



MORPHOMETRY, HABITAT AND STANDING CROP OF *Porteresia coarctata* AT BAKKHALI ESTUARY, COX'S BAZAR, BANGLADESH

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Abstract: Morphology, habitat, shoot density and standing crop (above and below ground biomass) of salt marsh *Porteresia coarctata* at Bakkhali estuary, Cox's Bazar were investigated from January 2006 to June 2006. Permanent plots of 50 m x 50 m from exposed (station I) and protected (station II) areas were selected. *P. coarctata* was found growing as monospecific stand and four-species association with seagrass *Halophila beccarii*, patches of mangroves (*Avicennia alba*, *A. marina* and *Acanthus ilicifolius*) and the seaweed *Ulva intestinalis* in the intertidal sandy clay substrate. *P. coarctata* also grew in three-species association with mangrove and seaweed, or with seagrass and seaweed as well as in two-species association with seagrass and *Imperata cylindrica*. The range of mean leaf length, internodes length of rhizome and individual shoot height were found 8.10-14.49 cm, 0.91-1.41 cm and 12.90-20.94 cm, respectively. The mean shoot density varied from 925.0 to 1545.0 shoots m⁻². The mean above and below ground biomass were 23.28-38.02 g DW (Dry Weight) m⁻² and 60.26-97.39 g DW m⁻², respectively. The pore water salinity, pH and NH₄-N were recorded 17.0-41.66‰, 6.0-6.47 and 1.80-3.70 μg l⁻¹, respectively. The variation of morphological parameters, shoot density and standing crop of *P. coarctata* between the two sampling stations attributed to the differences in habitat, soil organic matter and tidal action i.e., wave and current between the stations.

Key words: *Porteresia coarctata*, shoots density, biomass, Bakkhali estuary

Introduction

Grass land on the coast protects the area from erosion, filters suspended sediment from water, help to reduce wave and current energy and thus aids in the land building process. Grass land ecosystem on the coast is one of the most productive ecosystems in the world in term of annual vegetation production per unit area (Day *et al.*, 1989). The high primary production rate of such ecosystem is closely linked to the high nutrient input and production rate of associated fauna including fisheries (Barbara *et al.*, 1982). Some herbivores directly feed on live grass land vegetations on the coast, and a substantial amount of plant decomposed materials enter into the estuarine ecosystem (Newell, 2001).

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In Bangladesh, there is very little scientific information (Abu Hena, 2006; Abu Hena *et al.*, 2007) on the biology, ecology and productivity of the coastal grass land. Therefore, this preliminary study has been undertaken to investigate the morphometry, habitat, shoot density, standing crops (above and below ground) along with few ecological parameters of *P. coarctata* bed in the estuarine environment of Bakkhali, Cox's Bazar over a period of six months.

Materials and Methods

Study area: The study area was situated in the estuarine environment of Bakkhali, Cox's Bazar (20°85'40"-20°46'92" N and 91°96'60"- 92°34'37" E; Fig. 1) which has a maritime climate, and the temperatures buffered by the nearby ocean (Khan and Karim, 1982). The maximum air temperature, water salinity and rainfall observed in summer ranges from 31.1°-33.3°C, 33.47-34.71‰, 172.0-214.0 mm and minimum of them in dry season ranges from 24.8°-29.8°C, 5.81-12.81‰, 1.0-6.0 mm, respectively in the estuarine environment of Bangladesh (Mahmood *et al.*, 1978; Mahmood, 1986). Drought conditions prevail during the winter months i.e., November-February and rainfall is confined to the monsoon period. Normally, 80-90% of the annual rainfall occurs during the monsoon months (June-September). The area of *P. coarctata* bed is about 10 ha. The Bakkhali estuary is an important river estuary with a harbor and local fishery. The estuary is approximately 0.5 km wide and >10 m deep at its mid point. The tide in the area is semi-diurnal and maximum tidal amplitude is 3 m at spring tide (Mahmood, 1986).

Because of finance and time constrains, present study was conducted for six months from January to June 2006. Therefore, seasonal changes of the parameters studied for six months were not worthy. Sampling was done at monthly interval during the spring low tide. Two stations were selected in this area where one is considered exposed (station I) to sea energy forces i.e., direct wave action and the other (station II) is naturally protected from direct wave action (Fig. 1).

Morphological study: *P. coarctata* was randomly collected using trowel from the two stations. The collected samples were placed in the pre-labeled plastic bags and brought back to the Laboratory of Estuarine, Coastal and Aquaculture Research (LECAR), Institute of Marine Sciences and Fisheries, University of

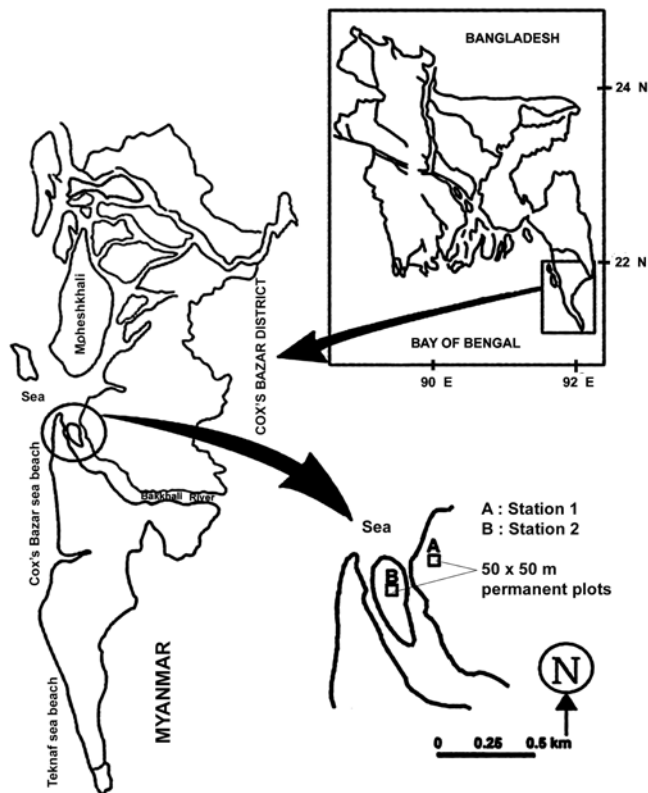


Fig. 1. Map of the Bakkhali estuary, Cox's Bazar showing the location of the sampling stations.

Chittagong. In the laboratory, the samples were washed carefully in running water. The leaf length, leaf width, rhizome length, internode length and shoot height were recorded. Specimens of *P. coarctata* were preserved in the museum of the Institute of Marine Sciences and Fisheries for future reference.

Estimation of shoot density and standing crop: A permanent plot of 50 m x 50 m at each station was established following the method described by Brower and Zar (1984). Five quadrates each of 20 cm x 20 cm, were randomly selected for measuring the shoot density in the permanent plots. Shoot density was investigated at monthly interval for six months following the procedure described by English *et al.* (1994). All plants including roots and rhizomes inside the quadrates were collected with a trowel and taken in plastic bags, and brought to the LECAR. The samples were washed and counted manually in the laboratory. The shoot number recorded from the individual quadrate was expressed as shoots m⁻².

For standing crop, the above ground parts (leaves and sheaths) were separated from roots and rhizomes. Any epiphytes or algal growth were removed carefully from the plants by scraping with a knife. Above and below ground parts of *P. coarctata* were then dried in an oven at 100°C for 4 hours to obtain dry weight (DW) following the procedure described by Schubauer and Hopkinson (1984) and Norhadi (1993). The standing crop values obtained from this study were expressed in gm per unit area (g m⁻²).

Soil sampling: The surface sediment (<10 cm deep) samples were collected from the permanent plots. Soil pH (wet) was recorded *in situ* using a pH meter (soil pH tester, TAKAMURA electric works Ltd., Japan). Soil samples were collected using a hand made mud corer (5.0 cm diameter), placed in the plastic bags and labeled. After collection, all samples were brought to the LECAR within 2-4 hrs for analysis. In the laboratory, the samples were dried at 100°C for 24 h and powdered, sieved through a 0.5 mm stainless steel sieve and stored in a desiccator. All determination was in triplicate and the mean value was used to obtain representation of each parameter. Dry soil pH was determined by soil tester following the procedure described by Boyd (1995). Soil texture was analyzed by hydrometer method following the procedure described by Bouyoucos (1962), soil organic matter following combustion method by Boyd (1995) and soil carbon by Nelson and Sommers (1982).

Pore water sampling: Pore water samples were collected from the permanent plots. After digging a soil sample, accumulation of pore water could usually be observed at the bottom of the hole. Once the small hole was filled with water, it was rapidly transferred into air tight plastic bottles. Pore water pH and salinity were measured *in situ* using a pen pH meter (S237734, HANA Instruments) and refractometer (News-100, TANAKA, Japan), respectively. The collected water samples were preserved by HCl for further analysis and brought to the laboratory placing inside an ice box. Pore water ammonium concentration was measured by phenol hypochlorite procedure described by APHA (Anon, 1976).

Statistical package for social science (SPSS) version-10 was used to analyze the mean values of morphometric parameters, shoot density, above and below ground biomass, and soil and pore water parameters. Simple t-test was used to compare the means of two sets of observations at two stations.

Results

Morphometry and habitat: The leaf length of *P. coarctata* varied significantly ($p < 0.05$) between the stations. In station II, leaves were comparatively longer. However, leaf width and internode lengths of *P. coarctata* were not significantly ($p > 0.05$) different

between the stations (Table 1). *P. coarctata* grew as monospecific pure stand and but also found in 4-species association with seagrass, mangrove and seaweed in this estuarine coastal area. Sometimes, *P. coarctata* grow in 3-species association sharing with seagrass and seaweed, or with mangrove and seaweed followed by 2-species association with seagrass or mangrove or coastal 'Uri' grass *Imperata cylindrica*.

Shoot density and standing crop:

The mean values of shoot density of *P. coarctata* were 925 shoots m⁻² and 1545 shoots m⁻² for station I and station II during the six months study period, respectively. However, in both stations shoot density fluctuated and showed irregular form during the study period. The shoot density of *P. coarctata* was recorded higher in station II compared to station I (Table 2).

The higher above ground biomass (AGB) of *P. coarctata* was 33.62±6.22 g (DW) m⁻² in April at station I and 50.24±6.97 g (DW) m⁻² in March at station II (Table 3). Higher mean AGB (36.36 g DW m⁻²) was observed in station II than that test in station I (23.28 g DW m⁻²).

Mean BGB was higher at station II (97.39 g DW m⁻²) than that in station I (60.26 g DW m⁻²). Monthly BGB showed irregular pattern throughout the study period (Table 4), and higher biomass was observed in the month of March at station I (116.96 ±10.91 g DW m⁻²) and station II (148.77 ±15.23 g DW m⁻²).

Physico-chemical parameters of soil and pore water: Monthly variation in the physico-chemical parameters of soil and pore water was observed. The sand component was 86%

Table 1. Morphological feature of *P. coarctata* collected from the intertidal area of Bakkhali estuary, Cox's Bazar, Bangladesh.

| Morphological feature | Station I | | Station II | |
|------------------------|-----------|------------------------|------------|-------------------------|
| | Range | Mean ± SE | Range | Mean ± SE |
| 1st leaf length (cm) | 1.70-14.0 | 8.10±2.50 ^a | 9.0-23.5 | 14.49±2.0 ^b |
| 1st leaf width (cm) | 0.30-0.5 | 0.40±0.1 ^a | 0.60-0.75 | 0.61±0.06 ^a |
| 2nd leaf length (cm) | 1.50-10.1 | 5.04±2.0 ^a | 1.40-26.6 | 13.93±3.44 ^b |
| 2nd leaf width (cm) | 0.20-0.4 | 0.34±0.02 ^a | 0.20-0.8 | 0.62±0.10 ^a |
| 3rd leaf length (cm) | 1.50-10.0 | 4.89±1.99 ^a | 3.60-25.6 | 12.80±2.89 ^b |
| 3rd leaf width (cm) | 0.10-0.5 | 0.30±0.01 ^a | 0.10-0.85 | 0.42±0.11 ^a |
| Internodes length (cm) | 0.30-2.5 | 1.41±0.05 ^a | 0.20-2.30 | 0.91±0.21 ^a |
| Shoot height (cm) | 8.0-19.6 | 12.9±1.85 ^a | 15.80-30.6 | 20.94±1.65 ^b |

Means in the different columns with different letter of superscripts are significantly different (t-test, p<0.05)

Table 2. Shoot density (shoots m⁻² ± standard error) of *P. coarctata* in the Bakkhali estuary, Cox's Bazar, Bangladesh.

| Month | Station I | | Station II | |
|----------|-----------|--------------------|------------|---------------------|
| | Range | Mean ± SE | Range | Mean ± SE |
| January | 575-1075 | 795 ±30.26 | 750-1100 | 880 ±29.49 |
| February | 700-1625 | 1070 ±36.07 | 1150-2000 | 1530 ±41.02 |
| March | 400-1025 | 725 ±31.92 | 2050-2875 | 2320 ±47.15 |
| April | 600-975 | 700 ±27.57 | 1025-2675 | 1725 ±48.8 |
| May | 800-1625 | 1185 ±37.69 | 550-1650 | 1065 ±39.12 |
| June | 400-1500 | 1080 ±39.26 | 1025-2250 | 1750 ±45.86 |
| Mean | | 925.0 ^a | | 1545.0 ^b |

Means in the different columns with different letter of superscripts are significantly different (t-test, p<0.05)

Table 3. Above ground biomass (AGB; g DW m⁻²) of *P. coarctata* of two Stations in the Bakkhali river estuary.

| Month | Station I | | Station II | |
|----------|-------------|--------------------|-------------|--------------------|
| | Range | Mean ±SE | Range | Mean ±SE |
| January | 2.20-20.30 | 14.11 ±4.77 | 12.85-22.17 | 16.1 ±5.00 |
| February | 24.45-43.30 | 31.93 ±5.99 | 32.17-49.25 | 39.035 ±6.29 |
| March | 4.97-28.95 | 15.67 ±5.29 | 43.72-62.25 | 50.24 ±6.97 |
| April | 28.13-49.25 | 33.62 ±6.22 | 33.90-63.40 | 49.145 ±7.45 |
| May | 14.92-45.48 | 23.28 ±6.16 | 10.85-29.55 | 22.8 ±5.41 |
| June | 8.30-27.32 | 21.08 ±5.32 | 25.80-69.43 | 40.81 ±6.85 |
| Mean | | 23.28 ^a | | 36.36 ^b |

Means in the different columns with different letter of superscripts are significantly different (t-test, p<0.05)

followed by 13% clay and 1% of silt. The wet and dry pH of soil were <7.0 in both stations. The range of organic matter was found 1.52-3.56% in the *P. coarctata* habitat of

Bakkhali estuary. A monthly variation in soil organic matter during the study period was noticed and recorded comparatively higher in dry months than in wet months (Table 5).

The pore water salinity and pH were almost uniform in the investigated stations. The ranges of pore water salinity and pH in the areas were 17.0-41.67 ‰ and 6.4-7.7, respectively. Comparatively, the pore water NH₄-N was recorded slightly higher (t-test, $P>0.05$) in the station II than the station I.

Table 4. Below ground biomass (BGB; g DW m⁻²) of *P. coarctata* in the Bakkhali estuary, Cox's Bazar, Bangladesh.

| Month | Station I | | Station II | |
|----------|---------------|--------------------|--------------|--------------------|
| | Range | Mean ±SE | Range | Mean ±SE |
| January | 7.75-26.68 | 21.14 ±5.32 | 20.48-30.28 | 23.96 ±4.88 |
| February | 47.75-103.98 | 64.91 ±9.25 | 110-167.63 | 140.26 ±11.29 |
| March | 103.75-155.05 | 116.93 ±10.91 | 90.18-269.53 | 148.77 ±15.23 |
| April | 39.15-87.78 | 64.15 ±8.93 | 67.9-151.75 | 114.69 ±11.85 |
| May | 14.85-45.28 | 30.7 ±6.57 | 43.25-68.88 | 68.19 ±8.14 |
| June | 41.25-115.48 | 63.73 ±9.88 | 32.45-108.88 | 88.47 ±10.80 |
| Mean | | 60.26 ^a | | 97.39 ^b |

Means in the different columns with different letter of superscripts are significantly different (t-test, $p<0.05$)

Table 5. Physico-chemical parameters of soil and pore water during the sampling period in the Bakkhali estuary, Cox's Bazar.

| Parameter | Station I | | Station II | |
|--|-------------|------------------------|------------|-------------------------|
| | Range | Mean ± SE | Range | Mean ± SE |
| Soil | | | | |
| pH (Wet) | 6.0-6.47 | 6.16±0.17 ^a | 6.0-6.66 | 6.32±0.5 ^a |
| pH (Dry) | 6.0-6.40 | 6.21±0.15 ^a | 6.1-6.6 | 6.37±0.42 ^a |
| Organic matter (%) | 1.52-3.11 | 2.07±0.59 ^a | 1.66-3.56 | 2.5±0.79 ^a |
| Organic carbon (%) | 0.78-1.64 | 1.09±0.31 ^a | 0.87-1.87 | 1.32±0.57 ^a |
| Pore water | | | | |
| Salinity (‰) | 20.34-41.67 | 32.77±7.4 ^a | 17.0-40.67 | 31.94±2.91 ^a |
| Water pH | 6.40-7.56 | 7.3±0.54 ^a | 6.4-7.7 | 7.19±0.72 ^a |
| NH ₄ -N (µg l ⁻¹) | 1.80-3.03 | 2.34±0.45 ^a | 2.51-3.7 | 3.22±0.69 ^a |

Means in the different columns with different letter of superscripts are significantly different (t-test, $p<0.05$)

Discussion

Morphometry and habitat: Like other coastal aquatic vegetations, in salt marshes; the plants size may be controlled by many factors i.e., flooding regime, wave action, soil salinity and availability of nutrients. Inter species competition and physical stress due to varying energy condition may result in size differences of coastal and estuarine vegetations worldwide (Day *et al.*, 1989). At Bakkhali river estuary of Cox's Bazar, the shoot length of *P. coarctata* was lower compared to the reported values by Adams (1963; 121.92-304.80 cm) and Mooring *et al.* (1971) for salt marsh *Spartina alterniflora* in the coastal area of USA. The higher (0.64-1.52 cm) leaf width of the *S. alterniflora* was also found by Adams (1963) compared to the recorded values for *P. coarctata* in the estuarine environment of Bakkhali. Compared to Station I, the higher leaf length (t-test, $P<0.05$) and shoot height (t-test, $P<0.05$) of *P. coarctata* were found in the Station II probably due to the variation of environmental factors i.e., organic enriched soil with less disturbance by anthropogenic and natural activities. It is assumed that the higher soil organic matter in Station II could be a factor for higher growth of *P. coarctata* in this area. Zafar and Hasan (2005) had such type of observation for other coastal aquatic macrophytes. In addition, based on observation, it was found that the tidal action was low in Station II which may have favored plant growth.

P. coarctata was reported growing in the intertidal brackish water of river mudflat system (Latha *et al.*, 2004) as like other species of temperate salt marsh grow in the estuaries and marine environment (Schubauer and Hopkinson, 1984; Weiss *et al.* 1979, Table 6). This study revealed that the estuarine area of Bakkhali inhabit relatively simple coastal band of salt marsh creating brackish water tidal marshes with complex distribution patterns of vegetation. Tidal salt marshes mainly occur in the coastal regions of temperate and subtropical countries including Britain, Ireland, France, Netherlands, Germany, Denmark, Australia, New Zealand, China, the United States, India and West coasts of Indo-Pacific regions (Hitchcock, 1951; Ranwell, 1967; Alderson and Sharp, 1994; Latha *et al.*, 2004). However, five genera of coastal grass inhabit in the coastal and estuarine area of Bangladesh, of which four grow in the South Asian and South East Asian subtropical and tropical coasts (Das and Siddiqi, 1985; Latha *et al.*, 2004; Swaminathan Research Foundation, 2004-2005).

Table 6. Comparison of habitat of salt marsh *P. coarctata* with the reported studies for other salt marsh worldwide.

| Location | Habitat description | Reference |
|-------------------------|---|---|
| Indian coast | Coastal mudflat and marine environment growing in mono specific condition and other species (mangrove) association | Latha <i>et al.</i> , 2004 |
| Coastal area, USA | River mudflat and coastal area growing in mono specific form with patches | Schubauer & Hopkinson, 1984; Weiss <i>et al.</i> , 1979 |
| Cox's Bazar, Bangladesh | Estuarine intertidal zone and river bank with seagrass (<i>Halophila beccarii</i>), mangroves (<i>Avicennia alba</i> , <i>A. marina</i> and <i>Acanthus ilicifolius</i>) and seaweed (<i>Ulva intestinalis</i>) and salt marsh (<i>Imperata cylindrica</i>) | This study |

Shoot density and standing crop: The shoot number of any aquatic plants per surface area is species dependent (Nienhuis *et al.*, 1989). *P. coarctata* shoot density in the study area was higher than those reported by Weiss *et al.* (1979), Schubauer and Hopkinson (1984) and Sanckez *et al.* (2001)

Table 7. Comparison of shoot density and standing crop (above and below ground biomass) of *P. coarctata* with reported studies for *Spartina* sp.

| Location | Shoot density (shoot m ⁻²) | AG biomass (g DW m ⁻²) | BG biomass (g DW m ⁻²) | References |
|------------------------------|--|------------------------------------|------------------------------------|------------------------------|
| Atlantic and Gulf coast, USA | 1215-2000 | - | - | Weiss <i>et al.</i> (1979) |
| Georgia, USA | 733-1234 | 175-733 | 310-315 | Schubauer & Hopkinson, 1984 |
| North-west Spain | 300-1944 | - | - | Sanckez <i>et al.</i> , 2001 |
| Cox's Bazar, B'desh | 400-2875 | 15.67-50.24 | 21.13-148.76 | This study |

(Table 7). Nienhuis *et al.* (1989) also revealed that the density of aquatic plants varies with geographical location and habitat characteristics. This statement was found to be consistent with the results obtained for this study. Furthermore, comparatively higher soil organic matter and pore water NH₄-N in station II probably supports the dense growth of *P. coarctata*. The AGB was lower compared to the values (175-733 g m⁻²) reported by Schubauer and Hopkinson (1984) in USA.

The below ground biomass (BGB) observed in this study was lower than that reported by Schubauer and Hopkinson (1984) from the coastal area of Georgia, USA probably due to the differences of the plant size, environmental differences and other geographical factors. Romero *et al.* (1994) stated that the higher BGB may provide a better anchorage

for the plants and higher storage capacity for carbohydrates and nutrients which later on support the overall growth and total biomass of plants.

Physico-chemical parameters of soil and pore water: Generally, the acid sulfate soil (<7) is common in the brackish water coastline of Bangladesh and this is the case for present study. Das *et al.* (2002) observed similar soil pH in the aquaculture ponds in the coastal area of Bangladesh. The pore water pH was slightly higher compared to the soil pH during the study period. The slightly alkaline pH of pore water in both the stations could be due to the reduction and inactivation of SO_4^- once the sediment water gets connected with air (Singh, 1989).

The soil texture in *P. coarctata* habitats was sandy clay. The sandy clay type of soil composition is also found in the saline soils of Bangladesh (Rahman *et al.*, 1993). Usually, the soil texture variation in the estuarine coastal area is produced during sedimentation process (Chou *et al.*, 2004). The higher percentage of sand in soil in the study area suggests that the estuarine habitat of Bakkhali river probably a depositional coast. The accreted lands of sand bar at the mouth of Bakkhali estuary, Cox's Bazar support this finding. Soil organic matter in the areas was higher than the recorded values (0.2-0.4%) as reported by Rajyalakshmi and Chandra (1987) in Chilka lagoon, India and in mangrove areas (0.5-1.7%) of Bangladesh (Zafar and Hasan, 2005). The higher soil organic matter content at station II revealed that the accumulation of carbon in the superficial soil is the results of the continuous input of organic matters from aquatic macrophytes i.e., salt marsh, mangroves and seagrass (Zafar and Hasan, 2005).

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