

DISTRIBUTION OF CALANOID COPEPODS IN THE ARABIAN SEA AND BAY OF BENGAL

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ABSTRACT

The distribution of calanoid copepods from the northern Arabian Sea and Bay of Bengal is discussed in relation to thermocline. The inshore offshore zonation of a neritic, shelf and oceanic communities was traced based on the species composition. Numerical abundance was high in the shelf stations. Secondary production considered in terms of copepod density showed the ratio 2:1 between the Arabian Sea and Bay of Bengal. The water column from the top layer of thermocline to surface was dominated by *Acrocalanus* spp., *Paracalanus* spp., *Eucalanus* spp., *Undinula vulgaris* and *Euchaeta* spp. In the discontinuity layer *Eucalanus attenuatus*, *Scolecithricella ctenopus*, *Haloptilus longicornis* and *Lucicutia flavicornis* were encountered. In the deeper collections from the Bay of Bengal bathypelagic copepods viz. *Heterostylis longicornis*, *Lucicutia clausi*, *Amallothrix indica* and *Euaugaptilus nudus* have been recorded here for the first time.

Key-words : Distribution, Calanoid copepods, Arabian Sea, Bay of Bengal.

INTRODUCTION

Calanoid copepods outnumber all other planktonic groups in numerical abundance and in the number of species, hence the group is often considered synonymous with secondary production. Studies on the copepods of the Indian Ocean is quite fragmentary when compared to the other world oceans. Apart from the work of Sewell (1912, 1929, 1939, 1947) the published information is mainly based on the International Indian Ocean Expedition (1962-1965). The ecology of selected groups of Calanoid copepods was studied by Silas and Pillai (1973), Fleminger and Hulsmann (1973), Saraswathy (1973), Tanaka (1973), Lawson (1977), Sarala Devi, Stephen and Rao (1979) and Stephen and Rao (1980). Few detailed observations from specific localities were also attempted from the coast of Pakistan by Haq, Ali Khan and Chughtai (1973) and the shelf and slope waters off Cochin by Stephen and Iyer (1979). Copepods of the Laccadive sea were analysed by Goswami (1980) and Madhupratap, Nair, Nair and Achuthankutty (1980) studied the copepod fauna of Andaman Sea. Win (1977) gave an account of the copepods of the Burma coast. The collections on board RV *Gaveshani* (Cruise 7 & 12) were designed to investigate the plankton population in the seas around India. This paper deals with the horizontal and vertical distribution of calanoid copepods from the northern area of Arabian Sea and Bay of Bengal.

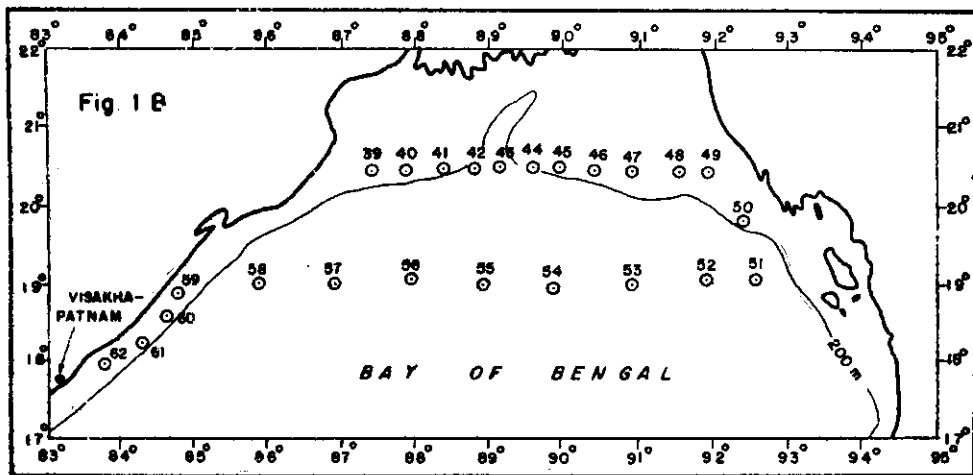
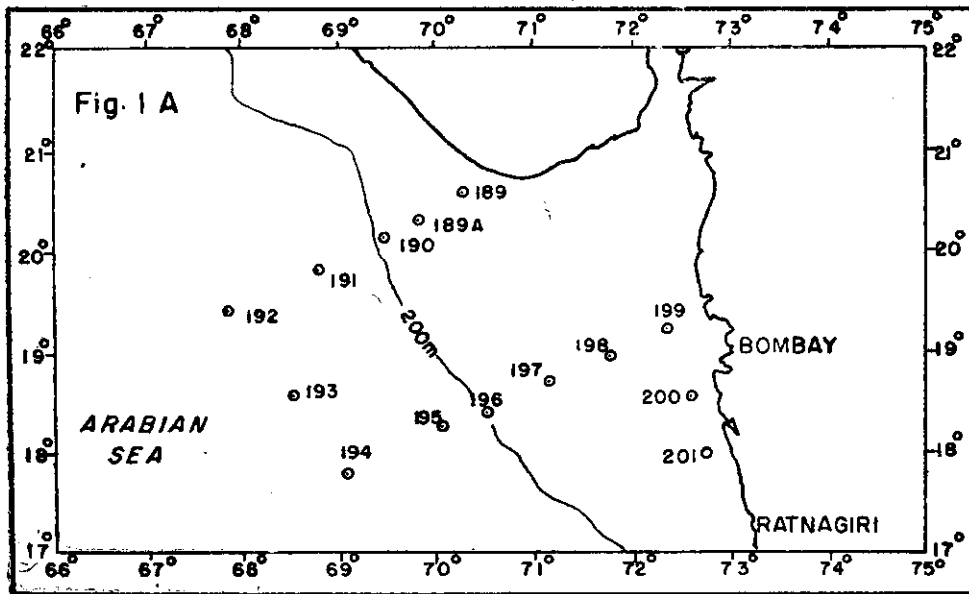


Fig. 1. Map showing the stations studied. A — Arabian Sea; B — Bay of Bengal.

MATERIALS AND METHODS

Zooplankton samples collected by RV *Gaveshani* in 1976 from Arabian Sea (Cruise 12) and Bay of Bengal (Cruise 7) were utilized for this study. The locations of the stations are given in Fig. 1A & B. During cruise 7, samples were collected in August along two sections across the Bay of Bengal between latitudes 18 and 21°N extending from the coast of India to Burma. The northern transect represents stations from the continental shelf and the southern transect those of the oceanic environment. During cruise 12, samples were collected in November between the same latitudes of the Arabian Sea. Vertical hauls were taken by the IOS net from 2 depths, i.e., from thermocline to surface and from 150 m to surface. In the Bay of Bengal the deep collections were taken from 500 m to thermocline or to surface. The data are comparable because of the similarity in sampling, latitudinal location of stations and coverage during the postmonsoon period. Taxonomic studies were based on suitable subsamples and the number of each species was converted to number per 100 m³. The data on relevant hydrographic parameters used are from the data sheets.

RESULTS AND DISCUSSION

Hydrography

The environmental parameters are shown in Fig. 2 (A & B). The surface temperature of the Arabian Sea was high and values ranged from 27.5 to 29.3°C. Within the upper 50 m layer a sharp decrease in temperature was noticed. Below this layer temperature gradually decreased and reached upto 17°C at 150 m depth. The surface salinity in the Arabian Sea showed high values, ranging between 33 to 36‰, even at nearshore stations. Oxygen values were high in the extreme surface layers, and ranged between 3 to 4.5 ml/l. Very low oxygen content was encountered in some stations within upper 50 metres. Below this a sharp decrease (less than 0.5 ml/l) was observed.

In the Bay of Bengal, temperature remained high between 28 and 29.5°C in the surface layers. The temperature gradient was not so evident in the upper 50 m. Below this, values decreased considerably reaching up to 15°C at 150 m layer. Compared to the Arabian Sea surface salinity was very low especially in the shelf stations. In the nearshore stations surface salinity varied from 23 to 29‰. In the oceanic stations slightly higher salinity (less than 33‰) was recorded, but at 150 m salinity remained high (above 35‰). Compared to the Arabian Sea dissolved oxygen was high (between 4 and 5 ml/l) in the surface layers but at 150 m, it decreased to nearly 0.5 ml/l. Cold waters of 10°C were observed in the deep stations from the Bay of Bengal.

Population of Calanoid copepods

Total population of calanoids in the two regions studied, along with the number of species recorded above the thermocline is depicted in Fig. 3A

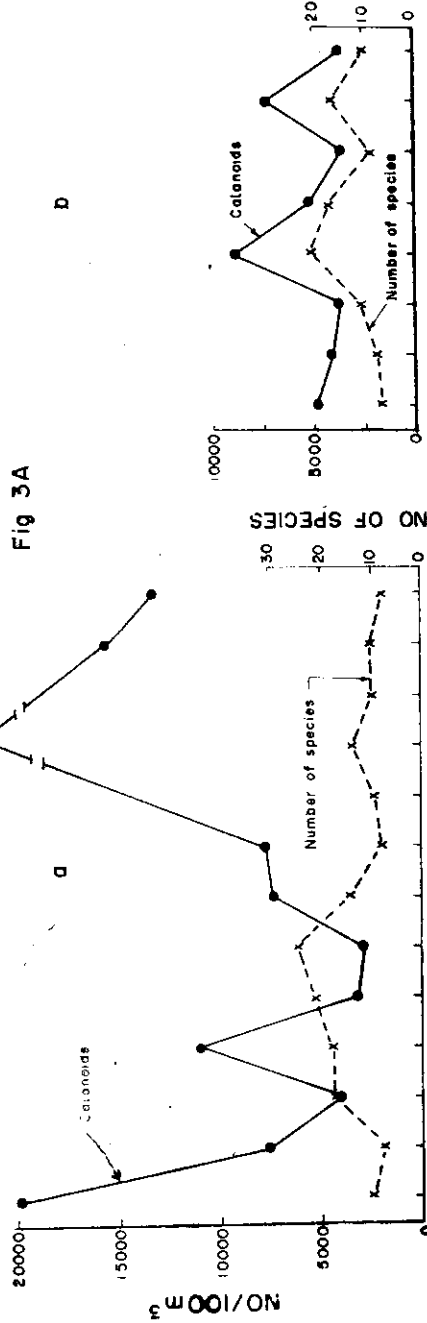
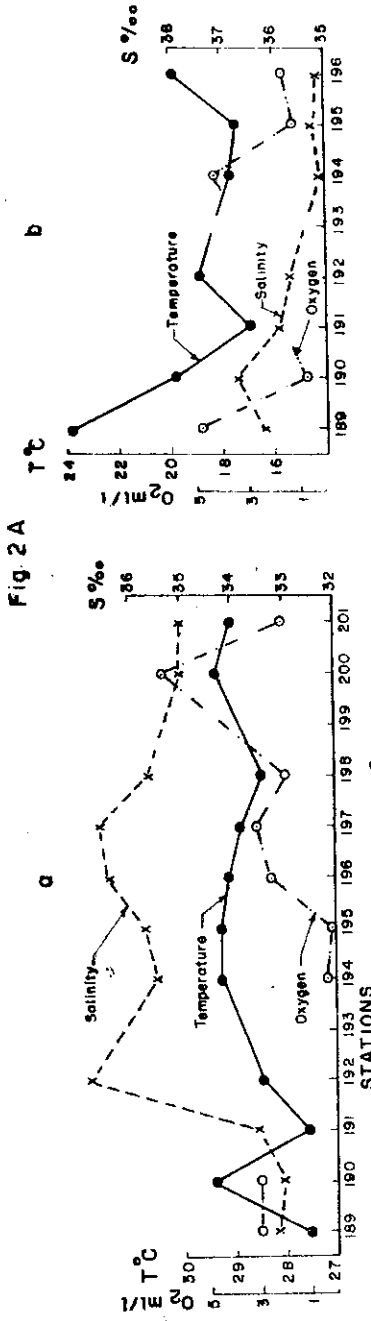


Fig. 2A. Hydrographical properties of Arabian Sea. a — above thermocline; b — below thermocline.

Fig. 3A. Distribution of calanoid population and the total number of species; in the Arabian Sea. a — above thermocline; b — below thermocline.

& B. Population density was maximum in the shelf stations and the species diversity was greater in oceanic region. In the Arabian Sea, stations 197 to 199 sustained maximum population (above 30,000/100 m³). While in the Bay of Bengal numerical abundance of copepods was comparatively low. Highest population was observed at stations 47 (18,600/100 m³) and 57 (14,600/100 m³). Highest density of copepods below the thermocline was noted at Station 192 (8,736/100 m³) in the Arabian Sea.

Species composition above thermocline

Distribution of the dominant species in the Arabian Sea (A) and Bay of Bengal (B) are given in Figs. 4, 5 and 6. The shelf area was dominated by *Paracalanus aculeatus*, *P. parvus* and *A. gibber*. In the oceanic region *Eucalanus pileatus*, *Eucalanus subtenuis*, *Undinula vulgaris*, *Cosmocalanus darwini*, *Euchaeta wolfendeni* and *Euchaeta consimilis* dominated. In the Arabian Sea *Euchaeta wolfendeni* was observed in greater number, but in the Bay of Bengal, *E. consimilis* was dominant. In the oceanic stations *Lucicutia flavicornis* and *Pleuromamma indica* were also recorded in very few numbers (Fig. 6A). In the Bay of Bengal (Fig. 6B) the above species were represented in fairly high numbers which may be due to the fact that the samples above thermocline were collected from 150 m to surface. In the Stations 197 to

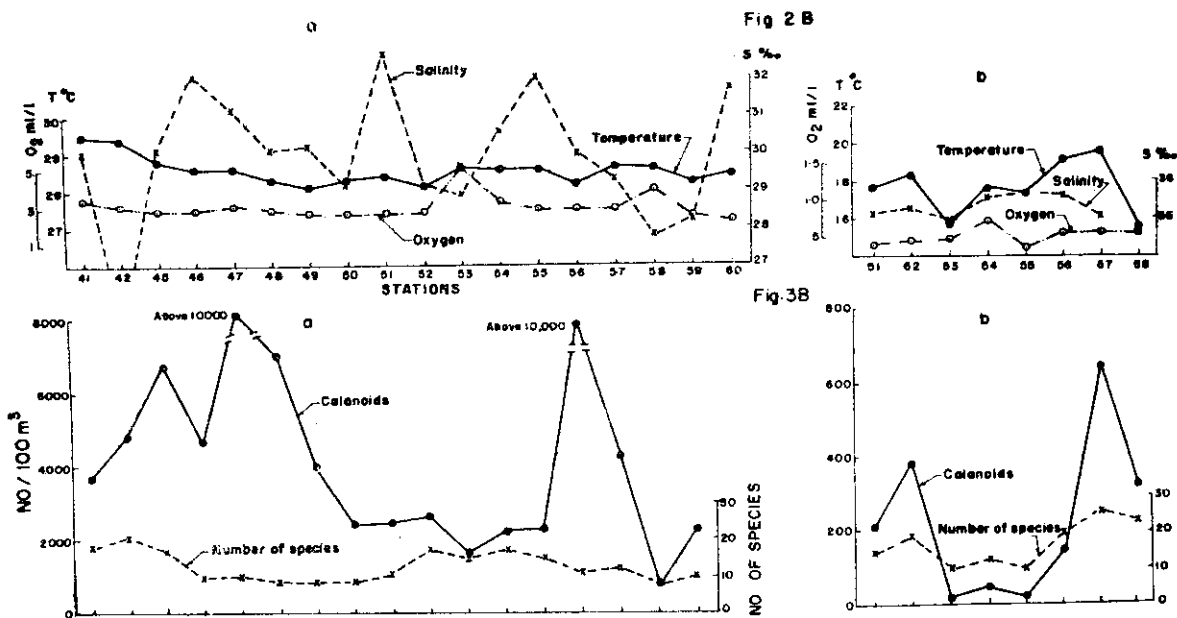


Fig. 2B. Hydrographical properties of Bay of Bengal. a — above thermocline; b — below thermocline.

Fig. 3B. Distribution of calanoid population and the total number of species in the Bay of Bengal. a — above thermocline; b — below thermocline.

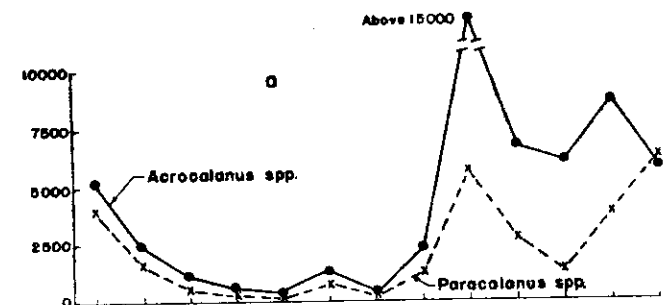


Fig. 4 A

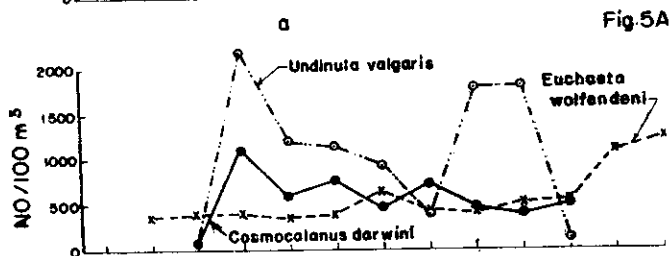
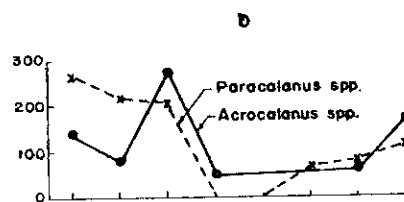


Fig. 5A

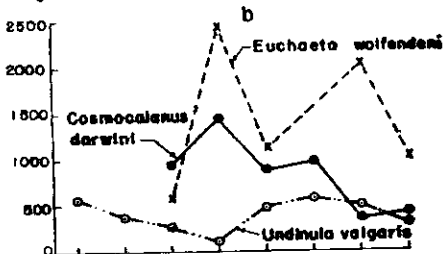


Fig. 6A

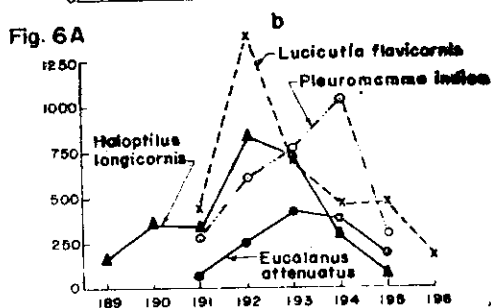
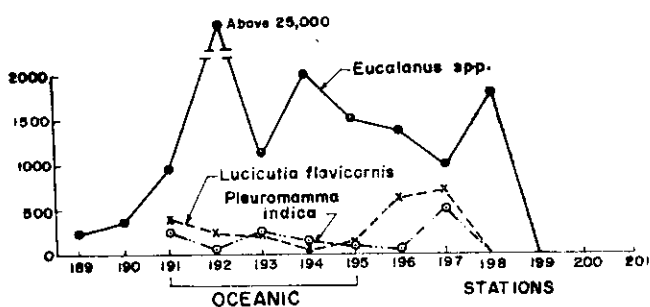
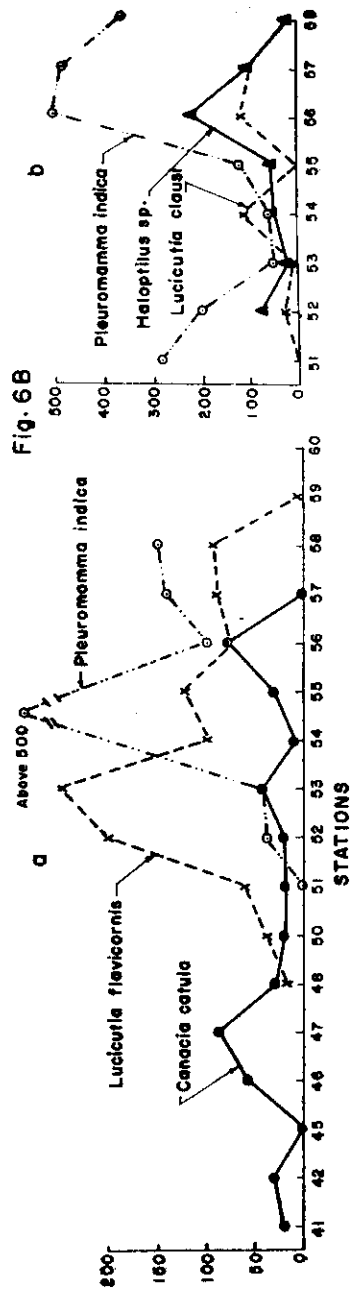
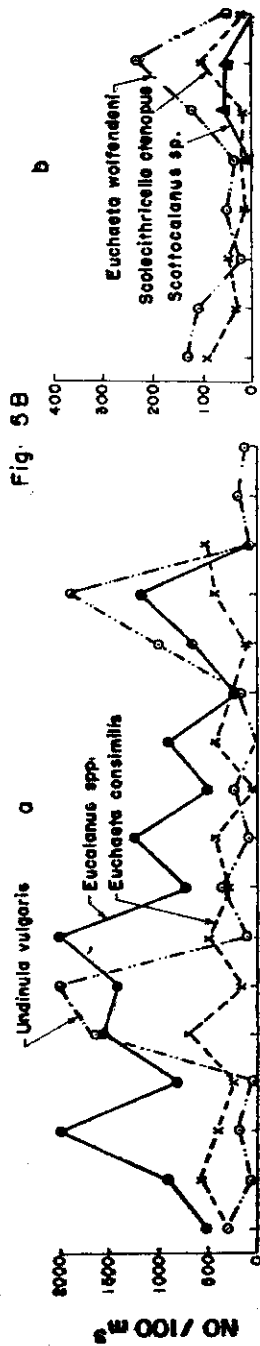
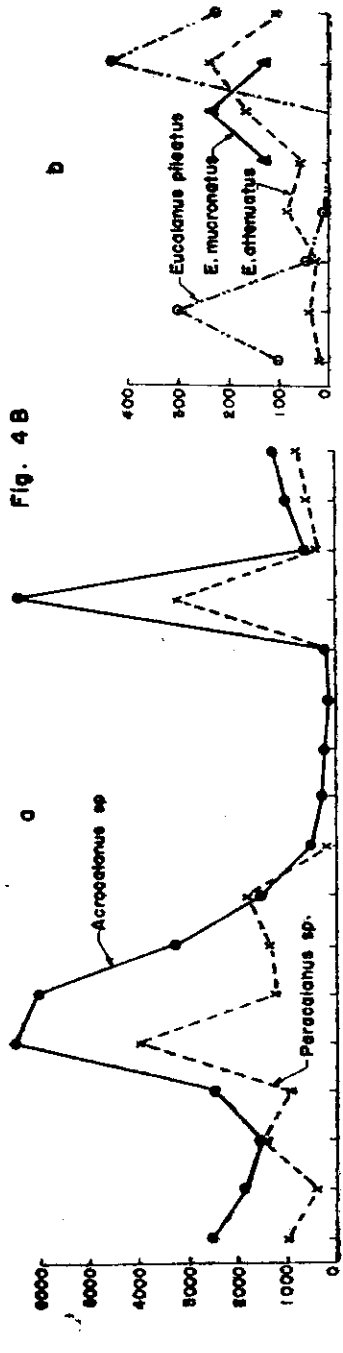


Fig. 4A to 6A. Distribution of dominant species in the Arabian Sea. a — above thermocline; b — below thermocline.

201 (Fig. 6A-a) in Arabian Sea indicated the presence of a distinct neritic population thriving above the thermocline. Neritic species such as *Acartia erythraea*, *Temora turbinata* and *Labidocera minuta* were dominant in these stations. But in the Bay of Bengal such a clear neritic community was not observed.

Calanoid population below thermocline

The species that are dominant below thermocline up to 150 m is shown in Fig. 6A-b. The species constituting the major population above the thermocline showed poor representation in the samples taken below the thermocline. In the Arabian Sea, the population below thermocline was characterised by the presence of *Eucalanus attenuatus*, *Haloptilus longicornis*, *Scolecithricella ctenopus*, *Pleuromamma indica* and *Lucicutia flavicornis*. The samples below the thermocline from the Bay of Bengal represented the copepod fauna up to



Figs. 4B to 6B. Distribution of dominant species in the Bay of Bengal. a — above thermocline; b — below thermocline.

500. In the deeper layers of the Bay of Bengal *Pleuromamma indica* was very abundant in some stations, contributing to 70% of the calanoids. In addition to the species present in the Arabian Sea (Fig. 6A & B), *Lucicutia clausi* and *Heterostylitis longicornis* were encountered below the thermocline. Immature forms of *Gaussia* sp. were obtained from stations 53, 55 and 58. *Lucicutia clausi*, *Heterostylitis longicornis*, *Euaugaptilus nudus* were recorded for the first time from the deeper collections of the Bay of Bengal. These species represent the mesopelagic calanoids.

Variability in zooplankton distribution was more distinct in the vertical realm than in horizontal plane. The environmental conditions of the north Indian Ocean is unique in many respects (Deitrich, 1973; Wyrski, 1973). The Indian Ocean is traversed by the Indian Peninsula which prevents the free circulation of the water masses. Another biologically significant feature especially of the Arabian Sea is the presence of oxygen deficient water layers over large areas. The oxygen poor layer exists below 100 to 1500 m and extends to the shelf region along the west and east coasts of India. The fauna of the northern Arabian Sea is influenced by the population of the Red Sea and Persian Gulf. The biological affinity and the dispersal of the dominant species along the west and east coasts of India is worth elucidating.

Neritic community

A distinct population of neritic species was encountered in the inner most stations. In the Arabian Sea, dense populations of *Acartia erythraea*, *A. spinicauda*, *Temora discaudata*, *T. turbinata*, *Labidocera minuta* were observed. Similarly from the nearshore waters off Bay of Bengal, *Paracalanus crassirostris*, *Acartia spinicauda*, *Temora discaudata* and *Pseudodiaptomus serricaudatus* were observed in very large numbers. They formed neritic assemblage which indicates the incursion of estuarine population in this area.

Shelf community

Paracalanus parvus, *Paracalanus aculeatus*, *Acrocalanus longicornis* and *Acrocalanus gibber* constituted about 70 to 80% of the copepod fauna in the shelf and slope areas. (Fig. 4A & B). Stations 196 to 201 in the Arabian Sea and 41 to 50 in the Bay of Bengal located in the shelf and slope region, showed maximum population of the above species. Stations 57 and 58 also sustained high population of the above species. Salinity in these stations was low which favoured the blooming of the species. *Undinula vulgaris* also formed a good portion of the copepod population in the shelf area.

Oceanic community

Eucalanus pileatus, *Eucalanus subtenuis*, *Cosmocalanus darwini*, *Euchaeta wolfendeni* and *Euchaeta consimilis* constituted about 60% of the population

of the oceanic environment. In addition *Lucicutia flavicornis*, *Pleuromamma indica* and *Candacia catula* were also encountered in the oceanic stations of the Bay of Bengal.

Vertical distribution

The copepod species aggregate at different depth levels depending mainly on the physico-chemical properties of the water layers. Considerable change in the fauna takes place below the warm surface layers. In the Arabian Sea the physical properties indicated that temperature discontinuity and oxygen deficit condition start from 50 to 70 m. This can inhibit the downward extension of the surface population. Sewell (1947), Vinogradov (1968) and Haq, Ali Khan and Chughtai (1973) had separated copepod population into different vertical groups. Based on the present observation dominant species of copepods from different depths can be grouped into the following 3 categories :

Warm surface water 0-50 m	Discontinuity layer between 50-150 m.	Between 150-500 m.
<i>Eucalanus pileatus</i>	<i>Eucalanus attenuatus</i>	<i>Euchirella curticauda</i>
<i>E. substenuis</i>	<i>E. elongatus</i>	<i>Scaphocalanus magnus</i>
<i>Acrocalanus longicornis</i>	<i>Euchirella amoena</i>	<i>Scottocalanus securifrons</i>
<i>A. gibber</i>	<i>Scolecithricella ctenopus</i>	<i>Amallothrix indica</i>
<i>Paracalanus aculeatus</i>	<i>Candacia truncata</i>	<i>Pleuromamma indica</i>
<i>P. parvus</i>	<i>Candacia catula</i>	<i>Gaussia immature</i>
<i>Undinula vulgaris</i>	<i>Lucicutia flavicornis</i>	<i>Heterostylitis longicornis</i>
<i>Cosmocalanus darwini</i>	<i>Pleuromamma indica</i>	<i>Augaptilus asceps</i>
<i>Euchaeta wolfendeni</i>		<i>Lucicutia clausi</i>
<i>E. consimilis</i>		* <i>Euaugaptilus nudus</i>

* New record from Indian Ocean.

Nair, Peter and Paulinose (1977, 1978), Madhupratap, Nair, Nair and Achuthankutty (1980) and Haq, Khan and Chughtai (1973) discussed the distribution of planktonic organisms in relation to thermocline from the Indian Ocean. The species composition in the northern part of the Arabian Sea was similar to that reported from the coast of Pakistan. In this study it was observed that thermocline acts as a barrier preventing the migration of meso-pelagic copepods to the pelagic realm. While discussing the vertical distribution of copepods Vinogradov (1968) stated that the layers between 150-500 m is occupied by *Pleuromamma indica*, *Euchaeta wolfendeni*, *Heterostylitis longicornis* and sometimes by *Eucalanus elongatus* and *Lucicutia maxima*. The present study also showed that *Pleuromamma indica*, *Heterostylitis longicornis*, *Lucicutia clausi*, *Eucalanus attenuatus* and *E. elongatus* are abundant in the samples taken below thermocline.

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REFERENCES

- Deitrich, G., 1973. The unique situation in the environment of the Indian Ocean. In: *The Biology of the Indian Ocean*, edited by B. Zeitzschel and S.A. Garlich, Springer-Verlag, Berlin Heidelberg, New York, p. 1-6.
- Fleminger, A. and K. Hulsemann, 1973. Relationship of Indian Ocean epiplanktonic calanoids to the world oceans. In: *The Biology of the Indian Ocean*, edited by B. Zeitzschel and S.A. Garlich, Springer-Verlag, Berlin, Heidelberg, New York, p. 339-348.
- Fleminger, A. and K. Hulsemann, 1974. Systematics and distribution of four sibling species comprising the genus *Pontellina* Dana (Copepoda, Calanoida). *Fisheries Bulletin of United States*, 72 (1).
- Ganapati., P.N. and K. Santhakumari, 1962. Systematics and distribution of planktonic copepods in the Lawson Bay, Waltair. *Journal of Marine Biological Association of India*, 5 (1): 76-107.
- Goswami, S.C., 1980. Zooplankton studies in the Laccadive Sea (Lakshadweep). Technical Report 01/79, National Institute of Oceanography.
- Haq, S.M., J. Alikhan and S. Chugtai, 1973. The distribution and abundance of zooplankton along the coast of Pakistan during postmonsoon and premonsoon months. In: *The Biology of the Indian Ocean*, edited by B. Zeitzschel and S.A. Garlich, Springer-Verlag, Berlin, Heidelberg, New York, p. 257-273.
- Lawson, T.J., 1977. Community interaction and zoogeography of the Indian Ocean — Candaciidae (Copepoda, Calanoida). *Marine Biology*, 43: 71-92.
- Madhupratap, M., V.R. Nair, S.R. Nair and C.T. Achuthankutty, 1980. Distribution of zooplankton in relation to thermocline of the Andaman Sea. Technical Report 02/80, National Institute of Oceanography.
- Nair, V.R., G. Peter and V.T. Paulinose, 1977. Zooplankton studies in the Indian Ocean. I. From Bay of Bengal during southwest monsoon period. *Mahasagar-Bulletin of the National Institute of Oceanography*, 10: 45-54.
- Nair, V.R., G. Peter and V.T. Paulinose, 1978. Zooplankton studies in the Indian Ocean. II. From the Arabian Sea during the postmonsoon. *Mahasagar-Bulletin of the National Institute of Oceanography*, 11: 35-43.
- Sarala Devi, K., R. Stephen and T.S.S. Rao, 1979. Distribution of *Haloptilus* (Copepoda, Calanoida) in the Indian Ocean. *Indian Journal of Marine Science*, 5: 159-165.
- Saraswathy, M., 1973. Distribution of *Gaussia* (Copepoda, Metridiidae) in the upper 200 m in the Indian Ocean. In: *The Biology of the Indian Ocean*, edited by B. Zeitzschel and S.A. Garlich, Springer-Verlag, Berlin, Heidelberg, New York, p. 336-338.
- Sewell, R.B.S., 1912. Notes on surface living copepoda of the Bay of Bengal. *Records of Indian Museum*, 7: 313 pp.

- Sewell, R.B.S., 1929. Copepoda of the Indian Seas — Calanoida. *Memoirs of Indian Museum*, **10**.
- Sewell, R.B.S., 1939. The free-swimming planktonic copepoda. "John Murray Expedition" Scientific Report, **7** (1-5).
- Sewell, R.B.S., 1947-1948. The free-swimming planktonic copepoda. "John Murray Expedition" Scientific Report, **8** (1-3).
- Silas, E.G. and P.P. Pillai, 1973. The calanoid copepod family Pontellidae from the Indian Ocean. *Journal of Marine Biological Association of India*, **15** (2): 771-858.
- Stephen, R. and H.K. Iyer, 1979. Species composition and coexistence of Calanoid copepods in the shelf waters off Cochin. *Mahasagar-Bulletin of the National Institute of Oceanography*, **12**: 227-239.
- Stephen, R. and T.S.S. Rao, 1980. Distribution of the bathypelagic family Arietellidae (Copepoda, Calanoida) in the upper 200 m in the Indian Ocean. *Journal of Plankton Research*, **2**: 5.
- Tanaka, O., 1973. On Euchaeta (Copepoda, Calanoida) of the Indian Ocean. *Handbook to the International Zooplankton Collections*, **IV**: 126-149.
- Win, K., 1977. A species list of zooplankton from the coastal waters of Burma. *Proceedings of the Symposium on Warm Water Zooplankton, Special Publication UNESCO/INIO*: 93-99.
- Wyrтки, K., 1973. Physical Oceanography of the Indian Ocean, In: *The Biology of the Indian Ocean*, edited by B. Zeitzschel and S.A. Garlich, Springer-Verlag, Berlin, Heidelberg, New York, p. 18-36.