

## ZOOPLANKTON STANDING STOCK AND DIVERSITY ALONG AN OCEANIC TRACK IN THE WESTERN INDIAN OCEAN

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### ABSTRACT

Zooplankton samples were collected from 13 stations situated in the oceanic realm between latitudes  $8^{\circ}49' N$  and  $19^{\circ}48' S$  in January–February, 1981. Standing stock varied between 1.6 and 10.4 ml/100 m<sup>3</sup> and was generally poor. Higher biomass was associated with area of higher nutrient concentration. Standing stock is compared with earlier observations from oceanic and coastal waters. Species diversity was fairly high and comparisons show an increasing diversity from estuaries to coastal environments and oceanic areas.

*Key-words* : Zooplankton, standing stock, diversity, Indian Ocean.

The major thrust in oceanographic studies of the Indian Ocean came from the International Indian Ocean Expedition (IIOE, 1960-65). Since then considerable amount of information on zooplankton abundance and composition is available from the neritic waters surrounding peninsular India (Anon, 1977; Nair, Peter and Paulinose, 1977, 1978; Achuthan Kutty, Madhupratap, Nair and Rao, 1980; Haridas, Menon and Madhupratap, 1980; Nair, Achuthan Kutty and Madhupratap, 1981) and the adjoining islands of Lakshadweep (Madhupratap, Wafar, Haridas, Narayanan, Menon and Sivadas, 1977; Goswami, 1979) and Andamans (Madhupratap, Achuthan Kutty and Nair, 1981). Comparatively very little information is available from the oceanic realm.

In January-February, 1981, zooplankton samples were collected on board R.V. *Gaveshani* from 13 stations in the western Indian Ocean. (Fig. 1). All samples were collected from the upper 200 m in vertical hauls during day time using a HT net (mouth area — 0.25 m<sup>2</sup>; mesh width — 0.3 mm) attached with a flowmeter. Biomass was estimated as displacement volume and common taxa and species were identified. Equitability and species diversity were calculated using two indices E (Heip, 1974) and D (Margalef, 1968).

The period of observation represented the northeast monsoon (December–March) in the northern Indian Ocean (approximately north of  $10^{\circ} S$ ) when the circulation is anti-cyclonic. The North Equatorial Current moves partially into the southern hemisphere flowing westward and the thermal equator is south of equator during this part of the year. The Equatorial Counter Current is between  $2^{\circ}$  and  $7^{\circ} S$  having an eastward direction. South of this, flows the broad South Equatorial Current and its core lies near the northern boundary of the current at  $10^{\circ} S$  to  $15^{\circ} S$  (Defant, 1961).

Surface salinity varied from 35.58‰ ( $6^{\circ}34' N$ ) to 34.48‰ ( $10^{\circ} S$ ). Surface temperature showed minimum value of  $27.3^{\circ} C$  at  $2^{\circ}45' N$  and maxi-

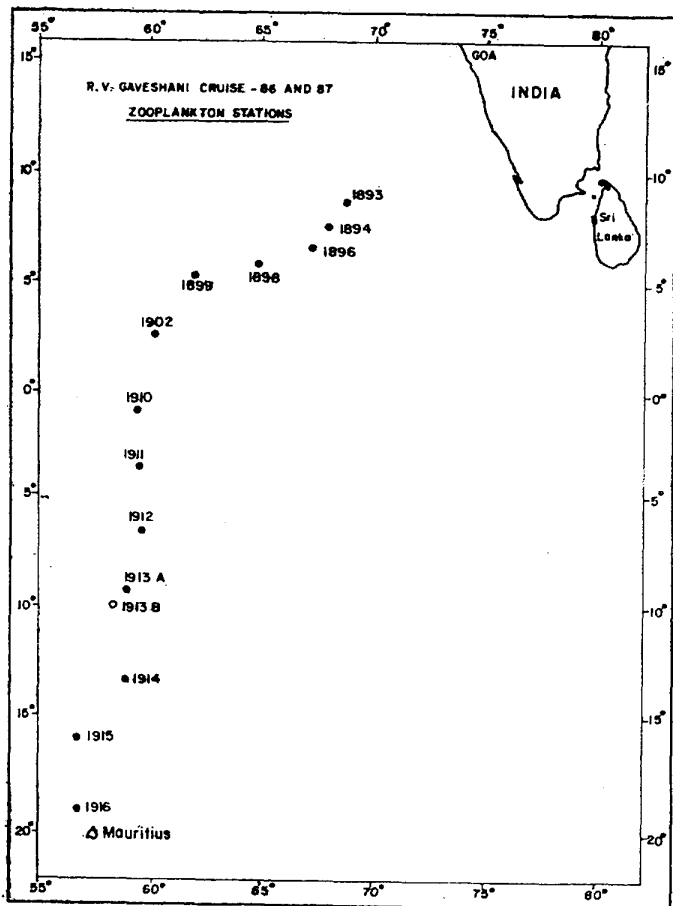


Fig. 1. Map showing the stations position.

num of  $28.6^{\circ}\text{C}$  at  $0^{\circ}34'S$ . A marked decrease in the depth of the isothermal layer was observed near equator and between  $10^{\circ}$  to  $13^{\circ}\text{S}$  suggesting upward movement of subsurface waters in these areas. Distribution of nutrients also supported this. In general, the concentration of nutrients were low (nitrate  $< 1 \mu\text{g-at/l}$ ; phosphate  $< 0.2 \mu\text{g-at/l}$ ) in the isothermal layer (Naqvi, personal communication). An increase in nutrient concentrations occurred in the surface layers in the equatorial region and again at about  $10^{\circ}\text{S}$  ( $\text{NO}_3 \sim 3 \mu\text{g-at/l}$ ;  $\text{PO}_4 \sim 0.5 \mu\text{g-at/l}$ ). Increase in nutrient concentrations was observed at st. 1902 also albiet the depth of isothermal layer being about 40 m.

Unlike the south-west monsoon season, the oceanic circulation is only moderately strong during north-east monsoon and no striking upwelling areas develop (Wyrski, 1973). Some shoaling of thermocline under favourable wind conditions may result in weak upwelling. The increase in nutrient concentrations and relatively shallow mixed layer observed are probably resultant of weak equatorial upwelling and divergence at the poleward side of the Counter Current. The increase in nutrients are however, no way comparable to other upwelling systems like off Saudi Arabia where phosphate and nitrate even at surface showed values as high as 1.61 and 21.1  $\mu\text{g-at/l}$  respectively (Rao, 1979).

Zooplankton standing stock ranged between 1.6 and 10.4 ml/100 m<sup>3</sup> (Table I). Maximum biomass (10.4 and 8.1 ml/100 m<sup>3</sup>) corresponded to areas where higher nutrient concentrations occurred. However, it may be mentioned that there is often a time lag between upwelling and development of phytoplankton and zooplankton populations. The zooplankton biomass was generally poor as could be expected in the oceanic realm.

A generally feature revealed by the IIOE data was that the eastern and western parts of the Indian Ocean become alternatively more productive during the NE and SW monsoons (Rao, 1979). A similar north-south track along 54-60°E in February on *Anton Bruun* showed comparable values (1 to 10.5 ml/100 m<sup>3</sup>; values approximated from IOSN standard hauls). The biomass decreased from north to south and south of 10°S values were very poor (IOBC, 1969). Another section along 74/75 °E in April on *Discovery* and in

Table I. Temperature-salinity ranges (upper 200 m), zooplankton biomass and species diversity indices.

Station	Temperature (°C)	Salinity (‰)	Depth of isothermal layer	Biomass (ml/100m <sup>3</sup> )	Species diversity index	
					D	E
1893	28.00 - 15.20	-	53	4.8	8.1	.44
1894	28.10 - 14.90	-	30	4.8	6.9	.31
1896	27.92 - 14.27	35.16 - 36.19	48	3.6	7.0	.26
1898	28.50 - 17.88	35.20 - 35.26	60	7.3	7.9	.48
1899	27.40 - 13.38	35.49 - 35.19	35	2.4	7.0	.43
1902	27.30 - 13.38	35.49 - 35.19	40	10.4	6.6	.45
1910	28.60 - 13.98	35.46 - 35.15	20	3.1	7.5	.35
1911	28.06 - 15.34	35.33 - 35.13	42	6.7	7.7	.37
1912	27.54 - 12.49	35.58 - 35.05	25	5.8	7.5	.27
1913 A	-	-	-	8.1	8.6	.48
1913 B	28.35 - 14.29	34.48 - 35.04	5	-	-	-
1914	28.35 - 20.77 (150 m)	34.61 - 35.29	18	4.6	6.7	.45
1915	-	-	-	1.6	7.0	.44
1916	-	-	-	2.3	6.4	.32

- No data.

Table II. Comparative ranges and averages (in parenthesis) of diversity indices.

Area	D	E	Source
Western Indian Ocean	6.4 - 8.6 (7.3)	.26 - .48 (.39)	Present study
Cochin Backwaters	1.9 - 5.5 (3.7)	.11 - .59 (.32)	Madhupratap (unpublished data)
Nearshore waters off Trivandrum	3.1 - 7.7 (5.9)	.03 - .57 (.24)	Haridas, Menon and Madhupratap (1980)
Andaman Sea	3.1 - 8.1 (5.7)	.25 - .72 (.50)	Madhupratap, Nair, Achuthan Kutty and Nair (1981)
Lakshadweep Sea Lagoons (Lakshadweep)	4.8 - 4.9	-	Madhupratap, Wafar, Haridas, Narayanan, Menon and Sivadas (1977)
Western Bay of Bengal (includes coastal and oceanic stations)	1.6 - 2.4 8.2 - 12.9 (9.9)	- .17 - .82 (.48)	Nair, Nair, Achuthan Kutty and Madhupratap (1981).

— No data

March along 57-58°E also showed similar results. Observations on *Anton Bruun* and *Argo* in August-September (SW monsoon) indicated considerable increase in standing stock in the northern part of the western Indian Ocean and relatively higher values in the southern hemisphere while it remained low in the eastern Indian Ocean. Very high standing stocks of zooplankton in certain areas like off Saudi Arabia and Somali were identified to be associated with coastal upwelling systems (Prasad, 1969).

Copepoda formed the dominant zooplankton component (83.3%) in the samples. This was followed by chaetognaths (4.5%), ostracods (2.6%), tunicates (2.4%) and siphonophores (2.2%). Hydromedusae, cladocerans, amphipods, euphausiids, sergestids, pteropods, heteropods and larvae of decapods, polychaetes, echinoderms and fishes constituted the rest of the zooplankton.

The oceanic realm is comparatively stable allowing communities to diversify. Diversity (D) was fairly high at all stations and variations were marginal (range 6.4 to 8.6). Equitability in the species distribution (E) was also high but slightly lower compared to results obtained earlier from some of the oceanic regions of Indian Ocean. It is clear from Table II that there is an increasing gradient from estuaries and lagoons to nearshore and coastal environments and oceanic regions sustain still higher diversity and evenness in species distribution.

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