Journal of the
Marine Biological Association of India

ABBREVIATION : *J. mar. biol Ass. India*

VOL. 17 AUGUST, 1975 No. 2

LARVAL DEVELOPMENT OF *CARIDINA PSEUDOGRACILIROSTRIS* REARED IN THE LABORATORY

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ABSTRACT

Complete larval development of *Caridina pseudogracilirostris* Thomas *et al.* was studied by rearing in the laboratory. Six zoeal stages were recognised in the larval development of this species. These stages are completed within nine days from hatching, after which the zoea transforms into first postlarva Detailed descriptions of zoea, postlarva and juvenile are given.

INTRODUCTION

SPECIES belonging to the genus *Caridina* H. Milne Edwards are distributed widely and are common in the fresh and brackish waters. Daday (1907) studied for the first time, the larval stages of *Caridina wyckii* (Hicks), collected from the Lake Victoria and Nyansa. This was followed by Gurney's work (1927) on the three larval and two postlarval stages of *Caridina nilotica* var. *typica* Bouvier and Shen's (1939) description of the five larval stages of *Caridina denticulata* de Haan. Glaister (1976) described four zoeal and one postzoeal stages of *Caridina nilotica aruensis* Roux by rearing them in the laboratory. From Indian waters, Nair (1949) described the first zoea of *Caridina leavis* Heller, while Babu (1963) studied the complete larval history of *Caridina propinqua* de Man by rearing experiments. Recently Lakshmi (1975) gave description of the early larval stages of *Caridina* sp. collected from the inshore waters of Cochin. The present work deals with the complete larval history of *Caridina pseudogracilirostris* Thomas *et al.*, a common shrimp found in the fresh and brackish water areas of Cochin.

The author expresses his indebtedness to Dr. E. G. Silas, Director, Central Marine Fisheries Research Institute and Dr. K. V. Sekharan for their keen interest and constant encouragements. He is thankfull to Mr. K. H. Mohamed and Dr. P. V. Rao for helpful suggestions and critically going through the manuscript. He is also thankful to Dr. C. S. Gopinadha Pillai for the translation of the German publication, to Mr. V. K. Pillai for supply of the berried specimen and to Miss S. Lakshmi for her assistance in the course of this study.

MATERIAL AND METHODS

A live berried specimen, measuring 29.0 mm in total length from tip of rostrum to the tip of telson was caught by the plankton net operated in the Cochin Backwater at a station north of Cherai on 16th September 1972. The 'berry' was found to be in an advanced stage of development. The specimen was carefully brought to the laboratory and kept in a 1000 ml capacity glass container having brackish water of 15–16‰ salinity. On the following morning (17–9–72) all the eggs in the berry were hatched and the first zoeae were seen actively moving about in the medium. About 500 zoeae were obtained from the hatching of eggs. They were further reared in brackish water medium having a salinity range from 15 to 16‰. Half of the medium along with the bottom sediment, was siphoned out from the container, twice in a week, and the original water level was maintained by adding fresh brackish water of the same salinity. No special food was given to the larvae, however they were found to feed actively on the algal layer formed on the sides of the container and the copepodites developed in the culture medium. During the experiments the water temperature in the container ranged between 23.0 to 28.0° C. Larvae were sturdy and active and the mortality was found to be negligible. In the development of larva from zoea I to postlarva I, distinct morphological changes occured at each moult, which is hence, considered as a stage. Zoea I moulted six times to become postlarva I. The entire experiment was done for a period of 92 days from the time of hatching of eggs. By this time the larvae reached the juvenile stage. Time taken for metamorphosis from zoea I to postlarva I as well as the total duration of each stage is given in Table 1.

Every day five larve were preserved in 5% formalin for detailed morphological studies. Total length was measured from the tip of rostrum to the tip of telson, excluding spines, and the carapace length from the tip of rostrum to the mid-posterior border of the carapace. Illustrations of the appendages were made with the aid of monocular microscope and camera lucida.

DESCRIPTION OF LARVAL STAGES

Zoea I (Fig. 1 a to i; 2 a): Total length (Tl) 1.40 to 1.54 mm; Carapace length (Cl) 0.49 to 0.52 mm.

A typical first stage caridean larva with large sessile eyes fused with carapace; rostrum small, unarmed, slightly decurved at tip; anterolateral angle of carapace slightly produced; abdomen six segmented, last segment joining the broadly triangular telson without an intervening articulation; three pairs of maxillipeds present.

Antennule (A 1) (Fig.1 b): peduncle long, unsegmented, carrying 2 flagella distally; outer with 3 aesthetes and 2 setae, inner seta long and plumose and reaches tip of aesthetes. Antenna (A 2) (Fig. 1 c): peduncle unsegmented, carrying a scale and flagellum, a long spine present at the base of flagellum; flagellum unsegmented, half the length of scale,carrying distally one long plumose and 3 short nonplumose setae; scale indistinctly 3-segmented distally, carrying 2 outer, 10 inner and apical setae, the outer apical seta being short, spine like and non-plumose. All other setae plumose. Mandible (Md) (Fig. 1 d): asymmetrical; incisor process with 2 to 4 stout teeth; molar process with rough cutting edge and 1 or 2 teeth; in between the processes 2 to 5 short stout teeth present. Maxillule (Mx 1) (Fig.1e): bilobed; proximal masticatory process with 5 to 6 spines and a small seta on inner anterior side; distal process with 6 short stout teeth; palp (endopod) unsegmented, carrying 4 apical setae

of which 2 are slender; vestigial exopod present as a small lobe carrying 2 long plumose setae. Maxilla (Mx 2) (Fig. 1 f): bilobed; protopod with 4 lobes, proximal lobe broad, bearing 9 bristle-like arched setae, other 3 lobes each with 2 stout setae; endopod without any distinct segment, but bears 2 inner lobes, proximal and distal

TABLE 1. *Larval development and moulting periodicity of* Caridina pseudogracilirostris

Date	Stage	Intermoult period in days	Number of days after hatching	Salient feature of the stage
17– 9–'72	Zoea I	..	..	Sessile eyes; A–1, A–2, Md–1, Mx–1, Mx–2, Mxp–1, Mxp–2 and Mxp–3 developed; telson not distinct from the last abdominal segment and with 7 pairs of spines.
18– 9–'72	Zoea II	1	1	Eyes stalked; A–1 peduncle 2–segmented; biramous bud of P–1 developed; telson with 8 pairs of spines.
20– 9–'72	Zoea III	2	3	A–1 peduncle 3–segmented; P–1 developed; biramous buds of P–2, P–3 and uniramous buds of P–4 and P–5 developed; telson distinct from the last abdominal segment; uropod developed.
22– 9–'72	Zoea IV	2	5	Base of rostrum with a small knob-like papilla; P–2 and P–3 developed; uniramous bud of pleopods developed.
23– 9–'72 24– 9–'72	Zoea V	1 to 2	6 to 7	P–4 and P–5 developed; pleopod buds biramous.
24– 9–'72	Zoea VI	1 to 2	7 to 8	Rostrum with a single dorsal tooth.
25– 9–'79 25– 9–'72 26– 9–'72	Postlarva I	1 to 2	8 to 9	Rostrum with 3 dorsal teeth; pleopods with setae, and the endopods of 2nd and 5th with appendix interna.
4–10–'72	Eight days old postlarva	8 to 9	17	Tl 3.09 to 3.68 mm; Cl 1.02 to 1.24 mm; rostrum with 4 to 5 dorsal and a single ventral teeth.
13–10–'72	Seventeen days old postlarva	9	26	Tl 7.1 to 7.8 mm; Cl 2.8 to 3.1 mm; rostrum with 8 dorsal and 11 ventral teeth; pereiopods without exopods; telson with 3 pairs of lateral and 4 pairs of terminal spines.
27–10–'72	Thirtyone days old postlarva	14	40	Tl 11.5 to 12.3 mm; Cl 4.69 to 5.01 mm; rostrum with 19 ventral teeth; carapace with only antennal spine.
18–12–'72	Juvenile	52	92	Rostrum with 9 to 10 dorsal and 24 to 27 ventral teeth; adult males with appendix masculina.

lobes with 3 and 2 setae respectively; inner distal margin of the endopod with 4 long setae; exopod broad without proximal extension and bears 5 long plumose setae along its margin. First maxilliped (Mxp 1) (Fig. 1 g): biramous; protopod with 12 to 13 long setae; endopod 4-segmented, distal segment with 3 long setae at its apex, 1st, 2nd and 3rd segments carry on its inner side 3, 1 and 1 setae respectively, a single seta present on the outer distolateral margin of 3rd segment; exopod longer than endopod, bearing 4 long apical and 2 sub-apical plumose setae. Second maxilliped (Mxp 2) (Fig. 1 h): biramous; protopod with 5 to 7 long plumose setae; endopod 4-

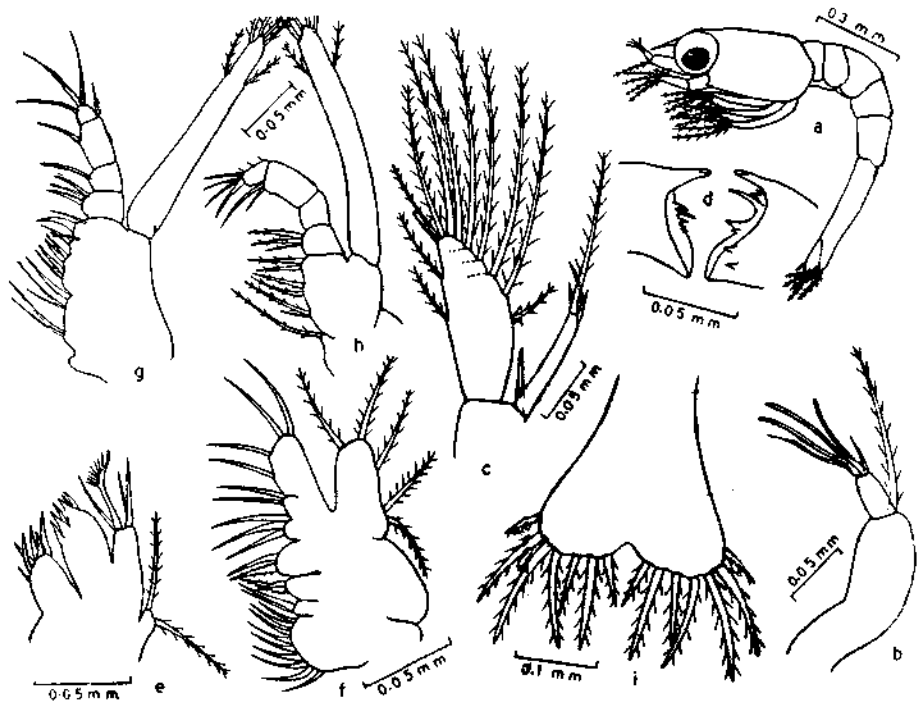

Fig. 1. *Caridina pseudogracilirostris.* Zoea I: a. lateral view; b. A–1; c. A–2; d. Md; e. Mx–1; f. Mx–2; g. Mxp–1; h. Mxp–2; i. T.

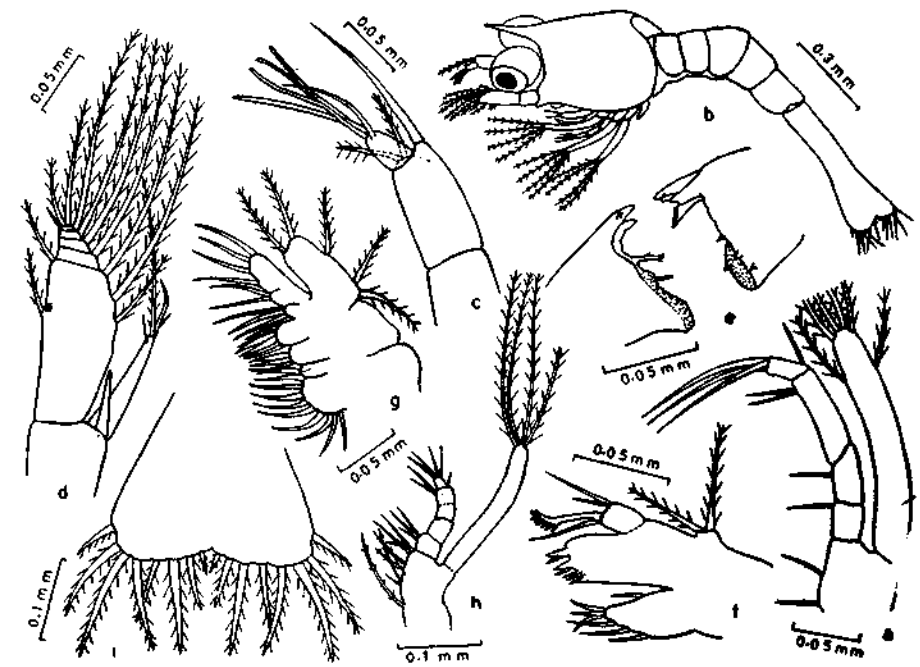

Fig. 2. *Caridina pseudogracilirostris.* Zoea I: a. Mxp–3. Zoea II: b. lateral view; c. A–1; d. A–2; e. Md; f. Mx–1; g. Mx–2; h. Mxp–2; i. T.

segmented, first segment with 3 and third segment with 2 setae on the inner side, distal segment with 4 setae, 2 of which are stout and spine-like; exopod longer than endopod carrying 4 long apical and 2 short sub-apical plumose setae. Third maxilliped (Mxp 3) (Fig.2 a):biramous; protopod with 2 setae on the inner side; endopod 4-segmented, first two segments, each carrying one slender seta on the inner side, third segment with 2 setae, distal segment with 3 long stout claw-like setae; exopod as long as endopod with 4 long apical and 2 stout sub-apical plumose setae. Telson (T) (Fig. 1i): broadly triangular with a median notch on the posterior margin, carrying 7 pairs of plumose setae, of which, the outer most one shortest and plumose on the inner side.

Zoea II (Fig. 2 b to i): Tl - 1.48 to 1.58 mm; Cl - 0.49 to 0.52 mm.

Eyes stalked (Fig. 2 b); carapace with a well defined pterygostomial spine; peduncle of antennule 2-segmented; biramous bud of first pereiopod (P 1) developed; telson with 8 pairs of spines.

A 1 (Fig. 2 c): peduncle 2-segmented, distal segment carries two plumose setae on its apical dorsal region; outer flagellum with 4 aesthetes and one long spine-like seta. A 2 (Fig. 2 d): distal part of scale 4-segmented; flagellum only half the length of scale carrying at its apex one long plumose seta and one short spine-like stumpy seta, in some cases 2 very small setae also seen. Md (Fig. 2 e): asymmetrical; incisor with 4 to 5 stout teeth on one side; below the incisor teeth, one movable tooth serrated on one side present. Mx 1 (Fig. 2 f): proximal masticatory process with 7 long setae and the distal with 7 teeth. Mx 2 (Fig. 2 g): distal lobe of protopod with 5 stout setae. Mxp 2 (Fig. 2 h): 3rd segment of endopod shows a faint division in the middle. Mxp 3: basis with 3 setae; endopod 5-segmented. T (Fig. 2 i): posterior margin with 8 pairs of plumose setae, outermost seta plumose only on the inner side, innermost pair of setae shortest.

Zoea III (Fig. 3 a to e): Tl–1.84 to 2.07 mm; Cl–0.51 to 0.58 mm.

Antennular peduncle 3-segmented; first pereiopod developed; biramous buds of 2nd and 3rd and uniramous buds of 4th and 5th pereiopods developed; telson separated from 6th abdominal segment by an articulating joint; uropod developed.

A 1 (Fig. 3 a): peduncle 3-segmented, proximal part of 1st segment swollen and carries a short seta, one plumose seta present on inner distal region; 2nd segment carries distally 2 plumose setae of which the inner one longer, and reaches almost to the tip of aesthetes, third segment with 2 long plumose setae; outer flagellum with one aesthetes and a seta; inner flagellum in the form of a papilla and carries a long seta. A 2 (Fig. 3 b): scale without distal segmentation, carrying one outer, 11 inner and apical setae, distolateral seta small, spine-like and non-plumose; flagellum short not reaching half the length of scale, carrying distally one short stout and 2 small slender setae. Md (Fig. 3 c): incisor with 4 to 6 stout teeth; cutting edge of molar further developed; in between incisor and molar processes 2 to 3 slender teeth present, of which one movable and serrated on one side. Mx 2: Exopod with 8 plumose setae around its outer and inner margin, its outer proximal region slightly extended. Mxp 1: number of setae on the inner side of protopod increased. Mxp 2: protopod with 9 setae, of which the proximal one long and plumose; endopod 5-segmented, distal segment with 4 setae of which one stout and claw-like. P 1 (Fig. 3 d): biramous; not fully developed; endopod 5-segmented; protopod and first 2 segments of endopod each

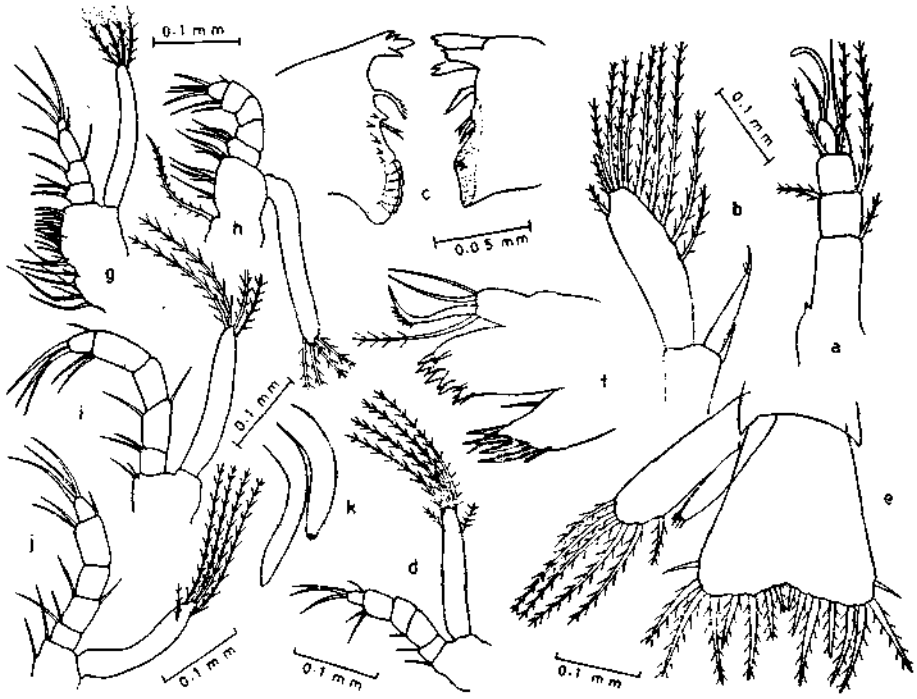

Fig. 3. *Caridina pseudogracilirostris*. Zoea III: a. A–1; b. A–2; c. Md; d. P–1; e. uropod and T. Zoea IV: f. Mx–1; g. Mxp–1; h. Mxp–2; i. Mxp–3; j. P–1; k. uniramous bud of P–4 and P.–5.

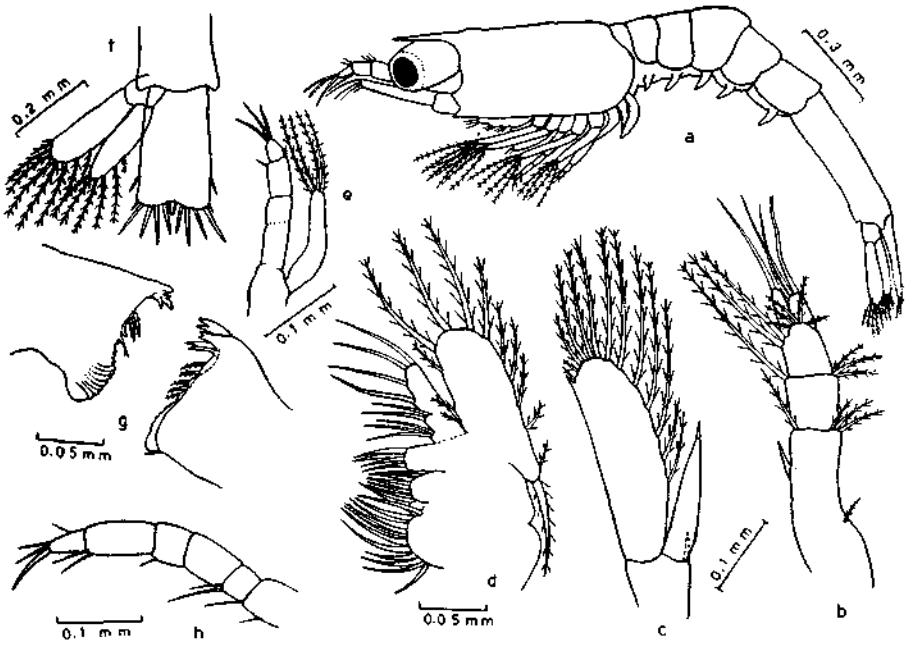

Fig. 4. *Caridina pseudogracilirostris*. Zoea IV: a. lateral view; b. A–1; c. A–2; d. Mx–2; e. P–3; f. uropod and T. Zoea V: g. Md; and h. P–5.

with one seta on the inner side, 4th segment with 2 setae on the inner side and one on the outer distolateral margin, distal segment with 3 long setae at its distal end, of which one is claw-like; exopod slightly longer than endopod with 4 long apical and 2 short sub-apical plumose setae. Exopod of uropod (Fig. 3 e) with 6 long plumose setae; endopod with 4 short setae at its apex. T: broader posteriorly, with 8 pairs of setae, outermost seta on either side non-plumose.

Zoea IV (Fig. 3 f to k; 4 a to f): Tl-2.05 to 2.22 mm; Cl-0.57 to 0.65 mm.)

Rostrum long and slender, at its base a small knob like papilla developed (Fig. 4 a); 2nd and 3rd pereiopods developed, uniramous buds of 4th and 5th pereiopods further enlarged, developing setae are indicated as small knob-like projections at the apex of the bud (Fig. 3 k); uniramous buds of pleopods appeared (Fig. 4 a).

A 1 (Fig. 4 b): proximal segment of peduncle slightly bulged outwards carrying a short plumose seta, a stout spine also present on ventral side of the segment. Distal region of the first and second segments beset with 4 plumose setae, 5 plumose setae present on the distal dorsal aspect of the 3rd segment, ventrally the same segment carries 4 long plumose setae; inner flagellum longer than the outer and carries a long seta apically; outer flagellum stumpy with one seta and 2 aesthetes. A 2 (Fig. 4 c): scale with 13 plumose setae at its inner and apical margin and one short spine at the outer distal margin; flagellum stumpy, with a short seta at its apex; the spine on protopod becomes smaller. Mx 1 (Fig. 3 f): proximal masticatory process with 7 setae and distal with 10 teeth; palp with 4 apical setae; exopod completely disappears. Mx 2 (Fig. 4 d): exopod with 13 plumose setae. Mxp 1 (Fig. 3 g): number of setae on protopod increases, some of proximal setae long and plumose, a single additional seta develops on the outer side of 2nd segment. Mxp 2 (Fig. 3 h): Segments of endopod more flattened. P 1 and P 2 (Fig. 3 j): almost identical; protopod with 2 to 3 setae, on inner side; endopod 5-segmented, 1st and 2nd segments each with 2 setae, 3rd segment with 2 to 3 setae, terminal segment with 3 long claw like setae. P 3 (Fig. 4 e): not fully developed; endopod 4-segmented; segmentation on 1st segment faint, terminal segment with 3 setae; exopod shorter than endopod with 4 long apical plumose setae. Exopod and endopod of uropod with 8 and 6 plumose setae respectively; exopod with a small spine at the distolateral edge (Fig. 4 f). T: almost rectangular in shape, with a pair of lateral spines and 6 pairs of distal setae.

Zoea V (Fig. 4 g, h; 5 a to k): Tl-2.50 to 2.64 mm; Cl-0.71 to 0.74 mm. 4th and 5th pereiopods uniramous and fully developed; all pleopod buds biramous but bare (Fig. 5 h to j).

A 1 (Fig. 5 a): 3rd segment of penduncle with 5 long plumose setae on the distal ventral side; inner flagellum nearly twice the length of outer and with a faint segmentation in the middle and carries 3 setae terminally, one of which twice the length of others; outer flagellum with 2 setae and 3 aesthetes. A 2 (Fig. 5 b): scale with 15 plumose setae and one spine; flagellum as long as scale, 2-segmented, the distal segment shows 2 faint notches indicating segmentation and bears an apical seta; the spine on the distal aspect of protopod 2/3rd the length of first segment of flagellum. Md (Fig. 4 g): incisor with 5 to 6 stout teeth; in between incisor and molar process, 3 to 5 serrated stout teeth present. Mx 1 (Fig. 5 c): proximal process with 8 long setae and distal with 11 teeth. Mx 2: exopod with 15 plumose setae on the broader and one plumose seta on narrower part. Mxp 2 (Fig. 5 d): endopod more flattened, terminal segment with 5 setae. Mxp 3 (Fig. 5 e): protopod with 4 long setae; exopod

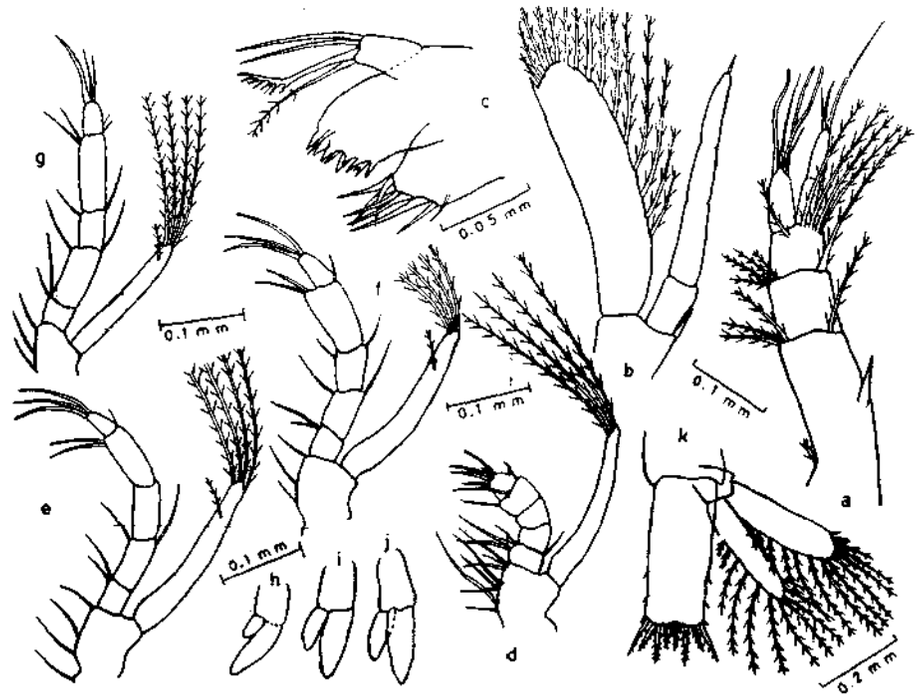

Fig. 5. *Caridina pseudogracilirostris.* Zoea V: a. A–1: b. A–2; c. Mx–1; d. Mxp–2; e. Mxp–3; f. P–1; g. P–3; h. pleopod I; i. pleopod II; j. pleopod III; k. uropod and T.

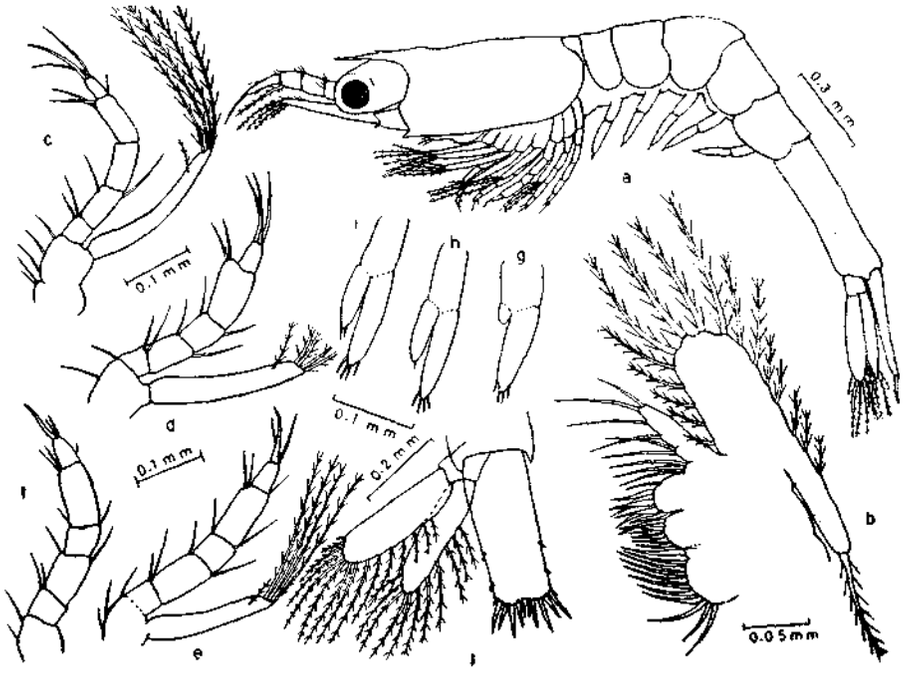

Fig. 6. *Caridina pseudogracilirostris.* Zoea VI: a. lateral view; b. Mx–2; c. Mxp–3; d. P–1; e. P–3; f. P–5; g. pleopod I; h. pleopod II; i. pleopod III; j. uropod and T.

shorter than endopod. P 1 and P 2 (Fig. 5f): almost identical, propodus stouter, developing chela seen as a projection with 2 long setae at its apex: exopod shorter than endopod. P 3 (Fig. 5 g): protopod with 3 setae; endopod 5 segmented, 1st four segments carry 2 setae each, distal segment carries 3 setae at its apex, of which one curved and claw-like; exopod as long as the first 3 segments of endopod bearing 4 long apical and 2 short sub-apical plumose setae. P 4 and P 5 (Fig. 4 h): both uniramous and almost identical in structure; protopod with 2 setae on its inner side; endopod 5 segmented; 1st and 4th segments each with 2 and 3rd segment with a single seta respectively, terminal segment carries 3 setae, of which one long and sickle-shaped. Endopod of 1st pleopod (Fig. 5 h) smaller as compared to that of 2nd and 5th pleopods. Exopod of uropod (Fig. 5 k) with 13 plumose setae and one spine; endopod with 11 plumose setae. T: rectangular with 3 pairs of short spines laterally and 5 pairs of setae distally.

Zoea VI (Fig. 6 a to j): Tl-2.47 to 2.68 mm; Cl-0.67 to 0.75 mm.

Rostrum with a single dorsal tooth (Fig. 6 a); exopod of all pleopods tipped with 4 short non-plumose setae, endopod of 2nd to 5th pleopods with 1 to 2 short non-plumose setae (Fig 6 g to i).

A 1: proximal segment with a bulge at the basal outer region which carries 3 short plumose setae; outer flagellum with one seta and 3 aesthetes. A 2: scale with 16 plumose setae and one spine. Mx2 (Fig. 6 b): exopod with 17 plumose setae, narrower region produced further. Mxp 3 (Fig. 6 c): basis with 4 to 5 setae; exopod as long as the first three segments of endopod. P 1 and P 2 (Fig. 6 d): both appendages almost identical in shape; protopod with 2 to 3 long setae; propodus thicker and the developing chela seen as a projection carrying at its apex 2 slender setae. Exopod of uropod (Fig. 6 j) with 14 plumose setae and one spine and endopod with 11 plumose setae.

Postlarva I (Fig. 7 a to j; 8 a to g): Tl-2.54 to 2.96 mm; Cl-0.70 to 0.86 mm.

Rostrum with 3 dorsal teeth (Fig. 8 a); carapace with pterygostomial and antennal spines; appendix interna developed on the endopod of 2nd to 5th pleopods.

A 1: peduncle 3-segmented, protuberance at proximal outer region of basal segment with 4 short setae; number of plumose setae at 1st and 2nd joints increase; outer flagellum 2 to 3-segmented, the distal segment with 3 terminal short setae (Fig. 7 a), 5 aesthetes in 2 groups of 3 and 2 present; inner flagellum 4-segmented with 4 short setae terminally. A 2 (Fig. 7 b): scale with 17 to 18 plumose setae and one spine; flagellum nearly 2 times the length of scale with 11 to 13 segments, basal 2 segments stouter. Md (Fig. 7 c): asymmeterical; incisor with 6 to 8 stout teeth; numerous grooves and transverse ridges present on the molar in addition to a few slender teeth; in between the 2 processes 4 to 5 slender teeth present. Mx 1 (Fig. 7 d): proximal masticatory process becomes more flattened bearing 9 to 10 long setae; the cutting edge of the distal masticatory process with 12 short teeth; palp with 2 distal setae. Mx 2 (Fig. 7 e): proximal masticatory process with 14 long arched setae; distal process with numerous bristle-like setae; endopod small and unsegmented; the flattened exopod with 19 plumose setae along its margin, of which 3 placed on the proximal extension of exopod. Mxp 1 (Fig. 7 f): exhibits great change; basis and coxa expanded and beset with setae; those on coxa being longer; endopod triangular, its inner basal region with 2 short setae; exopod slightly broader at proximal region bearing 7 to 8 plumose setae at outer and terminal

Fig. 7. *Caridina pseudogracilirostris*. Post larva I: a. antennular flagellum; b. A–2; c. Md; d. Mx–1; e. Mx–2; f. Mxp–1; g. Mxp–2; h. Mxp–3; i. P–1 and j. P–2.

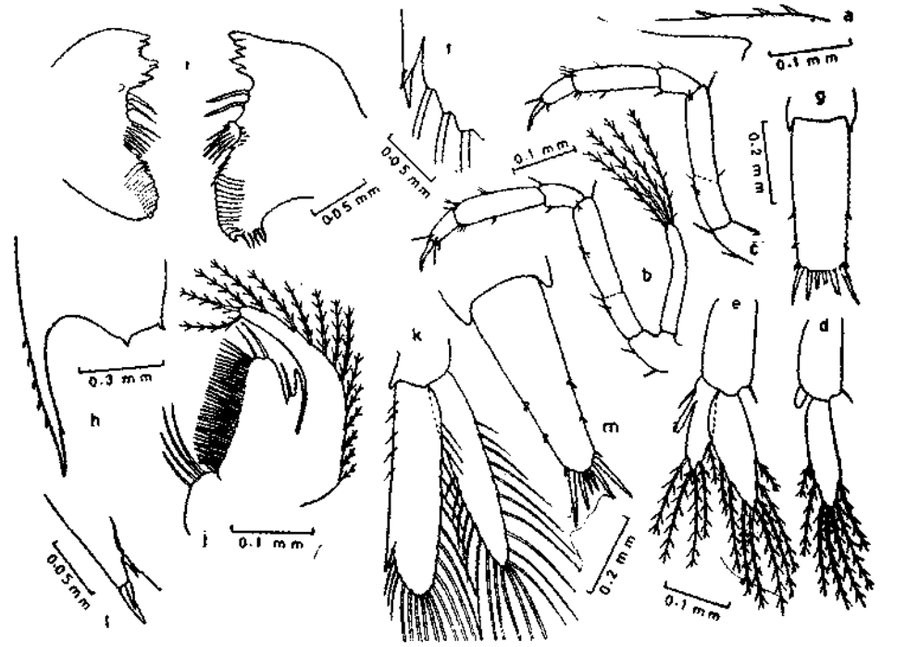

Fig. 8. *Caridina pseudogracilirostris*. Post larva I: a. rostral tip; b. P–3; c. P–4; d. pleopod I; e. pleopod II; f. diaeresis of uropodal exopod; g. T. Eight days old postlarva: h. rostrum; i. Md; j. Mxp–1 k. uropod; l. diaeresis of uropodal exopod and m. T.

regions. Mxp 2 (Fig. 7 g): dactylus and propodus not separate and together forms a flattened segment bearing a number of setae; bud of podobranch developed; exopod longer than endopod bearing 4 long apical plumose setae. Mxp 3 (Fig. 7 h): protopod with 2 setae on inner side; endopod 5-segmented, ischium, merus and carpus with 2 setae each, propodus slightly expanded bearing a number of bristle-like setae, dactylus ends in a claw-like seta; exopod shorter than endopod carrying 4 long plumose apical setae. P 1 (Fig. 7 i): chela fully developed, with a few terminal tuft of setae; exopod with 4 apical and 2 sub-apical plumose setae. P 2 (Fig. 7 j): longer than P1; chela fully developed with terminal tuft of setae; exopod shorter than endopod. P 3 (Fig. 8 b): dactylus of endopod ends in a claw-like spine and 2 small setae; 1st five segments carry 1, 2, 1, 2 and 1 spines respectively; exopod very small reaching middle of 2nd segment of endopod. P 4 and P 5 (Fig. 8 c): almost similar and uniramous; the division between ischium and merus indistinct, terminal segment ends in claw-like spine, first 4 segments carry one spine each. First pleopod (Fig. 8 d): exopod with 7 long plumose setae; endopod small and bare. 2nd to 5th pleopods almost identical in structure (Fig. 8 e): exopod with 8 to 9 and endopod with 4 to 6 plumose setae; appendix interna developed. Exopod of uropod with 15 to 16 and endopod with 14 to 15 plumose setae. Development of diaeresis started and it carries 2 spines (Fig. 8 f). T: with 2 pairs of short spines on the lateral margin (Fig. 8 g) and 4 pairs of spines distally, lateral spines placed at distal half of the telson.

Although rearing experiments of postlarva I were continued for 83 days, when it attained almost all the adult characters, only four samples were preserved for detailed studies (Table 1). Major changes occurred in the process of development during this period are given below.

Eight days old postlarva is characterised by having a rostrum with 4 to 5 dorsal and one ventral teeth (Fig. 8 h); carapace with pterygostomial and antennal spines; exopod present on first three pereiopods; telson with 2 pairs of lateral and 4 pairs of terminal spines. A 1: a circlet of plumose setae seen on the distal aspect of 1st segment; number of setae on 2nd and 3rd segments also increased; outer flagellum 3-segmented, carrying 5 aesthetes in 2 groups of 3 and 2, terminal segment with 2 short setae; inner flagellum 6-segmented longer than outer flagellum. Md (Fig. 8 i): 8 to 9 long and slender teeth present in between the incisor and molar processes. Mx 1 (Fig. 9 b): proximal masticatory process more flattened and carrying 13 long setae along its inner margin; distal process with 14 teeth. Mx 2 (Fig. 9 c): number of setae on the 3 masticatory processes increased; proximal part of the exopod produced further and slightly flattened distally carrying 5 setae, of which 2 long. Mxp 1 (Fig. 8 j): endopod unsegmented, slightly expanded at the proximal end bearing a plumose seta; exopod broader at the proximal region, carrying 15 plumose setae, distal ones longer. Mxp 2: basis and ischium, and propodus and dactylus coalesced; propodus bearing 4 long setae and the flattened dactylus bearing numerous long setae; podobranch further developed. Mxp 3 (Fig. 9 d): as ischium and merus, and propodus and dactylus are coalesced, endopod is only 3-segmented; distal segment broad with a row of closely set brush-like setae; exopod as long as the first segment of endopod with 4 long plumose terminal setae. P 1 (Fig. 9 e): chela becomes thicker; exopod present. P 2 (Fig. 9 f): exopod becomes smaller and only as long as the first segment of endopod. P 3 (Fig. 9 g): exopod represented only as a small bud-like projection; dactylus carries 2 more spines in addition to the terminal one. P 4 and P 5 (Fig. 9 h): both appendages almost same in structure; ischium with 1 and merus with 2 spines respectively; in addition to the terminal spine the dactylus carries 1 to 2 spines. Exopod and endopod of uropod (Fig. 8 k) with 21 plumose

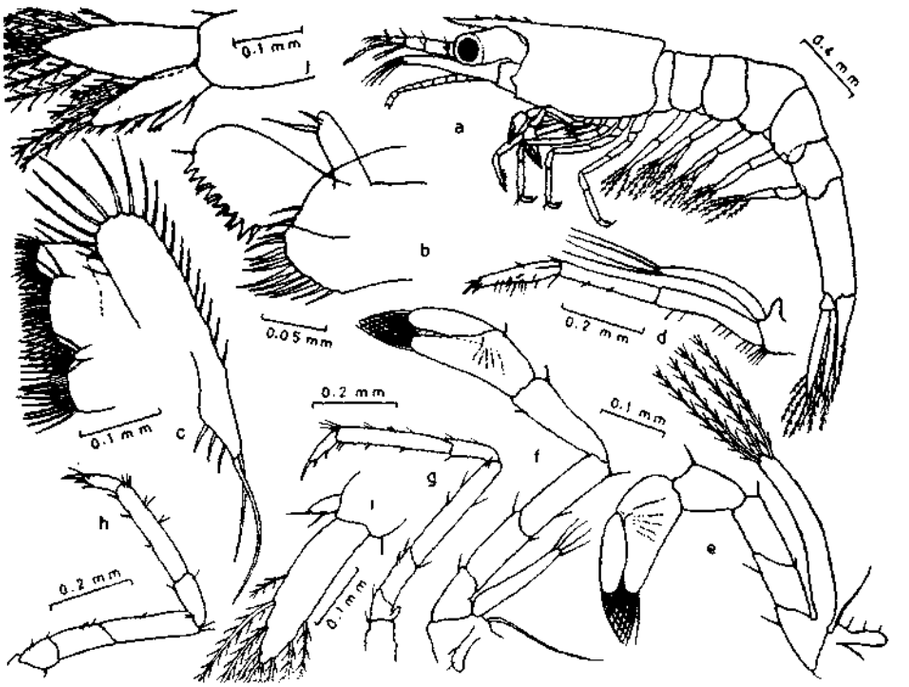

Fig. 9. *Caridina pseudogracilirostris*. Eight days old postlarva: a. lateral view; b. Mx-1; c. Mx-2; d. Mxp-3; e. P-1; f. P-2; g. P-3; h. P-5; i. pleopod I; j. pleopod II.

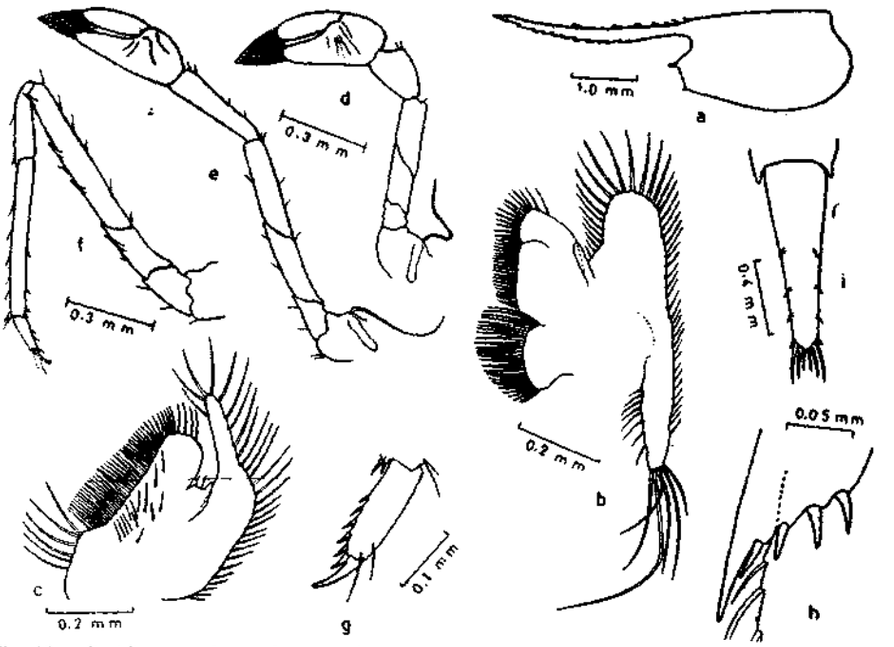

Fig. 10. *Caridina pseudogracilirostris*. Seventeen days old post-larva: a. Carapace; b. Mx-2; c. Mxp-1; d. P-1; e. P-2 f. P-4; g. dactylus of P-5; h. diaeresis of uropodal exopod; i. T.

setae, diaeresis with 3 spines. T (Fig. 8 m): tappering towards posteriorly bearing 4 pairs of spines.

Seventeen days old postlarva is characterised by rostrum with 8 dorsal and 11 ventral teeth; carapace with pterygostomial and antennal spines (Fig. 10 a); pereiopods without exopods; telson with 3 pairs of lateral and 4 pairs of terminal spines. A 1: apical spine of basal segment developed; outer flagellum 9-segmented, proximal segments broader bearing aesthetes; inner segment with 14 segments longer than outer. Mx 2 (Fig. 10 b): number of setae on masticatory processes and exopod increased, proximal extension of exopod bearing 6 long setae. Mxp 1 (Fig . 10 c): inner margin of the broad basis slightly concave; exopod broader proximally, distally it tappers and bears plumose setae along its margin. P 1 (Fig. 10 d): carpus shorter than chela, 1.5 to 1.7 times as long as broad with a small excavation anteriorly; fingers longer than palm, chela 1.9 to 2.0 times as long as broad; exopod absent. P 2 (Fig. 10 e): carpus shorter than chela, 3.4 to 3.6 times as long as broad; chela 2.2 times as long as broad. P 3: propodus 3.8 times as long as dactylus, dactylus with 4 spines of which the distal one more prominent. P 4 (Fig. 10 f): dactylus with 4 spines, terminal one being longer and stouter, propodus 4 times as long as dactylus. P 5: dactylus with 7 spines (Fig. 10 g.); and propodus 3.5 times as long as dactylus. Diaeresis with 5 spines (Fig. 10 h). T: with 3 pairs of lateral and 4 pairs of terminal spines (Fig. 10 *i*); the proximal 2 pairs of spines have shifted towards the dorsal surface of telson.

Thirty-one days old postlarva is characterised by rostrum longer than carapace with 8 dorsal and 19 ventral teeth (Fig. 11 a): carapace with antennal spines only; telson with 3 pairs of lateral and 4 pairs of terminal spines. Mx 2 (Fig. 11 b): the proximal extension of exopod further developed, carrying distally more than 10 long setae, the number of setae on exopod and protopod increased. Mxp 2 (Fig. 11 c): propodus carries 7 long setae; dactylus flattened and slightly concave on its topographically inner margin and bears a number of long setae; podobranch fully developed; exopod with a number of plumose setae distally. Mxp 3: number of closely set brush-like setae on the distal segment increased. P 3 and P 4: dactylus with 5 spines, terminal one being the longest (Fig. 11 d); P 5: dactylus with 14 spines (Fig. 11 e); diaeresis with 6 spines (Fig. 11 f). T: with 3 pairs of lateral and 4 pairs of terminal spines; the lateral spines shifted towards the dorsal surface of telson (Fig. 11 g).

Juvenile (Fig. 11 h to j; 12 a to g; 13 a to j): Tl-14.0 to 14.39 mm; Cl-5.88 to 6.21 mm.

Rostrum has attained the adult shape. Appendix masculina is fully developed on the 2nd pleopod of males. Rostrum is longer than carapace with 9 to 10 dorsal and 24 to 27 ventral teeth, reaches distinctly beyond the scaphocerite; tip of the rostrum is slightly curved upwards, considerable portion of the dorsal margin behind the sub-apical teeth being entire. Orbital angle is distinct and rounded. Antennal spine is present and the antero-lateral angle of the carapace is rounded. In one specimen, pterygostomial spine was present (Fig. 11 h).

A 1 (Fig. 12 a): stylocerite slender and pointed, reaching beyond the middle of basal segment; anterolateral tooth well developed. Md (Fig. 12 b): asymmetrical; incisor with 7 to 10 stout teeth; molar with a number of prominent ridges; in between the processes a number of slender teeth in 2 groups present, near the incisor 5 to 6 slender teeth and below it 11 to 13 bristle-like teeth present, the lower ones of these

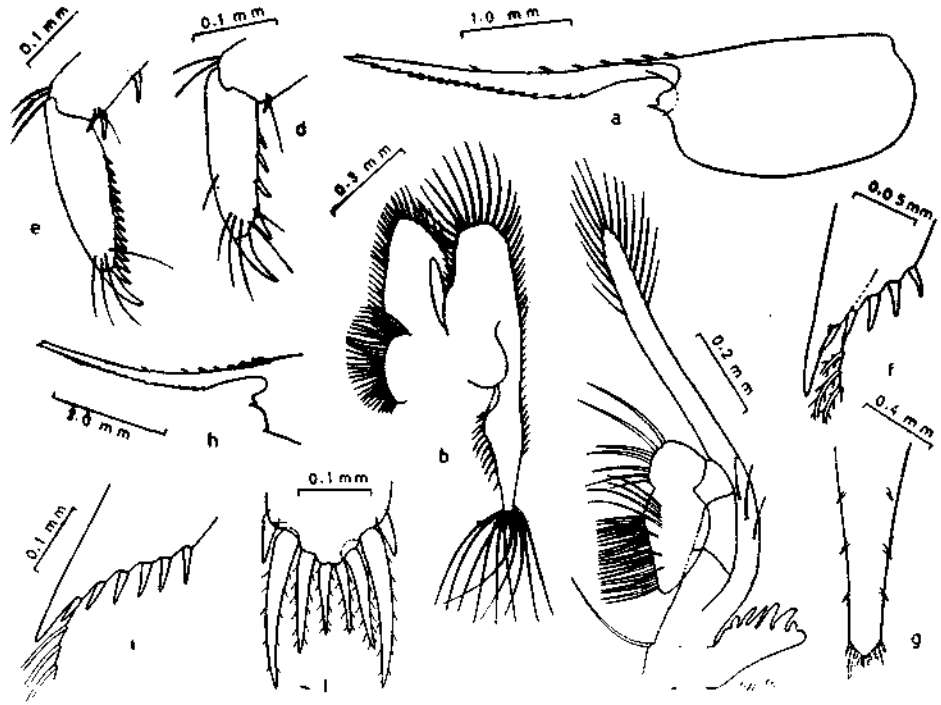

Fig. 11. *Caridina pseudogracilirostris*. Thirtyone days old post-larva: a. carapace; b. Mx–2; c. Mxp–2; d. dactylus of P–4; e. dactylus of P–5; f. diaeresis of uropodal exopod; g. Tuenile; h. rostrum; i. diaeresis of uropodal exopod; j. tip of T.

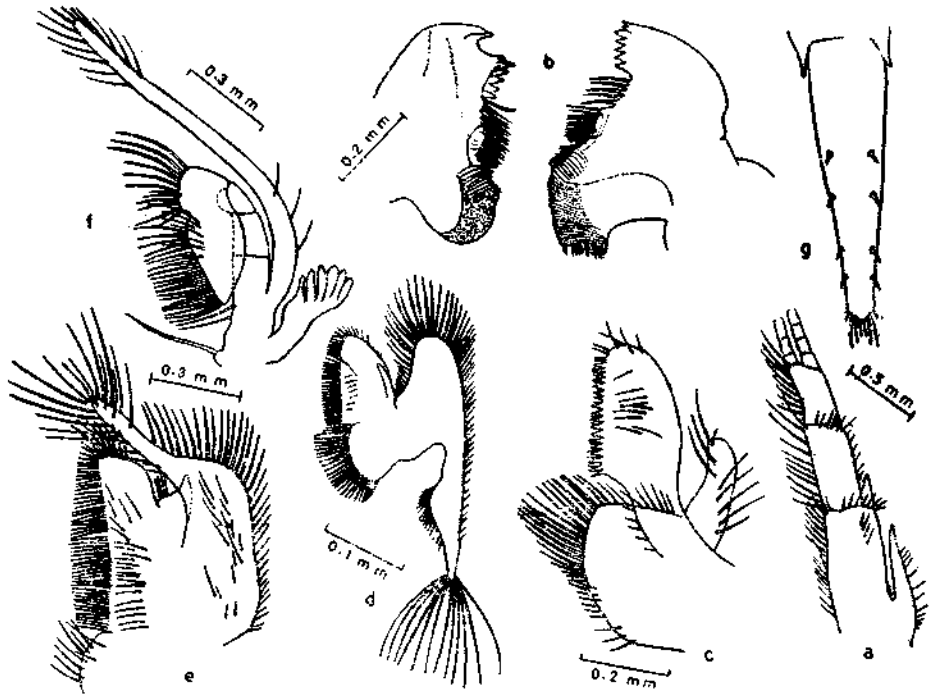

Fig. 12. *Caridina pseudogracilirostris*. Juvenile: a. A–1; b. Md; c. Mx–1; d. Mx–2; e. Mxp–1; f. Mxp–2; g. T.

teeth being smaller. Mx 1 (Fig. 12 c): having typical adult shape; proximal masticatory process flattened and the cutting edge in the form of a semicircle, bearing 35 to 40 slender setae along its margin; distal process with 30 to 35 teeth and a number of slender bristle-like setae; endopod with 8 to 10 slender setae. Mx 2 (Fig. 12 d): outer margin of coxopod almost like a semicircle bearing a number of long arched setae along its margin; basipod with a number of short bristle-like setae along its outer and distolateral margin; endopod small and unsegmented; distal process of the exopod bearing terminally 12 to 15 long setae, its proximal part expanded on the inner side bearing 15 short setae. Mxp 1 (Fig. 12 e): basipod elongated and inner margin slightly concave bearing rows of setae; exopod proximally expanded bearing a number of setae (about 34) along its outer margin; anterior part narrower bearing a number of long setae around its distal part; endopod small, triangular bearing 4 short setae on the proximal inner part. Mxp 3 (Fig. 13 a): endopod 3-segmented, distal segment with a row of short bristle-like setae; exopod with 9 pairs of plumose setae distally. P 1 (Fig. 13b): carpus shorter than chela, 1.8 to 2.0 times as long as broad with a shallow excavation anteriorly; chela 2.2 times as long as broad and fingers longer than palm. P 2 (Fig. 13 c): longer than P 1; carpus slightly longer than chela, 4.3 to 4.8 times as long as broad; chela 2.6 times as long as broad. P 3 (Fig. 13 d): ischium with 1 and merus with 3 spines; propodus 3.4 times as long as dactylus; dactylus with 8 spines of which the distal one being longer and stouter. P 4 (Fig. 13 e): almost same as P 3; propodus more than 4 times as long as dactylus; dactylus carries 7 spines. P 5 (Fig. 13 f): dactylus with 23 spines (Fig. 13 g), the spines branched (Fig. 13 h); propodus more than 4 times as long as dactylus. Endopod of first pleopod of male ovate, without appendix interna (Fig. 13 i). Appendix masculina developed on the endopod of 2nd pleopod of male (Fig. 13 j), longer and broader than appendix interna and bears terminally a tuft of bristles; apical hook-like bristles present on appendix interna. Diaeresis with 7 spines (Fig.11 i). T (Fig. 12 g): bears 4 pairs of dorsal spines, distal margin narrow and convex carrying 4 pairs of spines, the outermost spine on either side short and non-plumose, other 3 pairs of spines plumose (Fig. 11 j).

DISCUSSION

Six well defined zoeal stages are distinguished in the larval development of *Caridina pseudogracilirostris*. Six stages have also been reported in the larval history of *C. wyckii* (Hicks) by Daday (1907). However, the corresponding larval stages of these two species show marked differences, particularly in the pattern of development of pereiopods. In *C. wyckii* the bud like rudiments of pereiopods make their first appearance in the zoea I itself and in the subsequent stages a progressive development is observed. In the present species, the pereiopod buds develop for the first time in the zoea II stage only. First and second pereiopods are fully developed in the third stage (metazoea) of *C. wyckii*, whereas second pereiopod is only in the form of bud in the same stage of the present species. Fourth pereiopod which is fully developed in *C. wyckii* at the fourth stage (protomysis) is not developed to the same extent in the corresponding stage of *C. pseudogracilirostris*.

In *C. denticulata* (Shen, 1939), *C. nilotica* (Gurney, 1927), *C. propinqua* (Babu, 1963), and a *Caridina* sp. (Lakshmi, 1975) the larval development is abbreviated and their first zoea shows advanced development. Except in the case of *C. propinqua* even pleopod buds are developed in the first zoea of all the above mentioned species. In *C. pseudogracilirostris* pleopod buds make their appearance only on the fourth zoeal stage.

The various morphological features of first zoea of *Caridina nilotica aruensis* (Glaister, 1976) are almost comparable with that of the present species. But the first zoea of the present species can easily be distinguished from the other by the presence of exopod with 2 setae on maxillule. The 2nd, 3rd and 4th zoeal stages of *C. nilotica aruensis* however differ from the same stages of the present species particularly in the pattern of development of pereiopods. In *C. pseudogracilirostris*, only first pereiopod bud is developed in zoea II, whereas in the comparable stage of *C. nilotica aruensis* both first and second pereiopods are developed. In fourth zoea of the present species second and third pereiopods are developed, while all the pereiopods are developed in the same stage of *C. nilotica aruensis*. Further fourth pereiopod is biramous in the zoeal stage of *C. nilotica aruensis* while it is uniramous in the present species.

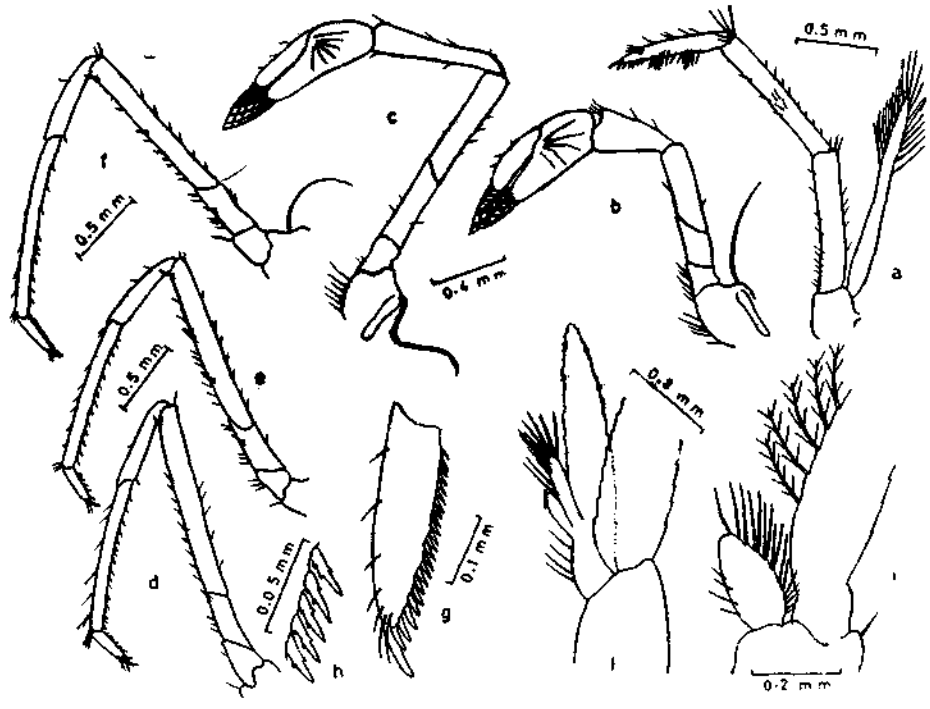

Fig. 13. *Caridina pseudogracilirostris*. Juvenile: a. Mxp–3; b. P–1; c. P–2; d.P–3; e. P–4; f. P–5; g. dactylus of P–5; h. spines on the dactylus of P–5; i. endopod of pleopod I of male; j. endopod of pleopod II of male.

One of the noteworthy characters observed in the development of *C. pseudogracilirostris* is the presence of a small vestigial exopod with 2 long plumose setae in the first maxilla of the first zoea. As in *Atyaephyra desmaresti* (Millet) (Gauthier, 1924), this vestigial exopod is retained in the first three zoeal stages.

Carapace of the first postlarva of *C. pseudogracilirostris* possesses an antennal spine and a small tooth at the anterolateral angles, while in advanced postlarval stages this tooth disappears completely. However in one of the laboratory reared juveniles this tooth is retained as a small pterygostomial spine. In *C. weberi* var.

sumatrensis de Man, Kemp (1918) observed such variations and opined that such variations cannot be regarded as having specific value in *C. weberi* group. In the light of this, the present observation on isolated instances of retention of a small pterygostomial spine in one of the specimens may be treated only as an aberration.

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