

## STUDIES ON THE LARVAL STAGES OF EUPHAUSIACEA FROM THE INDIAN SEAS

### 1. DIAGNOSTIC CHARACTERS OF POST-NAUPLIAR STAGES OF *EUPHAUSIA DIOMEDEAE* ORTMANN AND *E. DISTINGUENDA* HANSEN

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#### ABSTRACT

Developmental stages of Euphausiacea identified from the zooplankton samples collected during the cruises of R.V. *VARUNA* from the continental shelf waters of the south west coast of India have been described. Brief descriptions for the post-naupliar developmental stages (3 calyptopes and 6 furcilia stages) of the two species of *Euphausia*, *E. diomedae* Ortmann and *E. distinguenda* Hansen have been presented with relevant figures. The distinguishing characters between the larvae belonging to the two species which are the most abundantly occurring Euphausiacea in the epipelagic zone of the tropical waters of the Indian Ocean have been pointed out.

#### INTRODUCTION

FROM the Indian Ocean practically no work has been done on the larval development of euphausiids. Very brief descriptions of one stage of *Thysanopoda cornuta* Illig has been given by Illig (1930). Pillai (1957) described briefly one stage of *T. tricuspidata* Milne-Edwards and *Pseudeuphausia latifrons* (G. O. Sars) from the Travancore coast. Recently Ponomareva (1969) described and figured some of the early larval stages of *Euphausia diomedae* Ortmann and *Stylocheiron carinatum* G. O. Sars, based on specimens reared on board R.V. *VITYAZ*.

The material which formed the basis of the present study was obtained from the plankton samples collected with the Indian Ocean Standard Net (IOSN) in vertical hauls from the region of the continental shelf along the south west coast of India, between Calicut and Karwar (latitudes 11° 00'N and 15°00'N) and also from the Laccadive Sea during cruises of R.V. *VARUNA*. The sampling depth in the shelf region was from 5-10 metres above bottom to the surface and in the open sea it was from 200 metres to the surface.

Of the 24 known species of euphausiids from the Indian seas (Sebastian, 1966 ; Silas and Mathew, 1967), the two epipelagic species, *E. diomedae* and *E. distinguenda* are most common. This paper gives the diagnostic characters and illustrations of all the post-naupliar stages of these two species. In addition, in the samples collected from about 180 stations within the continental shelf area, the larval stages of several other species were also present. The occurrence of these stages has been given in Table 1.

The chief stages in the life history of an euphausiid are: the egg, the nauplius, the metanauplius, the calyptopis (typically 3 stages) and the furcilia (several stages). Of these, the last two were more frequently recorded in the plankton collections with the IOS Net.

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#### DIAGNOSTIC CHARACTERS OF LARVAL STAGES

##### *Euphausia dlomedae* Ortmann (1894)

(Fig. 1 : a-o)

The only previous work on the larval development of this species is of Ponomareva (1969) who briefly described the egg, the nauplius (2 stages) and the calyptopis I and II. She also gave a figure of furcilia II, which is re-identified here as furcilia I.

##### *Calyptopis-I* (Fig. 1 : a and b)

*Material* : 6 larvae ; Total length (TL) : 1.14-1.23 mm ; Mean (M) : 1.18 mm.

Eyes not stalked, but completely overlapped by carapace ; anterior and anterolateral margins of carapace fringed ; posteriorly directed dorsomedian spine present on posterior margin of carapace ; abdomen unsegmented ; pleopods and uropods undeveloped ; telson with a pair of lateral spines, three pairs of posterolateral spines and six terminal spines ; antennule unsegmented ; outer antennular flagellum present as bud ; antenna biramous, endopod unsegmented ; first pair of thoracic legs (Th-I) developed, endopod being unsegmented.

##### *Calyptopis-II* (Fig. 1 : c and d)

*Material* : 7 larvae ; TL : 1.50-1.70 mm ; M : 1.64 mm.

Eyes and carapace same as in calyptopis-I ; abdomen five-segmented ; pleopods and uropods not developed ; one additional median spine developed on tip of telson ; antennule three-segmented, outer and inner flagella as buds ; antenna and Th-I unchanged.

##### *Calyptopis-III* (Fig. 1 : e and f)

*Material* : 5 larvae ; TL : 2.14-2.28 mm ; M : 2.19 mm.

Eyes slightly enlarged and partly exposed, but not stalked ; denticles developed on postero-inferior margins of carapace ; abdomen six-segmented ; uropods developed and biramous ; no change in armature of telson ; length of telson 2.15 times its width at point of insertion of lateral pair of spines ; antennular flagella show progressive elongation ; basal segment of antennule with a long external terminal spine ; antenna and Th-I as in calyptopis-I ; Th-II appearing as buds.

##### *Furcilia-I* (Fig. 1 : g and h)

*Material* : 16 larvae ; TL : 2.54-2.81 mm ; M : 2.67 mm.

Eyes stalked and completely exposed ; posterior dorsomedian spine of carapace still present ; fringes on carapace present as serrations ; pleopods developed on first abdominal segment as non-setose buds ; length of telson 3.30 times its width at point of insertion of lateral pair of spines ; antennule, antenna and Th-I as in calyptopis-III ; antennular flagella further increased in length ; Th-II differentiated into exopod and unsegmented endopod ; Th-III developed as buds.

*Furcilia-II* (Fig. 1 : i and j)

*Material* : 26 larvae ; TL : 2.89-3.33 mm ; M : 3.15 mm.

Dorsomedian spine on posterior margin of carapace absent ; rostral hood developed, broad and provided with a rostral spine directed anteriorly ; five pairs of pleopods developed, first pair alone being setose ; length of telson 4.24 times its width at point of insertion of lateral pair of spines ; antennule, antenna and Th-I as in calyptopis-III ; endopod of Th-II four-segmented, of Th-III unsegmented ; Th-IV to Th-VI appearing as buds.

*Furcilia-III* (Fig. 1 : k and l)

*Material* : 4 larvae ; TL : 3.33-3.51 mm ; M : 3.43 mm.

Rostral hood slightly narrowed ; all five pairs of pleopods setose ; innermost posterolateral spines on telson altered in size and structure, becoming basally broad ; length of telson 5.14 times its width at point of insertion of lateral pair of spines ; antennule, antenna and Th-I as in calyptopis-III ; endopod of Th-II five-segmented, of Th-III four-segmented ; Th-IV with exopod and unsegmented endopod ; Th-V to Th-VIII present as buds.

*Furcilia-IV* (Fig. 1 : m)

*Material* : 5 larvae ; TL : 3.68-3.77 mm ; M : 3.73 mm.

Serrations on anterior and anterolateral margins of carapace less conspicuous ; rostral hood further narrowed and rostral spine elongate ; terminal telson spines reduced from seven to five ; length of telson 5.47 times its width at point of insertion of lateral pair of spines ; antennular flagella and antennal endopod indistinctly segmented ; Th-I and Th-II as in furcilia-III, endopod of Th-III and Th-IV five-segmented and four-segmented respectively ; endopod of Th-V elongated but not segmented ; Th-VI to Th-VIII remain as buds.

*Furcilia-V* (Fig. 1 : n)

*Material* : 8 larvae ; TL : 3.87-4.15 mm ; M : 4.00 mm.

Serrations on anterior and anterolateral margins of carapace totally absent ; rostral hood further narrowed and rostral spine elongated ; no change to nature of abdomen, pleopods and uropods ; terminal spines on telson reduced to three ; length of telson 5.92 times its width at point of insertion of lateral pair of spines ; antennular flagella and antennal endopod distinctly segmented ; Th-I to Th-III as in previous stage ; endopod of Th-IV five-segmented ; no change to Th-V ; Th-VI differentiated into exopod and unsegmented endopod ; Th-VII and Th-VIII remain as buds.

*Furcilia-VI* (Fig. 1 : o)

*Material* : 10 larvae ; TL : 4.25-4.62 mm ; M : 4.50 mm.

Rostral spine transformed into a typical rostrum ; terminal spines on telson reduced from three to one ; length of telson 6.40 times its width at point of insertion of lateral pair of spines ; Th-I as in adult ; endopod of Th-V five-segmented ; of Th-VI indistinctly segmented ; Th-VII and Th-VIII remain as buds, condition in adult.

From this stage the larvae pass on to the juvenile stage where they attain considerable increase in length (TL : 4.68-6.18 mm ; M : 5.96 mm). The telson narrows further. The sixth thoracic legs also attain the adult condition. The outer two pairs of posterolateral spines at the tip of the telson disappear gradually. The transition from the furcilia stage to the juvenile stage is not a clear cut one except in the size increment of the latter, hence the differentiation between the two stages is rather arbitrary, to be done mainly on the size of the animals.

### *Euphausia distinguenda* Hansen (1911)

(Fig. 1 : p-v)

#### *Calyptopis-I* (Fig. 1 : p)

*Material* : 5 larvae ; TL : 0.96-1.15 mm ; M : 1.04 mm.

Carapace smooth along its margins and with no posterodorsal median spine ; eyes, abdomen, antennule, antenna, telson and Th-I same as in calyptopis-I of *E. diomedea*.

#### *Calyptopis-II*

*Material* : 7 larvae ; TL : 1.49-1.58 mm ; M : 1.55 mm.

Carapace unchanged ; other salient characters are same as described for this stage in *E. diomedea*.

#### *Calyptopis-III*

*Material* : 5 larvae ; TL : 1.93-2.00 mm ; M : 1.95 mm.

Length of telson 2.10 times its width at point of insertion of lateral pair of spines ; Th-II undeveloped ; other characters as in corresponding stage of *E. diomedea*.

#### *Furcilia-I*

*Material* : 15 larvae ; TL : 2.37-2.54 mm ; M : 2.47 mm.

Carapace with a small crest in median line just behind rostral hood ; length of telson 2.76 times its width at point of insertion of lateral pair of spines ; Th-II and Th-III developed as buds. Larvae of both species resemble in other characters.

#### *Furcilia-II* (Fig. 1 : q and r)

*Material* : 16 larvae ; TL : 2.72-3.01 mm ; M : 2.86 mm.

First pair of pleopods setose ; three more pairs of non-setose pleopods developed behind first pair ; length of telson 3.58 times its width at point of insertion of lateral pair of spines ; Th-II and Th-III differentiated into exopod and unsegmented endopod ; Th-IV to Th-VI developed as buds.

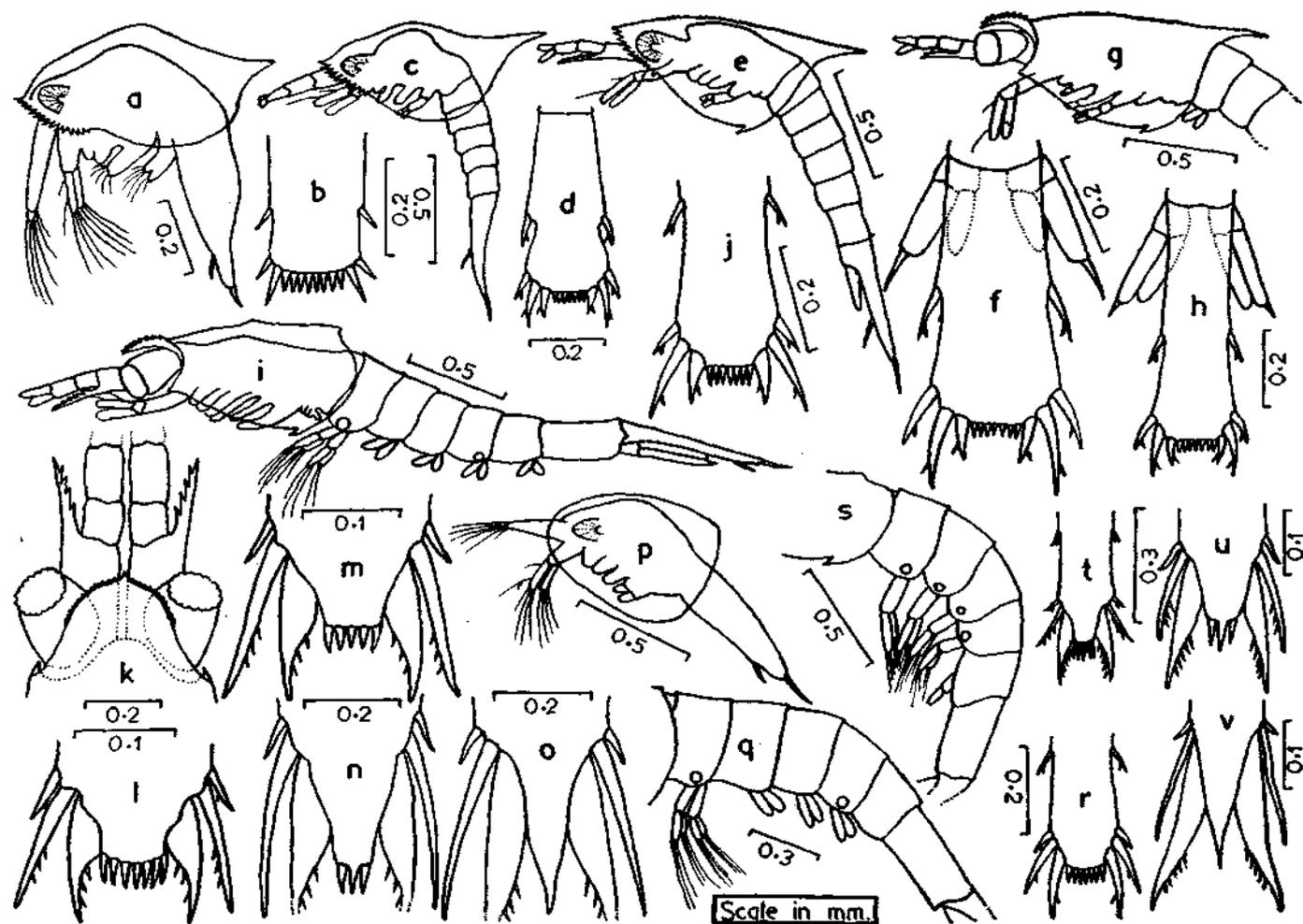


FIG. 1. a-o. larval stages of *Euphausia diomedeae* Ortmann. a. calyptopis-I; b. telson of same; c. calyptopis-II; d. telson of same; e. calyptopis-III; f. telson of same; g. furcilia-I. (cephalothorax and part of abdomen); h. telson of same; i. furcilia-II.; j. telson of same; k. furcilia-III. (cephalic portion); l. telson of same; m-o. telsons of furcilia-IV-VI. p-v. larval stages of *Euphausia distinguenda* Hansen; p. calyptopis-I; q. furcilia-II. (abdomen); r. telson of same; s. furcilia-III. (abdomen); t. telson of same; u. telson of furcilia-IV.; v. telson of furcilia-VI.

*Furcilia-III* (Fig. 1 : s and t)

*Material* : 12 larvæ ; TL : 3.00-3.33 mm ; M : 3.13 mm.

First four pairs of pleopods setose ; fifth pair developed as non-setose buds ; terminal telson spines reduced from seven to five ; innermost posterolateral spines on telson altered in size and structure being basally broad ; length of telson 4.53 times its width at point of insertion of lateral pair of spines ; Th-II five-segmented ; Th-III to Th-VI as in furcilia-II.

*Furcilia-IV* (Fig. 1 : u)

*Material* : 12 larvae ; TL : 3.16-3.42 mm ; M : 3.25 mm.

Terminal telson spines reduced to three ; length of telson 5.10 times its width at point of insertion of lateral pair of spines ; pleopods and thoracic legs as in furcilia-III.

TABLE 1. Larval stages and number of larvae of euphausiids from the continental shelf waters of the south west coast of India from R.V. VARUNA collections : 1966-'67

Species	No. of stations where larvae were taken	Total No. of specimens collected for each larval stage				
		C-I	C-II	C-III	Furciliae No. of stages in parenthesis	Juveniles
<i>Thysanapoda monacantha</i>	5	—	—	—	4* (4)	11
<i>T. tricuspidata</i>	7	1	1	2	24* (9)	—
<i>Euphausia diomedea</i>	14	—	1	20	199 (6)	187
<i>E. tenera</i>	6	—	—	—	50 (7)	7
<i>E. distinguenda</i>	32	502	496	753	1775 (9)	317
<i>Pseudeuphausia latifrons</i>	59	1	26	8	964 (13)	442
<i>Nematoscelis gracilis</i>	26	—	1	17	115* (6)	94
<i>Stylocheiron carinatum</i>	38	—	10	23	431 (9)	179
<i>S. affine</i>	20	—	3	2	186 (9)	83
<i>S. submii</i>	4	—	—	—	9* (5)	1
<i>S. microphthalma</i>	3	—	—	—	—	14
<i>S. maximum</i>	1	—	—	—	1* (1)	—
<i>S. longicorne</i>	1	—	1	1	3* (3)	—

\* Furcilia stages incomplete ; C-I—C-III Calyptopes stages I-III.

*Furcilia-V*

*Material* : 7 larvae ; TL : 3.33-3.51 mm ; M : 3.44 mm.

All five pairs of pleopods setose ; telson retains three terminal spines ; length of telson 5.63 times its width at point of insertion of lateral pair of spines ; endopod of Th-III segmented ; Th-IV differentiated into exopod and unsegmented endopod ; Th-V and Th-VI as in furcilia-II.

*Furcilia-VI* (Fig. 1 : v)

*Material* : 12 larvae ; TL : 3.46-3.68 mm ; M : 3.58 mm.

Terminal telson spine reduced to one ; length of telson 6.20 times its width at point of insertion of lateral pair of spines ; Th-IV as in furcilia V ; Th-V and Th-VI still rudimentary ; Th-VII developed as buds.

From this stage the larvae pass on to the juvenile stage (TL : 3.74-4.96 mm ; M : 4.62 mm) where they develop the full compliment of thoracic legs of which Th-VII and Th-VIII are rudimentary as in the adults. Other changes occur as in the juveniles of *E. diomedae*.

## DISCUSSION

The larval development of both the species, *E. diomedae* and *E. distinguenda* follows a similar pattern except for a few peculiarities in some of the characters. The chief distinguishing features between the larvae belonging to the two species are :

(1) In each eye of the furcilia larvae of *E. diomedae* the ommatidia are arranged in three sets ; one upper set directed upwards, a second lower set directed downwards and a third middle set arranged in a horizontal plane giving the eye a slightly oblong appearance. In the furcilia larvae of *E. distinguenda* the ommatidia in the eye are arranged in such a way that they face all directions giving the eye a rounded shape.

(2) The serrations on the anterior and anterolateral margins of the carapace and the spine on the posterior part of the carapace are very characteristic of the early larval stages of *E. diomedae*, these being absent in *E. distinguenda*.

(3) There are marked differences between the larvae of the two species in the development of the thoracic legs and pleopods and in the reduction in the number of terminal telson spines (Table 2).

Gurney (1942) has classified the larvae of *Euphausia* into three groups based on the pleopod formula, which are (a)  $1' \rightarrow 1'' + 4' \rightarrow 5''$  (one non-setose  $\rightarrow$  one setose + four non-setose  $\rightarrow$  five setose) ; (b)  $4' \rightarrow 4'' + 1' \rightarrow 5''$  and (c)  $1' \rightarrow 1'' + 3' \rightarrow 4'' + 1' \rightarrow 5''$ . Of these, the pleopod formula of the first group is applicable to *E. diomedae*. Gurney (1942) seems to have doubtfully placed *E. distinguenda* under the second group, but the present observations show that the pleopod formula of this species is similar to that of the third group. In the first group, there are three other species having the same pleopod formula. The fringes on the anterolateral margins of the carapace and a median dorsal spine on the posterior margin of the carapace in the early larval stages of these species namely *E. krohnii* Brandt., *E. brevis* Hansen and *E. lucens* Hansen are also alike (Lebour, 1926, 1949 ; Gurney, 1942 ; Boden,

TABLE 2. Sequence of development of pleopods and thoracic legs and reduction of terminal telson spines in furcilia larvae of *E. diomedeae* and *E. distinguenda*

Characters	Species	Fur-I	Fur-II	Fur-III	Fur-IV	Fur-V	Fur-VI	
Pleopods	<i>E. diom.</i>	N=1 : S=0	N=4 : S=1	N=0 : S=5	N=0 : S=5	N=0 : S=5	N=0 : S=5	
	<i>E. dist.</i>	N=1 : S=0	N=3 : S=1	N=1 : S=4	N=1 : S=4	N=0 : S=5	N=0 : S=5	
No. of terminal telson spines	<i>E. diom.</i>	7	7	7	5	3	1	
	<i>E. dist.</i>	7	7	5	3	3	1	
Thoracic legs	<i>E. diom.</i>	a :	3	4, 5, 6	5, 6, 7, 8	6, 7, 8	7, 8	7, 8
		b :	2	3	4	5	5, 6	6
		c :	1	1, 2	1, 2, 3	1, 2, 3, 4	1, 2, 3, 4	1, 2, 3, 4, 5
	<i>E. dist.</i>	a :	2, 3	4, 5, 6	4, 5, 6	4, 5, 6	5, 6	5, 6, 7
		b :	—	2, 3	3	3	4	4
		c :	1	1	1, 2	1, 2	1, 2, 3	1, 2, 3

N=non-setose and S=setose pleopods ; a, b, c : development of thoracic legs (a) as bud ; (b) differentiated into exopod and unsegmented endopod ; and (c) endopod segmented ; Fur-I—Fur-VI : furcilia stages I-VI.

1955). Of these *E. krohnii* is not known to occur in the Indian Ocean. *E. brevis* has been recorded from the Indian Ocean (Illig, 1930 ; Tattersall, 1939 ; Ponomareva, 1964 ; Baker, 1965) from different areas though during the present investigations it has not been seen in the plankton collected from the south west coast of India and the Laccadive Sea. *E. lucens* has been recorded only once from the Indian Ocean between 32°49'S and 37°09'S (Baker, 1965). In the third group three other species, *E. similis* G. O. Sars, *E. spinifera* G. O. Sars and *E. longirostris* Hansen are present. The developmental stages of these three are known. The latter two species are at present known from the colder waters of the southern Indian Ocean and the sub-antarctic and subtropical waters of the Atlantic and Pacific Oceans but have not been reported from the Indian Seas. *E. similis* is abundantly present in the Indian Ocean south of 30°S (Baker, 1965).

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