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Assessment of Plant Diversity of a Seasonal Tropical Wetland Forest Ecosystem in Bangladesh

SAJAL SAHA[1], MUHA ABDULLAH AL PAVEL*[2] & MOHAMMAD BELAL UDDIN[1]

[1]Department of Forestry and Environment Science, School of Agriculture and Mineral Sciences, Shahjalal University of Science and Technology, Sylhet 3114, Bangladesh; [2]Institute of Social Science, University of Lisbon, Av. Professor Aníbal de Bettencourt, 9, 1600-189 Lisbon, Portugal
*Corresponding author: pavel.sust@gmail.com

ABSTRACT

The quantitative analysis of plant diversity was explored on a seasonal tropical wetland forest ecosystem at Ratargul Swamp Forest. The simple random sampling protocol was adopted, and 30 plots (10 m×10 m) each with one subplot (2 m×2 m) was investigated for the vegetation survey. The study found about 539 individuals of 48 species belonging to 36 families. Poaceae was the dominant among all family. The upper (trees with all size) and lower (shrubs, herbs, climbers, grasses) stratum was dominated by *Pongamia pinnata* and *Clinogyne dicotoma*, respectively. The taxonomic diversity was moderate in both lower and upper strata. The value of floristic quality index was calculated at 19.92, which represents moderate vegetative quality. The outcome also revealed the disturbances which influenced the plant community, mostly due to branch cutting by human (<30%). The findings will be useful for the conservation and scientific management of biodiversity as a hotspot in seasonal tropical wetland forest system.

Keywords: Biodiversity, conservatism, disturbance, hotspot, wetland

INTRODUCTION

Tropical forests are the most species rich ecosystem in the world. Tropical swamp forests are more complex forest ecosystem with rich biodiversity that are associated with abundant trees and high shrubs (Keddy, 2010; Vijayakumar & Vasudeva, 2011; Islam *et al.*, 2017). Bangladesh, located in the delta of one of the world's major river systems, is a land of vast water and wetlands. More than two thirds of the landmasses of this country have been classified as wetlands according to the definition of the Ramsar Convention (Alam *et al.,* 2012).

The most important freshwater wetlands occur in the Hoar Basin apart from the Ganges-Brahmaputra delta, which is low lying plains in eastern Mymensingh and western Sylhet divisions, in the north eastern part of the country (Alam *et al.,* 2012). Wetland ecosystems are of great importance to Bangladesh due to its extent and its economic and ecological roles in sustaining life and livelihoods options in the country. Ratargul Swamp Forest (RSF) is one of the remaining fresh water swamp forests in Bangladesh. This falls under the category of fresh water wet evergreen forest (Sharmin *et al.*, 2016). These swamp forests have a wide range of biological, hydrological, economic social, cultural and aesthetic values (Vijayakumar & Vasudeva, 2011). It is one of the most important habitats for a large variety of flora and fauna of local, national and regional significance. However, rapidly increasing land development and extensive agricultural operations pose significant challenges to the survivability and sustainability of this wetland ecosystems. Remaining natural areas display varying degrees of diversity and quality of forest health because of habitat alterations. Moreover, many of the native plant species have been reduced or eliminated from vast areas where they formerly occurred. Besides, there is little quantitative information available on the composition and structure of flora in RSF.

So, it has become inevitable to assess qualitative and quantitative vegetation study at RSF to form baseline information for implementing proper management programme. The study was undertaken to determine the

species composition, floristic quality of the major plant communities of RSF.

MATERIALS AND METHODS

Study site

Ratargul Swamp Forest (RSF) lies between 25°00.025′N latitude and 91°58.180′E longitude in Gowainghat upazilla (Sub-district), Sylhet (district), Bangladesh (Figure 1; GOB, 2010). Administratively, it is under the Sylhet forest division and located nearly northeast of Sylhet, one of divisional city of Bangladesh. The total area of RSF is about 204 ha (Hossain *et al.*, 2016). The climate usually receives heavy rainfall. Total annual average rainfall is about 4162 mm. The temperature varies with average maximum 32°C in May-October to minimum 12°C in January. The relative humidity is about 74% in December to 90% in July-August. Geographically, the area is plain or low land, but the rest of the land is surrounded by water (Choudhury *et al.*, 2004). The soils are gray, heavy, silt-clay loam with clays that predominates. The soil under the vegetation is mostly clayey loam to clayey in texture. The soils become dry and heavy cracks after rainy season. The soil of the forest can be categorized as sandy to sandy-loam (Debashish *et al.*, 2013).

Sampling protocol

The simple random sampling protocol was adopted for the vegetation survey. Thirty sample square plots of 10 m×10 m (0.01 ha) were used for trees (dbh ≥ 5 cm), and one square subplot of 2 m×2 m was taken within each plot to count and identify seedlings (diameter at collar region < 2.5 cm and height < 1 m) (Pavel *et al.*, 2016), shrubs, and herbs. The location of each plot was recorded by hand mobile GPS (GARMIN, 12 channel) and area delineated through linear measuring tape. A comprehensive species and undergrowth survey was conducted. All species composition was divided into two strata. One was upper stratum, and another was lower stratum. Trees with all sizes were considered as upper stratum whereas shrubs, herbs, climbers and grasses together were considered as lower stratum. The name and presence number of

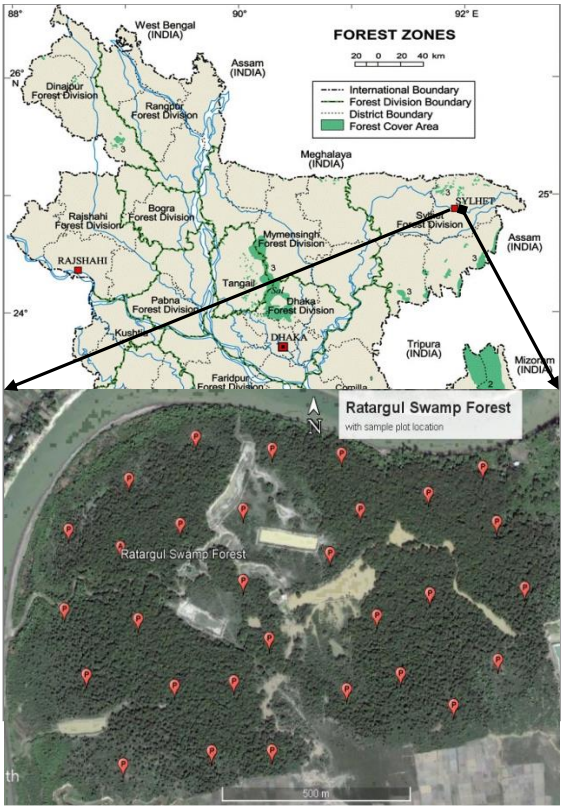

Figure 1. Location map of Ratargul Swamp Forest (RSF) (GOB, 2010).

disturbances in each plot were recorded by visual estimation. Then, percentage value for each of disturbance for all sample plot was made.

The crude density refers to the number of individuals of a particular species per unit area. The proportion of a species to that of stand is referred to as relative density. Additionally, frequency refers to the degree of dispersion in terms of percentage occurrence. The dispersion of species in relation to that of all the species is termed as relative frequency of a species. Again, the estimated number of individuals of a species per unit area is referred to as abundance. The parameters commonly were used to characterize the structure of plant community by the following formula (Shukla & Chandel, 2000):

$$\textit{Density of a species} = \frac{\text{Total number of individuals of a species in all the sample plots}}{\text{Total number of sample plots studied}}$$

$$\textit{Relative density of a species} = \frac{\text{Total number of individuals of a species}}{\text{Total number of individuals of all species}} \times 100$$

$$Frequency\ of\ a\ species = \frac{\text{Total number of quadrates in which the species occur}}{\text{Total number of quadrates studied}} \times 100$$

$$Relative\ frequency\ of\ a\ species = \frac{\text{Frequency of the species}}{\text{Sum of the frequencies for all species}} \times 100$$

$$Abundance\ of\ a\ species = \frac{\text{Total number of individuals of a species in all quadrates}}{\text{Total number of quadrates of which the species occured}} \times 100$$

Diversity Index is a quantitative measure that reflects how many different types there are in a dataset and simultaneously considers how evenly they are distributed (Okpiliya, 2012). The Shanon-Wiener index for floristic diversity is used to measure the density and relative density of RSF (Rahman *et al.*, 2013). Species richness index and species evenness index were also calculated using Margalef's formula (1958):

Shannon-Wiener index $(H') = -\sum Pi \ln pi$
Species diversity index (SDI) $= S/N$
Species richness index $(R) = (S-1)/\ln N$
Species evenness index $(E) = H/\ln S$
Simpson index $(D) = \sum_{i=1}^{s} \boldsymbol{Pi}^2$

Where, S is the number of species; *i* is the number of individuals of each species; *Pi* is the number of individuals of one species divided by total number of individuals in the samples; N is the total number of individuals in the sample.

Floristic quality assessment (FQA) is a promising tool based on the concept of species conservatism. It is an indication of native vegetative quality for an area: generally, low vegetative quality (1-19); high vegetative quality (20-25) and "natural area" quality (>35) (Swink & Wilhelm, 1994). The coefficient of conservatism (CC) were consider ranked based on some criteria (Table S3). The floristic quality was calculated by the following formulas (Andreas *et al*., 2004; Mortellaro *et al*., 2012):

Mean CC $= \sum_{i=1}^{n} CCi/N$

Floristic quality index (FQI) $= (\sum_{i=1}^{n} CCi/N)\sqrt{N}$

FQI native $= (\sum_{i=1}^{n} CCi\ /\ Nn)\sqrt{Nn}$

Adjusted FQI $= \frac{(\sum_{i=1}^{n} CCi\ /\ N)}{10} \frac{\sqrt{Nn}}{\sqrt{N}} (100)$

Where, N is the number of species; N_n is the number of native species; CC_i is coefficient of conservatism assigned to each species. The SPSS 20 and MS Excel 2007 were used to conduct the statistical analysis.

RESULTS

Species Composition and Abundance

The study revealed a total of 48 plant species, and among them trees (19), shrubs (3), herbs (14), climbers (7) and grasses (5) in RSF (Table S1; Table S2). The trees were highest (40%), followed by herbs (29%), climbers (15%), grasses (10%) and shrubs (6%) (Figure 2).

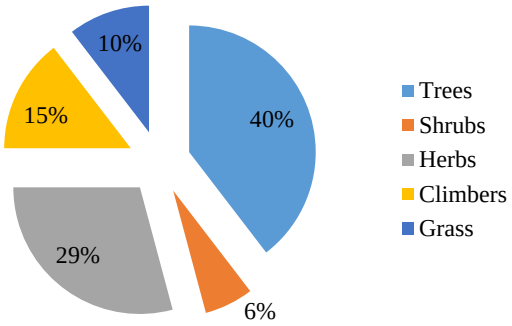

Figure 2. Percentages of plant species in RSF.

The family of Poaceae was the dominant among all. *Calamus guruba* was the largest in total abundance (6.42) followed by *Pongamia pinnata* (6) and *Phragmites kakra* (5). They were highly dominant and broadly dispersed in RSF. Besides, *Clinogyne dicotoma*, *Barringtonia acutangulata*, and *Vetiveria zizanioide* were abundance at 4.88, 4.75 and 4.67, respectively; while these can be termed as co-dominant species and less dispersed. *Artocarpus lacucha* and *Terminalia arjuna* were the lowest abundance species (Table 1). A total of 19 species were found in the upper stratum. The highest number of individuals found of *Pongamia pinnata* (40%) followed by *Barringtonia acutangulata* (28%) and *Syzygium formosanum* (11%). A total of 268 number of tree species has density of 8.91 (Table 1). Besides, 29 species were found in the lower stratum. The highest number of individuals were *Clinogyne dicotoma* (47%) followed by *Calamus guruba* (17%), *Vetiveria zizanioides* (10%) (Table 2).

Table 1. Quantitative structure of upper stratum in Ratargul Swamp Forest.

Scientific Name	Family	N	%	F	RF	D	RD	A
Pongamia pinnata	Fabaceae	108	40	60	24.32	3.60	38.57	6.00
Barringtonia acutangulata	Lythraceae	76	28	53.33	21.62	2.53	27.14	4.75
Syzygium formosanum	Myrtaceae	30	11	33.33	13.51	1.00	10.71	3.00
Crataeva nurvala	Capparidaceae	28	11	26.67	10.81	0.93	10.00	3.50
Trewia nudiflora	Euphorbiaceae	10	4	10.00	4.05	0.33	3.57	3.33
Lagerstroemia speciosa	Lythraceae	6	2	10.00	4.05	0.20	2.14	2.00
Anthocephalus chinensis	Rubiaceae	4	2	6.67	2.70	0.13	1.42	2.00
Ficus Benghalensis	Moraceae	4	2	6.67	2.70	0.13	1.42	2.00
Terminalia arjuna	Compretaceae	1	0	3.33	1.35	0.03	0.35	1.00
Artocarpus lacucha	Moraceae	1	0	3.33	1.35	0.03	0.35	1.00
Total		268				8.91		

Note: number-N; frequency-F; relative frequency-RF; density-D; relative density-RD; abundance-A

Table 2. Quantitative structure of lower stratum in Ratargul Swamp Forest.

Scientific Name	Family	N	%	F	RF	D	RD	A
Clinogyne dicotoma	Marantaceae	127	47	86.67	21.67	4.23	31.75	4.88
Calamus guruba	Arecaceae	45	17	23.33	5.83	1.5	11.25	6.43
Vetiveria zizanioides	Poaceae	28	10	20	5	0.93	7	4.67
Eupatorium odoratum	Compositae	20	7	26.67	6.67	0.67	5	2.5
Asparagus racemosus	Liliaceae	18	7	20	5	0.6	4.5	3
Thelypteris palustris	Thelypteridaceae	13	5	16.67	4.17	0.43	3.25	2.6
Sccharum spontanium	Poaceae	8	3	6.67	1.66	0.27	2	4
Phragmites kakra	Poaceae	5	2	3.33	0.83	0.17	1.25	5
Bambusa vulgaris	Poaceae	4	1	10	2.5	0.13	1	1.33
Salvadora persica	Poaceae	3	1	3.33	0.83	0.1	0.75	3
Total		271				9.03		

Note: number-N; frequency-F; relative frequency-RF; density-D; relative density-RD; abundance-A

A total of 271 individuals have density of 9.03 (Table 2). The result of most different indices in upper stratum was less than lower stratum, while Simpson index was higher in upper stratum than lower stratum. The species diversity index was less in lower stratum (0.065) than upper stratum (0.068). In addition, the value of Shanon-Weiner index was 1.8 in upper stratum and 2.5 in lower stratum (Table 3).

Table 3. Different diversity index for upper stratum and lower stratum in Ratargul Swamp Forest.

Species	Floristic diversity index				
	H´	D	SDI	R	E
Upper stratum	1.8	0.246	0.068	3.19	0.604
Lower stratum	2.5	0.139	0.065	4.17	0.763

Note: Shannon-Wiener index-H´; Simpson index-D; Species diversity index-SDI; Species richness index-R; Species evenness index-E.

Floristic Quality

The coefficients of conservatism (CC) values were assigned to each species based on their located areas (Table S1, Table S2). The native mean of CC is also an indication of native vegetative quality (Figure 3). Approximately 83% of plants were assigned into the ruderal areas (0 - 4), while 17% into obligate to natural areas (5 - 10). Among 48 species, 75% were considered native and 25% were considered non-native. The means species richness was 48. The number of native species observed as 36. The floristic quality was enumerated as 19.92 whereas native floristic quality as 23. The value of adjusted floristic quality was 24.89 that should be remained in RSF (Table 4).

Table 4. Floristic quality index in Ratargul Swamp Forest.

Indices	Value
Species richness	48
Native species richness	36
Mean (C)	2.88
Mean (C) native	3.83
Floristic quality index	19.92
Floristic quality index(native)	23
Adjusted floristic quality index	24.89

Note: Coefficients of conservatism-C

Disturbances

The recorded total numbers of disturbances were 80 in all sample plots. The mean of disturbance was 2.67. Eight types of disturbance were found; among them branch cutting in wet season and grazing in dry season were mostly observed. The mostly observed disturbance was branch cutting in RSF (~ 29%), followed by nearly 28% in insect and disease epidemics (Figure 4).

DISCUSSION

The result represents 539 individuals that belong to 36 families and 48 species in RSF. Poaceae represented as the highest number of species among all species. The taxonomic diversity was moderate in both lower and upper strata in RSF based on the value 0 for low to 5 for high. About 75% native and 25% non-native species were identified. As consequences, native plant communities were influenced. Similarly, Mortellaro *et al*. (2012) assured that the non-native plant species (approx. 15%) altered the native plant communities. Uddin *et al.* (2013) also explained the same observation from managed forest in the north-eastern of Bangladesh. Furthermore, the value of floristic quality index was calculated at 19.92 representing moderate vegetative quality because this value fall between low vegetative quality (1-19) and high vegetative quality (20-35) index. The native floristic quality index was calculated at 23 but it should be 24.89 for this study area. It is an index that measures the conservatism of the species found in the plot. Swink & Wilhelm (1994) reported similar observation in this forest. The results revealed the disturbances influenced in plant community and the mostly observed disturbance was branch cutting by human (< 30%) in RSF (Figure 4). Both Pavel *et al.* (2016) and Uddin *et al.* (2013) reported similar observations from protected forests in Bangladesh.

As consequences, the socioeconomic changes, increasing human activities greatly change the community structure; species diversity and plant cover (Shaltout & El-Sheikh, 2002). Therefore, forest characterization is an important factor is influencing the tree species richness in RSF. Pavel *et al.* (2016) reported similar study from managed forest in the north-eastern areas of Bangladesh.

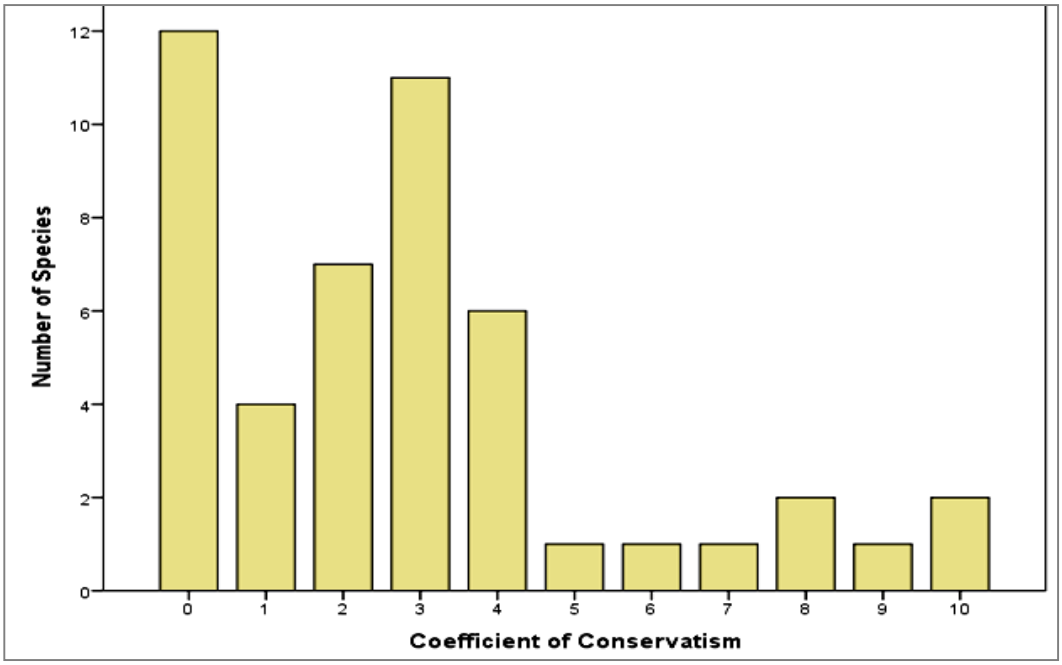

Figure 3. Distribution of coefficient of conservatism designation for graded plants in Ratargul Swamp Forest.

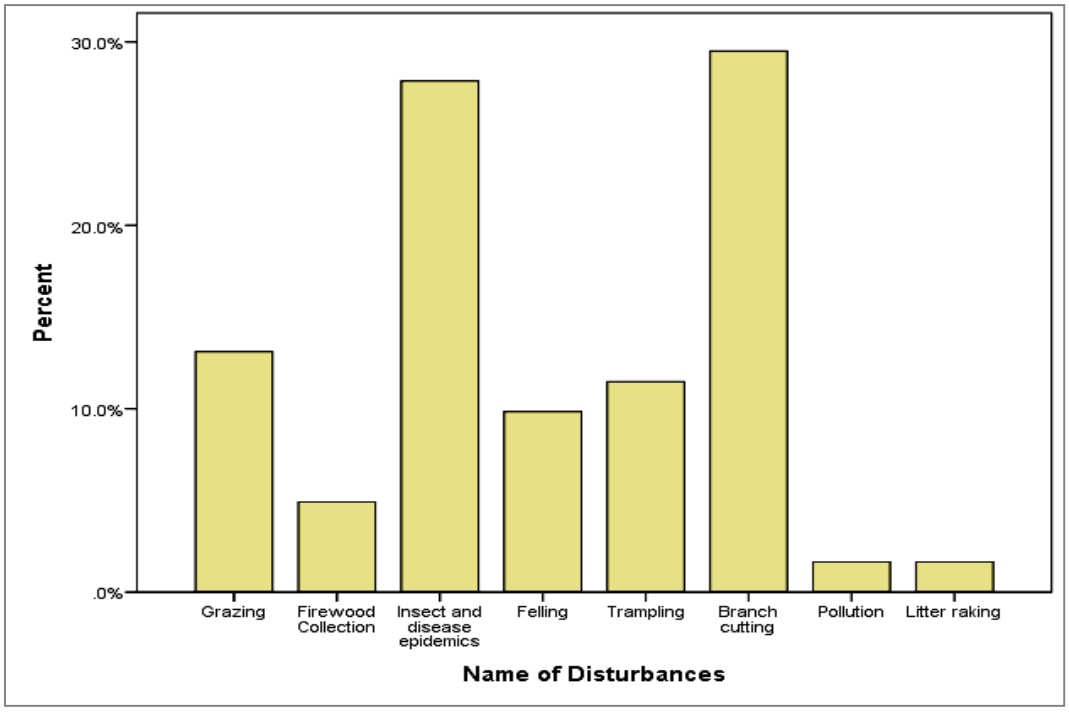

Figure 4. Distribution and percentage of disturbances in Ratargul Swamp Forest.

CONCLUSION

The diversity of plant was moderately present in RSF. The diversity and richness will be degraded in RSF near future due to the impacts of continuous threats. The awareness urgently needs to be created among the local people about the importance of conservation of biodiversity. The alternative income generating options need to be provided and promoted to local people to conserve the biodiversity of RSF.

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