



# Habitat Heterogeneity and Spatio-Temporal Distribution of Macrobenthos in a Tropical Estuarine Mangrove Ecosystem

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## Abstract

This paper deals with spatio-temporal distribution of macrobenthos and their relationship with physico-chemical environment and sediment properties in estuarine mangrove ecosystem of Chorao, Goa. The complex mangrove habitats provide nutrient and play vital role in the establishment of healthy mangrove fauna. The mangrove of Chorao is inhabited by 14 species of mangrove and associated flora in different substrata. The macrofaunal density in the four study stations varied significantly. Total numerical count was 7960 at C1, 3300 at C2, 6705 at C3 and 7075 at C4. The wet weight biomass was 27.18 at C1, 17.62 at C2, 15.85 at C3 and 24.30 at C4. There was strong seasonality in the occurrence of fauna in the study area. The average macrofaunal taxa was dominated by polychaeta (55%), crustacea (26%) and mollusca (14%). The other groups like nematode, echiurida and nemertenea was insignificant. The epibenthic feeding forms of polychaetes and scavengers/browsers of crustacean were more common in the sandy substratum, while deposit feeders were common in muddy substratum at Chorao mangrove. The result of the present study suggests that mangrove ecosystem with different substrata and physico-chemical parameters supports varied fauna and had different effect on the benthic community.

**Keywords:** Abundance, Distribution, Environmental Parameters, Macrobenthos, Mangroves

## 1. Introduction

The mangrove ecosystem is ideally situated at the inter phase between terrestrial and marine environment. They are predominant habitats in the tropics and subtropics and have been reported to be of immense ecological and socioeconomic significance and hence categorized under ecologically sensitive zone<sup>13</sup>. As a detritus-based ecosystem, leaf litter from the mangroves provides the basis for adjacent aquatic and terrestrial food webs<sup>1</sup>. It also serves as breeding, feeding and nursery grounds for most of the commercially important finfish and shellfishes, on which thousands of coastal people depend for their livelihood (Manson, et al. 2005). India has approximately 2.7% of the world's mangroves, covering an estimated area of 4,827 sq km. Almost 80% of the mangrove forests are located

along the east coast and the remaining 20% are located on the west coast<sup>13</sup>.

Benthic macro fauna are important components of coastal food webs. Many fish species in estuarine ecosystems are strongly dependent taxa available that reside on the sediment surface, such as amphipods, mysids and surface deposit feeders<sup>23,21</sup>). Studies on benthic diversity, population dynamics and species diversity of mangrove ecosystem and their relationship to the environmental conditions are important for understanding the mangrove ecosystem and their sustainable use<sup>25</sup>. The climate change and the anthropogenic processes are bringing sequential changes in the coastal marine environment. The understanding of such changes is essential for resource management<sup>22</sup>. Water quality and benthos characteristics have been investigated in coastal ecosystems around the

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world<sup>26</sup>. The health of benthic communities is related to water quality conditions in fringing communities, such as mangroves. Therefore a study on structure, composition and seasonal distribution of macrobenthic fauna in the intertidal areas of the a tropical mangrove ecosystem at Chorao Island Goa was carried out with reference to environmental characteristics. The result is reported in this communication.

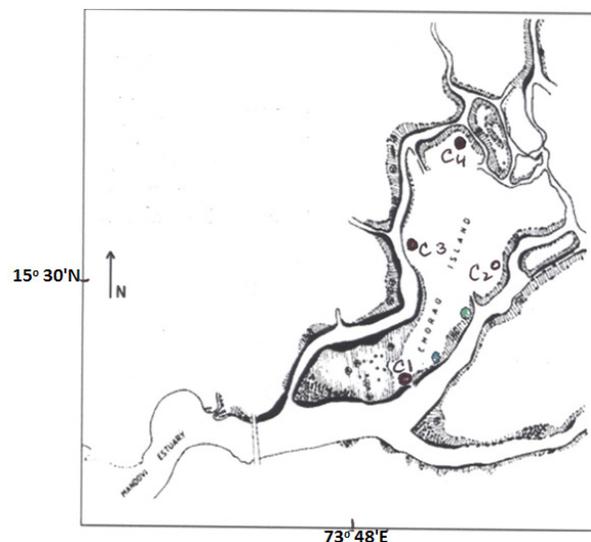
## 2 Materials and Method

### 2.1 Study Area

The Mandovi estuary lies within latitude 15°09' and 15°33' North and longitude 73°45' and 74°14' east in Goa. It is seasonally influenced by semi diurnal tides that flow westwards and empty into the Arabian Sea at Aguada Bay on central west coast of India, carrying the waste from the adjacent agriculture lands and mining industries, in addition to domestic municipal effluents. The present study area of Chorao island (15°32' 50.00"N, 73°52' 45.8"E) falls within Mandovi estuary. The Chorao is the largest among the islands of Goa and had great history behind. The western part of the island (15°30' 53"N, 73°51' 27"E) is covered with thick mangrove forest and is declared a bird sanctuary called Salim Ali Bird sanctuary. The total area of the sanctuary is 178 hectares. There are 14 species of mangrove with low vegetation having zonation of *Rhizophoramucronata*, *Avicenniaofficinalis*, *Bruguiraapiculata* *Sonnertia alba* clearly identifiable within the sanctuary. It provides refuge to wide variety of avifauna<sup>6</sup>. The details of stations are presented in Figure 1. The present study was undertaken in four stations, occupied by dominant mangrove forest. The four sites in the fringe of mangrove varied in microclimatic nitche. The distributions of stations include one each in the following area:

- *Avicennia officinalis* zone – Includes small patch of *A. marina*, *A. alba* growing in the edge of the eastern side (station C1) dominated by the silty sand.
- *Rhizophora mucronata* zone – Includes patches of *R. apiculata* on the western side (station C2) dominated by muddy sediment..
- *Bruguiera apiculata* zone – Forms dense stand with *B. cylindrica* in the central part (station C3) in a sandy muddy sediment.

- *Sonnertia alba* zone - Grows with *S. caseolaris* spreads in the north western side of the sanctuary (station C4) in a sandy silt sediment.



**Figure 1.** Map of Chorao island showing location of study area.

## 3. Sample Collection and Analysis

Sediment in replicate were collected monthly (March 2014-February 2015) using a metal quadrant of 25 cm × 25 cm size up to a depth of 15 cm. The macrofauna was recovered after sieving through a 0.5 mm mesh sieve in the field and the sample was preserved in 5% buffered formalin and brought to the laboratory. Animals were sorted and identified to taxa level. Interstitial water from each station was collected for the dissolved oxygen, salinity temperature and pH. The environmental parameters were analyzed by following the method given in<sup>3</sup>. Sediment texture was determined by the method of<sup>9</sup>. The organic carbon of the sediment was analyzed by wet oxidation method<sup>8</sup>. Fauna were identified to the lowest taxonomic level with the help of literature; The density of benthos was expressed as No./m<sup>2</sup>.

## 4. Results

### 4.1 Physico-Chemical Characteristics

Table 1 shows the environmental parameters in the study area; Total rainfall during June 2014-October 2014 was 2810.9 mm and relatively high rain fall was observed in

**Table 1.** Seasonal variation in average value of environmental parameters at the study stations

Season	Parameters	C1	C2	C3	C4
Pre monsoon	Temperature (°C)	29.8	30.2	29.5	29.7
	Salinity (psu)	31.55	30.24	29.65	30.42
	DO (ml/l)	3.98	3.46	3.02	3.29
	pH	7.6	6.8	7.7	7.4
Monsoon	Temperature (°C)	22.8	25.0	26.0	24.2
	Salinity (psu)	21.14	23.57	20.28	19.66
	DO (ml/l)	5.18	4.36	5.05	4.89
	pH	7.2	8.0	7.4	7.4
Post monsoon	Temperature (°C)	28.4	29.0	28.6	28.2
	Salinity (psu)	28.74	27.15	29.14	26.56
	DO (ml/l)	4.45	4.14	5.22	4.16
	pH	8.2	7.9	7.6	7.4

July-August 2014 which is expected. The temperature of interstitial water ranged from 29.5°C-30.2°C in pre-monsoon 22.8 to 26.0 °C in monsoon and 28.2 to 29.0 °C in post-monsoon season. The highest temperature was in April–May and lowest in the monsoon season. Salinity ranged from 29.65-31.55 psu in pre-monsoon 19.66 to 23.57 in monsoon and 27.15 to 29.14 psu in post-monsoon season. Low salinity in monsoon is the result of precipitation and freshwater runoff; Dissolved oxygen was in the range of 3.02 to 3.98 ml in pre-monsoon, 4.36 to 5.18 ml in monsoon and 4.14 to 5.22 ml in post-monsoon season. Stations 1 and 2 exhibited the highest DO values throughout the study period. Low DO concentrations recorded during the summer season which in part is attributable to higher water temperature. pH ranged from were 6.8-7.7 in pre-monsoon, 7.2 to 8.0 in monsoon and 7.4 to 8.2 in post-monsoon season. The lowest pH was at Station C2 during the monsoon season and the highest was 8.2 at Station 1 during the post monsoon season.

#### 4.2 Mangrove Sediment Characteristics

The percentage sediment percentage is given in Table 2. Mangrove substratum was mainly composed of sand with an admixture of silt and clay in different proportion (percentage). The average sand fraction ranged between 12.5-60.4 % in pre-monsoon, 18.8-69.2 % in monsoon and 16.2-70.5 % in post monsoon. The fraction of silt was in the range of 28.5-45.5 % in pre-monsoon, 21.4–40.3 % in monsoon and 25.3–47.3 % in post monsoon respec-

tively. Similarly, the fine particles of clay mud was in the range of 11.1-58.9 % in pre-monsoon 8.3–46.7 % in monsoon and 4.2-55.3 % in the post-monsoon. The sediment organic carbon was in the range of 19.4 to 34.6 % at C1, 19.8 to 38.6 % at C2, 19.8 to 37.4 % at C3 and 21.9 to 38.2 % at C4 respectively. Changes in sediment composition were mainly due to transport of sediments by tides and currents. The sediment type was silty sand, muddy, silty clay and sandy silt. The average organic carbon in sediment was similar at all stations with seasonal variations. The values were in the range of 19.4 to 34.6 at C1, 19.8 to 38.4 at C2, 19.8 to 37.4 at C3 and 21.9 to 38.2 mg/g at C4, respectively (Table 3).

#### 4.3 Macrofaunal Abundance

The density and abundance of macrofauna is presented in Table 4. The average density (no./m<sup>2</sup>) ranged from 280-1350 at C1, 125-450 at C2, 180-875 at C3 and 225-1025 at C4 respectively. There was a strong seasonal variation in the abundance of macrobenthic fauna. The lowest benthic fauna was observed in the wet monsoon season while the highest was observed in the pre-monsoon season. The summer season is the time of breeding of most of the intertidal fauna in the mangrove environment that is why the highest density was recorded in this period. It is also responsible in the significant variation of density of macrofauna. Station-wise, the maximum density was recorded in the silty sand at C1 and minimum at C2 in muddy sediment. Total wet weight biomass also varied significantly.

The larger heavier organisms were responsible for significant variation in the standing crop of benthos.

**Table 2.** Average value (%) of sediment characteristic of the mangrove of Chorao

Season	Sediment type	C1	C2	C3	C4
Pre-monsoon	Sand	60.4	26.2	12.5	48.3
	Silt	28.5	45.5	29.6	35.2
	Clay	11.1	39.3	58.9	16.2
Monsoon	Sand	69.2	38.2	18.8	59.7
	Silt	22.5	40.3	24.5	21.4
	Clay	8.3	21.5	56.7	18.9
Post-monsoon	Sand	70.5	32.7	16.2	42.5
	Silt	25.3	47.5	28.5	40.3
	Clay	4.2	20.0	55.3	18.2

**Table 3.** Total sediment organic carbon (mg/g) at the study station

Month	C1	C2	C3	C4
March '14	28.5	27.6	22.5	29.2
April	24.7	28.5	19.8	27.6
May	21.8	26.7	21.7	22.8
June	30.3	29.8	28.5	28.6
July	34.6	38.4	34.2	35.2
August	31.5	36.7	37.4	38.2
September	22.9	24.5	30.1	34.2
October	24.5	19.8	24.2	21.9
November	23.6	23.4	21.6	23.2
December '14	19.4	23.8	19.8	26.2
January '15	21.5	22.6	29.2	25.9
February '15	23.5	27.2	26.3	27.5

### 4.4 Faunal Composition

Figure 2 illustrates that there was a preponderance of marine forms in the macroinvertebrate assemblage of the present study. The dominant groups representing the fauna were polychaeta crustacean and mollusca (Figure 2). The polychaetes contribution was in the range of 42 to 56 % and crustaceans contributed from 28 to 42 %. The mollusca contribution was 11 to 15 %. The other group contributed from 5 to 11 %. The polychaetes had the more representation of deposit feeding and predatory forms while the crustacean had the dominance of amphipoda

and isopoda. Decapods were common at most stations and the post larvae of shrimp and crabs were found at all the stations. The mollusca was mainly represented by gastropoda and bivalvia. The other group is represented by Echiurid worms, nemertean worms, nematode and oligochaeta.

**Table 4.** Seasonal abundance in macrofaunal density (no./m<sup>2</sup>) at the study sites of the Chorao mangrove

Month	C1	C2	C3	C4
March '14	775	225	675	480
April	825	350	525	775
May	1350	375	850	1025
June	400	175	500	475
July	325	125	250	275
August	280	100	180	325
September	325	175	325	275
October	400	250	375	425
November	380	425	525	475
December '14	550	400	675	550
January '15	625	450	825	850
February '15	925	375	750	975
Biomass (g/m <sup>2</sup> )	2718	1762	1585	2430

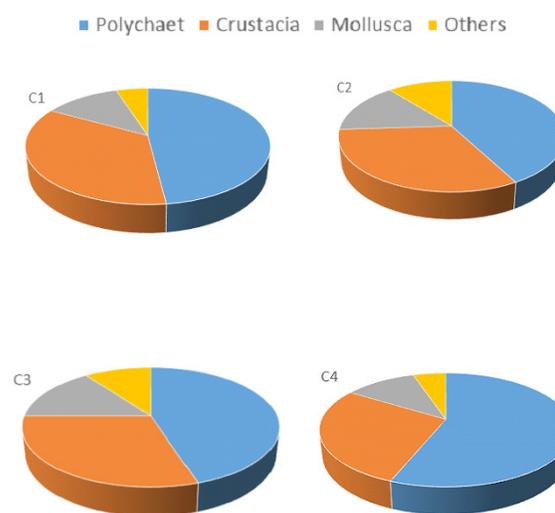


Fig. 2: Percentage composition of major taxa at the study stations.

**Figure 2.** Percentage composition of major taxa at the study stations.

## 5. Discussion

### 5.1 Water Quality Parameters

Mangrove sediments are highly anaerobic rich in sulphide and organic matter<sup>16</sup>. Variations observed in water quality parameters at the study stations can be attributed to hydrographical patterns in climate and biological activity<sup>11</sup>. Generally, water temperature is influenced by the intensity of solar radiation, evaporation, freshwater influx and cooling and mixing up with ebb and flow from adjoining waters of Mandovi estuary<sup>12</sup>. In the present study, summer peaks and monsoonal troughs in water temperatures were similar to those reported by others<sup>11</sup>. Salinity acts as a limiting factor in the distribution of living organisms and its variation caused by dilution and evaporation influences faunal distribution in the intertidal zone<sup>17</sup>. In the present study, salinity at all the four stations was high in summer and low in the monsoon season indicating that variation in salinity at study sites was affected by freshwater runoff entering the creek systems of estuarine mangrove at Chorao. The high organic carbon associated with finer sediment is a common feature observed by others also<sup>12,18</sup>.

Higher pH observed in summer season could be attributed to the removal of CO<sub>2</sub> by the photosynthetic organisms and the lower pH during monsoon season could be due to the dilution of saline water by freshwater inflow<sup>1</sup>. The relatively low DO values observed in the summer are attributable to the prevalence of high saline waters in the mangrove channels from Mandovi estuary as well as fluctuations in temperature and salinity. By contrast sediments with a mixture of organic matter, sand and clay, but low sulphide, seem to support higher abundances of benthic macrofauna. Distribution and ecology of benthic communities in relation to station and season of the present study showed influence of the environmental parameters. This is in support of earlier studies<sup>11,17</sup>.

The mangrove fauna basically derive from adjacent estuarine and marine environment and its stratification depends mainly on tidal inundation by saline water<sup>7</sup>. Limited quantitative information has been published on estuarine mangrove habitats of Goa including macroinvertebrate fauna and their relationship to environmental factors. This study provides a baseline for the distribution, abundance and diversity of benthic macroinvertebrate fauna of Chorao mangroves in Goa. The occurrence of different taxa in the present study is similar to that

observed by others on the east and west coast of India<sup>27,4</sup>. However the macrobenthic density observed in this study (140–1113 no./m<sup>2</sup>) were higher than that reported by<sup>2</sup> in Mandovi-Zuari estuarine system. The densities were comparable to those observed in the other mangrove swamps of India<sup>26</sup>. The high densities recorded in the pre- and post-monsoon season could be due to high temperatures and turbidity coupled with stable environmental conditions<sup>24</sup>. Post-monsoon season (Nov-Feb) peaks in density and higher abundance in pre-monsoon were also reported for the west coast of India<sup>5</sup>. These studies have reported the dominance of polychaetes over mollusks in mangrove fauna due to silty clay and muddy substratum. Soft mangrove substrates favor tube dwellers over diggers and burrowing animals, such as bivalves. The present study corroborates it. The high diversity of polychaete indicates favorable ecological conditions that exist in mangrove ecosystems (Ajmal and Murugesan; 2005).

## 6. Conclusions

This study provides insights into the effects of a range of environmental parameters on macro benthic communities of Chorao mangroves in Goa. Altogether 76 species of benthic macroinvertebrate fauna, belonging to five major groups, were identified at the four sampling stations. Station 1 was dominated by sandy sediment, high salinity, high DO and relatively low sulphide levels. The region displayed the high abundance and standing crop biomass. The temporal distribution of benthic macro invertebrate fauna exhibited the highest density during pre-monsoon season. The decrease of benthos during the monsoon may be attributable to low temperatures and salinities. Considering the importance of flora and fauna of mangrove and constant threat regular monitoring of this ecosystem is required to assess its health.

## 7. Acknowledgement

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