



Distribution of Rhizophoraceae mangroves of intertidal regions of Odisha coast, India

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ABSTRACT

Phytosociological analysis of the Rhizophoraceae mangroves was carried out in Bhitarkanika mangrove division, Odisha to describe the forest composition and structure, and to assess the distribution of these species. Ten transect plots of 10 m x 100 m with a total area of one hectare were established perpendicular to the coast line in five different mangrove blocks of the study site. A total of 8 species of trees and saplings were recorded. Three community types were recognized namely *Rhizophora apiculata* - *R. mucronata*, *Bruguiera-Kandelia candel* and *Ceriops* reflecting the zonation in this forest. The maximum number of trees was 6780/ha found in Kadua block. *R. apiculata* was most successful in distribution with 6440 saplings and trees/ha followed by *R. mucronata* (3600/ha). Trees of both the *Rhizophora* species were mostly growing under Low Tide Lines (LTL) while the *Bruguiera* and *Ceriops* species occurred around the High Tide Lines (HTL). The IVI values of *R. apiculata* indicates maximum in Mahanadi deltaic region whereas *R. mucronata* exhibits maximum in core areas of Bhitarkanika. The present study also reveals the fact that *Bruguiera gymnorrhiza* is well-adapted in the varying salinities between LTL and HTL.

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1. Introduction

Mangroves are typically tropical and subtropical coastal vegetations found in inter-tidal zones of river deltas and backwater areas. Mangrove has been defined as "any woody, tropical facultative halophyte that is an obligate inhabitant of 'mangal' (wetland community) (Tomlinson, 1986; Krauss and Ball, 2012). They form a dynamic ecosystem, which flourishes only in the region where there is influx of both fresh and tidal water. Mangrove forests dominate one-quarter of the world's tropical coastline. Mangroves have been defined by Hamilton and Snedaker (1984) as salt tolerant ecosystems of the intertidal regions along coastlines. The total area of Indian mangroves is estimated to be 4827 km² distributed along the coastal States/Union Territories, which account for about 5% percent of the World's mangrove vegetation and 0.4 percent of the geographical area. Mangroves forests are widely distributed throughout the

tropics where they grow abundantly along the coasts (Choong *et al.*, 1990). Mangroves are fast disappearing at a time when there are clear indications of potential changes in climate, sea level and the levels of UV-B radiation. Indiscriminate exploitation of mangrove resources without any land use plan has degraded mangrove ecosystems in India. India has lost 40 percent of its mangrove area cover during the last 100 years (Anonymous, 1987).

The state of Odisha has an area of 195 km² under Mangrove forests, which comes to 0.125 % of geographical area and 0.414 % of actual forest cover (Daniels and Acharjyo, 1997). Worldwide concern to conserve mangroves necessitated propagation of mangroves to re-establish them on barren and swampy land along tidal creeks around degraded salt-marshy wetlands of Mahanadi delta where mixed stands of Rhizophoraceae mangroves depending on the intensity and the frequency of tidal inundation at the experimental site. The present paper highlights ecological structures of mangroves ecosystem of Odisha coast with a

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special reference to Rhizophoraceae family based on phytosociological studies.

2. Materials and methods

2.1 The study site

The study site is located at 20° 4' - 20° 8' N Latitude and 86° 45' - 87° 5' E Longitude in Bhitarkanika sanctuary (19° N - 22° N and longitude 85° E - 87° E) and reserve forest of Mahanadi delta area in the north-eastern coastal plain of Kendrapara district. This area receives water from three rivers, known to be rich in species diversity and trees are dense and tall like those of Sunderbans (Selvam, 2003). Four forest blocks in the Bhitarkanika wildlife sanctuary were selected for carrying out vegetation survey. The area of Bhitarkanika forest block is 1712 ha, Dangmal 636 ha, Kakranasi 310 ha, and Thakurdia 272 ha (Chadha and Kar, 1999). Bhitarkanika and Dangmal blocks constitute the core area. These sites experience tide of semi diurnal type. The mean sea level in the region is about 1.66 m. The Bhitarkanika sanctuary is bounded by river Dhamra in the north, the river Hansua to the west and Bay of Bengal on the eastern and southern sides. The sanctuary encompasses 35 km sea coast known as 'Gahirmatha Coast' from Dhamra mouth to Barunei, the mouth of river Hansua. The area has about 200 km of water body inside the sanctuary and falls in the deltaic region of the river Brahmani, Baitarani, and their distributaries. The estuarine rivers- Brahmani, Baitarani, Kharasrota, Dhamra, Pathasala, Maipura, Hansua and Hansina during their course flow into the Bay of Bengal are further criss crossed by numerous creeks, channels, and nallahs, thus providing the peculiar ecological niche for the growth, development of rich and varied mangrove life forms, both flora and fauna along with their associates. There are many villages within the sanctuary as well as surrounding it. The population in these villages has been growing very fast. Part of the population rise is because of the heavy influx of refugees from East and West Bengal and habitations are reported to have been started by clearing mangrove forests. A total of 81 villages are adjacent to the mangrove forests.

2.2 Collection and preparation of herbarium specimen

Plants were collected from the study sites at regular intervals and detailed field notes were recorded on the spot which included field number, date of collection, locality, habit, habitat, associated species. The specimens were identified with the help of regional flora viz., the flora of Orissa (Saxena and Brahmam, 1994-96), the botany of Bihar and Orissa (Haines, 1921-25) and its supplement (Mooney, 1950) and different monographs and revisionary works. After collection, the specimens were carefully pruned to convenient

size and poisoned in formaldehyde to prevent defoliation. Care was taken to arrange them properly so that all parts are well displayed. The collected species were pressed in the blotters and to avoid infection, the blotters were frequently changed. The specimens were sprinkled with naphthalene powder and when fully dried these were poisoned with 4% solution of HgCl₂ in dehydrated alcohol and kept under pressure for about a week. After these processes, the specimens were mounted on to the herbarium sheets (42 × 28 cm) by the application of animal glue. For better adhesion, the mounted materials were again kept under pressure for two days. Then field data were transferred to the herbarium labels from the field note book after which the mount boards were kept as herbarium specimen following standard methods (Lawrence, 1951; Jain and Rao, 1977).

2.3 Phytosociological analysis

Phytosociological studies were carried out during 2010-2011 by laying random quadrats (10 × 10 m²). Ten transect plots of 10 × 100 m² (1 ha) were taken perpendicular to the coast line. Each transect was divided into 10-12 subplots of 10 × 10 m² from Low Tide Line (LTL) towards High Tide Line (HTL). The total study area was divided into five blocks, viz., Kadua, Kansaridia and Kharnasi forest blocks of Mahanadi deltaic area and Bhitarkanika and Khola forest blocks of National Park region. Every tree (DBH >10cm) and sapling (DBH 2-10 cm) present within each plot was counted. The diameter of trees and saplings was also measured. The canopy of each tree was mapped to construct the forest profile. Phytosociological analysis in five study sites was carried out by following Mishra (1968), Kershaw (1973), Cintron and Novelli (1984) and Snedaker and Snedaker (1984). The structural parameters viz., abundance, density, frequency, basal area, relative parameters and IVI were calculated from the data obtained from quadrats.

3. Results and discussion

3.1 Phytosociological analysis

The Kansaridia forest block contain highest number of tree species followed by Bhitarkanika, Kadua, Khola and Kharnasi blocks. Bhitarkanika is a part of core area of the Bhitarkanika wildlife sanctuary. Among the five forest blocks studied in the coastal stretches of Odisha, Kansaridia protected forest block of the Mahanadi deltaic region exhibit maximum diversity and abundance of Rhizophoraceae mangroves (Table 1). Availability of fresh water through Bhitarkanika (Maipura river) and Brahmani rivers and saline water from sea in core area helped wide range of niches for different species to occur and, thus, species diversity is the highest. Structural analysis of vegetation of different study sites showed that *R. apiculata* and *R. mucronata* exhibited

greater density, frequency and IVI values across all sites (Table 1). The species with lower density and IVI were found different from one site to the other. All the species showed contagious distribution. Odum (1971) has mentioned that contagious distribution is commonest in nature, random distribution is found only in very uniform environment and regular distribution occurs where severe competition exists between individuals. A/F ratio range in Kharnasi block was proportionately less wide compared to other blocks.

3.2 Community distribution along tidal lines

Eight species were recorded within the ten sampling plots in five different forest blocks. These consisted of 8 tree species (Fig. 1) and two shrubs. It can be seen that 2

Rhizophoraceae species (25 %) of the genus *Rhizophora* are true mangrove species, and these represent 49.8% of the true mangrove species found in Odisha Coast (Upadhyay and Mishra, 2008). Cluster analysis using a Bray-Curtis dissimilarity measure and group average sorting strategy showed three groups in the sample plots, reflecting the zonation within the mangrove forest (Clifford and Stephenson, 1975). The three zones, extending from the seaward to the landward side were characterized by the following three community types (Fig. 2): 1. *Rhizophora apiculata*-*Rhizophora mucronata* community, 2. *Bruguiera*-*Kandelia candel* community and, 3. *Ceriops* community.

The *Rhizophora apiculata*-*Rhizophora mucronata* community occupied the seaward fringe and had a width of



Fig. 1. Distribution of Rhizophoraceae family mangroves in Bhitarkanika and Mahanadi delta Mangrove Division. a. creek showing Rhizophoraceae plants along the bank; b. *Rhizophora apiculata*; c. *Rhizophora mucronata*; d. *Bruguiera gymnorhiza*; e. *Bruguiera cylindrica*; f. *Bruguiera parviflora*; g. *Ceriops tagal*; h. *Ceriops decandra*; i. *Kandelia candel*.

Table 1
Phytosociological parameters of Rhizophoraceae mangroves.

Sl. No.	Species	Dn (%)	F (%)	A (%)	A/F	RD (/1000)	RF	RDn	IVI
Kadua block									
1	<i>Rhizophora apiculata</i> Bl.	15.70	90.00	17.44	0.19	870	25.71	0.23	26.82
2	<i>Rhizophora mucronata</i> Lam.	3.60	50.00	7.20	0.14	128	14.29	0.05	14.47
3	<i>Brugiera gymnorrhiza</i> L.	5.10	50.00	10.20	0.20	0.58	14.29	0.08	14.36
4	<i>Brugiera paviflora</i> Roxb.	0.70	30.00	2.33	0.08	0.03	8.57	0.01	8.58
5	<i>Brugiera cylindrica</i> Bl.	15.40	60.00	25.67	0.43	0.62	17.14	0.23	17.37
6	<i>Ceriops decandra</i> Griff.	26.60	70.00	38.00	0.54	0.41	20	0.40	20.40
7	<i>Ceriops tagal</i> Perr.	1.60	40.00	4.00	0.10	0.02	11.43	0.02	11.45
8	<i>Kandelia candel</i> L.	-	-	-	-	-	-	-	-
Kansaridia block									
1	<i>Rhizophora apiculata</i> Bl.	17.5	60	29.17	0.49	830	20.69	0.32	21.84
2	<i>Rhizophora mucronata</i> Lam.	4.95	45	11.40	0.27	168	15.52	0.09	15.78
3	<i>Brugiera gymnorrhiza</i> L.	4.5	20	22.50	1.13	0.8	6.90	0.10	7.00
4	<i>Brugiera paviflora</i> Roxb.	2.1	25	7.75	0.30	0.1	8.62	0.04	8.67
5	<i>Brugiera cylindrica</i> Bl.	9.1	55	15.92	0.28	0.5	18.97	0.19	19.16
6	<i>Ceriops decandra</i> Griff.	12.2	65	19.19	0.30	0.2	22.41	0.23	22.65
7	<i>Ceriops tagal</i> Perr.	4.45	60	7.53	0.13	0.1	20.69	0.09	20.78
8	<i>Kandelia candel</i> L.	7.5	60	12.50	0.21	0.4	20.69	0.13	20.82
Kharnasi block									
1	<i>Rhizophora apiculata</i> Bl.	-	-	-	-	-	-	-	-
2	<i>Rhizophora mucronata</i> Lam.	-	-	-	-	-	-	-	-
3	<i>Brugiera gymnorrhiza</i> L.	3.1	40	7.75	0.19	210	33.33	0.16	33.70
4	<i>Brugiera paviflora</i> Roxb.	-	-	-	-	-	-	-	-
5	<i>Brugiera cylindrica</i> Bl.	0.3	20	1.50	0.08	40	12.50	0.02	12.55
6	<i>Ceriops decandra</i> Griff.	8.5	60	10.90	0.23	370	39.58	0.50	40.45
7	<i>Ceriops tagal</i> Perr.	1.9	40	4.67	0.15	50	27.08	0.11	27.24
8	<i>Kandelia candel</i> L.	8	50	13.71	0.24	510	37.50	0.42	38.43
Bhitarkanika block									
1	<i>Rhizophora apiculata</i> Bl.	19.3	60	32.17	0.54	662	20.69	0.33	21.68
2	<i>Rhizophora mucronata</i> Lam.	28.5	100	28.50	0.29	626	34.48	0.48	35.59
3	<i>Brugiera gymnorrhiza</i> L.	4.2	70	6.00	0.09	0.29	24.14	0.07	24.21
4	<i>Brugiera paviflora</i> Roxb.	2	50	4.00	0.08	0.06	17.24	0.03	17.28
5	<i>Brugiera cylindrica</i> Bl.	4.7	60	7.83	0.13	0.12	20.69	0.08	20.77
6	<i>Ceriops decandra</i> Griff.	2.8	50	5.60	0.11	0.03	17.24	0.05	17.29
7	<i>Ceriops tagal</i> Perr.	1.1	40	2.75	0.07	0.01	13.79	0.02	13.81
8	<i>Kandelia candel</i> L.	2.9	50	5.8	0.12	0.16	17.24	0.05	17.29

Sl. No.	Species	Dn (%)	F (%)	A (%)	A/F	RD (/1000)	RF	RDn	IVI
Khola block									
1	<i>Rhizophora apiculata</i> Bl.	4.1	50	8.20	0.16	141	17.24	0.07	17.45
2	<i>Rhizophora mucronata</i> Lam.	9.9	60	16.50	0.28	217	20.69	0.17	21.07
3	<i>Brugiera gymnorrhiza</i> L.	2.4	40	6.00	0.15	0.17	13.79	0.04	13.83
4	<i>Brugiera paviflora</i> Roxb.	1.5	50	3.00	0.06	0.04	17.24	0.03	17.27
5	<i>Brugiera cylindrica</i> Bl.	8.2	80	10.25	0.13	0.20	27.59	0.14	27.73
6	<i>Ceriops decandra</i> Griff.	2.8	50	5.60	0.11	0.03	17.24	0.05	17.29
7	<i>Ceriops tagal</i> Perr.	-	-	-	-	-	-	-	-
8	<i>Kandelia candel</i> L.	2.6	60	4.33	0.07	0.14	20.69	0.04	20.73

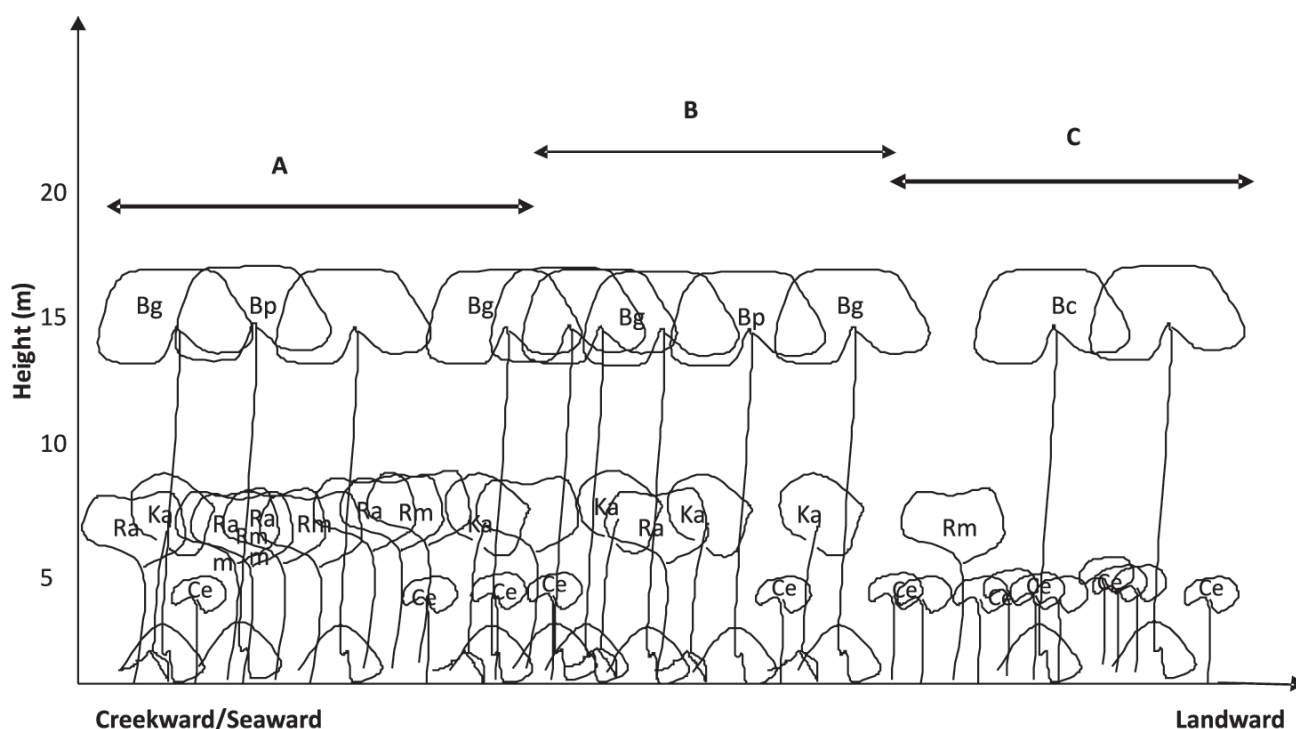


Fig. 2. Profile diagram of Rhizophoraceae mangroves, showing the community changes from beach toward inland. (A) *Rhizophora apiculata*-*R. mucronata* community, (B) *Bruguiera*-*Kandelia* community and (C) *C. decandra* community. Abbreviations in canopy: Ra = *Rhizophora apiculata*; Rm = *Rhizophora mucronata*; Bp = *Bruguiera parviflora*; Bg = *Bruguiera gymnorrhiza*; Bc = *Bruguiera cylindrica*; Ka = *Kandelia candel*; Ce = *Ceriops decandra/tagal*.

40 m. The substrate of the region consisted of sandy mud with a pH of 5.6 ± 0.2 and electrical conductivity 9.8 ± 0.5 mS/cm along the LTLs. The community was dominated by pure stands (80%) of *Rhizophora apiculata* and *R. mucronata*. The other species occurring in the community were *Bruguiera gymnorrhiza* and *Kandelia candel* (Fig. 2). This community is still young, with a homogenous structure with respect to plant distribution. The density and the basal area were very high in comparison to other communities.

Trees were generally small with an average diameter of 27 cm. Trees of 6 m height formed one layer A (Fig. 2). Saplings were also dense and composed mostly of *Rhizophora apiculata* (31.3%) and *Rhizophora mucronata* (24.2 %).

Bruguiera-*Kandelia candel* community occurred behind the *Rhizophora apiculata*-*Rhizophora mucronata* community. It comprised a community with a more heterogenous floristic composition in B region (Fig. 2), in which 6 species of trees were recorded. The two dominant

species were *Bruguiera gymnorrhiza* and *Bruguiera cylindrica* with optimal importance values (IVI) of 33.70 and 20.77 respectively. The density of this community was slightly lower than that of the *Rhizophora* community. The basal area, however, was half of the *Rhizophora* community. Trees in this community were bigger, with an average diameter of 32 cm. The big trees were mostly *Kandelia candel* and *Bruguiera gymnorrhiza* with average diameters of 54 cm and 31 cm respectively (Table 1). The largest tree was *Kandelia candel* with a diameter of 78 cm. It also showed

Table 2

Average DBH of different species of Rhizophoraceae mangroves.

Sl. No.	Name	DBH (cm)
1	<i>Rhizophora apiculata</i> Bl.	26.52 ± 1.12
2	<i>Rhizophora mucronata</i> Lam.	27.33 ± 2.11
3	<i>Brugiera gymnorrhiza</i> L.	31.00 ± 1.58
4	<i>Brugiera paviflora</i> Roxb.	21.35 ± 1.47
5	<i>Brugiera cylindrica</i> Bl.	29.19 ± 1.12
6	<i>Ceriops decandra</i> Griff.	17.11 ± 0.98
7	<i>Ceriops tagal</i> Perr.	14.28 ± 0.84
8	<i>Kandelia candel</i> L.	54.00 ± 2.87

the highest DBH at the study sites (Table 2).

Ceriops community developed on better drained and firm soils. The soil pH was low i.e., 4.3 ± 0.6 and electrical conductivity 6.23 ± 0.51 mS/cm along HTLs. *Ceriops decandra* was the most dominant species with the highest IVI of 40.45 (Table 1). Its density was 70.2% of the total density and the basal area was 78.6 % of the total basal area within this community. This indicated the dominance of the species in the community becoming the determining species of the habitat. At least two canopy layers were recognized in C region (Fig. 2). The top layer was dominated by *Bruguiera gymnorrhiza* which reached a height of 16 m. The second layer consisted of *Ceriops decandra* and *Ceriops tagal* of height around 3 m. Such distribution is favourable for optimum utilization of the light intensity thus making the forest highly productive in comparison to the homogeneous community with single layered canopy structure.

4. Conclusion

The Rhizophoraceae mangroves of Mahanadi delta and Bhitarkanika, Odisha contained a good number of species which showed good survival and regenerative ability. *Bruguiera gymnorrhiza* L. plants exhibits better adaptability

to varying levels of salinities along the tide lines whereas *Rhizophora apiculata* Bl. and *Rhizophora mucronata* L. resemble higher tolerance to salinity as its ecological occurrences. The functional importance of this mangrove forest to the coastal environment should be recognized and efforts should be made to conserve this remnant forest.

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