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STUDIES ON LARVAL EUPHAUSIIDS FROM THE SOUTHWEST COAST OF INDIA WITH NOTES ON THEIR DEVELOPMENTAL PATHWAYS AND BREEDING SEASONS

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ABSTRACT

In spite of the exhaustive studies done the world over on the larval euphausiids, the developmental pathways of several species remain unknown or partly understood. The fact that larval euphausiids form a sizable portion of the zooplankton in the sea makes a study of the larval biology more important. A large number of zooplankton samples collected from the southwest coast of India have been examined for the occurrence and the developmental stages of some major species of euphausiids. As a result of the studies the complete post-naupliar stages of *Pseudeupausia latifrons, Euphausia diomedeae, E. sibogae, E. tenera, Nematoscelis gracilis, Stylocheiron armatum* and *S. affine* have been obtained. The full complement of post-naupliar stages of *S. affine* has been identified and the developmental pathway has been traced for the first time. Critical discussions have been made in the article on the various life history stages of important species. A study on the occurrence and abundance of the larval stages in the different months have enabled to understand the active breeding seasons of five of the species. Thus it has been found that *Pseudeuphausia latifrons, E diomedeae* and *S. armatum* have an active breeding season from December to April while *E. sibogae* and *S. affine* have it from August to December and October to February respectively. *S. affine* has been found to be a continuous breeder.

INTRODUCTION

THE EUPHAUSIIDS, as a major constituent of the zooplankton, play a key role in the economy of the sea. A fairly large portion of the euphausiids in the plankton of the epipelagic zone, where the pelagic fishes and other nektonic animals make active feeding, is composed of larval forms. This fact has led to pursuing exhaustive studies oriented towards various aspects of larval euphausiids by several authors the world over and hence the literature on larval euphausiids is voluminous. Brinton (1975), while working on the distribution of euphausiids of the Southwest Asian waters has reviewed the past works on the larval euphasiids. Others who have made comprehensive reviews of the literature on larval euphausiids are Mauchline and Fisher (1969) and Mauchline (1980).

When compared to the work done in the other world oceans there is practically very little information available on the larval euphausiids of the Indian Ocean. The earliest reference on larval euphasiids of the Indian ocean is that by Illig (1930) who described in brief one early furcilia of *Thysanopoda cornuta* taken from 10° 08'S and 97° 15'E and a late furcilia of *T. egregia* collected from 27° 58'S and 9°140'E and an other furcilia, probably the last, of an unidentified species of *Thysanopoda*. Pillai(1957) described from the southwest coast of India, the third calyptopis, the first and fourth furciliae and the post-larva of *Pseudeuphausia latifrons*, the first furcilia of *T. tricuspidata* and the fifth furcilia and the post-larva of *Nematoscelis tenella*. He has also described some more furciliae of *T. tricuspidata* and *N. tenella* without assigning them to any specific stage. Ponomareva (1969) described in brief the eggs and some of the early larval stages of *Euphausia diomedeae* and *Stylocheiron carinatum* based on the material reared onboard R.V. *Vityaz* during her cruises in the Indian Ocean.

Mathew (1971) described for the first time the complete postnaupliar developmental stages of *E. diomedeae* and *E. distinguenda* (= *E. sibogae*) based on material collected from the southeastern Arabian Sea and Mathew (1972) described in detail, again for the first time the complete post-naupliar developmental stages of *S. carinatum* (= *S. armatum*) obtained from the same area. The geographic distribution of the larvae of *Nematoscelis gracilis*, *N. atlantica*, *N. microps N. tenella*, *N. megalops* and the larvae and juveniles (pooled) of *T. aequalis* and *T. subaequalis* (at present not a valid species) in India Ocean has been studied by Brinton and Gopalakrishnan (1973). Knight (1973) described the metanauplius stage of *T. tricuspidata* partly making use of the material obtained from the tropical Indian Ocean. Mathew (1975) made a detailed study, describing the body appendages including the mouth parts of the post-naupliar stages of *E. diomedeae*, *E. distinguenda* (= *E. sibogae*) of the southwest coast of India. A critical review of the larval development in Euphausiacea has been carried out by Silas and Mathew (1977). The classification and nomenclature of the euphausiid larval stages, the dominant stages and the skipping of stages among the furciliae are critically examined by them.

The present paper deals with the larval material obtained for 12 species of euphausiids from the southwest coast of India. All the larval stages obtained have been identified, assigned to the respective stages, and based on this the developmental pathways have been traced as far as possible for each of the species.

The author is deeply indebted to Dr. E.G. Silas, former Director of the Central Marine Fisheries Research Institute, Cochin under whose guidance and supervision this work has been carried out. His thanks are also due to Dr. P.S.B.R. James, the Director of the Institute for his keen interest in this work.

MATERIAL AND METHODS

The larval euphausiids for the present study were obtained from the zooplankton samples collected from the southwest coast of India during the cruises of R. V. *Varuna*. Indian Ocean Standard Net of 0.33 mm mesh size (Currie, 1963) was used for making vertical hauls from 200 m to the surface in the oceanic areas and from five metres above bottom to the surface in the continental shelf area.

The larval euphausiids were identified mainly based on the literature by Lebour (1926a, 1926b), Macdonald (1927, 1928), Boden (1950, 1951, 1955) and Lewis (1955). In addition, the own experience of the author gained over several years by comparing and contrasting the different larval forms occurring in the plankton has also helped to a great extent in this regard. The larval stages were determined under a stereoscopic microscope by examining the development of cephalothorax, the eye and the segmentation of abdomen in the case of calyptopes and the armature of the telson and the pleopod formula in the furciliae.

RESULTS AND DISCUSSION

Larvae of 12 species have been obtained from the plankton, but all of them were not represented by the full complement of the calyptopis and furcilia stages. The species which had all the typical stages of furciliae were *Pseudeuphausia latifrons, Euphausia diomedeae, E. sibogae, E. tenera, Nematoscelis gracilis, Stylocheiron armatum* and *S. affine*. Though the variant forms of larvae were not very common they occurred in case of some species.

Thysanopoda monacantha (Fig. 1)

One larva each of four furcilia stages occurred in the plankton. Since the larval sequence is not complete it is not possible to ascertain the exact position of each of the stages. The larval descriptions made by Hansen (1910) for *T. agassizi*, by Hansen (1912) for *Thysanopoda* sp. and by Lebour (1950) for *T. cristata* have been attributed to *T. monacantha* by Brinton (1975). He has illustrated one early calyptopis and also three furciliae, each with a pleopod complement of 2″2′, 4″1′ and 5″ respectively, which he presumed to represent furciliae 2, 3 and 4. (″ = setose pleopod and ′ = non-setose pleopod). But the pleopod condition of the furciliae obtained during the present studies makes it to reconsider the stages proposed by Brinton (1975). The present material indicates that there is a stage with one non-setose pleopod which could be considered as furcilia-1 and another stage with one setose and three nonsetose pleopods which may correspond to furcilia-2. Under these circumstances it is reasonable to think that the furcilia larvae figured by Brinton (1975) may represent furciliae-3, 5 and 6, while the present material may represent furciliae-1, 2, 4 and 6. Now it becomes possible to make, arbitrarily, the pleopod formula of *T. monacantha* as $2' \rightarrow 1''3'$ $2''2' \rightarrow 3''2' \rightarrow 4''1' \rightarrow 5''$. The above formula need not be final as there could be still some more typical furcilia stages with different combinations of pleopod development and setation on terminal part of telson. Therefore more studies are required to trace the pathway of development at the post-naupliar level of this species.

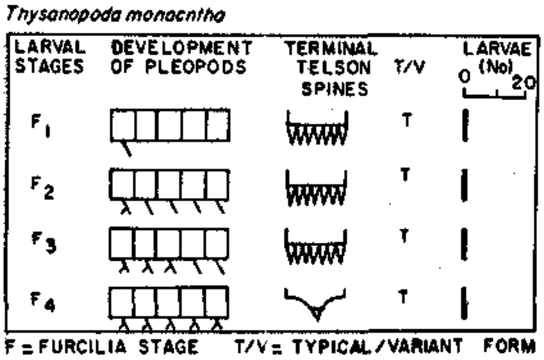
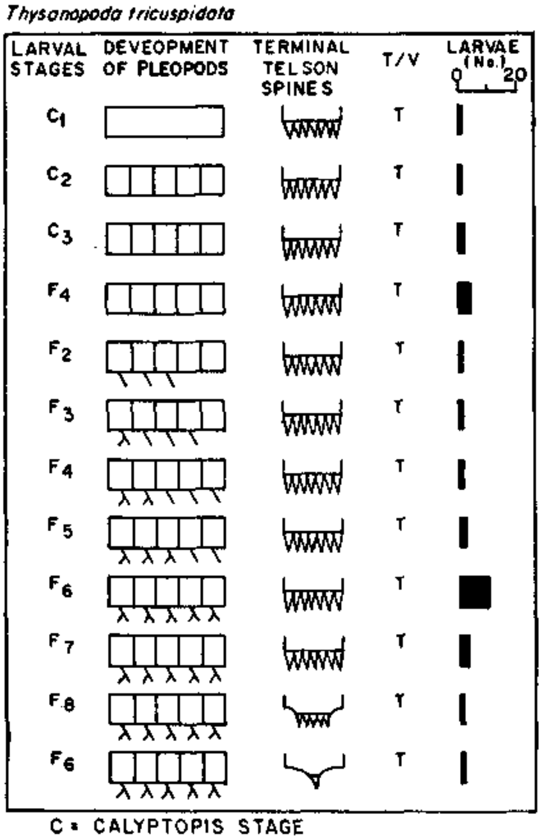


Fig. 1. Sequence in the development of post-naupliar stages in *Thysanopoda monacantha* along with the number of larvae obtained for each stage.

Thysanopoda tricuspidata (Fig. 2)

All the three calyptopes and also nine furciliae occurred in the present material. The furcilia series is in no way complete. This is a species which usually possesses a large number of variant forms. The present material is numerically not very abundant and hence seggregation of actual furcilia stages from the variants based on the theory of dominant forms is not attempted.

Lebour (1950) has reviewed the works done on the larval development in *T. tricuspidata*. Since then Pillai (1957) has described in brief one early furcilia collected from the Kerala coast. Knight (1973) has described the second nauplius, metanauplius and all the three calyptopis stages based on material collected from the Indian Ocean and the Pacific. In Lebour's (1950) words, *T. tricuspidata* is much the most variable in pleopod succession of any *Thysanopoda* species – indeed than any euphausiid known. "The occurrence of large number of variant forms in the developmental pathway of *T. tricuspidata* is especially surprising", say Mauchline and Fisher (1969), "because this species is oceanic in distribution and there is usually a fairly close correlation between a more stereotyped pathway of development and a more oceanic distribution. The species showing the most variable patterns of development are usually distributed throughout coastal or continental slope areas." The various furcilia stages of this species considered here were obtained exclusively from the shelf area. It is also significant to state here that the larvae of this oceanic species have been taken from stations having depth less than 50 m even.



Fog. 2. Sequence in the development of post-naupliar stages in *Thysanopoda tricuspidata* along with the number of larvae obtained for each stage.

Pseudeuphausia latifrons (Fig 3)

This species has in its life history three calyptopis and 11 typical furcilia stages of which the pathway of development of furciliae could be expressed as 0 → 1′ → 2′ → 3′ → 1″2′ → 1″3′ 2″ 2′ → 3″ 1′ → 3″2′ → 4″1′ → 5″. All the above typical stages and one variant form were obtained during the present investigations. The stage with two setose and one non-setose pleopods is considered here as variant form because if its previous stage with 1″3′ pleopods is considered as a typical stage, as it is done here, in its next moult it is quite unlikely to get a larva with 2″1′ pleopods. If the stage which is considered here as a variant form is to be considered as a typical stage it should have jumped from the stage with 1″2′ pleopods to a stage with 1″3′ pleopods. Then the F6 would become a variant form. But since more number of larvae were obtained for the F-6 stage this may be considered as a typical stage based on the theory of dominance.

The pathway of larval development in *P. latifrons* is fairly well understood due to the works of Tattersall (1936), Gurney (1947), Sheard (1953) and Pillai (1957). However, none of them could obtain the complete set of larval forms of this species. Tattersall (1936) had 11 furcilia stages of which one was a variant form. She did not have one typical stage with 3″2′ pleopods. Gurney (1947) described 10 furciliae. This was also incomplete in that the missing stage of Tattersall and also the last furcilia in the series were absent. Sheard (1953) had all the three calyptopes but had only eight furciliae of which one with five setose pleopods and five spines on the tip of the telson could have been a variant form. Pillai (1957) has described in brief the last calyptopis and the first and fourth furciliae of *P. latifrons* from the southwest coast of India.

(3)→ 5″ (1). (The numbers in brackets indicate the number of terminal telson spines in each stage).

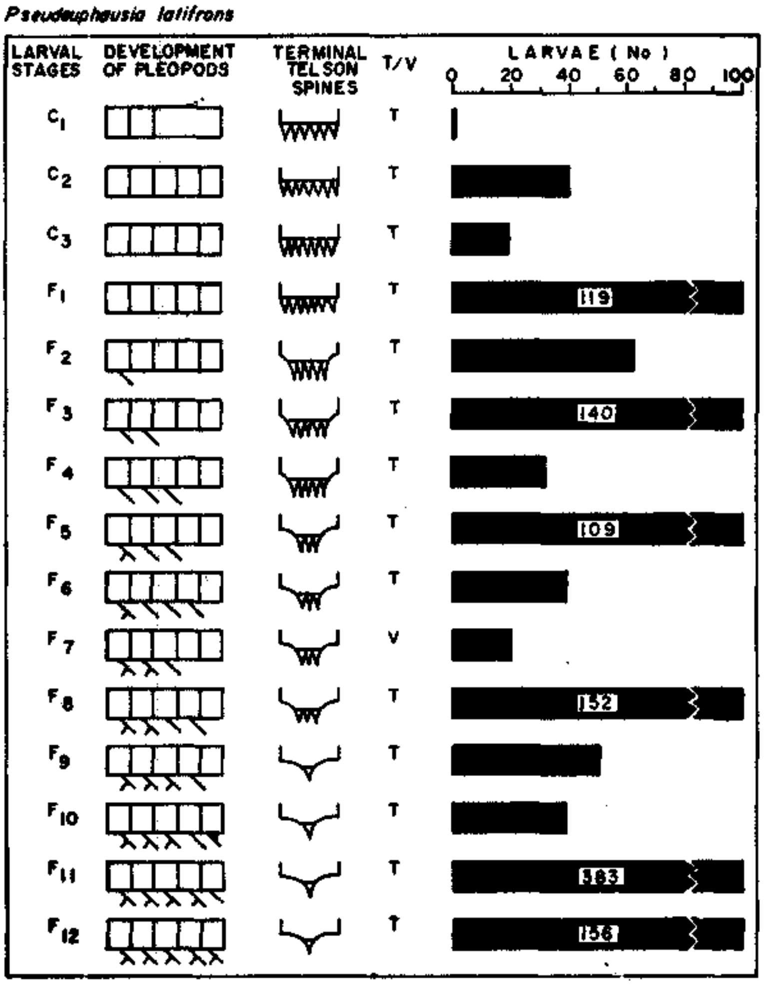


Fig. 3. Sequence in the development of post-naupliar stages in *Pseudeuphausia latifrons* along with the number of larvae obtained for each stage.

Euphausia diomedeae (Fig. 4)

This species was represented in the collections by all the typical post-naupliar stages except the first calyptopis. No variant forms were taken. The different furciliae followed the way of 1′ → 1″4′ → 5″ (7) → 5″ (5) → 5″

The complete post-naupliar stages of *E. diomedeae* were described and illustrated by Mathew (1971). In 1972 he gave an account of the various life history stages of this species with details on the differentiation of organs such as antennule, antenna, mandible, first and second maxillae, walking legs, pleopods and uropods including telson. Ponomareva (1969) has described the early larval stages of this species from egg upto second furcilia except the third calyptopis and first furcilia based on reared material.

Euphausia sibogae (Fig. 5)

The larval forms of *E. sibogae* were abundant in the samples examined. Three calyptopes and nine furciliae occurred, of which three furciliae were variants. The first variant was a stage with $4''1'$ pleopods and had four spines on the tip of the telson. The next variant form again had the same pleopod sequence but had two spines on the tip of the telson. The third variant was represented by larvae with pleopod condition as in the previously mentioned variants but had only one spine at the tip of the telson. Thus the typical furcilia stages took a course as $1' \rightarrow 1''3' \rightarrow 4''1'$ (5) $\rightarrow 4''1'$ (3) $\rightarrow 5$ (3) $\rightarrow 5''$ (1).

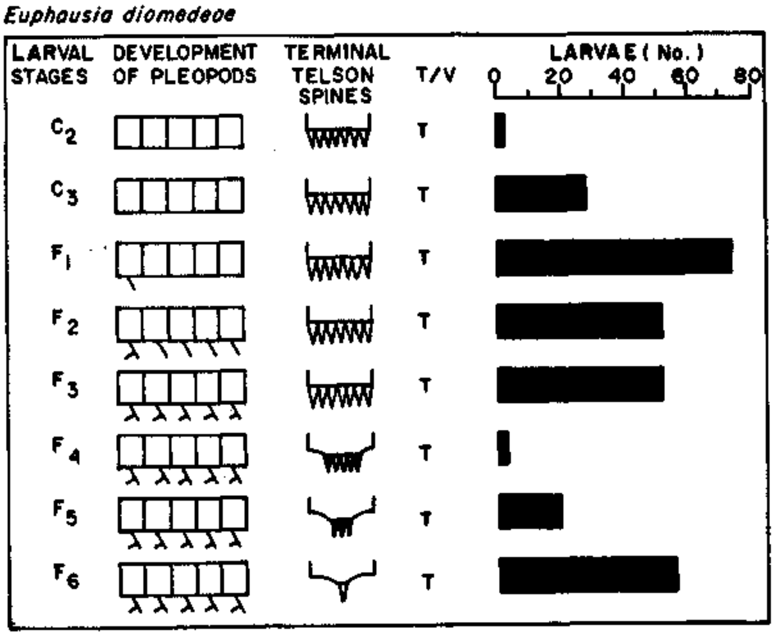


Fig. 4. Sequence in the development of post-naupliar stages in *Euphausia diomedeae* along with the number of larvae obtained for each stage.

Gurney (1942) while discussing the mode of pleopod development in various species of the genus *Euphausia*, doubtfully proposed a particular sequence of development for *E. distinguenda* which has been reviewed and corrected by Mathew (1971). But as the larvae described by Mathew are now considered to be of *E. sibogae*, it is yet to be seen whether the larvae of the former species follow the same pathway of development suggested for the latter species.

Euphausia tenera (Fig. 6)

None of the calyptopis stages was encountered. However, the furcilia stages were complete with six typical stages. The pleopod succession and the mode of reduction of spines on the tip of telson followed the same course as in *E. diomedeae*. One variant form with five setose pleopods and four terminal telson spines was also present.

The larval descriptions of *E. tenera* has been made by Lebour (1950) and Boden (1955). But they could not obtain all the furcilia stages. Lebour briefly described the three calyptopes and the first three furciliae from the Bermuda waters. The furciliae were of typical stages and they correspond with the first three furciliae in the present material. But what Bodon has described in 1955 included some variant forms also. He could not obtain any of the calyptopis stages. The first and second stages described by him with 1"3' pleopods and 4"1' pleopods were obviously variant forms. The next four stages described by Boden represented typical stages and they belonged to furciliae three to six. However, Birnton (1975) doubted the validity of the larval specimens described under *E. tenera* by Boden (1955). Brinton (1975) has figured the third calyptopis and the first and second furciliae of this species obtained from the Southeast Asian waters.

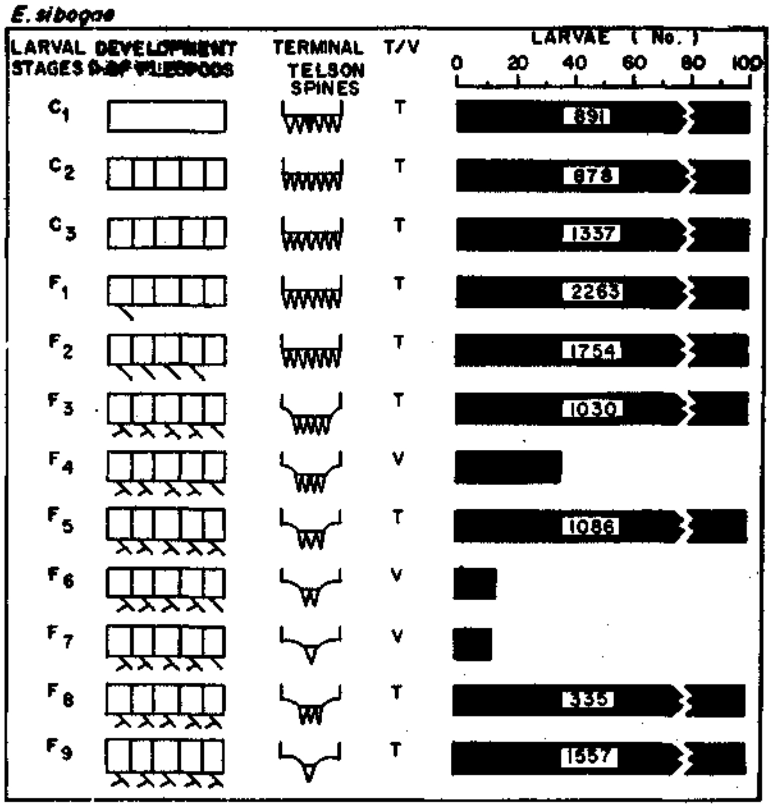


Fig. 5. Sequence in the development of post-naupliar stages in *Euphausia sibogae* along with the number of larvae obtained for each stage.

Nematoscelis gracilis (Fig. 7)

The present material collected from the continental shelf area appears to provide the complete sequence of furcilia stages. Altogether there were six furcilia stages of which two were variant forms.

The larval history of closely related species of *N. gracilis* has been worked out by some authors namely Lebour (1926a, 1926b) and Casanova-Soulier (1968) for *N. atlantica* and Gurney (1947) and Lebour (1950) for *N. tenella.* Gopalakrishnan (1973, 1975) attempted a study of the furcilia stages of all the seven species of *Nematoscelis* and he found that five of them including *N. gracilis* have a pleopod and terminal telson formula of 1′ (7) → 1″3′ (5)→ 4″1′ (3). The furcilia statges obtained from the present material follow the above course with the addition of the last furcilia stage with 5″ (1) formula. Two variant forms were also encountered during the present studies; one with 3″1′ (5) and the other with 5″ (3) formula.

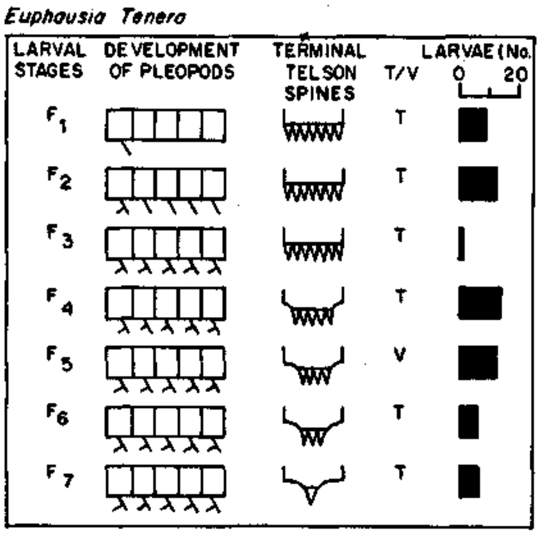


Fig. 6. Sequence in the development of post-naupliar stages in *Euphausia tenera* along with the number of larvae obtained for each stage.

Stylocheiron armatum (Fig. 8)

The material contained all the post-naupliar stages from second calyptopis to the sixth furcilia. It also had three variant forms. However, one of the variant (one with 5″ (3) formula) cannot be strictly considered as a variant form, but as a stage which is usually skipped off by larvae in the course of their development. Therefore, only very few numbers of larvae occurred in this stage. The mode of pleopod development and the reduction of terminal telson spines follow the sequence as 0 → 1′ → 1″2′ → 3″2′ → 5″ (5) → 5″ (3) → 5″ (1).

S. armatum being a little known species its larval development has not been described so far. But since the species is established partly on *S. carinatum* of G.O. Sars (1883, 1885), Ortmann (1893), Hansen (1910), Tattersall (1912, 1939), and Illig (1930), what all information available on the larval development of *S. carinatum* may have to be considered for *S. armatum* also. The life history studies of *S. carinatum* have been done by Hansen (1912) (furcilia 3 and 5), Lebour (1950) (egg and nauplius), Lewis (1955) (calyptopis 1-3 and furcilia 1 and 2). Soulier (1965) has described a few larval

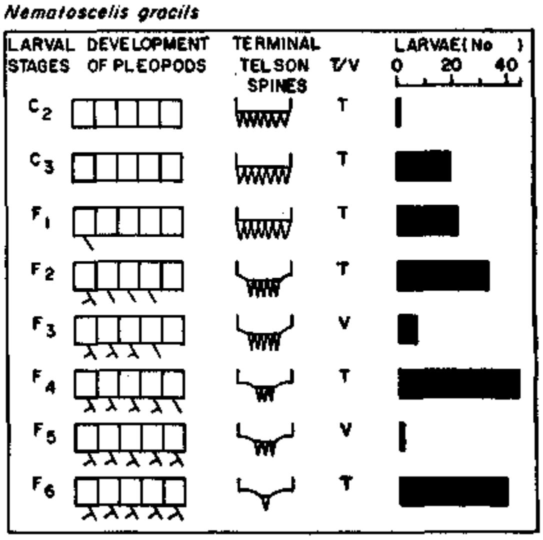


Fig. 7. Sequence in the development of post-naupliar stages in *Nematoscelis gracilis* along with the number of larvae obtained for each stage.

stages belonging to *S. carinatum*. Ponomareva (1959) has made some observations on living material on board R.V. *Vityaz*. She observed the hatching of egg and the development of nauplius through metanauplius and calyptopis. A figure of the second furcilia is also given. In spite of the above works a complete picture of the larval history, especially those of the later furciliae was not available. Mathew (1972) made a detailed study of all the typical larval stages from calyptopis (three stages) to the last stage of furcilia (six stages). However, a detailed examination of the adult specimens collected from the present study area which were considered as *S. carinatum* revealed more closer affinities to *S. armatum* and hence the larval history worked out by Mathew (1972) and probably by some others can be considered as that of *S. armatum*. However, unless studies are made on comparable material of both the species from other areas, the differences at the various levels cannot be understood.

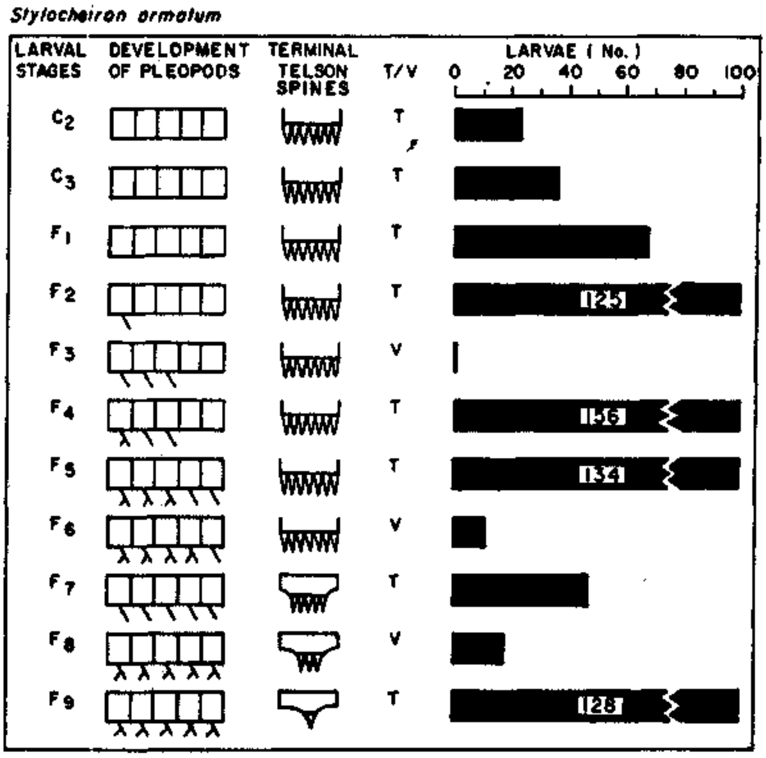


Fig. 8. Sequence in the development of post-naupliar stages in *Stolocheiron armatum* along with the number of larvae obtained for each stage.

Stylocheiron affine (Fig. 9)

The course of larval development in *S. affine* is the same as that of *S. armatum*. The present material included all the postnaupilar stages from calyptopis-2 to the last furcilia. Detailed descriptions of larval stages of this species have not been given so far. As in the case of *S. armatum* some variant forms also occurred but their position in the larval chain was not the same in both the cases. One variant form with a single specimen occurred in between furcilia-3 and 5, another in between furcilia-5 and 7 and a third variant form was present in between furcilia-7 and 9. Brinton (1975) briefly described and illustrated one calyptopis and four furciliae obtained from the Southeast Asian waters.

Stylocheiron suhmi (Fig. 10)

Only five furcilia stages were present in the present collections which in no way represented a complete series. The number of larvae in each stage was also meagre and hence no attempt is made here for a critical study of the validity of the different stages obtained. However, those stages which correspond to the actual furcilia stages of other species of the genus *Stylocheiron* can be considered as real stages.

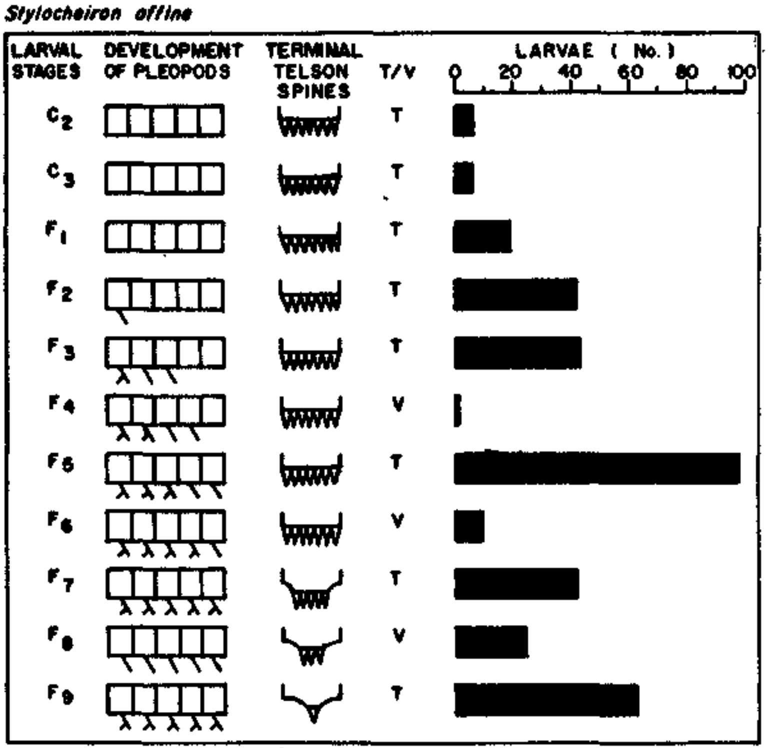


Fig. 9. Sequence in the development of post-naupliar stages in *Stylocheiron affine* along with the number of larvae obtained for each stage.

In this way it could be stated that the present material contained three actual and two variant stages of *S. suhmi.*

The calyptopes of *S. suhmi* have been described by Lebour (1926b) and the other stages by Lebour (1926a, 1950). She could also get a number of variant forms. Gurney (1947) has briefly reviewed the work of Miss Lebour on the larval stages of this species. Casanova (1974) described all the calyptopes and furciliae of this species.

Stylocheiron longicorne (Fig. 11)

The larval material was very poor. Three typical stages of furcilia were present which could be fixed at the corresponding stages of

S. armatum and *S. affine* as first, third and fifth furciliae. No variant forms occurred.

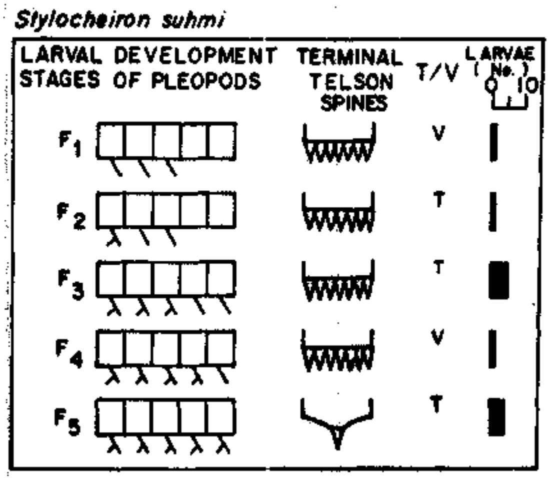


Fig. 10. Sequence in the development of post-naupliar stages in *Stylocheiron suhmi* along with the number of larvae obtained for each stage.

Stylocheiron maximum

Lewis (1955) was the first to identify with certainity two larval stages of this species; a second calyptopis and one second furcilia. A stalk eyed euphausiid larva has been tentatively assigned to this species by Gurney (1942, 1947) and Lebour (1950). The present material (one larva with a non-setose pleopod) belongs to the second furcilia described by Lewis (1955).

SEASONAL ABUNDANCE OF LARVAL STAGES AND BREEDING AMONG SELECTED SPECIES

The recent studies on the breeding and breeding seasons of several species of Euphausiacea have brought to light a complexity of problems. Smiles and Pearcy (1971) and Brinton (1976) have found that euphausiids of not only equatorial region but also of mid-latitudes may have a proportion of breeding females at all times of the year, however, with periods of more intense breeding. Therefore, it is but natural to find the larval stages in the plankton throughout the year. In the Firth of Clyde, Mauchline and Fisher (1969) found to have definite breeding seasons in *Thysanoessa raschi* and *T. longicaudata*. Gros and Cochard (1978) found that there is continuous breeding, of course with two periods of intense breeding within the populations of *Nyctiphanes couchi* from February to August. During the present investigations the larval stages of some common species were found in the plankton for a greater part of the year, with varying intensity. Therefore, it was sought to understand whether it would be possible to have some information on the breeding habits of these species by a study of the intensity of the occurrence of their different larval stages in the various months. (Since any of the early life-history stages such as egg, nauplius and metanauplius were not obtained in the IOS Net it is difficult to say anything definite on the time of incidence of the breeding activity of any of the species. It would be reasonable to think that the actual breeding had started prior to the occurrence of larval stages in abundance in the plankton).

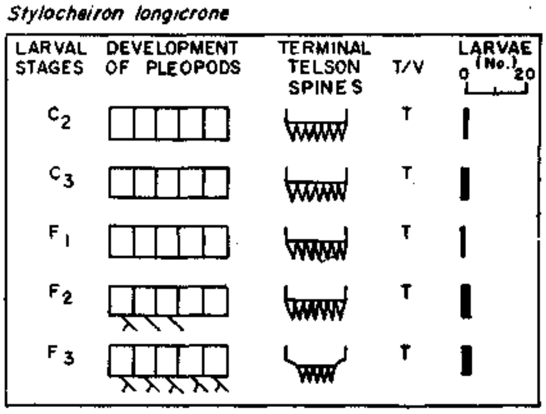


Fig. 11. Sequence in the development of post-naupliar stages in *Stylocheiron longicorne* along with the number of larvae obtained for each stage.

Five of the species which were represented by all the post-naupliar developmental stages, at least in one month or another, have been selected to study the seasonal abundance of their different larval stages. For obtaining a quantitative picture of the various larval stages collected from the sampling stations in the different months, their number per 1000 m^3 of water was estimated taking into consideration the positive stations where each of the larval stages occurred. The results thus obtained, along with the form and structure of the

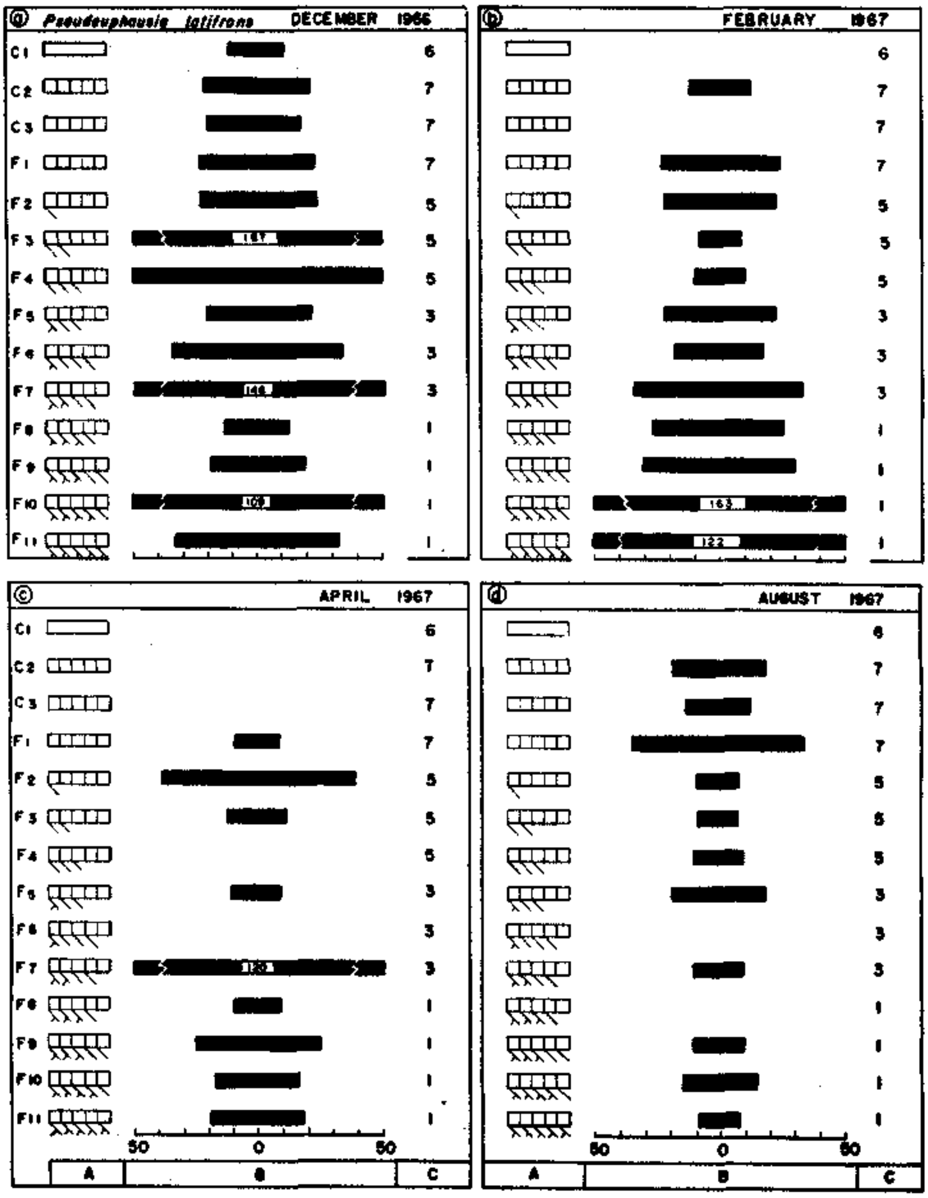


Fig. 12 a-d. Seasonal variations in the abundance of post-naupliar stages of *Pseudeuphausia latifrons* (December, 1966 to August, 1967). CI-C3 = calyptopis stages, FI-F6 = furcilia stages, A = pattern of pleopod development, B = numerical abundance of larval stages (No. per 1000 m^3 of water), C = number of terminal telson spines.

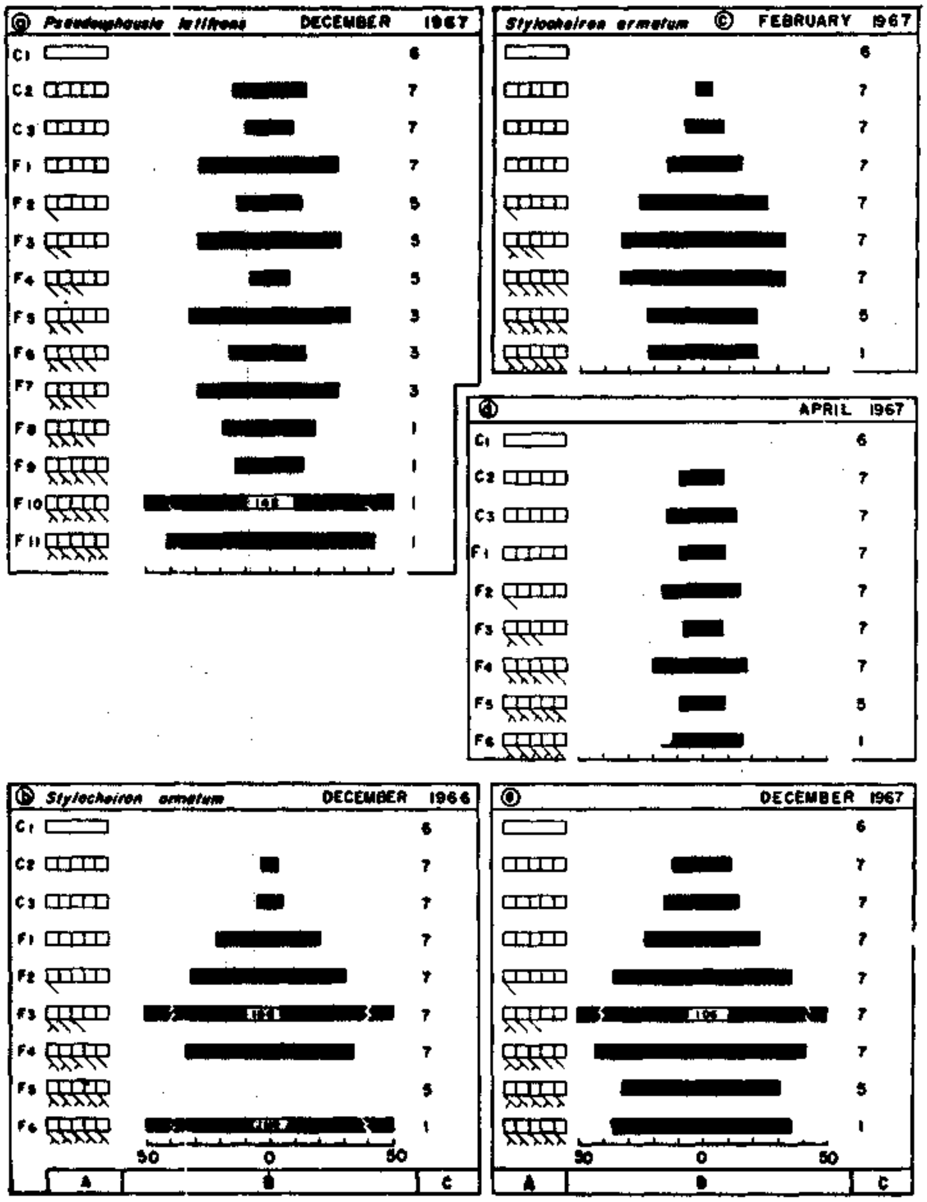


Fig. 13 a. Seasonal variations in the abundance of post-naupliar stages of *Pseudeuphausia latifrons* (December, 1967) and b-e. of *Stylocheiron armatum* (December, 1966 to December, 1967).

body are given diagrammatically in Figures 12 to 16. For the purpose of this study the variant forms were not considered.

Pseudeuphausia latifrons (Figs. 13; 14 a)

In December, 1966 the full complement of the larval stages was present and this was the only month when the first calyptopis was encountered. The furciliae 3, 4, 7 and 10 were especially abundant. In February except calyptopes 1 and 3 all the other stages were present, the last two furcilia stages being exceptionally abundant. In April the variety of larval stages

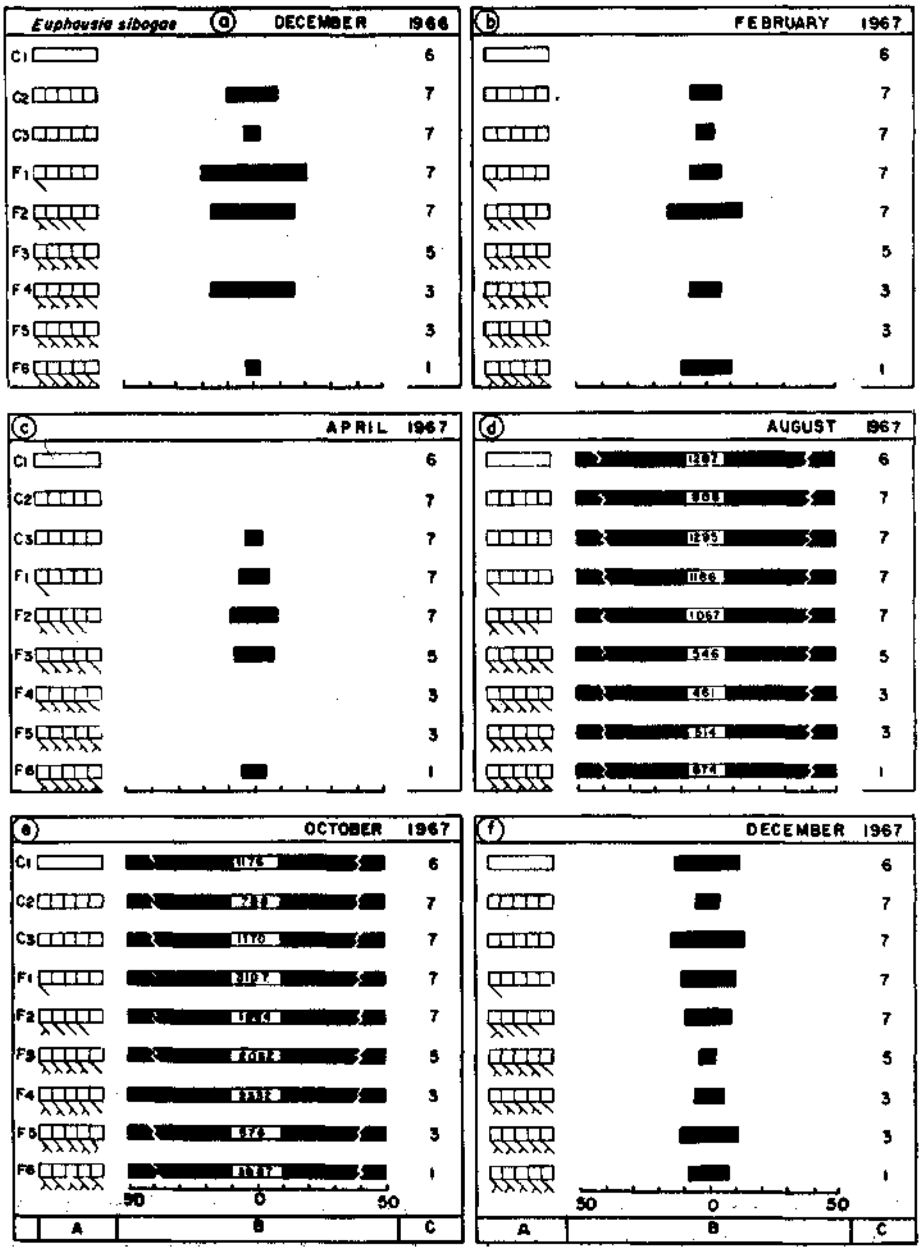


Fig. 14 a-f. Seasonal variations in the abundance of post-naupliar stages of *Euphausia sibogae* (December, 1966 to December, 1967).

as well as their number were less than in the previous months. The calyptopis stages and the fourth and sixth furciliae were absent in this month. The month of June had a few larvae of furcilia stage-10 (29 larvae per 1000 m³ of water). In August all the larval stages except calyptopis-1 and furcilia-6 and 8 were present in the samples but at a reduced rate. In December, 1967 there was an abundance of the larval stages. Except calyptopis-1 all the other stages were represented, with the maximum larvae under furcilia-10.

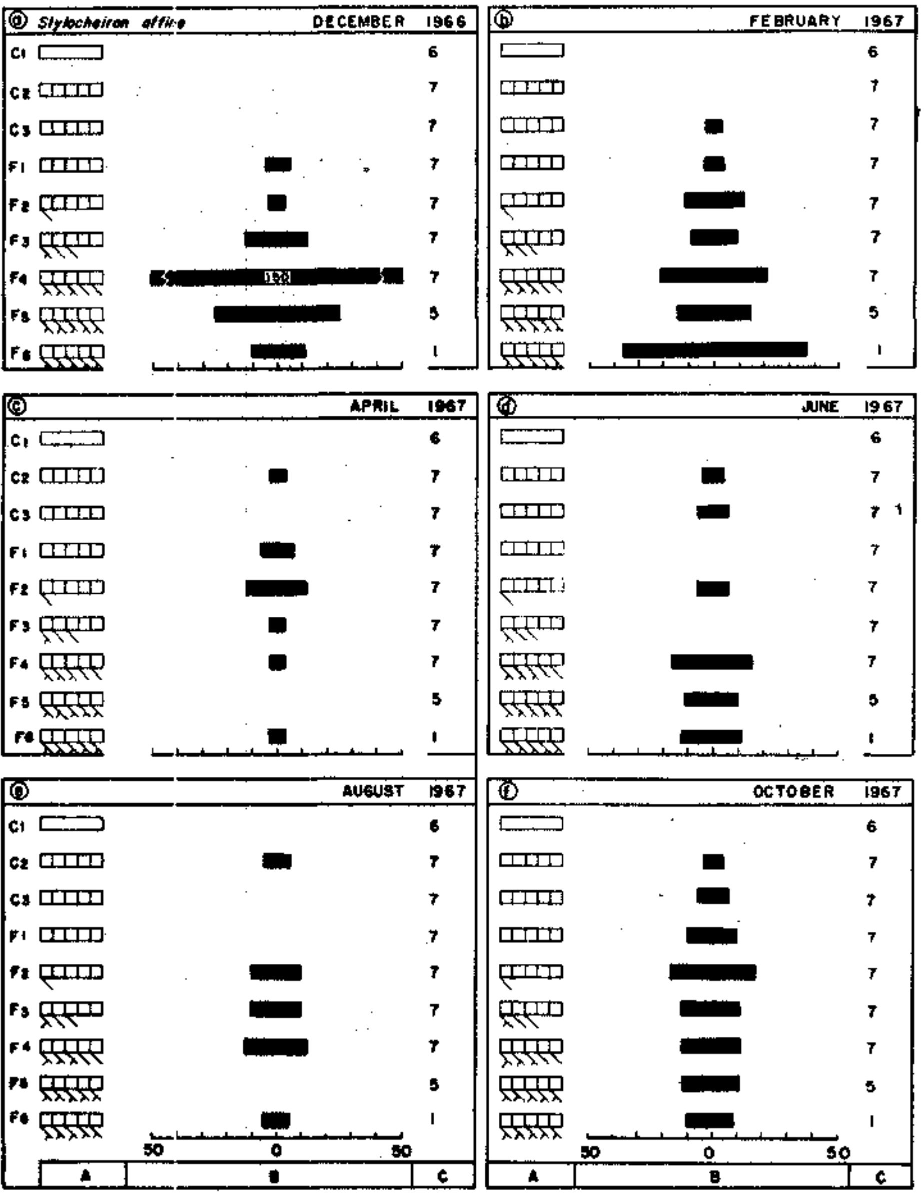


Fig. 15 a-f. Seasonal variations in the abundance of post-naupliar stages of *Stylocheiron affine* (December, 1966 to October, 1967).

The dominance of early larval stages in December, 1966 indicates that the breeding is at its peak in this month. Simultaneously with this the abundance of the last furcilia in this month shows that the breeding had started even before December but later than October. The preponderance of late furciliae in February may be considered as an indication of reduced intensity of breeding. Similarly the absence of calyptopes and the abundance of the late furciliae in April may indicate the tail end of the breeding season in this species. The occurrence of larvae in somewhat moderate numbers in August with the slight abundance of the early stages is not clear as to whether a new brood stock was responsible for this or the breeding continued through June. But the inadequacy of sampling in June makes it difficult to arrive at any conclusions.

Euphausia diomedeae (Fig. 16 b-e)

The first calyptopis was absent in the plankton. In December, 1966 the third calyptopis was the most abundant stage. The early furciliae were also relatively abundant. All the furcilia stages were present in February, while among the calyptopes only the third stage was present. The larvae of early and last furciliae were numerically abundant in this month than in December. In April eventhough each of the larval stages was numerically less abundant, all the typical post-naupliar stages except the first calyptopis were present in the plankton. The third furcilia was comparatively more in this month. After April there was a long gap in the occurrence of larvae until December, 1967. However, a single specimen of third calyptopis was obtained in October. In December, 1967 the condition improved and in this month calyptopis-2 and 3 and all the furciliae except stage 4 and 5 were present.

The pattern of occurrence and the abundance of the larval stages of *E. diomedeae* indicate that the peak breeding season in February was preceded by a less intense breeding in December when more of the early furciliae dominated in the plankton. This may be considered as the beginning of the breeding. After the intense breeding in February it diminished in April and thereafter the breeding ceased.

Euphausia sibogae (Fig. 12 a-g)

From December, 1966 to April, 1967 the larval stages of this species were sparse in the plankton in respect of both quantity and the number of stages. In December, 1966 except the first calyptopis and third and fifth furciliae, all the other stages were present though in extremely fewer numbers. In February the larval occurrence was still poor. In April the condition was no better and in June the larvae were absent. However, in August there was a drastic change in regard to the larval abundance. Large number of larvae belonging to all three calyptopes and all the six furciliae were present in this month. The early stages were relatively more in this month. In October the larval population in general increased further especially with regard to the furciliae. By December, 1967 there was again a sudden decrease in the number of larvae. However, all the typical post-naupliar stages were present.

The breeding intensity of *E. sibogae* as revealed by the variations in the occurrence and abundance of different larval stages is that the peak breeding occurs during the August-October period and thereafter it is at a reduced rate until December. The abundance of late furciliae in August indicates that the breeding has started even earlier to this month but probably later than June. From February to April the breeding continued with least intensity.

Stylocheiron armatum (Fig. 14 b – e)

The larval stages of this species was not present from June to October. Also the calyptopis - 1 was never encountered in any of the months.

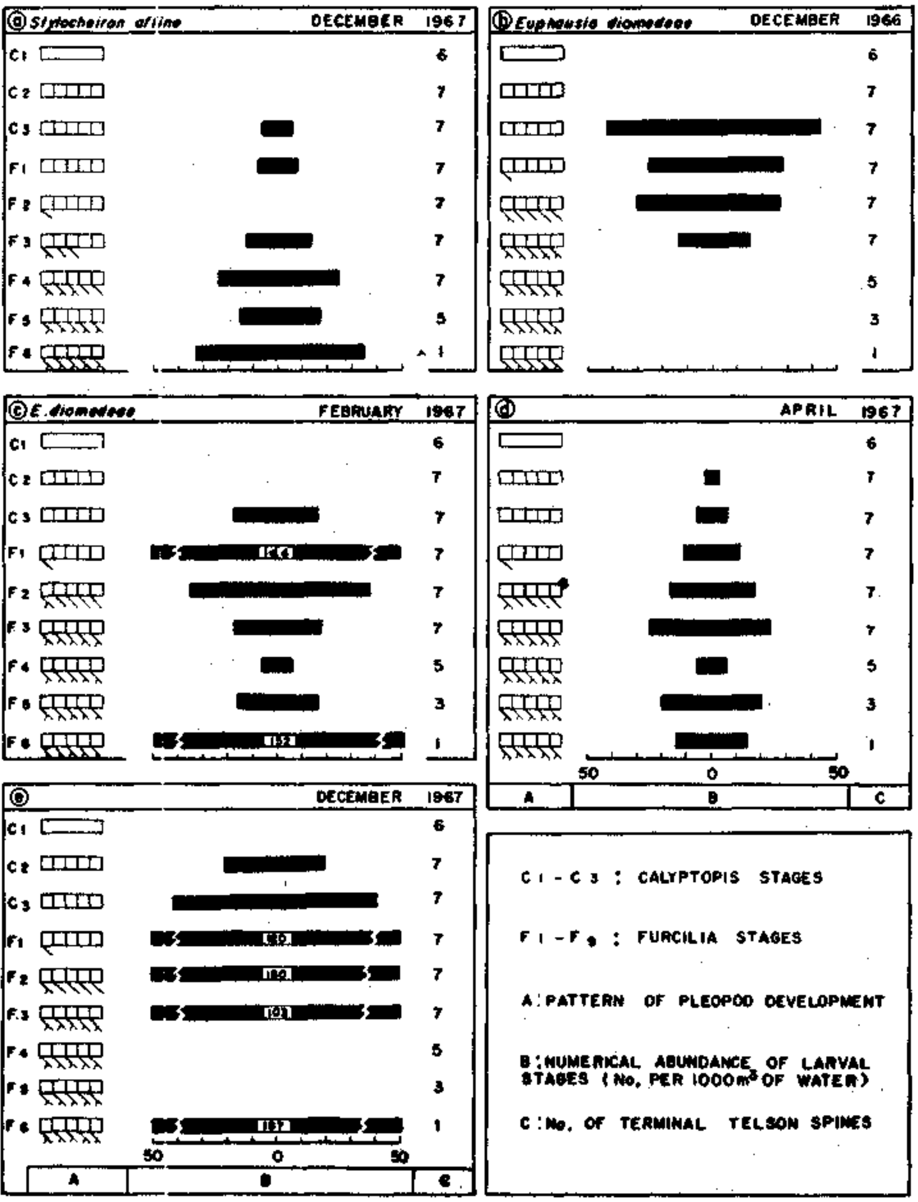


Fig. 16 a. Seasonal variations in the abundance of post-naupliar stages of *Stylochiron affine* (December, 1967) and b-e. of *Euphausia diomedeae* (December, 1966 to December, 1967).

All the stages of furciliae were represented in the month of February, April and December, 1967.

In December, 1966 the intermediate furcilia (F-3) and the late furcilia (F-6) were the dominant forms. In February the intermediate furciliae were the most abundant. In April eventhough all the typical stages except the first calyptopis were present, a numerical abundance of any of the stages was not noticed. The pattern of abundance of larval stages in December, 1967 was almost the same as in February; the intermediate furciliae being dominant over all the others.

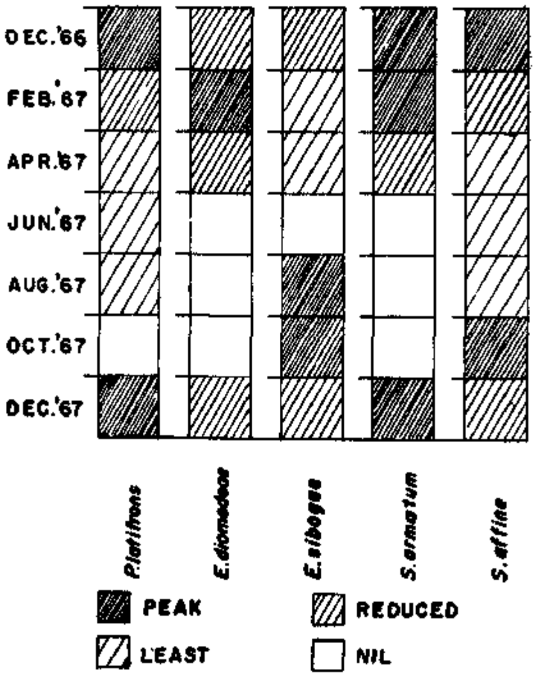


Fig. 17. Breeding intensities in different months among five species of euphausiids of the continental shelf area as revealed by a study of larval stages.

In *S. armatum*, December to February period appears to be the peak breeding season when the intermediate and late furciliae dominated the samples. In April the overall reduction in the quantity of larvae with the dominance of the later furciliae indicates the continuance of breeding but at a reduced rate. From June to October probably no breeding takes place in this species.

Stylocheiron affine (Figs. 15 a-f; 16 a)

This was a species whose larvae were present throughout the year in the area under investigation. The complete stages of furciliae could be collected in December, 1966, February and October, 1967. In December, 1966 the calyptopes were totally absent. Of the furciliae the fourth stage was the most dominant. A few specimens of third calyptopis were present in February. The last furcilia dominated over all the other stages in this month. In April the larval population was comparatively thin. Almost the same trend was continued in June and August. In October all the post-naupliar stages except the first calyptopis were present though at a reduced proportion. The second furcilia was the dominant stage. Again in December, 1967 the last furcilia dominated over the others.

The regular occurrence of larval stages in all the months under consideration shows that breeding is almost continuous in *S. affine*. However, the preponderance of the various stages in different months points to the periods of intensive breeding. October to December appears to be the peak breeding period when early and intermediate furciliae dominated over all the others. The dominance of the last furcilia in February and December, 1967 shows that the intensity of breeding has reduced. After February the breeding continued with minimum intensity.

The intensity of breeding among different species of euphausiids as revealed by a study of the variations in the occurrence and numerical abundance of the larval stages among five species of euphausiids is diagrammatically represented in Fig. 17. Since a sequential succession of the dominant stages month after month could not be traced on account of the wide gap in between two successive samplings, further studies based on frequent sampling are required before any definite conclusions are made on the breeding habits of the species considered above and also other species. Another drawback of the present study was the lack of information on the naupliar stages of the respective species considered. In spite of these lacunae, the present studies give some information on the breeding pattern of some of the species of euphausiids in the present area of investigation.

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