

Zooplankton Biomass & Composition in the Western Bay of Bengal during Late SW Monsoon

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Copepoda formed the predominant group except in the southern region where a swarm of pelagic tunicates reduced their contribution to only 19% of the total zooplankton count. Decapod larvae occurred in fairly large numbers all along the coastal and neritic regions of the southwestern Bay of Bengal. Other groups like chaetognaths, ostracods, amphipods, euphausiids, fish eggs, fish larvae, polychaetes, cladocerans, planktonic molluscs, etc. contributed to a lesser percentage of the general composition of zooplankton. Upwelling along the southern part of the western Bay of Bengal during this season may account for the rich zooplankton population towards the south.

Zooplankton biomass distribution is an index to the fertility of the sea and it provides information on the fishery potential. The current reversals and upwelling owing to monsoonal influence^{1,2} have particular bearing on the secondary production of the Indian Ocean especially north of 10°S lat. Information on zooplankton standing crop of the Indian Ocean mainly comes from the International Indian Ocean Expedition³⁻⁶ and subsequent studies⁷⁻¹¹. Total zooplankton biomass and the distribution of different groups along the western Bay of Bengal during late SW monsoon form the subject of the present investigation.

Materials and Methods

Samples from 47 stations were collected (Fig. 1) during the 37 to 40 cruises of *R V Gaveshani* (August-September 1978) from the western Bay of Bengal. Vertical hauls from 500 m to surface were made using Heron-Tranter net (mouth area 0.25 m², mesh size 500 μ m) with a flow meter attached. At a few shallow coastal stations, vertical hauls were made either from 200 m or 150 m to surface.

Biomass was estimated as displacement volume and expressed as ml/100 m³ of water filtered. Groups of zooplankton were sorted and enumerated from aliquots and converted to numbers/100 m³ of water filtered. For interpretation and comparison of data, each cruise is being treated as a separate zone.

Results

Temperature and salinity—There was not much variation in the temperature of the surface water (Table 1). At most of the stations the temperature fluctuated between 28 and 29°C. Deeper water temperature also did not show any significant variation. At 500 m the

temperature throughout the western Bay of Bengal was $10 \pm 1^\circ\text{C}$. Fluctuation in salinity was seen in the northern part of the western Bay of Bengal and towards the southern region the values were relatively high and stable (in zones 3 and 4 > 33‰). Salinity in deeper waters did not vary much. At 500 m the salinity value was $34.5 \pm 0.5\text{‰}$.

Biomass—Distribution of total zooplankton biomass (Table 1) indicated a general increase from north to south. Relatively higher biomass was

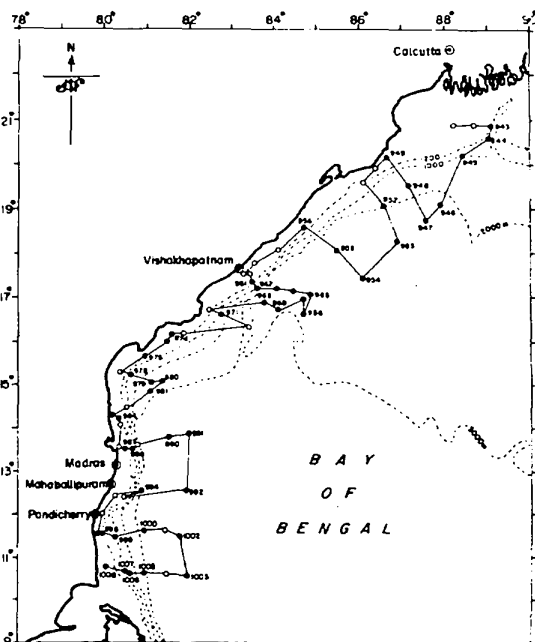


Fig. 1—Cruise (37 to 40) tracks of *R V Gaveshani* (Closed circles indicate zooplankton stations)

Table 1—Temperature, Salinity and Biomass Values at Different Stations

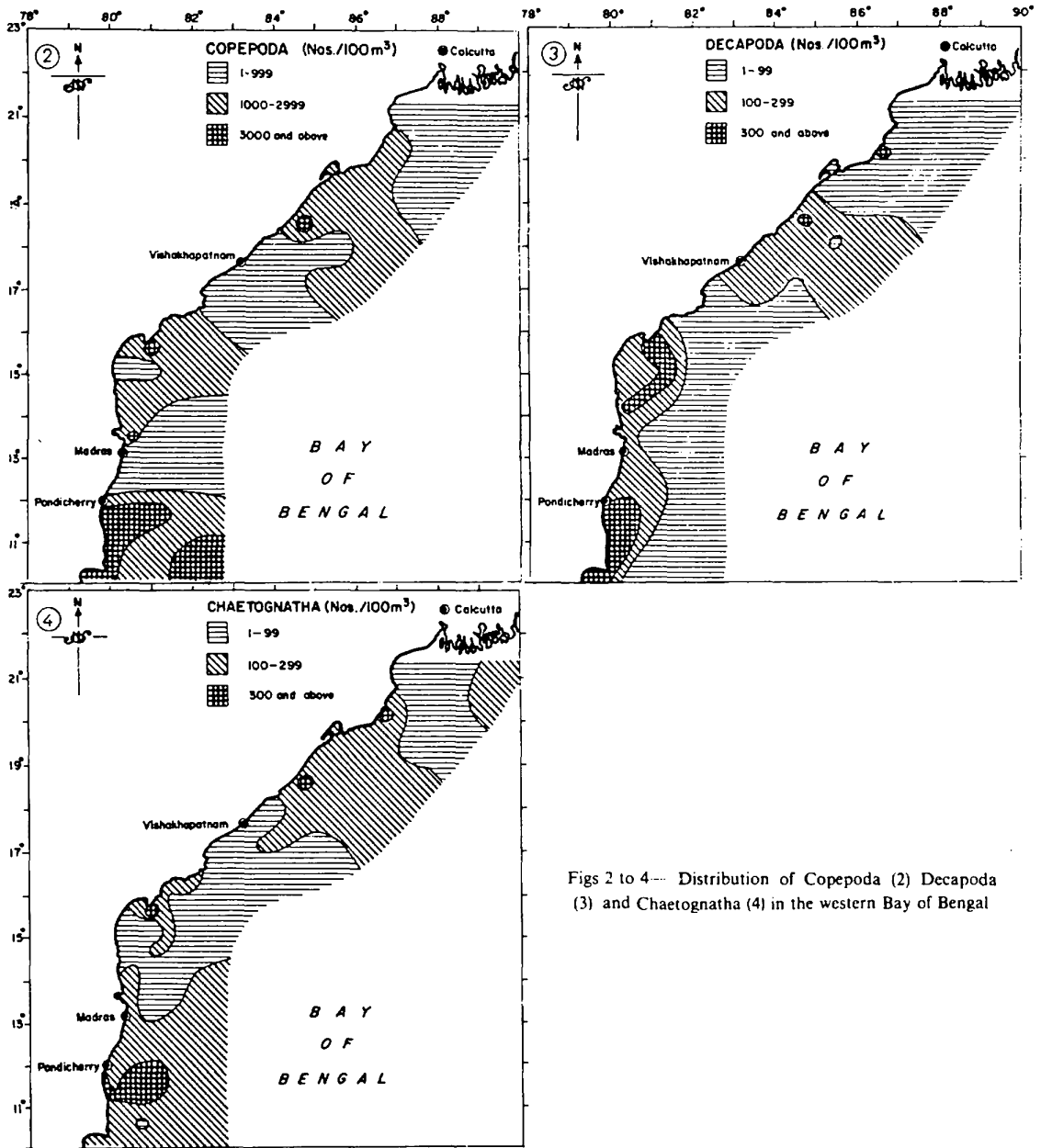
Date	St No.	Surface water temp. (°C)	Surface water sal. (‰)	Total zooplankton biomass (ml/100 m ³)
Cruise 37/Zone 1 (Aug. 1978)				
15	943	28.9	—	2.06
	944	29	—	1.35
16	945	28.81	32.49	2
17	946	28.2	30.49	2.08
	947	28.8	31.19	1
18	948	29.02	30.33	2.64
	949	29.61	—	1.7
	952	29.2	29.85	3.13
19	953	28.53	30.89	10.22
	954	29.4	31	4.32
20	955	—	29.63	1.85
	956	29.85	—	4.73
Cruise 38/Zone 2 (Aug. 1978)				
24	961	28.3	29.73	1.1
	962	29.2	32.9	1.2
	963	29.4	31	2.3
	964	28.5	30.43	2.77
	965	28.5	31.37	3.34
25	966	28	31	3.22
	967	28.7	30.43	3.68
	968	28.4	—	1.47
26	969	28.9	33.4	3.61
27	971	28.4	32.6	3.32
28	974	27.4	33.71	3.26
	975	26.9	33.12	5.1
	976	27.4	33.62	8.64
29	978	28.2	32.7	3.02
	979	28.4	32.89	2.83
	980	28.8	32.06	3.86
	981	28.5	32.12	6.19
30	983	28.5	32.1	3.5
	984	29.3	32.07	3.01
Cruise 39/Zone 3 (Sept. 1978)				
3	987	28.2	34.1	7.85
	988	28.6	33.78	2.04
4	990	28	33.73	1.05
	991	28.8	33.69	2.58
	992	28.6	33.76	1.19
5	994	28.6	33.73	1.59
Cruise 40/Zone 4 (Sept. 1978)				
5	997	28.4	33.5	34.01
	998	28.6	33	10.2
	999	28.6	33.8	4.96
6	1000	28.3	33.2	4.23
	1002	28.8	33.63	3.48
	1003	28.3	33.72	3.86
7	1005	28	33.41	6.46
	1006	28.4	33.6	40
	1007	28.3	34.39	480
	1008	28.7	33.62	60

observed at stations located within the 200 m depth of zones 1 to 3. However, isolated pockets of moderately high standing crop were observed in the oceanic regions of zones 1 and 2 (Table 1). All stations sampled in zone 4 recorded moderate to high values. But here also, as in the other zones, a decrease in biomass values with increase in depth was noted. Geometrical mean of biomass for zones 1-4 were 2.5, 3.07, 2.84 and 15.35 ml/100 m³ respectively which further indicated the richness of zooplankton in the southwestern region of the Bay of Bengal. Highest biomass values (40-480 ml/100 m³) were noted between sts 1006 and 1008, the maximum being at st 1007. The only other station falling in the high biomass range was st 997. Barring these 4 stations, zooplankton biomass at 31 stations was within the lowest range (1-3.9 ml/100 m³) while that of remaining 12 stations was within the middle range (4-10.9 ml/100 m³).

Distribution of zooplankton components—Copepoda: Copepods formed the dominant group in zones 1 to 3, constituting about 60% of the total zooplankton count, whereas their contribution in the 4th zone was only 19%. In general, the number of copepods ranged from 300/100 m³ at st 946 to 18707/100 m³ at st 997 (Fig. 2), forming 27.4% of the total zooplankton. Their highest counts were in the 4th zone (1216-18707/100 m³). The lowest density of this group was in the northern halves of zones 1 and 2 and almost the entire part of zone 3. *Acrocalanus similis*, *Paracalanus parvus*, *Undinula vulgaris*, *Euchaeta marina*, *Eucalanus subcrassus* and *Corycaeus speciosus* were the common species encountered.

Decapoda : Epipelagic decapods and decapod larvae had fairly wide distribution in the western Bay of Bengal and constituted 11.4% of the total zooplankton. Zone 2 showed maximum density (12.7%) followed by zone 4 (11.6%), zone 1 (10.6%) and zone 3 (4.77%). They were numerically more abundant in southern regions (Fig. 3). They ranged in number from 22 to 29039/100 m³ with higher densities along the coastal and neritic regions. *Lucifer hansenii*, *L. penicillifer* and *L. typus* (Sergestidae) were abundant. Penaeid larvae were represented in small numbers. Brachyuran zoeae were present in all the samples. Several species of caridean and anomuran larvae were also observed in small numbers.

Chaetognatha : Contribution of chaetognaths to total zooplankton counts was 2.9%. Their zone-wise abundance indicated an increasing trend towards north which was 14.7, 6.7, 7.4 and 1.2% from zone 1 to zone 4 respectively. Their numerical abundance ranged between 26 and 1735/100 m³. Isolated pockets of high density (300/100 m³ and above) were mostly restricted to a few coastal stations. Moderate abundance (100-299/100 m³) was seen towards south of Madras and

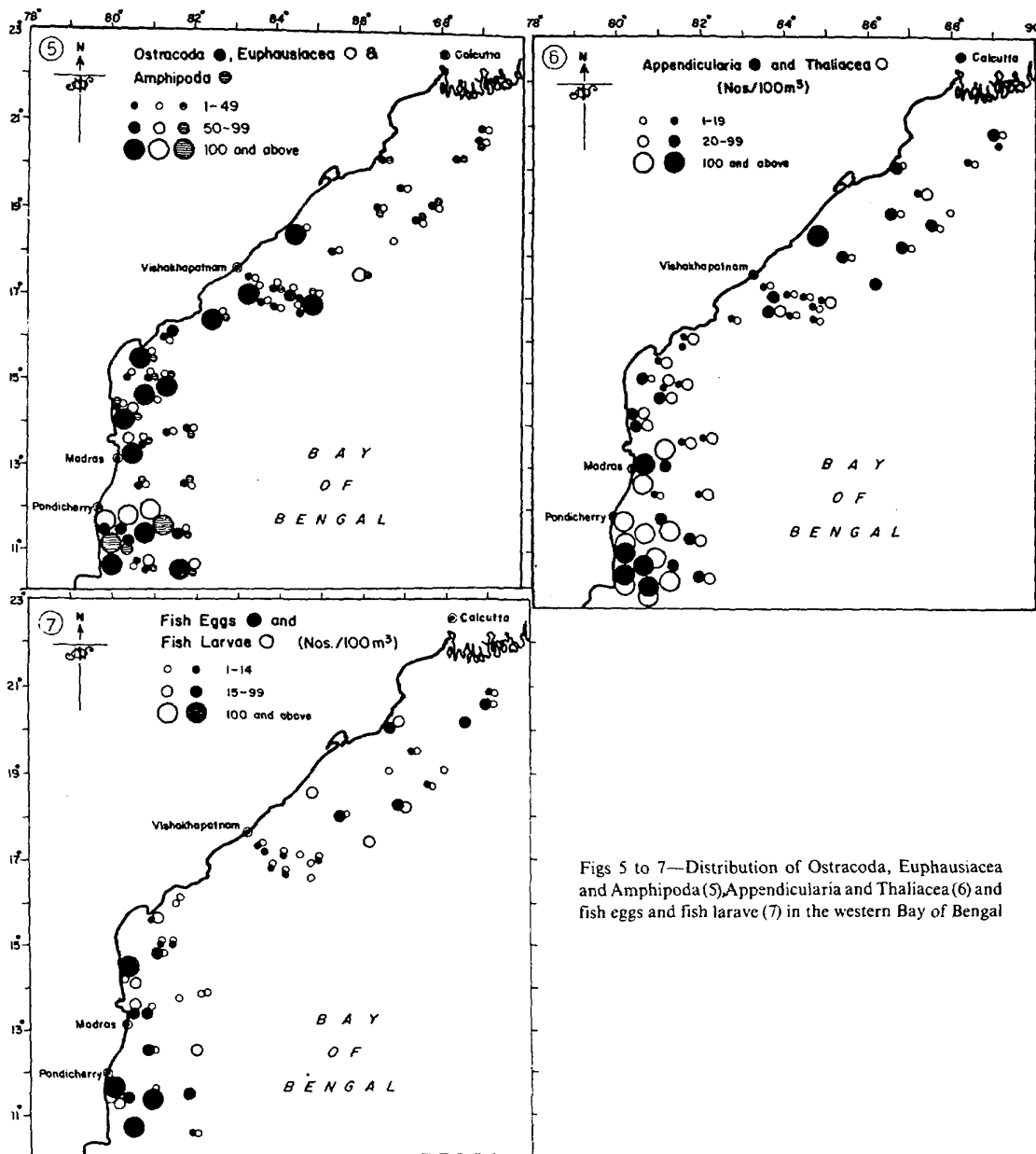


Figs 2 to 4— Distribution of Copepoda (2) Decapoda (3) and Chaetognatha (4) in the western Bay of Bengal

north of Visakhapatnam but were poorly represented (1-99/100 m³) between these two and the northern most part except for a few patches of moderate density (Fig. 4). *Sagitta enflata*, *S. neglecta*, *S. bipunctata*, *S. bedoti* and *Pterosagitta draco* were the commonly occurring species.

Ostracoda, Amphipoda and Euphausiacea : Percentage contribution of these to the total zooplankton counts was 0.94, 0.73 and 0.62 respectively. While the first 2 groups were fairly well

represented, amphipods showed a restricted distribution (Fig. 5). These groups also sustained a higher abundance towards the southern region. The maximum number of ostracods (1071/100 m³) and euphausiids (450/100 m³) was collected from st 1000 whereas amphipods abundantly occurred at st 997 (1573/100 m³). Ostracods were mainly represented by *Cypridina dentata*, *Conchoecetta giesbrechti* and *Spinoecia porrecta*. The common species of euphausiids occurring in this area were *Euphausia*



Figs 5 to 7—Distribution of Ostracoda, Euphausiacea and Amphipoda (5), Appendicularia and Thaliacea (6) and fish eggs and fish larvae (7) in the western Bay of Bengal

diomediae, *Thysanopoda* spp. *Pseudeuphausia latifrons* and *Stylocheiron carinatum*. Species belonging to the family *Hyperiidæ* were dominant among the amphipods.

Tunicates : Thaliacea (doliolids and salps) formed 33.7% of the total number of zooplankton (doliolids 22.3%, salps 11.4%). Although in zones 1 to 3 their contribution was relatively less, they showed very high abundance in the 4th zone (40.3%), thus dominating even copepods in numerical abundance. They also had a wide distribution, but doliolids always dominated

salps in all the zones. A large swarm of doliolids (5,300-60,000/100 m³) and salps (6,000 - 15,000/100 m³) were observed between sts 1006 and 1008, the highest being at st 1007.

Distribution pattern of appendicularians was similar to that of Thaliacea (Fig. 6). Their over-all contribution to the total zooplankton counts was 19.2%. Although their population was poor in zones 1 to 3 (1-6%), they formed 23.4% of the total zooplankton count in the 4th zone. Aggregation of appendicularians was seen between sts 1006 and 1008 (4200/100 m³ to

51,000/100 m³) with their highest counts at st 1007.

Fish eggs and Fish larvae : Fish eggs and larvae constituted a very small percentage of the total zooplankton (0.85%) and 0.15% respectively) collected. They were encountered in about 90% of the stations with higher numbers towards the southern areas (Fig. 7). Number of fish eggs ranged from 3/100 m³ to 1155/100 m³ and fish larvae from 3/100 m³ to 68/100 m³.

Other groups : Other groups of zooplankton occurred either in small numbers or at few stations forming only a small percentage of the total counts. Of these, hydromedusae had a fairly wide distribution and were recorded from 81% of the stations with maximum abundance towards the southern region. Siphonophores were present in almost all the stations in varying numbers. Ctenophores and anthozoan larvae were represented in small numbers at a few stations and were completely absent in zone 3.

Polychaetes were widely distributed. They were encountered in 96% of the stations and showed an increasing trend towards the south. Pteropods, chiefly constituted by *Creseis acicula* and *Cavolinia* sp., were recorded from 62% of the stations and they showed maximum density in the 4th zone (mean number, 59/100 m³) followed by the 1st zone (mean number, 36/100 m³). Heteropods, on the other hand, were occasionally collected from the southern region. Other gastropods were collected from 81% of the stations with a maximum mean number of 82/100 m³ in zone 4. Cephalopod larvae were poorly distributed and were mostly confined to the 1st zone.

Cladocerans, *Evadne tergestina* and *Penilia avirostris*, occurred at 55% of the stations. They recorded the highest abundance at st 956 (158/100 m³) and showed a decreasing trend towards the south and were completely absent in zone 4. Mysids, isopods and cirripede larvae were poorly represented in the collections. However, a large number of mysids collected from st 1008 (4042/100 m³) was an exception. Stomatopod larvae were observed from 40% of the stations. They were present in all the zones having a maximum mean density of 15/100 m³ in zone 4.

Larvae and juveniles of echinoderms were collected in small numbers from 36% of the stations and were absent in the 4th zone. Cyphonautes larvae and *Amphioxus* juveniles were present at a few stations.

Discussion

Biomass values obtained in the present study were, in general, lower than the values reported earlier for the same season from the western Bay of Bengal^{9,10}. This may primarily be due to different types of nets used. The earlier collections were made using the Indian Ocean Standard Net (mouth area 1 m² and mesh size 300 μm)¹². This would have resulted in the loss of smaller organisms through the wider mesh and also by

the avoidance of zooplankters due to the smaller mouth area of the HT net. Nevertheless, the general trend in total biomass distribution was in agreement with the earlier report⁹ where an increase in biomass from north to south was evident. The primary production during this season in the western Bay of Bengal also followed a similar pattern¹³. The very high biomass observed at a few stations off Nagapattinam was due to the swarming of pelagic tunicates caused by a mild upwelling resulting in phytoplankton bloom¹⁴.

Numerical abundance of all the major groups except Chaetognatha showed an increasing trend towards the south. A swarm of tunicates reduced the predominance of copepods in the 4th zone although their numerical counts increased towards south. The tunicate population at stations other than where swarming was observed also indicated their abundance along the southern region. On the contrary, the IIOE data for this season had indicated a higher abundance of tunicates along the northern part of the east coast of India¹⁵.

Decapod larvae were reported to be abundant along the coastal waters of India¹⁶ and their maximum abundance was observed in the southern region⁹ as in the present study. The incidence of fish eggs and larvae was relatively less, but their occurrence has been reported to be more in the Bay of Bengal, but away from the Indian coast⁵. Numerical abundance of chaetognaths in the present collections was relatively lower than previously recorded⁹, but the general pattern of distribution between Madras and Visakhapatnam agreed with that of IIOE data for the same season¹⁷. Other groups such as amphipods, euphausiids, planktonic molluscs, etc. were moderately distributed in the western Bay of Bengal with their maximum abundance along the southeast coast of India⁵.

An earlier study conducted in June 1978 (ref. 18) showed an increase in secondary production from north to south along the east coast of India with maximum biomass (av. 33.2 ml/100 m³) between Madras and Visakhapatnam. This has been attributed to upwelling¹⁹ which leads to high plankton production in the area during June-July⁵. In the present study also, a general increasing trend in zooplankton biomass from north to south was observed with maximum biomass (av. 15.35 ml/100 m³) along the southern part of the western Bay of Bengal. Upwelling along the southwestern part of the Bay of Bengal during this period^{14, 20, 21} would have resulted in high zooplankton production along the southern region.

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References

- 1 Dietrich G, in *The biology of the Indian Ocean*, edited by B Zeitzschel (Springer-Verlag, Berlin) 1973, 1.
- 2 Currie R I, Fisher A E & Hargreaves P M, in *The biology of the Indian Ocean*, edited by B Zeitzschel (Springer-Verlag, Berlin) 1973, 37.
- 3 Prasad R R, *2nd Int Oceanogr Congr Moscow* (1969) 239.
- 4 Prasad R R, *Proc natn Inst Sci, India*, **35** (1969) 399.
- 5 Panikkar N K & Rao T S S, *Handbook to the international zooplankton collections (IOBC Cochin)* **5** (1973) 111.
- 6 Qasim S Z, *Indian J mar Sci*, **6** (1977) 112.
- 7 Paulinose V T & Aravindakshan P N, *Proceedings symposium on warm water zooplankton* (Spl Publ UNESCO/NIO) 1977, 132.
- 8 Peter K J, Iyer H K, Simon John & Radhakrishna E V, *Proceedings symposium on warm water zooplankton* (Spl Publ UNESCO/NIO) 1977, 80.
- 9 Nair R V, George Peter & Paulinose V T, *Mahasagar - Bull natn Inst Oceanogr*, **10** (1977) 45.
- 10 Nair R V, George Peter & Paulinose V T, *Mahasagar - Bull natn Inst Oceanogr*, **11** (1978) 35.
- 11 Peter G & Nair R V, *Mahasagar - Bull natn Inst Oceanogr*, **11** (1978) 169.
- 12 Currie R I, *Deep Sea Res*, **10** (1963) 27.
- 13 Radhakrishna K, Bhattathiri P M A & Devassy V P, unpublished data.
- 14 Madhupratap M, Devassy V P, Nair S R S & Rao T S S, *Indian J mar Sci*, **9** (1980) 69.
- 15 Nair R V & Iyer H K, *Indian J mar Sci*, **3** (1974) 150.
- 16 Menon P G & Paulinose V T, *Handbook to the international zooplankton collections (IOBC Cochin)* **5** (1973) 163.
- 17 IOBC International Indian Ocean expedition plankton atlas, **4** (Fasc 2) 1973.
- 18 Nair S R S, Nair V R, Achuthankutty C T & Madhupratap M, *J Plankton Res* (1980) (in press).
- 19 La Fond E C, *Andhra Univ Mem Oceanogr*, **1** (1954) 117.
- 20 Anand S P, Murty C B, Jayaraman R & Aggarwal B M, *Bull natn Inst Sci, India*, **38** (1968) 1.
- 21 Murty C S & Varadachari V V R, *Bull natn Inst Sci, India*, **38** (1968) 80.