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STUDIES ON THE LARVAL HISTORY OF TWO SPECIES OF EUPHAUSIACEA FROM THE INDIAN SEAS*

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ABSTRACT

The literature on the larval development in Euphausiacea of the Indian Ocean is very poor. The present paper deals in detail with the complete post-naupliar development of two species of the genus *Euphausia*; *E. diomedea* Ortmann 1894 and *E. distinguenda* Hansen 1911. These are the two most abundant euphausiids in the tropical Indian Ocean. Three calyptopis and six furcilia stages were identified for *E. diomedea*; all of them being typical stages. But for *E. distinguenda* three calyptopis and twelve furcilia stages were identified of which six furciliae are variants. The types of variants seen are also discussed.

INTRODUCTION

VERY little is known about the larvae of euphausiids and their developmental stages in the tropical waters of the oceans. In the Indian Ocean particularly, no substantial work has so far been done in this field. The earliest reference on larval euphausiids in the Indian Ocean is that by Illig (1930) who worked on the *VALDIVIA* Expedition material and briefly described one early furcilia of *Thysanopoda cornuta* Illig, taken from 10°08' S-97° 15'E, and another furcilia probably the last of an unidentified species of *Thysanopoda* Milne Edwards taken from 30°25' S-58°35'E. These are the only larval descriptions appearing in this work although larvae of 27 species had been collected during the Expedition from the Indian Ocean side and are listed as occurring in this area. Pillai (1957) has described from the Kerala Coast the calyptopis-III, furcilia-I, Furcilia-IV and postlarva of *Pseudeuphausia latifrons* (G.O. Sars), the furcilia-I of *T. tricuspidata* Milne Edwards and the furcilia-V and post-larva of *Nematoscelis tenella* G. O. Sars. He has also described some more furciliae of *T. tricuspidata* and *N. tenella* without specifying the stage numbers. Kurian (1954) has described in brief some stages of (not assigned to any particular stage) of larvae of *Nyctiphanes simplex* taken off Trivandrum, but the identity of the species appears to be erroneous since the species is not known from the Indian Ocean. Ponomareva (1969) described in brief and also illustrated some of the early larval stages of *Euphausia diomedea* Ortmann, one of the most abundant species in the tropical Indian Ocean. The larvae for the study were reared on board *R. V. VITYAZ* during her cruise to the Indian Ocean. The stages described are the egg, the nauplius (2 stages) the metanauplius, the calyptopis-I and II

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and the furcilia-II. Based on the reared larvae she has also described the egg, the nauplius, the calyptopis-I and II and the furcilia-II of *Stylocheiron carinatum* G. O. Sars. Mathew (1971, 1972) gave the diagnostic characters of all the post-naupliar stages upto juvenile of *E. diomedae*, *E. distinguenda* and *S. carinatum* based on the material collected from along the south west coast of India and the Lakshadweep Seas.

In the present paper an attempt has been made to describe in detail the complete post-naupliar developmental stages (calyptopes and furciliae) of *E. diomedae* and *E. distinguenda*. For the source of the material which formed the basis of the present work reference may please be made to Mathew (1971).

The author is greatly indebted to Dr. E. G. Silas for guidance, examining the material, helpful suggestions and critically going through the manuscript and his sincere thanks are due to him.

DESCRIPTION OF DEVELOPMENTAL STAGES

Euphausia diomedae Ortmann (1894), (Figs. 1 - 5)

Calyptopis-I (Fig. 1 a-j)

Material: 6 larvae of Total Length (TL) 1.14 mm (3); 1.19 (1); 1.21 (1); 1.23 (1).

Carapace hooded anteriorly and bears denticles on anterior and anterolateral margins; developing compound eyes, cephalothorax and part of abdomen seen completely covered over by carapace; posteriorly carapace produced into a dorsomedian spine directed slightly upwards; no denticle developed on inferior margins of carapace. Abdomen (Ab) unsegmented; a pair of ventrolateral spines present at about one fourth length of Ab from distal end; towards posterior end of Ab (telson in future) present three pairs of posterolateral spines and another six spines at tip; innermost pair of posterolateral spines resemble terminal spines in shape and size and placed more or less terminally, thus giving a false impression that totally eight terminal spines present on telson (Tel).

Antennular (A1) peduncle unsegmented; it bears at its distal end a rudimentary bud-like structure, outer flagellum with three long and one short setae; inner flagellum not noticeable but two long spines represent its position; antenna (A2) biramous and its peduncle two-segmented; anterior ramus of A2 bears four long and one short spines terminally and two other lateral spines; mandible (Md) consists of a cutting, a dentate and a grinding portion; in between dentate part and grinding part or molar protuberance a movably articulated toothed dentiform projection—*lacina mobilis*—present having a bunch of thin setae at its base; palp of first maxilla (Mx1) consists of two segments of which distal segment bears two long spines; inner masticatory lobe carries seven spines of varying lengths and sizes while outer masticatory lobe carries three very strong spines having accessory spinules on them; exopod of Mx1 small and it carries four plumose spines directed in four directions; second maxilla (Mx2) five lobed and carries a segment terminally; a number of long strong spines present on all lobes internally which in turn bears small spinules on them; terminal segment with three spines.

First thoracic leg (Th1) developed and biramous, its endopod being two-segmented; a short but strong spine present at outer junction where exopod unites

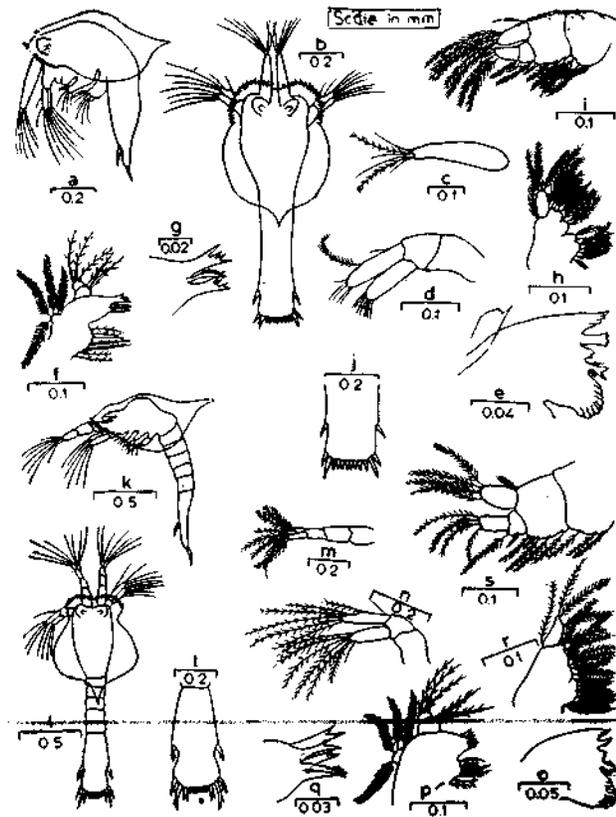


Fig. 1. *Euphausia diomedea*. a-j. calyptopis-I: a. lateral view; b. dorsal view; c. antennule; d. antenna; e. mandible; f. Mx1; g. outer masticatory lobe of Mx1; h. Mx2; i. Th1; j. Tel part. k-t. calyptopis-II: k. lateral view; l. dorsal view; m. A1; n. A2; o. Md; p. Mx1; q. outer masticatory lobe of Mx1; r. Mx2; s. Th1; and t. Tel part.

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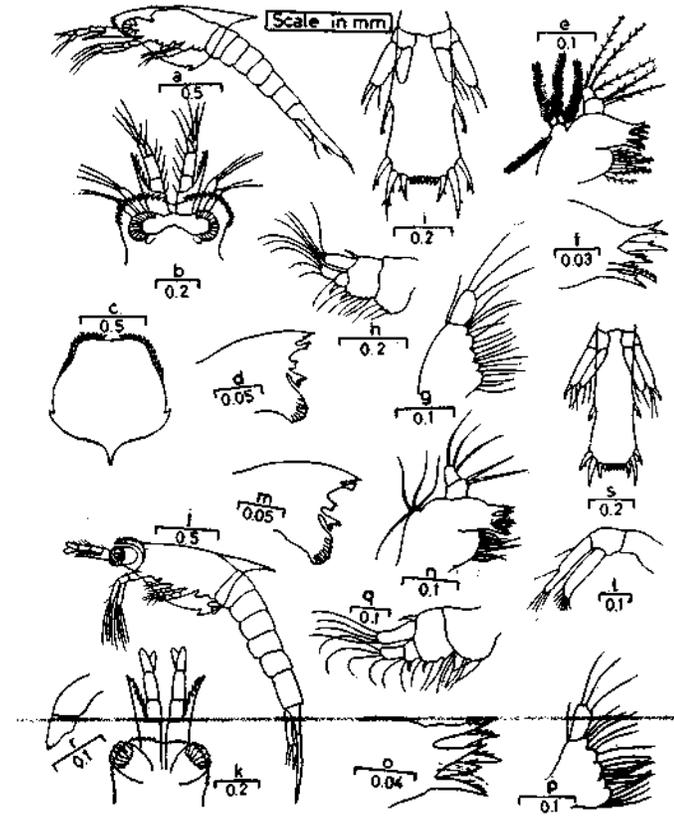


Fig. 2. *Euphausia diomedea*. a-i. calyptopis-III: a. lateral view; b. dorsal view of cephalic region; c. dorsal view of carapace; d. Md; e. Mx1; f. outer masticatory lobe of Mx1; g. Mx2; h. Th1; i. Tel with uropods. j-s. furcilia-1: j. lateral view; k. dorsal view of cephalic region; l. A2; m. Md; n. Mx1; o. outer masticatory lobe of Mx1; p. Mx2; q. Th1; r. Pl 1; and s. Tel with uropods.

with basipodite; exopod and distal end of endopod carry four long spines each terminally; proximal segment of endopod bears a short and a long spine each on outer margin; several spines of varying shape and size present on basipodite and coxopodite.

Calyptopis-II (Fig. 1 k-t)

Material: 9 larvae of TL 1.50 mm (1); 1.58 (1); 1.63 (1); 1.67 (4); 1.70 (2).

Carapace still hooded anteriorly and denticles present more towards anterior portion; posterior median spine on carapace more elongated and pointed than in calyptopis-I; lateral denticles on inferior margin of carapace still not developed; compound eyes fully overlapped by carapace and well distinguished; posterior portion of carapace wider than anterior portion; carapace still covers a portion of five-segmented Ab; pleopods (Pl 1-5) absent; Tel still in common with Ab 6; lateral spines on Tel more robust and each of them bears a denticle at its inner margin towards middle; a constriction present on Tel posterior to these spines; all three pairs of posterolateral spines well developed, middle one being longest; inner pair of posterolateral spines clearly distinguishable from terminal spines; an additional spine developed on tip of Tel thus making altogether seven terminal spines; uropods not yet developed, but slight thickening of tissues just anterior to lateral spines present where uropods to develop.

A1 distinctly biramous and peduncle three-segmented; outer ramus of flagella longer than inner one and both flagella bear long spines terminally; A2 same as in previous stage, except for size increase; Md and Mx2 same as in calyptopis-I; five strong spines present on outer masticatory lobe of Mx1; no difference in structure of Th 1; no other thoracic leg developed.

Calyptopis-III (Fig. 2 a-i)

Material: 5 larvae of TL 2.14 mm (2); 2.19 (2); 2.28 (1).

No change in shape and structure of carapace except development of a pair of lateral denticles on its inferior margin; posteriorly eyes not yet stalked and still covered by carapace; Ab six-segmented and Tel well differentiated, armature of latter same as in calyptopis-II; length of Tel 2.15 times its width at point of insertion of lateral pair of spines; uropod consists of a basal segment and two ramii, outer ramus-exopod-longer than inner and carries a strong spine posteriorly on outer corner.

A1 three-segmented and basal segment produced externally into a strong, pointed but basally broad spine extending to a little beyond distal segment of A1 peduncle, with a set of small spinules on its margin; flagella of A1 further increased in length than in previous stage but unsegmented; A2, Md, Mx1, Mx2 and Th1 unchanged; Th 2 visible as rudimentary bud.

Furcilia-I (Fig. 2 j-s)

Material: 16 larvae of TL 2.54 mm (4); 2.60 (1); 2.63 (3); 2.72 (2); 2.74 (1); 2.75 (2); 2.80 (2); 2.81 (1).

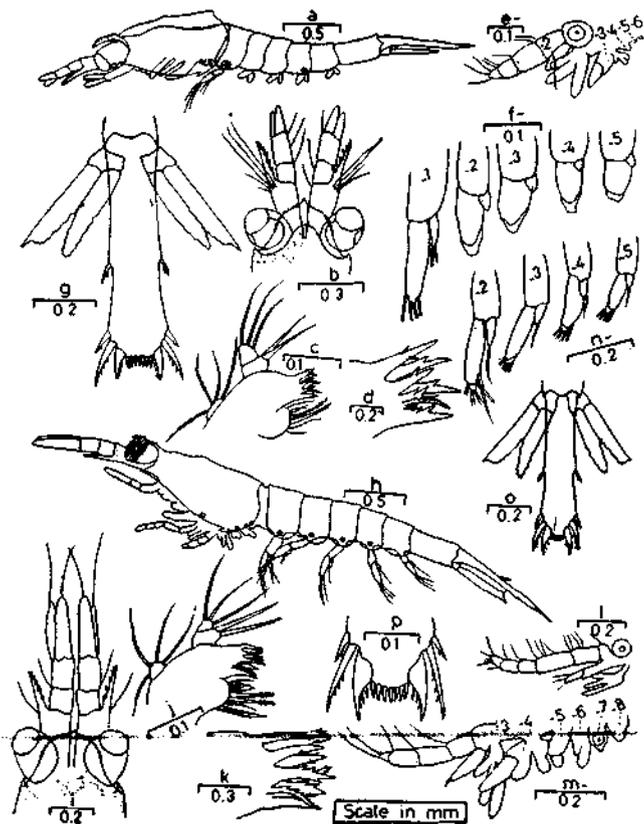


Fig. 3. *Euphausia diomedea*. a-g. furcilia-II: a. lateral view; b. dorsal view of cephalic region; c. Mx1; d. outer masticatory lobe of Mx1; e-6. Th2 to Th6; f1-5. Pls1-5; g. Tel with uropods. h-p. furcilia-III: h. lateral view; i. dorsal view of cephalic region; j. Mx1; k. outer masticatory lobe of Mx1; l. Th2; m 3-8. Th3 to Th8; n2-5. Pls2-5; o. Tel with uropods; and p. terminal part of Tel.

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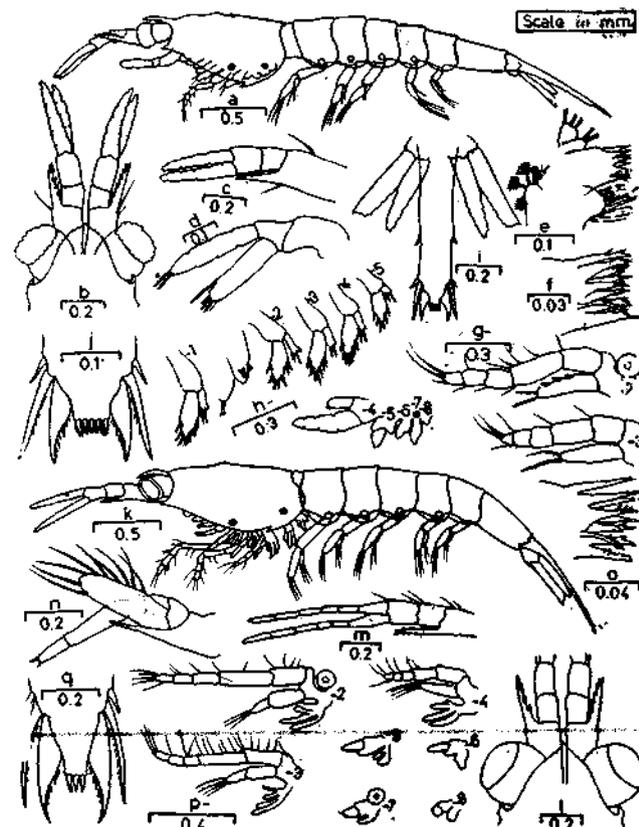


Fig. 4. *Euphausia diomedea*. a-j. furcilia-IV: a. lateral view; b. dorsal view of cephalic region; c. A1; d. A2; e. Mx1; f. outer masticatory lobe of Mx1; g. 2-8. Th2-Th8; h1-5. Pls1-5; i. Tel. with uropods; j. terminal part of Tel.; k-q. furcilia-V: k. lateral view; l. dorsal view of cephalic region; m. A1; n. A2; o. outer masticatory lobe of Mx1; p2-8. Th2-Th8; and q. terminal part of Tel.

Eyes distinctly stalked and project out of carapace; posterior median spine on carapace still retained, anterior and anterolateral margins of carapace strongly serrated than denticulated; Ab well differentiated; P1 developed as simple non-setose buds on Ab 1; Tel and uropods also well defined; strong spine at tip of exopod of uropod reduced in size than in previous stage; unlike in calytopis-III endopod of uropod not very smaller than exopod; armature of Tel remains same.

Excepting a little lengthening of A1 flagella no change in structure of A1, A2, Md, Mx2 and Th 1; outer masticatory lobe of Mx1 with seven spines on it; Th2 differentiated into exopod and unsegmented endopod; Th3 developed as bud.

Furcilia-II (Fig. 3 a-j)

Material: 26 larvae of TL 2.89 mm (1); 2.95 (2); 2.98 (1); 3.07 (1); 3.09 (1); 3.12 (2); 3.16 (6); 3.18 (3); 3.19 (1); 3.21 (2); 3.23 (2); 3.32 (2); 3.33 (2).

Carapace narrowed and elongated anteriorly into a rostral hood with a small median spine-like process in front; serrations on margins of carapace still retained; eyes completely project out of carapace by long stalks; dorsomedian spine on posterior end of carapace lost; mid-dorsal part of carapace with a slight elevation representing dorsal keel in adult; Ab more elongate and all five pairs of PIs developed, first pair setose and others simple and non-setose buds; a photophore developed at base of first pair of PIs; Tel same as in previous stage; exopod and endopod of uropod further lengthened and provided with several setae on inner margins of exopod and on both margins of endopod; spine at posterior and on outer corner of exopod further reduced in size.

No change to A1 and A2 except growth and addition of more setae; Md, Mx1, Mx2 and Th 1 unchanged; endopod of Th 1 four-segmented and bears setae on inner margin; photophore and a trilobed gill developed at base of Th2; exopod leaf-like; Th3 differentiated into exopod and unsegmented endopod and gill present as a trilobed structure; Th 4 to Th 6 present as buds.

Furcilia-III (Fig. 3 k-q)

Material: 4 larvae of TL 3.33 mm (1); 3.44 (1); 3.45 (1); 3.51 (1).

Rostral hood further narrowed; eyes well developed and ommatidia clearly distinguishable and pigmented; in Ab all PIs setose; Ab photophore developed at base of P1 2 also; distal end of Tel much narrower; structure and shape of inner pair of posterolateral spines altered, basal part being swollen very much; uropods unchanged; no change in structure of Md and Mx2; outer masticatory lobe of Mx1 developed two more spines on it making a total compliment of nine spines; Th1 unchanged; endopod of Th2 five-segmented and provided with several setae on all segments internally; endopod of Th3 four segmented; Th5 differentiated into exopod and unsegmented endopod; Th6 and Th7 present as buds; photophore developed at base of Th7.

Furcilia-IV (Fig. 4: a-j)

Material: 5 larvae of TL 3.68 mm (1); 3.72 (1); 3.73 (1); 3.74 (1); 3.77 (1).

Rostral hood again narrowed and elongated; serrations on anterior and anterolateral margins of carapace reduced into minute projections; Ab as in furcilia-III;

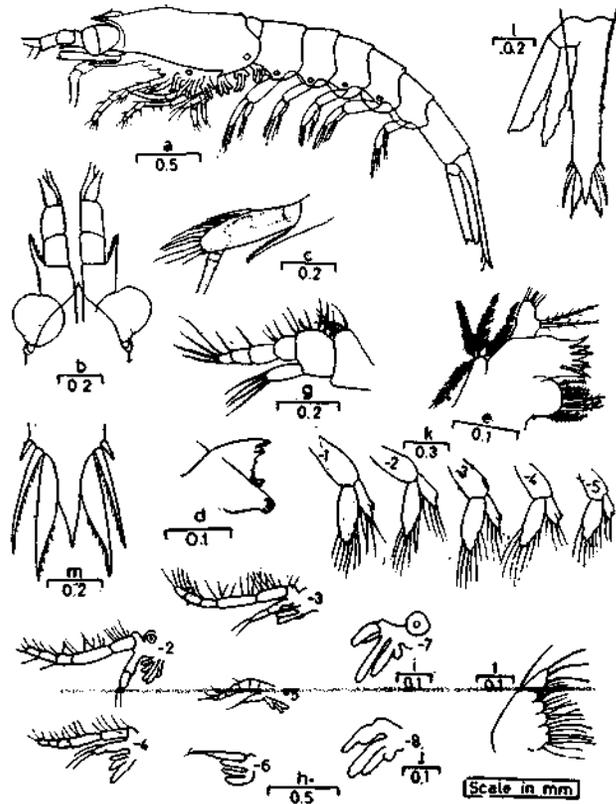


Fig. 5. *Euphausia diomedea*. a-m. furcilia-VI: a. lateral view; b. dorsal view of cephalic region; c. A2; d. Md; e. Mx1; f. Mx2; g. Th1; h2-6. Th2-Th6; i. Th7; j. Th8; k1-5. P1-5; l. Tel. with uropods; and m. terminal part of Tel.

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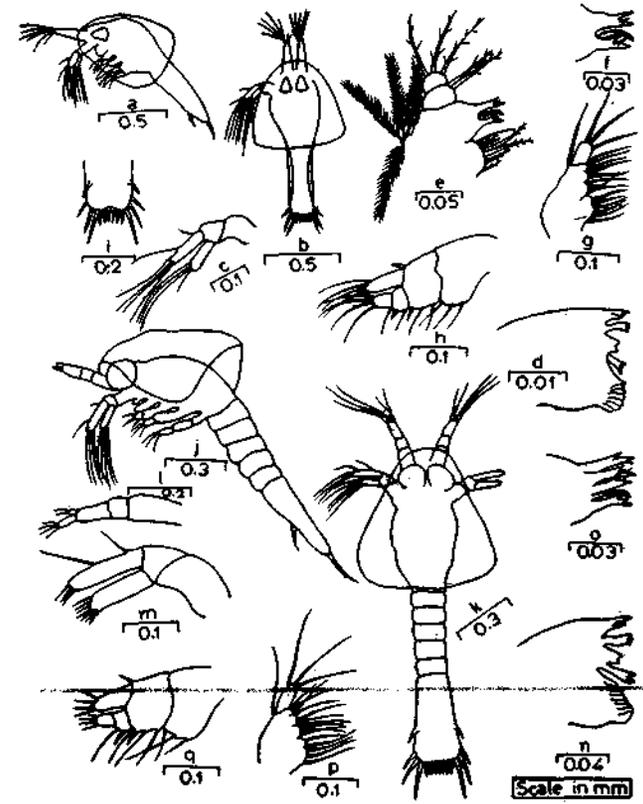


Fig. 6. *Euphausia distinguenda*. a-i. calyptopis-I: a. lateral view; b. dorsal view; c. A1; d. Md; e. Mx1; f. outer masticatory lobe of Mx 1; g. Mx2; h. Th1; i. Tel; j-q. calyptopis-II: j. lateral view; k. dorsal view; l. A1; m. A2; n. Md; o. outer masticatory lobe of Mx1; p. Mx2; and q. Th1.

distal part of Tel further narrowed, its lateral spines and outer pair of posterolateral spines reduced in length and thickness than in previous stages; number of terminal spines reduced from seven to five; all Pl well developed as in adults.

Flagella of A1 lengthened considerably and show signs of segmentation; A2 also shows indications of changing into a scale and a flagellum, flagellum showing beginning of future segmentation; mouth parts all without any change except growth; no change to Th 1; Th2 and Th3 increased in lengths; endopod of Th4 gives a four segmented appearance; Th5 differentiated into exopod and unsegmented endopod; buds of Th6 and Th7 emerged out as finger-shaped structures.

Furcilia-V (Fig. 4 k-q)

Material: 6 larvae of TL 3.87 mm (1); 3.93 (2); 4.00 (2); 4.15 (1).

Serrations on anterior and anterolateral margins of carapace disappeared completely; no change in Ab; Tel narrowed still further, its lateral pair of spines and outer pair of posterolateral spines gradually reduced in length; terminal spines of Tel reduced to three; flagella of A1 six-segmented; A2 totally changed its shape and its endopod shows four segments, two peduncular and two flagellar segments; insertion of scale or exopod of A2 below base of second protopodal segment gives a false appearance that three peduncular segments present for flagellum; exopod or scale becomes enlarged and flattened and provided with a number of setae on its inner and distal margins; first protopodal segment developed a strong spine projecting from outer corner; Th1 to Th3 unchanged; endopod of Th4 five-segmented; Th5 unchanged; Th6 differentiated into exopod and unsegmented endopod; Th7 and Th8 present as buds.

Furcilia-VI (Fig. 5 a-m)

Material: 10 larvae of TL 4.25 mm (1); 4.32 (1); 4.49 (2); 4.55 (2); 4.58 (3); 4.62 (1).

Rostral spine on rostral hood long and sharp; median dorsal keel on carapace more pronounced; Tel further narrowed its outer posterolateral spines very feeble and minute with only one spine on it.

A1 flagella very long and many segmented; spine at distal end of basal segment of A1 peduncle projecting outside reduced in size and reached slightly beyond distal end of second segment; A2 scale developed more bristles on its inner and distal margins; a small spine present at distal end on outer corner of scale; spine on first protopodal segment developed several spinules on its inner margin; in Md lacina mobilis still present but rudimentary; Mx1 and Mx2 unchanged.

Th1 shows great changes from all previous stages; endopod more elongated and four-segmented; Th2 to Th4 increased in size; endopod of Th5 five-segmented; endopod of Th6 shows indistinct segmentation; Th7 and Th8 remain as buds.

The larvae of the sixth furcilia stage moult as juveniles and during this stage they increase in size; Th6 which was not fully developed in the last furcilia stage attain adult condition. Th7 and Th8 remain as buds even in the adults.

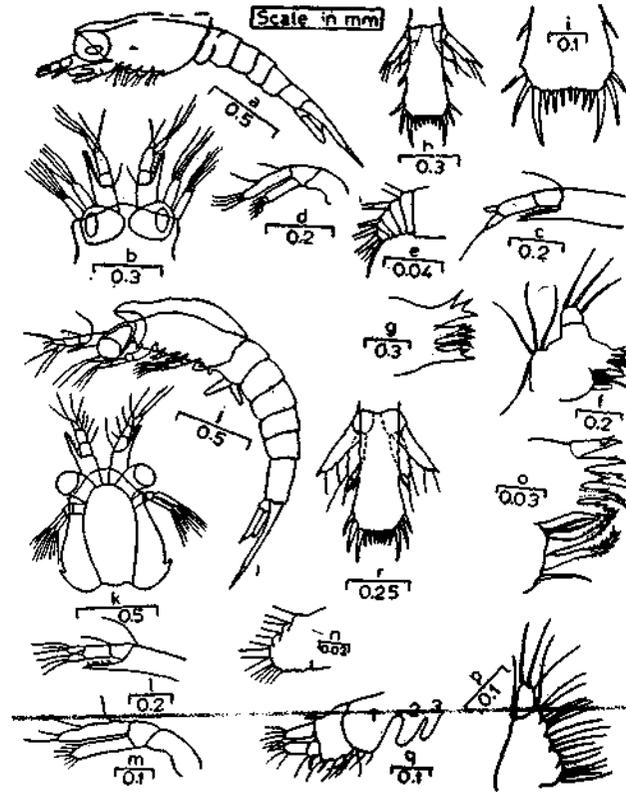


Fig. 7. *Euphausia distinguenda*. a-i. calyptopis-III: a. lateral view; b. dorsal view of cephalic region; c. A1; d. A2; e. tip of A2 endopod enlarged; f. Mx1; g. outer masticatory lobe of Mx1; h. Tel. with uropods; i. tip of Tel enlarged. j-r. furcilia-I: j. lateral view; k. dorsal view of cephalothorax; l. A1; m. A2; n. tip of A2 endopod enlarged; o. outer and inner lobe of Mx1; p. Mx2; q 1-3. Th1 to Th3; and r. Tel. with uropods.

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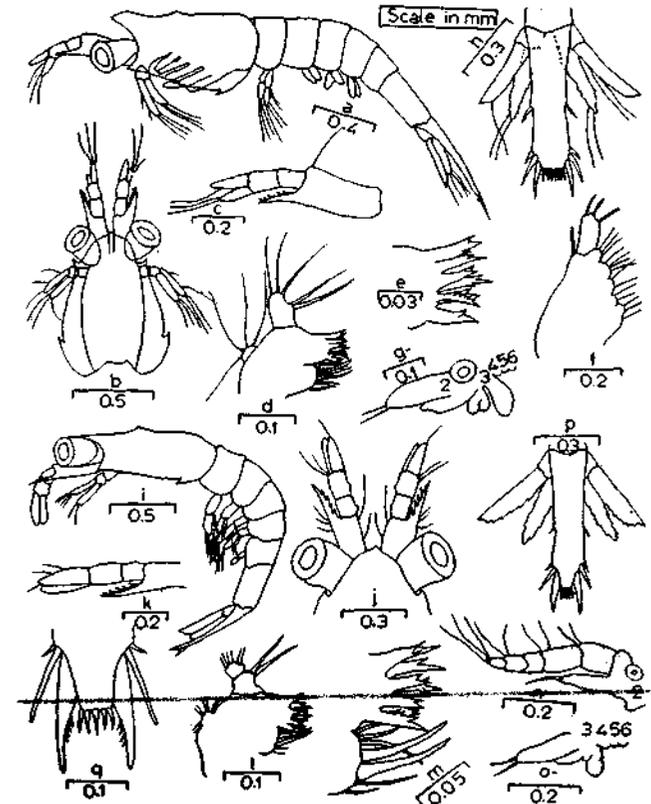


Fig. 8. *Euphausia distinguenda*. a-h. furcilia-II: a. lateral view; b. dorsal view of cephalothorax; c. A1; d. Mx1; e. outer masticatory lobe of Mx1; f. Mx2; g2-6. Th2-Th6; h. Tel. with uropods. i-q. furcilia-III: i. lateral view; j. dorsal view of cephalic region; k. A1; l. Mx1; m. outer masticatory lobe of Mx1; n2. Th2; o3-6. Th3-Th6; p. Tel with uropods; and q. tip of Tel.

Euphausia distinguenda Hansen (1911), (Fig. 6-9)*Calyptris-I* (Fig. 6 a-i)

Material: 5 larvae of TL 0.96 mm (1); 0.97 (1); 1.00 (1); 1.10 (1); 1.15 (1).

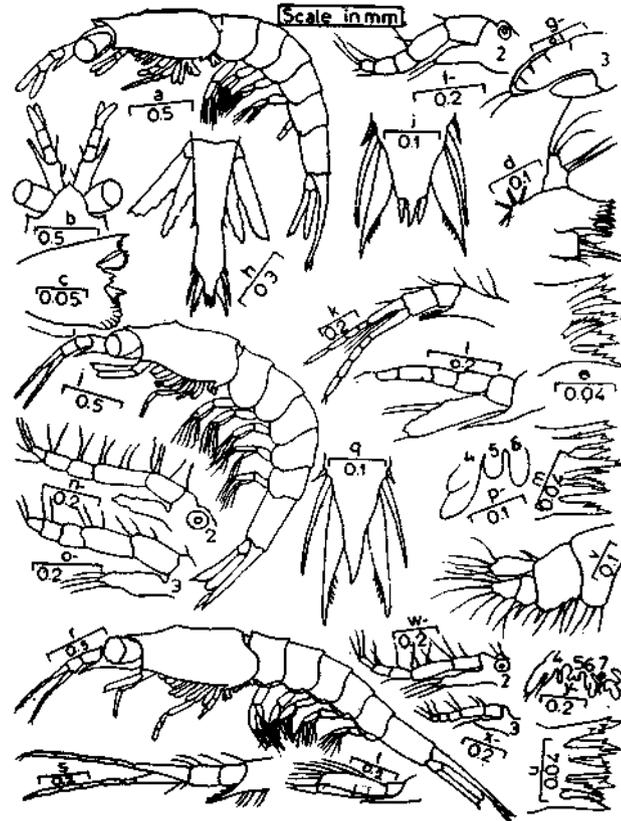


Fig. 9. *Euphausia distinguenda*. a-i. furcilia-IV: a. lateral view; b. dorsal view of cephalic region; c. Md; d. Mx1; e. outer masticatory lobe of Mx1; f2. Th2; g3. Th3; h. Tel with uropods; i. tip of Tel; j-q. furcilia-V: j. lateral view; k. A1; l. A2; m. outer masticatory lobe of Mx1; n2. Th2; o3. Th3; p4-6. Th4-Th6; q. tip of Tel.; r-y. furcilia-VI: r. lateral view; s. A1; t. A2; u. outer masticatory lobe of Mx1; v. Th1; w2. Th2; x3. Th3; and y4-7 Th4-Th7.

Carapace smooth on its margins, hooded anteriorly and covers cephalothorax completely and part of Ab; Ab unsegmented and Tel not distinct from Ab; a pair of ventrolateral spines present at about less than one fourth length of Ab from distal end; terminally three pairs of posterolateral spines and six terminal spines present on Tel. Unlike in *E. diomedea* inner pair of posterolateral spines in calyptris-I discernable from terminal spines by difference in size and also their position.

A1 peduncle short and unsegmented; outer antennular flagellum present as a bud and several spines present on it; inner flagellum not developed, instead two

spines mark its place; A2 biramous with two segmented peduncle; anterior ramus bears four long bristles terminally and two other short spines on its anterior margin; posterior ramus bears three long and one short bristles terminally; Md, Mx1 and Mx2 same as in calyptopis-I of *E. diomedea*.

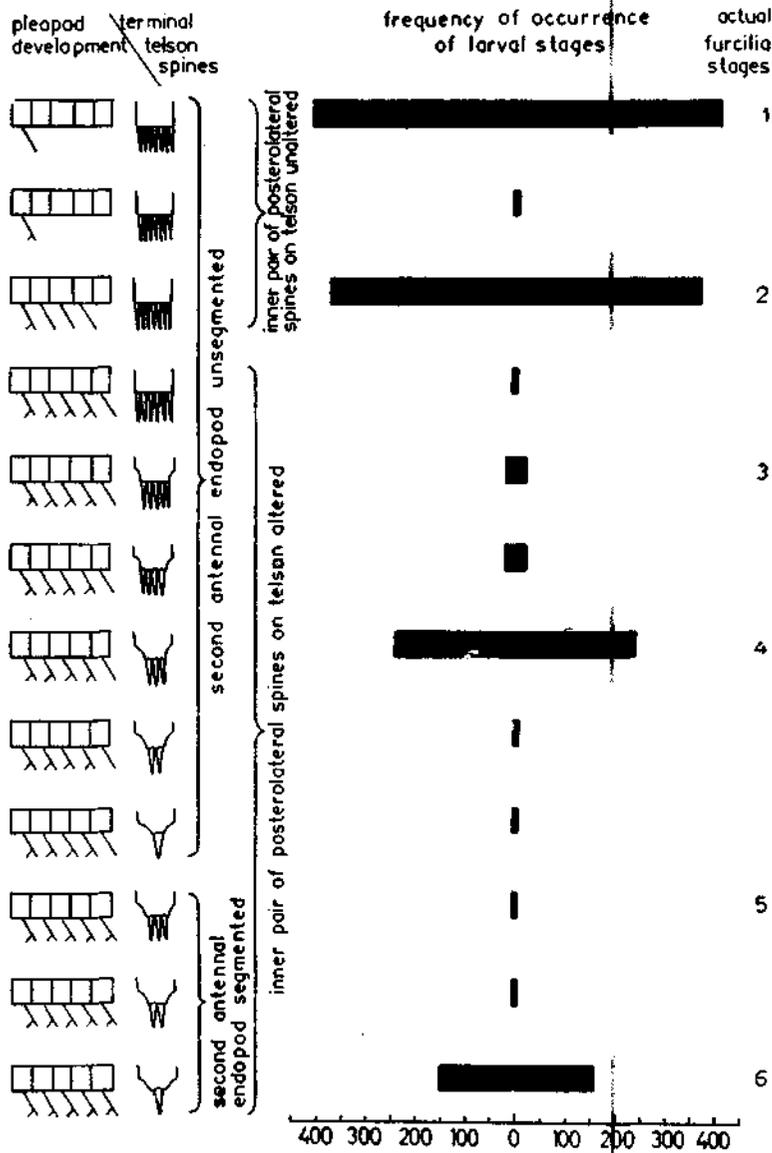


Fig. 10. *Euphausia distinguenda*. Furciliae; development and stage frequency.

Th1 developed and biramous, endopod being two-segmented; exopod, endopod, basipodite and coxopodite provided with spines of varying sizes.

Calyptopis-II (Fig. 6 j-k)

Material: 7 larvae of TL 1.49 mm (1); 1.54 (1); 1.56 (2); 1.57 (1); 1.58 (2).

Carapace still hooded anteriorly but withdrawn from Ab part; compound eyes well distinguishable; Ab five-segmented; broad and long Tel part still fused with Ab 6; no indication of uropods on Tel; one additional spine developed on tip of Tel, thus making a total of seven terminal spines.

A1 peduncle three-segmented of which middle one short; outer and inner flagella as buds and bear several bristles; no change to A2 excepting size increment and presence of more spines on posterior ramus; no change to Md and Mx2; Mx1 developed two more spines on outer masticatory lobe; Th1 same as in calyptopis-I.

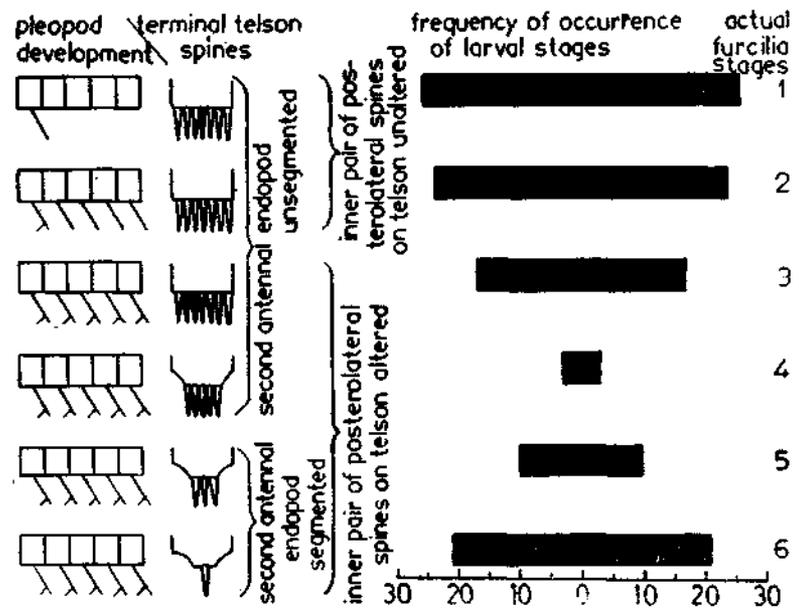


Fig. 11. *Euphausia diomedea*. Furcillae; development and stage frequency.

Calyptopis-III (Fig. 7 a-i)

Material: 5 larvae of TL 1.93 mm (2); 1.94 (1); 1.97 (1); 2.00 (1).

Eyes stalked and projects partly out of carapace; carapace still broader anteriorly; a pair of lateral spines developed on posterior inferior margin of carapace; carapace slightly elevated in dorsomedian line towards middle line where future crest to be developed; Ab six-segmented; Tel well distinguishable; uropods developed and biramous; endopod shorter than exopod; tip of exopod ends in a short spine.

A1 flagella still as buds; a strong spine developed on distal end of basal segment of A1 externally and it reaches almost tip of third peduncular segment; A2 at this stage with about five segment towards tip of posterior ramus which in subsequent stages get united. All mouth appendages same as in previous stage; Th2 not yet developed.

Furcilia-I (Fig. 7 j-r)

Material: 15 larvae of TL 2.37 mm (2); 2.42 (4); 2.48 (3); 2.52 (1); 2.54 (5).

Eyes stalked and project out of carapace; anterior portion of carapace extends forwards and shows indications of narrowing into a rostrum; crest on dorsomedian line of carapace more pronounced and moved slightly forwards from middle point; no change to Ab; a pair of simple non-setose pleopods developed on Ab1; Tel further narrowed and elongated.

A1 flagella further developed in size but still unsegmented; no clear-cut segmentation visible on tip of posterior ramus of A2; two more spines developed on outer masticatory lobe of Mx1, thus making a total of seven spines on it; no change to Md, Mx2, Th1 and Th2; Th3 developed as buds.

Furcilia-II (Fig. 8 a-h)

Material: 16 larvae of TL 2.72 mm (4); 2.74 (1); 2.77 (1); 2.85 (1); 2.93 (1); 2.95 (3); 2.98 (2); 3.01 (1).

Rostral hood further narrowed and projects far anteriorly terminating into a point; crest on dorsomedian line of carapace still more discernable; Tel and uropods more developed; Pl 1 setose; three more pairs of simple non-setose Pls developed behind first pair.

A1 flagella slightly more elongated; no change to A2; outer masticatory lobe of Mx1 still carries seven spines on it; no change to Md and Mx2; Th2 and Th3 differentiated into exopod and unsegmented endopod; a photophore and a bilobed gill developed at base of Th2; Th4 to Th6 developed as buds.

Furcilia-III (Fig. 8 i-q)

Material: 12 larvae of TL 3.00 mm (2); 3.04 (2); 3.05 (3); 3.09 (1); 3.29 (3); 3.33 (1).

Rostral hood projects further anteriorly and developing rostral spine visible; dorsomedian crest on carapace more pronounced; Tel further narrowed and elongated; inner pair of posterolateral spine on Tel altered in size and shape, being basally broad and distally narrow; two spines lost from tip of Tel, thus reducing original number of seven to five; Ab with first four pairs of Pls setose; last pair developed as non-setose buds; A1 and A2 unchanged; outer masticatory lobe of Mx1 still with seven spines only; endopod of Th2 five-segmented; Th3 differentiated into exopod and unsegmented endopod and gills developed as buds at its base; Th4 to Th6 remain as buds.

Furcilia-IV (Fig. 9 a-i)

Material: 12 larvae of TL 3.16 mm (1); 3.17 (3); 3.20 (2); 3.28 (1); 3.30 (2); 3.31 (1); 3.36 (1); 3.42 (1).

Rostral hood thinned and narrowed; rostral spine more distinct; Pl 5 still non-setose; Tel still more narrowed and with three terminal spines; outermost pair of posterolateral spines on Tel reduced in length and thickness; A1 flagella more elongated but unsegmented; no change to A2, Md, Mx1 and Mx2; Th1 and

Th2 show increase in size; endopod of Th3 four-segmented, but segmentation incomplete; Th4 to Th6 still as buds.

Furcilia-V (Fig. 9 j-r)

Material: 7 larvae of TL 3.33 mm (2); 3.43 (1); 3.44 (1); 3.48 (1); 3.51(2).

From this stage onwards larvae gradually acquire an adult appearance even though many of larval characters retained. Rostrum forms a well pointed spine; dorsomedian crest on carapace well developed; Pl 1-5 setose; Tel still with three terminal spines; outermost pair of posterolateral spines gradually reduced in length and inner pair of posterolateral spines increased in size; middle pair long but narrow; A1 flagella long and each distinctly five-segmented; no change to A2; outer masticatory lobe of Mx1 with eight spines; no change to other mouth parts; Th1 not changed its shape or structure; not much change to Th2 also; Th3 five-segmented and attained more setae on endopod as well as on exopod; Th4 differentiated into exopod and unsegmented endopod; Th5 and Th6 still as buds.

Furcilia-VI (Fig. 9 s-y)

Material: 12 larvae of TL 3.46 mm (1); 3.49 (1); 3.56 (2); 3.59 (2); 3.60 (1); 3.61 (3); 3.65 (1); 3.68 (1).

Rostrum more like that of an adult, short but pointed; Tel also shaped as in an adult with only one terminal spine; outermost pair of posterolateral spines very feeble and difficult to distinguish; A1 flagellae long and slender with seven segments each; A2 changed its shape with an expanded scale-like exopod having numerous bristles on its inner margin and a long slender five-segmented endopod; basipodite of antenna produced externally into a strong spine; Th1 still unaltered; Th2 to Th6 as in previous stage; Th7 developed as a bud with a photophore at its base.

The larvae in furcilia-VI stage pass on to the juvenile stage when Th1, Th4, Th5 and Th6 attain adult shape. The Th7 and Th8 remain as buds even in the adults. From telson outer and middle posterolateral spines gradually disappear leaving only terminal and innermost pair of posterolateral spines. External spine on basal segment of A1 peduncle gets shortened and gradually disappears.

DISCUSSION

In the calyptopis stages of euphausiids the development and transformation of body parts such as A1, A2, the cephalothorax and the Ab with the Tel are almost similar at each stage. More of variations occur in the furcilia stages. Individual variation in the furcilia stages is great that a comparison of stages between two species is rather not possible. Sometimes it takes a longer period for one species to get some fresh organs developed or larval organs altered or lost, while in others these may be effected very early in their life history. Similarly the sequential development, alteration or reduction of a combination of organs at particular stages occur very rarely in different euphausiids.

Generally the species which are distributed in the coastal or continental shelf waters show a large number of variant forms in their life cycle (Frost, 1935; Einarsson, 1945). This is the case with *E. distinguenda* for which 12 different

furciliae were identified during the present investigations (Fig. 10). But of these 12 stages only 6 represent the typical furcilia stages, the other 6 being variants or irregular forms of some typical stage.

In the early furcilia stage of *E. distinguenda* one specimen was obtained with a single setose P1 alone. But there is no typical stage to represent this form. In fact this is a variant form of the second typical furcilia and has evolved from the first typical stage. In the normal condition the first furcilia of *E. distinguenda* with a simple non-setose P1 when passes on to the second stage acquires setae on the first P1 and also develops three more pairs of non-setose P1s on the second, third and fourth Ab segments. But in the above variant the only change to the Ab is the setation of P1.

The second variant occurs in between the typical second and third stages. Here the variation is in respect of the number of terminal telson spines, that is, totally only six, versus seven or five to be typical stage. A typical stage of seven spines normally moults to one with five spines. The above abnormal stage with 6 spines resulted when a seven spined stage moulted to its next stage of five spines.

The third furcilia stage with four setose and one non-setose P1s and with five terminal spines on Tel, during the process of moulting to the fourth typical stage with four setose and one non-setose P1s and three terminal spines on Tel has given rise to three different variants. They are: 1) with four spines, 2) with two spines and 3) with one spine on the terminal portion of Tel; the P1 condition being the same in all.

The next variant is in between stages V and VI. The retention of two Tel spines instead of one is found in the variants of stage V.

In the case of the oceanic species, the developmental trend will be more rigid and hence the variant forms are generally absent. Thus in *E. diomedae*, which is an oceanic species, no variant forms were recognised during the present investigations (Fig. 11).

In order to find out the dominant stages and also to see whether jumping of stages takes place during the development of the present two species, the frequency of occurrence of larvae in each stage was plotted in a histogram. As a result it was seen that in *E. diomedae* (Fig. 11) there are five dominant stages only, and jumping of stage takes place from stage III to V, that is, all the larvae of the stage III do not moult to stage IV, but some of them may moult directly from stage III to stage V thus avoiding stage IV. This is ascertained from the presence of very few numbers of larvae at stage IV. Similarly in *E. distinguenda* (Fig. 10) jumping of stages takes place at two levels; one is from stage II to stage IV and the other is from stage IV to stage VI. Stages III and V were available only in fewer numbers in the collections.

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