PROCEEDINGS

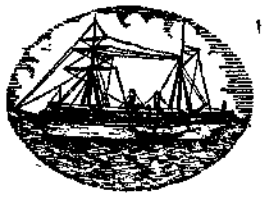
SYMPOSIUM ON CRUSTACEA

HELD AT

ERNAKULAM

FROM JANUARY 12 TO 15, 1965

PART I



SYMPOSIUM SERIES 2

MARINE BIOLOGICAL ASSOCIATION OF INDIA

MARINE FISHERIES P.O., MANDAPAM CAMP

INDIA

EUPHAUSIACEA FROM INDIAN SEAS: SYSTEMATICS AND GENERAL CONSIDERATIONS*

M. J. SEBASTIAN‡

Central Marine Fisheries Research Institute, Mandapam Camp, India

ABSTRACT

Taxonomic studies on the Euphausiacea collected from the Laccadive-Maldive and adjoining regions of the Indian Ocean are carried out. Twenty-three species of euphausiids are recorded from this locality with suitable remarks on their biology and keys for their identification.

The classification of this order is at present chiefly based on the male copulatory organ, the antennule and the elongated thoracic limbs which are easily broken off on collection and preservation. Hence the identification of female specimens is not quite easy. An attempt is made here to assess the systematic significance of the thelycum. The thelyca of the common forms are described and figured.

INTRODUCTION

THE importance of euphausiids in the dietary of oceanic fishes and baleen whales of the Boreal and Antarctic waters is quite well known. But todate we have very little precise information on their significance to the fisheries of the tropics. The present study, essentially taxonomic in nature, is intended as a preliminary to a more detailed investigation of the euphausiid fauna in relation to the fisheries of the Indian waters.

The Euphausiacea of the Indian Ocean is known mainly through the works of Tattersall (1906, 1911, 1925 and 1939), and Illig (1930). In addition, Euphausiacea have been studied from some restricted localities in the Indian Ocean and adjoining seas by Wood-Mason and Alcock (1891), Alcock and Anderson (1894), Anderson (1897), Hansen (1912), Colosi (1917), Torelli (1934), Pillai (1957), Boden (1954, in part) and Ponomareva *et al.* (1962).

In the systematics of Euphausiacea the nature of the male copulatory organ, the petasma, has come to stay as a very important taxonomic character following the works of Hansen (1910, 1911 and 1912). Thus, it is fairly easy to identify an adult male on the basis of the characteristics of the petasma; however, difficulty arises when females are to be identified where so many other morphological details have to be looked into. In a few instances species are erected on the basis of only small differences in the processes of the petasma with the result that their females are at present quite inseparable. In this connection, the taxonomic value of the female receptor organ, the spermatheca or thelycum, was stressed by Einarsson (1942 and 1945) but no subsequent worker seems to have paid attention to its study. During the present work the specific nature of the thelyca was again noticed and it was felt desirable to have them described and figured. The following report also provides a list of all the species hitherto recorded from the Indian Ocean, keys for their identification and short notes on the local species with suitable illustrations.

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‡ Present Address: Marine Biological Laboratory, Trivandrum-7.

Area of Investigation, Material and Method

The material for the present study was obtained from the plankton samples collected on board *R. V. Varuna* and kept in the Central Marine Fisheries Research Institute. The plankton samples were collected from the seas off the west and south coasts of India, including the Laccadive-Maldive region (Fig. 1). The nets used in the collection of samples were made of different fabrics and were of different dimensions, but the majority of the collections were made with a half metre net with filtering cone of mosquito-netting. The maximum depth sampled by the net is 200 metres; however, on a few occasions when the author himself was on board the vessel, plankton samples from deeper waters were collected which yielded fully adult specimens of *Thysanopoda* and *Nematoscelis*. A few samples were collected with an Isaccs-Kidd midwater trawl also. Only qualitative work of a taxonomic nature is attempted in this study.

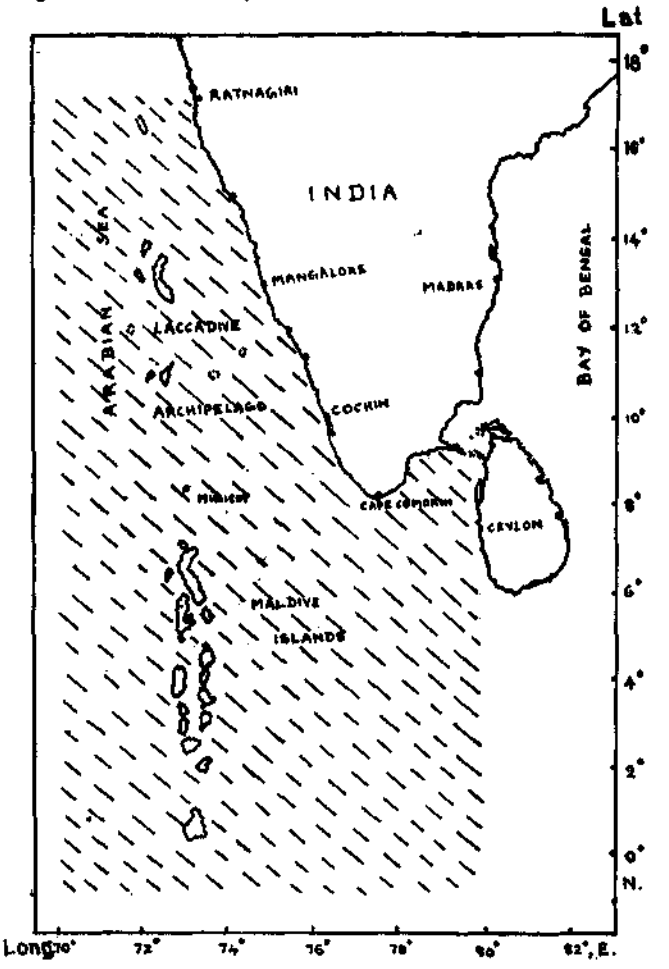

Fig. 1. Area investigated.

The Importance of External Sexual Characters in the Classification of Euphausiacea

1. *The petasma.*—Hansen (1910, 1911 and 1912) has clearly demonstrated the specific nature of the copulatory organ formed by the endopods of the first pair of pleopods of the male, and all subsequent workers duly recognised it as an important taxonomic character. Figure 2 *a* shows the

different parts of the petasma as they are referred to by Hansen (1910). The endopod of the first pair of pleopod is modified in the adult males of all the species except *Bentheuphausia amblyops* (G. O. Sars). Instead of the above modification *B. amblyops* shows the presence of a few spines on the basipodite (Einarsson, 1942). The specific nature of the petasma is easily understood from the fact that small differences in its structure is the only means of distinguishing closely related species like *Euphausia gibboides* Ortmann and *E. sanzoi* Torelli. Likewise, differences in the petasma provide the major distinguishing character among *Euphausia* spp. of the *gibba*-group and some species of *Nematoscelis*.

2. *The spermatheca or thelycum.*—As the petasma in the different species show specific differences and considerable diversity of form it is only natural that the thelycum should also show correspondingly specific structural modifications. Hence the author has made special efforts following Einarsson (1942 and 1945) to assess the systematic significance of the thelycum.

The thelycum is formed of parts of sternal as well as coxal origin (Fig. 2, *b.d.f.*). This view was held by Raab (1913), Ruud (1932), Bargmann (1937) and Einarsson (1942). In many cases extensive fusion of the sternal and coxal plates occur which makes recognition of their separate identity difficult. Even then the general configuration of the thelycum is quite specific. Small differences in the shape of the thelyca in virginal and fertilised females are noticed by Ruud (1936) who on this basis considers *Meganyctiphanes Calmani* Colosi synonymous with *M. norvegica* (M. Sars). Chiefly

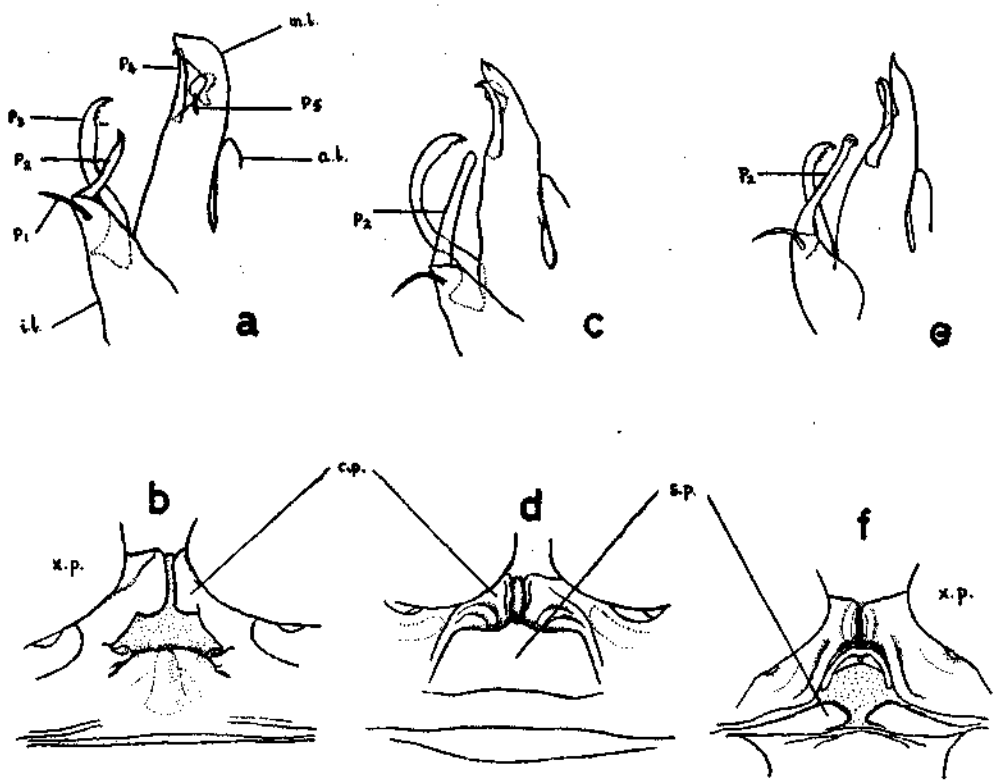

FIG. 2. Comparison of petasma and thelyca in three species. (*a*) *Thysanopoda acutifrons*: petasma; (*b*) same: thelycum; (*c*) *T. orientalis*: petasma; (*d*) same: thelycum; (*e*) *T. microphthalma*: petasma; (*f*) same: thelycum. *i.l.*, inner lobe; *m.l.*, median lobe; *a.l.*, auxiliary lobe; P1, spine-shaped process; P2, terminal process; P3, proximal process; P4, lateral process; P5, additional process; *c.p.*, coxal plate; *s.p.*, sternal plate; *x.p.*, coxopodite. [Figs. after Hansen (1910) and Einarsson (1942).]

on the basis of the identity of the thelyca in *Nematoscelis megalops* and *N. difficilis*, Einarsson (1942) considers the latter a synonym of the former. Einarsson (1945) found that a thelycum is absent in *Nyctiphanes couchii* (Bell). He has described the thelycum in the following eleven species (Einarsson, 1942 and 1945): *Thysanopoda orientalis* Hansen, *T. acutifrons* Holt and Tattersall, *T. microphthalma* G. O. Sars, *Nematoscelis megalops* G. O. Sars, *N. microps* G. O. Sars, *N. atlantica* Hansen, *N. gracilis* Hansen, *Meganyctiphanes norvegica* (M. Sars), *Thysanoessa longicaudata* (Kroyer), *T. inermis* (Kroyer), and *T. raschii* (M. Sars).

The present paper describes and figures the thelyca in the following twelve species of this locality: *Thysanopodat ricuspidata* Milne-Edwards, *T. monacantha* Ortmann, *T. aequalis* Hansen, *T. orientalis* Hansen, *Euphausia diomedeae* Ortmann, *E. distinguenda* Hansen, *Nematoscelis gracilis* Hansen, *N. microps* G. O. Sars, *N. tenella* G. O. Sars, *Nematobrachion boopis* (Calman), *N. flexipes* (Ortmann) Calman and *Stylocheiron longicorne* G. O. Sars.

It is seen that in taxonomy the thelycum is as important a character as the petasma. Figures 2 *a*, *c* and *e* show the petasma of three different species, *Thysanopoda acutifrons*, *T. orientalis* and *T. microphthalma*. The thelyca of the above species shown in Figs. 2 *b*, *d* and *f* provide equally conspicuous specific differences. Similarly, the thelyca are helpful in the indentification of the females of *Nematoscelis*, which are otherwise difficult for specific identification. Apart from their taxonomic value, a knowledge of the morphology of the thelyca will be helpful in any consideration of systematic affinity within the group.

Euphausiacea Known from the Indian Ocean

Tattersall (1939) listed forty-two species; however, Illig's (1930) records from tropical Indian Ocean of *Thysanoessa gregaria* and *T. parva* (northernmost records from west of Sumatra) and *E. similis* var. *armata* (east of Ceylon) were not included. The species *Thysanoessa macrura* recorded from 34° 31·2′ south latitude (Illig, 1930), *Euphausia spinifera* from 34° 19′ s. latitude (John, 1936) and *E. lucens* from 35° 10′ s. latitude (John, *l.c.*) are included here though they are denizens of more southern waters. Illig (1930) has reported the occurrence of *E. superba*, *E. crystallorophias* and *E. triacantha* at one or two stations in southern Indian Ocean. However, literature on distribution shows that *E. crystallorophias* is reported to occur only along the coasts of the Antarctic continent, *E. superba* under the pack-ice, along its edge and in the colder waters of the Antarctic zone and *E. triacantha* in the Antarctic and in the coldest waters of the Sub-Antarctic zones (Rustad, 1934; John, 1936). As such, these species are not included here among the Indian Ocean forms. An important later addition to the list is the new species *Thysanopoda subaequalis* Boden (1954) reported from the Straits of Mozambique. *Nematobrachion sexspinosus* is added following the studies of Ponomareva *et al.* (1962).

The species are: *Bentheuphausia amblyops* (G. O. Sars), 1883; *Thysanopoda tricuspidata* Milne-Edwards, 1830; *T. monacantha* Ortmann, 1893; *T. aequalis* Hansen, 1905; *T. pectinata* Ortmann, 1893; *T. acutifrons* Holt and Tattersall, 1905; *T. orientalis* Hansen, 1910; *T. microphthalma* G. O. Sars, 1885; *T. obtusifrons* G. O. Sars, 1883; *T. cornuta* Illig, 1905; *T. subaequalis* Boden, 1954; *Pseudeuphausia latifrons* (G. O. Sars), 1883; **P. colosii* Torelli, 1934; **Euphausia eximia* Hansen, 1905; **E. messanensis* Colosi, 1916; **E. sanzoi* Torelli, 1934; *E. diomedeae* Ortmann, 1894; *E. mutica* Hansen, 1905; *E. recurva* Hansen, 1905; *E. brevis* Hansen, 1905; *E. similis* G. O. Sars, 1885; *E. tenera* Hansen, 1905; *E. hemigibba* Hansen, 1910; *E. pseudogibba* Ortmann, 1893; *E. paragibba* Hansen, 1910; *E. distinguenda* Hansen, 1911; *E. gibboides* Ortmann, 1893; *E. similis* var. *armata* Hansen, 1911; †*E. spinifera* G. O. Sars, 1885; †*E. lucens* Hansen, 1905; †*Thysanoessa macrura* G. O. Sars, 1883; *T. inermis* (Kroyer) 1846; *T. gregaria* G. O. Sars, 1883; *T. parva* Hansen,

* The records are from the Red Sea. Tattersall's (1925) record of *Euphausia gibboides* from off the coast of Natal probably represents *E. sanzoi* Torelli (Tattersall, 1939; and Brinton, 1962).

† Southern boundary species.

1905; *Nematoscelis megalops* G. O. Sars, 1885; *N. microps* G. O. Sars, 1883; *N. gracilis* Hansen, 1910; *N. tenella* G. O. Sars, 1883; *Nematobrachion boopis* (Calman), 1896; *N. flexipes* (Ortmann), Calman, 1893; ‡*N. sexspinosus* Hansen, 1911; *Stylocheiron carinatum* G. O. Sars, 1883; **S. armatum* Colosi, 1917; *S. affine* Hansen, 1910; *S. suhmii* G. O. Sars, 1883; *S. microphthalma* Hansen, 1910; *S. longicorne* G. O. Sars, 1883; *S. elongatum* G. O. Sars, 1883; *S. maximum* Hansen, 1908; and *S. abbreviatum* G. O. Sars, 1883.

The salient features of taxonomic value regarding these species are to be found in the keys provided, which, however, do not include the Red Sea forms *Euphausia messanensis, Stylocheiron armatum* and *Pseudeuphausia colosii*. Thelycal characters have been taken into account in the key for the first time wherever found appropriate. In the preparation of the following keys liberal use has been made of the works of Hansen (1910, 1911 and 1912), Einarsson (1942), Sheard (1953) and Boden (1954).

Key to the Genera Represented in the Indian Ocean

1 *a*. Eyes ill-developed; photophores absent; all the eight thoracic limbs fully developed, none much elongated; endopod of first pair of pleopod not transformed into copulatory organ in the male; exopod of uropod with a transverse suture. (Family Bentheuphausiidae Colosi, 1917).....*Bentheuphausia* Sars, 1885
[The only species known is *B. amblyops* (Sars), 1883.]

1 *b*. Eyes well developed; photophores present; eighth, or seventh and eighth pairs of thoracic endopods rudimentary; second or third pair sometimes elongated and modified into prehensile organs; exopod of uropod without transverse suture; endopod of first pair of pleopod modified into copulatory organ in male. (Family *Euphausiidae* Holt and Tattersall, 1905).

2 *a*. None of the thoracic endopods much elongated or modified as prehensile organs.

3 *a*. Only eighth thoracic endopod rudimentary; seventh though small is five-segmented. .....*Thysanopoda* Milne-Edwards, 1830

3 *b*. Seventh and eighth thoracic endopods rudimentary and unsegmented.

4 *a*. Exopod of seventh thoracic limb well developed; no ovisac in female..... .....*Thysanoessa* Brandt, 1851 (in part)

4 *b*. Exopod of seventh thoracic limb rudimentary; ovisac present or not.

5 *a*. Carapace produced into a truncate frontal plate; no rostrum; distal three segments of sixth thoracic limb greatly reduced; ovisac present in female.. .....*Pseudeuphausia* Hansen, 1910

5 *b*. Carapace not produced into a frontal plate; rostrum present; sixth thoracic limb similar to fifth; ovisac absent.....*Euphausia* Dana, 1850

2 *b*. Second or third thoracic endopods very much elongated and usually modified as prehensile organs.

6 *a*. Second thoracic endopod much elongated.

7 *a*. Second thoracic limb rather strong, the last two segments armed with spiniform bristles on both margins; ovisac absent.... .....*Thysanoessa* Brandt, 1851 (in part)

‡ Included after its record by Ponomareva *et al.* (1962).

7 *b*. Second thoracic limb slender and almost naked except for an apical tuft of straight and stout bristles; ovisac present in female.. .....*Nematoscelis* Sars, 1883

6 *b*. Third thoracic endopod much elongated.

8 *b*. Third thoracic endopod with an apical tuft of straight and stout bristles; seventh thoracic endopod five-segmented; upper part of eye not narrowed or divided into big crystal cones; ovisac absent.....*Nematobrachion* Calman, 1905

8 *b*. Third thoracic endopod forming a true or false chela by the apposition of stiff, apically curved spiny setae arising from the ultimate and penultimate segments; seventh thoracic endopod only two-segmented; eyes usually with upper part narrowed and divided into big crystal cones; ovisac present in female.....*Stylocheiron* Sars, 1883

KEY TO THE SPECIES OF *Thysanopoda* KNOWN FROM THE INDIAN OCEAN

1 *a*. Carapace with deep cervical groove; sixth abdominal segment shorter than fifth; maxillula with pseudexopod not overreaching outer margin of third segment; bathypelagic; upto 79 mm.....*T. cornuta* Illig, 1905

1 *b*. Carapace without distinct cervical groove; sixth abdominal segment longer than fifth; maxillula with pseudexopod overreaching outer margin of third segment.

2 *a*. Denticle(s) present on or near postero-lateral margin of adult carapace.

3 *a*. Abdominal segment(s) armed with dorsal spine(s).

4 *a*. Dorsal spine on third abdominal segment only; no spine at base of rostrum; single lateral denticle on carapace; 25–32 mm..... .....*T. monacantha* Ortmann, 1893

4 *b*. Dorsal spine on third to sixth abdominal segments; spine present at base of rostrum; two lateral denticles on carapace; 15–26 mm..... .....*T. tricuspidata* Milne-Edwards, 1830

3 *b*. Abdominal segments unarmed.

5 *a*. Lobe from upper distal end of first antennular segment with several teeth on its outer, lateral margin; petasma without spine-shaped process; 15–20 mm.....*T. aequalis* Hansen, 1905

5 *b*. Lobe from first antennular segment with a single tooth on its outer, lateral margin; petasma with spine-shaped process.

6 *a*. Lobe from first antennular segment covering more than half the second segment; 18 mm.....*T. subaequalis* Boden, 1954

6 *b*. Lobe from first antennular segment covering less than half the second segment; 20 mm.....*T. obtusifrons* Sars, 1883

2 *b*. Denticles absent on or near postero-lateral margin of adult and subadult carapace.

7 *a*. Lobe from first antennular segment with its distal margin pectinate; 29–44 mm.....*T. pectinata* Ortmann, 1893

7 *b*. Lobe from first antennular segment not pectinate.

8 *a*. Antennular lobe acutely spiniform in lateral view; terminal and proximal processes of petasma subequal with end of terminal process having a transverse row of saw-teeth just behind the flatly arched terminal surface; major sternal lobe of thelycum formed of two leaf-like outgrowths; 20–23 mm.....*T. microphthalma* G. O. Sars, 1885

8 *b*. Atennular lobe not acutely spiniform in lateral view; proximal process of petasma about twice as long as terminal; major sternal lobe of thelycum formed of a single broad plate.

9 *a*. Dorsal hind margin of fourth and fifth abdominal segments slightly acuminate in the middle; terminal process of petasma with a broadly rounded, unarmed end; sternal lobe of thelycum without a conspicuous longitudinal ridge in the middle; 23–38 mm..... .....*T. orientalis* Hansen, 1910

9 *b*. Dorsal hind margin of fourth and fifth abdominal segments not acuminate; terminal process of petasma shorter with its distal fourth slightly curved and tapering; sternal lobe of thelycum with a conspicuous longitudinal ridge in the middle; 35–50 mm..... .....*T. acutifrons* Holt and Tattersall, 1905

KEY TO THE SPECIES OF *Euphausia* KNOWN FROM THE INDIAN OCEAN

1 *a*. Two pairs of lateral denticles on carapace; no dorsal spines on third to fifth abdominal segments; proximal process of petasma with a secondary process or prominence near its distal end.

2 *a*. A small upper distal pectinate lobe with 9–10 spiniform processes on first antennular segment; 16–30 mm.....*E. eximia* Hansen, 1905.

2 *b*. A large upward-pointing lobe (in female) or a recurved one (in male) on upper distal end of first antennular segment; a slender spiniform process at upper distal inner angle of second antennular segment; 16–20 mm.....*E. recurva* Hansen, 1905

2 *c*. A small forward-pointing bifid lobe on upper distal end of first antennular segment; process at upper distal inner angle of second antennular segment absent or replaced by a triangular protuberance.

3 *a*. No process on second antennular segment; 8–13 mm.....*E. mutica* Hansen, 1905

3 *b*. A single process on second antennular segment; 8·5–10 mm..... .....*E. brevis* Hansen, 1905

3 *c*. Two processes on second antennular segment; 12–19 mm..... .....*E. diomedeae* Ortmann, 1894

1 *b*. Only a single pair of lateral denticles on carapace; no dorsal spine on third abdominal segment.

4 *a*. No conspicuous lobe on upper distal end of first antennular segment; a single process on second antennular segment; 8–9 mm..... .....*E. tenera* Hansen, 1905.

4 *b*. A conspicuous lobe present on upper distal end of first antennular segment.

5 *a*. Lobe on first antennular segment bifid; two blunt upper distal projections on second antennular segment; 19–33 mm..... .....*E. similis* G. O. Sars, 1885

5 *b*. Lobe on first antennular segment angular; no process on upper distal end of second antennular segment; 10–18 mm.....*E. lucens* Hansen, 1905

1 *c*. Only a single pair of lateral denticles on carapace; a dorsal spine or process present only on third abdominal segment.

6 *a*. No conspicuous lobe at upper distal end of first antennular segment .. ..*E. distinguenda* Hansen, 1911

6 *b*. A conspicuous lobe present at upper distal end of first antennular segment.

7 *a*. The above lobe bifid; 16–23 mm..... .....*E. similis* v. *armata* Hansen, 1911

7 *b*. The above lobe angular.

8 *a*. Second antennular segment with short, broad, sub-rectangular lobe.

9 *a*. Distal part of terminal process of petasma simple; median lobe with a single triangular tubercle near base of lateral process; 22–30 mm..... .....*E. gibboides* Ortmann, 1893

9 *b*. Distal part of terminal process of petasma bifid; median lobe with two triangular tubercles..... .....*E. sanzoi* Torelli, 1934

8 *b*. Second antennular segment with a small, sharp tooth.

10 *a*. Dorsal spine on third abdominal segment about half as long as fourth segment; distal part of median lobe of petasma not much narrowed; 12–16·5 mm.....*E. hemigibba* Hansen, 1910

10 *b*. Dorsal spine on third abdominal segment less than half as long as fourth segment; distal part of median lobe of petasma narrowed to less than half the width of proximal part.

11 *a*. Dorsal keel on third antennular segment not reaching second segment and ending in an almost vertical border; lateral process of petasma without proximal dilation and additional teeth; 13–15 mm..... .....*E. pseudogibba* Ortmann, 1893

11 *b*. Dorsal keel on third antennular segment decreasing in height backwards and almost reaching second segment; lateral process of petasma with proximal dilation carrying three acute teeth; 14–17 mm..... .....*E. paragibba* Hansen, 1910

1 *d*. A single pair of lateral denticles on carapace; dorsal spine present on third to fifth abdominal segments; lobe from first antennular segment multi-digitate; spine on second segment strong and bifid; 21–29 mm..... *E. spinifera* G. O. Sars, 1885

KEY TO THE SPECIES OF *Thysanoessa* RECORDED FROM THE INDIAN OCEAN

1 *a*. Lateral margin of carapace without any denticle; sixth abdominal segment with a strong upper distal spine; 32 mm..... *T. inermis* (Kroyer), 1846

1 *b*. Lateral margin of carapace with a denticle; sixth abdominal segment without upper distal spine.

2 *a*. Sixth abdominal segment shorter than the sum of the two preceding segments.

3 *a*. Setae along lower margin of fifth and sixth segments of second to fourth pairs of thoracic endopods slender, non-ciliated and much shorter than the terminal setae of seventh segment; 9–10 mm..... *T. parva* Hansen, 1905

3 *b*. Setae along lower margin of fifth and sixth segments of third to fifth pairs of thoracic endopods strong, conspicuously ciliated and as long as or longer than the terminal setae of seventh segment..... *T. gregaria* G. O. Sars, 1885

2 *b*. Sixth abdominal segment almost or fully as long as the sum of the two preceding segments ..... *T. macrura* G. O. Sars, 1885

KEY TO THE SPECIES OF *Nematoscelis* KNOWN FROM THE INDIAN OCEAN

1 *a*. Maxillula with a pseudexopod; elongated pair of thoracic limbs with long bristles arising from the ultimate as well as penultimate segments; third to sixth pairs of thoracic endopods with three segments beyond the knee; terminal process of petasma longer and stouter than proximal process; sternal plate of thelycum with a finger-like process between and over coxal plates and with an anterior round margin; 20–26 mm..... ..... *N. megalops* G. O. Sars, 1885

1 *b*. Maxillula without pseudexopod; elongated pair of thoracic limbs with long bristles arising only from ultimate segment; third and fourth pairs of thoracic endopods with only two segments and fifth and sixth pairs with only one segment beyond the knee; terminal process of petasma much slender and shorter than proximal process; thelycum with coxal plates more or less angular.

2 *a*. Lower part of eye considerably larger than upper part; terminal and spine-shaped processes of petasma at least about half as long as proximal process, the distal outer margin of which is even, not serrated; coxal plates of thelycum angular with sides having deep notches at about midway; 15–20 mm..... *N. microps* G. O. Sars, 1883

2 *b*. Lower part of eye equal to or smaller than upper part; petasma with terminal and spine-shaped processes several times shorter than proximal process, the outer margin of which is serrated towards the end; coxal lobe of thelycum angular without any constriction of its sides.

3 *a*. Lower part of eyes not smaller than upper part; terminal process of petasma short, but yet longer than basal diameter of proximal process; coxal lobe of thelycum angular with straight sides..... *N. gracilis* Hansen, 1910.

3 *b*. Lower part of eyes smaller than upper part; terminal process of petasma very short, at the most as long as basal diameter of proximal process; coxal lobe of thelycum angular with sides arched; 15–21 mm..... *N. tenella* G. O. Sars, 1883

KEY TO THE SPECIES OF *Nematobrachion* KNOWN FROM THE INDIAN OCEAN

1 *a*. Abdominal segments without dorsal spines; frontal plate obtuse, without rostrum; eyes dark brownish, divided by a groove into an upper section more than twice as deep as lowerr; first antennular segment without any process from its distal outer angle; second antennular segment with a slightly produced acute angle at its upper distal outer angle; 19–21 mm... .....*N. boopis* (Calman), 1896

1 *b*. At least fourth and fifth abdominal segments with conspicuous dorsal spines; frontal plate terminating in a slender rostrum; eyes black, constricted into an upper section somewhat deeper than lower; first antennular segment with a long spiniform process from its distal outer angle; second antennular segment with a very conspicuous process from its upper distal outer angle.

2 *a*. Third to sixth abdominal segments each with single postero-dorsal spine, that on third segment much longer; maxillula without pseudexopod; process from second antennular segment with its proximal half plate-shaped and distal spiniform; 22–26 mm.....*N. flexipes* (Ortmann) Calman, 1893

2 *b*. Fourth and fifth abdominal segments each with a postero-dorsal row of three spines, none on other segments; maxillula with pseudexopod; process from second antennular segment is a large, oblong plate slightly acuminate at the acute end; 23 mm..... .....*N. sexspinosus* Hansen, 1911

KEY TO THE SPECIES OF *Stylocheiron* KNOWN FROM THE INDIAN OCEAN

1 *a*. Penultimate segment elongate, third pair of thoracic endopods with long setae arising laterally; a small spur on inferior distal margin of antepenultimate segment; 11–15 mm. .....*S. carinatum* G. O. Sars, 1885

1 *b*. Penultimate segment of third thoracic endopod with elongate setae arising more or less terminally, but no real chela is formed; ultimate segment very short with many elongate setae; no spur on distal margin of antepenultimate segment; adults usually below 14 mm.

2 *a*. Eyes oblong, upper part not divided into prominent crystal cones; sixth abdominal segment more than three times as long as deep; 13 mm.....*S. elongatum* G. O. Sars, 1885

2 *b*. Eyes with upper part divided into large crystal cones; sixth abdominal segment in adult less than three times as long as deep.

3 *a*. Two crystal cones in a transverse row in upper part of eye; 5·5–6·4 mm..... .....*S. microphthalma* Hansen, 1911

3 *b*. Three crystal cones in a transverse row in upper part of eye; 8 mm..... .....*S. suhmii* G. O. Sars, 1885

3 *c*. Four to six crystal cones in a transverse row in upper part of eye; 6–8 mm.

A variant with 5–8 crystal cones is reported by Brinton (1962) from the Pacific. In it the length of the sixth abdominal segment is less than 1·6 times its depth..... .....*S. affine* Hansen, 1910.

3 *d*. Nine to nineteen crystal cones in a transverse row in upper part of eye; 6·4–9·5 mm., female upto 13 mm.

A variant with 7–8 crystal cones is noticed by Brinton (*l.c.*) in which the length of the sixth abdominal segment is more than 1·6 times its depth..... .....*S. longicorne* G. O. Sars, 1883

1 *c*. Penultimate segment of elongate thoracic endopod with setae arising terminally; one of the setae elongate, stiff and immovably fused against which closes a stout curved spine of ultimate segment so that a true chela is formed; ultimate segment elongated, carrying no long setae but a few short curved spines or teeth terminally; no spur on distal margin of antepenultimate segment; adults above 14 mm.

4 *a*. Upper part of eye much smaller than lower; fourth and fifth abdominal segments dorsally keeled and with posterior acute teeth; 15–16 mm..... .....*S. abbreviatum* G. O. Sars, 1883

4 *b*. Upper part of eye at the most slightly smaller than lower; fourth and fifth abdominal segments dorsally unarmed; 23–24 mm..... .....*S. maximum* Hansen, 1908

Species of Euphausiacea Represented in the *R. V. Varuna* Collections

Thysanopoda tricuspidata Milne-Edwards

Thysanopoda tricuspide M.-Edwards, 1830.

Thysanopoda tricuspidata M.-Edwards, 1837; G. O. Sars, 1885; Hansen, 1910, 1911 and 1912; Zimmer, 1914; Illig, 1930; Tattersall, 1936; Boden, 1954.

Represented by few numbers throughout the area covered by the survey. The Isaccs-Kidd midwater trawl collected them in abundance along with *T. monacantha* from several places. The length of adult specimen is reported to be 10–20 mm. (Boden, 1954), but in the present collection almost all the adult specimens measured more than 20 mm., the maximum length being 26 mm. In a large collection from lat. 8° 10′ N. and long. 75° 55′ E., five males were present for every female, Probably a shoaling species. Has a very wide distribution in the tropical Indian Ocean.

Thelycum with a small triangular sternal lobe and with longitudinally folded coxal lobes. Only a single spermatophore with an elongated stem is carried (Figs. 15 and 16).

Thysanopoda monacantha Ortmann

Thysanopoda monacantha Ortmann, 1893; Hansen, 1911 and 1912; Zimmer, 1914; Tattersall 1939; Boden, 1954.

T. agassizi Ortmann, 1893; Hansen, 1910.

T. lateralis Hansen, 1905 *a*.

T. ctenophora Illig, 1908.

More abundant in this region than *T. tricuspidata* and in an Isaccs-Kidd trawl from lat. 8° 10′ N. and long. 75° 55′ E., no less than 400 adult specimens were caught. They measured 25–29 mm. whereas the Siboga specimens measured only 23·5–25 mm. Males were few in number only, about three males per eighty females. Usually large specimens were found in plankton hauls from depths exceeding 200 metres.

Thelycum with a horse-shoe-shaped plate. Two distinct spermatophores borne on narrow stems. Widely distributed in tropical Indian Ocean.

Thysanopoda aequalis Hansen

Thysanopoda aequalis Hansen 1905 (*b*), 1910 and 1912; Tattersall, 1911 and 1939; Zimmer, 1914; Illig, 1930; Boden, 1954.

Found in few numbers only; most of the specimens seen by me are males. Thelycum as shown in Fig. 17; somewhat similar to that in *T. tricuspidata*.

Thysanopoda orientalis Hansen

Thysanopoda orientalis Hansen, 1910, 1911 and 1912; Illig, 1930; Tattersall, 1939; Boden, 1954.

Found in few numbers, but more abundant in deeper hauls. The thelycum with a very broad sternal plate which almost covers up the spermathecal opening. Coxal plates are rounded lobes. Spermatophores, a pair.

Thysanopoda pectinata Ortmann

Thysanopoda pectinata Ortmann, 1893; Hansen, 1905 (*b*), 1910, 1911 and 1912; Illig, 1930; Tattersall, 1939.

T. ctenophora Illig, 1908.

Parathysanopoda foliifera Illig, 1909.

Rarely found. Only males were seen by me and hence the thelycum is not described.

Euphausia diomedeae Ortmann

Euphausia diomedeae Ortmann, 1894; Hansen, 1905 (*b*), 1910, 1911 and 1912; Illig, 1930; Torelli, 1934; Tattersall, 1939; Boden, 1954; Pillai, 1957.

The most abundant species. The setose lobe of the petasma with only seven setae; none was found with eight setae as reported by Pillai (1957).

The thelycum has an angular sternal lobe which becomes obtuse in larger specimens (Figs. 23, 24). Spermatophore single.

Euphausia distinguenda Hansen

Euphausia distinguenda Hansen, 1911 and 1912; Illig, 1930; Torelli, 1934; Tattersall, 1939.

This species is reported from the north-west parts of the Indian Ocean by Tattersall (1939) and Illig (1930) and from the Red Sea by Torelli (1934). According to Tattersall it is the most abundant euphausiid in the area explored by the John Murray Expedition.

Hansen described this species from the tropical East Pacific. According to him *E. distinguenda* is distinct from *E. pseudogibba*, *E. paragibba*, etc., in the absence of a conspicuous lobe from the first antennular segment and from *E. sibogae*, Hansen, 1908, in having the upper distal outer angle of second antennular segment raised as a short, oblique keel forming a nearly ear-like, rounded process directed upwards and somewhat forwards. The petasma shows striking similarity to that of *E. sibogae*. However, no further direct comparison of these two very closely related species has been made by Hansen. A close study of the descriptions of these two species brings out the following differences:—

	E. distinguenda	*E. sibogae*
1.	Median gastric keel seen from side rather high and even angular.	Keel somewhat high at the middle, but not really angular.
2.	Upper distal outer angle of second antennular joint with a rather short, high, oblique keel directed upwards and somewhat forwards, forming almost an ear-like, rounded process.	Second antennular joint without any distal protuberance or produced angle.
3.	Endopod of uropod slightly longer than the exopod and as long as or even a little longer than the telson.	Rami of uropods subequal in length and a little shorter than the telson.
4.	Terminal process of petasma with a rather long foot and a very long, curved heel.	Foot is not long and the heel moderately long, somewhat curved.
5.	Setiferous lobe with five setae from the triangularly produced terminal part and about four setae along the outer margin.	Terminal margin with five setae, besides two rather short setae on the outer margin.
6.	Length of both sexes from 10 to 14·5 mm.	8 to 8·5 mm.

Apart from this, a comparison of the figures of the petasma (Hansen, 1910 and 1912) shows that in *E. distinguenda* the tip of the proximal process reaches almost to the level of the tip of the terminal process, whereas, in *E. sibogae* the tip of the proximal process is much behind the level of the tip of the terminal process.

In the present material, the petasma showed resemblance to that of *E. sibogae*. The number of setae along the proximal outer margin of the setiferous lobe varied from 2 to 4. Rami of uropods are subequal in length and a little shorter than the telson. The upper distal outer angle of second antennular segment showed a low keel which is not prominent as an erect ear-like lobe. Adult males measured 10–12·5 mm. It is interesting to note that these specimens show some features characteristic of *E. sibogae*. No explanation could be found except to believe that the specimens represent a distinct population of *E. distinguenda*.

The species occurs mostly in swarms. A few stages in the development of the thelycum are shown in Figs. 20, 21 and 22.

Euphausia tenera Hansen

Euphausia tenera Hansen, 1905 (*b*), 1910, 1911 and 1912; Illig, 1930; Tattersall, 1939; Boden, 1954;

E. gracilis G. O. Sars, 1885. Represented in small numbers.

Euphausia brevis Hansen

E. brevis Hansen, 1905 (*b*), 1910, 1911 and 1912; Illig, 1930; Tattersall, 1939; Boden, 1954. Found very rarely.

Euphausia pseudogibba Ortmann

E. pseudogibba Ortmann, 1893; Hansen, 1905 (*a*), 1910, 1911 and 1912; Illig, 1930; Tattersall, 1939; Boden, 1954.

Found occasionally. Regarding its distribution, Boden (1954) remarks that it is apparently confined to the Atlantic. It has been recorded from the Indian Ocean by Illig (1930) and Tattersall (1939).

Pseudeuphausia latifrons (G. O. Sars)

Euphausia latifrons G. O. Sars, 1883 and 1885; Hansen, 1908; Tattersall, 1906.

Pseudeuphausia latifrons Hansen, 1910, 1911 and 1912; Illig, 1930; Tattersall, 1936 and 1939; Boden, 1954; Pillai, 1957.

A few specimens found in a collection from lat. 7° 48′ N. and long. 76° 28′ E.

Nematoscelis microps G. O. Sars

Nematoscelis microps G. O. Sars, 1883 and 1885; Hansen, 1908, 1910, 1911 and 1912; Illig, 1930; Ruud, 1936; Tattersall, 1939; Einarsson, 1942; Boden, 1954.

N. rostrata G. O. Sars, 1885; Ortmann, 1893.

The coxal lobe of the thelycum angular with the sides having deep constriction at about midway. Its tip is rounded. The females of *Nematoscelis* spp. were identified chiefly on the basis of the descriptions of thelyca by Einarsson (1942).

Nematoscelis gracilis Hansen

Nematoscelis gracilis Hansen, 1910, 1911 and 1912; Tattersall, 1911, 1939; Illig, 1930; Einarsson, 1942.

The coxal plate of thelycum angular with straight sides and almost pointed tip (Figs. 28 and 29).

Nematoscelis tenella G. O. Sars

Nematoscelis tenella G. O. Sars, 1883 and 1885; Hansen, 1905 (*b*), 1910, 1911 and 1912; Tattersall, 1911 and 1939; Illig, 1930; Boden, 1954.

N. mantis Chun, 1896.

N. sarsii Chun, 1896.

Ovigerous females occur in plankton hauls from depths exceeding 200 m. during the month of November.

The coxal lobe of thelycum angular with the sides arched (Fig. 33).

Nematobrachion boopis (Calman)

Nematodactylus boopis Calman, 1896.

Nematobrachion boopis Calman, 1905; Hansen, 1905 (*a, b*), 1910, 1911 and 1912; Tattersall, 1911 and 1939; Illig, 1930; Boden, 1954.

Occasional finds only in deeper plankton hauls. Thelycum as shown in Fig. 25; more complicated than that of *N. flexipes*, with the thelycal orifice partly covered by ventral and lateral plates.

Nematobrachion flexipes (Ortmann) Calman

Stylocheiron flexipes Ortmann, 1893.

Nematodactylus flexipes Calman, 1896.

Nematobrachion flexipes Calman, 1905; Hansen, 1905 (*b*), 1910, 1911 and 1912; Tattersall, 1911 and 1939; Illig, 1930; Boden, 1954.

More common than *N. boopis* (Calman). Boden (1954) remarks that this species has never been reported from the Indian Ocean. However, the species is already recorded from the Indian Ocean by Tattersall (1911 and 1939) and Illig (1930).

Thelycum more simple compared to that of *N. boopis*; the thelycal orifice is a more or less round opening.

Stylocheiron carinatum G. O. Sars

Stylocheiron carinatum G. O. Sars, 1883 and 1885; Hansen, 1910, 1911 and 1912; Tattersall, 1911 and 1939; Illig, 1930; Boden, 1954.

One of the common species of *Stylocheiron*. Exhibits shoaling habits at least during the breeding season. Ovigerous females with 4–6 heavily yolked eggs in the ovisac during February to April.

Stylocheiron affine Hansen

Stylocheiron affine Hansen, 1910, 1911 and 1912; Illig, 1930; Tattersall, 1939; Boden, 1954.

Only forms with the normal number of crystal cones of the eye were found. Fairly common.

Stylocheiron longicorne G. O. Sars

Stylocheiron longicorne G. O. Sars, 1883 and 1885; Hansen, 1910, 1911, and 1912; Tattersall, 1911 and 1939; Illig, 1930; Boden, 1954.

S. mastigophorum Chun, 1887 (*partim*).

Fairly common throughout the area explored; bigger specimens are caught by hauls from depths exceeding 200 m.

Thelycum formed of two prominent plates meeting in the middle and having an anterior Y-shaped cleft on the sides of which the paired spermatophores are attached.

Stylocheiron microphthalma Hansen

Stylocheiron microphthalma Hansen, 1910 and 1912; Tattersall, 1911; Illig, 1930.

This very small species is only occasionally found.

Stylocheiron elongatum G. O. Sars

Stylocheiron elongatum G. O. Sars, 1883 and 1885; Hansen, 1905, 1910, 1911 and 1912; Tattersall, 1911 and 1939; Illig, 1930; Boden, 1954.

A few subadults measuring 6·5–8 mm. were obtained from lat. 9° 03′ N. and long. 73° 20′ E., north of Minicoy island.

Boden (1954) remarks that this species is found only in Atlantic waters. The species has been reported from the Indian Ocean by Tattersall (1911 and 1939) and Illig (1930).

Stylocheiron abbreviatum G. O. Sars

Stylocheiron abbreviatum G. O. Sars, 1883 and 1885; Hansen, 1905 (*a*), 1910 and 1912; Tattersall, 1911 and 1939; Illig, 1930; Boden, 1954.

More common than *S. maximum*. Few specimens measuring 16 mm. were obtained but the majority were much smaller.

Stylocheiron maximum Hansen

Stylocheiron maximum Hansen, 1908, 1910, 1911 and 1912; Illig, 1930; Tattersall, 1939; Banner, 1949; Boden, 1954.

The species was found rarely; only subadults were seen.

A study of the euphausiid fauna of this region shows that among these many species encountered, judging from their size, abundance, shoaling habits, etc., the most important species are *Euphausia diomedeae* and *E. distinguenda*. Next in importance may come *Thysanopoda monacantha* and *T. tricuspidata* which, however, are ill-represented in the conventional plankton net collections. Further detailed study of the biology, development and distribution of the above species is desirable from the fisheries point of view.

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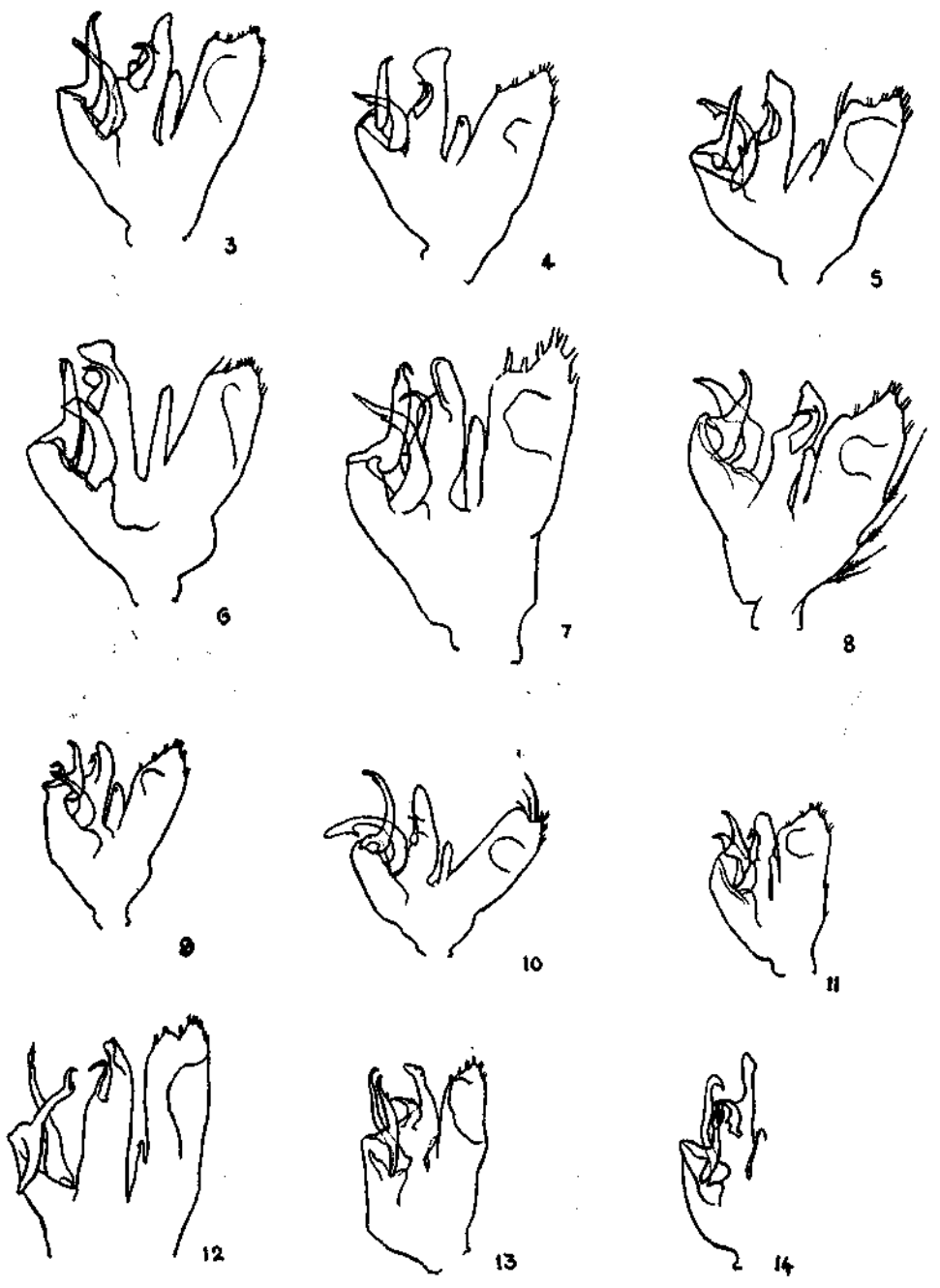
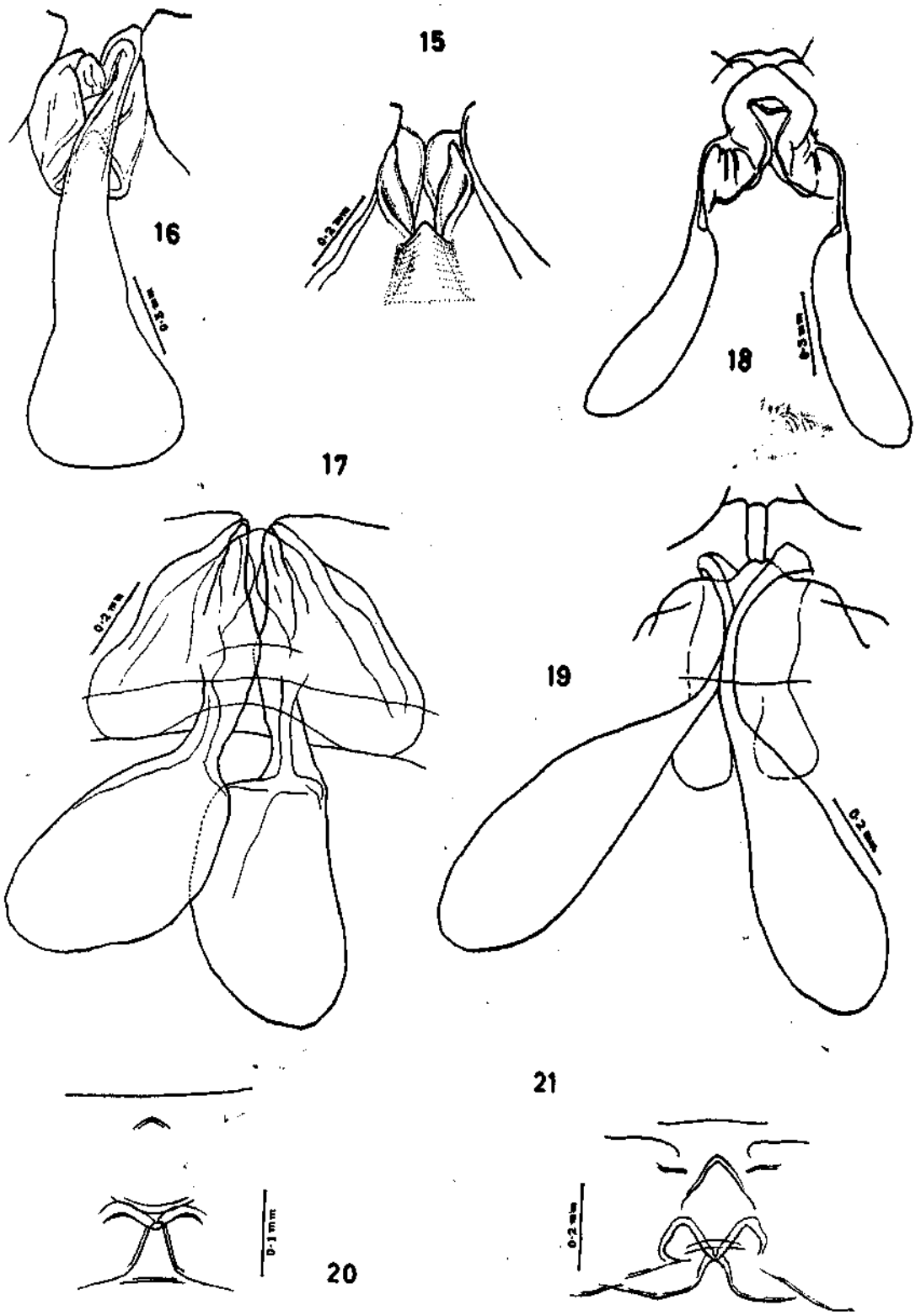
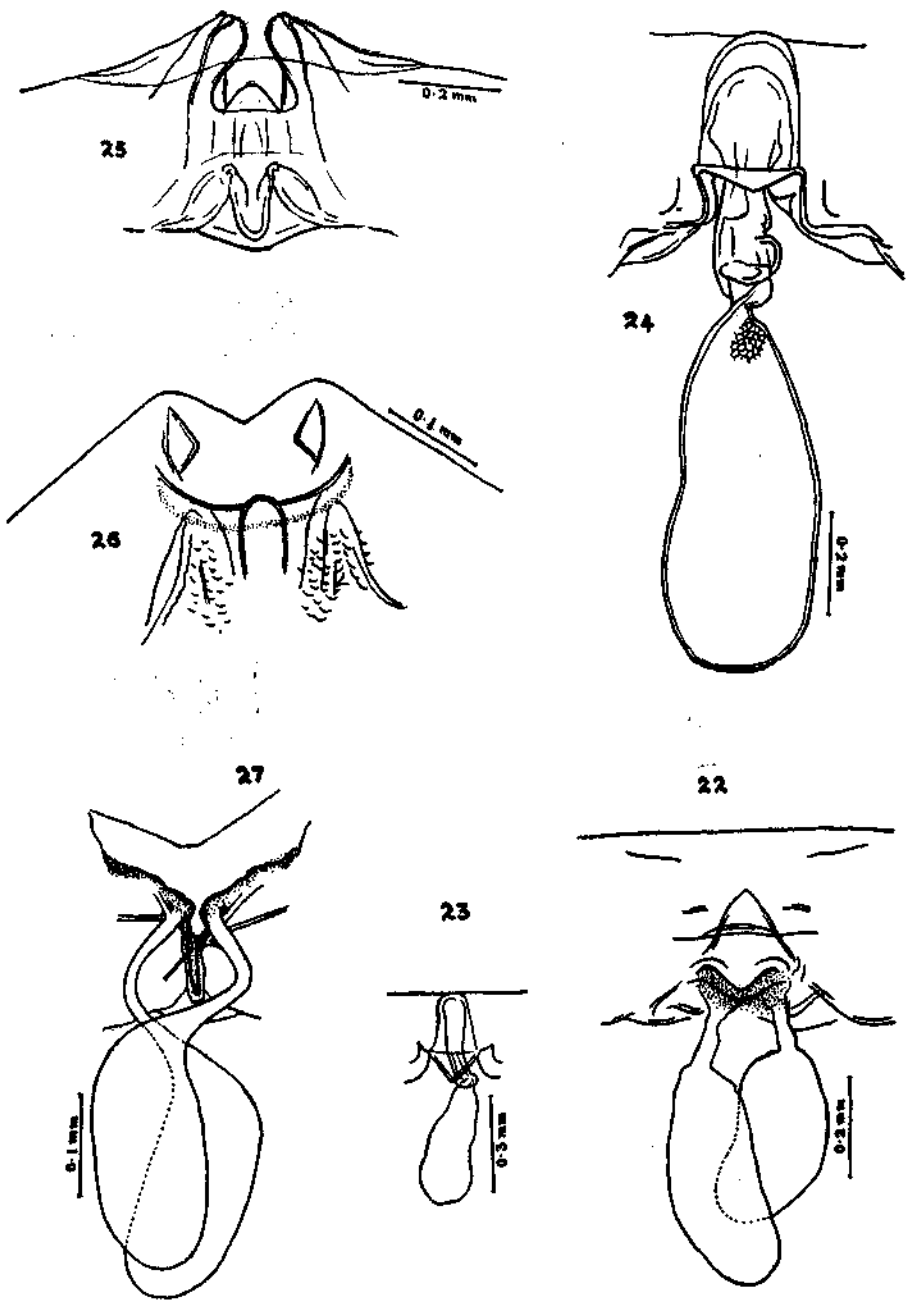


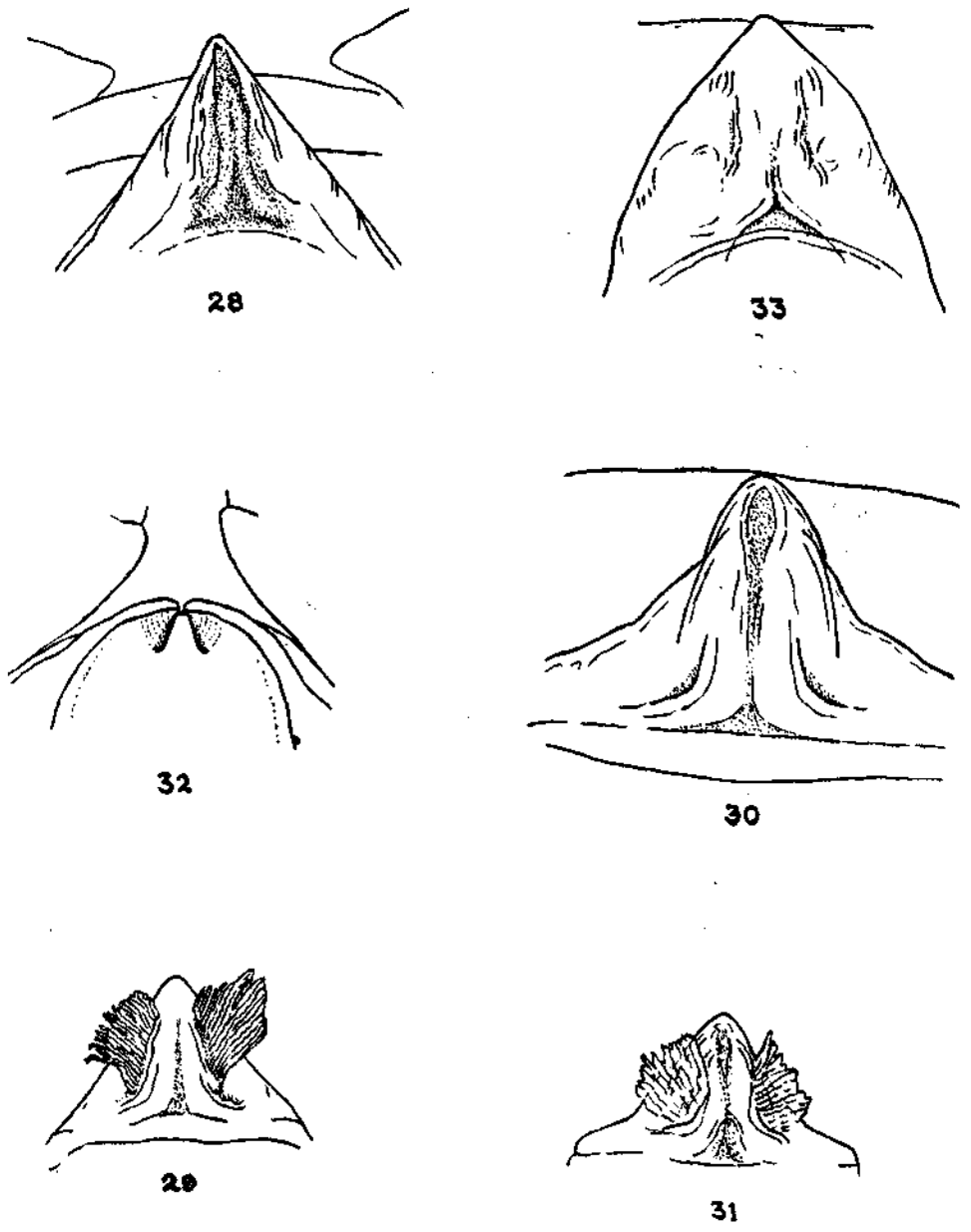
FIGS. 3–14. Showing the specific nature of petasma in *Euphausia* spp. (Figs. mostly after Hansen, 1910 and 1912); (3) *E. eximia*; (4) *E. brevis*; (5) *E. gibboides*; (6) *E. recurva*; (7) *E. diomedeae*; (8) *E. distinguenda*; (9) *E. tenera*; (10) *E. mutica*; (11) *E. sibogae*; (12) *E. hemigibba*; (13) *E. paragibba*; (14) *E. pseudogibba*.



FIGS. 15–21. Thelyca in different species showing their specific nature. (15) *Thysanopoda tricuspidata*; (16) same, with spermatophore; (17) *T. aequalis*; (18) *T. monacantha*; (19) *T. orientalis*; (20) *Euphausia distinguenda* (young); (21) same, adult without spermatophore.



FIGS. 22–27. Thelycum in different species. (22) *Euphausia distinguenda*, with spermatophore; (23) *E. diomedeae*; (24) same, large female measuring 20 mm.; (25) *Nematobrachion boopis*; (26) *N. flexipes*; (27) *Stylocheiron longicorne*.



FIGS. 28–33. Thelycum in *Nematoscelis* spp. (28) *N. gracilis*; (29) same, with spermatozoa; (30) *N. microp*; (31) same, with spermatozoa; (32) *N. megalops* (after Einarsson, 1942); (33) *N. tenella*.

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DISCUSSION

Dr. R. D. Turner: How did you identify the females? Is it by laboratory methods of allowing the females to copulate with identified males?

Mr. M. J. Sebastian: It is possible, though with some difficulty, to identify many female euphausiids on the basis of a number of structural details which they share in common with the males. In such cases the thelycum

presents a single morphological character which enables easy identification. And in cases where the species are separated only on the basis of minute differences in the petasma, as in the case of *E. gibboides* and *E. sanzoi*, it is hoped that these studies on the thelyca may turn out to be useful.

Dr. V. Hansen: It is difficult to rear the euphausiids in the laboratory. Have you been able to identify their larvae?

Mr. M. J. S.: No. Only the systematics of the adults are dealt with here. The larval development of many species of euphausiids of this region is yet to be studied.

Dr. J. H. Wickstead: Are there any different populations in your collections?

Mr. M. J. S.: *Eupheasia distinguenda* obtained in those collection represent a population distinct from those described from elsewhere.

Dr. E. G. Silas: Is there any possibility of females escaping the sampling net, they being smaller than the males?

Mr. M. J. S.: No. I do not think so.

Dr. V. Hansen: Have you examined collections from the guts of fishes?

Mr. M. J. S.: No. I have not examined.