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Embryonic development of larvae on the pleopods of the spiny lobster *Panulirus polyphagus* (Herbst) and the sand lobster *Thenus orientalis* (Lund) from Bombay waters

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ABSTRACT

Development of laivae to phyllosoma stage while still on the pleopods in the spiny lobster *Panulirus polyphagus* (Herbsc)and the sand lobster *Thenus orientalis* (Lund)was studied. Growth of the larvae at the time of hatching appeared more in the natural habitat than in the aquarium in both the species. The larvae hatched were in phyllosoma stage and not in naupliosoma orprephyllosoma stage. Differences described in phyllosoma larvae of P. *polyphagus* and *T. orientalis* here may help in their identification.

Investigations on the early larval stages of various species of spiny and sand lobsters were carried out by various workers by allowing them to hatch in aquaria. Gilchrist (1913, 1916) discovered the earliest free-swimming stage called naupliosoma, which moulted into first stage phyllosoma within 4-6 hours, in the spiny lobster *Jasus lalandii.* In the same species von Bonde (19:56) recorded an earlier stage called prenaupliosoma moulting into naupliosoma. Feliciano (1956) noticed prenaupliosoma stage within the egg in *Panulirus argus.* This was followed by many hatching experiments in the aqjaria. Prasad and Tampi (1957, 1959), Sims (1965) and Ong (1967) reported about the laivae hatching into phyllosoma stage I in different species of spiny and sand lobsters but Deshmukh (1968) observed emergence of prephyllosoma in *P. polyphagus.* Naupliosoma hatching into phyllosoma stage I was observed in *Scyllarusacquinoctialis* (Robertson 1969) whereas only phyllosoma stage I was observed in *Scyllarus americanus, S. depressus* and 5. *planorbi* by Robertson in 1968, 1971 and 1979 respectively. Lesser (1974) found the larvae released as both naupliosoma and phyllosoma stage I in *Ibacus alticarinatus.*

This study has shown some additional characters from those described by Ong (1967) and Deshmukh (1968) in the larvae of P. *polyphagus* and by Prasad and Tampi (1957) in *T. orientalis* larvae. Hence, both the larvae have been described here again .

MATERIALS AND METHODS

Ovigerous females of *P. polyphagus* were encountered in the trawler landings round the year and of *T. orientalis* between September and March at the landing centres New Ferry Wharf and Sassoon dock in Bombay. As the embryos develop, the colour of the eggs on

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the pleopods changes from brick-red to yellow, then cream and finally dirty grey in the former and yellow to cream and then dirty grey in the latter. Pleopods bearing embryos in the final dirty grey condition from several specimens of each of the 2 species were collected during 1985-87 and preserved in 10% formalin for microscopic examination.

RESULTS AND DISCUSSION

Panulirus polyphagus

The fertilized eggs on the pleopods were brick-red and almost spherical measuring about 0.6 - 0.7 mm in diameter in the beginning. Each egg was attached by its funiculus to the central stalk which was firmly attached to the bristles on the endopodite of the pleopod (Fig. 1 a). At this stage the space between the inner homogeneous egg content and the outer chitinous capsule was wider. As the embryo developed, this gap gradually got filled up.

With the initiation of development, the eggs turned transparent and the eyes appeared like specks under the microscope. The egg of about 0.8 mm diameter had unorganized eyes in the form of brown pigments. There were 2 lateral eyes and a small, faint and brown median eye. An egg measuring 1.5 mm possessed some appendages (Fig. 1 b) embedded in the heavy yolky mass.

In the next stage the embryo was about 1.8 mm, the eyes were prominent and clear in the form of dots. When it was opened and seen under the microscope the eyes looked organized and crescent shaped (Fig. 1 c). The corneal facets developed in all the 3 eyes. Body of the embryo was bent and the appendages were folded around passing from the space in between the eyes. Yolk was still abundant in the cephalic region and embedded in it were the developing delicate cephalic appendages, mouth parts, 3 pairs of thoracic appendages and abdomen.

As the growth advanced, the egg shell splitted and the embryo became free. At this stage the embryo clung to the shell, which was still attached to the central suilk through its funiculus, by means of its appendages.

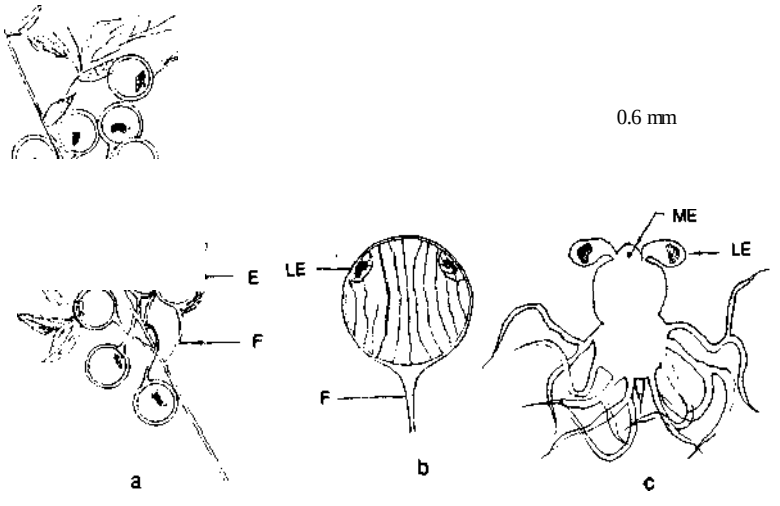

Fig. 1. *Panulirus polyphagus.* a. Eggs attached lo the bristles in the pleopod. b. Impressions of appendages appearing in between lateral eyes of the embryo, c. Embryo after opening the egg. E, Egg; E, funiculus; ME, median eye; I .E. lateral eye.

Fig. 2.Phyllosc. *palyphagux.*

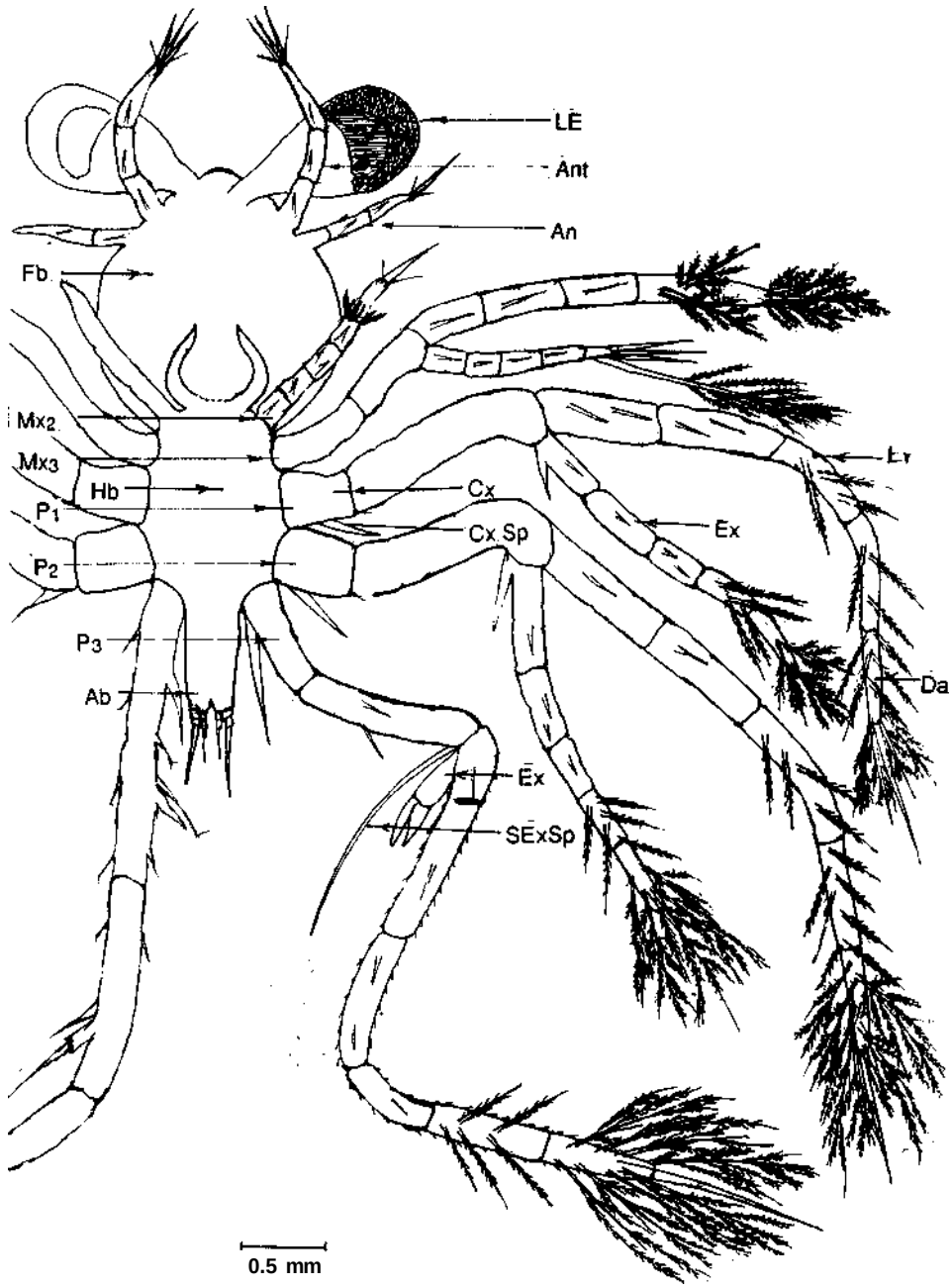

Fig.3. Fully grown phyllosoma on the pleopod *of Panulirus polyphagus.* Fb, Fore body; Hb, hind body; Ab, abdomen; LE, lateral eye; An, antenna; Ant, antennule; Mx^, second maxiUiped; Mx_5, third maxiUiped; P_p first pereiopod; P_2, second pereiopod; P_3, third pereiopod; Cx, coxopodite; En, endopodite; Ex, exopodile; D, daclylopodiie; Cx Sp, coxal spine; SEx Sp, subexopodal spine.

First maxilla situated behind the mandible was biramous and without a palp (Fig. 4 b). Each ramus was provided with 3 long sharp masticatory spines, which were without seta. Some of such spines were setose in *Jasus edwardsii* (Lesser 1973).

Second maxilla was 2 segmented and had 4 long plumose seiae emerging from the small distal segment (Fig. 4 c).

First maxilliped was small and 2 jointed, the basal one being broad and shield shaped (Fig. 4 d) on the inner side of which 3 small setae were present. From the outer margin at the joint, 2 and from the inner margin of the distal smaller structure, 3 long pointed setae were given out. Deshmukh (1968) described it in the phyllosoma stage I of the same species as a small, simple protuberance with a terminal short seta. Second maxilliped (Mx_2) was uniramous and 5 jointei (Fig. 3). Its terminal segment bore a prolonged spine with 2 setae at its base. The joint of the 4th and 5th segments was encircled by a number of setae. There was a single long seta from the second segment.

Fig. 4. Moulh appendages cf phyllosoma of *Panulirus polyphagia,* a, Mandible; b, first maxilla; c, second maxilla; d, first maxilliped.

Third maxilliped (Mx_3) was biramous witha well developedbut much smaller exopodite than the endopodite (Fig. 3). The endopodite was 5 segmented with setae in the last 2 segments. At the distal end of the last segment 3 long and on the body of 4th segment innumerable sufficiently long plumose natatory setae were present. The exopodile was 5 jointed with 3 aesthetascs and a long plumose natatory seta at the distal end. The last segment was also covered with a number of long plumose natatory setae. Deshmukh (1968) did notrefertothcendopoditeof3rd maxilliped in phyllosoma stage I.

First pereiopod (P_1) was biramous with a well-developed exopodite which was slightly shorter than the endopodite (Fig. 3). Both these podites were segmented. A coxal spine emerged from the Coxopodite. Endopodite was 5 segmented and ended in a long spine. A few scattered setae were present on the first 2 segments. The remaining 3 segments were beset with a number of long plumose seme, maximum being on thedactylopodite. Exopodite was slightly thinner than the endopodite. Distal end of it bofe an uncountable cluster of plumose natatory setae whereas Deshmukh (1968) reportedonly 5_0pairs of these setae. At the base of the exopodite there was a prominent subexopodal spine.

Second pereiopod,(P_2) was identical to the first but for some minor differences. The dactylopodite of the endopodite was longer (Fig. 3) and the plumose natatory setae on both the rami were more than on the rami of the first pereiopod.

Third pereiopod (P_3), also biramous (Fig. 3), had a very small exopodile. Coxal spine was very long. Endopodite wns 5 segmented and its dactylopodite ended in a long spine. The base of the spine was encircled by innumerable longplumose natatory setae. Through-

out the length of the endopodite, at intervals, long setae were present. Along both the margins of the endopodite small setae were uniformly spread. The small exopodite had a pointed bifid tip. The subexopodal spine coming out from the base of exopodite was longer than the exopodite itself. Deshmukh (1968) did not mention anything about the innumerable plumose natatory setae and other long and short setae on this pereiopod.

Abdomen (Ab) was small and unsegmented with sides running parallel to each other (Fig. 3). Its posterior margin was bifid and each of it bore 2 long spines.

Thenus orientalis

The eggs of *T. orientalis* attached to the pleopods were cream coloured, round and about 1.1 mm in diameter. The attachment of the eggs to the pleopods, development of lateral and median eyes and em bedding of the appendages in the yolky mass between the lateral eyes, were all similar to *P. polyphagus.* Fully grown embryos (Fig. 5) measured 2.8-3.1 mm in length and possessed cephalic region with cephalic appendages, mouth parts and 5 pairs of thoracic appendages, and also small abdomen.

The forebody was sub circular and broader than the hind body which was almost circular. The abdomen was nearly half the length of the hind body.

The lateral eyes (LE) were longer than the antennules, each having a long, fairly thick and unsegmented stalk. The antennule (Ant) was segmented and had a lateral process towards the base. Both the antennules and their lateral processes terminated in 3 setae. Prasad and Tampi (1957) described the antennule in phyllosoma stage I of aquarium-hatched eggs of *T. orienialis* as long, slender and unsegmented with 3 terminal spines and a short spine a little above the middle of its length. In phyllosoma stage II, they noticed an indication of segmentation at the starting point of the spine while in stage III, the antennule was observed unsegmented and the short spine got enlarged intoadiverticulum. This study showed that this diverticulum is nothing but the lateral process.

The antenna (An) was short, segmented and less than half the length of antennule. It ended with segmented and pointed setae. According to Prasad and Tampi (1957) the antenna was unsegmented.

Mandibles in *T. orientalis* (Fig. 6 a) were similar to those in *P. polyphagus* in all respects.

First maxilla was biramous with masticatory spines (Fig. 6 b). The anterior ramus had 4 and the posterior 5 setose spines. Prasad and Tampi (1957) did not mention abou^ this mouth appendage even upto phyllosoma stage IV.

Second maxilla observed by Johnson (1971) and Prasad and Tampi (1957) could not be traced during this investigation.

First maxilliped was short stump like protuberance with 3 setae at the tip (Fig.6 c). Prasad and Tampi (1957) mentioned it only in phyllosoma stage III but did not refer to any seta on it.

Second maxilliped was uniramous, 5 jointed and the terminal segment ended in a spine (Fig. 6 d). Setae were present in the third, fourth and fifth segments. This was similar to the one described by Prasad and Tampi (1957) in phyllosoma stage I.

Third maxilliped (Mx_3) was very long uniramous and 5 segmented (Fig. 5). Dactylus had 3 plumose setae and third and fourth segment had a number of plumose setae. Coxal spine observed by Prasad and Tampi (1957) could not be noticed.

First 3 pereiopods (P_v P_2, P_3) were biramous with coxal spines (Fig. 5). The last segment of the endopodite was long and terminated in a long spine. Many plumose setae were present on the last 3 segments. Small non-plumose setae were scattered on

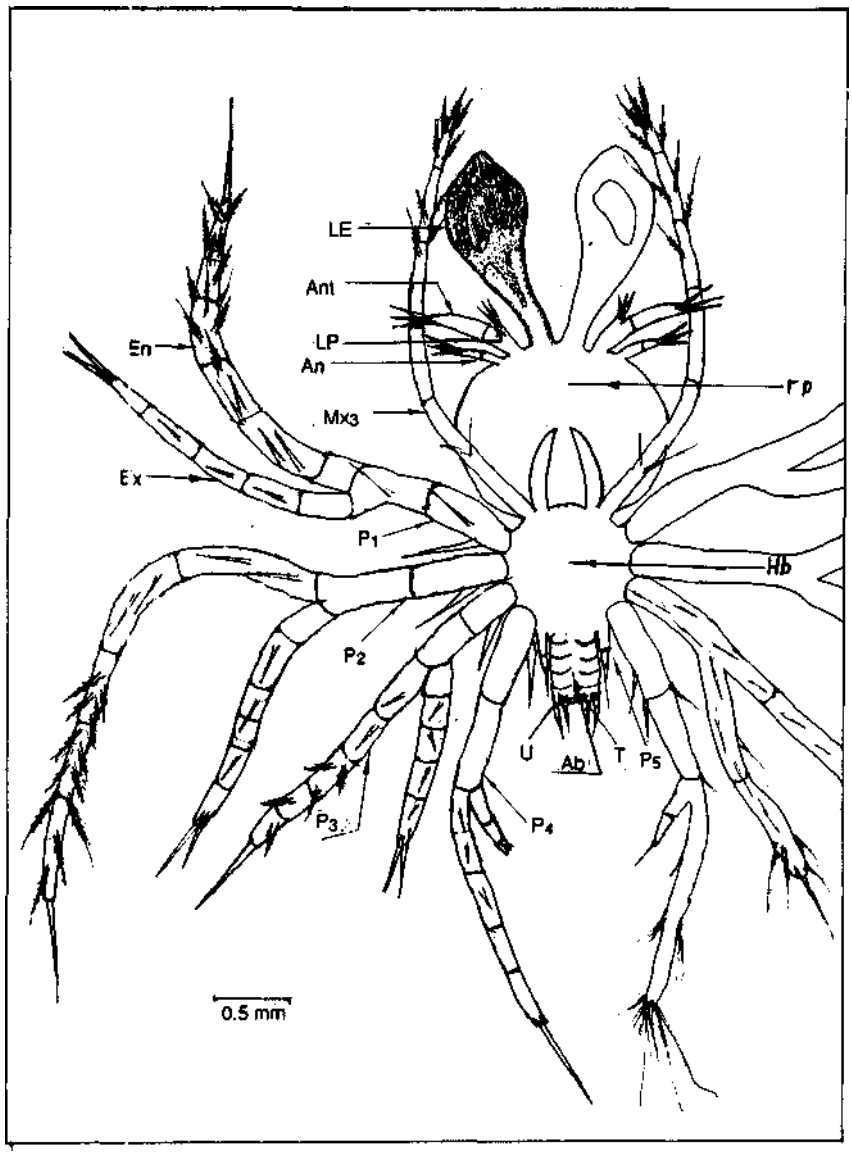

Fig. 5. Fully grown pliyllosoma on the pleopod of *Thenus orienlalis.* Lp, lateral process; P_4, fourth pcreiopod; P,, fifth pereioped; U, uropod; T, telson (for other abbreviations see Fig. 3).

the first 2 segments. The exopodite was shorter than the endopcdite and terminated in 2 spines. AccordingtoPrasadandTampi(1957), the exopodite had well developed natatory setae which however, could not be noticed in this study.

Fourth pereiopod (P_4) was also biramous with a coxal spine. The long endopodite ended in a spine. Though the first 2 segments of it were devoid of setae, a few long and simple setae were found scattered on the last 3 segments. The exopodite was comparatively very

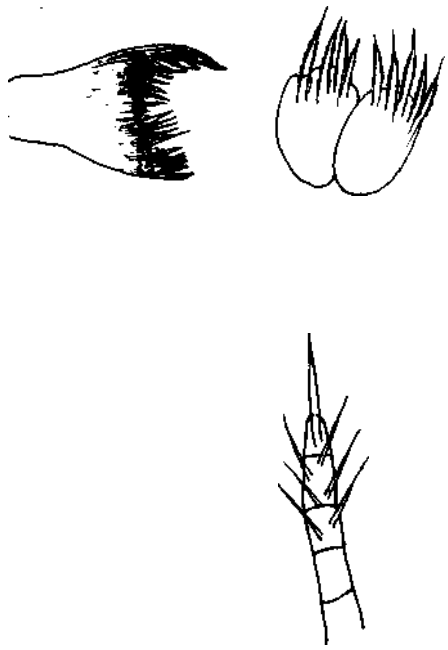

Fig. 6. Mouth appendages of phyllosoma of *Thenus orienlalis*. a, Mandible; b, first maxilla; c, first maxilliped; d, second maxilliped.

small, 2 segmented and ended in 2 small protuberances. However, according to Prasad and Tampi (1957) the fourth pereiopod was uniramous in phyllosoma stage I and became biramous in phyllosoma stage II when the exopodite appeared as an unsegmented rudiment.

Fifth pereiopod (P_5) was small, uniramous reaching upto the end of the abdomen. It was 3 segmented, broad at the base and terminated into a spine. Prasad and Tampi (1957) made first reference to its segmentation only in phyllosoma stage IV.

Abdomen (Ab) was segmented (Fig. 5). Telson was round and medially situated. Uropods were biramous and had 2 bristles. Prasad and Tampi (1957) noticed the indications of segmentation of abdomen in phyllosoma stage IV only.

It was observed in this study that the development of larvae in both *P. polyphagias* and *T. orientalis*, while still attached to the pleopods, was more advanced than that of the aquarium-hatched larvae described by Deshmukh (1968) in phyllosoma stage I and by Prasad and Tampi (1957) in phyllosoma stage I-IV respectively. The differences observed are given in Tables 1 and 2. Further, differences noticed between these 2 species in phyllosoma stage I are given in Table 3. These may help in the identification and fixing of species in the plankton samples.

Table 1. Differences with the findings of Deshmukh (1967) observed in the larvae of *Panulirus polypnagus*

Deshmukh (1967)	Present findings
1. Antennule and antenna unsegmented and smooth	Antennule and antenna segmented and with a number of setae
2. First maxilliped a simple protuberance with a terminal short seta	First maxilliped 2 jointed with long and short setae
3. Last segment of the exopodite of the third maxilliped provided with 3 pairs of long and plumose setae; no reference to endopodite	Last segment of the exopodite of the third maxilliped provided with 3 aeslhetascs and a long plumose natatory seta at the distal end; endopodite prominent with well developed plumose natatory setae
4. Distal end of the exopodite of the first pereiopod bore 5 pairs of natatory setae	Distal end of the exopodile of the first pereiopod bore a cluster of plumose setae
5. Third pereiopod withnoreferencetothesubexopodal spine and plumose natatory setae on the endopodite	Third pereioped with a subcxopodal spine from the base of the exopodite; last segment of the endopodite ended in a long spine; innumerable plumose natatory setae on the endopodite

Table 2 . Differences with the findings of Prasad and Tampi (1957) observed in the larvae of *Thenus orientalis*

Prasad and Tampi (1957)	Present findings
1. Antennule unirarr ous and unsegmented	Antennule segmented and with a lateral process
2. Antenna unsegmented	Antenna segmented
3. First maxilliped mentioned only in phyllosoma stage m	First maxilliped short and stump like
4. Coxal spine on thj third maxilliped present	Coxal spine on the third maxilliped not noticed
5. Fourth pereiopoduniramous in phyllosoma stage I while a rudiment of exopodite appeared in phyllosoma stage n	Fourth pereiopod biramous
6. Fifth pereiopod segmented in phyllosoma stage IV	Fifth pereiopod segmented
7. Abdomen showed signs of segmentation in phyllosoma stage IV only	Abdomen segmented

Table 3. Differences in phyllosoma stage I larvae of *Panulirus polyphagia* and *Thenus orientalis*

P. pilyphagus	*T. orientalis*
1. Fertilized eggs smaller measuring about 0.8 mm in diameter	Fertilized eggs very much large measuring about 1.1 m in diameter
2. Larvae small rang ing between 1.6 and 1.9 mm in size	Larvae large ranging between 2.8 and 3.1 mm in size
3. Body and append tges with spinous setae	Body and appendages smooth
4. Eyes unstalked	Eyes stalked
5. Antennule unirarr ous	Antennule with a lateral process
6. Third maxilliped biramous	Third maxilliped uniramous
7. Pereiopods 3 pair;	Pereiopods 5 pairs
8. Subexopodal spine on third pereiopod present	Subexopodal spine on third pereiopod absent
9. Abdomen unsegmented	Abdomen segmented
10. Uropod and telson not developed	Uropod and telson present

In both the species larvae hatched in phyllosoma stage I and not in naupliosoma or prephyllosoma stages as some believed. Deshmukh (1968) referred to a short lived prephyllosoma stage in *P. polyphagus*. Probably a few larvae hitched before time in the artificial condition of the aquarium, which he might have referred to as prephyllosoma. Though Prasad and Tampi (1957) also observed the embryos of *T. orientalis* hatching in phyllosoma stage I in the aquarium, this study proved further that the development was more advanced in nature than in artificial condition. It is possible that the larvae hatched in captivity were premature as all parts were not well developed a id that is why they did not survive for more than 13 days as reported by Chen (1990) on the culture of spiny lobster in Taiwan.

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