle with 3 setae, proximal segment of peduncle with 8 setae and one stout spine on inner side, protuberance of stylocerite further defined and with 7 setae, of which 4 are long and non-plumose; antennal exopod with 20 plumose setae and one stout spine along margin; left mandible with 6 stout teeth inclusive of movable tooth on incisor process; exopod of maxilla with 12 plumose marginal setae, proximal masticatory processes with 4 and distal process with 3 setae respectively; 3 additional plumose setae developed at base of exopod of maxilliped I, epipod slightly enlarged; pereiopod IV biramous,endopod 4-segmented ending in a claw; pereiopod V long, propodus with 4 setae and a strong spine developed on inner side of base of dactylus, outer spines on either side of posterior margin of telson conspicuously long, lateral spines feeble; exopod of uropod with one spine and 18 setae, endopod with 14 setae.

Zoea VII (Fig. 4 k-r; 5 a-j) TL 3.85 to 4.43 mm.

Rostral teeth serrated on the ventral surface, 3 plumose setae under 2nd teeth; uniramous buds of pleopods developed. 2nd abdominal segment with a branching orange-red chromatophore laterally, that on 3rd segment more conspicuous and branching off to the 2nd. A reddish branched chromatophore also present on the ventral side of 3rd segment.

Inner flagellum of antennule as long as outer one and carries 4 slender setae at tip; outer flagellum with a finger-like terminal projection bearing 3 slender setae; inner side of proximal segment bears 9 plumose setae and a stout spine; stylocerite bears 5 non-plumose and 3 plumose setae; antennal flagellum as long as exopod which bears 23 plumose setae and one spine at tip of outer margin; left mandible with 7 teeth on incisor process; distal lacinia of maxillule with 7 stout and one slender teeth, proximal lacinia with 5 teeth and one plumose seta terminally and with one spine on inner margin; exopod of maxilla carries 21 plumose setae; base of exopod of maxilliped I slightly expanded carrying 4 plumose setae; subapical setae on exopods of all pereiopods have increased in number, pereiopod V largest of all limbs, propodus of which carry 5 setae. Buds of pleopods appear as small stumps; telson narrow posteriorly, tip with 10 spines, outermost ones longest and conspicuous exopod of uropod with 23 setae in addition to 2 at its base, endopod with 19 setae.

Zoea VIII (Fig. 5 k–v; 6 a-j) TL 3.93 to 5.10 mm.

Buds of pleopods biramous, non-setose. Orange-red chromatophores present on lateral sides of carapace, 2nd and 3rd abdominal segments and on

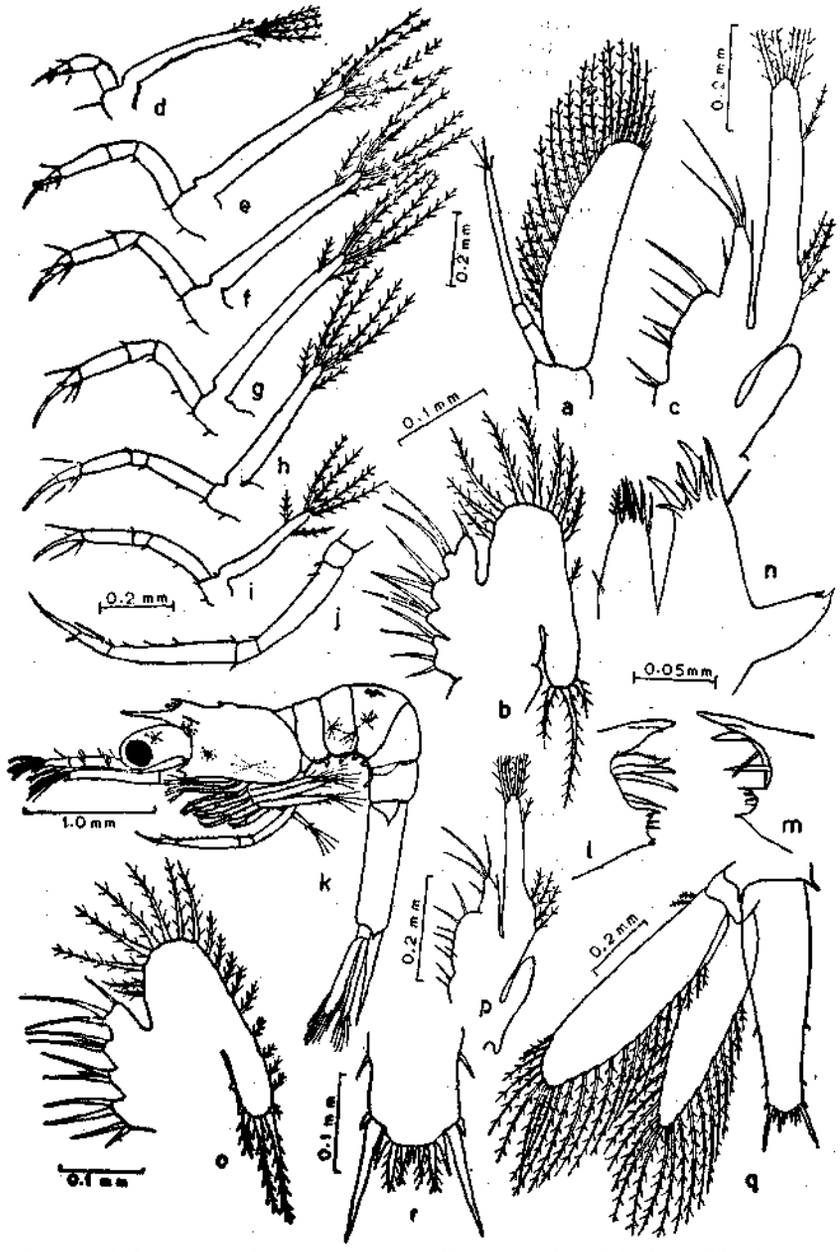


Fig. 4. *M. idella:* zoea VI, a-antenna, b-maxilla, c-maxilliped I, d-maxilliped II, e-maxilliped III, f-pereiopod I, g-pereiopod II, h-pereiopod III, i-pereiopod IV, j-pereiopod V, k-zoea VII lateral view, l-left mandible, m-right mandible, n-maxillule, o-maxilla, p-maxilliped I, q-telson and uropod, and r-distal part of telson.

1st and 3rd joints of pereiopod V; reddish branched chromatophores on ventral side of 3rd abdominal segment more pronounced. Due to the combined effects of these chromatophores larva acquires an orange-red tinge.

Outer flagellum of antennule subdivided into 2 on inner side, its apex bearing 2 slender setae and inner side bearing 6 aesthetes in 2 groups of 4 and 2, proxi mal segment with 11 plumose setae and one stout spine on inner side, number of setae on outer side increase and those at mid length of segment arranged as a circle around the segment; margin of antennal exopod with 26 plumose setae and one stout spine, flagellum long 3–segmented, 3rd segment very long having 2 lateral and 6 apical setae; right mandible with 6 teeth on incisor process; exopod of maxilla with 27 plumose setae, masticatory processes with 5, 3, and 2 setae respecitively; basipod of maxilliped I with 9 marginal setae, base of exopod further expanded and bears 5 plumose setae; 4 setae at joint of propodus and dactylus of pereiopod I to IV: tip of telson pointed; endopod of uropod with 21 setae.

Zoea IX (Fig. 6 k-r; 7 a-s) TL 4.67 to 5.88 mm.

Pereipods I and II chelate, exopod of pleopods setose.

Outer flagellum of antennule divided into 2 branches, outer branch 2-segmented bearing 4 apical setae; inner branch with 9 aesthetes in 3 groups of 4, 3 and 2; antennal flagellum longer than exopod, 3rd segment bearing 3 pairs of minute setae laterally on the distal half and 5 setae apically, exopod with 27 setae and one spine; right mandible with 7 teeth on incisor process and 6 on molar; exopod of maxilla with 28 plumose setae; basipod of maxilliped I with 12 setae; 2nd segment of endopod of maxilliped III with 3 setae; pereiopod I and II chelate, fingers with 2 setae each, spine on inner side of dactylus of pereiopod V strong and well developed; exopod of pleopod II, III and IV with 2, 2 and 3 plumose setae respectively, endopods feebly developed; tip of telson pointed, and bears 8 spines in all, outermost spine on either side conspicuously large; exopod of uropod with 26 setae and one spine in addition to 3 setae at its base; endopod with 26 plumose setae.

Zoea X (Fig. 7 t; 8 a-r; 9 a-d) TL 5.68 to 6.07 mm.

Rostrum with characteristic double curve, appendix interna on pleopods II to V.

Outer branch of outer flagellum of antennule 4-segmented, distal segment bears 5 slender setae, inner branch with 9 aesthetes in 3 groups of 4, 3 and 2, inner flagellum 3-segmented bearing 4 slender setae at its tip, 13 setae and one stout spine on inner side of proximal segment, a group of setae arranged as a semicircle at base of peduncle near the stylocerite indicating position of statocyst; antennal flagellum considerably long, elongated, 3rd segment subdivided into 4 in distal half and a small segment at its base, minute setae appear at each division, 26 plumose setae and one spine on margin of exopod; mandibles with 9 teeth on incisor processes and 6 on molar processes; distal lacinia of maxillule with 8 stout and one slender teeth, proximal with 6 teeth and one plumose seta terminally and with a single spine on inner margin; exopod of maxilla with 38 plumose setae, masticatory processes with 5, 4 and 4 setae respectively; basipod of maxilliped I with 13 setae, base of exopod expanded further and carries 7 plumose setae, lower lobe of epipod well developed; basipod of maxilliped II with one long and one short setae, terminal segment of endopod with a spine and 3 setae in addition to claw; chela of I and II pereiopods well developed, relative size of claw on dactylus reduced; variable number of setae on exopod and endopod of pleopod II to V; appendix interna developed as small projections from inner margin of endopods of all pleopods except first;

outer spines on tip of telson very long; exopod of uropod with 30 setae and a spine in addition to 3 setae at its base.

Fig. 5. *M. idella:* zoea VII, a-tip of rostrum, b-antennule, c-antenna, d-maxilliped II, e-maxilliped III, f-pereiopod I, g-pereiopod II, h-pereiopod III, i-pereiopod IV, j-pereiopod V. k-zoea VIII lateral view, l-antennule, m-antenna, n-right mandible, o-left mandible, p-maxilla, q-maxilliped I, r-buds of pleopod I, s-buds of pleopod II, t-buds of pleopod III, u-buds of pleopod IV, and v-buds of pleopod V.

Post-larva I: (Fig. 9 e-o; 10 a-m) TL 6.02 to 6.50 mm.

Except for its size, post-larva I has most of the characteristics of the adult. It has also acquired a bottom living habit.

Carapace with branchiostegal and antennal spines only; supra-orbital spine no longer present; rostrum long, extending up to distal segment of antennular peduncle, with 9 teeth on dorsal and one on ventral side.

Outer and inner antennular flagella slender, both 12-jointed, inner branch of outer flagellum bearing 11 aesthetes in 5 groups of 1, 2, 2, 3 and 3, peduncle 3-segmented, basal segment bearing statocerite and statocyst the longest, antero-lateral spine on basal segment produced beyond margin on segment, inner side of basal segment bearing 8 setae and one spine, a number of setae present in a circle along joints of segments; antennal flagellum slender and very long bearing 28 segments, 5 times longer than antennal scale, margin of antennal scale with 36 plumose setae and a well-defined spine at tip of outer margin, a small spine on outer margin of basal segment of antenna present; incisor and molar parts of mandible distinctly separated from one another, incisor process tapering from base and ending in 3 stout teeth, right side molar process stout with 5 blunt teeth, left molar process ending irregularly in 6 blunt teeth and 2 slender ones; maxillular palp terminates in a curved protuberance and one slender seta, distal lacinia with 10 terminal teeth and 3 marginal spines, proximal lacinia with 7 spiny teeth; shape of maxilla considerably altered, exopod with plumose setae all round, endopod simple and bare, basis with 2 endites, each terminating in 6 coarse bristle-like setae; basis of maxilliped I with 27 setae, endopod small and bearing only a single seta apically, exopod bearing 4 long setae and 4 short sub-apical setae, base of exopod expanded and it bears 10 setae, epipod bilobed; endopod of maxilliped II 5-segmented, propodus and dactylus broad and bearing several short setae; endopod of maxilliped III 3-segmented and profusely setose, exopod as long as 1st segment of endopod and bearing apical setae.

TABLE 1. *Measurements of* M. idella *larvae at different stages of development.*

Stage	Size range (mm)	Mean size (mm)	Mean carapace length (including rostrum) (mm)	Mean carapace length (excluding rostrum) (mm)	Mean length of 6th abdominal segment (mm)	Mean length of telson (mm)
Zoea I	1.92–2.10	2.01	0.57	0.22	0.59*	....
Zoea II	2.14–2.36	2.24	0.61	0.33	0.65*	....
Zoea III	2.33–2.62	2.46	0.65	0.35	0.48	0.34
Zoea IV	2.35–2.70	2.56	0.69	0.38	0.55	0.36
Zoea V	2.70–2.93	2.86	0.76	0.42	0.61	0.42
Zoea VI	3.12–4.08	3.58	0.82	0.52	0.72	0.50
Zoea VII	3.85–4.43	4.12	1.09	0.64	0.91	0.55
Zoea VIII	3.93–5.10	4.58	1.23	0.69	0.98	0.65
Zoea IX	4.67–5.88	5.47	1.43	0.87	1.09	0.75
Zoea X	5.68–6.07	5.83	1.56	0.88	1.16	0.79
Post-larva I	6.02–6.50	6.24	1.72	....	0.95	0.72
Post-larva II	6.20–6.90	6.57	1.86	....	1.15	0.81

* including tail fold.

Pereipods devoid of exopods, endopods 5-segmented, pereiopod I and II chelate, latter stoutest, but pereiopod V longest, all pleopods setose, appendix interna with curved hooks in sub-apical region to connect with same of other side; telson with sharply pointed tip bearing only 4 spines and 2 setae, anterior 2 pairs of lateral

spines movable and have shifted towards dorsal aspect of telson; disto-lateral margin of exopod with a movable spine in addition to one seen in previous stage.

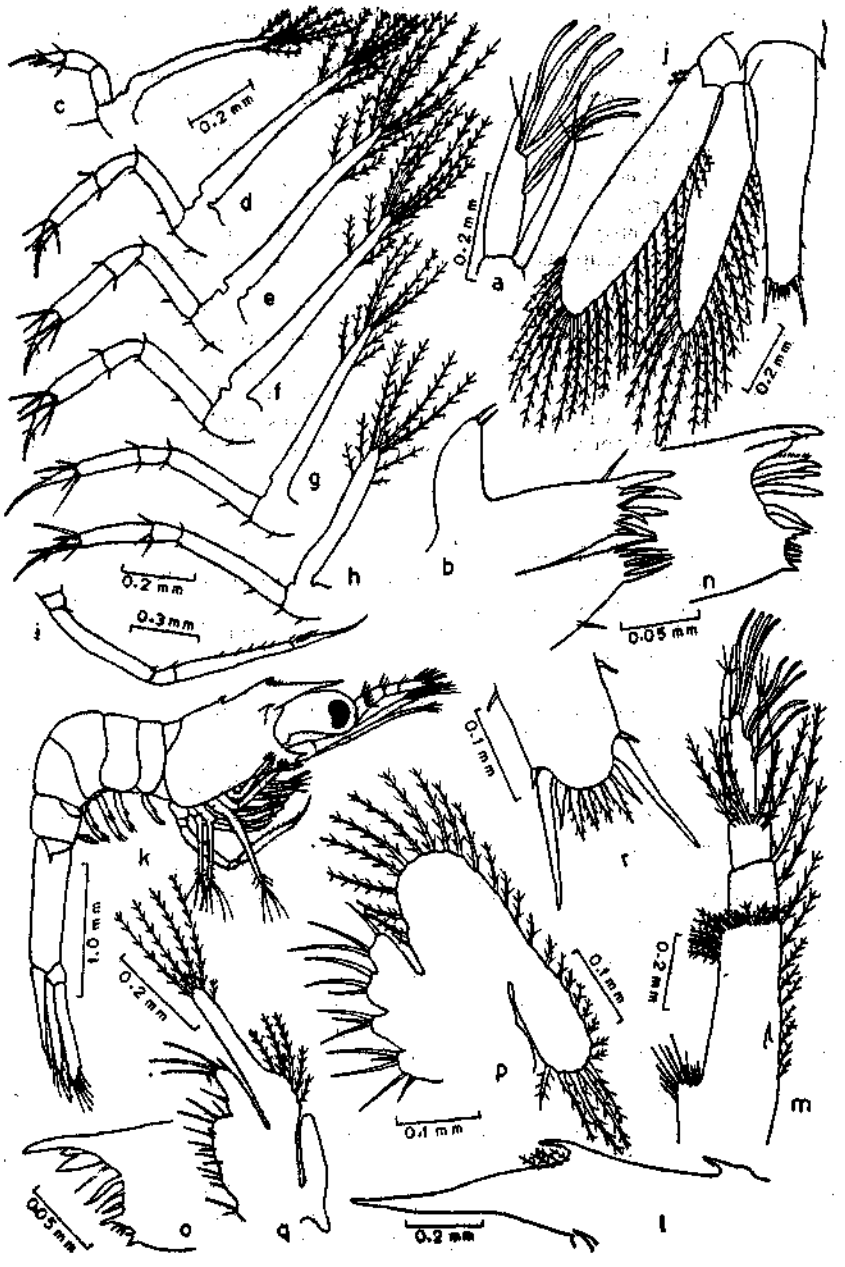


Fig. 6. *M. idella:* zoea VIII, a-antennule tip, b-maxillule, c-maxilliped II, d-maxilliped III e-pereiopod I, f-pereiopod II, g-pereiopod III, h-pereiopod IV, i-pereiopod V, j-telson, k-zoea IX lateral view, l-rostrum, m-antennule, n-left mandible, o-right mandible, p. maxilla, q-maxilliped I, and r-distal portion of telson.

Post-larva II (Fig. 10 n-r; 11 a-p) TL 6.20 to 6.90 mm.

Rostrum further developed, 10 teeth on dorsal and 2 on ventral side, branchiostegal spine less prominent; inner branch of antennular flagellum with 8 aesthetes in 3 groups of 2, 2 and 4, statocyst, stylocerite and depression to hold eye every prominent; antennal flagellum long and slender, 6 times as long as antennal scale, 1st segment of antennal flagellum with several setae arranged in a semicircle, spine on basal segment more prominent; molar process of mandible on either side with an additional tooth ending in a cluster of hairy bristles; terminal protuberance of maxillular palp finger-shaped, distal lacinia with several terminal teeth and 3 marginal spines, proximal lacinia with more than 10 teeth distributed irregularly; number of setae on basipod and basal expansion of maxilliped I show increase; those on pereiopods, pleopods and uropod have also increased.

The increase in the total length of the larvae noticed at the different stages of development are given in Table 1. The linear growth of the larvae was continuous throughout the period of their development and at no stage any reduction in total length or carapace length was noticed. The linear growth between stages was relatively high from zoea VI onwards. However, in the length of the 6th abdominal segment and the telson there was some reduction when the final zoea metamorphose into the post-larva.

BREEDING CYCLE

In its natural habitat *i.e.*, Cochin Backwater with its associated canal systems, *M. idella* breeds during the monsoon months (June to November) when the salinity of water is relatively low. Experiments conducted on the rearing of the species in the laboratory have provided information on the larval forms and on breeding cycle of the species.

Under normal conditions, the females kept in troughs for hatching will do so the very next morning. Certain amount of skill (generally acquired by practice) is needed for determining the stages of development of eggs before selecting the spawners. Hatching normally takes place in the early hours of the morning between 2 a.m. and 6 a. m. There is no special behaviour associated with the process of hatching although the parent female seldom took food when offered on the previous evening. The hatched larvae were dispersed by the mother by the fanning movements of its pleopods. When hatching was completed, the female was removed from the trough to avoid any predation by the parent.

As the fertilised eggs ("berry") on the pleopods of the female are developing, its ovary also begins to attain full maturity and it acquires greenish colour by the time hatching of the eggs takes place. Soon after the hatching of eggs, the parent female feeds freely when food is offered and it is observed to be busily engaged in the act of cleaning its body with pereiopod I. When a mature male was introduced in the same trough on the second day after the hatching of the eggs, it took the function of protecting the female by keeping her always within the confines of his extended chelipeds. On the second night, after the introduction of the male, the female moulted, mated and acquired berry. This happened within 72 hours after the hatching of the eggs of the earlier batch. The berry was green and the eggs were 0.42 mm to 0.64 mm along their longest axis. In the days that followed, the berry changed colour from green to yellow to dull white, as the embryo inside developed. The spawning of the eggs took place on the morning of 14th day after acquiring the berry. This cycle of events was found to be repeated in several experiments conducted in the laboratory and it is now clear that *M. idella*, after

attaining maturity, breeds every 17th or 18th day and each time about 5000 larvae are produced.

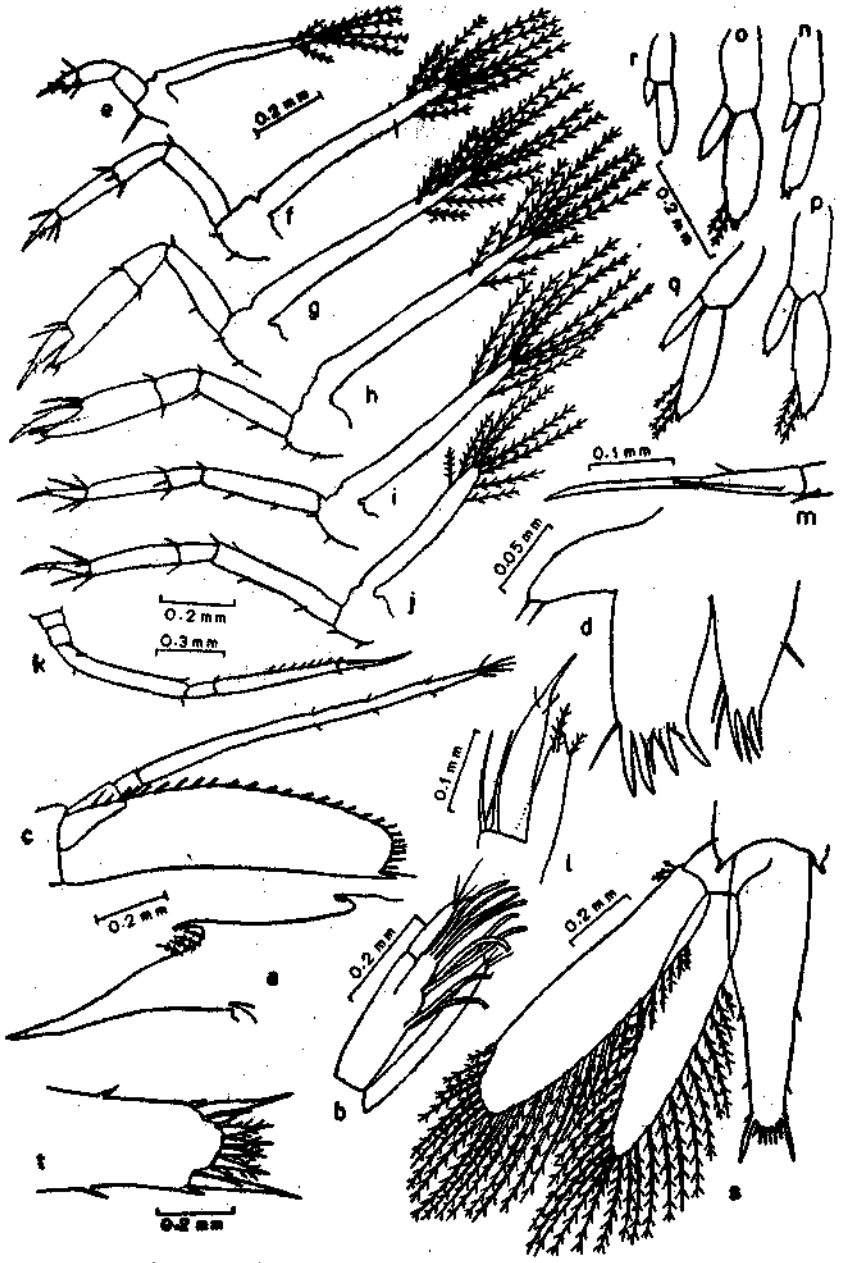


Fig. 7. *M. idella:* zoea IX, a-rostrum, b-antennular flagellum, c-antenna, d-maxillule, e-maxilliped II, f-maxilliped III, g-pereiopod I, h-pereiopod II, i-pereiopod III, j-pereiopod IV, k-pereiopod V, l-dactylus of pereiopod II, m-dactylus of pereiopod V, n-pleopod I, o-pleopod II, p-pleopod III, q-pleopod IV, r-pleopod V, s-uropod and telson, zoea X, and t-distal part of telson.

Some of the larvae obtained from the first hatching were reared through various stages till they reached adulthood and finally matured. One of the female of this brood acquired berry exactly when it was 120 days old and 42 mm in total length.

REARING EXPERIMENTS

Although the experiments showed that the newly hatched larvae could survive up to 5 days without food, they were provided with appropriate food from the time they were taken in rearing experiments. The process of rearing of larvae required constant attention as slight changes or delays in the schedule of feeding or removal of excretory, material from the bottom of jar adversely affected their normal growth and survival. Freshly hatched *Artemia* nauplii were given as food, and the same were readily accepted by the larvae at all stages of development. Prepared food materials like dried egg powder, cooked and mashed rice, wheat flour, wheat flour and egg mixture, dried prawn meat, etc. were also tried with little success. Slightly crushed advanced stage eggs of caridean prawns were readily accepted when offered and this food was used to feed them in one set of experiments. Finely chopped fresh meat of prawn was given as food for the larvae after several washing from 4th stage onwards with considerable success. The larvae took this food in preference to *Artemia* nauplii when the chopped particles were about 1/3rd the size of the larvae. Generally it can be stated that the larvae preferred relatively larger pieces of solid food particles which they could hold in their appendages as they moved about and ate. The use of prawn meat as food of the larvae has, however a restricted application as it has a tendency to spoil the water.

Feeding was done only once a day between 8 a.m. and 10 a.m. The *Artemia* nauplii were introduced into the jars with the help of a pipette. Normally more than 500 nauplii were introduced into the beaker containing 50 to 75 larvae. During the course of its swimming, when a larva came in contact with an *Artemia* nauplius, it suddenly swam backwards and then with a darting forward motion captured the nauplius with its appendages. Larvae were often seen clinging to their own moults and dead larvae. If sufficient food was not provided they attacked newly moulted larvae, and ate them up. This cannibalistic tendency was seen from the 4th stage onwards although the 2nd stage larvae were often seen to devour the dead larvae lying at the bottom of the jars. The larvae also seem to feed on the green algal vegetation that normally developed along the sides of the jar on continued use, as the presence of such algae seemed to reduce the mortality rate.

Moulting: In normal healthy conditions, the larvae moulted within 2 to 4 days more or less regularly. The process of moulting normally occurred during the early hours of the morning just as hatching. Up to zoea VI stage, each moulting resulted in a new stage but thereafter, some of the moults brought in minor changes only. Invariably zoea I moulted into zoea II stage in 48 hours after hatching. In larval stages from zoea VI onwards, there were atleast 2 moults for every morphological stage (Table 2), and in some cases 3 to 4 moults were seen between 2 successive stages. Variations in the number of interstage moults were quite common between zoea VI and VII and between zoea X and post-larva I. The first moults in each of these stages generally resulted in the increase in size of the larvae and also showed indications of the morphological changes that took place in subsequent stage. From the results of the experiments given in Table 2, it could be seen that the zoea underwent 15 moults in 2 experiments and 16 moults in another experiment before metamorphosing into post-larva I. In some of the rearing experiments it was seen that the larvae, after attaining certain stage, continued to moult at regular

intervals but failed to develop into the next morphological stage. In an experiment in which 2 larvae of the same stage were reared in the same container one developed normally and the other remained in zoea X stage for 27 days, during which time it

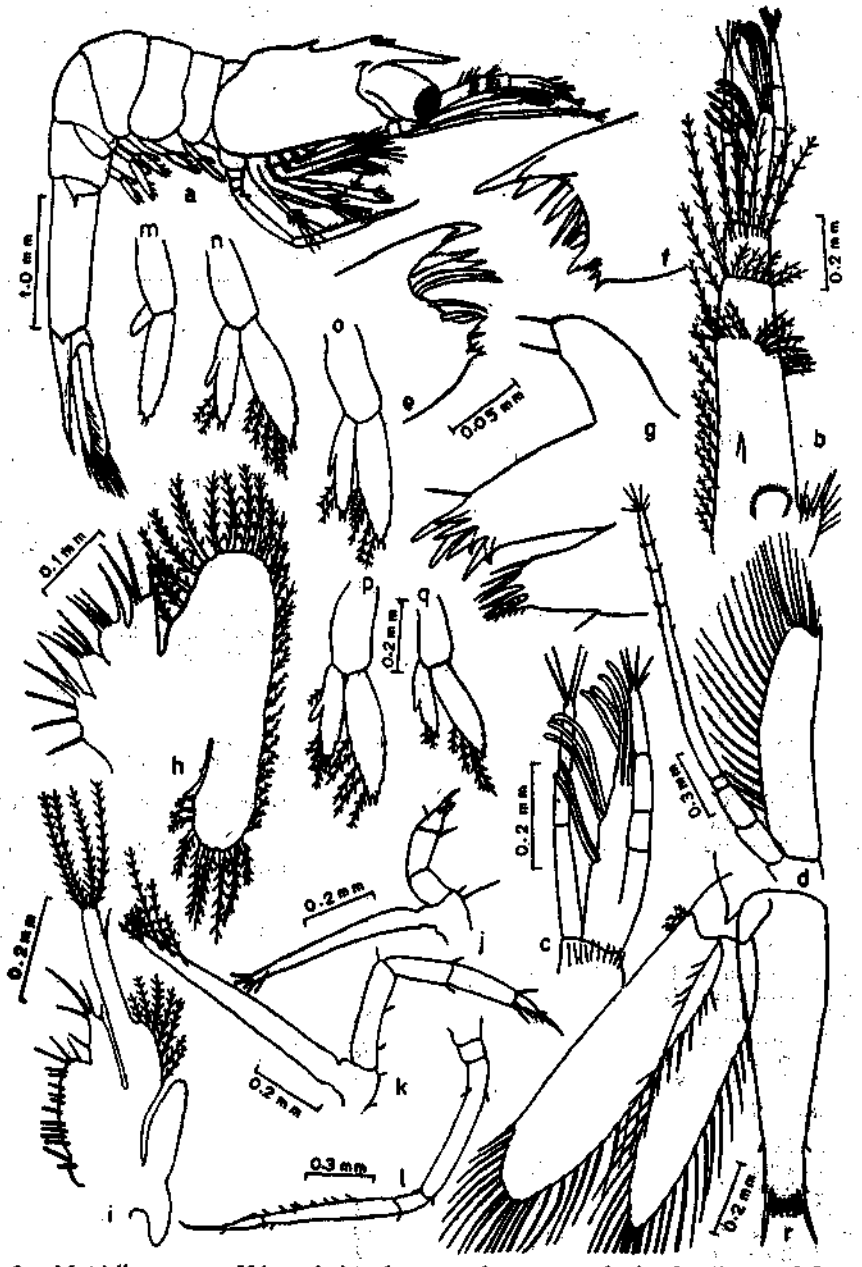


Fig. 8. *M. idella:* a-zoea X lateral view, b-antennule, c-antennule tip, d-antenna, e-left mandible, f-right mandible, g-maxillule, h-maxilla, i-maxilliped I, j-maxilliped II, k-maxilliped III, l-pereiopod V, m-pleopod I, n-pleopod II, o-pleopod III, p-pleopod IV, q-pleopod V, and r-telson and uropod.

moulted 9 times and died without developing into a post-larva. Considerable variations were noticed during the transformation of zoea X into post-larva I (Table 3) and they were mostly pertaining to morphological characteristics such as number of rostral teeth and the constituting elements of antennule, maxillule and pereiopods. Similar variations were noticed in the larval development of the caridean shrimp *Tozeuma carolinensis* by Provenzano and Dobkin (1962). The period of zoeal development seen generally at 39 to 42 days also increased if the number of moults in zoea VI and X changed.

TABLE 2. *Larval development and moulting periodicity of* M. idella.

Date	Stage	Intermoult period in days	Number of days after hatching	Salient feature of the stage
Experiment I				
21-3-72	Zoea I	..	..	Sessile eyes, no pereiopods, telson not distinct from 6th segment
23-3-72	Zoea II	2	2	Stalked eyes, pereiopod I and II developed.
26-3-72	Zoea III	3	5	Rostrum with epigastric tooth, telson distinct from 6th segment, uropod developed.
28-3-72	Zoea IV	2	7	Rostrum with 2 dorsal teeth, pereiopods III and V developed.
30-3-72	Zoea V	2	9	Buds of pereiopod IV developed.
2-4-72	Zoea VI	3	12	All pereiopods developed.
5-4-72	Zoea VIa	3	15	.....
7-4-72	Zoea VII	2	17	Uniramous buds of pleopods developed, rostral teeth serrated on ventral side.
10-4-72	Zoea VIIa	3	20	.....
12-4-72	Zoea VIII	2	22	Pleopods biramous, non setose.
15-4-72	Zoea VIIIa	3	25	.....
17-4-72	Zoea IX	2	27	Pereiopods I and II chelate exopod of pleopod with setae.
19-4-72	Zoea IXa	2	29	.....
22-4-72	Zoea X	3	32	Appendix interna developed.
26-4-72	Zoea Xa	4	36	.....
29-4-72	Post-larva I	3	39	Spines on the ventral side of rostrum developed. Larva settles to the bottom of the container and uses walking legs to move about. No exopod on pereiopods.
2-5-72	Post-larva II	3	42	
4-5-72	Post-larva III	2	44	
7-5-72	Post-larva IV	3	47	
10-5-72	Post-larva V	3	50	
15-5-72	Post-larva VI	5	55	
19-5-72	Post-larva VII	4	59	
Experiment II				
21-3-72	Zoea I	..	..	
23-3-72	Zoea II	2	2	
27-3-72	Zoea III	4	6	
29-3-72	Zoea IV	2	8	
31-3-72	Zoea V	2	10	
2-4-72	Zoea VI	2	12	
4-4-72	Zoea VIa	2	14	
6-4-72	Zoea VIb	2	16	
9-4-72	Zoea VII	3	19	

TABLE 2. (Contd.)

Date	Stage	Intermoult period in days	Number of days after hatching	Salient feature of the Stage
11-4-72	Zoea VIIa	2	21	
13-4-72	Zoea VIII	2	23	
17-4-72	Zoea VIIIa	4	27	
19-4-72	Zoea IX	2	29	
23-4-72	Zoea IXa	4	33	
25-4-72	Zoea X	2	35	
29-4-72	Zoea Xa	4	39	
2-5-72	Post-larva I	3	42	
Experiment III				
1-4-72	Zoea I	..	...	
3-4-72	Zoea II	2	2	
7-4-72	Zoea III	4	6	
9-4-72	Zoea IV	2	8	
13-4-72	Zoea V	4	12	
17-4-72	Zoea VI	4	16	
21-4-72	Zoea VIa	4	20	
24-4-72	Zoea VII	4	23	
27-4-72	Zoea VIIa	3	26	
1-5-72	Zoea VIII	4	30	
4-5-72	Zoea VIIIa	3	33	
8-5-72	Xoea IX	4	37	
10-5-72	Zoea IXa	2	39	
13-5-72	Zoea X	3	42	
17-5-72	Zoea Xa	4	46	
23-5-72	Post-larva I	6	52	

Behaviour of larvae: The larvae were very active and they constantly moved about in containers in a characteristic way with their heads always pointing downwards. Occasionally they were seen attaching themselves to the walls of the container wherever there was algal growth. They were positively phototactic and always congregated along the sides of the jar where there was maximum light. In earlier stages the food particles were held by the first pair of pereiopods before gnawing with their mouth parts. After the zoea IV stage, when 5th pair of pereiopods developed, these were used for catching the prey. While feeding, they moved about in the medium carrying food particles in their appendages. They preferred larger food particles and were often seen clinging to them at the bottom of the container if they could not come up along with the food material they held. From zoea VIII stage onwards, they were seen searching forfood at the bottom of the container. The habit of walking and bottom living tendencies were acquired by the larva only after metamorphosis. From post-larva onwards they were seen continuously browsing on the bottom of the container and they seldom came up to the surface unless disturbed. In all these stages the larvae were found to be hardy and capable of adjusting themselves to wide changes in salinity within a short time. When the larvae at any stage were transferred from lower salinity medium to higher salinity medium, *e.g.* from 10‰ to 20‰ or from 12‰ to 30‰, they showed unrest and made 3 or 4 sudden jerking movements and thereafter they continued to behave normally.

Mortality: Hatching was normally complete and unhatched eggs were never seen on the pleopods of the parent. Even without any special care, the survival of the zoea I was nearly 100%, provided that the salinity of the medium was maintained

above 10‰ . In fresh water, zoea I could survive only up to 48 hours. Zoea II stage appeared to be a critical stage in the development as they were able to pass through this stage only if proper food was given and salinity of water was maintained at a level above 10‰ . If these conditions were not provided, the larvae

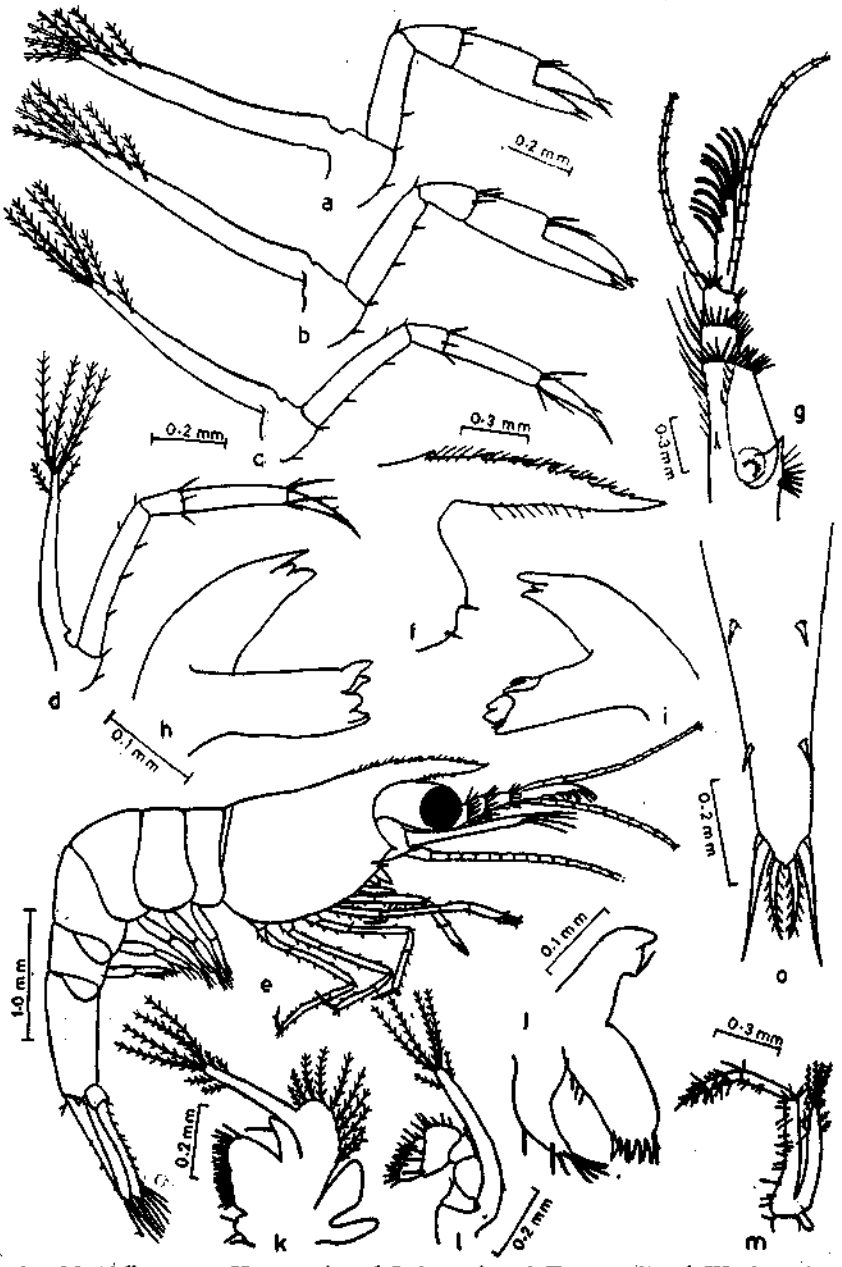


Fig. 9. *M. idella:* zoea X, a-pereiopod I, b-pereiopod II, c-pereiopod III, d-pereiopod VI, e-postlarva I lateral view, r-rostrum, g-antennule, h-right mandible, i-left mandible, j-maxillule, k-maxilliped I, l-maxilliped II, m-maxilliped III, and o-telson tip.

TABLE 3. *Variations noticed in morphological features during the metamorphosis of zoea X to post-larva I of* M. idella.

Characters	Zoea X	Zoea Xa	Zoea Xb	Zoea Xc	Post-larva I
Total length (mm)	5.80	4.14	4.48	4.93	6.50
Rostral tooth (dorsal/ventral)	2/0	5/0	8/0	8/1	9/1
Antennule:					
No. of segments on peduncle	2	2	3	3	3
No. of segments of inner flagellum	3	2	4	5	12
No. of segment on outer branch of outer flagellum	4	3	5	6	12
No. of aesthetes	9	5	9	8	11
Maxillule:					
No. of setae on endopod	2	1	1	1	1
Protuberance of endopod	a	a	p	p	p
No. of setae on basis	7	7	11	12	13
No. of setae on coxa	9	8	10	7	7
Exopods on pereiopod I to IV	p	p	p	a	a
Appendix interna on 2nd to 5th pleopod	p	a	a	p	p
Movable spine on exopod of uropod	a	a	p	p	p

a=absent. p=present.

died *en masse*. This condition is probably due to the absorption of the yolk granules which disappeared on the 4th day after the larvae were hatched. The rate of survival was high in subsequent stages, although in zoea VI and zoea X there appeared to be some increase in the mortality rate. Temperature appeared to be not a significant factor in the survival of larvae under the condition in which the larvae were reared during the present investigation.

TABLE 4. *Characters of first zoea of different species of* Macrobrachium *and the number of zoeal stages.*

Species	Size of zoea I (mm)	Colour of 3rd abdominal segment	Total No. of zoeal stages	Duration of larval life in days
M. rudis (*Palaemon rudis* Menon,1938)	1.75	A median elongated and slightly branching pink chromatophore flanked by two smaller yellow ones.	?	?
M. rudis (*P. rudis* Rajyalakshmi,1960)	1.92 to 2.06	Orange-red chromatophores on the mid-dorsal side and pink and blue pigment around it.	?	?
M. rosenbergii (*P. carcinus* Menon,1938)	2.00 to 2.25	A branching chromatophore of pink colour on the dorsal side.	?	?
M. rosenbergii (Ling,1969)	2.00 to	Two prominent pairs of chromatophores.	8	30–45
M. rosenbergii (Uno and Kwon,1969)	2.20 1.92	One contractive and two expansive ones.	11	33–43
M. scabriculum (*P. scabriculus* Rajyalakshmi,1960)	1.76 to 2.01	No chromatophore.	?	?
M. mirabile (*P. mirabilis* Rajyalakshmi,1960)	2.02 to 2.27	Pink and blue pigment in the mid-dorsal region, a large finely branch edorange brown chromatophore one on each side the branches of which ramify all over the segment and extend on to the preceding and succeeding segments.	?	?

TABLE 4. (contd.)

Species	Size of Zoea 1 (mm)	Colour of 3rd abdominal segment	Total No. of zoeal stages	Duration of larval life in days
M. malcolmsonii (*P. malcomsonii* Rajyalakshmi,1960)	2.06 to 2.28	Prominent orange-red dendritic chromatophore on the dorsal side the branches of which extend on to second segment.	?	?
M. malcolmsonii (Kewalramani *et al.*, 1971)	2.00	?	16	45
M. nipponense (Kwon and Uno,1969)	2.06	One expansive at mid-portion and 2 contractive at outer portion.	9	18–20
M. carcinus (Lewis and Ward,1965)	1.44	?	?	90
M. carcinus (Choudhury,1971)	2.00 to 2.10	Two pairs of bright red chromatophores with long dendrities on the dorsal side.	12	56–66
M. acanthurus (Choudhury,1970)	2.25 to 2.35	Two pairs of small red chromatophores with small dendrities, the central pair very close, bluish pigments scatter around these	10	32–42
M. australiense, (Fielder,1970)	3.15	Dark red chromatophores on the abdomen.	3	6
M. idella (*P. idae* Aiyer,1949)	1.85	A median elongated branching chromatophore and two others laterally.	?	?
M. idella (present observation)	1.92 to 2.10	Blue and orange-red branching chromatophore on dorso-median aspect and orange-red branching chromatophore on lateral aspect.	10	39–52

DISCUSSION

As compared to the widely distributed penaeid prawns of India, *Macrobrachium idella* is rather poorly known to the fishing industry as its capture fishery is restricted to the estuarine regions of Western India. Nevertheless, it shares many of the virtues of a very popular species of the same genus, *M. rosenbergii,* which is claimed to be the most suitable prawn for industrial culture in fresh and brackish water areas. *M. idella* was reported from the commercial catches of prawn from the brackish water regions of Kerala by Henderson and Matthai (1910) and Nataraj (1947). Its embryology was worked out in considerable detail by Aiyer (1949).

The newly hatched larva of *M. idella* is a typical zoea having close resemblance to those of other species of the genus, which have a long larval history. Although specific identifications of the larvae of this species as well as those of the same genus form a difficult task,the relatively smaller size and characteristic colouration can help in separting larva of *M. idella* from those of others. A comparative statement of specific characters of zoea I of different species of *Macrobrachium* is given in Table 4. Juveniles of *M. idella,* however, can be easily differentiated from those of *M. rosenbergii* by the presence of three vertical black lines along the sides of their carapace. In *M. rosenbergii* these lines are horizontal in disposition (Plate I).

The general pattern of larval development of *M. idella* has close similarities with that of *M. rosenbergii* (Ling and Merican, 1961; Ling, 1962, 1964, 1969; Uno and Kwon, 1969) *M. carcinus* (Choudhury, 1971) and *M. malcolmsoni* (Kewalramani,

et. al., 1971). In the present study it has been observed that the zoea of *M. idella* undergoes 14 to 15 moults before it is metamorphosed into post-larva I, but only 10 morphological stages have been recognised and described (Table 2). Ling (1962) found 12 zoeal stages in *M. rosenbergii* but in a subsequent study (1969) he grouped

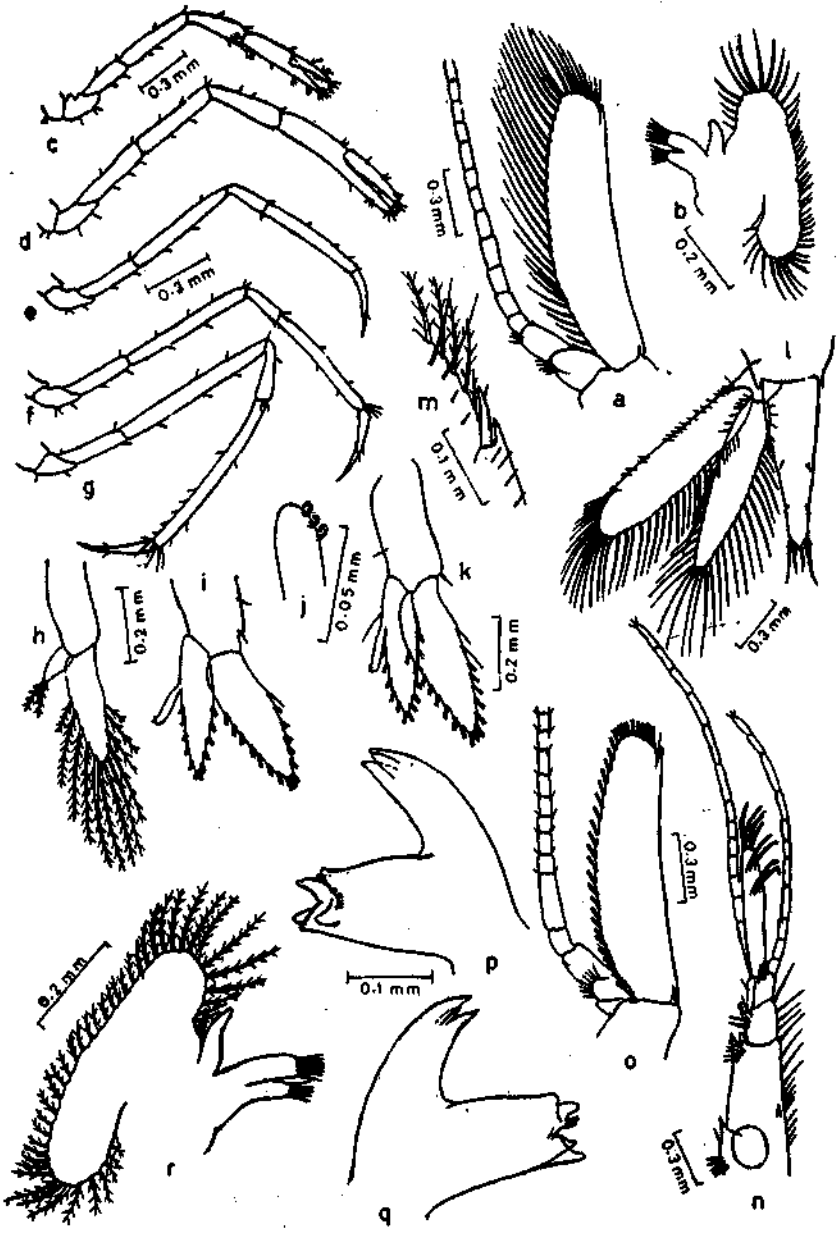


Fig. 10. *M. idella:* Post-larva I, a-antenna, b-maxilla, c-pereiopod I, d-pereiopod II, e-pereiopod III, f-pereiopod IV, g-pereiopod V, h-pleopod I, i-pleopod II, j-tip of appendix-interna of pleopod III, k-pleopod III, l-uropod and telson, m-exopod of uropod. Postlarva II, n-antennule, o-antenna, p-right mandible, q-left mandible, and r-maxillule.

these larvae into 8 morphological stages. Uno and Kwon (1969) described 11 stages in the development of the same species from Japan. Kewalramani *et al.*, (1971) described 16 stages obtained in 16 moults in *M. malcolmsoni*. Choudhury (1970) found 10 morphological stages in the zoeal development of *M. acanthurus* and 12 stages in *M. carcinus* (Choudhury, 1971) although he observed a number of moults (number not specified) occurring without significant morphological changes between stages VI and X in both the species. Variations in the number of moults and morphological stages in the larval development of these species, therefore,, appear to be common. It is possible that these differences are the result of confusion made in recognising the moults with different morphological stages. Ten morphological stages in the larval development of most of the species of *Macrobrachium* appear to be a common feature. Several deviations from the pattern of development were seen during the course of these experiments. Some larvae seem to skip over some stages, while others remain at certain stages almost indefinitely without moulting and undergoing development. Some passed through several moults without undergoing any appreciable morphological changes. In an extreme case, a zoea after attaining Xa stage remained in the same stage and continued to moult every 3rd day for 27 days and died without transforming into post-larva. Another larva attained post-larval stage within 27 days of hatching after skipping several intermediate stages. These are, no doubt, deviations from the normal pattern of development and are possibly caused as a result of changes in environment or feeding as observed by Pike and Williamson (1964) and Broad (1957) in Pandalidae and Palaemonidae respectively.

Reduction in the total length of larvae during its metamorphosis from last zoea to post-larva I is noticed in several species of *Macrobrachium* (Uno and Kwon, 1969; Uno, 1971). In *M. idella* reduction of length of post-larva I is not noticed at any time during these experiments. However, during the intermoult development of the three specimens shown in Table 3, size reduction have been noticed.

Among the three basic pattern of larval development noticed in Palaemonidae (Sollaud, 1923), that of *M. idella* perhaps fits into the first category by virtue of its larger number of larval stages which are characteristic of the brackish water prawns producing relatively large number of eggs. This is in contrast with the abbreviated larval history of several purely freshwater species belonging to the same genera; in some of which the eggs hatched out even directly into post-larvae.

The small amount of yolk granules present in the zoea I and II of *M. idella* disappear completely by the 4th day after hatching making it expedient on them to feed and ingest food from the environment for survival. This is perhaps the major cause of the high rate of mortality noticed at the time of moulting from 2nd to 3rd stage. Many of the earlier workers were unable to get past the 2nd stage in their rearing experiments. The zoea II stage is therefore considered as a critical stage in the larval history of several species of *Macrobrachium* including *M. idella*. Successful rearing of the larval forms beyond this stage is dependent on the availability of appropriate food and provision of suitable conditions of salinity and temperature of the water in which they are reared. Temperature of water did not appear to be of much importance. Surface temperature of water in these areas vary from 23.0°C to 28.0°C and the daily variation in ambient temperature never exceeds 3.0°C. During the course of present experiments best results were obtained when the salinity of water was maintained between 12‰ to 18‰ and when the supply of *Artemia* was regularly maintained.

The newly hatched larvae of *M. idella* became mature and spawn within 120 days in the laboratory. In nature the species may spawn at still shorter intervals.

Once maturity is attained the species continues to spawn every 20 days, each time producing as many as 5000 larvae. These characteristics of the species together with its readiness to spawn in confined waters make it an ideal species for culture

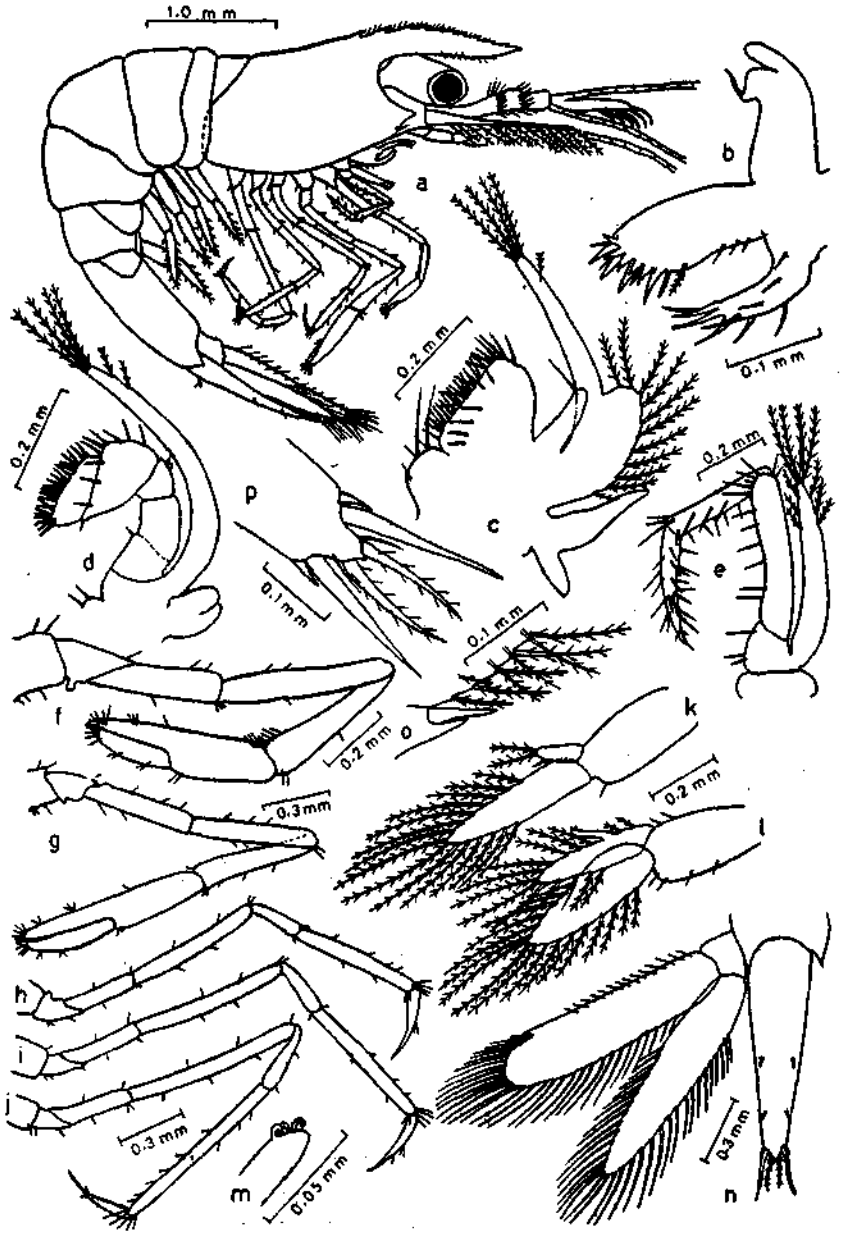


Fig. 11. *M. idella* : a-post-larva II, b-maxillule, c-maxilliped I, d-maxilliped II, e-maxilliped III, f-pereiopod I, g-pereiopod II, h-pereiopod III, i-pereiopod IV, j-pereiopod V, k-pleopod I, l-pleopod V, m-appendix interna tip, n-uropod and telson, o-exopod of uropod, and p-telson tip.

operations in brackish waters. Besides, it would appear, that *M. idella* is a species which can be cultivated entirely in brackish water environments. Mohamed (1972) stated that approximately 8000 km² of brackish water areas presently lying unutilised along the coastal regions of India can be brought under effective prawn cultivation by adopting modern culture techniques. Commercial culture of this species in these area will, no doubt, be very profitable and it will certainly add new dimensions to the development of prawn fishery in the country.

REFERENCES

AIYER, R.P. 1949. On the embryology of *Palaemon idae* Heller. *Proc. zool. Soc. Bengal*, **2** (2): 101 - 148.

BROAD, A.C. 1957. The relationship between diet and larval development of *Palaemonetes*. *Biol. Bull.* **112**: 162-170.

CHOUDHURY, P. C. 1970. Complete larval development of Palaemonid shrimp *Macrobrachium acanthurus* (Wiegmann, 1836) reared in the laboratory. *Crustaceana*, **18** (2) : 113-132.

————1971. Complete larval development of the Palaemonid shrimp *Macrobrachium carcinus* (L) reared in the laboratory (Decapoda, Palaemonidae), *Ibid.*, **20** (1) : 51-69.

FIELDER, D. R. 1970. The larval development of *Macrobrachium australiense* Holthuis, 1950 (Decapoda, Palaemonidae), reared in the laboratory. *Ibid.*, **18** (1) : 60-74.

HENDERSON, J. R. AND G. MATTHAI 1910. On certain species of Palaemon from South India. *Rec. Indian Mus.*, **5** : 277-306.

HOLTHUIS, L. B. 1950. The Decapoda of the Siboga Expedition. Part X. The Palaemonidae collected by the Siboga and Snellius Expeditions with remarks on other species. I. Subfamily: Palaemonidae. *Siboga-Exped. Leiden*, **39** a 9: 1-267.

————1952. A general revision of the Palaemonidae (Crustacea Decapoda Natantia) of the Americas II. The subfamily Palaemoninae. *Allan Hancock Found. Publ.*, **12** : 1-396.

LEWIS, JOHN B. 1961. Preliminary experiments on the rearing of the freshwater shrimp, *Macrobrachium carcinus* (L). *Proc. Gulf Caribb. Fish. Inst.*, **14** : 199-201.

————AND JONET WARD 1965. Developmental stages of the palaemonid shrimp *Macrobrachium carcinus* (Linnaeus, 1758). *Crustaceana*, **9** : 137-148.

LING, S.W. 1962. Studies on the rearing of larvae and juveniles and culturing of adults of *Macrobrachium rosenbergii* (de Man). *Indo-Pacif. Fish. Counc., Curr. Affairs Bull.*, **35** : 1-11.

————. 1964. A general account on the biology of the giant freshwater prawn, *Macrobrachium rosenbergii* and methods for its rearing and culturing. Paper presented to the Indo-Pacific Fisheries Council, 11th session, 16–31 October, 1964, Contributed paper No. 40.

————. 1969a. The general biology and development of *Macrobrachium rosenbergii* (de Man). *FAO Fish. Rep.*, (57) **3** : 589-606.

————. 1969 b. Methods of rearing and culturing *Macrobrachium rosenbergii* (de Man). *Ibid.*, (57) **3** : 607-619.

————AND A. B. O. MERICAN 1961. Notes on the life and habits of the adults and larval stages of *Macrobrachium rosenbergii* (de Man). *Proc. Indo-Pacif. Fish. Counc.*, **9** (2): 55-60.

KEWALRAMANI, H.G., K.N. SANKOLLI AND S. S. SHENOY 1971. On the larval history of *Macrobrachium malcolmsonii* (H. Milne-Edward), in captivity. *J. Indian Fisheries Association*, **1** (1): 1-25.

KWON, C.S. AND Y. UNO 1969. The larval development of *Macrobrachium nipponense* (de Haan) reared in the laboratory. *Bull. de la Soc. Franco-Japanaise d'oceanogr.*, **7** (4): 278-294.

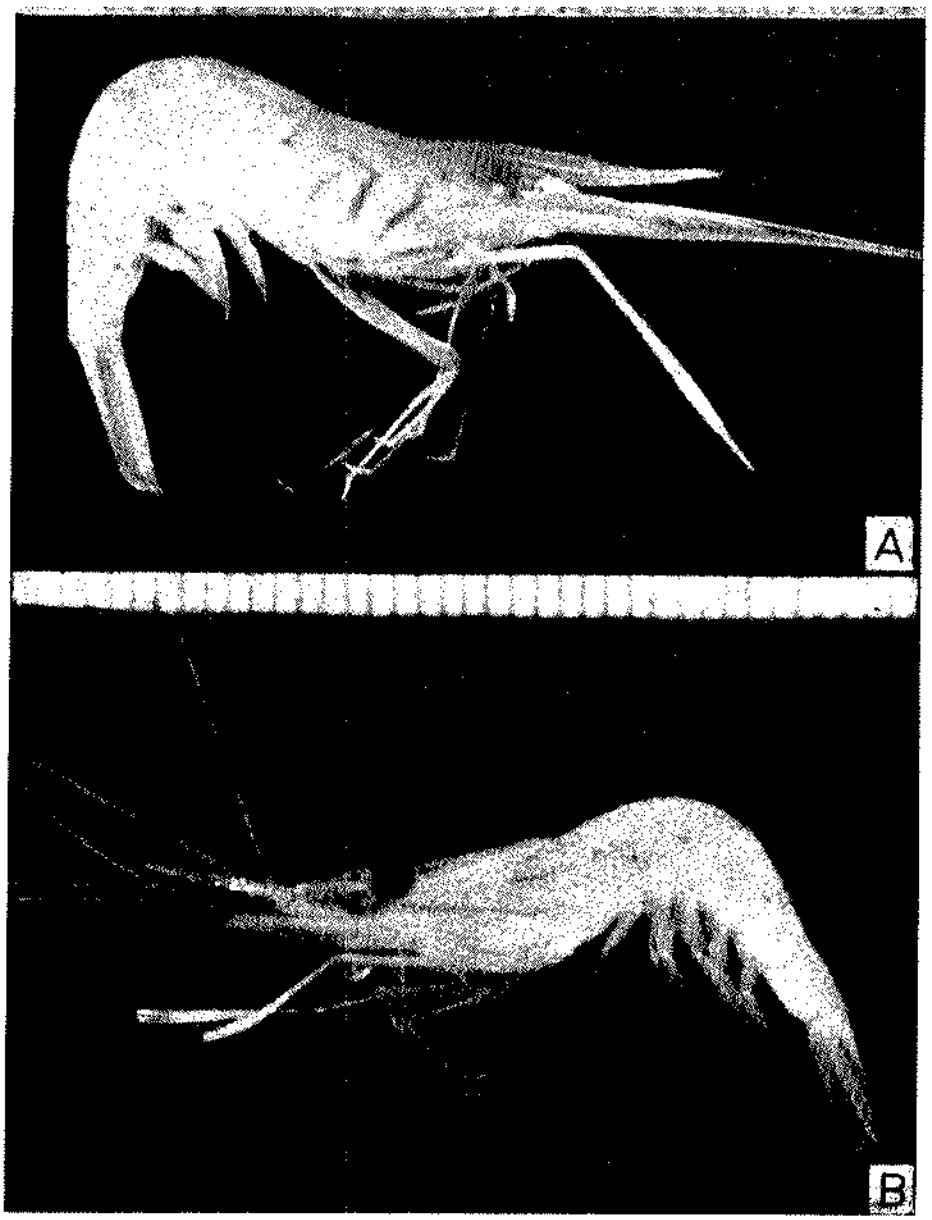


PLATE I. A. *Macrobrachium idella*, 43 mm in total length; and B. *M. rosenbergii*, 38 mm in total length.

MENON, M.K. 1938. The early larval stages of two species of Palaemon. *Proc. Indian Acad. Sci.*, B (4), **8** : 288-294.

MOHAMED, K.H. 1972. Marine prawn culture in India - an appraisal of the present status and future prospects. *Proc. Seminar on Mariculture and mechanised fishing. Madras. Dept. of fisheries. Govt. of Tamilnadu.* pp. 31-33.

NATARAJ, S. 1947. Preliminary observations on the Bionomics Reproduction and Embryonic stages of *Palaemon idae* Heller. *Rec. Indian Mus.*, **45** (1): 89-96.

PIKE, R.B. AND D.I. WILLIAMSON 1964. The larvae of some species of pandalidae (Decapoda). *Crustaceana*, **6** : 265-284.

PROVENZANO, ANTHONY J. JR. AND S. DOBKIN 1962. Variation among larvae of decapod crustacea reared in the laboratory. *American Zoologist*, **2** (3): 152.

RAJYALAKSHMI, T. 1960. Observations on the embryonic and larval development of some estuarine Palaemonid prawns. *Proc. Nat. Inst. Sci. India*, **26** B (6): 395-408.

RAO, R. MALLIKARJUNA 1965. Breeding behaviour in *Macrobrachium rosenbergii* (de Man.) *Fish. Technol.*, **2** : 19-25.

SOLLAUD, E. 1923. Le developpement larvaire des Palaemoninae. I. Partiedescriptive. La condesation progressive de l'ontogenese. *Bull. Biol. France et Belg.*, **57** - 509-603.

UNO, Y AND C.S. KWON 1969. Larval development of *Macrobrachium rosenbergii* (de Man) reared in the laboratory. *J. Tokyo Univ. Fish.*, **55** (2): 179-190.