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RESEARCH ARTICLE

# STUDY OF FLORAL COMPOSITION AND VEGETATIVE CHARACTERISTICS OF *Porteresia* BED ALONG THE UPSTREAM MATLA ESTUARINE BELT, INDIAN SUNDARBANS

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**ABSTRACT**

Anthropogenic disturbances pose serious threat to mangrove forest in Indian Sundarbans leading to shrinking pressure on halophytic floristic composition in this geographical locale. A vegetation study, during post-monsoon, along the upstream Matla estuarine belt belonging to central sector of Indian Sundarbans revealed a poor combination of four true mangrove species *Acanthus ilicifolius* L., *Avicennia officinalis* L., *Sonneratia apetala* Buch. Ham. and *Exoecaria agallocha* L. along with two mangrove associates *Porteresia coarctata* (Roxb.) Tateoka and *Suaeda maritima* Dumort. The lower inter-tidal region was found to be dominated by *Avicennia officinalis* and *Exoecaria agallocha* community which was sequentially replaced by *Sonneratia apetala*, *Acanthus ilicifolius*, *Porteresia coarctata* and *Suaeda maritima* towards the supralittoral zone. *Porteresia coarctata*, locally known as dhani ghas, appeared to be the pioneer species of mangrove mudflat in the study zone. During 1998 – 2019 study period, mean surface water salinity in the selected station was highest (25.88 ‰ ± 1.20) during pre-monsoon and lowest (9.96 ‰ ± 0.34) in monsoon months. Quadrate-wise measurements of different vegetative parameters of *P. coarctata* revealed that total plant height (combination of root and shoot height) was in the range of 13.34 cm – 42.43 cm (30.69 cm ± 8.48). Leaf length varied in the range between 11.03 cm and 26.5 cm. Average number of leaves was in the range of 6 – 12 per plant. Although root length and shoot length appeared to be positively correlated ($r = 0.63$; significant at 5% level), shoot or stem length did not appear to influence number of leaves to a significant extent ($r = 0.34$). The present ecological study demands for stringent monitoring along the entire stretch of the selected study area of Indian Sundarban to assess the role of anthropogenic stress on halophytic species composition and their ecological health.



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## INTRODUCTION

Mangrove forest or 'mangal' is a general term used to describe a variety of tropical inshore communities by several species of trees or shrubs that grow in saltwater (Nybakken, 1997). Located along the banks of estuaries, mud-flats and in the transition zone of terrestrial-marine ecosystems mangroves create luxuriant or sparse network of halophyte vegetation which are of utmost significance in terms of their varied socio-ecological services. They have developed an adaptive ability to live in waterlogged saline soils subjected to regular tidal flooding and can thrive in a complex sensitive environment having fluctuating eco-biological parameters where normal flora can't exist due to the former's highly specialized morphological and physiological adaptations (Kathiresan and Bingham, 2001; Hogarth, 2015).

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Mangroves are categorically classified as true mangrove and mangrove-associate species. The true or exclusive mangroves occur only in mangrove habitat or rarely elsewhere and the mangrove associates or non-exclusive mangrove species comprise a large number of species typically occurring along the landward margin of the inter-tidal wetland and often on non-mangrove habitats such as rainforest, salt marsh, peat swamp or low land fresh water swamps (Hogarth, 2015; Santisuk, 1983; Giesen *et al*., 2007). True or exclusive mangroves exhibit the special morphological and physiological characteristics like breathing roots or pneumatophores, viviparous or crypto-viviparous embryo development, tidal dispersal of propagules, absence of understory and growth rings, highly efficient mechanism for nutrient retention and salt tolerance (Alongi, 2009). Although, a total of 24 true mangrove and 10 mangrove-associate species were recorded from different stations of Indian Sundarbans, periodical area specific monitoring on mangrove species diversity is essential and therefore necessitates the urgency to revisit the mangrove belts frequently to ascertain various environmental and anthropogenic factors putting constant shrinking pressure on mangrove diversity (Barik and Chowdhury, 2014). The present field-survey is an attempt to properly assess the mangrove vegetation and thereby understand the floral composition along the upstream stretch of River Matla, now undisturbed from ferry services in the study-zone, in the vicinity of Canning Township, West Bengal (India) which falls in the central sector of Indian Sundarbans.

**Description of the Study Area:** Field-work for present study was carried out at Canning (22°18′41.9″ North Latitude & 88°40′34.8″ East Longitude) which is administratively and geographically positioned in South 24 Parganas district of West Bengal, India along the south bank of Matla riverine belt that falls in the central sector of Indian Sundarbans. With a total area of 10.20 $km^2$, the station has an important fish landing station. The climate of the study zone is maritime-tropical and categorically divided into four weather-periods *viz.* pre-monsoon (February/ March to May/ June), monsoon (June/ July to September), post-monsoon (October to November) and dry period or winter (December to January). Average diurnal temperature gradually increases from January and achieves the peak value in May/ June. The area experiences three different phases of mean temperature which increases from February through May and thereafter gradually decreases till October and then sharply falls in January due to chill-factor caused by flow of northwesterly wind from Himalayas. The rainfall pattern in Sundarbans differs from the overall pattern of rainfall over the entire district of South 24 Parganas because of the former's close proximity to Bay of Bengal. During a 2011 – 2012 study, a maximum of 839.8 mm and a minimum of 0.2 mm amount of rainfall were recorded in August (monsoon) and November (post-monsoon) respectively. In the same study, the amount of rainfall recorded during monsoon period was 1597.6 mm (Pitchaikani *et al.,* 2017). Annual variation of relative humidity, a vital weather parameter that reflects air's moisture content, ranges between 16 % and 99 %.

## MATERIALS AND METHODS

Halophytic floral vegetation of the selected station was thoroughly assessed to pin-point the actual composition of different true-mangrove and mangrove-associate species. Field-work was carried out along the north-western bank of Matla riverine system during December, 2019 and January, 2020 which belong to winter period of the study area. The mangrove mud-flat receives high tide water twice a day as the area experiences semi-diurnal nature of tide. *Porteresia coarctata* vegetation in the supra-littoral zone of the mangrove mud-flat in the selected station was chosen for quadrate study. A line transect was laid towards landward margin from the high-tide level of the mud-flat. Along the line transect, three plots, each being 400 $m^2$ (20 m x 20 m) in area were selected. Five quadrants, each of 1 m x 1 m area, were randomly laid in each plot with total fifteen quadrants covering three plots. Quadrants have been serially numbered as Q-1 to Q-15 (Quadrate 1 to Quadrate 15). Three individual plant species of *P. coarctata* were randomly sampled from three points in each quadrate with all vegetative parts as accurately as possible. Collected samples were washed properly to remove adhered non-plant materials. Three randomly sampled individual species per quadrate, i.e., Q-1 to Q-15, were tagged as P-1, P-2, P-3 (Plant 1, Plant 2, Plant 3) and this similar trend was followed in serial order till the last quadrate, Q-15, where individuals have been tagged as P-43, P-44 and P-45 respectively. During the entire study period, every possible step was taken to cause minimum harm to the marsh vegetation. Measurements of different vegetative parts of each plant body like shoot and root length, leaf length and breadth, number of leaves per shoot were accurately recorded in the field in order to avoid any distortion in the real data. Values presented in Table 2 and Figure 2 are average of triplicate observations (3 individuals) per quadrate for each vegetative part of the plant body. Surface water samples were collected in cleaned bottles during high tide from the present station in pre-monsoon, monsoon and post-monsoon months of the period 2015 - 2019 and salinity was measured using a salinity refractometer on the spot and all the values were cross-checked in the laboratory following the method as outlined in Strickland and Parsons, 1972. These values along with data from previous workers have been presented in Figure 1.

## RESULTS AND DISCUSSION

In the study zone which falls along the upstream region of Matla estuarine system, a moderately healthy halophytic floral composition having moderate to dense vegetation of four true mangrove species – 1) *Acanthus ilicifolius* L., 2) *Avicennia officinalis* L., 3) *Sonneratia apetala* Buch. Ham. and 4) *Exoecaria agallocha* L. along with thick to sparse network of two mangrove associate species – 1) *Porteresia coarctata* (Roxb.) Tateoka and 2) *Suaeda maritima* Dumort. Were observed (Table 1). Measurements of different vegetative characteristics of *Porteresia coarctata*, recorded in Table 2, revealed that the marsh vegetation of *P. coarctata* in the present study zone possesses an average shoot length in the range of 9.67 cm (Quadrate 04) to 31.83 cm (Quadrate 09) whereas the average root length varied between 3.67 cm (Quadrate 04) and 10.17 cm (Quadrate 13). Total plant height was found in the range of 13.34 cm (Quadrate 04) to 42.43 cm (Quadrate 09). The average number of leaves per shoot was maximum with 12 leaves in Quadrate 9 and minimum with 6 leaves in Quadrate 2. Range of maximum leaf length was 16.23 cm to 26.5 cm in Quadrate 11 whereas a minimum leaf length in the range of 11.03 cm to 22 cm was recorded in Quadrate 5. No major variation was observed in leaf breadth and in all quadrates, average leaf breadth varied between 0.3 cm and 0.4 cm. Mangrove ecosystem in Sundarbans is constantly changing across temporal and spatial scales due to different natural and anthropogenic forces. Increasing water salinity and immersed land-blocks along the coastal belt as a result of severe climatic events, like tropical cyclone Aila, (2004), Bulbul (2019), Amphan (2020) are set to adversely impact the sensitive ecosystem of the Royal Bengal tiger dominated Sundarban mangrove forest. A combination of freshwater availability and water salinity along with other abiotic environmental parameters like nutrient availability, aquatic pH and temperature, annual fluctuation in air temperature and its moisture content, precipitation etc. have a measurable effect on floral diversity of mangroves in Sundarbans. The mudflat of Canning (study zone) belongs to an elongated tidal point bar of the Matla River. During the late medieval period, the lower Gangetic basin had started shifting from the west to east that resulted in severance of connections of many local rivers with the Ganga and as a result rivers like Matla became mere brackish waters as they had neither any link with the mighty Padma and instead of sweet waters from the Ganga they became subjected to inflow of saline waters from Bay of Bengal (Mukherjee, 2017).

**Table 1. Salt-tolerant floristic composition of the study area**

| Floral Category | Sl. No. | Binomial name | Family | Local name | Distribution (as observed) |
|---|---|---|---|---|---|
| True-mangrove | 1 | *Acanthus ilicifolius* L. | Acanthaceae | Horkonch kanta/ Hargoza | Sparse vegetation |
| | 2 | *Sonneratia apetala* Buch. Ham. | Sonneratiaceae | Keora | Moderate vegetation |
| | 3 | *Exoecaria agallocha* L. | Euphorbiaceae | Gewa/ Goan | Moderate vegetation |
| | 4 | *Avicennia officinalis* L. | Avicenniaceae | Bani | Moderate to dense vegetation |
| Mangrove-associate | 1 | *Porteresia coarctata* (Roxb.) Tateoka | Poaceae | Dhani ghas, Harkanta | Dense vegetation |
| | 2 | *Suaeda maritima* Dumort. | Chenopodiaceae | Gire shak | Sparse vegetation |

**Table 2. Quadrate-wise measurements of vegetative parameters of *P. coarctata***

| Quadrate Number | Stem Length (cm) | Root Length (cm) | Number of Leaves | Minimum Leaf Length (cm) | Maximum Leaf Length (cm) |
|---|---|---|---|---|---|
| **1** | 27.67 (2.32) | 8.67 (1.65) | 9 (1.69) | 15.33 (1.02) | 24.33 (1.84) |
| **2** | 25.83 (2.09) | 8.5 (1.08) | 6 (1.24) | 15.83 (2.01) | 22.33 (0.84) |
| **3** | 16.27 (3.39) | 8.57 (0.61) | 7 (1.24) | 13.17 (1.02) | 26.27 (1.63) |
| **4** | 9.67 (2.25) | 3.67 (1.64) | 9 (2.05) | 15.0 (1.22) | 21.57 (1.24) |
| **5** | 18.23 (2.91) | 7.77 (0.91) | 10 (1.24) | 11.03 (2.34) | 22.0 (1.77) |
| **6** | 29.07 (2.07) | 8.0 (1.22) | 11 (1.88) | 22.27 (1.93) | 23.43 (2.57) |
| **7** | 17.83 (1.43) | 8.5 (1.08) | 9 (0.94) | 13.03 (1.73) | 24.07 (2.18) |
| **8** | 11.67 (1.65) | 4.33 (1.88) | 9 (2.05) | 14.13 (2.81) | 23.93 (1.49) |
| **9** | 31.83 (2.72) | 10.6 (0.94) | 12 (0.94) | 13.33 (2.32) | 21.5 (1.47) |
| **10** | 28.77 (2.98) | 7.83 (1.02) | 10 (2.49) | 15.67 (2.96) | 22.77 (0.91) |
| **11** | 17.0 (2.45) | 7.73 (1.02) | 7 (1.63) | 16.23 (2.02) | 26.5 (0.70) |
| **12** | 20.0 (2.48) | 7.67 (2.49) | 10 (2.62) | 11.3 (2.49) | 23.77 (1.40) |
| **13** | 30.67 (3.39) | 10.17 (0.62) | 12 (1.88) | 14.06 (1.78) | 25.7 (1.68) |
| **14** | 27.27 (3.18) | 8.17 (1.43) | 10 (1.24) | 11.83 (2.09) | 23.53 (1.83) |
| **15** | 28.83 (3.17) | 9.5 (0.71) | 9 (2.82) | 14.73 (1.67) | 26.43 (0.98) |

N.B. Each value presented in table is mean of three morphological observations, i.e., three individual species per quadrate; figures within parenthesis indicates +/- standard deviation.

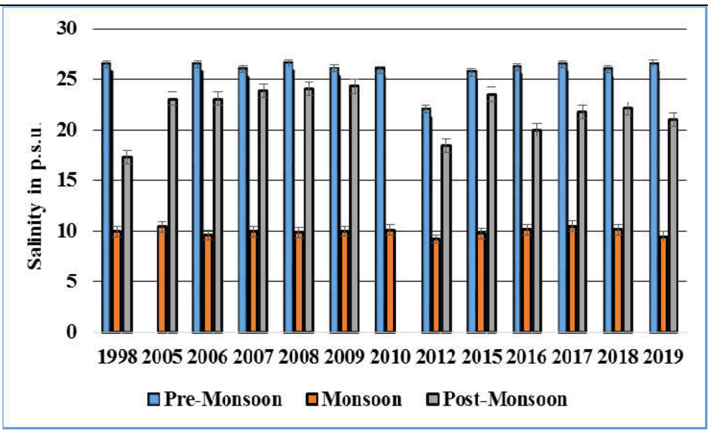


**Figure 1. Variations of surface water salinity (in p.s.u.) from 20 years periodic study (1998 – 2019) during three major seasons at Canning; present study station (based on data from Sarkar *et al.* [2002], Ghosh and Banerjee [2013] and study by present author)**

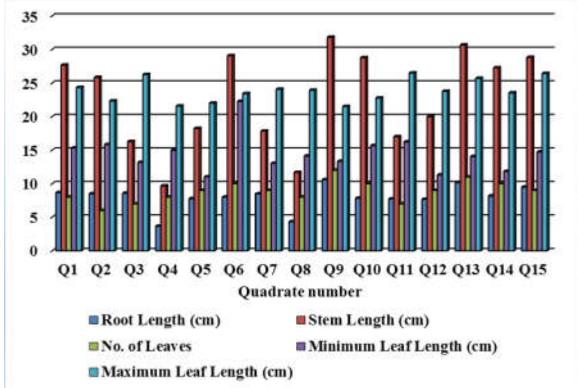


**Figure 2. Quadrate-wise variation of vegetative parameters of *P. coarctata***

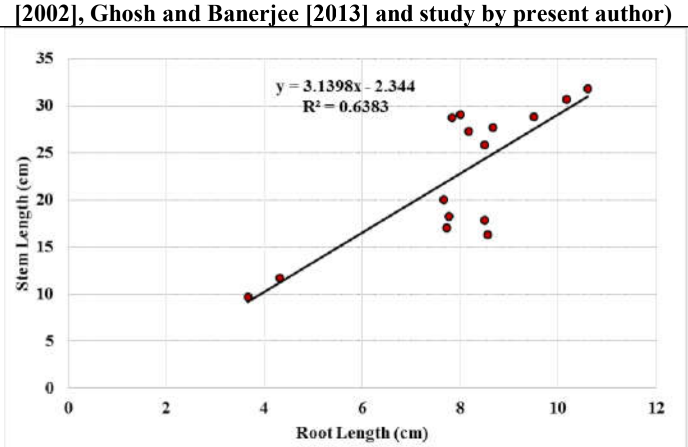


**Figure 3. Linear relation - root length x stem length**

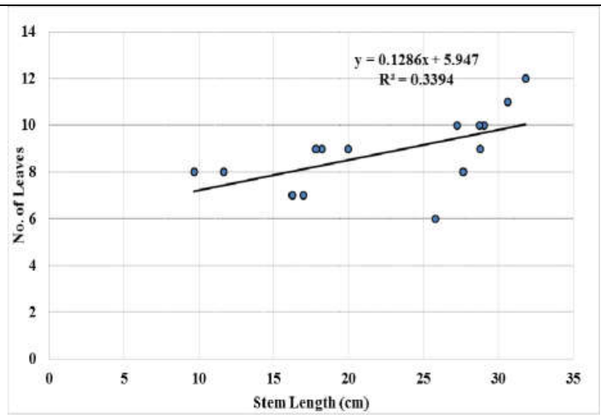


**Figure 4. Linear relation - stem length x number of leaves**

River Matla started to dry up when the upstream freshwater discharge from the river Bidyadhari and Karatia had stopped. Salinity is one of the most vital ecological drivers influencing health, species distribution, growth and productivity of mangrove vegetation (Ball, 2002). Surface water salinity in the present field-work station has been periodically monitored by few researchers (Sarkar *et al.,* 2002; Ghosh and Banerjee, 2013) and a comparative account of the same between 1998 and 2019 has been given in Figure 1. The sequence of salt-tolerant vegetation, in the study zone, exhibited poor zonation because of limited floral composition. The extreme inter-tidal area on the riverbank is mainly dominated by *Avicennia officinalis* and *Exoecaria agallocha* community. Further landward, the zone is occupied by *Sonneratia* population which is, then, replaced by *Acanthus ilicifolius*. Thick network of *Porteresia coarctata* along with moderate vegetation of another mangrove-associate *Suaeda maritima* form the ultimate layer of halophytic vegetation along the landward margin. *Avicennia officinalis* and *Exoecaria agallocha* appeared to be the predominant species along the riverine belt. Studies have shown that the distribution of mangrove species within a mangrove area depends mainly on accessibility and allocation of seeds or seedlings, as well as tolerance of species to flooding and soil salinity, creating zonation of species (Abu Hena *et al.,* 2013).

*Porteresia coarctata* (Roxb.) Tateoka, a subtropical halophytic perennial grass, grows upright in stands of densely spaced stems with thick mats of roots and rhizomes. They possess linear, coriaceous leaves with spinulose margins. They act as pioneer species in the succession process of mangrove formation along the estuaries of India. It grows on the newly deposited sediments and thereby help to enhance sedimentation developing a favorable substratum for the growth of mangroves. *Porteresia* beds usually prefer polyhaline zones having salinity range of 18 – 35 ‰. The species has special glands that secrete excess salt, allowing it to withstand intense heat and daily exposure to salt water. It prefers lower salinity for germination and early growth (Jagtap, 1985). Of the whole plant body, what is seen above the soil surface is the shoot system, while below, covered by soil, is an equally important portion – the root system. The shoot is the emblem of greenness because of the green leaves while the root, growing in darkness, is never green (Gangulee *et al.,* 2002). Grasses whether annual or perennial are mostly herbaceous, i.e., not woody, monocotyledon plants with jointed stems and sheathed leaves. They are usually upright, cylindrical with alternating leaves, anchored to the soil by roots. Grasses have leaf blades that narrow into a sheath, a stem, a collar region where leaves attach to the shoot system, roots, tillers and during the reproductive stage an inflorescence develops (Anonymous, 2020).

The salt marsh develops in a rigorous environment that shows wide variations in several environmental factors like salinity, temperature and substrate. A sudden rainstorm during low tide may reduce surface salinities to a great extent, whereas the return of high tide may supply the marsh bed with nearly full strength seawater (Nybakken, 1997). In a study carried out along the Goa coast, India, average shoot height considered as total plant height was in the range of 36.1 – 83.5 cm of which the highest (83.5 cm) and lowest (36.1 cm) values were recorded during September (Monsoon) and February respectively (Jagtap *et al.,* 2006). Estimated value of total plant height measured in the present study, 13.34 cm – 42.43 cm (30.69 cm ± 8.48), was less compared to the plant height recorded by Jagtap *et al.* (2006) which may be attributed to seasonal difference in eco-biological variables in these two different geographic locales. While root length (independent factor) versus stem length (dependent factor) was plotted together, a high correlation value ($r = 0.63$, $p < 0.05$, $n = 14$) indicates stem length tends to increase with increasing root length (Figure 3), whereas, no significant relationship was obtained between stem length (independent factor) and number of developed leaves (dependent factor) per plant ($r = 0.39$) which indicates stem or shoot length does not appear to be an influencing factor on number of leaves (Figure 4). Available data during 1998 – 2012 study period (Sarkar *et al.*, 2002; Ghosh and Banerjee, 2013) along with present study for the period 2015 – 2019 revealed that surface water salinity gradually increased through post-monsoon reaching at its peak during the month of May (pre-monsoon, Figure 1). Annual variation in salinity was in the range of 9.2 ‰ (9.96 ‰ ± 0.34) during monsoon to 26.5 ‰ (25.88 ‰ ± 1.20) in pre-monsoon months. This factor could be held responsible behind comparatively poor data in some vegetative characteristics of *Porteresia* bed along the upstream belt of Matla estuarine system. Jagtap *et al.* (2006) opined that the luxuriant growth and high biomass content of *P. coarctata* during monsoon compared to other seasonal periods was due to lower salinity along with high nutrients. This could be substantiated from the fact that during monsoon, rivers get flooded with cities' pollutant loads because of precipitation which along with the factor of low (Evaporation – Precipitation) value reduces the surface water salinity. The less saline conditions favors the initiation of tiller primordial and luxuriant growth resulting in the higher biomass during monsoon period (Jagtap *et al.,* 2006). As the present study-period belonged to post-monsoon season, the surface water that nourishes the marsh vegetation, during this time, experiences a gradual increase in salinity content compared to monsoon and therefore could have impacted the overall vegetative characteristics of the species.

**Conclusion**

With tolerance to wide salinity range and adaptability to sandy and muddy substratum, *P. coarctata* vegetation has immense ecological significance in providing natural protection, conservation and restoration of estuarine and creek systems in India. The habitats of this perennial grass in the country have been categorized under ecologically sensitive zone and protected vide Coastal Regulation Zone (CRZ) Act, 1990 along with mangroves (Sengupta and Majumder, 2010). The present study was very much restricted to single station and post-monsoon or winter period (December & January) of the study zone which fall in the central sector of Indian Sundarbans. The area experiences several anthropogenic disturbances, such as diverse construction activities, soil dredging etc. along with prominent threat from various point and non-point sources of pollution along the entire stretch of adjacent riverine system. This necessitates a thorough study to monitor the species composition and variation in different vegetative characteristics of *P. coarctata* bed to determine the level of ecological crisis this halophytic vegetation will experience in near future.

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