

latitudinal difference may also influence the carbon content of zooplankton.

Estuarine, nearshore and oceanic zooplankton have their own characteristic composition, diversity and abundance. In the estuarine habitat, the fauna is constituted of relatively fewer groups and species. In the nearshore waters the number of representative groups and species are more than in the estuary. The diversity is maximum in oceanic waters where many taxonomic groups are represented. This progressive change in the composition of zooplankton appears to be reflected in the organic content of these organisms. The variations might be a cumulative effect of the available food, species composition of zooplankton and physiological state of the constituent organisms.

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Production & Associations of Zooplankton in Estuarine & Nearshore Waters of Goa

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(Zooplankton production in the Zuari and Mandovi estuaries indicated 2 peaks—one in November and another in March/April. In the nearshore waters very high value of zooplankton biomass was observed in April associated with *Trichodesmium* bloom. Mean rate of production in Mandovi, Zuari and nearshore waters was 51, 69 and 136 mgC₂m²/day respectively. Crustaceans contributed to the major part of the phytophagous and euryphagous populations while chaetognaths and coelenterates formed an appreciable part of the predators. In the estuaries, higher diversity of zooplankton was associated with predominance of carnivores. In the nearshore waters community at the initial stages was dominated by filter feeders and omnivores and later by a high ratio of predators.)

Ecology of zooplankton in the nearshore waters of Goa has been investigated¹⁻⁶. Secondary production⁷ and variations in organic carbon content of zooplankton⁸ in the Mandovi-Zuari estuarine system have been estimated. (In an estuarine habitat mostly herbivores and omnivores predominate with a relatively low percentage of predators. However, carnivores play an important role in maintaining ecological balance in any environment.) Plankton associations of the tropical region differ from higher latitudes in an increase in the relative biomass of predators⁹. In this study structure of trophic interrelations within the zooplankton community is assessed quantitatively. Rate of secondary production in Mandovi and Zuari estuaries and nearshore waters is also estimated and compared with earlier reports.

Two sets of Zooplankton samples were collected in vertical hauls (5 m to surface) using methods described earlier⁸, (from Mandovi (15° 29' N and 73° 49' E) and Zuari (15° 25' N and 73° 49' E) estuaries during Jan. to Dec. 1978 and from nearshore waters (15° 30' N and 73° 42' E) during Jan. to May 1978. The depths for estuarine and nearshore areas ranged from 6 to 8 m and 12 to 15 m respectively.

For estimation of secondary production mean biomass value for each month was considered and rate of production estimated⁷ based on organic carbon values⁸ for the same set of samples. Each sample (20%) was analysed for the enumeration of different taxa. Dry weight estimates were made separately for herbivores, omnivores and predators. Predatory copepods formed a negligible part of total copepods and hence were not separately treated.

Zooplankton production—Production of zooplankton in Zuari, Mandovi and nearshore waters for different months are given in Table 1 and Fig. 1. Zooplankton biomass in the Zuari estuary ranged between 6 and 78.7 mg dry wt/m³/day with a mean value of 33 mg dry wt/m³/day. In Mandovi estuary,

Table 1—Rate of Secondary Production in Mandovi, Zuari and Nearshore Regions during 1978

[Values expressed in mgC₂m²/day]

	Mandovi	Zuari	Nearshore
Jan.	18.35	33.71	30.69
Feb.	38.77	61.42	148.83
March	47.18	45.9	61.05
April	53.38	80.2	329.01
May	32.28	62.72	112.42
June	17.47	12	—
July	34.34	40.68	—
Aug.	18.79	199.38	—
Nov.	221.89	119.12	—
Dec.	26.03	27.82	—
Mean	50.85	69.3	136.4

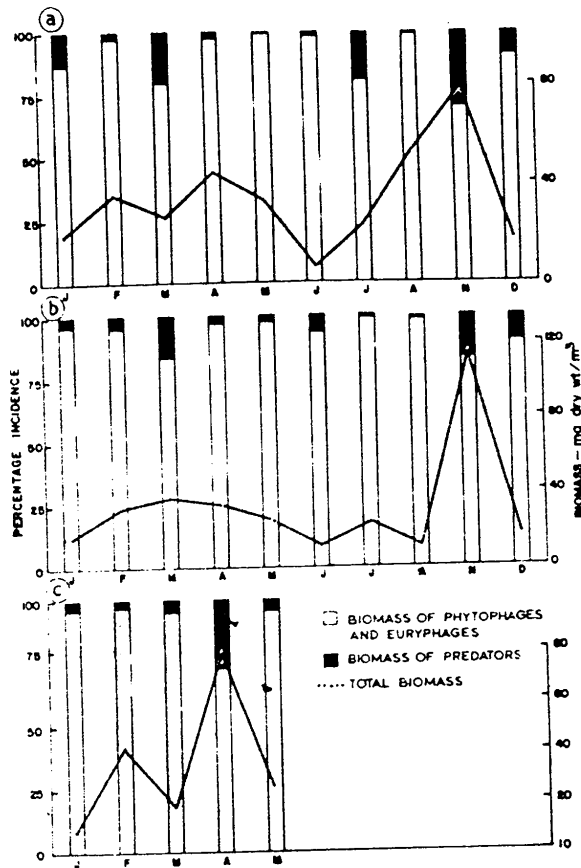


Fig. 1. Zooplankton biomass and percentage contribution of 2 different components in Zuari (a) and Mandovi (b) estuaries and nearshore waters (c)

variations in biomass ranged from 11.2 to 113 mg dry wt m^{-3} day (mean 31.8 mg dry wt m^{-3} day). In both the estuaries maximum production was observed in November. Zooplankton biomass in the nearshore waters during January to May varied between 8.3 and 78.7 mg dry wt m^{-3} day. Mean biomass of 34.7 mg dry wt m^{-3} day was relatively higher than that from Mandovi and Zuari estuaries. Mean rate of secondary production in the nearshore waters was approximately twice more than that of the estuaries (Table 1).

Composition of zooplankton—Numerical abundance of different groups are given in Tables 2 to 3. Euryphagy to a certain extent is a feature of most plankton organisms. For studying the trophic interrelationship within the community the different groups of zooplankton are segregated into phytophages euryphages and predators.

Phytophagous and euryphagous zooplankton: Crustaceans formed the major part of phytophages and euryphages in the collections (Tables 2 to 3). Copepods dominated most of the collections. An appreciable part of copepod species belonging to Eucalanidae, Paracalanidae, Centropagidae, Pseudodiaptomidae, Temoridae, Lucicutidae and

Acartidae are either herbivores or omnivores. Predatory copepods belonging to the families Oncaecidae, Corycaecidae and Pontellidae formed only a negligible part of total copepod biomass. Cladocera was represented by *Evadne tergestina* and *Penilia avirostris* of which the former was more common. In November *P. avirostris* was very abundant at both the estuaries. Cirriped nauplii were confined to estuarine region only. Amphipods though rare were better represented in Mandovi. Mysids and isopods were restricted to estuarine stations while ostracods were recorded only in the nearshore waters. In the nearshore waters stomatopod larvae were found from March to May and were rare in the estuaries.

Sergestids which formed the major part of the decapod larvae were represented mainly by *Lucifer hansenii*. At Zuari *L. hansenii* dominated the collection in February. Brachyuran larvae were found throughout the period of observation. Anomuran larvae mainly constituted by porcellanid zoea were better represented in Zuari.

Polychaetes were fairly represented at all the 3 regions. Among the molluscan veligers gastropods were better represented in Mandovi estuary while Zuari estuary and nearshore waters sustained higher density for lamellibranchiates. *Creseis acicula* was rarely encountered in the collections. Copelates were occasionally found in the collection and were absent during the SW monsoon. Doliolids were sparse.

Predators: Chaetognaths constituted the major part of the carnivore population (Table 2 to 3). *Sagitta bedoti* was the dominant chaetognath in the estuary followed by *S. enflata*. In the nearshore waters *S. enflata* was more abundant. Occasionally *S. ferox*, *S. robusta* and *S. neglecta* were found in the nearshore collections. From June to August hydromedusae were not found in estuarine collections. In the nearshore waters hydromedusae were observed from March-May. Siphonophores and ctenophores were not very common. Fish eggs and larvae were common at all regions. In the estuaries they were relatively more abundant during November, December and February.

Percentage biomass of carnivores in Zuari showed a wider range (0.1 to 29.2) than that of Mandovi (0.6 to 16.6). Maximum carnivore biomass at both the estuaries was observed in November. In the nearshore waters carnivores formed 2.8 to 26.4% of total zooplankton biomass with highest incidence in April.

In the Mandovi and Zuari estuaries zooplankton production is mainly dependent on the salinity variations with Zuari being more productive than Mandovi. Mean rate of secondary production at both the estuaries in the present study is higher than that reported earlier. When production is estimated based on horizontal surface hauls alone, it may not represent

Table 2—Different Groups of Zooplankton in Zuari and Mandovi Estuaries during 1978
[Values given are percentages of total number]

Group	Jan.	Feb.	March	April	May	June	July	Aug.	Nov.	Dec.
ZUARI ESTUARY										
Phytophages and euryphages										
Polychaetes	—	0.9	0.09	0.02	0.54	0.55	0.4	—	0.42	—
Cladocerans	—	0.8	—	0.2	—	—	—	0.5	33.36	—
Copepods	80.9	31.91	80.4	68.6	86.4	78.74	90.38	83.9	36.56	87.87
Mysids	0.1	—	—	—	—	—	0.2	—	—	—
Isopods	—	—	—	—	—	—	—	0.1	—	—
Cirriped larvae	—	6.8	—	1	0.8	1.66	0.2	—	—	0.54
Amphipods	—	—	—	—	—	—	—	0.1	0.64	0.24
Sergestids	10.3	50.2	12.81	23.91	2.16	9.67	6.21	2	5.48	2.74
Anomuran larvae	—	—	0.04	—	—	0.54	0.01	—	0.02	0.1
Brachyuran larvae	1	0.6	0.52	1.42	0.27	0.01	1.17	1	0.64	—
Other decapods	3	0.6	1.24	3.3	0.38	4.14	0.6	1.1	1.48	2.19
Stomatopod larvae	0.1	0.04	—	—	—	—	—	—	—	0.14
Lamellibranchiates	—	—	0.05	—	—	—	0.2	14	2.44	0.14
<i>Creseis</i>	—	—	—	—	—	—	—	—	0.42	—
Gastropods	—	1.65	1.7	0.66	0.54	—	—	11	0.26	—
Echinoderm larvae	—	—	0.7	—	—	—	—	—	—	—
Copelates	—	—	0.1	0.03	—	—	—	—	0.34	0.81
Doliolids	—	—	—	—	—	—	—	—	0.42	—
Predators										
Hydromedusae	—	0.05	0.04	—	0.01	—	—	—	11.26	0.1
Siphonophores	—	—	0.04	—	—	—	0.02	—	0.81	—
Ctenophores	—	0.1	0.01	—	—	—	—	—	0.2	—
Chaetognaths	4.5	5.2	2	0.66	8.63	4.14	0.57	0.06	4.2	4.28
Fish eggs	0.1	0.75	0.1	0.04	—	—	0.04	0.1	0.42	0.27
Fish larvae	—	0.4	0.15	0.16	0.27	0.55	0.4	—	0.64	0.58
MANDOVI ESTUARY										
Phytophages and euryphages										
Polychaetes	—	0.68	0.33	0.16	—	0.14	.25	—	—	0.14
Cladocerans	—	—	0.25	—	—	—	—	1.02	12.7	—
Copepods	81.75	65.56	57.22	66.34	88.4	74.5	93.64	98.3	61.53	73.93
Mysids	—	—	0.16	0.1	—	—	0.16	—	0.07	—
Isopods	—	—	—	—	—	—	0.04	—	—	—
Cirriped larvae	—	3.9	0.03	1.57	—	—	0.15	—	—	—
Amphipods	—	0.95	—	—	—	0.07	0.08	0.04	0.03	—
Sergestids	2.06	10.57	9.21	14.06	1.47	1.69	2.05	0.3	12.23	1.06
Anomuran larvae	—	—	0.03	—	—	—	—	—	0.1	0.01
Brachyuran larvae	2.06	7.35	1.25	1.66	74	0.31	0.28	0.1	2	6.24
Other decapods	11.42	3.27	3.52	3.83	2.94	0.34	2.77	0.12	1.8	15.45
Stomatopod larvae	—	—	0.03	—	—	—	—	—	—	—
Lamellibranchiates	—	—	—	1.57	—	—	—	—	4	—
Gastropods	1.06	0.18	2.7	2.68	—	2.54	—	—	2.5	—
Brachipod larvae	—	—	0.05	—	—	—	—	—	—	—
Copelates	—	0.14	0.25	—	—	—	—	—	0.02	0.07
Predators										
Hydromedusae	—	0.01	0.05	0.77	—	—	—	—	0.1	0.11
Siphonophores	—	—	—	0.02	—	—	—	—	0.12	—
Ctenophores	—	0.02	0.01	—	—	—	—	—	0.1	—
Chaetognaths	1.67	6.36	24.7	7.1	6.63	1.07	0.04	0.04	2	2.48
Fish eggs	0.07	0.43	0.1	—	—	—	—	0.02	0.3	0.32
Fish larvae	—	0.64	0.11	0.14	—	0.34	0.24	0.06	0.4	0.19

Table 3—Different Groups of Zooplankton in Nearshore Waters of Goa during 1978

[Values given are percentages of total number]

Group	Jan.	Feb.	March	April	May
Phytophages and euryphages					
Polychaetes	—	0.02	0.06	0.37	—
Cladocerans	0.92	0.88	1.9	1.34	0.7
Ostracods	—	—	0.26	—	—
Copepods	95.13	83.67	71.5	88.8	57.61
Amphipods	—	0.03	—	0.01	—
Sergestids	1.71	1.83	12.03	1.37	12.54
Anomuran larvae	—	—	—	—	0.2
Brachyuran larvae	0.71	0.35	1.18	1.24	4.2
Other decapods	0.22	0.42	1.48	0.28	5.01
Stomatopod larvae	—	—	0.08	0.09	0.02
Lamellibranchiates	0.1	—	0.95	0.56	0.37
<i>Crescis</i>	—	—	—	0.02	0.74
Gastropods	—	0.16	0.06	0.35	—
Copelates	—	—	0.28	2.53	0.04
Predators					
Hydromedusae	—	—	0.02	0.19	0.42
Siphonophores	0.14	0.18	—	—	0.1
Ctenophores	—	—	—	0.19	0.07
Chaetognaths	0.57	3.13	10.82	2.53	15.5
Fish eggs	0.5	9.05	0.15	0.1	2.44
Fish larvae	—	0.28	0.03	0.03	0.04

the entire population in the area, particularly when taken during day time. Vertical (as in present study) or oblique hauls can provide better representation of different groups of zooplankton and hence a more reliable rate of production. Secondary production in the Mandovi-Zuari estuarine system is slightly higher than that in Cochin backwaters¹⁰. Primary production in the present area is also relatively more than that of Cochin backwaters¹¹.

In both the estuaries high biomass of predators was often found after a time lag of 2 to 3 months and was usually associated with higher diversity (Table 2). In tropical waters high species and trophic diversity were associated with predominance of predators¹².

The time of present observation in the nearshore waters coincided with *Trichodesmium* phenomenon occurring every year from January to April/May¹³ in this area. During this period a steady increase in secondary production was observed from January-April (Table 1). The mean production is higher than the reported value for coastal waters¹⁴. In the bloom area communities at the initial succession stage will be predominantly herbivores/omnivores which would later develop into a region with high ratio of carnivores⁶. Hence contribution of carnivores increased from January to April (Table 3) coinciding with the bloom period.

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Seasonal Variations in the Microflora from Mangrove Swamps of Goa

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Seasonal variations in bacterial and fungal counts from the water and sediment samples of mangrove ecosystem of Goa show that this ecosystem supports a very high population of fungi and bacteria.

Mangrove is one of the specialized ecosystems of tropical zone^{1,2}. Its foliage is continuously shed into the estuarine environment and gets decomposed in the swamp forming a part of the detrital material³⁻⁵. Microbial flora plays an important role in this process⁶⁻⁸.

This communication deals with seasonal changes in some of the physico-chemical features and microbiological counts in the mangrove swamps of Goa during 1978-79.

Three stations were selected along the Mandovi-Zuari estuaries (Fig. 1). Water and sediment samples were collected in sterile containers and analysed within 6 hr. The samples were serially diluted and plated in duplicate on nutrient agar and saboraaud agar plates, incubated at room temperature for the total counts of heterotrophic bacteria and fungi respectively. The media were prepared in 50:50 distilled water and sea