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SPATIAL DISTRIBUTION OF EUPHAUSIACEA (CRUSTACEA) IN THE SOUTHEASTERN ARABIAN SEA

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ABSTRACT

The quantitative geographical distribution of euphausiids of the tropical Indian Ocean has not been studied in detail. Considering this lacuna in our knowledge, a study was undertaken on the spatial distribution of euphausiids of the southeastern Arabian Sea (west coast of India including the Lakshadweep Sea) for the first time. The Arabian Sea and the Bay of Bengal, closed at their northern parts, present special hydrographical features which influence the distribution and abundance of zooplankton in these areas. Here the 10°N latitude is thought to be an effective barrier against the penetration of several oceanic species of euphausiids northwards. This is because of the significant changes in the water quality north of 10°N, being influenced by the discharge from major rivers of the Indian sub-continent. During the present study the spatial distribution of 22 species of euphausiids has been worked out as a result of which it has been found that the species namely *Thysanopoda monacantha, T. tricuspidata* and *Stylocheiron maximum* which were believed hitherto being restricted to areas south of 10°N are distributed further northwards.

INTRODUCTION

THE DISTRIBUTION of Euphausiacea of the world oceans is fairly well documented. In the Indian Ocean, eventhough records of occurrence have been made from 1883 onwards, a study on the quantitative distribution of euphausiids in space and time and their relationship with the environment is lacking. Leaving aside the occasional and stray faunistic records made during the expeditions, the works giving more emphasis to the geographical and seasonal distribution of euphausiids in general and of various species in particular of specified areas in the Indian Ocean are those of Baker (1965), Roger (1966), Weigmann (1970), Gopalakrishnan (1974), Legand *et al.* (1975) and Mc William (1977).

Gopalakrishnan and Brinton (1969) attempted an ocean wide treatment of the quantitative and seasonal geographical distribution of the total euphausiids of the Indian Ocean based on the samples obtained during the INTERNATIONAL INDIAN OCEAN EXPEDITION. Their work also highlighted the distribution of various species of euphausiids collected during the 'LUCIAD EXPEDITION' which cruised between latitudes 5°N and 5° S during July - September, 1962. Later Brintona and Gopalakrishnan (1973) made a detailed study on the geographical distribution and ecology of some common species of euphausiids of the Indian

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Ocean. In two comprehensive reviews, Mauchline and Fisher (1969) and Mauchline (1980) have dealt with in general the distribution of euphausiids in the Indian Ocean as a whole. Two other works which attempted the ocean wide distribution of euphausiids of the Indian Ocean are those of Brinton (1975) and Ponomareva (1975). However, synoptic data based on collections made over a period of time for any specified region is wanting.

In the present paper the spatial quantitative distribution of euphausiids in the continental shelf and the oceanic waters along the southwest coast of India (southeastern Arabian Sea) is presented for the first time.

Material and Methods

The euphausiids were collected on board R. V. *VARUNA* during her cruises in the following areas in the southeastern Arabian Sea: (1) the continental shelf area between latitudes 11° 32' N and 14° 54' N and longitudes 70°30' E and 75°30' E, (2) the oceanic area outside the continental shelf between latitudes 07°30' N and 18°00' N and longitudes 70°30' E and 75°55' E and (3) the oceanic area between latitudes 08°00' N and 14°45' N and longitudes 71°45' E and 77°12' E. With regard to the first set of samples bimonthly sampling from December, 1966 to December, 1967 for zooplankton was carried out from 30 fixed stations distributed in six latitudinal sectors within the area mentioned above. Open vertical hauls were made from 5 m above bottom to the surface in the shelf waters by means of an Indian Ocean Standard Net (IOS Net) of 0.33 mm mesh size (Curie, 1963). A total of 180 samples were analysed for euphausiids.

The second set of samples used in the present study were collected non-systematically from deeper waters in the oceanic areas beyond the continental shelf. Thirty six zooplankton samples formed the basis of this study. The samples were made by the IOS Net as open vertical hauls from depths ranging from 250-1300 m to the surface.

The third set of samples analysed during the present study were those collected at irregular intervals from the neritic as well as oceanic waters as horizontal hauls in varying depths using an Isaacs Kidd Mid-water Trawl (IKM Trawl) (Isaacs and Kidd, 1953). A number of hauls were taken from the Deep Scattering Layer (Silas, 1969) in the Lakshadweep Sea. A total of 96 samples have been examined for euphausiids.

The material collected from the shelf waters was sorted out into adults, juveniles and larvae, while that in the deep water hauls from the oceanic area was categorised into adults and immatures only; the latter including both juveniles and larvae. The euphausiids of IKM Trawl samples were composed exclusively of adults. The total material obtained as analysed into larvae, juveniles and adults (males and females) is given in Table 1. The maximum length observed in either sex in the case of each species is also indicated in the Table.

The quantitative estimates for euphausiids have been carried out for 1000 m^3 of water following the method adopted by Gopalakrishnan and Brinton (1969) and Brinton and Gopalakrishnan (1973). The ring diameter of IOS Net being 113 cm, covers almost 1 m^2 area and hence the vertical column of water travelled by the net upto 200 m could be considered as the volume of water filetred by the net during a haul, assuming that the filtration efficiency of the net was 100 per cent. However, for estimating the quantity of water filtered by the IOS Net during the deep water hauls in the oceanic area the actual volume of water filtered by the net was calculated by using the formula $\pi r^2 h$. The numerical estimates for the euphausiids caught in the

TABLE 1. *The euphausiids obtained from the continental shelf and oceanic waters of the west coast of India in IOS Net and IKM Trawl, and the maximum lengths observed for either sex of each species*

Species	Occurrence (No.)									Maximum length (mm)	
	IOS Net							IKM Trawl			
	Shelf				Oceanic			Shelf & Oceanic			
	Larvae	Juv.	Male	Female	Imm.	Male	Female	Male	Female	Male	Female
Bentheuphausia amblyops	–	–	–	–	–	–	1	–	–	–	17.00
Thysanopoda monacantha	4	6	–	–	–	9	17	1683	2166	27.00	27.75
T. tricuspidata	28	–	–	–	11	–	–	669	1358	26.00	27.00
T. astylata	–	–	–	–	–	–	4	32	24	15.00	16.00
T. orientalis	–	–	–	–	–	2	12	71	147	25.00	26.00
T. pectinata	–	–	–	–	–	–	–	26	49	32.50	34.00
Pseudeuphausia latifrons	1362	598	106	166	7	37	43	–	–	7.50	7.75
Euphausia diomedeae	283	254	4	4	227	323	554	320	1069	16.00	17.50
E. tenera	50	7	2	–	–	29	48	1	–	9.00	9.25
E. sibogae	12350	802	361	526	177	1250	1824	1	4	11.50	12.50
E. pseudogibba	–	–	–	–	–	3	6	6	2	13.25	11.00
Nematoscelis tenella	–	–	–	–	–	1	–	3	5	14.50	15.00
N. gracilis	161	114	11	24	70	179	352	17	109	12.50	16.25
Nematobrachion flexipes	–	–	–	–	4	1	7	203	387	15.00	21.75
Stylocheiron armatum	721	259	294	473	317	281	415	–	–	6.75	9.00
S. affine	357	162	131	181	37	128	201	–	–	6.00	7.25
S. suhmi	12	4	3	3	–	9	10	–	–	5.25	5.00
S. microphthalma	–	1	–	2	–	3	3	–	–	5.75	5.75
S. indicum	–	–	–	–	–	9	13	–	–	11.75	13.50
S. longicorne	8	7	–	–	55	150	194	–	16	9.50	13.50
S. abbreviatum	–	–	–	7	1	1	6	28	265	14.50	16.50
S. maximum	1	1	–	–	–	–	4	33	75	19.50	22.00

IKM Trawl were made as number per hour of trawling.

Spatial Distribution of Species

Bentheuphausia amblyops (G. O. Sars, 1885)

A single immature female specimen (based on description by Einarsson, 1942) of this bathypelagic species was caught in a haul made in the early morning hours from 1000 m depth to the surface at 16°06' N and 72°10' E where the depth to the bottom was 1600 m (Fig. 7 c).

Thysanopoda monacantha Ortmann, 1893

In the shelf area the northern limit of *T. monacantha* extended upto 13°30' N. However, the majority occurred south of 12°12' N (Fig. 2 b). The number per 1000 m^3 of water ranged between six and 29. No adults were taken from the shelf waters.

The species was never taken in good numbers with the IOS Net from the oceanic waters. Their number per 1000 m^3 of water ranged between one and six only. However, out of the 38 stations sampled the species occurred at 12 stations which shows their wide spread distribution (Fig. 4 b). The northernmost limit of distribution in the oceanic area was 12° N. Only adults were present in six day and six night samples.

T. monacantha was one of the species most abundantly and frequently caught with the IKM Trawl in the oceanic area. High concentrations of this species were found south of 11°N. The highest number of 1,830 specimens per one hour trawling was taken at 10°00' N and 72°00' E near Suheli Par Island of the Lakshadweep group. This mesopelagic species was caught at a single day station from a depth of 400 m. The depth of sampling at those night stations at which this species was taken ranged between 40 and 120 m which suggests that they make extensive vertical migrations in the night to the surface waters.

Thysanopada tricuspidata Milne - Edwards, 1837

T. tricuspidata is a widely distributed species in the tropical and subtropical seas. Only larval forms were obtained from the shelf waters. They were strictly confined to the southern parts of the area studied (Fig. 1 a). Their northern limit in the shelf area extended slightly beyond 12°N. The only occasion when this species occurred beyond this limit was during a collection at 13°30' N near the shelf edge. The larvae occurred in shallow areas also, for instance, in a 40-0 m haul made at a station which had a depth of about 50 m three specimens were captured. The average number per 1000 m^3 of water at the various stations during the entire period of studies ranged between two and 21.

In the oceanic waters *T. tricuspidata* was sparsely collected with the IOS Net. Larvae and juveniles alone were obtained in these samples. Out of the 38 samples collected, only six contained this species of which three were taken during the day (Fig. 4 c). The species was found to be mainly confined to the 10°N latitudinal belt. A single specimen was taken at 16°06'N also. The number per 1000 m^3 of water at the various stations of their occurrence varied from one to 10.

T. tricuspidata was collected in good numbers from the oceanic area with the IKM Trawl (Fig. 8 c) and formed the second abundant species, the first being *T. monacantha*. This epipelagic species occurred at 26 stations, five being sampled during the day of which one was sampled from 70-0m. While the females dominated in 10 samples, the males

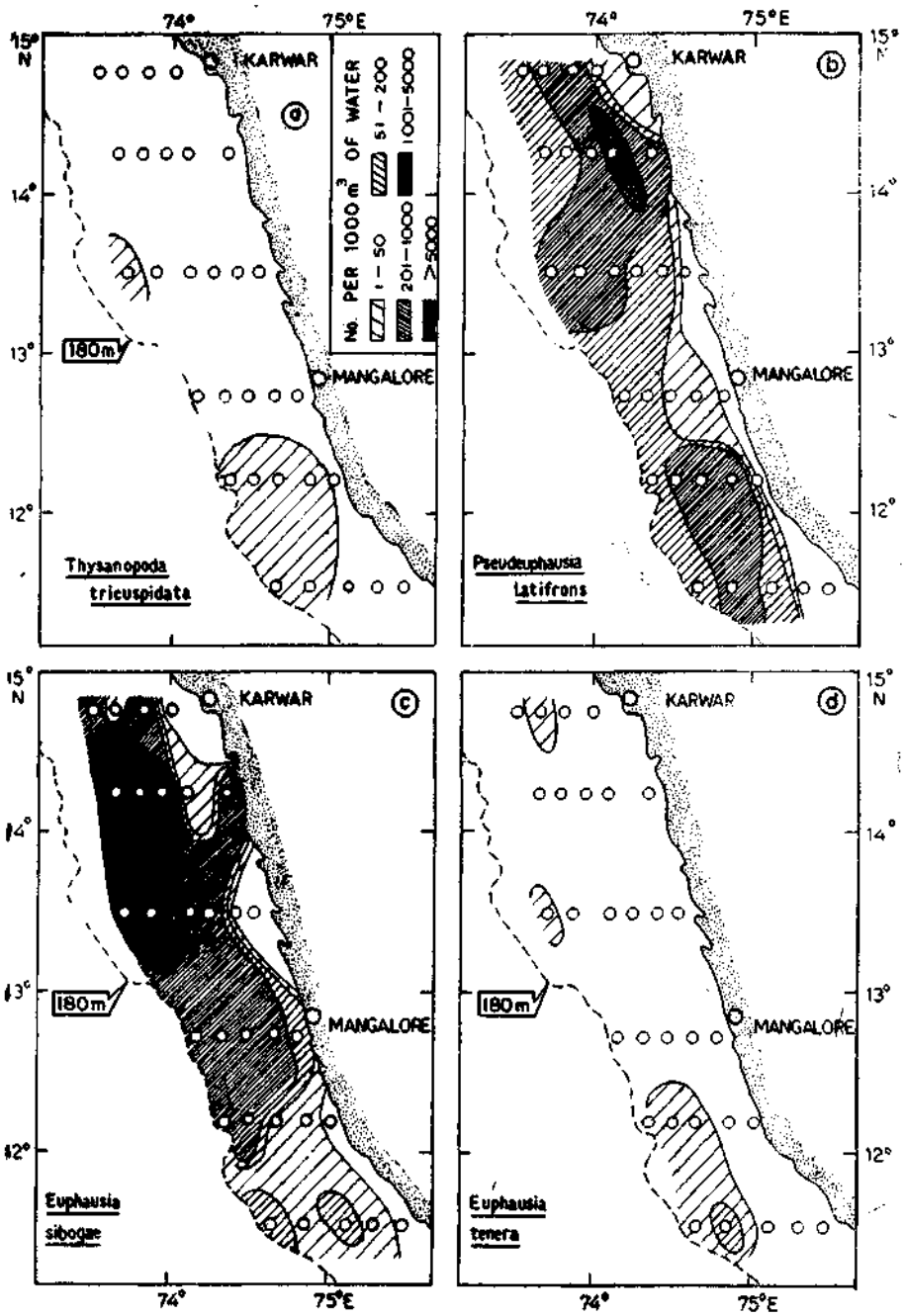

Fig. 1. Spatial distribution of euphausiids in the shelf waters : a. *Thysanopoda tricuspidata*, b. *Pseudeudephausia latifrons*, c. *Euphausia sibogae* and d. *E. tenera*.

dominated in nine samples. In one sample both occurred in equal proportion. At two stations males alone were present while at another four stations only females occurred.

There was an overall female dominance with 67%.

Thysanopoda astylata Brinton, 1975

While this species was absent in the shelf waters, it occurred in a few samples taken from the oceanic waters One female each was present in four deep water hauls made between 09°30' N and 10°00' N (Fig. 7 c), from depths ranging from 950 to 1200 m to the surface. Three of the samples were collected during day. All the specimens were subadults.

The IKM Trawl captured *T. astylata* from five stations (Fig. 9 c) in the oceanic area of which one was sampled during the day from 400-0 m. The number per one hour trawling ranged between three and 30 only. The northern limit of the species extended upto a little beyond 10° N.

Thysanopoda orientalis Hansen, 1910

A few specimens occurred in the deepwater samples taken at five stations which occupied between 08°00' N and 11°00' N on the continental slope (Fig. 7 c). The maximum number of seven per 1000 m^3 of water was taken at a station at 9°41'N and 75°10'E. Relatively more specimens were taken during the day.

T. orientalis occurred along with *T. pectinata* at three stations where the IKM Trawl was operated. Its number per one hour trawling ranged between 25 and 156. A day haul made from 400-0 m contained 29 specimens while one of the night samples collected from 100 - 0 m contained 20 specimens. However, the maximum number of 169 was taken in a night sample trawled from 300-0 m (Fig. 9 c).

Thysanopoda pectinata Ortmann, 1893

This was a rarely occurring species which was present in one day sample hauled from 400-0 m and two night samples hauled from 100-0 and 300-0 m respectively near 9°N. Their number per one hour trawling by the IKM Trawl ranged between 15 and 17 (Fig. 9 c).

Pseudeuphausia latifrons (G.O. Sars) 1883

This was the third abundant species in the shelf waters where it enjoyed a widespread distribution. It was present even at the shallowest stations. At the different stations their average number per 1000 m^3 of water varied between 25 and 2368. A north - south difference in occurrence was not very significant (Fig. 1 b). However, the population was found to be sparse in the mid-sectors.

P. latifrons was not an abundant species in the oceanic waters. Its occurrence was mainly limited to the continental slope and also in the Lakshadweep waters (Fig. 5 d). The maximum number of 61 per 1000 m^3 of water was from a shelf edge station at 10°00' N 75°30' E. The species occurred at 12 stations of which six were sampled in the day.

Euphausia diomedeae Ortmann, 1894

E. diomedeae had a relatively smaller population in the shelf waters and was represented mostly by larvae and juveniles. A few adults were taken on two occasions. In the shelf waters they were mostly confined to the deeper area (Fig. 2 a). They occurred at 13 stations and their average number during the whole period of investigation at the different stations varied between three and 338 per 1000 m^3 of water. A latitudinal difference in the distribution was not very much pronounced though a slight concentration was noticed in the southern area.

In the oceanic area *E. diomedeae* was widely distributed. It occurred at all but four stations sampled with the IOS Net. The negative

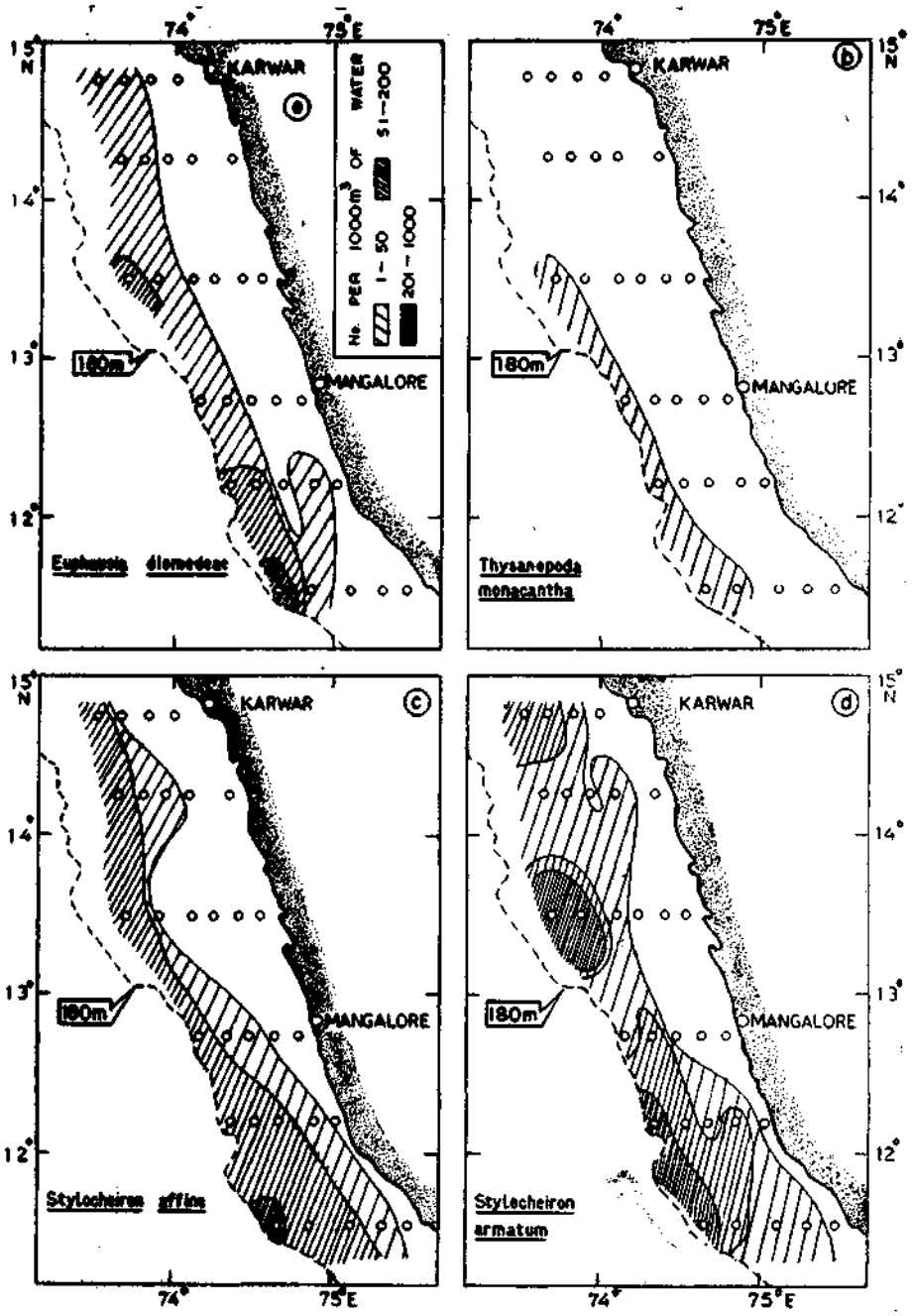

Fig. 2. Spatial distribution of euphausiids in the shelf waters : a. *Euphausia diomedeae*, b. *Thysanopoda monacantha*, c. *Stylocheiron affine* and d. *S. armatum*.

stations were closer to the continental shelf edge which is an indication of their oceanic nature (Fig. 4 d). The number per 1000 m^3 of water ranged between six and 279.

In the IKM Trawl collections the number of specimens ranged between one and 338 per one hour trawling. It was found to be more between latitudes 10°N and 12°N (Fig. 8 d). In all but one sample the females dominated. The percentage composition of males and females was 22.40 and 77.60 respectively.

Euphausia tenera Hansen, 1905

This species was sparsely distributed in the shelf waters. It was mainly confined to the southern sectors (Fig. 1 d). The maximum of 74 per 1000 m^3 of water was taken around 11°N 75°E where the depth to the bottom was about 80 m. In the other areas its number ranged between three and 20 per 1000 m^3 of water.

In the oceanic area also *E. tenera* was found to be confined to the southern parts between 7°N and 12°N. Though it occurred at 15 stations, it was always taken in small numbers being in the range of one to 41 per 1000 m^3 of water (Fig. 5 b). A single specimen occurred in an IKM Trawl sample collected at 10°22' N 73°55' E (Fig. 9 c).

Euphausia sibogae Hansen, 1908

This was by far the commonest and the abundantly caught species in the shelf area. When considered for the whole period of studies the maximum number of 13,450 per 1000 m^3 of water was taken from a shelf station. The abundance was found to be more towards the northern parts (Fig. 1 c). The percentage composition of males to females was 40.70 and 59.30.

In the oceanic area, in the deep water samples collected with the IOS Net, this species was the most abundant and the frequently caught (Fig. 5 a). This shoaling species occurred in varying numbers and its number ranged from 1 to 3,563 per 1000 m^3 of water. It occurred in all but four samples. The main area of concentration of this species was towards cotinental slope. In the Lakshadweep water the density was relatively low. The IKM samples contained only five specimens of *E. sibogae* (Fig. 9 b).

Euphausia pseudogibba Ortmann, 1893

This equatorial oceanic epipelagic species was least represented in the area under investigation. A few adults were collected by the IOS Net and the IKM Trawl in the oceanic area. The species was found restricted to the southernmost region of 10°N. It occurred in five samples collected with the IOS Net off Cochin and Cape Comorin; not very far away from the continental shelf edge. The density was below four per 1000 m^3 of water (Fig 5 c). The IKM Trawl collected this species at three stations around 9°N (Fig. 9 d).

Nematoscelis tenella G. O. Sars, 1883

A single specimen of this equatorial-central mesopelagic species was taken from a station at 8°10' N 75°20' E which was sampled during the day (Fig. 7 c). Another eight specimens occurred in a sample collected with the IKM Trawl from 300-0 m at 9°00' N 74°58' E (Fig. 9 b).

Nematoscelis gracilis Hansen, 1910

In the shelf area *N. gracilis* was widely distributed but in moderate numbers. The number per 1000m^3 of water varied between four and 94 (Fig. 3 b). Like most other species, its main centres of abundance was in the southern areas. Towards the north a gradual thinning of the population was noticed. This species was always found away from the costal waters.

The samples collected with the IOS Net from the oceanic area showed that *N. gracilis* was a widely distributed species there (Fig. 6 a). It was taken at all but two stations, in

moderate numbers ranging between three and 175 per 1000 m^3 of water. A slight aggregation was noticed towards the continental slope areas.

The IKM Trawl collected the species at five stations only of which two were engaged during the day. Their number per one hour trawling ranged from two to 69 (Fig. 9 d).

Nematobrachion flexipes (Ortmann, 1893)

The IOS Net samples from the oceanic area contained relatively less number of specimens of this species. They occurred at the rate of one to seven per 1000 m^3 of water (Fig. 6 b). Though the species exhibited patchy distribution it occurred over a wide area.

N. flexipes was present in moderate numbers in the IKM Trawl samples. Except on three occasions its number per one hour trawling was below 50 (Fig. 9 a). The maximum number taken was 177 followed by 163 and 68 per one hour trawling.

Stylocheiron armatum Colosi, 1917

This was the second abundant species in the shelf area (Fig. 2 d). Like *E. sibogae* it appeared in swarms, occasionally forming isolated patches of high density. A wide range in the numerical abundance, of the magnitude of 10 to 848 per 1000 m^3 of water, was noticed. Though a striking north-south difference was not discernible its population tended to be more in the southern sectors.

As in the shelf area, in the oceanic area also this epipelagic species was quite abundant and widespread spatially (Fig. 6 c). Here also the population was concentrated more towards the southern part of the area under study. The maximum number of 884 per 1000 m^3 of water was taken in a day sample from the continental slope at 9°00'N 75°58'E.

Stylocheiron affine Hansen, 1910

S. affine was abundantly present in the shelf area, particularly in the southern sectors where it came into the neritic waters (Fig. 2 c). In the northernmost sector its numerical abundance was of the order of three to 134 per 1000 m^3 of water. On the other hand its number ranged between 13 and 195 in the mid-sectors and between 13 and 229 in the southern sectors.

In the oceanic area also the species was widely distributed (Fig. 6 d). It was always taken in moderate numbers and the number ranged from one to 82 per 1000 m^3 of water. It is quite possible, as in the case of other epipelagic species, that the deep water hauls made in the oceanic area might have sampled much of the water column devoid of this rather non-migrating species and hence a moderate number was only obtained in the plankton.

Stylocheiron suhmi G. O. Sars, 1883

The species occurred sporadically in the shelf waters. Though its distribution was highly patchy it was present in four of the latitudinal sectors (Fig. 3 a). At the various stations the number ranged between three and 31 per 1000 m^3 of water.

As in the shelf waters, *S. suhmi* was taken rarely from the oceanic waters also. Five of the seven stations where the species occurred were in the northern part of the area under study (Fig. 7 a). The number per 1000 m^3 of water varied between one and seven only.

Stylocheiron microphthalma Hansen, 1910

In the continental shelf area the species occurred towards the shelf edge at three stations in the fifth and sixth latitudinal sectors (Fig. 4 d). In the oceanic waters the species was present in the IOS Net samples only. Three of the samples taken from between

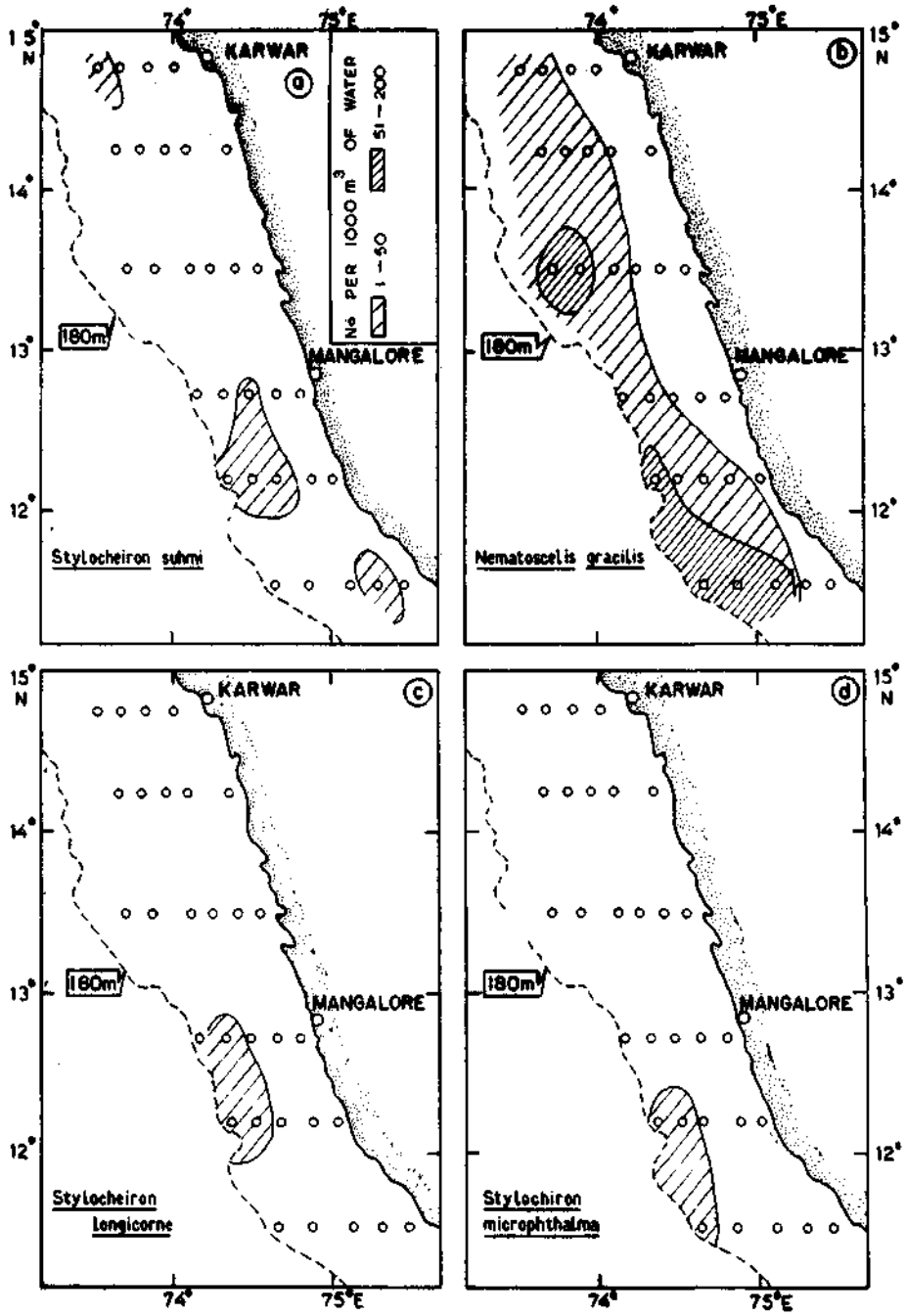

Fig. 3. Spatial distribution of euphausiids in the shelf waters : a. *Stylocheiron suhmi*, b. *Nematoscelis gracilis*, c. *S. longicorne* and d. *S. microphthalma*.

9°45' N and 10°40 'N and one sample from 16°00' N contained it (Fig. 7 d).

Stylocheiron indicum Silas and Mathew, 1967

This species was taken at a single station

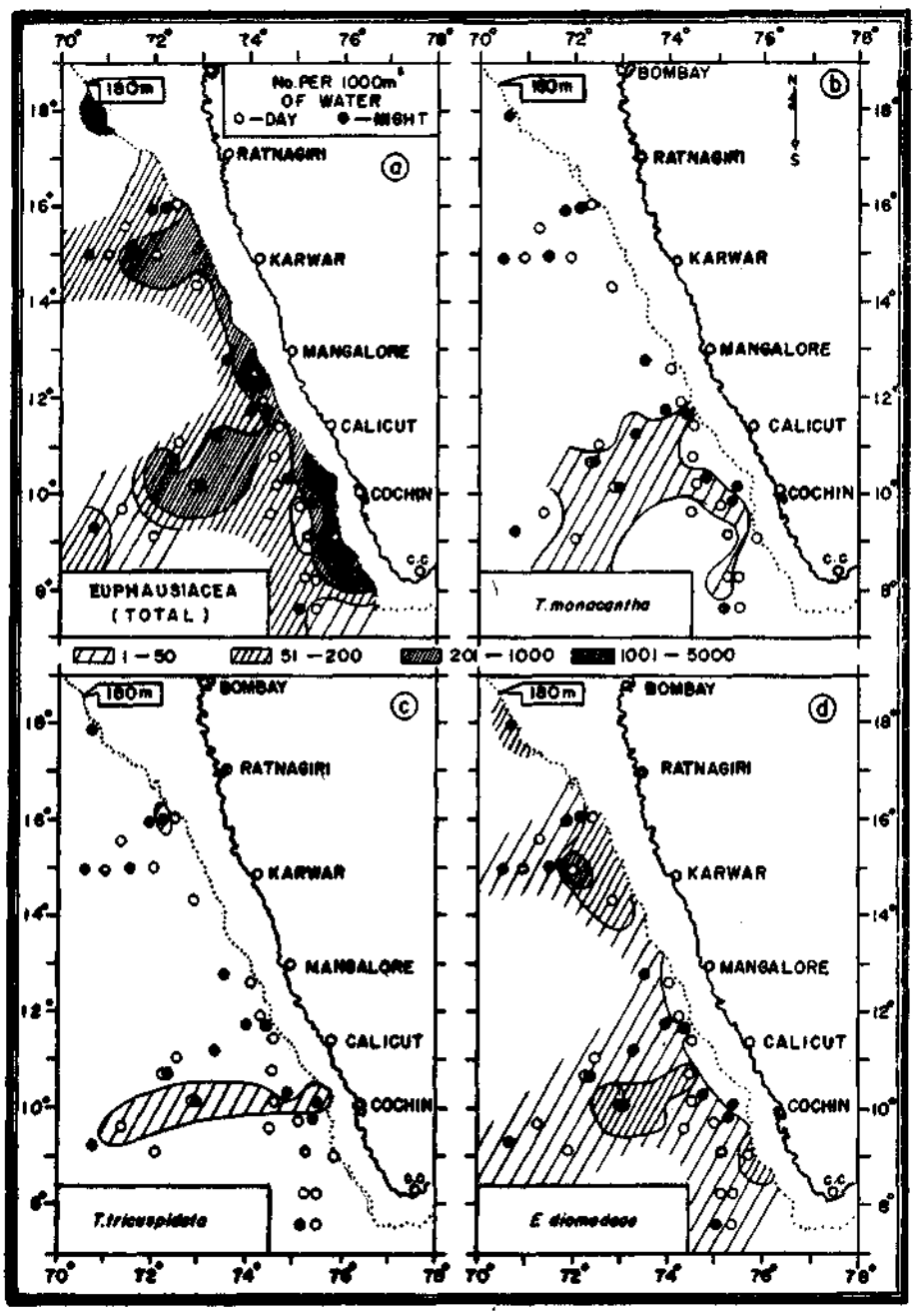

Fig. 4. Spatial distribution of total euphausiid and different species in the oceanic area of the west coast of India, based on IOS Net samples: a. *Euphausiacea* (total), b. *Thysanopoda monacantha*, c. *T. tricuspidata* and d. *Euphausia diomedeae*.

on the continental slope where the depth to the bottom was 320 m. The plankton haul made at 9°00'N 75°58'E was from a depth of 300-0 m (Fig. 7 d).

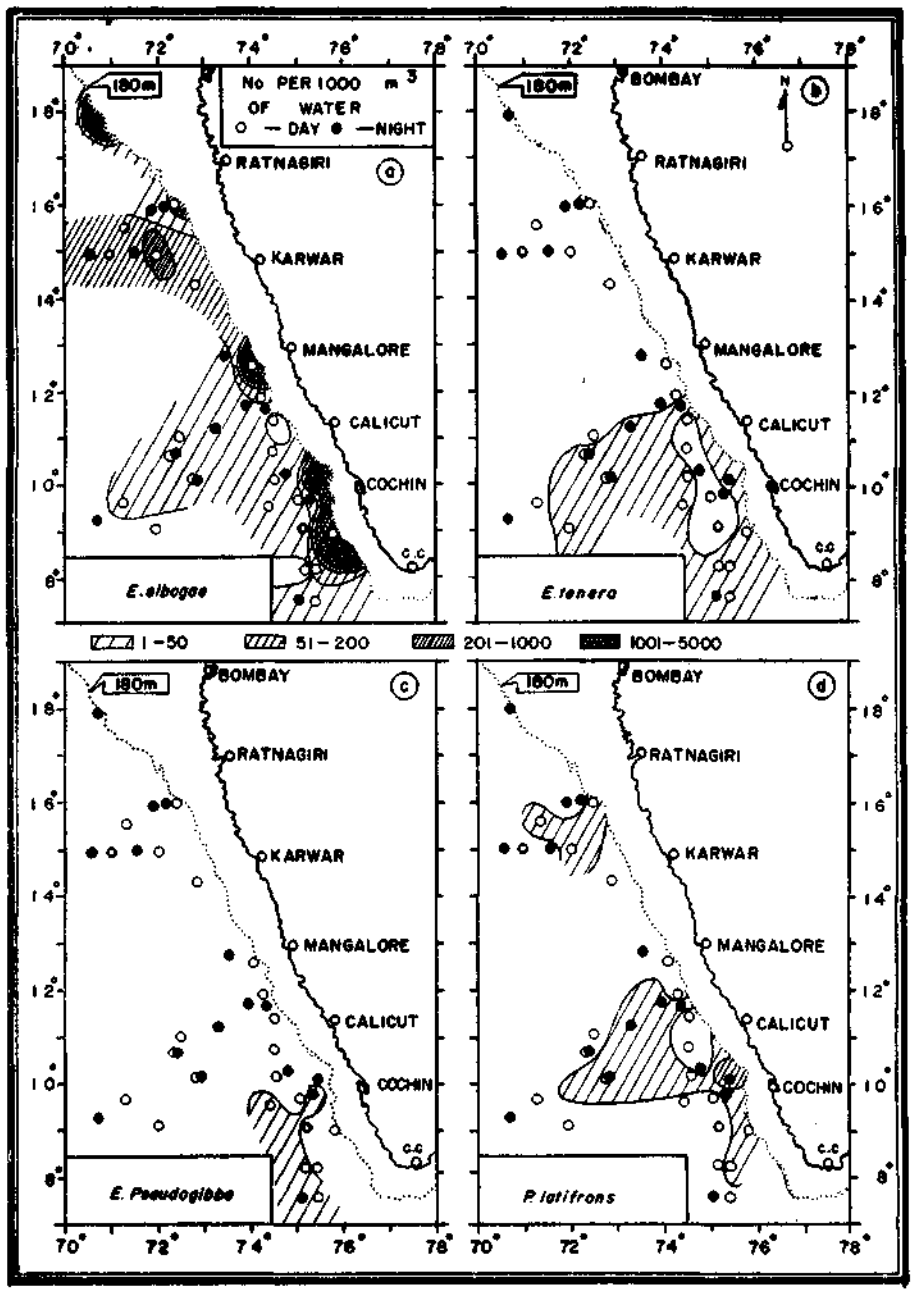

Fig. 5. Spatial distribution of euphausiids in the oceanic area based on IOS Net samples: a. *Euphausia sibogae*, b. *E. tenera*, c. *E. pseudogibba* and d. *Pseudeuphausia latifrons*.

Stylocheiron longicorne G. O. Sars, 1883

S. longicorne was rare in the shelf region where it was taken at three stations towards the shelf edge; one in the mid-sector and the others

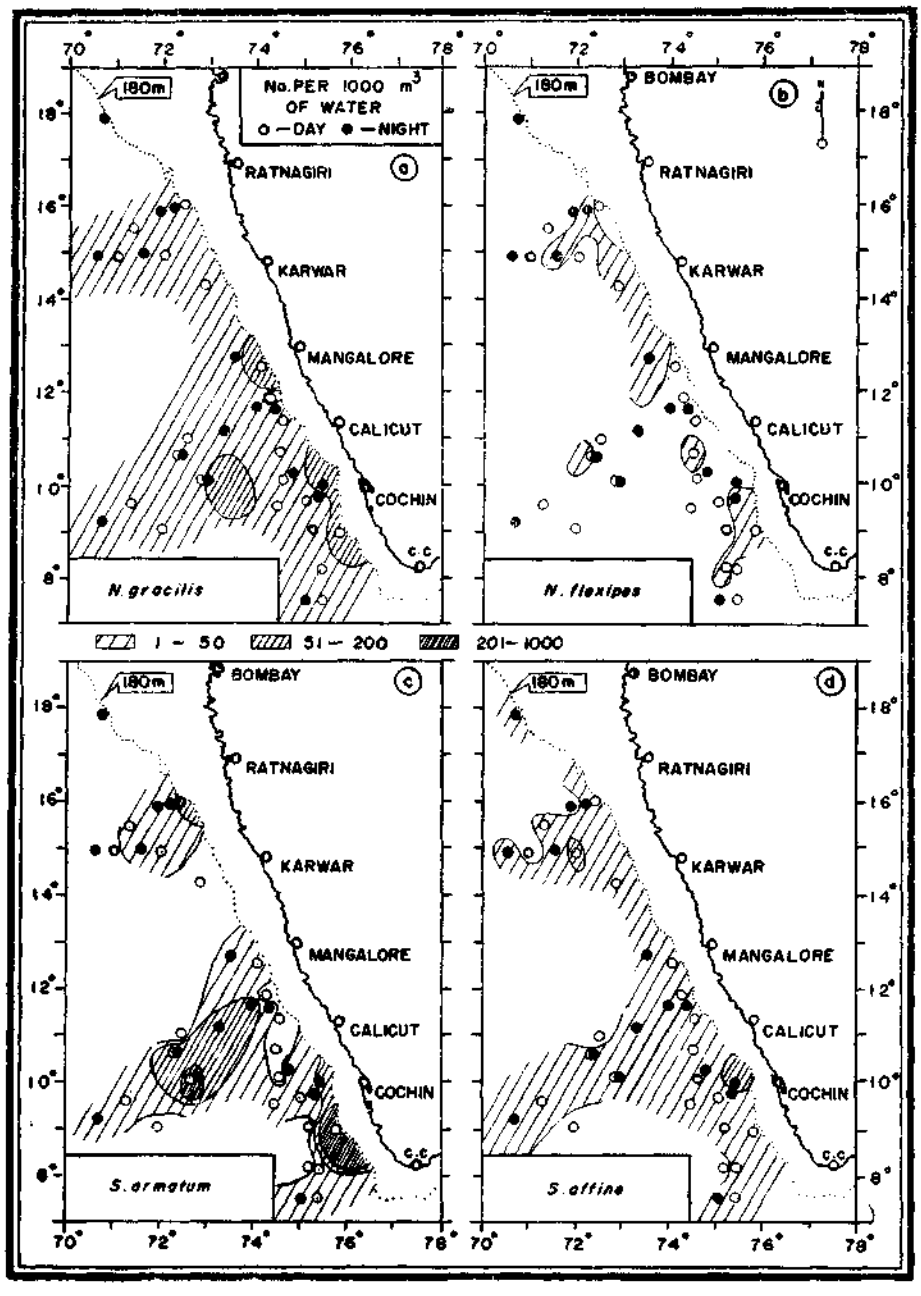

Fig. 6. Spatial distribution of euphausiids in the oceanic area based on IOS Net samples: a. *Nematoscelis gracilis*, b. *Nematobrachion flexipes*, c. *Stylocheiron armatum* and d. *S. affine*.

in the southern sector. Their number per 1000 m³ of water ranged between one and 11 (Fig. 3 c).

In the oceanic area the species showed a wide spread occurrence in samples collected with the IOS Net, and was present in 33 out

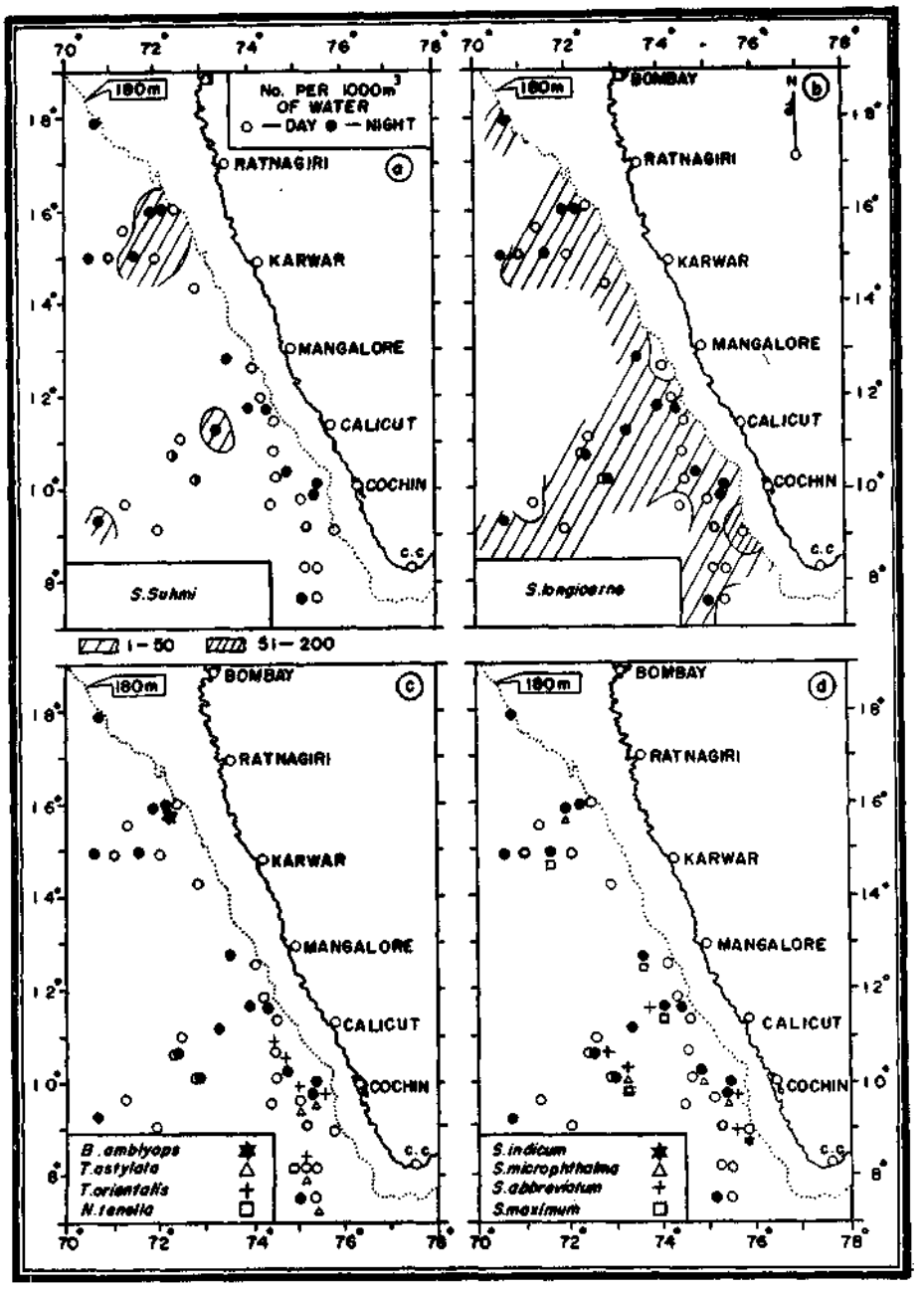

Fig. 7. Spatial distribution of euphausiids in the oceanic area based on IOS Net samples: a. *Stylocheiron suhmi*, b. *S. longicorne*, c. *Bentheuphausia amblyops*, *Thysanopoda astylata*, *T. orientalis*, *Nematoscelis tenella* and d. *S. indicum*, *S. microphthalma*, *S. abbreviatum* and *S. maximum*.

of 38 samples. However, it always occurred in moderate numbers only. The maximum number per 1000 m^3 water was 71 from a station at 9°00' N and 75°58' E which was

very close to the shelf (Fig. 7 b). In samples collected with the IKM Trawl the species was represented by 13 females in one night haul and other three females in a day sample (Fig. 9 b).

Stylocheiron abbreviatum G. O. Sars, 1883

This typically central epipelagic species was rarely caught from the shelf area where only seven adult females were taken from one

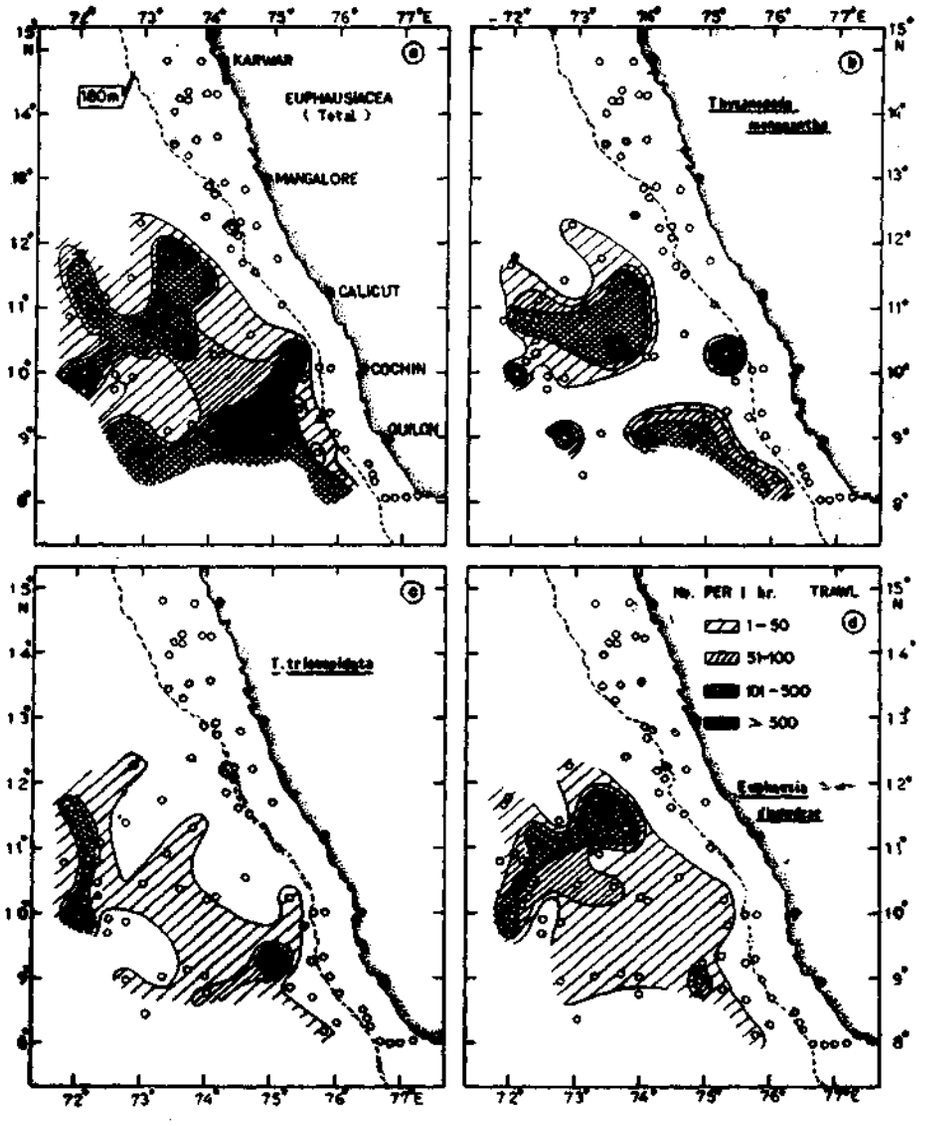

Fig. 8. Spatial distribution of total euphausiids and of different species in the oceanic area based on IKM Trawl: a. *Euphausiacea* (total), b. *Thysanopoda monacantha*, c. *T. tricuspidata* and d. *Euphausia diomedeae*.

night station on the shelf edge at latitude 12°12' N.

Net. Its number per 1000 m^3 of water ranged from two to seven (Fig. 7 d). The species

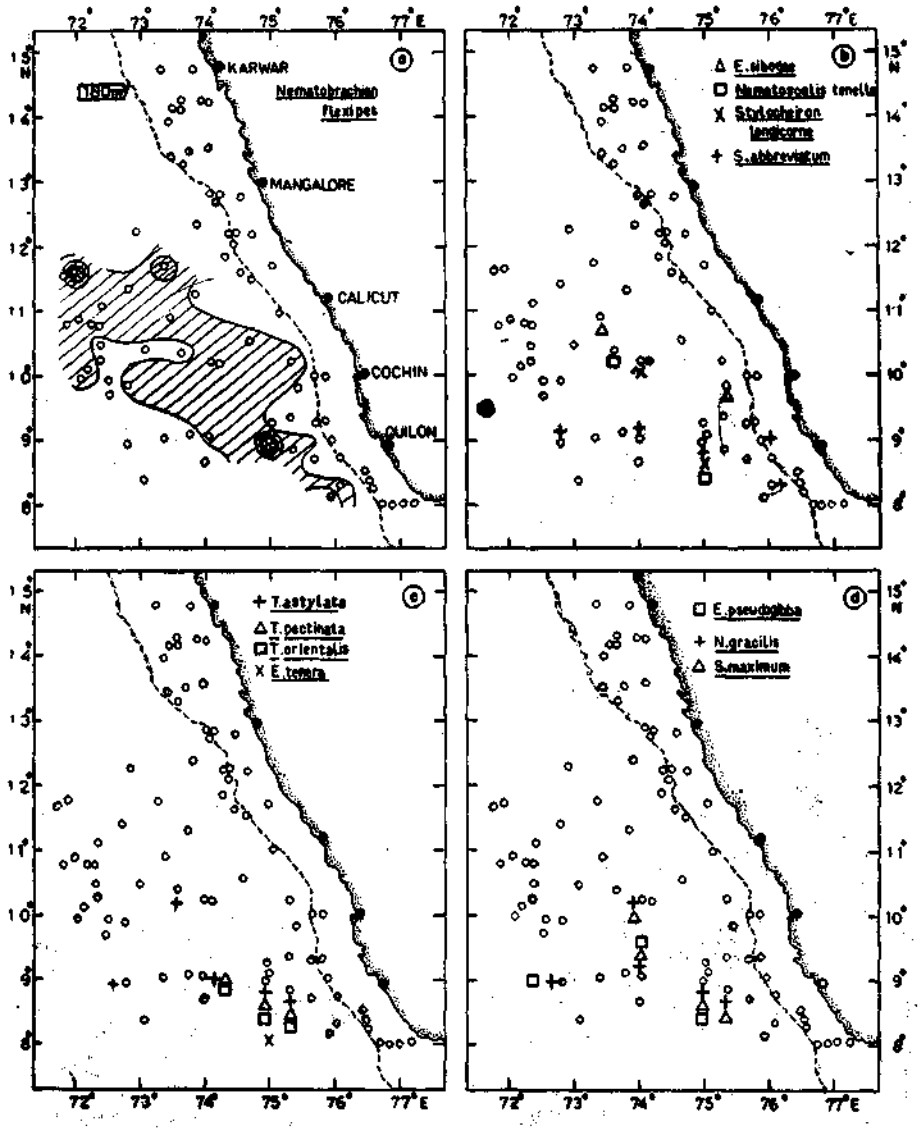

Fig. 9. Spatial distribution of euphausiids in the oceanic area based on IKM Trawl samples: a. *Nematobrachion flexipes*, b. *Euphausia sibogae*, *Nematoscelis tenella*, *Stylocheiron longicorne*, *S. abbreviatum*, c. *Thysanopoda astylata*, *T. pectinata*, *T. orientalis*, *E. tenera*, and d. *E. pseudogibba*, *N. gracilis* and *S. maximum*.

In the oceanic area the species occurred in five of the samples collected with the IOS IKM Trawl (Fig. 9 b). Excepting on one occurred in a few samples collected with the

occasion the number per one hour trawling ranged between one and seven only. The trend in the occurrence of *S. abbreviatum* (the catch of 275 specimens in a single haul) indicated that it was not a rare species, at least in the oceanic part of the study area. The capability of this carnivorous species to avoid the net might have been one reason for their least occurrence in the IOS Net collections.

Stylocheiron maximum Hansen, 1908

The two stations at which *S. maximum* occurred in the shelf waters occupied the shelf edge region. Being a mesopelagic species no adults were taken from the shelf area. In the oceanic area four IOS Net samples contained one female each of this species (Fig. 7 d). The IKM Trawl yielded more specimens, but at four stations only (Fig. 9 d).

Discussion

The euphausiids being an assemblage of planktonic organisms of wide ranging sizes and swimming capacities, sampling with one type of gear alone may not be enough to get a representative sample of all the species. Those large species which are relatively fast moving may dodge a rather slow moving net with smaller mesh size and this could result in a wrong conclusion about their distribution.

In the present material the larger species namely *T. monacantha* and *T. tricuspidata* were almost absent in samples collected with the IOS Net. But the samples obtained by the IKM Trawl contained large number of these species especially in deeper hauls. The present study shows that in biomass the above two species because of their large sizes may surpass the hitherto been considered abundant species of *E. sibogae* and *E. diomedeae* in the Arabian Sea. Also the total euphausiid biomass in the Arabian Sea and probably in the other seas and oceans may be much more than what is thought to be. This increases the importance of euphausiids in the marine economy.

In the Indian Ocean the region north of 10°N latitude consists of the Arabian Sea and the Bay of Bengal which according to Brinton and Gopalakrishnan (1973) is dominated by coastal species of euphasiids. The abundance of these coastal species has indicated that the waters are coastal in quality. Therefore, the species of euphausiids obtained during the International Indian Ocean Expedition from the Arabian Sea and the Bay of Bengal were not many. The significance of the 10°N latitude in terms of the distribution of euphausiids has been adequately discussed by Brinton and Gopalakrishnan (1973) and Mauchline (1980). Brinton and Gopalakrishnan found the 10°N as an effective barrier against the penetration of many of the true oceanic species northwards. Thus about 10 tropical and subtropical circumglobal species in their collections did not occur north of this latitudinal barrier.

The present material come from the area between 07°32'N and 18°00'N in the neritic and oceanic waters in the southeastern Arabian Sea and it allows a closer examination of the latitudinal range, especially the northern boundaries of different species in comparision with what have been found by the previous authors (Weigmann, 1970; Brinton and Gopalakrishnan, 1973; Brinton, 1975; Ponomareva, 1975). The results of the study have been summarised in Table 2.

The present study has extended the northern limits of distribution of six species from 10°N to further northwards (Fig. 10, Table 2). Significant extension was found in the case of three of the oceanic species namely *T. monacantha, T. tricuspidata* and *S. maximum*. The northern Indian Ocean 'form' of *S. longicorne* of Brinton (1962) is the species distributed in the Arabian Sea and the Bay of Bengal (Brinton, 1975). According to him *S. longi-*

TABLE 2. *The northern boundary in the geographical distribution ofdian Ocean In euphausiids in the eastern Arabian Sea as observed by the previous investigators, in comparision with the authors' findings*

Species	Weigmann (1970)	Brinton & Gopalakrishnan (1973)	Brinton (1975)	Ponomareva (1975)	Present investi-gations
B. amblyops	-	-	-	-	16°06'N
T. monacantha	13°30'N	10°00'N	10°00'N	10°46'N	13°23'N
T. tricuspidata	13°30'N	10°00'N	10°00'N	-	16°06'N
T. astylata	-	10°00'N	10°00'N	-	10°22'N
T. orientalis	-	10°00'N	02°00'N	-	10°63'N
T. pectinata	-	10°00'N	10°00'N	-	09°15'N
P. latifrons	T.O	T.O	T.O	-	10°00'N
E. diomedeae	T.O	T.O	T.O	-	17°55'N
E. tenera	10°00'N	15°00'N	10°00'N	-	14°45'N
E. sibogae	T.O	T.O	T.O	-	17°55'N
E. pseudogibba	07°24'N	10°00'N	10°00'N	-	09°35'N
N. tenella	-	08°00'N	08°00'N	16°05'N	09°00'N
N. gracilis	T.O	T.O	T.O	-	16°00'N
N. flexipes	09°00'N	15°00'N	10°00'N	-	16°06'N
S. armatum	T.O	T.O	T.O	-	16°00'N
S. affine	T.O	T.O	T.O	12°10'N	17°55'N
S. suhmi	08°00'N	10°00'N	-	16°05'N	16°06'N
S. microphthalma	-	05°00'N	10°00'N	12°10'N	15°20'N
S. indicum	-	T.O	-	-	09°00'N
S. longicorne	23°00'N	10°00'N	13°00'N	-	17°55'N
S. abbreviatum	09°00'N	10°00'N	12°00'N	10°02'N	12°12'N
S. maximum	-	-	12°00'N	-	15°03'N

T. O. = Throughout eastern Arabian Sea.

corne is absent in the eastern Arabian Sea. However, the present studies indicate that this mesopelagic species is widespread in the oceanic waters in this sea area.

dant in the area under the present investigations. In addition, the species namely *T. monacantha, T. tricuspidata, N. flexipes* and *S. longicorne* were also found to be numerically abundant

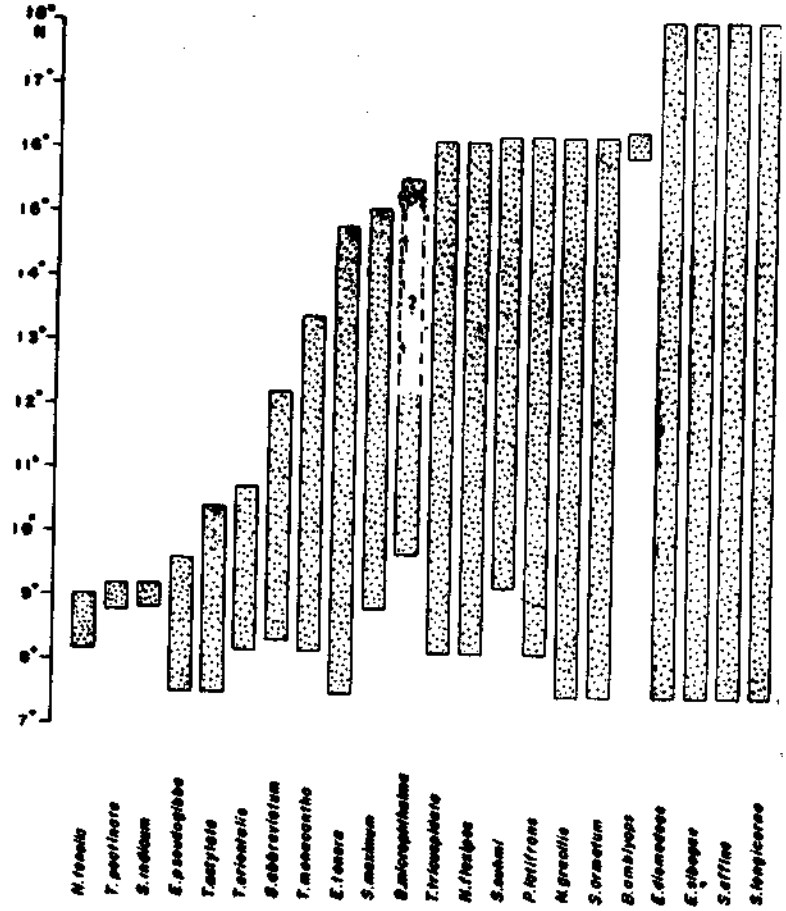

Fig. 10. Latitudinal range of euphausiids in the area investigated (Material obtained from the continental shelf and the oceanic waters collected with the IOS Net and the IKM Trawl have been pooled and considered).

The characteristic species of the northern Indian Ocean as suggested by Brinton and Gopalakrishnan (1973) namely *P. latifrons, E. diomedeae, E. sibogae, N. gracilis, S. carinatum* (= *S. armatum*) and *S. affine* have been found to be widespread and numerically abundant in the oceanic area. These larger species except *S. longicorne* were caught in large numbers in the IKM Trawl collections. Probably their capability to evade the IOS Net might have been one of the reasons why they did not occur in the standard net collections examined

by Brinton and Gopalakrishnan (1973) for understanding the spatial distribution. The mesopelagic species *S. longicorne* was abundant in the deep water hauls made in the oceanic waters of the present study area. However, according to Brinton (1975) this species is absent in the eastern Arabian Sea.

It is the first time that a quantitative study is made of the geographic distribution of Euphausiacea of the southeastern Arabian Sea. Nevertheless many areas of ecology and biology of euphausiids of the Arabian Sea remain to be investigated. The works on the larval development of *E. diomedeae*, *E. sibogae* (= *E. distinguenda*) (Mathew, 1971, 1975) and *S. armatum* (= *S. carinatum*) (Mathew, 1972), the growth pattern among the post-naupliar stages of the above three species (Mathew, 1980 a), the egg potential in *T. tricuspidata* (Mathew, 1980 b) the sexual dimorphism in *S. indicum* (Mathew, 1980 c) and a critical study of developmental stages of euphausiids (Silas and Mathew, 1977) have thrown more light on the biology of euphasiids in this sea area. An immediate need is quantified information of the vertical distribution, dirunal migration, role in the Deep Scattering Layers, importance as forage for fishes such as tunas, food habits and reproductive strategy. It is hoped that the future programmes will give adequate attention to elucidate these aspects.

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