

## 45. Geographical variation in the distribution of different calanid species in the Indian Ocean.

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### ABSTRACT

The species composition of Calanidae in the Indian Ocean was studied from zooplankton collections taken between 24°N to 40°S and 20°E to 120°E. *Nannocalanus minor* was widespread with high density along the African and Arabian coast. *Calanus australis* was confined to the vicinity of the subtropical convergence and the maximum population was encountered from South African waters. *Undinula vulgaris* and *Cosmocalanus darwini* were abundant in the productive upwelling zones off Arabia, Somalia and Sumatra, the former being totally absent in the south central Indian Ocean. *Canthocalanus pauper* was widespread and abundant in the northern Indian Ocean. *Neocalanus gracilis* was well represented in the equatorial Indian Ocean and also at a few stations in the northern Arabian Sea. *N. robustior* was found to inhabit the equatorial and southern region, and *N. tonsus* was distributed in the southern provinces especially in the South African waters. *Calanoides carinatus* the copepod which is associated with upwelling was encountered along the Arabian and Somali coasts. This study also indicated occasional surfacing behaviour of *C. carinatus*. The hydrographical features that restrict the distribution of the above species are highlighted in this paper.

### INTRODUCTION

Variability among species of Calanidae in the northern and southern hemisphere has been well documented from the Atlantic and Pacific Oceans since the classic work of Brodsky (1959). In the studies of Mullin (1969), Frost (1974), Mullin & Evans (1976), Fleminger & Hulseman (1977) geographical distribution of different species were discussed. Bradford & Jillet (1974) redefined the genera defin-

ing geographical limits to the species in the world oceans. Zoogeography of the *Calanus (helgolandicus)* group from the Pacific and Atlantic was reviewed by Bradford (1979). Apart from the reports of Sewell (1947), De Decker & Mombeck, (1964), De Decker, (1973) and Grice & Hulseman, (1967) distribution of Calanidae in the Indian Ocean has not been studied in detail. The more recent regional investigations on copepods (Smith, 1982; Madhupratap & Haridas, 1986; 1990; Stephen 1992) did not concentrate on geographic distribution. Stephen et al. (1992) give the distribution of *Undinula* and *Calanoides* in the Indian Ocean. This paper deals with the geographic distribution of species of Calanidae in the Indian Ocean from 24°N to 40°S, 20°E to 120°E based on samples collected during the International Indian Ocean Expedition (1960-65) and forms the first comprehensive study on the family from this ocean.

### MATERIAL AND METHODS

Calanid species from the upper 200m were studied from the IIOE zooplankton samples collected using the Indian Ocean Standard Net, with 113 cm mouth opening and 330 µm mesh size (IOBC, 1969). Calanidae were studied from 342 selected standard samples which include representative stations from each 5° Marsden square (between 24°S to 40°S and 20°E to 120°E). For the preparation of distribution maps 26 non-standard samples (horizontal surface hauls), collected on board R.V. Patanela were also included since they represent the sub-tropical and sub-

antarctic provinces of the Indian Ocean.

The generic definition given by Bradford (1988) is followed in this paper in which Calanidae is redefined to include 8 genera of which *Nannocalanus*, *Calanus*, *Cosmocalanus*, *Undinula*, *Canthocalanus*, *Neocalanus* and *Calanoides* were encountered in the Indian Ocean. Distribution maps were prepared based on numerical abundance.

## RESULTS AND DISCUSSION

### *Nannocalanus* Sars, 1925 (Fig. 1)

*N. minor* was widespread, though numerically not very abundant. High densities were noted (>200 ind./std.haul) along the African and Arabian coasts. Around the Indian Peninsula the species was rare and observed mostly off the west coast. The species is tolerant to a wide temperature range, from 30°C to 13.4°C (surface).

### *Calanus* Leach, 1819 (Fig.1).

*C. australis* was limited to the southern Indian Ocean with high densities near

the coast of Africa. Maximum population (>400/std. haul) was noted in the vicinity of the subtropical convergence where temperature variation between the surface and 200m is only 22°C to 11°C. The analysis of the *Patanela* samples showed that the species was well represented in the south Central Indian Ocean also.

*Cosmocalanus* Bradford & Jillett, 1974 (Fig. 2).

*Cosmocalanus darwini* (Lubbock, 1860) is widespread with high density (>400 /std. haul) in the Somali Arabian coast and also in the equatorial region. Distribution is well extended in the central and southern sectors though in very few numbers. The species is tolerant to wide temperature range but showed affinity to areas of high salinity (>35‰)

### *Undinula* Scott, 1909. (Fig. 3)

*U. vulgaris* (Dana, 1849) is abundant in the coastal environments. Highest numerical abundance (>400/std. haul) was encountered in waters adjacent to the continents and it tolerated wide fluctuations in temperature and salinity.

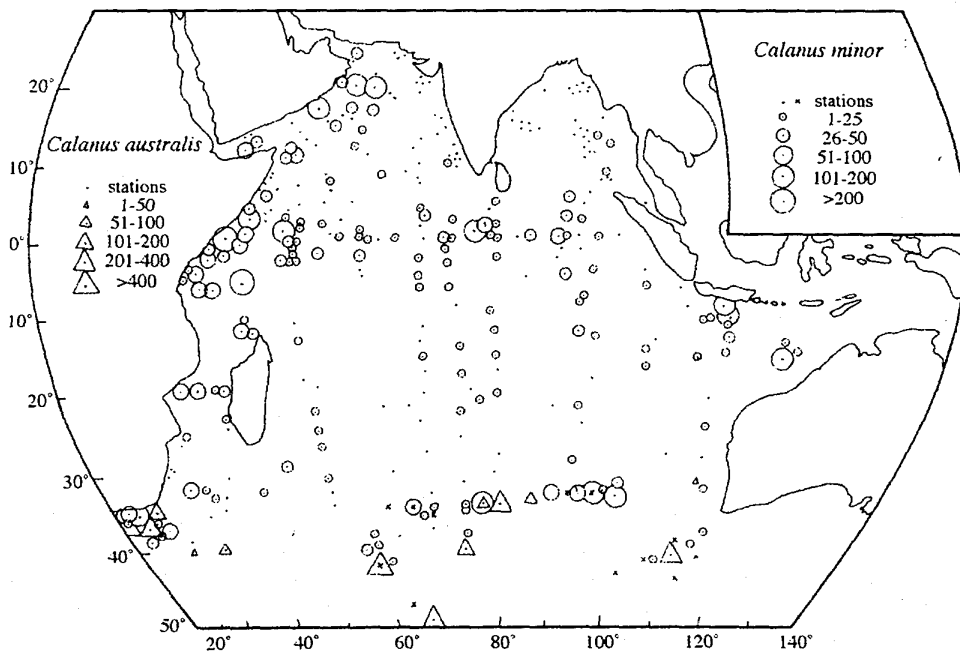


Fig. 1. Distribution of *Nannocalanus minor* and *Calanus australis* in the Indian Ocean.

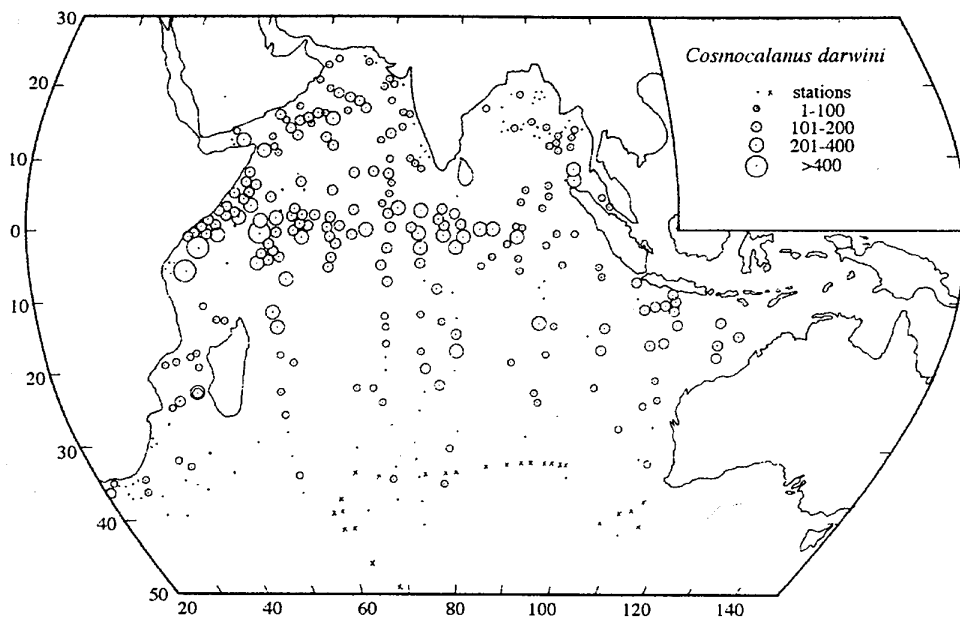


Fig. 2. Distribution of *Cosmocalanus darwini* in the Indian ocean.

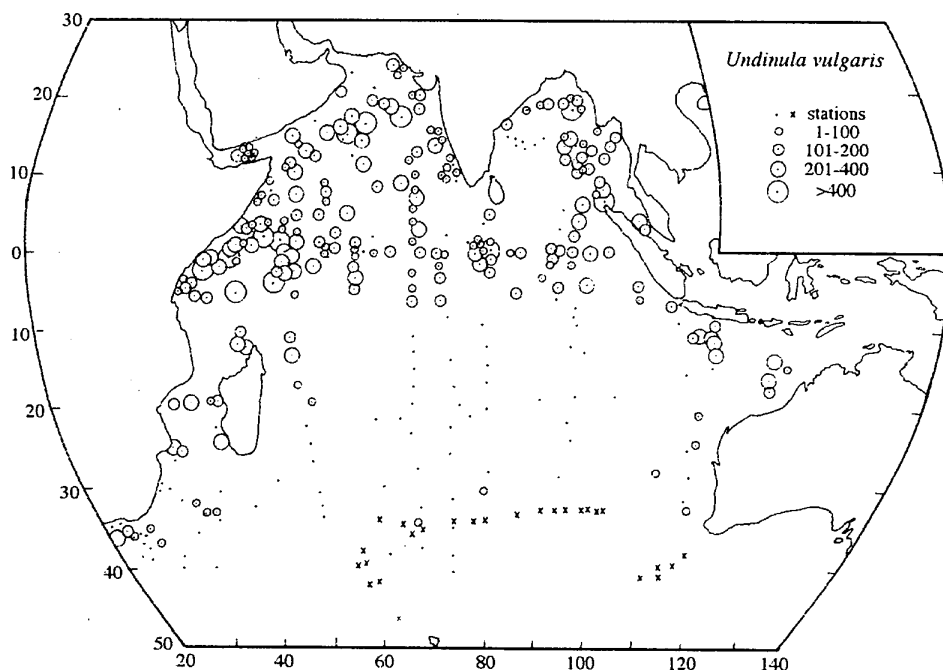


Fig. 3. Distribution of *Undinula vulgaris* in the Indian Ocean.

*Canthocalanus* A. Scott 1909 (Fig. 4)  
*C. pauper* (Giesbrecht, 1892) was widespread and abundant in the northern Indian Ocean. High densities (>400/std. haul) were observed in the coastal regions of Somalia, Arabia, and

Malay Archipelago. In the southern Indian Ocean this species was observed only from areas adjacent to land masses. *C. pauper* showed preference to the productive coastal environments.

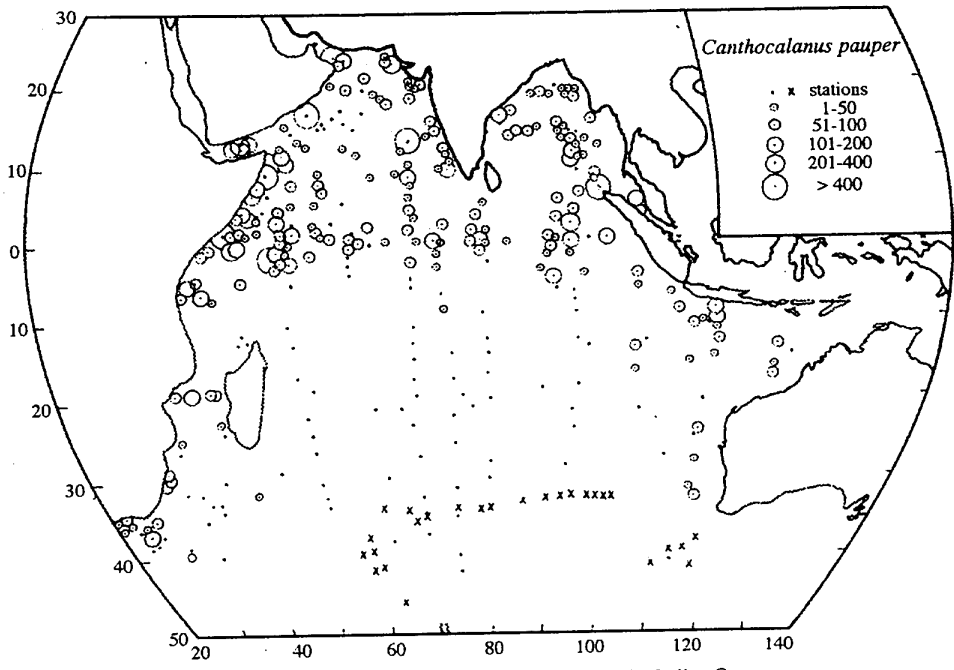


Fig. 4. Distribution of *Canthocalanus pauper* in the Indian Ocean

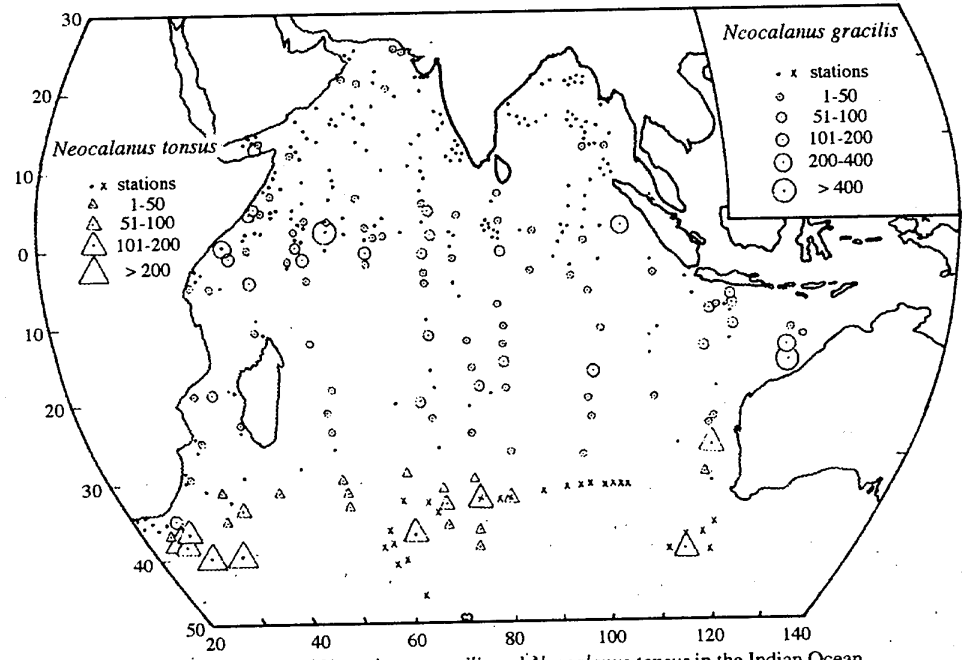


Fig. 5. Distribution of *Neocalanus gracilis* and *Neocalanus tonsus* in the Indian Ocean.

*Neocalanus* Sars, 1925 (Fig. 5 & 6)  
*N. gracillis* (Dana, 1849) (Fig. 5) was well represented in the tropical and subtropical regions of the Indian Ocean. High densities (>400/std. haul) were encountered at one station in the

equatorial belt and another in the area between Java and Australia. Except for a few stations in the northern Arabian Sea the species was absent around the Indian Peninsula. Surface temperature of most of the positive stations was

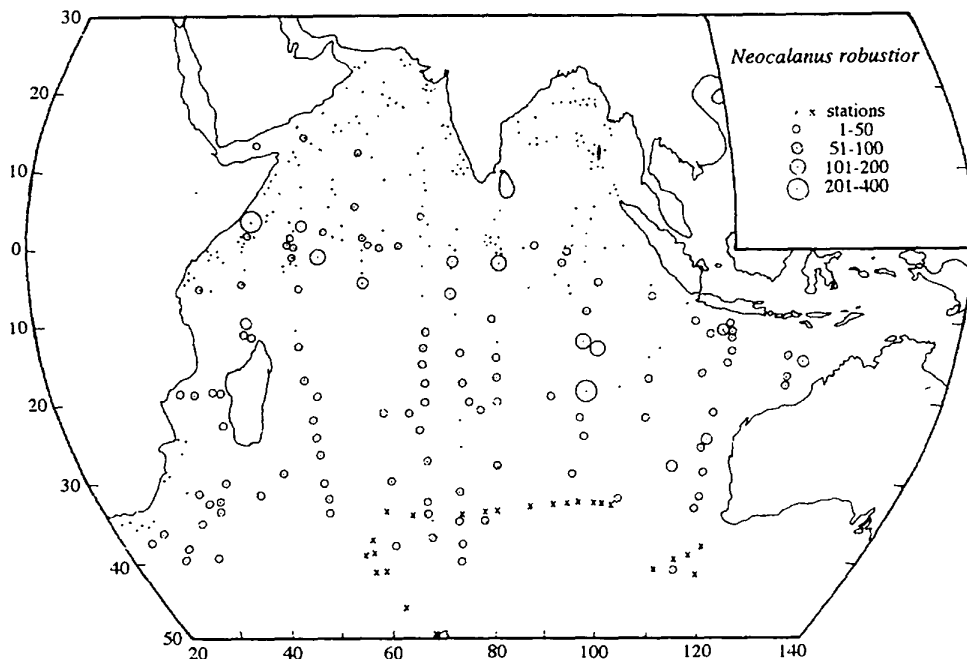


Fig. 6. Distribution of *Neocalanus robustior* in the Indian Ocean.

below 27.5°C. *N. robustior* (Giesbrecht, 1888) (Fig. 6) was observed mostly in the equatorial and southern Indian Ocean. Only a few stations in equatorial and southern central Indian Ocean showed high numerical abundance (>200/std. haul). In the Arabian Sea the species was observed at three stations, in the Gulf of Aden, near the Arabian coast and the central Arabian Sea. The distribution map shows the preference of the species to the area south of the equator where comparatively lower temperature (26°C to 21°C) for the surface is observed. *N. tonsus* (Brady, 1883) (Fig. 5) occurred in the subantarctic part of the Indian Ocean. This species was found in high densities (>200/std. haul) on Agulhas Bank and adjacent waters. The surface collections taken by R.V. Patenela also showed the presence of the species.

*Calanoides* Brady, 1883 (Fig.7)

Occurrence of *Calanoides carinatus* (Kroyer, 1849) was mostly noted from the Arabian and Somali coast (Fig. 7) and many stations sustained high densities (>800/std. haul). The distribution is extended up to 24°N and 54°E, during the south west monsoon period when the temperature of surface water is

reduced to 24° to 17°C. In the southern Indian Ocean the species is confined to the coastal regions of Africa and Australia. A bloom of 9225 specimens/std. haul was observed near Java.

The family Calanidae remains one of the well studied group of marine copepods, but most of the earlier information deals with species from the Atlantic and Pacific. During the present analysis, in the Indian Ocean the genus *Nannocalanus* was represented by only *N. minor* and *Calanus* by *C. australis*. *N. minor* is widespread in the tropical and subtropical regions of the world oceans. The *Calanus* specimens in South African waters were described as *C. agulhensis* by De Decker et al. (1991). The *Calanus* specimens encountered in the IIOE collections were confirmed as *Calanus australis* (Fleminger, pers. comm.). A number of species and varieties of *Calanus* spp have been recognized from the Atlantic and Pacific Oceans (Brodsky, 1959). Variations are not encountered in the Indian Ocean, which may be due to the absence of arctic mixing in the northern Indian Ocean which prevents the intrusion of *C. finmarchicus* and the proliferation of sibling species in the northern Indian Ocean. The present study

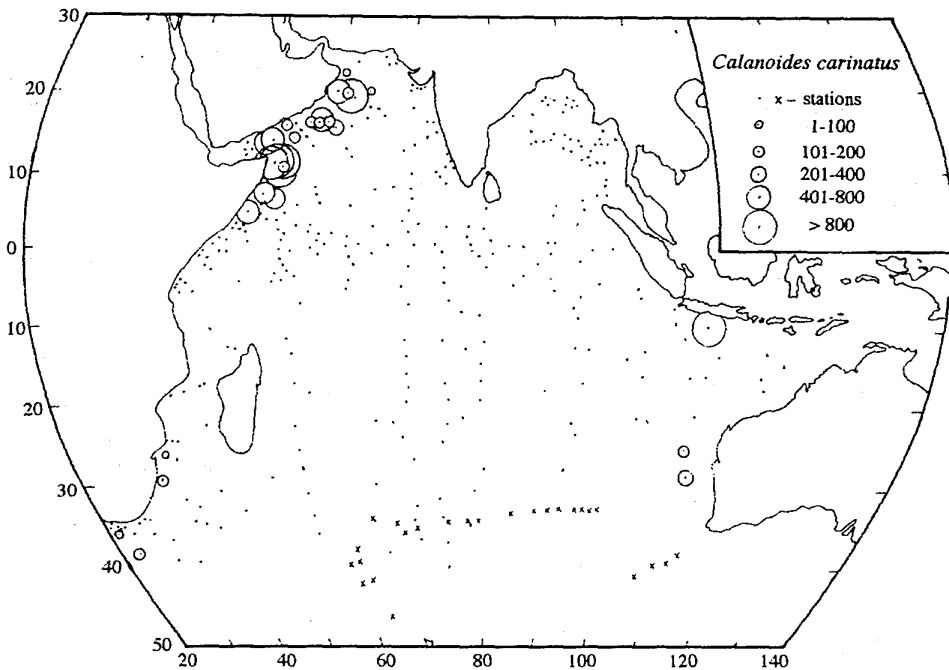


Fig. 7. Distribution of *Calanoides carinatus* in the Indian Ocean.

shows that *N. minor* is common in the north Indian Ocean and also intrusion of *C. australis* towards the south occurred. The circumpolar distribution of *C. australis* was suggested by Brodsky (1959). Fleminger (pers. comm.) also expressed the view that *C. australis* should be found in the boreal region of the southern hemisphere, mainly in the vicinity of the subantarctic convergence. This study confirms that *C. australis* is present at southern latitudes, south of 30°S in the Indian Ocean.

The genus *Neocalanus* includes 6 species of which *N. gracilis*, *N. robustior* and *N. tonsus* were encountered in the Indian waters. *N. gracilis* and *N. robustior* are widespread in the equatorial and southern Indian Ocean, the former had a wide geographical range in the northern latitudes. Mullin & Evans (1976) showed that *N. gracilis* and *N. robustior* are sympatric in tropical and subtropical waters of the Pacific and that the distribution of the former extends further to the north and south. In the Indian Ocean the distribution pattern is also apparently similar for these species with *N. gracilis* showing

wider distribution in northern hemispheres and *N. robustior* more towards the southern hemisphere. *N. tonsus* is a subantarctic species and in the present study this species was observed south of 30°S. De Decker & Mombeck (1964) considered *C. tonsus* as a deep water form, occurring occasionally in surface layers. High concentrations of the species are also encountered in surface waters.

Previous records of *Calanoides carinatus* are given for the Malay Archipelago, African Waters (De Decker, 1973) and Arabian Sea (Sewell, 1947). During the present study high densities of *C. carinatus* specimens were observed from many stations along the Arabian and Somali coast during August and for Australian and African waters in October and January. De Decker & Mombeck (1964) reported the swarming of *Calanoides* stage V in south African Waters, *Calanoides carinatus* was also observed in deeper collections from the northern Indian Ocean (Stephen, unpubl.). This study shows the extend of the geographical coverage of calanid species in the Indian Ocean.

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