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LABORATORY CULTURE OF A HARPACTICOID COPEPOD *LAOPHONTE SETOSA* (BOECK)

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Laophonte setosa (Boeck) was cultured to use copepod as a supplementary food for shrimp larvae. The life history comprised of six naupliar and six copepodid stages, the last being the adult. Complete development took 18 to 20 days. Maximum growth of the larvae was recorded at room temperature (25.0 to 27.0° C) and salinity of 20‰. Temperature and salinity tolerance experiments indicated that the nauplii are the most susceptible to these changes. Developing stages were fed on freshly collected detritus. The larvae consumed voraciously, gulping frequently, the food material. The feeding was interrupted temporarily prior to moulting. When the food was scarce, the nauplii assumed elongated form instead of the usual sub-circular shape.

The development of *L. setosa* resembled in all essential aspects that of other harpacticoid copepods, the interesting features being the presence of large labrum and a long seta on the exopod of mandible of the nauplii. The copepodid stages showed minor changes in the size of the segments and number of setae on the paired legs.

INTRODUCTION

Laboratory culture of a harpacticoid copepod *Laophonte setosa* (Boeck) was undertaken primarily to use this copepod as a supplementary food for shrimp larvae. Earlier workers (Krishnaswamy, 1950, 1955; Ummerkutty, 1960; Farhrenback, 1962; Abraham and Gopalan, 1975) have carried out investigations on the larval stages of some members of this group. No published account seems to be available where only detritus is used for feeding the developmental stages. In the present investigations, larvae of *L. setosa* were reared in laboratory on detritus.

MATERIAL AND METHODS

Ovigerous females were picked out from freshly collected zooplankton samples and were kept singly in finger-bowls containing 300 ml of filtered seawater. Hatching took place within 10-15 hr after their release in finger bowls. All the developmental stages were fed on freshly collected detritus which was thoroughly cleaned and cut into small pieces. The development was observed throughout the naupliar and copepodid stages up to the adult. Different stages were preserved in 5% buffered formaldehyde for subsequent study. Drawings were made with the aid of a camera lucida. Total lengths were measured from the anterior margin of the body to the posterior margin of the caudal region, excluding caudal rami and the caudal setae. For temperature and salinity tolerance experiments, 20 to 30 specimens were used. The observations were made after every 8 hr and averaged survival rates are given.

DEVELOPMENTAL STAGES

In the life history, six naupliar stages and five copepodid stages precede the adult. The instars are separated by only one moult. The duration from

Culture of *Laophonte setosa*

hatching of an egg to copepodid stage I is about eight days. The live nauplii are faint brownish in colour and dorso-ventrally compressed. There is a large trilobed labrum which probably helps the nauplii for adhering to detritus food material. A brief description of the naupliar stages is given below (Fig. 1).

Naupliar stage I (Fig. 1, 1)

Length 0.062 mm; *Antennule* (A_1) 3-segmented, terminal segment having three setae, two apical and one at its mid-length; middle segment has a single seta; no seta on basal segment; *Antenna* (A_2) biramous with a well developed masticatory spine; exopodite 3-segmented, terminal segment bearing three setae, two apical and one lateral, middle segment does not bear setae, basal segment has a single seta; endopodite 2-segmented, prehensile, ending in a claw. *Mandible* (*Md*) biramous, exopodite 1-segmented, endopodite knob-like, having four fine setae; caudal armature consists of a pair of delicate setae.

Naupliar stage II (Fig. 1, 2)

Length 0.072 mm; terminal segment of A_1 with four setae, the other two segments with a single seta each; terminal segment of exopodite of A_2 also shows an additional seta; the structure of *Md* as in stage 1; caudal armature consists of a seta on each side, faint indentation in the middle of the posterior region of the body.

Naupliar stage III (Fig. 1, 3)

Length 0.082 mm; middle segment of antennal exopodite now bears a single seta. A_1 and *Md* as in previous stage; posterior region of the body divided into two halves, each bearing two setae.

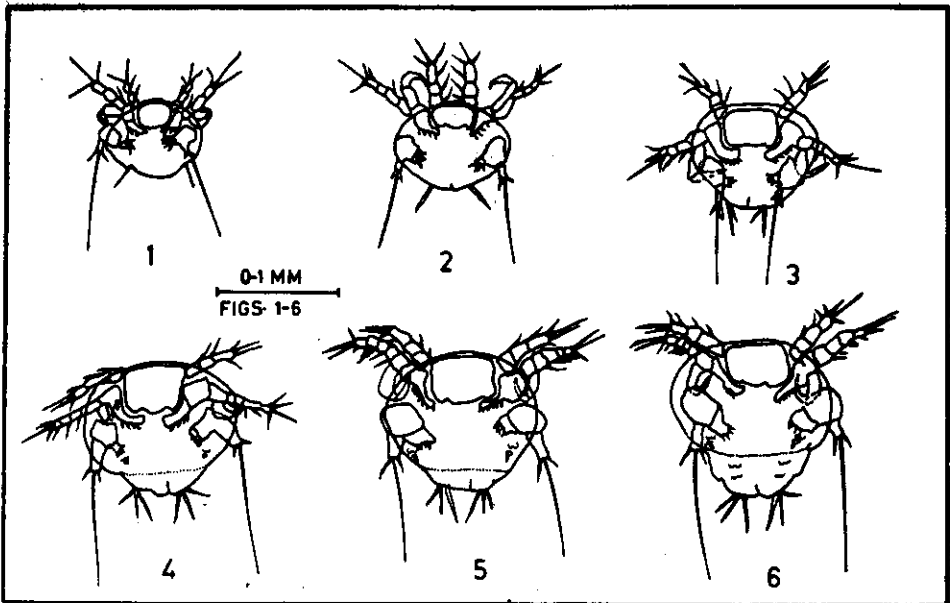


Fig. 1, 1-6. Naupliar stages, first to sixth

Naupliar stage IV (Fig. 1, 4)

Length 0.112 mm; body shows differentiation into anterior half and posterior half; posterior region bifid in the middle; two halves divided again; A_1 , A_2 and Md as in previous stage; rudiments of *maxillae* (Mx) and *maxillipeds* (Mxp) visible. Caudal armature consists of three setae on each side.

Naupliar stage V (Fig. 1, 5)

Length 0.121 mm; exopodite of A_2 4-segmented, third segment has two setae, first and second segment with a seta each; A_1 , mouth parts and caudal armature as in previous stage.

Naupliar stage VI (Fig. 1, 6)

Length 0.133 mm. It moults into first copepodid stage. A_1 3-segmented, basal segment being the longest; terminal segment has five setae, paired apical and lateral setae and a single seta in mid-length. A_2 and Md as in previous

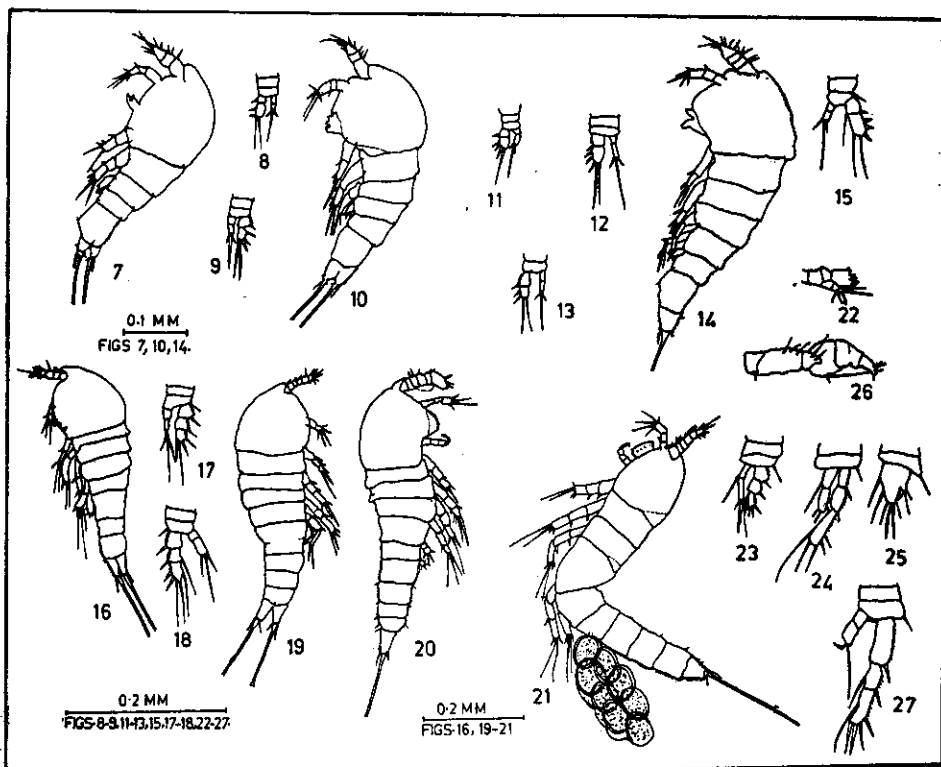


Fig. 2. 7 - Copepodid stage 1; 8 & 9 - first and second paired legs of copepodid stage 1; 10 - copepodid stage 2; 11-13 - first to third leg of copepodid stage 2; 14 - copepodid stage 3; 15 - third leg of copepodid stage 3; 16 - copepodid stage 4; 17 & 18 - first and third leg of copepodid stage 4; 19 - copepodid stage 5 (female); 20 - copepodid stage 5 (male); 21 - Adult (female); 22 - Adult (female) mandible; 23-25 - 1st, 2nd and 5th legs of adult female; 26 - Adult (male) antennule; 27 - third leg of adult male

Culture of *Laophonte setosa*

stages; besides *Mx* and *Mxp*, two pairs of rudimentary swimming legs present. Caudal armature has three setae on each; innermost seta longest.

Copepodid stages (Fig. 2, 7-27)

Copepodid stage I (Fig. 2, 7)

Length 0.387 mm; body consists of 3-segmented prosome and 2-segmented urosome; furcal ramus short and stumpy with two setae, inner seta being longer than urosome; mouth parts resemble adult copepod except for their size and addition of few setae in the latter; A_1 3-segmented bearing one, two and six setae respectively; A_2 consists of protopodite and two segments of the endopodite bearing two spines and four setae; exopodite absent and apparently represented by a single seta. Mandibular palp 2-segmented, distal segment with four setae; *Mx* 2-segmented; *Mxp* 3-segmented; terminal segment with spines and setae; two pairs of biramous legs and a rudimentary third pair present; protopodite of each leg divided into coxopodite and basipodite; rami of first and second paired legs 2-jointed, third leg with a single joint; distal joint of exopod of first leg (Fig. 2, 8) has two apical setae and two lateral spines; second leg (Fig. 2, 9) with three spines and two setae on distal joint of exopod; distal joint of endopod of both legs with three setae each.

Copepodid stage II (Fig. 2, 10)

Length 0.430 mm; number of segments increased to six, four prosomal and two urosomal; A_1 3-segmented, terminal segment with an aesthete; no essential differences in structure of A_2 and other mouth parts from previous stage; three pairs of swimming legs present, 4th pair rudimentary; in first leg (Fig. 2, 11), distal joint of exopod has three spines and a single seta; second leg (Fig. 2, 12) bears three lateral spines and two setae as in the corresponding leg of previous stage; distal joint of exopod of third leg (Fig. 2, 13) bears two spines and two setae; endopod of all legs has similar structure, with distal joint having three setae.

Copepodid stage III (Fig. 2, 14)

Length 0.494 mm; urosome has an additional segment as compared to previous stage; A_1 4-segmented; A_2 and mouth parts as in previous stages; distal joint of exopod of second leg has three spines and two setae; in third leg (Fig. 2, 15), first joint of exopod with a spine and a seta; second joint with three spines and two setae; exopod of 4th leg with two spines and two setae.

Copepodid stage IV (Fig. 2, 16)

Sexes can be differentiated in this stage; females larger in size than males; lengths: female - 0.560 mm, male - 0.527 mm; body comprises of eight segments with equal number of prosomal and urosomal segments; A_1 5-segmented in both sexes, terminal segment with an additional seta as compared to the previous stage; mandibular palp with five setae as in adult; four pairs of legs present; exopod in all legs 3-jointed, endopod 2-jointed with three setae; terminal joint of exopod of first leg (Fig. 2, 17) has a pair of spines and a pair of setae; middle and the basal joint with a spine each; in second and third legs (Fig. 2, 18), exopod of terminal joint has two spines and three setae, middle joint having a spine and a seta; 4th leg similar to first leg except that in the former, middle joint bears a seta on the inner side.

Copepodid stage V (Fig. 2, 19 & 20)

Sexual differentiation more pronounced, males can be easily distinguished from females by the presence of an additional urosomal segment and by geniculation of A_1 in the former; lengths: female-0.602 mm, males-0.569 mm; five pairs of legs, 5th pair flap-like with setae; terminal joint of exopod of first leg with two spines and two setae; middle joint has a lateral spine and an inner seta; in second and third legs, exopod has two spines and three setae; fourth leg similar to first leg of the previous stage except that the middle joint has a spine and an inner seta.

Fifth copepodid stage moults into an adult, females larger in size than males.

Copepodid stage VI - Adult female (Fig. 2, 21)

Length 0.688 mm; body consists of nine segments, five cephalothoracic (prosome) and four abdominal (urosome); anterior and posterior regions clearly demarcated; body more or less transparent; ovary and its branches appear as dark bands along the gut; genital segment bears egg-sacs laterally; furcal ramus short, broader than long; apical furcal seta longer than abdomen.

A_1 6-segmented, having the following proportion of percentage of length:

1	2	3	4	5	6	= 100
16	18	20	10	9	27	

Terminal segment with thirteen setae, aesthete extends beyond tip of A_1 ; A_2 3-segmented, distal segment with five setae. Masticatory part of mandibular blade

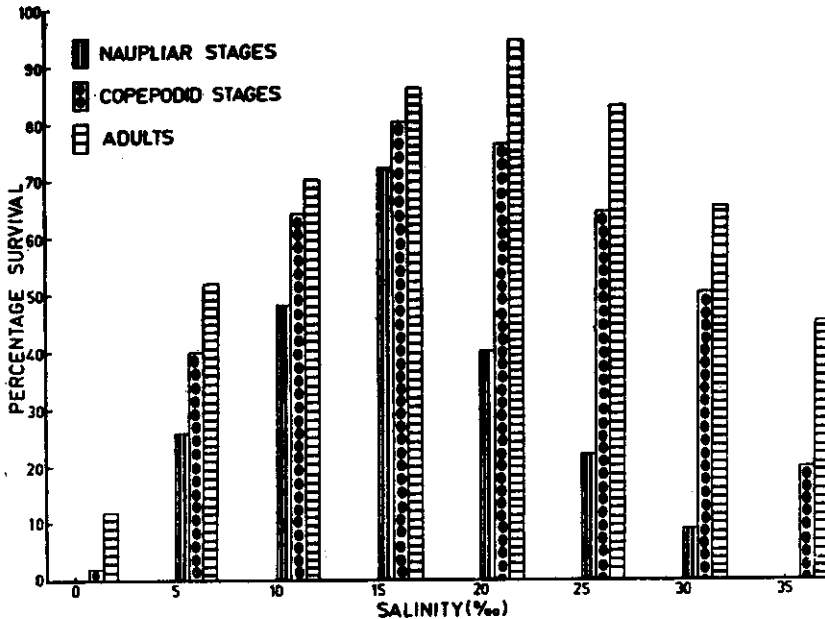


Fig. 3. Percentage survival of the developmental stages in different salinities

Culture of *Laophonte setosa*

with numerous teeth (Fig. 2, 22); *Mx* have well developed claws on terminal segment; *Mxp* with spines and tuft of hairs; five pairs of legs present, 5th pair laminar in form; in the first leg (Fig. 2, 23), distal joint of exopod has three spines and two setae; distal joint of exopod of second leg (Fig. 2, 24) with four spines and a seta; third leg similar to second leg; exopod of 4th leg has four spines only; endopod of 5th leg (Fig. 2, 25) represented by a small lobe bearing three setae; exopod has a large lobe with setae and bristles as shown.

Copepodid stage VI — Adult Male

Length 0.645 mm; males can be distinguished from females by their smaller size, geniculation of A_1 and by 6th vestigial leg; urosome has an additional segment as compared to females; A_1 6-segmented, geniculated and serves as a grasping organ (Fig. 2, 26). A_2 and mouth parts as in females.

Exopod of first leg has three spines and two setae; second and third legs are similar in structure with distal joint of endopod with two setae (Fig. 2, 27); exopod of 4th leg has five spines and a single seta; endopod with only two setae; fifth leg flap-like with five setae, 6th leg further reduced and vestigial.

GENERAL OBSERVATIONS

Adults of *L. setosa* occur in the Mandovi estuary almost throughout the year but more abundantly during post-monsoon months (October to January). Few specimens were recorded in the zooplankton samples taken from the Zuari estuary where high saline conditions prevail even during monsoon months (Goswami and Singbal, 1974). To ascertain whether there is any relationship between their distribution and the prevailing ecological conditions in the two estuaries, salinity and temperature tolerance experiments were done in the laboratory. The results indicate that former has more effect on the larvae than

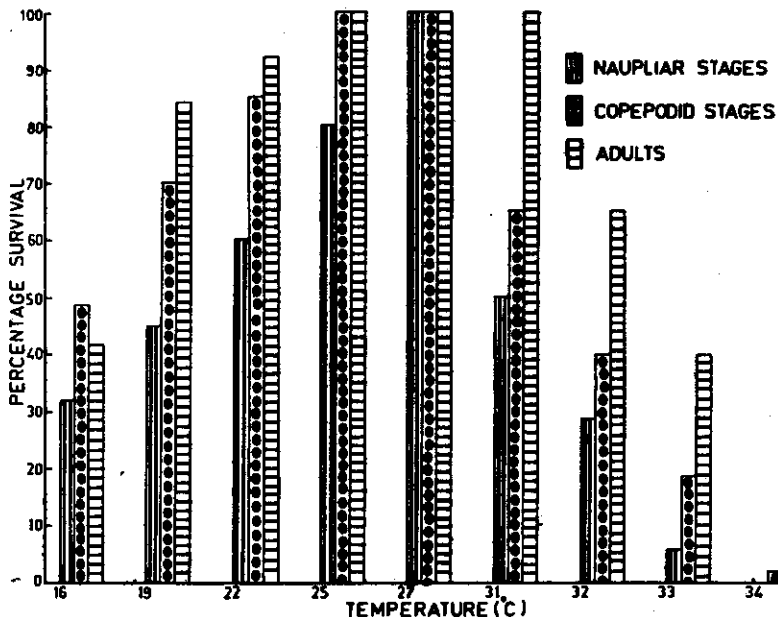


Fig. 4. Percentage survival of the developmental stages at different temperatures

the latter. Nauplii are more susceptible to the changes in the salinity (Fig. 3). No nauplii survived in freshwater and in waters of salinity of 35‰ or more. Survival rate increased from 5 to 15‰ and the maximum survival rate of the nauplii and copepodid stages was in 20‰. The adults are euryhaline and on acclimatization, they could tolerate a wide range of salinity (0 to 37.5‰). Optimum temperature for the developmental stages ranged from 25.0 to 27.0°C. The larvae could tolerate lower temperature but temperatures of 34.0°C and beyond were lethal. The average salinity and temperature in the Mandovi estuary during post-monsoon period are 16.92‰ and 27.4°C respectively (unpublished data). These experiments indicate that the occurrence of *L. setosa* in the two estuaries depend more or less upon the hydrographical conditions and so explain the abundance of this species in the Mandovi estuary during post-monsoon season. The mating behaviour was observed under stereoscopic microscope. The male is active and on contacting the female, starts clasping her body, generally at the caudal seta. The male ultimately secures a position at right angles to the body of the female. The male mates with adult female but occasionally tries unsuccessfully with a fifth copepodid female or with an ovigerous female. Fahrenback (1962) also observed futile mating behaviour of male with female of fifth copepodid stage in *Diarthrodes cystoecus*.

Development of *Laophonte setosa* resembles in all essential features that of other harpacticoid copepods. The presence of large labrum, 3-segmented antennule, prehensile endopod of the antenna in the nauplii agree with the observations of Krishnaswamy (1955) in *Leptastacus euryhalinus*. Rao (1958) has described 2-segmented antennule in the nauplii of *Euterpina acutifrons*. The exopodite of mandible is 1-segmented in *L. setosa* as observed in *Epactophanes richardi* (Borutskii, 1964). The 2-segmented exopodite of the mandible has been reported in *Tisbe furcata* (Johnson and Olson, 1948), *Macrosetella gracilis* (Krishnaswamy, 1950), *Tisbintra jonesi* (Ummerkuty, 1960) and in *Nitocra spinipes* (Abraham and Gopalan, 1975). The maxilla and maxilliped appear as rudimentary structures in the third naupliar stage and in this aspect the present species resembles *T. jonesi*. The development of body segments and of the swimming legs is gradual and confirms the observations of earlier workers (Krishnaswamy, 1955; Rao, 1958; Ummerkuty, 1960; Fahrenback, 1962) with minor changes in the size of segments and the number of setae on the paired legs. The number of antennular segments remain the same in the adults of both sexes in *L. setosa* but have been reported to be different in the females and males of *M. gracilis* (Krishnaswamy, 1950) and *T. jonesi* (Ummerkuty, 1960).

The present study has shown that the adults of *Laophonte setosa* can tolerate wide fluctuations in temperature and salinity. The copepodid stages of *L. setosa* are voracious feeders, gulping detritus food material frequently. Qasim and Sankaranarayanan (1972) have also stated that detritus is ingested as food by a wide variety of estuarine animals and constitutes an additional pathway between organic production and animal nutrition. The species can be easily reared and maintained for many generations. Being a prolific breeder (11,250 individuals/l in 45 days) with ability to sustain on detritus only, this copepod is an ideal live supplementary food for the mass culture of shrimp and fish larvae.

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DISCUSSION

- RAYMONT : In your experiments, have you tried feeding on specific diets instead of detritus?
- GOSWAMI : No, only detritus was used.