Contributions to Marine Sciences Dedicated to Dr. C. V. Kurian, 1979: 243–255

EARLY LARVAL STAGES OF *PALAEMON (PALAEMON) CONCINNUS* DANA (DECAPODA, PALAEMONIDAE)

N. N. PILLAI

Central Marine Fisheries Research Institute, Cochin–682018

ABSTRACT

First seven zoeal stages of *Palaemon (Palaemon) concinnus* Dana were reared in the laboratory and the developments studied. Rearing was carried out in the medium having a salinity range of 10-12‰ and by feeding with freshly hatched *Artemia* nauplii. In the larval development each of the successive moult leads to the following stage upto zoea VI and thereafter moults 2-3 times before developing into zoea VII. Relatively high mortality was observed in zoea III and zoea VI stages.

INTRODUCTION

Palaemon (Palaemon) concinnus Dana, a widely distributed shrimp in the Indo-Pacific region, was recorded for the first time from Indian waters from the irrigation canals of river Krishna opening into the Bay of Bengal (Dutt and Ravindranath, 1974). A single berried specimen collected from Cochin backwaters was reared in the laboratory. When the eggs hatched out the larvae were reared up to zoea VII and the following description deals with the first seven zoeal stages of the species.

MATERIAL AND METHODS

During an experimental cast net operation to collect caridean prawns for biological studies, one berried female of *Palaemon (Palaemon) concinnus* was caught on 22.9.1973 from the Thevara canal near Cochin. Total length (from tip of rostrum to tip of the telson excluding terminal spines) and carapace length (from tip of rostrum to the mid dorsal posterior margin of carapace) of this species were 54 and 24 mm respectively. The specimen was brought to the laboratory alive and kept in a 5 litre glass trough containing 4 liters of filtered water having a salinity of 10‰. Continuous aeration was provided. The trough was covered with organdy cloth to prevent the shrimp from jumping out of water. Eggs started hatching out during the early morning hours on 23.9.1973. The female was removed from the trough immediately after completion of hatching of all the eggs. The sides of the trough was covered by black cloth to ensure uniform distribution of larvae. In order to clear the trough the larvae were attracted to one side by a light from a table lamp after stopping the aeration and the bottom sediments carefully siphoned out. Then half of the water was changed daily with water having a salinity range of 10-12‰ which was prepared by diluting the seawater with chlorine free tap water. Temperature of the medium varied between 25°C to 28°C during the period of experiments. From the third day onwards larvae were fed with freshly hatched out, *Artemia* nauplii. While the individual larvae by each moult metamorphosed to

the next stage, 1st and 2nd zoea took 3 days, zoea III took 2 days, zoea IV and V from 5 to 7 days to develop to the next stage. Zoea VI moulted 2 to 3 times before developing to the next stage, taking 7 to 13 days in the process. There was no significant mortality in the first 2 stages but from stage III onwards mortality was considerable and it occurred during the time of moulting to the next stage. Maximum mortality was observed in zoea VI. None of the larvae survived beyond zoea VII.

Larvae in all stages were preserved in 5% formaldehyde for detailed morphological studies. 5 specimens were examined in each stage for detailed study.

The following abbreviations are used in describing various larval stages:-

Tl—Total length; Cl—Carapace length; A1—Antennule; A2—Antenna; Md—Mandible; Mx1—Maxillule; Mx2—Maxilla; Mxp1—Maxilliped I; Mxp2—Maxilliped II; Mxp3—Maxilliped III; P1—Pereopod I; P2—Pereopod II; P3—Pereopod III; P4—Pereopod IV; P5—Pereopod V; Ur—Uropod; T—Telson.

DESCRIPTION OF LARVAL STAGES

Zoea I (Fig. 1 a to k); Tl 2.37—2.62 mm (2.45 mm*); Cl 0.70—0.74 mm (0.73 mm*).

Rostrum slender and pointed without any tooth; carapace smooth, antero-lateral angle produced to form pterygostomial spine (Fig. 1a); eyes large and sessile; A1, A2, mouth parts and biramous buds of P1 (Fig. 1j) and P2 developed; abdomen 6 segmented; T not demarkated from the last abdominal segment.

A1 (Fig. 1b): uniramous; long, slender and unsegmented, more than 4 times the length of outer flagellum; carrying distally 2 flagella; outer flagellum carries at its apex 3 aesthetes and 2 setae, of which inner seta plumose; inner flagellum long and plumose. A2 (Fig. 1c): biramous; endopod as long as the proximal segment of exopod, bearing at its apex a short spine and one long plumose seta; exopod 5 segmented, proximal segment longest, 9 long plumose setae present along the inner and distal margin of exopod, a short non plumose seta present at the distal outer aspect, 2 short plumose setae present at the lateral outer aspect; peduncle unsegmented. Md (Fig. 1d): almost symmetrical; incisor with 1-2 stout teeth; molar with one small tooth on one side; in between the 2 processes 2 slender teeth present. Mx1 (Fig. 1e): not fully developed; uniramous; endopod with 2 short setae at its distal end; distal and proximal lacinia each with 4 short stout teeth apically. Mx2 (Fig. 1f): exopod with 5 long plumose setae along its margin, of which the outer proximal one being the longest and directed backwards; endopod bearing 2 setae, one apical and another at the basal projection on inner side; protopod with 3 masticatory processes, 2 distal processes each with 3 setae and proximal process with 6 setae. Mxp1 (Fig. 1g): biramous; basipod protuberant, bearing 3 to 5 setae; endopod unsegmented, with 3 apical and 2 lateral setae; exopod more

*Figure in bracket pertains of the mean length.

than twice the length of endopod bearing apically 4 long plumose setae. Mxp2 (Fig. 1h): biramous; basis with a short seta on the inner side; endopod 3 segmented, distal segment with a claw-like seta and 3 short setae, middle segment distally with 2 setae; exopod twice as long as endopod bearing 4 long plumose setae apically. Mxp3 (Fig. 1i): biramous; basipod with one long slender seta on the inner margin, endopod 3 segmented, proximal segment bearing 2 short setae on the inner side,

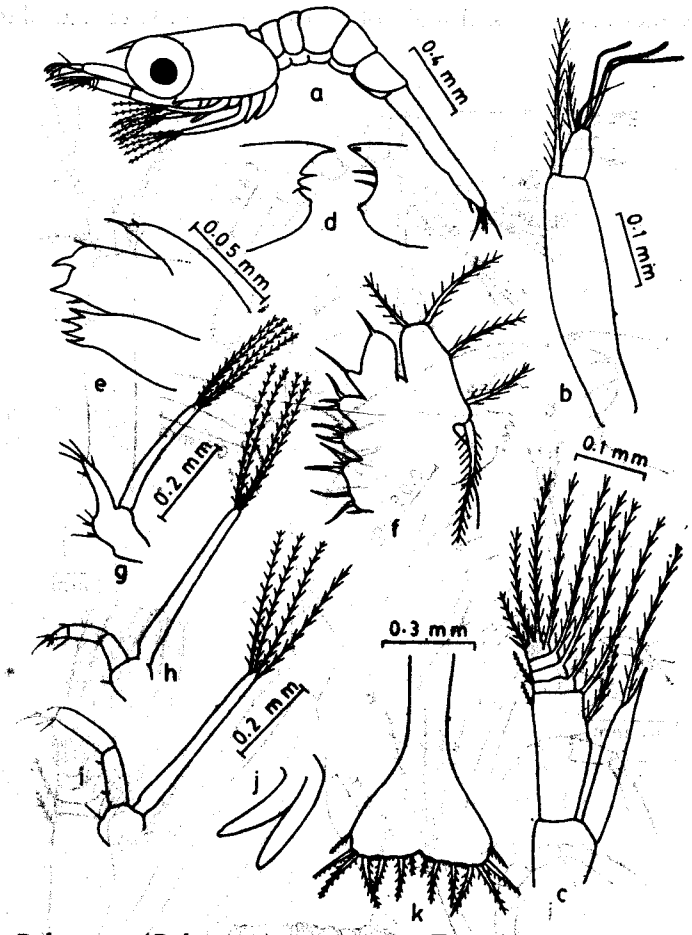

Figure 1. *Palaemon (Palaemon) concinnus*. *Zoea* 1.
a—lateral view; b—A1; c—A2; d—Md; e—Mx1; f—Mx2; g—Mxp1; h—Mxp2; i—Mxp3; j—bud of P1; k—T.

middle segment with 2 slender setae at the distal inner margin, apical segment ends in a claw like seta and a short hair-like seta; exopod longer than endopod bearing 4 long plumose setae at its apex. T (Fig. 1k): broad, concave posteriorly bearing 7 spines on each side, outer 2 distal spine on either side plumose only on the inner side.

Zoea II (Fig. 2a to j; 3 a, b); Tl 2.36—2.46 mm (2.45 mm); Cl 0.71—0.75 mm (0.72 mm).

No appreciable change in Tl; eyes stalked; supraorbital and pterygostomial spines present; Pl and P2 developed (Fig. 2a); T with 8+8 spines (Fig. 2j).

A1 (Fig. 2b): peduncle faintly segmented; 3 short plumose setae seen at the outer aspect of the peduncle at the place of segmentation; distally the peduncle carries 2 flagella and 2 short plumose setae; outer flagellum with 3 aesthetes and one non plumose seta; inner flagella long and plumose. A2 (Fig. 2c): endopod bearing one spine and 3 setae distally of which one seta long and plumose. Md

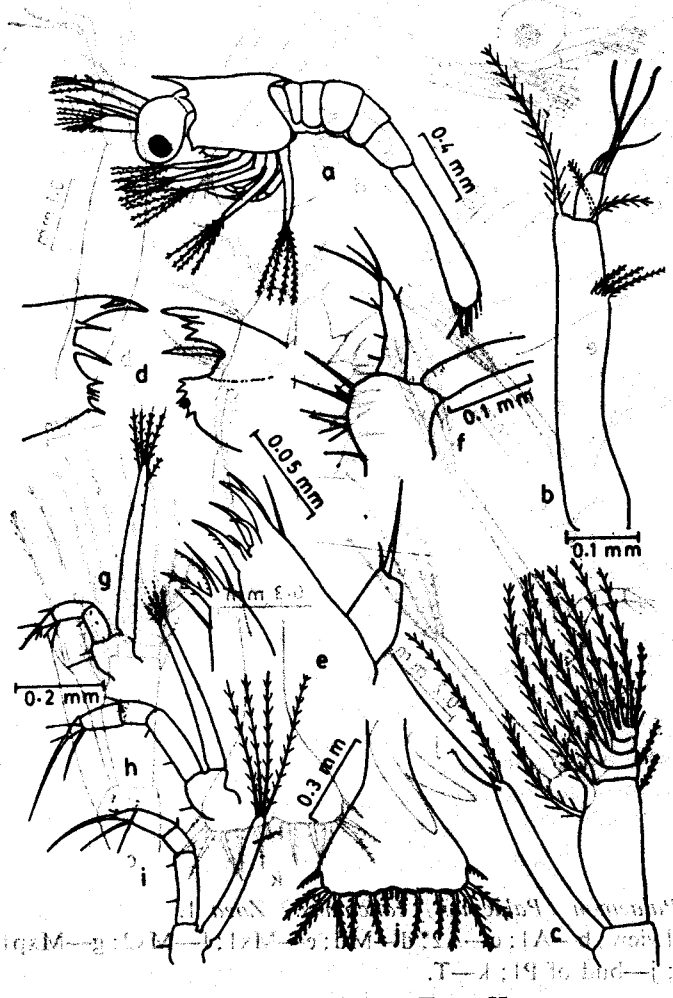

Figure 2. *Palaemon (Palaemon) concinnus. Zoea II*
a—lateral view; b—A1; c—A2; d—Md; e—Mx1; f—Mxp1; g—Mxp2; h—P1; i—P2; j—T.

(Fig. 2d): asymmetrical; incisor on one side with 4 and the other side with 3 stout teeth; molar with a number of short teeth; in between the 2 processes 1 to 2 slender teeth present. Mx1 (Fig. 2e): fully developed; endopod with 2 distal setae of which one is long; distal lacinia with 9 long and stout and 2 short and stout and one slender teeth; proximal lacinia with 5 long teeth of which some are plumose. Mx2 (Fig. 3a):

exopod with 7 plumose seate; basal seta of endopod becomes longer; distal masticatory process of protopod with 3 long and 1 short seta, middle with 2 long setae and proximal process with 4 long and one short setae. Mxp1: basipod with 8 setae along the inner side; endopod unsegmented with 3 apical and 3 to 4 inner lateral and one outer lateral small seate (Fig. 2f). Mxp2 (Fig. 2g): basis with 2 seate on the inner side; proximal segment of endopod with one short inner seta, middle segment distally carries 3 setae; exopod with 4 long apical and 1 short sub apical plumose seta. Mxp3 (Fig. 3b): endopod 4 segmented, distal segment bears

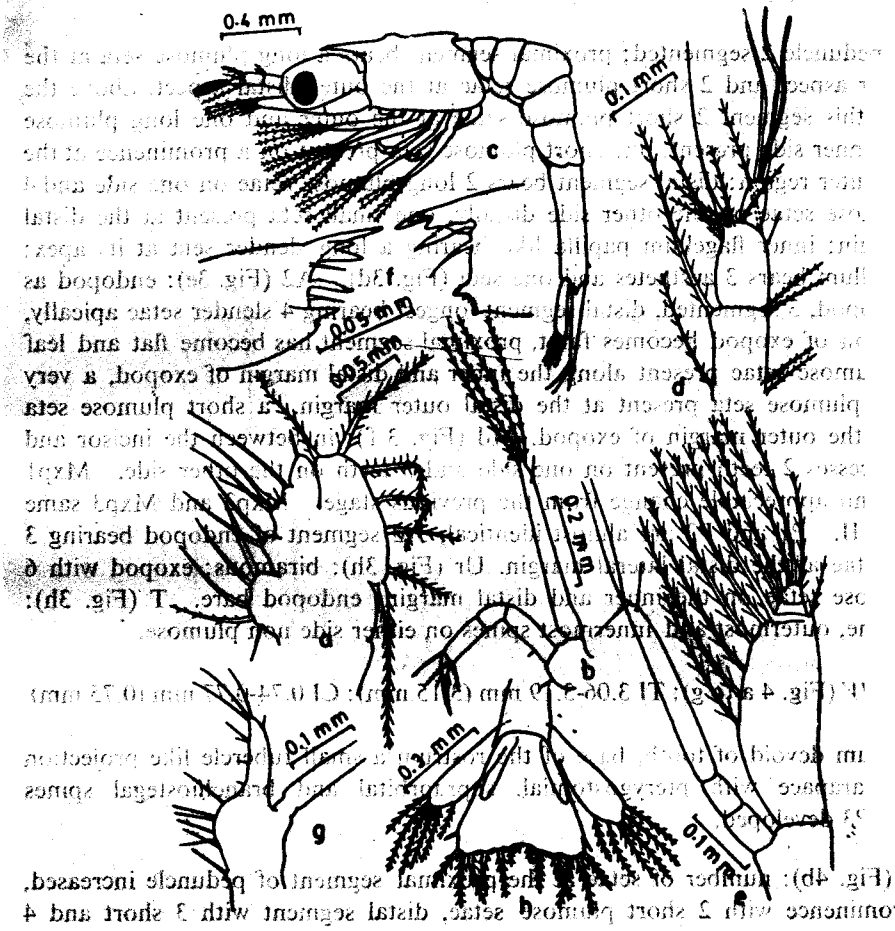

Figure 3. ***Palaemon (Palaemon) concinnus. Zoea II.***
a—Mx2, b—Mxp3. *Zoea III*. c—Lateral view, d—anterior part of A1, e—A2, f—Md, g—basipod and endopod of Mxp1, h—Ur and T.

2 short setae and one claw like seta which is serrated, 3rd segment distally carries 3 serrated setae, exopod with 4 long plumose apical and one short sub apical seta, P2 and P3 (Fig. 2h, i): identical; basipod with one seta at the inner side; and oblique segmented 1st segment with 2 setae on the inner side, 2nd with one seta on the outer distal margin. 3rd carries 2 long setae at the inner distal margin, terminal segment

with 1-2 short setae and one long seta which is more than half the length of the endopod; exopod as long as endopod bearing 4 long plumose setae apically and one short sub apical seta. T (Fig. 2 j): 8 spines on each side, innermost spine on both sides non plumose, outer most spine on either side plumose only on the inner side.

Zoea III (Fig. 3 c to h); TI 2.65-2.95 mm (2.82 mm); CI 0.73-0.78 mm (0.76 mm).

Biramous buds of P3 developed; T demarkated from last abdominal segment by an articulating joint; Ur developed (Fig. 3 c,h).

A1: peduncle 2 segmented; proximal segment bears a long plumose seta at the distal inner aspect and 2 short plumose setae at the outer distal aspect, above the middle of this segment 2 short plumose setae at the outer and one long plumose seta at its inner side present, one short plumose seta present on a prominence at the proximal outer region; distal segment bears 2 long plumose setae on one side and 4 short plumose setae on the other side distally, one small seta present at the distal outer margin; inner flagellum papilla like bearing a long slender seta at its apex; outer flagellum bears 3 aesthetes and one seta (Fig. 3d). A2 (Fig. 3e): endopod as long as exopod, 3 segmented, distal segment longest bearing 4 slender setae apically, segmentation of exopod becomes faint, proximal segment has become flat and leaf like, 11 plumose setae present along the inner and distal margin of exopod, a very small non plumose seta present at the distal outer margin, a short plumose seta present at the outer margin of exopod. Md (Fig. 3 f): in between the incisor and molar processes 2 teeth present on one side and 3 teeth on the other side. Mxp1 (Fig. 3g): no appreciable change from the previous stage. Mxp2 and Mxp3 same as in zoea II. P1 and P2 are almost identical, 3rd segment of endopod bearing 3 serrated setae at the distal lateral margin. Ur (Fig. 3h): biramous; exopod with 6 long plumose setae on the inner and distal margin, endopod bare. T (Fig. 3h): 8 + 8 spine, outermost and innermost spines on either side non plumose.

Zoea IV (Fig. 4 a to g); TI 3.06-3.19 mm (3.15 mm); CI 0.74-0.77 mm (0.75 mm).

Rostrum devoid of tooth, base of the rostrum a small tubercle like projection present; carapace with pterygostomial, supraorbital and branchiostegal spines (Fig. 4a); P3 developed.

A1 (Fig. 4b): number of setae at the proximal segment of peduncle increased, basal prominence with 2 short plumose setae, distal segment with 3 short and 4 long plumose setae at the distal aspect; outer flagellum with 3 aesthetes and one seta. A2 (Fig. 4 c): exopod unsegmented, bearing 14 plumose setae along its inner and distal margin, distally the outer margin of exopod is produced to form a spine, in some specimens a non plumose short seta is observed in between the last and penultimate setae at the distal margin. Md: in between the incisor and molar processes 3 teeth are present. Mx1 no appreciable change from the previous stage. Mx2: no appreciable change from the previous stage except the setae on the middle and proximal mastimatory processes become plumose; terminal short seta of endopod has also become plumose. Mxp1: exopod with 4 plumose apical and one short subapical seta. Mxp2 (Fig. 4d): basis with 3 setae on the inner side of

which middle one long and slender. Mxp3: basipod with 2 setae on the inner side, distal segment of endopod carrying 3 short setae and a serrated claw like seta distally. P1 and P2 same as in the previous stage. P3 (Fig. 4e): biramous; basipod with 1 short seta on the inner margin; endopod 4 segmented, 1st segment with 1 seta on the inner margin, 2nd segment with one seta on the outer distolateral margin, 3rd segment with 2 long setae at the distolateral margin on the inner side, terminal segment with 2 short seta and one long claw like seta; exopod shorter than endopod

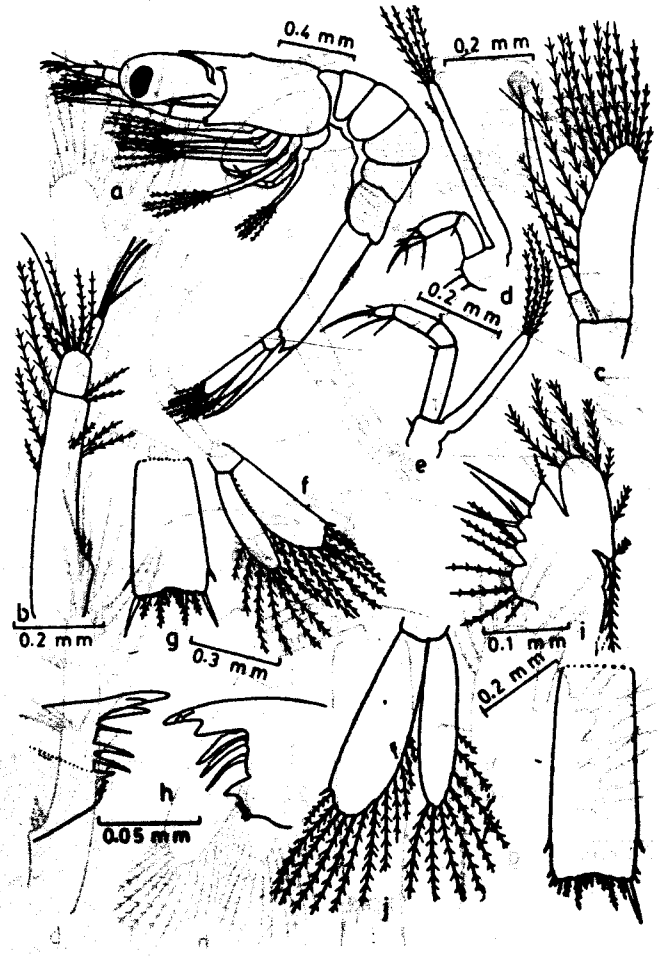

Figure 4. *Palaemon (Palaemon) concinnus. Zoea IV.*
a—lateral view; b—A1; c—A2; d—Mxp2; e—p3; f—Ur; g—T. *Zoea VI*
h—Md; i—Mxp2; j—Ur; k—T.

bearing 4 long plumose setae apically. Ur (Fig. 4f): exopod with 10 long plumose setae along its inner and distal margin and one distolateral spine on the outer margin, endopod with 7 long plumose setae. T (Fig. 4g) narrower than in the previous stage, carrying one lateral and 5 terminal spines on either side, inner and 2 outer spines on both sides non plumose.

Zoea V (Fig. 4 h to k; 5 a to d); TI 2.88-3.21 mm (3.05 mm); CI 0.74-0.78 mm (0.75 mm).

P5 developed; bud of P4 developed (Fig. 5 a); T almost rectangular (Fig. 4 k).

A1 (Fig. 5 b); 3 short setae present on the distal prominence of the proximal segment of peduncle, a circlet of short plumose setae developed at about 2/3rd distal distance from the bottom of this segment; distal segment bears 5 long plumose setae on one side and 4 short plumose setae on a prominence on the other side at

Figure 5. *Palaemon (Palaemon) concinnus*. *Zoea V*.
a—lateral view; b—A1; c—A2; d—P5. *Zoea VI*. e—Md; f—Mx1; g—Mx2; h—Ur; i—T.

the proximal region; inner flagellum reaching $\frac{1}{2}$ the length of outer, and bearing long slender seta at its apex; outer flagellum bearing 3 aesthetes at its apex. A2 (Fig. 5c); endopod 4 segmented, of which the distal one is the longest, bearing 6 slender non plumose setae at its apex; exopod with 16 plumose setae and 1 spine,

Md (Fig. 4 h); and Mx1 without much change from the previous stage. Mx2 (Fig. 4 i): exopod with 8 plumose setae. No change in Mxp1, Mxp2, Mxp3, P1 and P2. P3: basipod with 2 short setae; 1st segment of endopod with 2 short setae on the inner side, exopod with 4 long plumose apical and 1 short sub apical seta. P5 (Fig. 5 d): uniramous; basipod with 1 short seta on the inner side; endopod 4 segmented, 3rd segment with 2 short setae distolaterally, distal segment ends in a long claw like seta. Ur (Fig. 4 j): exopod with 11 to 12 long plumose setae and 1 spine and endopod with 8 long plumose setae. T (Fig. 4 k): almost rectangular, 3 lateral and 5 terminal spines on either side, of the 5 terminal spines the inner and outer are non plumose.

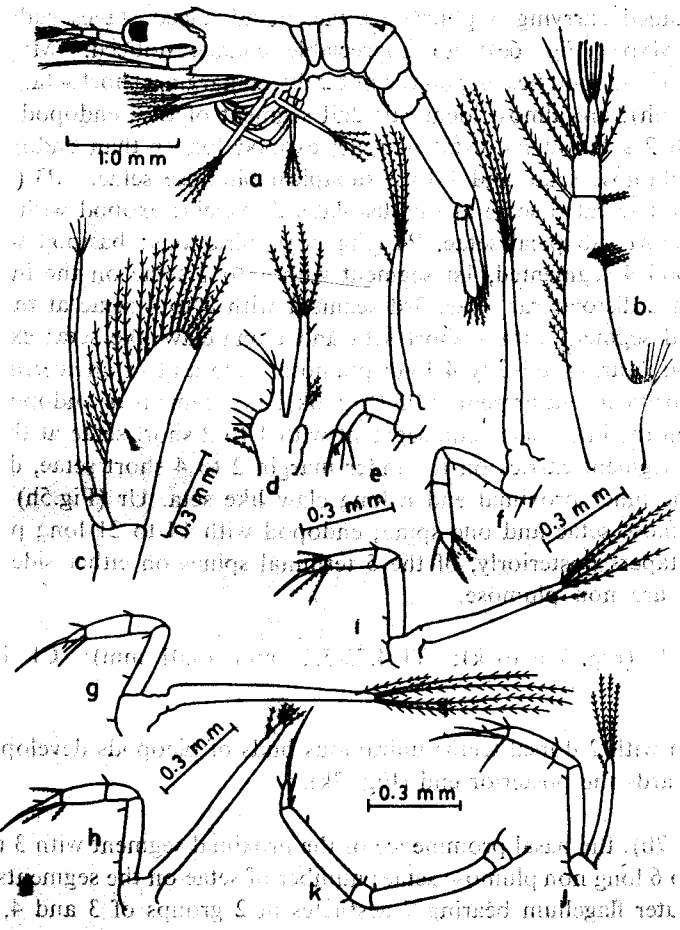

Figure 6. ***Palaemon (Palaemon) concinnus. Zoea VI.***
a—lateral view; b—A1; c—A2; d—Mxp1; e—Mxp2; f—Mxp3; g—P1; h—P2; i—P3; j—P4; k—P5.

Zoea VI **(Fig. 5 e to i; 6 a to k); TI 3.62-3.83 mm (3.73 mm); CI 0.82-0.92 mm (0.88 mm).**

Rostrum with a dorsal tooth; P4 developed; (Fig. 6a).

AI (Fig. 6b): the prominence at the outer distal aspect of distal segment of peduncle bears 4 short plumose setae and 3 to 5 long slender non plumose setae, inner side bears 6 to 10 plumose setae and the number of setae forming a circlet in the distal segment increased; inner and outer flagellum are of equal size; outer flagellum bears 3 to 4 aesthetes and 1 seta and inner flagellum with 2 non plumose setae. A2 (Fig. 6c): endopod 5 segmented apically bearing 5 to 6 short slender non plumose setae; exopod leaf like bearing 19 to 24 plumose setae and one spine. Md (Fig. 5e): in between the incisor and molar processes 4 teeth are present on one side and 4 to 5 on the other side. Mx1 (Fig. 5f): endopod with 3 setae apically of which one is long; distal lacinia with 8 teeth and proximal lacinia with 7 teeth. Mx2 (Fig. 5g): exopod with 11 to 14 plumose setae. Mxp1 (Fig. 6d): base of exopod slightly expanded carrying 3 plumose setae, in advanced stages rudiments of gill developed. Mxp2 (Fig. 6e): no appreciable change noticed. Mxp3 (Fig. 6f): 2nd segment of endopod bearing on the outer distal margin a short seta. P1 (Fig. 6g); and P2 (Fig. 6h): are almost identical; 2nd segment of the endopod of advanced zoea VI with 2 setae at its distal margin; exopod longer than endopod bearing 4 long apical plumose setae and 1 to 3 subapical plumose setae. P3 (Fig. 6 i): 3rd segment with 4 serrated setae at the distolateral margin; exopod with 4 long apical and 1 to 2 short subapical setae. P4 (Fig. 6 j): biramous; basipod with 1-2 short setae; endopod 4 segmented, 1st segment with 1 to 2 setae on the inner side, 2nd segment with 2 distolateral setae, 3rd segment with 3 to 4 setae at the distolateral margin, distal segment with 1 short seta and a long claw like seta; exopod shorter than endopod bearing apically 4 long plumose setae and in advanced stage larvae one short subapical seta present. P5 (Fig. 6k): 1st segment of endopod with 1 to 2 short setae on the inner side; 2nd segment with 1 to 2 short setae at the distolateral margin; 3rd segment carries on the inner margin 2 to 4 short setae, distal segment carries on the inner proximal end a long claw like seta. Ur (Fig.5h): exopod with 17 to 21 plumose setae and one spine; endopod with 14 to 21 long plumose setae. T (Fig. 5 i): tapers posteriorly, of the 5 terminal spines on either side, inner and 2 outer spines are non plumose.

Zoea VII (Fig. 7 a to k); TI 4.75-5.26 mm (5.01 mm); CI 1.18-1.31 mm (1.23 mm).

Rostrum with 2 dorsal teeth; uniramous buds of pleopods developed (Fig. 7a); T tapers towards the posterior end (Fig. 7k).

AI (Fig. 7b): the basal prominence of the proximal segment with 3 to 4 plumose setae and 5 to 6 long non plumose setae; number of setae on the segments of peduncle increased; outer flagellum bearing 7 aesthetes in 2 groups of 3 and 4, distally this flagellum bears 2 to 3 long slender setae; inner flagellum as long as outer, bearing at its apex 3 slender non plumose setae. A2 (Fig. 7c): endopod longer than exopod, 5 to 8 segmented, apical segment bearing 5 short non plumose slender setae; exopod bearing 28 to 29 plumose setae and 1 spine. Md (Fig. 7 d): 5 to 7 teeth on one side and 5 to 6 teeth on the other side in between incisor and molar processes. No change in Mx1. Mx2 (Fig. 7e): exopod with 18 to 21 plumose setae. Mxp1 (Fig. 7 f): base of exopod slightly expanded bearing 3 to 4 plumose setae on the outer margin. Mxp3 (Fig. 7g): 2nd segment of endopod with 2 setae distally and

3rd segment with 4 setae. P1 (Fig. 7h): 3rd segment of endopod with 4 setae along its distal lateral margin. P3: 2nd segment of endopod sometimes with 3 distolateral setae; exopod with 4 long plumose setae apically and 2 to 3 subapical setae. P4 (Fig. 7i): and P5 (Fig. 7 j): without much appreciable change from the previous stage. Ur: exopod with 26 to 28 plumose setae and one spine; endopod with 26 to 27 long plumose setae. T (Fig. 7 k): tapers posteriorly, convex at the distal region bearing 3 pairs of lateral and 5 pairs of terminal setae.

Figure 7. *Palaemon (Palaemon) concinnus. Zoea VII.*
a—lateral view; b—A1; c—A2; d—Md; e—Mx2; f—Mxp1; g—Mxp3; h—P1; i—P4; j—P5; k—T.

DISCUSSION

The sequence of development of pereopods in *Palaemon (Palaemon) concinnus* closely resembles that of *Macrobrachium rosenbergii* (Ling, 1969; Uno and Kwon, 1969); *M. nipponense* (Kwon and Uno, 1969); *M. idella* (Pillai and Mohamed, 1973); *Palaemon macrodactylus* (Georgiandra Little, 1969); *Leptocarpus potamiscus* (Pillai,

1973); *Leandrites celebensis* (Pillai, 1973). In all these species P1 and P2 develop in zoea II and P3 and P5 in the subsequent stage, P4 being the last one to develop among the pereopods. But in *Palaemon elegans* (Tsurnamal, 1963) first four pereopods develop in zoea II and P5 is developed later. In all these species a minimum of three stages were observed between the stages after the development of the uniramous bud of pleopods and postlarva I. In the present species uniramous buds of pleopods are developed in zoea VII, and as such a minimum of three more zoeal stages could be expected before the larvae develop to postlarva I.

A reduction in length of rostrum was observed from zoea IV onwards and in zoea VII it reaches only to ½ the length of eye. This indicates that the short nature of rostrum becomes apparent in zoeal stages and continues in the young specimens which according to Holthuis (1950) differ from the older by having shorter rostrum. Such a reduction in length of rostrum is not seen in *Palaemon (Palaender) semmelinkii* (Jagadisha and Sankolli, 1977).

The basal lobe of endopod of Mx2 in *Macrobrachium* sp. (Ling, 1969; Kwon and Uno, 1969; Uno and Kwon 1969; Pillai and Mohamed, 1973); *Leander* sp. (Gurney, 1942); *Leptocarpus* sp. (Pillai, 1973); *Palaemon* sp. (Tsurnamal, 1963; Pillai, 1966; Georgiandra Little, 1969); *Palaemonetes* sp. (Hubschman and Broad, 1974) ; *Palaemon (Palaender) semmelinkii* (Jagadisha and Sankolli, 1977) carry 2 setae. But in all the zoeal stages of the present species there is only a single seta, in which character it agrees with the zoea of *Periclimenes* sp. (Gurney, 1942; Pillai, 1950; Pillai, 1955).

From the second zoea onwards in all the zoeal stages of *Macrobrachium* sp. (Ling, 1969; Kwon and Uno, 1969; Uno and Kwon, 1969; Pillai and Mohamed, 1973); *Leptocarpus* sp. (Pillai, 1973); *Leandrites* sp. (Pillai, 1974); *Leander* sp. (Gurney, 1942); *Periclimenes* sp. (Gurney, 1942; Pillai, 1955); *Palaemon* sp. (Tsurnamal, 1963; Georgiandra Little, 1969); *Palaemon (Palaender) semmelinkii* (Jagadisha and Sankolli, 1977) a prominent lateral spine was observed on the 5th abdominal segment. This spine is absent in all zoeal stages of the present species. In *Palaemon tenuipes* (Pillai, 1966) also this spine is absent. This feature does not seem to be a diagnostic character of the larvae of species of *Palaemon* since some species possess this spine (Tsurnamal, 1963; Georgiandra Little, 1969) while others including the present species do not have the spine (Pillai, 1966).

ACKNOWLEDGEMENT

The author is grateful to Dr. E. G. Silas, Director, Central Marine Fisheries Research Institute, Cochin for his keen interest in this work and the encouragements and to Dr. M. J. George, Shri K. H. Mohamed and Dr. P. Yedavyasa Rao for their guidance and for going through the manuscript and giving helpful suggestions. He is also grateful to Miss S. Lakshmi for her assistance in the collection of literature.

REFERENCES

DUTT, S. AND K. RAVINDRANATH. 1974. A new record for *Palaemon (Palaemon) concinnus* Dana, 1852 (Decapoda, Palaemonidae), from India. *Curr. Sci.*, 43: 123-124.

GEORGIANDRA LITTLE. 1969. The larval development of the shrimp, *Palaemon macrodactylus* Rathbun reared in the laboratory and the effect of eye stalk extirpation on development. *Crustaceana,* **17:** 69–87.

GURNEY, R. 1942. *Larvae of decapod crustacea. Ray. Sco. Lon.,* 1–306.

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

HUBSCHMAN, J. H. AND A. C. BROAD. 1974. The larval development of *Palaemonetes intermedius* Holthuis, 1949 (Decapoda, Palaemonidae) reared in the laboratory. *Crustaceana,* **26:** 89–103.

JAGADISHA, K. AND K. N. SANKOLLI 1977. Laboratory culture of the prawn, *Palaemon (Palaender) semmelinkii* (de Man) (Crustacea, Decapoda, Palaemonidae). Proc. Symp. Warm Water Zoopl., UNESCO/NIO. 619-633.

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

LING, S. W. 1969. The general biology and development of *Macrobrachium rosenbergii* (de Man). *FAO. Fish. Rep.,* (57) **3:** 589–606.

PILLAI, N. K. 1950. The larval stages of *Periclimenes (Ancylocaris) grandis* Stimson. *Bull. Res. Inst. Univ. Kerala Ser.,* C **1:** 27–45.

PILLAI, N. K. 1955. Pelagic crustacea of Travancore. 1. Decapod larvae. *Bull. Res. Inst. Univ. Kerala Ser.,* C.**4:** 48–101.

PILLAI, N. N. 1973. Larval development and rearing of the brackish water shrimp *Leptocarpus potamiscus* (Kemp, 1917) (Decapoda, Palaemonidae). *J. mar. biol. Ass. India,* **15:** 669–684.

PILLAI, N. N. 1974. Larval development of *Leandrites celebensis* (De Man) (Decapoda: Palaemonidae), reared in the laboratory. *J. mar. biol. Ass. India,* **16:** 708–820.

PILLAI, N. N. AND K. H. MOHAMED. 1973. Larval history of *Macrobrachium idella* (Hilgendorf) reared in the laboratory. *J. mar. biol. Ass. India,* **15:** 359–385

PILLAI, S. VENUGOPALA. 1966. Early development and larval stages of *Palaemon tenuipes* (Henderson) *J. mar. biol. Ass. India,* **8:** 329–338.

TSURNAMAL, M. 1963. Larval development of the prawn *Palaemon elegance* Rathke (Crustacea, Decapoda) from the coast of Israel. *Israel. J. Zool.,* **12:** 117–141.

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