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Original Research Paper

Diversity of Oceanic Zooplankton in Andaman Sea

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Density
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ABSTRACT

Andaman Sea is partially isolated portion of the northeastern Indian Ocean which lies enclosed between the coast of Burma, Thailand and Malaysia on the east and the chain of Andaman and Nicobar Islands and Sumatra Islands of Indonesia on the west. The biomass, density, diversity and distribution of oceanic zooplankton were studied from 10 stations along the continental slope of Andaman Sea during September 10-20, 2008 by onboard research vessel ORV Sagar Manjusha. A total of 96 species of zooplankton belonging to 19 groups and 74 genera were recorded during the study. Copepods were the dominant group at all the stations and their composition of occurrence ranged from 30.39% at station 4 to 44.30% at station 7. The volume of zooplankton ranged between 4.7mL/100m^3 and 12.7mL/100m^3 at stations 6 and 3 respectively. However, the numerical density of zooplankton along the study area showed minimum as 17300 No./100m^3 and maximum as 31620 No./100m^3 at these stations. The data pertaining to physicochemical parameters of seawater were also collected and the results discussed.

INTRODUCTION

Andaman Sea occupies an area of 6.02×10^5 km^2 and has a volume of 6.6×10^5 km^2 with an average depth of 1096m and a maximum depth of 4360m. It contains a relatively extensive basin, a north-south arc of volcanic island and seamounts including the Barren and Narcondam Islands in this sea, delineates this basin from 2 smaller basins on the north and south (Wyrtki 1961, Rodolfo 1966, Curray & Moore 1974). It is connected to the Bay of Bengal by numerous channels which are broadly interruptions in the ridge that lies on the western boundary. Among them are the Preparis Channel, divided into north and south portions by the islands with a depth of 200m; the Ten Degree Channel, between the Andaman and Nicobar groups of Islands with a depth of about 800m; and the Great Channel, between Great Nicobar Island and Sumatra. This Sea is also connected with the South China Sea through the Strait of Malacca. Strong tidal currents occur in this strait which has a depth of 30m and a width of 35km at its narrow part (Rodolfo 1966).

Zooplankton is distributed universally in world oceans and generally measures several microns to 2cm in size and some species are considerably larger. Aside from playing a vital role in the trophic levels of marine food chain that leads to commercially important fisheries, zooplankton are responsible for biogeochemical cycles of many important chemical elements. Zooplankton abundance and distribution are strongly dependent on factors such as ambient nutrient concentration, the physical state of water column and the abundance of phytoplankton. Although voluminous intensive studies on marine zooplankton in the tropical seas of India are available, all those information were restricted to either coastal or neritic waters. The studies pertaining to the zooplankton of oceanic

waters, especially on continental slope, are very scanty. The Andaman Sea is one of the least explored regions of the Indian Ocean. Very few investigations have been conducted in this area since the pioneering work of Sewell (1928, 1929, 1932). However, the previous works in Andaman waters on zooplankton abundance, distribution in relation to thermocline and diversity (Madhupratap et al. 1981a,b & c), chaetognaths (Nair et al. 1981) and copepods in Campbell Bay (Goswami & Rao 1981) were reported. Furthermore, the studies on these organisms in the oceanic waters of eastern Arabian Sea (Goswami 1983), Indian Ocean (Vijayalakshmi 1984, Dalal & Parulekar 1986), standing stock of zooplankton on west coast of India and Lakshadweep archipelago (Achuthankutty et al. 1989, Goswami & Uma Goswami 1990), Straits of Malacca (Rezai et al. 2003) are worth mentioning. However, present investigation has been undertaken along the Continental slope of Andaman Sea to assess the distribution and diversity of zooplankton communities.

MATERIALS AND METHODS

The Andaman and Nicobar Islands of India have an exclusive economic zone of 0.6 million km^2 with the continental shelf of 35,000km^2. The present study was carried out in the continental slope region of Andaman Sea bordering the Andaman and Nicobar archipelago. The zooplankton samples were collected from 8 stations along the Andaman Sea including volcanic islands of Barren and Narcondam at a mean distance of 20-30 nautical miles between the stations (Fig. 1) during September 10-20, 2008. The depth of the study area is 530-3117m. The GPS coordinates of the stations along with the date and time of sampling are given in Table 1.

The sampling of zooplankton was performed by onboard ORV Sagar Manjusha. The water samples were collected by Niskin water sampler and all the physicochemical parameters were analysed in *in situ* condition. The atmospheric and seawater temperatures were measured by mercury thermometer with an accuracy of 0.1°C. Salinity of surface seawater was measured by Refractometer Model ERMA RHS-10 while the pH was measured using water proof pH SCAN 3, Eutech Instruments. The data on the atmospheric pressure during the study was collected by ship meteorological instrument and the values were expressed in hPa. The record of wind speed and wind direction was collected by using ship meteorological instrument and the values were expressed in % for former and m/sec for latter.

Zooplankton samples were collected by surface haul using Heron-Tranter Plankton net having 0.7m dia mouth 3m long with a mesh size of 200µ for 10 minutes at 2 knot speed. The amount of water passed through was calculated by using flow meter while hauling the net. The collected plank-

Table 1: Coordinates of sampling stations in Andaman Sea.

Station	Coordinates	Date of Sampling	Time (hrs)
1	Latitude 10º 59.861'N Longitude 94º 04.955'E	12.09.2008	06:30
2	Latitude 11º 30.551'N Longitude 93º 15.320'E	15.09.2008	05:30
3	Latitude 12º 00.012'N Longitude 93º 15.153'E	16.09.2008	05:25
4	Latitude 12º 33.482'N Longitude 93º 15.265'E	16.09.2008	15:40
5	Latitude 12º 58.560'N Longitude 93º 14.331'E	17.09.2008	05:30
6	Latitude 13º 36.267'N Longitude 93º 15.207'E	17.09.2008	12:45
7	Latitude 13º 29.052'N Longitude 94º 15.505'E (Narcondam Island)	18.09.2008	07:00
8	Latitude 12º 19.325'N Longitude 93º 51.24.2'E (Barren Island)	19.09.2008	05:45

ton samples were preserved in 4% formalin. The wet weight of the zooplankton was determined after washing with distilled water and thereafter filtering through filter paper. The dry weight was determined by drying the filtered samples in a hot air oven at 70°C till constant weight. The results were calculated as mg/100m^3 of seawater. Zooplankton volume was measured by displacement method. In this method samples were filtered and blotted with filter paper and the mass was transferred to measuring cylinder having known volume of 4% formalin prepared in seawater. The rise in level of seawater in measuring cylinder was recorded. The distance between final and initial reading gives volume of zooplankton. The results were expressed as mL/100m^3 of seawater. The numerical density of zooplankton was calculated by using Sedgewick Rafter Counting Cell. The species were identified up to species level under binocular microscope by referring standard manuals and monographs.

The species diversity of zooplankton was calculated according to the Shannon-Weiner formula.

$H' = - \Sigma \, Pi \log_e Pi$

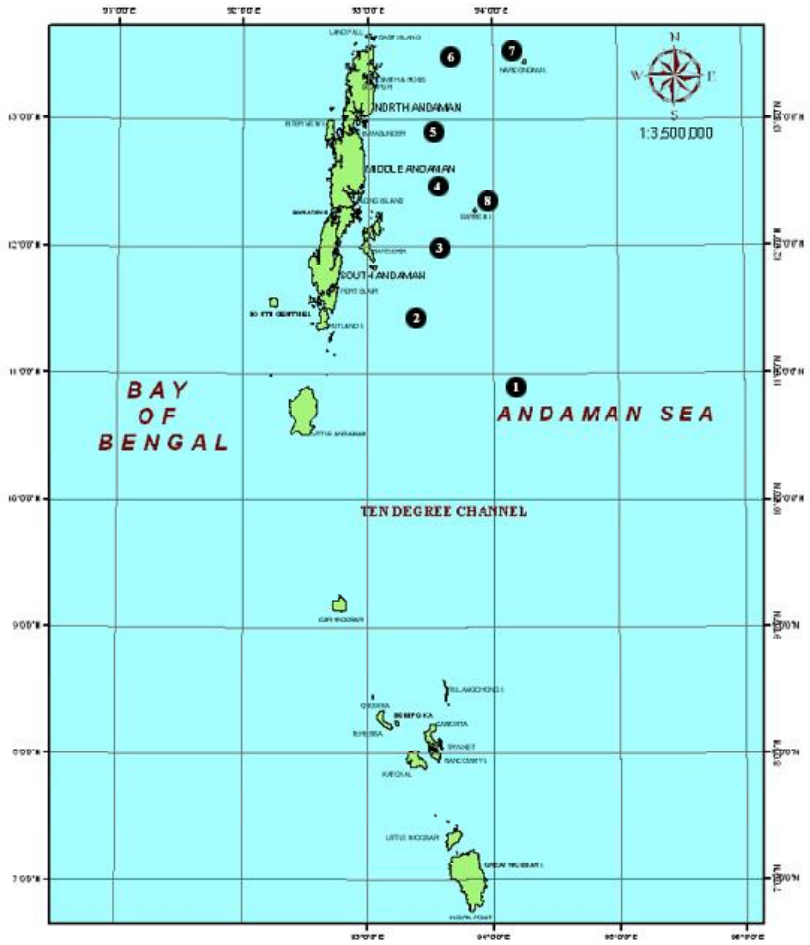

Fig. 1: Map showing the sampling stations in Andaman Sea.

Where, Pi = Proportion of the *i*th species in the collection and H'= Diversity of a theoretically infinite population.

The similarity of species between stations were calculated using Jaccard index as follows.

$C_j = J/a+b-J$

Where, J = Number of species common at any two stations, a = Number of species at one station and b = Number of species at other station.

RESULTS AND DISCUSSION

Physicochemical parameters: The physicochemical parameters of the oceanic waters are the prime factors indicating the water quality which directly influence primary, secondary and tertiary productivities of the marine environment. The quintessence of the results acquired for the physico-chemical parameters of surface seawater collected along the Andaman Sea revealed that there is no significant variation among the stations for all parameters studied (Table 2). The values of salinity observed during the study varied between 32.0 and 34.0 ppt at stations 4, 6 and 7, and 2, 5 and 8 respectively. The atmospheric temperature, measured at all the stations, shows the variation of 23.5°C to 29.0°C while surface seawater recorded minimum as 28.0°C at station 1 and maximum as 29.2°C at station 6. It is fascinating to note that the seawater temperature was drastically reduced to 14.7°C at 250m depth in station 5, 11°C at 800m depth in station 6, 18.6°C at 250m depth in station 7 (Narcondam Island) and 12.3°C at 500m depth in station 8 (Barren Island) from their surface seawater temperature of above 28°C, indicating the presence of strong cold water current existing in the study area. The values of pH showed 8.11 as minimum at station 2 and maximum as 8.40 at stations 7 and 8. The barometric pressure of the study area was recorded between 1005 hPa and 1013 hPa at stations 4 and 7, and 5 respectively. The wind speed during the study period was quite high as at 8 to 25 knot, while the wind direction was observed as 210° at station 3 and 290° at station 1.

Zooplankton: The quantitative and qualitative estimation, distribution and diversity of zooplankton collected from 8 stations along Andaman Sea are depicted in Tables 3 and 4. A total of 96 species of zooplankton belonging to 19 groups and 74 genera were recorded during the study.

Composition of zooplankton: Copepods were the dominant group at all the stations and their composition of occurrence ranged from 30.39% at station 4 to 44.30% at station 7. Foraminiferans were the subdominant group in most of the stations and their percentage composition varied from 6.90% at station 1 to 14.70% at station 4. Besides that, Chaetognaths, Appendicularians, Crustacean larvae and Molluscs occurred in considerable composition at quite a number of stations. Copepods were the

Table 2: Environmental parameters collected at the sampling stations.

Station	Atmospheric Temp. (ºC)	Seawater Temp. (ºC)	Salinity (ppt)	pH	Water Depth (m)	Barometric Pressure (hPa)	Wind Speed (knot)	Wind Direction
1	22.5	28.0	33.0	8.18	3117	1012	15.0	290º
2	29.0	28.5	34.0	8.11	1460	1010	25.0	230º
3	26.0	28.7	33.0	8.19	504	1012	19.0	210º
4	25.5	28.6	32.0	8.23	400	1005	8.0	230º
5	23.5	28.4	34.0	8.23	590	1013	14.0	230º
6	28.5	29.2	32.0	8.31	530	1011	10.0	240º
7	27.0	28.4	32.0	8.40	770	1005	10.0	230º
8	26.5	28.4	34.0	8.40	1109	1012	8.0	260º

Table 3: Quantitative and qualitative estimation of zooplankton at different stations along Andaman Sea

Station	1	2	3	4	5	6	7	8
Fresh weight (mg/100m^3)	3630	2610	4580	4150	3470	2540	3340	2860
Dry weight (mg/100m^3)	980	816	1240	1200	975	718	940	804
Volume (mL/100m^3)	10.4	6.2	12.7	12.3	9.0	4.7	9.8	8.5
Numerical density 28340 (No/100m^3)	24780	31620	30580	26570	17300	27560	25840	
Group				**Percentage Composition**				
Amphipods	2.30	1.39	1.71	1.47	-	-	-	1.32
Annelid larvae	4.60	4.17	4.70	3.45	1.37	-	-	3.27
Appendicularians	5.75	5.55	4.27	3.92	10.27	6.93	10.06	7.84
Chaetognaths	7.47	6.94	5.13	5.39	6.85	7.92	10.74	11.76
Cladocerans	4.60	-	2.99	1.96	4.79	1.98	-	5.23
Copepods	37.93	34.72	33.33	30.39	39.73	42.57	44.30	39.22
Crustacean larva	6.70	12.5	6.84	8.82	4.79	7.92	6.74	6.54
Doliolids	1.72	-	2.14	1.96	-	-	-	1.31
Echionoderm larvae	1.15	-	1.71	2.45	-	-	3.36	2.61
Foraminiferans	6.90	11.12	13.67	14.70	10.27	9.97	10.74	7.84
Isopods	-	-	-	-	-	-	-	2.61
Leptomedusae	-	1.39	3.43	1.96	1.37	-	1.34	-
Molluscs	4.60	4.17	7.69	5.88	6.85	3.96	4.70	2.61
Ophisthobranchs	-	1.39	-	1.47	-	-	1.34	-
Ostractods	4.12	5.55	4.70	4.42	4.79	3.96	5.34	-
Pisces	4.60	6.94	1.71	2.94	2.74	6.93	-	-
Radiolarians	4.12	1.39	-	3.43	3.43	1.98	-	3.27
Salpids	1.72	1.39	3.42	2.94	-	2.97	-	1.96
Siphonophores	1.72	1.39	2.56	2.45	2.75	2.97	1.34	2.61
Total no. of groups	16	15	16	18	13	12	11	15

only group found in all the stations of study. The total number of zooplankton groups obtained from the different stations ranged from 11 to 18 at stations 7 and 4 respectively. The number of species recorded for individual groups ranged from 1 to 37 (Fig. 2)

Biomass of zooplankton: The biomass of zooplankton in terms of fresh weight, dry weight, volume and numerical density was estimated for all the stations. The fresh weight of zooplankton ranged from 2540mg/100m^3 at station 6 to 4580mg/100m^3 at station 3, whereas dry weight varied from 718mg/100m^3 to 1240mg/100m^3 for the same set of stations. Similarly, the volume of zooplankton ranged between 4.7mL/100m^3 and 12.7mL/100m^3 at stations 6 and 3 respectively. However, the numerical density of zooplankton along the study area showed minimum as 17300 No./100m^3 at station 6 and maximum as 31620 No./100m^3 at station 3.

Diversity and distribution of zooplankton: Although 96 species of zooplankton were recorded from the study area, their distribution was

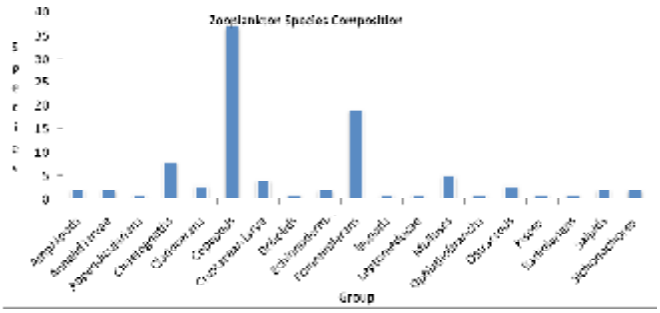

Fig. 2: Species composition of different zooplankton groups in Andaman Sea.

widely varied from 62 at station 6 to 80 at station 3. The species diversity of zooplankton was ranged from 2.18 at station 5 to 3.45 at station 3 (Fig. 3). The diversity of copepods was found dominant as it was represented by 37 species followed by foraminiferans comprised of 19 species. It is noteworthy to state that the Appendicularian *Oikopleura dioica,* Copepods *Lucicutia flavicornis, Microsetella gracilis, Microsetella norvegica, Nannocalanus minor, Oithona brevicornis* and *Oncaea venusta*, and Crustacean, Cypris larvae and Nauplii were the only species distributed at all the stations of study. It is also observed that the Isopod *Angeliera phreaticola* was recorded only at station 7, i.e., Narcondam Island. However, the species belonging to remaining groups have different degrees of distribution.

Similarity Index: The species similarity index has been calculated between stations and the values are depicted in Table 5. The maximum similarity index of 0.75 was observed between stations 2 and 5 while minimum of 0.48 between stations 1 and 7.

The Andaman and Nicobar Islands have steeper continental slope with the depth of about 3500m on the eastern and western slopes which is very irregular and has not yet been fully chartered. This is the region where the complex air-sea interaction phenomenon releases enormous energy for the genesis of the tropical cyclones which hit the east coast of India and the northeastern coast of Bay of Bengal almost every year (Gouveia et al. 1981). The sea surface temperature observed from the present study site is quite comparable with the earlier records of 27-28°C made by Ramaraju et al. (1981). A noticeable difference in the temperature of the waters was also made below 1500m in this area and it gradually decreased from 5°C at about 1500m to 3°C at 1900m. However, the present study reports the drastic changes in temperature even at the depth of 250m in two stations while comparing with its surface water. The salinity of the surface seawater, observed in the present study, shows the marginal variation among 8 stations (Table 2), which is agreed with the earlier findings varied from 31.87 to 33.6 ppt (Ramaraju et al. 1981) in this region. It is also reported that the thickness of the isohaline layer in the study area ranges from 11 to 31m depth. The minor fluctuations in the salinity might be attributed to the variable quantities of freshwater inflow through the Straits of Malacca, South China Sea and tropical rain forests of Sumatra Islands.

Zooplankton, being secondary producers, play a crucial role in the transfer of energy to higher trophic levels in the sea; the continental slope water of Andaman is oligotrophic in nature with low primary productivities. The production of large quantities of detritus, therefore, appears to supplement the inadequacy of these waters. The biomass of zooplankton in terms of volume calculated through the present observation ranges from 4.7 mL/100m^3 to 12.7mL/100m^3 at stations 6 and 3. These values were nearly close to the previous records of 1.8 to 14.4 mL/100m^3 in these waters (Madhupratap et al. 1981a). The average biomass values, reported from the Bay of Bengal ranged from 6.3 to 8.4 mg/100m^3 during southwest monsoon (Nair et al. 1977) and 2.5 to 15.4 mg/100m^3 during late southwest monsoon (Achuthankutty et

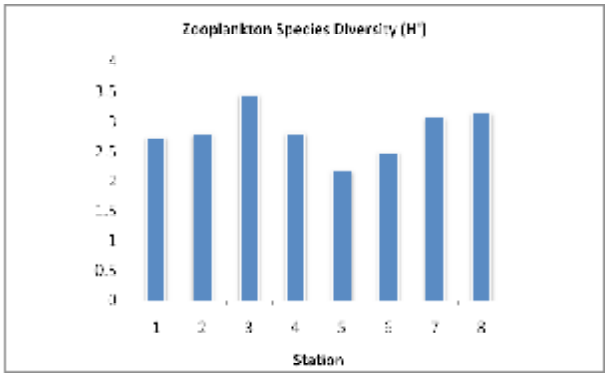

Fig.3: Zooplankton species diversity at different stations in Andaman Sea.

Table 4: Distribution and diversity of zooplankton along the sampling stations in Andaman Sea.

Sl. No.	Species	Stations 1	2	3	4	5	6	7	8
	(1) Foraminiferans								
1.	*Amhistegina lessoni* (d'Orbigny)	+	+	+	+	+	+	-	+
2.	*Amphisorus hemprichii* (Ehrenberg)	-	+	+	+	+	-	+	+
3.	*Cibicides lobatulus* (d'Orbigny)	-	+	+	+	+	-	+	+
4.	*Calcarina calcar* (d'Orbigny)	+	+	+	+	+	+	-	-
5.	*Elphidium crispum* (Linne)	-	-	-	+	+	-	+	+
6.	*Globigerina tricolunoides*	-	+	+	-	+	+	+	+
7.	*Globigerina sacculifer* (Brady)	+	+	+	-	+	+	+	+
8.	*Loxostomum limbatum* var *costulatum* (Cushman)	+	+	-	+	+	+	+	+
9.	*Loxostomum rostrum* (Brady)	+	+	+	+	+	-	+	-
10.	*Loxostomum truncatum* (Phleger and Parker)	-	-	+	+	+	-	+	+
11.	*Planobulina mediterranensis* (d'Orbigny)	+	+	+	+	+	+	+	-
12.	*Quinqueloculina seminulum* (Linne)	-	+	+	+	+	+	+	+
13.	*Quinqueloculina subcuneata* (Cushman)	-	+	+	-	+	+	+	-
14.	*Rosalina floridana* (Cushman)	-	+	+	-	+	+	-	-
15.	*Rosalina globularis* (d'Orbigny)	+	+	-	+	+	+	+	-
16.	*Rosalnia bradyi* (Cushman)	+	-	+	+	+	+	+	-
17.	*Siphonia reticulata* (Czjzek)	-	-	-	+	+	+	-	+
18.	*Spirillina lateseptata*	-	+	-	+	+	-	+	+
19.	*Triloculina oblonga* (Montagu)	-	+	+	-	+	-	+	+
	(2) Appendicularians								
20.	*Oikopleura dioica*	+	+	+	+	+	+	+	+
	(3) Copepods								
21.	*Acartia erythracea*	+	-	+	+	+	+	+	+
22.	*Acartia southwelli* (Sewell)	+	+	+	+	+	-	+	+
23.	*Acrocalanus gracilils* (Giesbrecht)	+	+	-	+	+	+	+	+
24.	*Copilia mirabilis* (Dana)	+	-	+	-	-	+	+	+
25.	*Corycaeus catus* (F. Dahl)	+	+	+	+	+	+	-	+
26.	*Corycaeus danae* (Giesbrecht)	+	+	-	+	+	-	+	+
27.	*Corycaeus speciosus* (Dana)	+	+	+	+	+	+	+	+
28.	*Centropages dorsispinatus*	-	+	+	+	+	+	+	+
29.	*Euchaeta concinna*	-	+	+	+	+	+	+	+
30.	*Eucalanus attenuatus* (Dana)	+	+	+	+	-	-	+	+
31.	*Euterpina acutifrons* (Dana)	+	+	+	-	-	+	-	+
32.	*Isias tropica* Sewell	+	+	+	+	+	-	+	-
33.	*Labidocera acuta* (Dana)	+	-	+	-	-	+	+	+
34.	*Longipedia coronata* (Claus)	+	+	+	+	-	+	-	+
35.	*Longipedia weberi* (A. Scott)	+	+	+	-	+	+	+	-
36.	*Lucicutia flavicornis* (Claus)	+	+	+	+	+	+	+	+
37.	*Macrocypris mima*	+	+	+	+	+	-	+	-
38.	*Macrosetella gracilis* (Dana)	+	+	+	+	+	+	+	+
39.	*Metacalanus aurivilli* (Cleve)	+	+	+	+	-	+	+	+
40.	*Metis jausseamei* (Richard)	+	+	+	+	-	+	+	+
41.	*Microsetella norvegica* (Boeck)	+	+	+	+	+	+	+	+
42.	*Microsetella rosea* (Dana)	-	-	+	-	+	+	+	-
43.	*Miracia efferata* (Dana)	+	-	+	+	-	+	+	+
44.	*Nannocalanus minor* (Claus)	+	+	+	+	+	+	+	+
45.	*Oithona brevicornis* (Giesbrecht)	+	+	+	+	+	+	+	+
46.	*Oithona linearis* (Giesbrecht)	+	-	+	+	-	+	+	+
47.	*Oithona similis* (Claus)	+	+	-	+	-	+	-	-

Table cont....

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48.	*Oncaea venusta* (Philippi	+	+	+	+	+	+	+	+
49.	*Paracalanus parvus* (Claus)	+	+	-	+	+	+	+	+
50.	*Pontella danae* (Giesbrecht)	+	-	+	+	+	+	+	+
51.	*Pontellina plumata* (Dana)	-	+	-	-	+	+	+	+
52.	*Pseudodiaptomus serricaudatus* (T. Scott)	-	+	+	+	+	+	+	+
53.	*Sapphirina nigromaculata* (Dana)	-	+	+	+	+	+	+	+
54.	*Sapphirina ovatolancoelata*a (Dana)	-	+	+	-	+	+	+	-
55.	*Scoleithrix danae* (Lubbock)	+	-	+	-	-	-	-	-
56.	*Temora discaudata* (Giesbrecht)	+	+	+	-	+	+	+	+
57.	*Undinula vulgaris* (Dana)	-	-	-	-	-	-	+	+
	(4) Amphipods								
58.	*Hyperia medusarum*	+	+	+	+	-	-	-	+
59.	*Parathemisto* sp.	-	-	+	+	-	-	+	+
	(5) Isopods								
60.	*Angeliera phreaticola* (Chappuis and Delamare Debouteville, 1952)	-	-	-	-	-	-	+	-
	(6) Ostracods								
61.	*Conchoecia indica*	+	+	+	-	-	+	+	-
62.	*Cypridina sinosa*	+	+	+	+	+	+	+	-
63.	*Macrocypris minna*	+	+	+	+	+	+	+	-
	(7) Leptomedusae								
64.	*Proboscidactyla stellata*	-	+	+	+	+	-	+	-
	(8) Crustacean larvae								
65.	Cypris larva of Lepas, Barnacle	+	+	+	+	+	+	+	+
66.	Nauplii	+	+	+	+	+	+	+	+
67.	Larvae of *Labidocera pavo*	-	-	+	+	+	+	+	+
68.	Mysis stage of penaeid prawn	+	+	+	+	+	-	-	+
	(9) Annelid larvae								
69.	Setiger larva	+	+	+	-	+	-	-	+
70.	Spirobis larva	+	+	+	+	+	-	-	-
	(10) Cladocerans								
71.	*Evadena tergestina*	+	-	+	+	+	-	-	+
72.	*Cypris* sp.	-	-	-	-	-	+	-	+
73.	*Podon* sp.	+	+	+	+	+	+	-	-
	(11) Chaetognaths								
74.	*Eukrohnia minuuta*	-	-	+	-	+	+	-	+
75.	*Sagitta enflata*	-	+	+	+	+	-	-	+
76.	*Sagitta hamata*	+	-	+	-	+	-	+	+
77.	*Sagitta hexaptera*	+	+	-	-	+	+	+	+
78.	*Sagitta hispida*	+	-	+	-	+	-	-	-
79.	*Sagitta lyra*	+	-	+	+	-	-	-	-
80.	*Sagitta maxima*	-	+	-	+	-	-	+	+
81.	*Sagitta robusta*	-	+	+	+	-	+	+	+
	(12) Doliolids (Cyclomyaria)								
82.	*Dolioletta gengenbauri*	+	-	+	-	+	-	+	+
	(13) Echinoderms								
83.	Bipinnaria larva of starfish	+	-	+	-	+	-	+	+
84.	Echinopluteus larva of sea urchin	+	-	+	-	-	-	+	+
	(14) Radiolarians								
85.	*Acanthometron* sp.	+	+	-	+	+	+	-	+
	(15) Siphonophores								
86.	*Porpita porpita*	+	+	+	+	+	+	+	+
87.	*Diphyes chamissonis*	-	-	+	+	-	-	+	+
	(16) Molluscs								

Table cont....

....Cont. Table

88.	*Janthina janthina*	+	+	+	+	-	+	+	+
89.	*Janthina fragilis*	+	-	+	-	+	-	-	+
90.	*Spiratella* sp.	+	+	+	-	+	+	-	+
91.	Veliger larva	+	+	+	+	-	+	+	+
92.	Pedi veliger larva	-	-	+	-	-	-	+	+
	(17) Salpids (Desmomyaria)								
93.	*Salpa maxima*	+	-	+	+	-	+	-	+
94.	*Salpa (Pegea) confoederata*	+	-	+	+	-	+	-	+
	(18) Opithobranchs								
95.	*Crseis acicula*	-	-	+	+	-	-	+	+
	(19) Pisces								
96.	Fish eggs	+	+	+	+	+	+	-	-
	Total number of species	65	65	80	67	58	62	70	72
	Species diversity (H')	2.75	2.80	3.45	2.82	2.18	2.50	3.08	3.15

al. 1989). Geographical distribution of zooplankton in the Indian Ocean, based on the International Indian Ocean Expedition (IIOE) data, shows highly productive areas around the Somali and Arabian Sea followed by northern Bay of Bengal which is also moderately high biomass (Rao 1993).

Among 16 groups of zooplankton encountered from the present study, copepods were the dominant group at all the stations as their dominance ranged from 30.39% to 44.30%. Madhupratap et al. (1981c) also reported 53.9% of copepods in Andaman waters. However, the present study indicated the increment in the copepod diversity over the period of years. A total of 37 species of copepods recorded from the study area is well agreed with the findings of Madhupratap et al. (1981c) as it recorded 48 species belonging to 33 genera while 32 species with the composition of 52.7% noticed by Goswami & Uma Goswami (1990) in Lakshadweep Islands. However, the productivity of zooplankton was poor in Andaman waters while comparing with Arabian Sea. Goswami (1983) reported 24 zooplankton taxa comprised of 80 species of copepods alone with the composition of 65% in the coastal waters of Goa. In general, the composition of copepods was constituted by a number of neritic and oceanic species. Forminiferans were also fairly abundant in the study area, although they were not reported in the earlier studies around these oceanic waters. The species diversity indices for the zooplankton of Andaman Sea waters indicted that the values were quite comparable with Lakshadweep waters (0.2-4.0) observed by Achuthankutty et al. (1989). The low biomass, density and diversity of zooplankton in the oceanic waters might be attributed to the low primary productivity of 273mg C/m^3/day (Battathiri & Devassy 1981) coupled with the lack of adequate level of nutrients in seawater which are responsible for enhancement of productivity. Furthermore, the variation in the zooplankton composition might be due to diel vertical migration of these organisms and influence of oceanic currents.

The epitome of the results obtained for the zooplankton biomass, distribution and density form the present study once again confirms that the Andaman Sea is the highly productive sea of Indian Ocean. The presently sampled stations have moderate productivity as they fall in neritic waters of Andaman Sea and it is corroborated with the variations observed by Rezai et al. (2003) in Straits of Malacca where the biomass of zooplankton was gener-

Table 5: Species similarity index between stations.

Station	1	2	3	4	5	6	7	8
1		0.56	0.54	0.55	0.60	0.55	0.48	0.57
2			0.59	0.62	0.75	0.60	0.56	0.52
3				0.56	0.66	0.56	0.64	0.63
4					0.64	0.53	0.53	0.58
5						0.62	0.68	0.59
6							0.53	0.55
7								0.63

ally higher in waters close to the coastal areas than in the offshore areas. The availability of nutrients in higher concentration, which leads to primary productivity in the coastal waters, could be the causative factor for this trend of variation.

The results obtained from the study revealed that the distribution, biomass, density and diversity zooplankton species in Andaman Sea are comparatively higher in order. However, the minor variations for these variables recorded between different stations might be due to diel vertical migration of zooplankton, oceanic current pattern, etc. Furthermore, it is suggested that the further survey to cover the rest of the part of Andaman Sea, which is not covered in the present study, will provide a wide spectrum on the profile of planktonic communities in this Sea.

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